Wash Zone Report

A Monitoring Review

National Rivers Authority
Anglian Region
Central Area
Brampton

NRA

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Wash Zone Report

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Wash Zone Report

Part I

The Wash
NRA Monitoring Review

EXECUTIVE SUMMARY

The Wash estuary supports internationally important biological communities and offers a rich resource for a variety of different users including commercial fishermen, tourists and farmers. The biological communities and the many users of the Wash depend on good water quality.

Water quality management in the Wash is the responsibility of the Anglian Region of the National Rivers Authority (NRA). The NRA undertake detailed monitoring programmes to ensure that Environmental Quality Standards are met.

This report summarises the monitoring work carried out in the Wash and its tributary estuaries up to the end of 1992. Water quality data from the tributary estuaries has been summarised by making reference to routinely collected data and to existing water quality reports. Much of the data collected in the Wash embayment is reported here for the first time.

Surveys carried out to date have shown water quality in the Wash system to be generally of very good quality.The NWC scheme designated the Witham and Welland estuaries as Class A and the Great Ouse estuary as Class B. The Nene estuary is currently designated as Class D, largely a consequence of low dissolved oxygen levels and limited biological life. The main influence on water quality in the Nene is believed to be the inputs of both sewage and industrial effluents that are made to it.

Bacterial monitoring in the Wash is carried out in areas where sewage pollution may pose a risk to health, i.e the Bathing Waters and the shellfish harvesting areas. The two EC designated bathing waters in the Wash have complied with the bathing water directive since 1989; in fact monitoring of these beaches (along with six non-identified beaches) has shown bacterial levels to have been decreasing since 1989. Monthly sampling of the 18 shellfish beds in the Wash has shown that shellfish in the northern and western areas of the Wash to contain the lowest numbers of bacteria. The greatest contamination of shellfish occurs in and around the mouth of the Great Ouse estuary, and harvesting is prohibited at one site. Bacterial monitoring of the sediments and water column in the Great Ouse has clearly implicated King's Lynn STW in these findings.

Both subtidal and intertidal benthic surveys have been carried out in the Wash and the tributary estuaries. Part II of the report describes in detail the large-scale subtidal survey that was carried out in the Wash embayment in 1991. The survey showed the Wash to support a rich and diverse fauna, particularly in the deep water channels. There was some evidence of disturbance around the mouth of the Great Ouse estuary, but this part of the Wash offers a very harsh physical environment to the benthic fauna and the results could merely be reflecting this fact. Biological surveys carried out in the tributary estuaries have shown that the benthic fauna is largely consistant with the physical and hydrographic regime of those estuaries. This may not be the case in several sections of the Nene estuary, where low diversity may reflect poor water quality. Also a short section of the Great Ouse, downstream of the sewage works appears to be impacted by organic effluent but this situation may have been brought about by the low flows in the Great Ouse during the drought period.

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Special thanks are due to Dr Nigel Grist of Unicomarine Ltd, who produced Part II of the report and to Clive Turner, marine data technician, who produced Part III, and helped, along with Fergus Charlton, to provide the water quality data contained within the main report.

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1. INTRODUCTION

The Anglian Region of the National Rivers Authority (NRA) routinely monitor the four main tributary estuaries that drain into the Wash but, until recently, little information relating to water quality in the Wash embayment had been collected by the NRA or its predecessor organisition, Anglian Water.

The aim of this report is to review existing information in order to highlight any water quality problems and to identify any gaps in current knowledge. The information can then be used to formulate a monitoring programme for the Wash which will take into account the needs of all designated users of the estuary.

Water quality data from the tributary estuaries have been summarised using both existing NRA reports and previously unpublished data. NRA water quality data from the Wash embayment is reported here for the first time.

2. The Wash System : Physical Aspects.

The Wash embayment, with its four main tributary estuaries forms the largest estuarine system in Britain. The Wash is an area of open coastal water with a tidal range of about 6.5m (on a spring tide), one of the largest in the North Sea.

The surface area of the Wash between Gibraltar Point and Hunstanton (Figure 2.1) is about 700 km^2 at high water on a spring tide, and about 350 km^2 at low water on a spring tide. At low water numerous sandbanks and intertidal mudflats are exposed.

The four main rivers that discharge into the Wash, the Witham, Welland, Nene and Great Ouse have a catchment of 15,650 Km^2, about 12% the area of England. The Witham Estuary is 11 km long and runs from the Grand Sluice in Boston to Tabs Head in the Wash. The Welland Estuary is about 22 km long and runs from Spalding Sluice to Tabs Head, where it shares a common lower channel with the Witham. The Nene Estuary runs for about 40 km from the Dog-in-a-Doublet Sluice to Crab's Hole in the Wash. The Great Ouse Estuary is about 60 km in length and runs from Brownshill Staunch near Earith to Cork Hole in the Wash.

The main water current into the Wash is an extension of the Norwegian Current (itself an extension of the North Atlantic and Gulf Stream) that flows in a south easterly direction from Scotland. This current may in fact be transporting waters from the Humber and the Tees estuaries, as well as thousands of tonnes of sediment, along the east coast margin and into the Wash.

Several conflicting theories regarding the source of sediment in the Wash have been proposed (with both marine and fluvial sources being suggested) although it is now generally accepted that the sediment in the Wash is primarily of marine origin, believed to emanate from the south Lincolnshire coast (Dugdale et al, 1987). The major sediment sources and transport paths in the Wash are illustrated in Figure 2.2. The amount of sediment carried over the intertidal flats has been estimated at a massive 30,000 to 120,000 tonnes per tide depending on the state of the tidal cycle. It has been estimated that the amount of sediment carried onto the intertidal flats during one spring tide is roughly equivalent to the total annual river supply (which is believed to be between 40,000 and 170,000 tonnes per year, Evans and Collins, 1987).

There is a natural tendency for these sediments to be deposited on areas only covered by the highest tides. The accreted sediments have often been turned into agricultural land, once a man-made sea bank has been constructed and the salt has been leached out of the soil. Land reclaimed using this technique often leads to very productive farming areas. Reclamation of land for agricultural purposes around the Wash has been occurring since the Middle ages, and now totals some 32,000 hectares (North, 1987).

3. Uses of the Wash System

3.1 Commercial Fisheries

There are several commercial shellfisheries for both mussels and cockles within the Wash. These are all proposed as harvesting areas under the Shellfish Hygiene Directive (91/492/EEC). Commercially significant fisheries for brown and pink shrimp also exist, with landings for the latter comprising almost 100% of the total for England and Wales. In addition to these main species, whelks, oysters and flatfish are also exploited commercially. Eels are caught on a commercial basis in the tributary estuaries, with the NRA being responsible for the granting of licences to the fishermen.

All other commercial fishing in the Wash is overseen by the Eastern Sea Fisheries Joint Committee (ESFJC), who are responsible for formulating the long term policies for the fishing industry. The committee have the authority to impose restrictions and formulate regulations on all aspects of the fisheries, from the granting of licences and leases to the determining of the size of vessels, nets and dredges.

An important management strategy employed by the committee is the creation of reserves, within which the collection of identified species (usually cockles and mussels) is prohibited, allowing the recovery of depleted stocks.

3.1.1 The Mussel Fishery

Details of mussel and cockle landings from Wash ports since 1977 are shown in figure 3.1. Although no details are shown of individual port landings, mussels and cockles are landed in roughly equal proportions in King's Lynn and Boston.

Over the last decade mussel stocks in the Wash have fluctuated greatly. In recent years the only successful spatfall and recruitment of mussels occurred in 1986. Since then little or no recruitment has taken place and there has been an associated decline in landings.

Between February and October 1990 ESFJC closed all the main mussel beds in the Wash in an attempt to allow the severely depleted stocks to recover. Between January and September 1991 scalps between the Nene and Great Ouse estuaries were closed for the same purpose. However, despite these measures, towards the end of 1991 the majority of mussel beds were in a very poor state. In 1992 the mussel fishery in the Wash had reached an all time low and although overfishing has played a part in the decline of stocks, the lack of any new recruitment in recent years is believed to be the main cause of the hardship being experienced by the fishermen.

ESFJC have predicted that the fishery will not recover unless mussels are relayed from areas elsewhere on the U.K. Even if such recycling was to take place the potential of those mussels would not be realised until 1996 (ESFJC, 1992).

3.1.2 The Cockle Fishery

Cockle landings at Wash ports since 1977 are shown in Figure 3.1. In October 1988, after three very productive years, Daseleys and Seal Sands, at the mouth of the Great Ouse estuary, were closed for cockle harvesting and remained closed until the summer of 1990. The closure of the beds enabled the cockles to spawn, recover their stocks and increase in weight prior to harvesting.

Between 1989 and 1990, following the closure order, there was an 82% increase in fishable stocks (1834 tonnes). In 1991 the cockle fishery was extremely productive with 41 vessels bringing in 8,911 tonnes. Between February and April 1992 all public beds were again closed to allow cockle stocks to recover, and in 1992 the fishery was again highly productive with some 7,300 tonnes of cockles being landed (ESFJC, 1992).

3.1.3 Shrimp Fishery

Both brown and pink shrimp are fished commercially in the Wash estuary and there has been a pink shrimp fishery in the Wash for at least a century. Pink shrimp (Pandalus montagui) can be found over a wide area of the Wash but commercial fishing activity is usually concentrated in the deep water channels (Warren, 1973). Following the decline in the Thames and Morcambe Bay fisheries the Wash landings of Pandalus now account for virtually 100% of the U.K. catch.

Brown shrimp, Crangon crangon, are usually found in the sheltered channels and in the lower estuaries. The brown shrimp catch in the Wash usually accounts for around 25% of the total catch for the U.K.

However, erratic stocks and a sudden collapse in the price of shrimp has recently resulted in severe hardship for the shrimp fishermen (ESFJC, 1992).

3.1.4 Fin Fish

Although an important breeding ground for juvenile plaice, sole and cod (Riley, 1987) only occasionally has offshore fishing reached a commercially viable level and then only for short periods. During 1990 over 3 tonnes (value c.£2340) of mullet were captured in the Wash, however this was an exceptional year and usually only negligible catches are made (ESFJC, 1990).

Little data exists for commercial fish captures within the Wash embayment. However data does exist for total fish weights landed at the ports within the Wash (see fig. 3.2)

The Wash provides migratory passage for eels, and these are caught on a commercial basis in the tributary estuaries

3.2 Conservation and Biological Interest

The Wash is a site of international importance for nature conservation and contains some of the most important coastal wetland areas in Britain. The national and international importance of the Wash as an area of outstanding biological interest was recognised by its designation as a Site of Special Scientific Interest (SSSI) between 1972 and 1976 and its subsequent renotification under the Wildlife and Countryside Act in 1981. The Wash was declared a RAMSAR site and Special Protection Area (SPA) in March 1988. The Wash National Nature Reserve is the largest in England (EN,1992)

The Wash is of international and national importance for waders and wildfowl and supports significant wintering passerines and breeding bird populations. The first comprehensive bird studies in the Wash embayment were carried out as part of the Wash water storage scheme feasibility study (Central Water Planning Unit, 1976). A list of titles produced is given in the bibliography in Part III.

Despite land reclamation for agricultural purposes the Wash still maintains one of the largest salt marshes in Britain, with a virtually continuous fringe between Snettisham andGibraltar Point.

The Wash is now believed to support a population of about 4,000 common seals, the second largest in Europe after the Shetland Isles. The spread of phocine distemper in 1988 (as a result of which 1400 seal corpses were found in the Wash alone) and a revision of the methodologies used to estimate seal populations (which were being overestimated) has brought the figure down from the estimated 7,000 in 1978 (Vaughn, 1978).

3.3 Recreation and Amenity.

The main holiday resorts in the Wash, Hunstanton and Heacham, with their large sandy beaches, attract a significant number of tourists in the summer months. There are two bathing waters recognised under the EC Bathing Waters Directive (76/160/EEC), these are at Old Hunstanton Beach and Heacham North Beach. There are six other bathing waters not identified under this directive, these are all located in the Eastern Wash.

Although there is little recreational sailing in the main body of the Wash (due to adverse tidal conditions) areas within the mouths of the tributary estuaries are popular areas for these activities.

There is free public access to the shores and saltmarsh of the Wash and these areas attract many walkers and bird-watchers. The shooting of wildfowl is a popular local sport and several wildfowling clubs exist within the Wash area.

3.4 Other Uses

Cargo ships from (principally) the seaports of Boston, King's Lynn and Sutton Bridge import timber, animal feed, refined oil products, steel and aggregates and export general cargo, sugar beet and grain.

Farmers use the saltmarsh around the Wash as grazing areas for cattle and sheep, although this practice has declined in recent years. Cattle grazing is most common on the Western shores of the Wash.

There are RAF practice bombing ranges at Holbeach and Wainfleet, each range covers around 40 km^2 of intertidal mudflats and saltmarsh.

All four tributary estuaries receive inputs from sewage treatment works and industry. The major discharges are described in detail in Section 4.3 below.

4. Environmental Quality

4.1 Introduction

The National Rivers Authority is the regulatory body responsible for the control of pollution of controlled waters in England and Wales.

Water quality management is mainly based on an Environmental Quality Objective (EQO) approach. The EQOs that are set for all water bodies require the quality of that water body to be suitable for all identified uses. In order to achieve an EQO, all substances that have the potential to pollute are given a numerical Environmental Quality Standard (EQS). An EQS is the maximum amount of substance which can be present in the receiving water without it having an adverse effect on the defined uses.

The European Union (EU) sets mandatory EQSs for all of the highly toxic or persistent substances that make up List 1 (also called black list) of the EC Dangerous Substances Directive (76/464/EC). EQSs for other substances are set by member states, after taking into account all local considerations.

The NRA use EQSs to set consent conditions for discharges to surface waters. Consent conditions are usually set in terms of maximum concentrations of substances and maximum effluent flow rate. The conditions are determined using mathematical models which take into account the contribution from other discharges and the background concentrations within the receiving waters to ensure that the EQS is not exceeded.

The NRA have a responsibility to monitor the quality of effluent discharges and their receiving waters to ensure that EQOs are met. The NRA fulfils its obligations by undertaking detailed monitoring programs in all controlled waters.

4.2 Freshwater Flows into the Wash

Whilst the NRA has a comprehensive network of flow guages across its rivers these are not specifically located to measure freshwater flows into the Wash. The difficulty arises because conventional gauging stations can only make accurate measurements if there is a significant river gradient. The nature of fenland rivers is such that there is virtually no gradient and consequently any measured flows are well inland. Also, because of substantial irrigational requirements there are often little or no freshwater flows to tide in summer. All net flows to tide have to be estimated from combinations of diversions and abstraction and are therefore prone to significant errors.

Nevertheless, the guages showed that between 1989 and 1991 a prolonged period of drought reduced flows to about half their normal levels.

The effects of the drought are clearly evident from figures 4.1 to 4.3 which show the freshwater flows in the tributary estuaries between January 1990 and December 1992 (note the axes are to different scales). Low flows were observed from March 1990 to September 1992.

4.3 Inputs from Sewage and Industrial Discharges

All four tributary estuaries are similar in that they have one major sewage discharge (the Nene has three in total) and relatively few industrial discharges along their length.

The locations of all discharges to the Welland, Witham, Nene and Great Ouse are shown in Figures 4.4 to 4.7 respectively.

The following section covers all major consented discharges to the Wash system. The catchments of all four estuaries are predominantly agricultural and diffuse sources of contamination (for example through land drainage run-off) are likely to be appreciable.

4.3.1 Major discharges to the Welland Estuary

Spalding STW, comprising primary settlement and two stage filtration with Flocor towers, is consented for both treated effluent and storm overflows. A limit of 15,720m^3 per day of treated sewage containing not more than 60mg/l BOD and 120 mg/l suspended solids was issued in 1988. There is no consent for Ammonia, which is discharged at a concentration of around 13 mg/l (NRA, 1993). The plant generally operates within its consent limits.

Tinsley's vegetable and food processing plant discharges into the Holbeach river, a short distance above its confluence with the tidal Welland. The effluent consistently failed to meet the consent conditions imposed in 1989 (maximum BOD of 75 mg/l for a flow of 8,000m^3 per day) and poor water quality resulted. The company are currently installing extensive treatment facilities, which should be completed by spring 1995. The new consent limit of 20 mg/l BOD and 50 mg/l suspended solids, enforceable on completion of the works, should result in substantial improvements in water quality.

4.3.2 Major discharges to the Witham Estuary

Boston STW has a consent to discharge up to 10,000m^3 per day with a limit of 70mg/l suspended solids and 35mg/l BOD. The works perform well and rarely exceed the consent limits.

Hunter Timber Engineering operate in Boston and deploy a variety of timber treatment processes. Historically dieldrin was used as a preservative and more recently 'Protim', containing PCP (Pentachlorophenol) and Lindane, has been used. Following a major spillage in 1989 (and several minor ones prior to it) no discharge has been allowed and a consent application in 1991 was refused. Following removal of contaminated land and implementation of measures to prevent further spillage, it is expected that a new consent will be issued.

Calders and Granidge have conducted various timber treatments for about 100 years. Contaminated surface water drainage (containing dieldrin, lindane and creosote) is entering the South Forty Foot Drain, approximately 2km upstream of the confluence with the Witham. The company is now undertaking extensive modernisation and clean up operations and full treatment of the contaminated surface water will soon be introduced (NRA, 1993)

4.3.3 Major discharges to the Nene Estuary

Flag Fen STW, serving Peterborough, has the greatest influence on water quality in the Nene. The works normally discharge around 60,000m^3 of effluent per day and the discharge consent allows for up to 20 mg/l BOD and 120 mg/l suspended solids. These criteria are usually met (there is a 10% failure rate). The works have no limit on the amount of Ammonia that may be discharged, and the average concentration of Ammonia is high, at around 25 mg/l. The effluent is discharged into the counter drain, where it causes chronic water quality problems (the flow in the drain comprises almost 100% sewage effluent) before it is pumped into the Nene estuary just downstream of the Dog-in-a-doublet Sluice. These high ammonia concentrations downstream of the Dog-in-a-doublet are polluting the estuary and give much cause for concern. There are no plans for any improvements to be carried out at the works.

Sutton Bridge STW discharges around 11,000m^3 of effluent per day, following primary settlement. Currently the works has a fairly relaxed consent of 200 mg/l BOD and 200mg/l suspended solids. New treatment is to be introduced during 1994 in order to meet the new consent limits of 60 mg/l suspended solids, 40 mg/l BOD and 20 mg/l Ammonia.

Improvements at **West Walton STW**, which serves Wisbech and discharges around 14,000m^3 per day, have ensured that the works comply with discharge consent limits of 60 mg/l suspended solids, 40 mg/l BOD and 20 mg/l Ammonia.

McCains Foods are consented to discharge 4,000m^3 of effluent per day. During the summer the consent allows for up to 200mg/l BOD and 200mg/l suspended solids. These limits are doubled (ie 400/400) during the winter. This consent is inadequate to meet water quality objectives and McCains are currently installing new plant to meet a proposed consent of 60 mg/l Suspended solids, 40 mg/l BOD and 20 mg/l Ammonia.

The **Potato Marketing Board** at Sutton Bridge have an intermittent discharge with an insignificant organic load to the estuary. However the fungicides that are used to control rotting and to inhibit sprouting of the potatoes are toxic and of some concern to the NRA. The company used to use a fungicide called tecnazene (1,2,4,5,-tetrachloro-3-nitrobenzene) and although this substance is not found at any significant levels in the estuary, the compounds it readily breaks down into (anisole and aniline) are equally toxic and have been found in significant concentrations in the sediments around the discharge. Tecnazene has now been replaced by a fungicide called chlorpropham (isopropyl 3-chlorophenylcarbamate), which is believed to be equally toxic. The NRA are currently investigating the toxicity of chlorpropham in order to set consent limits.

Haywoods undertake vegetable processing at Sutton Bridge and discharge around 4,000m^2 of effluent per day. The company will be introducing a treatment plant in order to meet a river's need consent of 60 mg/l BOD and 40 mg/l suspended solids. The new plant, which will include effluent screening, aeration and settlement, will be fully operational by 1995. The discharge is currently covered by a deemed consent.

4.3.4 Major discharges to the Great Ouse Estuary

King's Lynn STW comprises primary settlement only and discharges around 20,000m^3 of effluent per day on the ebb tide only. At present the discharge consent only stipulates that no more than 200 mg/l suspended solids may be present in the effluent. There is no consent for BOD or Ammonia which are discharged at concentrations of around 500 mg/l and 26 mg/l respectively. The effluent from the works contains around 4.0x10^7 faecal coliforms per 100ml and is the principal contributor to the bacterial contamination of the mouth of the Great Ouse and the shellfish beds in the SE Wash.

The toxicity of the effluent from the works varies considerably. The majority of toxicity tests show the LC_{50} (96 hours) (ie the concentration of effluent required to induce a 50% mortality over 96 hours) for shrimp is usually between 9% and 25%, but can be as low as 3%. An LC_{50} of 3% cannot be accounted for by the usual toxins found in sewage and provides some cause for concern. Investigations are required to determine the origin of the toxins present.

The NRA are currently producing a new consent for the works, to be implemented by December 1995. The new consent will require the effluent to be UV disinfected in order to significantly reduce the bacterial load to the estuary.

Dow Chemical Co Ltd have been discharging effluent from the manufacture of herbicides and Latex since 1959. In 1977 they commenced production of Dursban, the trade name for the organo-phosphorous insecticide chlorpyrifos (0,0-diethyl 0-3,5,6-trichloro-2-pyridyl phosphorothioate). Dursban is extremely toxic, particularly to brown shrimp and a unique (at the time) shrimp toxicity test was therefore included in the consent. The test requires that 50% of the shrimp should survive after 96 hours in the effluent when diluted five times with sea water (ie LC_{50} (96 hours) should be greater than 17%). Dow usually operate well within their consent limits, and in fact the effluent is usually of such low acute toxicity it is impossible to induce a 50% mortality. The volume of the discharge should not exceed 1025m^3 and is only disharged on an ebbing tide.

Porvair Ltd manufacture porous plastic materials and recover spent solvents by distillation. The effluent contains traces of these solvents, but is low in both volume (the consent allows up to 200m^3 of effluent to be discharged on each ebb tide) and toxicity and the plant operates within the consent limits. Shrimp toxicity tests are also included in the consent and state that the LC_{50} (96 hours) must be greater than 4%. Toxicity tests to date have resulted in an LC_{50} of around 50%, well below the consented limit.

The British Sugar Corporation Factory at King's Lynn discharged to the Great Ouse estuary half a kilometre above Freebridge during the October-February sugar beet campaign. The effluent, which was pumped into lagoons before being discharged into the estuary, comprised cooling water and waste from the washing and refinement of sugar beet and had a high BOD concentration (around 3,000 mg/l). The factory operated well within the consent limits of 6000 mg/l BOD and 200 mg/l suspended solids. The factory was closed in February 1994, after the 1993/94 sugar beet campaign. The only discharge from the plant will now comprise of contaminated surface waters, and these will be discharged under the current consent conditions. There are no plans to empty the contaminated lagoons into the estuary

4.3.5 Major Direct Inputs to the Wash

4.3.5.1 Hunstanton Sea Outfall

There is only one potentially major discharge to the Wash itself. The **Hunstanton STW Sea Outfall** was decommissioned in 1990 and sewage was diverted to nearby Heacham STW, where it undergoes tertiary treatment. The outfall is now used to discharge waste from **nitrate removal plants at Fring and Sedgeford,** as well as serving as a **storm sewage outfall**. The discharge consent requires the effluent to contain no more than 800 mg/l nitrate, 3,000 mg/l sulphate and 17,000 mg/l chloride. The storm sewage outfall may only be operated when the rate of flow in the sewer exceeds a certain level (174 litres per second). The outfall was due to commence operating in December 1991, but a fractured outfall pipe and subsequent changes in the consent conditions did not allow effluent to be discharged until mid 1993.

4.3.5.2 Inputs from the Tributary Estuaries-Annual Total Loads to the Wash

If the average concentration of a particular substance within a discharge is multiplied by the average annual flow of that discharge then a total annual load of the substance can be calculated. Such calculations are carried out annually by the NRA for Paris Commission and North Sea Conference Annex 1A purposes, in order to estimate the total load to estuaries and coastal waters in England and Wales.

Table 4.1 summarises the 1990, 1991 and 1992 annual loads (in kg/year) to the Wash for substances monitored for Paris Commission purposes. In order to put these data into context the annual loads to the Wash are also expressed as percentage total loads to all coastal waters in England and Wales.

For each year data for 'high load' and 'low load' are given. The need for high and low loads arises when a substance is present, in any given sample, at a concentration below the analytical limit of detection. High loads assume that the substance was present at exactly the level of detection and low loads assume the substance was not present at all. For example if results showed a substance to be present at <0.5 mg/l (ie the level of detection is 0.5 mg/l and the substance was present below this concentration) then the 'high' load would be 0.5 mg/l, the low load would be 0 mg/l.

Due to the nature of the calculations (multiplying small spot sample concentrations by very large (and not always accurate) annual flow measurements) the data in Table 4.1 can only be regarded as a best estimate of the true picture.

The data in Table 4.1 gives little cause for concern and shows that on a national level the Wash system accounts for very little of the total input of controlled substances to U.K coastal waters. The total load of most heavy metals is low, usually accounting for less than 1% of the total load to coastal waters in England and Wales. Exceptions to this were mercury and copper which, at 58 kg and 8026 kg (low load) respectively in 1992, accounted for around 1.6% of the total load. The annual load of Total Oxidised Nitrogen (TON) is around 4,000 tonnes, accounting for about 3-4% of the total load.

TABLE 4.1 ANNUAL LOADS TO THE WASH ESTUART

	1990 high load	% total load	1991 high load	% total load	1992 high load	% total load
Cr	41	-	-	-	-	-
Hg	27	0.29	59	0.92	120	2.13
Cd	135	0.29	78	0.20	257	0.82
Cu	3,446	0.69	2,753	0.54	8,046	1.53
Zn	9,423	0.30	10,173	0.33	29,279	0.82
Pb	2,522	0.59	1,066	0.23	4,612	1.06
HCH	4	0.96	10	1.62	13,413	2.71
NH3	749,481	1.22	768,726	1.08	1,274,827	1.95
TON	4,097,066	4.78	3,505,914	2.99	-	-
Total N	4,698,221	-	4,274,640	1.81	-	-
Ortho P	764,086	2.39	915,676	2.98	936,711	4.27
SPM	37,104,999	1.72	10,963,697	0.56	86,255,235	2.97

	1990 low load	% total load	1991 low load	% total load	1992 low load	% total load
Cr	41	-	-	-	-	-
Hg	15	0.33	43	1.10	58	1.68
Cd	106	0.47	27	0.10	164	0.75
Cu	3,365	0.74	2,692	0.63	8,026	1.58
Zn	8,571	0.25	10,171	0.33	29,271	0.83
Pb	2,286	0.69	809	0.21	4,383	1.12
HCH	4	0.93	10	2.56	13,412	3.88
NH3	748,188	1.14	766,120	1.17	1,270,840	1.93
TON	4,087,666	4.60	3,492,285	2.98	-	-
Total N	4,688,213	-	4,258,405	1.85	-	-
Ortho P	762,783	2.27	915,648	3.01	936,612	4.29
SPM	37,084,974	1.63	10,898,323	0.56	-	-

data represents Kg/year : see text above for explanation of headings
SPM = Suspended Particulate Matter (suspended solids)

4.4 Estuarine Water Quality

4.4.1 Previously published reports.

Data from the Witham and Welland estuaries were last reported in April 1993 (NRA, 1993) and cover the period 1989 to August 1992. Little published data exists for the Nene estuary, with the last water quality report (Dyer and Grist, 1989) only covering 1988. Water quality reports from the Great Ouse are available from 1983 to 1985 (AWA, 1986) and from 1989 to 1991 (NRA, 1993c).

4.4.2 Introduction

Routinely collected water quality data has been selected from the most downstream routine monitoring point in each of the four tributary estuaries in order to assess the quality of the water entering on the Wash. The locations of the selected sites are shown in Fig. 4.8. It would be unwise to use this data to assess the quality of the estuaries as a whole, the reports listed in section 4.4.1, together with the introductory summaries at the beginning of each section, should be used for this purpose.

The principal water quality measures (DO, TON, Ammonia and BOD) covering the period January 1987 to December 1992 have been reported.

A wide range of other determinands have been analysed but have only been included where they are present at levels which merit further consideration.

Information on other determinands is available from either the reports detailed in section 4.4.1 or from Appendix C of this report.

High and low water results from the Witham estuary have been reported separately but due to data retrieval problems this was not practicable for the other estuaries.

4.4.2.1 NWC Estuary Classification Scheme

The NWC Estuary Classification Scheme combines an assessment of chemical, biological and aesthetic quality (on a points score basis) and assigns estuaries to one of four classes, with Class A indicating excellent quality and Class D indicating bad water quality.

When the NWC classification scheme is applied to the Wash tributary estuaries, the following classifications are obtained:

Witham	Class A
Welland	Class A
Nene	Class D
Great Ouse	Class B

4.4.3 The Witham Estuary

4.4.3.1 Introduction

There are two routine monitoring sites on the estuary, Boston Swing Bridge and Cut End. Water quality in the estuary is generally good, with dissolved oxygen levels rarely falling below 70%. There are occasionally instances of oxygen supersaturation in the estuary, presumably related to algal activity. Highest DO values tend to occur at high water, indicating this is marine algal activity.

The 1993 Witham and Welland Ecological study (NRA, 1993) reported levels of HCH and Copper in excess of the EQS values. Although few samples were taken, and interpretation is therefore difficult, it would appear that these exceedences may be associated with the freshwater input into the estuary. Levels of HCH have fallen since 1989, possibly as a consequence of the low rainfall and reduced discharge of contaminated surface waters.

Summaries of all results from the Witham for the period 1990 to 1992 are included within Appendix C.

4.4.3.2 The Witham at Cut End

[NRA site codes R03BIHCEH1T (high water) and R03BIHCEL1T (low water)]

Results for the principal water quality parameters are shown in figures 4.9 to 4.11, with yearly averages being presented in Table 4.2.

Ammonia (Figure 4.9)

Low water Ammonia levels have remained constant since 1987 at around 0.3 mg/l. High water concentrations are generally lower, although uncharacteristically high values in 1987 and 1990 pushed up the annual averages to 0.46 and 0.31 mg/l respectively.

TON (Figure 4.9)

TON values fluctuated widely between 1987 and 1992, with much higher values being recorded at low water during the winter months. TON levels appear to have reduced during the drought period, although peaks were still observed during the winter months. Such results seem to indicate that the main source of TON to the estuary is from the surrounding agricultural land and levels are highest during periods of greater land run-off.

Dissolved Oxygen (Figure 4.9)

Between 1987 and 1992 DO rarely fell below 70% saturation at both high and low water. Annual averages for DO are high: around 89% at low water and 97% at high water (see Table 4.5) High peaks in DO (of up to 150%) may indicate the presence of algal blooms. These peaks appear to be almost exclusively associated with high water, indicating marine algal activity may be the cause. This is in contrast to the Welland-see section 4.4.4.2 below.

HCH (Figure 4.10)

Although the yearly average (high and low water combined) for HCH has always been below the estuarine EQS of 20 ng/l this value was often exceeded at low water during 1987 and 1988 (See Fig 4.10). Recent years have seen a large improvement in this situation, with only one exceedence (in 1991) at both high and low water. The reduction in HCH levels may, in part, be a consequence of the low freshwater flows reducing the input of contaminated surface waters. However, it is encouraging to note that levels of HCH have remained low throughout the winter of 92/93, when rainfall levels returned to normal.

BOD (Figure 4.11)

Between 1990 and 1992 BOD values remained relatively constant, with slightly higher levels being recorded at low water.

Copper (NRA, 1993)

The annual average for copper exceeded the EQS at low water in 1990 and 1991 and at high water in 1992. However for EQS purposes the degree of complexation is not taken into account (see Page 25 for an explanation of this).

TABLE 4.2 THE WITHAM AT CUT END : ANNUAL AVERAGES

	HCH Low Water			HCH High Water		
year	n	ave	sd	n	ave	sd
1987	12	18.2	15.3	12	8.4	6.7
1988	11	23.6	15.6	12	12.7	11.4
1989	4	14.3	11.9	4	2.4	0.7
1990	5	8.3	3.8	-	-	-
1991	12	9.5	7	10	3.8	3.4
1992	12	6.2	2.7	12	3.5	2.3
	TON Low Water			TON High Water		
year	n	ave	sd	n	ave	sd
1987	12	10.3	5.9	12	7.3	6.6
1988	11	6	4.2	12	3.9	4.9
1989	12	1.8	3.4	12	1.3	2.9
1990	12	1.4	3.7	12	0.42	0.6
1991	12	3.2	3.8	12	0.86	1.5
1992	12	8.9	8	12	2.5	2.7
	NH3 Low Water			NH3 High Water		
year	n	ave	sd	n	ave	sd
1987	12	0.28	0.1	12	0.46	0.82
1988	11	0.32	0.17	12	0.25	0.2
1989	11	0.3	0.15	11	0.14	0.12
1990	12	0.3	0.22	12	0.31	0.5
1991	12	0.34	0.12	12	0.09	0.07
1992	12	0.34	0.17	12	0.11	0.1
	DO Low Water			DO High Water		
year	n	ave	sd	n	ave	sd
1987	11	87.7	18.5	10	107	20.6
1988	10	92.5	8.6	10	100	8.9
1989	12	83.1	9.4	12	88.6	11.9
1990	12	90.4	9.8	12	90.5	8
1991	12	87.1	11	12	94.1	15.2
1992	12	90.5	14.5	12	101.4	15.7

n = no. samples ave = average sd = standard deviation
Data expressed as mg/l except HCH = ng/l, DO = % saturation

4.4.4 The Welland Estuary

4.4.4.1 Introduction

Water quality data from the Welland is somewhat limited. Two sample points, Pinchbeck Marsh and Moulton Marsh were established for the Operational Investigation of the Welland and Witham that was undertaken between 1989 and 1992 (Full results from these points can be found in NRA, 1993). There is a routinely monitored site at Fosdyke Bridge (see section 4.4.4.2 below).

Water quality in the Welland is generally good. During the period 1989-1992, Dissolved Oxygen levels rarely fell below 60%, and several very high levels were recorded,suggesting the probability of algal blooms. Peaks in BOD were often recorded during the autumn.

Copper was present at or slightly above the estuarine EQS limit of 5 ug/l, which is surprising given that there appears to be no copper inputs to the estuary. Given that most of the copper is likely to be present in the form of a complex which is unavailable to the biota, such results give no cause for concern.

Most determinands were present below their EQS value and often below the level of detection. Summaries of all water quality data collected in the Welland during 1990-1992 are contained within Appendix C.

4.4.4.2 The Welland Estuary at Fosdyke Bridge.

[NRA site code R05BIWELL600F]

Results for the principal water quality measures are shown in figures 4.12 and 4.13 Annual averages of Ammonia, TON, BOD and Dissolved oxygen are presented in Table 4.3.

Ammonia (Figure 4.12)

The annual average for ammonia has remained relatively constant since 1987 at around 0.48 mg/l. There is a marked seasonality to the data, with higher values generally being recorded in the winter months.

Dissolved Oxygen (Figure 4.12)

DO levels at Fosdyke Bridge are similar to those recorded at Cut End in the Witham with annual means remaining remarkably constant at around 88% saturation (see Table 4.3). Elevated DO levels in the summer months may indicate the presence of algal blooms. Such blooms may result in low overnight DO levels.

Dissolved Oxygen levels are generally higher at low water, indicating that any algal activity is associated with the freshwater end of the estuary. This interpretation is also suggested by the BOD results.

BOD (Figure 4.13)

The highest BOD levels were always recorded at low water and were usually between two and five times higher than the high water values. High BOD values are often associated with algal activity and the fact that all high values were recorded at low water strongly suggests that the algae has a freshwater source.

HCH Gamma (Figure 4.13)

The only result for HCH in 1990 was very close to the estuary EQS limit of 20 ng/l. Results since have been well below the EQS, although only 2 samples per year have been collected.

TON (Figure 4.13)

Although TON levels are not particularly high in the estuary attention is drawn to the seasonal variation. Figure 4.13 shows that winter values are consistently around 5 times higher than summer ones. The much reduced values in the summer months could be a result of phytoplankton activity.

TABLE 4.3 THE WELLAND AT FOSDYKE BRIDGE : ANNUAL AVERAGES

	NH3 (mg/l)			DO (% saturation)		
year	no	ave	sd	no	ave	sd
1987	6	0.46	0.33	6	98.8	34.5
1988	8	0.32	0.19	8	79.3	9
1989	15	0.66	0.6	15	85.4	24.9
1990	28	0.42	0.38	26	89.4	30.5
1991	28	0.55	0.34	27	88.9	25.4
1992	28	0.42	0.36	28	87	16
	TON (mg/l)			BOD (mg/l)		
year	no	ave	sd	no	ave	sd
1987	6	7.7	3.7	-	-	-
1988	8	4.9	4.9	-	-	-
1989	16	3.1	2.9	-	-	-
1990	27	2.4	3.2	-	-	-
1991	28	3.6	4.1	12	4.3	3.9
1992	28	4.9	4.3	12	2.2	1.8

n = no. samples ave = average sd = standard deviation

4.4.5 The Nene Estuary

4.4.5.1 Introduction

In terms of water quality the Nene is by far the worst of the four tributary estuaries. Prior to 1988 the Nene was (mis)classified as Class A under the NWC classification system. Increased sampling of the estuary in 1988 soon showed this classification to be incorrect and the estuary has subsequently been downgraded to Class D around Sutton Bridge, largely as a consequence of very low dissolved oxygen levels and high levels of Ammonia. Mathematical modelling of the estuary indicates that the major influences on water quality are the trade and sewage effluents discharged to the Nene and its tributary systems.

Poor flushing of the estuary is believed to be responsible for many of the water quality problems. The mouth of the Nene is very shallow and may prevent full evacuation of the river contents, which are subsequently pushed back up the river with the next high tide. If this is the case then the discharges will be entering a body of water which still has very high residual effluent concentrations and poor water quality will result.

The NRA's lower Nene Catchment Management Plan (CMP), published recently, considers many of the water quality problems and suggests possible measures that may be taken to improve the current situation. Major effluent improvement programmes are required, and indeed many of these are already underway. Considerable survey work carried out in 1993 to assess the scale of the problem and to determine what remedial action can be taken.

A statistical summary of all results collected at the nine routinely monitored sites in the estuary between 1990 and 1992 is given in Appendix C.

4.4.5.2 The Nene estuary at Nene Lighthouse

[NRA site code R05BINENE750L]

All results for the principal water quality descriptors are shown in Figures 4.14 and 4.15. Annual averages are given in Table 4.4.

Dissolved Oxygen (Figure 4.14)

Between 1987 and 1990 the annual DO saturation at Nene Lighthouses was around 64%, with levels dropping as low as 30%. 1990 saw an increase in Dissolved Oxygen levels and this trend has continued to the present date, with the annual mean value in 1992 being 86%.

Ammonia (Figure 4.14)

In its upper reaches the Nene has the highest ammonia levels of the four tributary estuaries, although values recorded at Sutton Bridge are relatively low and comparablewith those recorded in the Welland (see section 4.4.4.2). A maximum value of 17.5 mg/l was recorded and this value has been excluded from Figure 4.15 to better show the fluctuations in the results. The annual average at this site is around 0.6 mg/l, substantially lower than some of the sites further upstream.

BOD (Figure 4.15)

Despite quite low dissolved oxygen values at this site the BOD values are relatively low with few results exceeding 4 mg/l. This may indicate that the organic matter contained within the effluents is readily oxidised.

TON (Figure 4.15)

As with the other estuaries, TON levels vary depending on season with higher values generally being recorded in the winter months. TON levels at Sutton Bridge are not particularly high and average around 4 mg/l.

TABLE 4.4 THE NENE AT NENE LIGHTHOUSE : ANNUAL AVERAGE

	DO (% saturation)			TON (mg/l)		
year	n	ave	sd	n	ave	sd
1987	17	65	15	17	6.9	3.7
1988	6	63.8	19.6	6	6.7	4
1989	13	61	18.3	13	1.9	3
1990	11	67	18.9	12	0.7	1.1
1991	17	74	19.7	11	3.3	2.5
1992	17	86	22.1	13	4.6	3.6
	BOD (mg/l)			NH3 (mg/l)		
year	n	ave	sd	n	ave	sd
1987	-	-	-			
1988	-	-	-			
1989	-	-	-			
1990	8	2.8	1.2	6	0.42	0.53
1991	17	2.64	1.63	14	0.56	0.62
1992	21	2.8	1.6	25	0.25	0.26

n = number of samples ave = average sd = standard deviation

4.4.6 The Great Ouse Estuary

4.4.6.1 Introduction

There are eight routine monitoring sites within the estuary, the locations of which are shown in Figure 4.8. All results from routine surveys for the periods 1983-1985 and 1989-1991 are available from AWA (1986) and NRA (1993c) respectively. A summary of water quality data collected in 1990-1992 appears in Appendix C.

The quality of the Great Ouse estuary is generally good. Tester (1986) reported a sag in Dissolved Oxygen concentrations just downstream of King's Lynn during the sugar beet campaign, with worst conditions occurring during October and November. More recent results failed to highlight such a sag but, before the factory was closed in February 1994, the large organic loads discharged to this part of the estuary were still believed to have an influence on dissolved oxygen concentrations.

The EQS value for copper in estuaries is 5 ug/l (dissolved copper). In 1986 copper levels as high as 56 ug/l (total copper) were recorded from the estuary. Copper has a relatively high toxicity to aquatic life and the results gave cause for concern. However it is known that copper is often bound by naturally occurring complexing materials. When copper is complexed its availability, and therefore its toxicity, to biological life is much reduced. In order to assess the degree of complexing in estuaries the NRA commissioned a study into copper speciation in the Great Ouse estuary. The study was carried out by WRc .The report concluded that over 98% of dissolved copper was present in the form of complexes and that free copper ions were likely to be present in concentrations of less than 0.1 ug/l. The findings therefore suggest that even if copper is present at levels above the EQS value (5 ug/l) it is unlikely to be present in a form freely available to aquatic life.

In 1989 and 1991 copper levels were averaging 5ug/l (the EQS limit), with highest concentrations being recorded from the upper estuary. The EQS for copper was not exceeded in 1992, averaging around 4.75 ug/l at most sites.

4.4.6.2 The Great Ouse Estuary at the Point

[NRA site code R02BI62M01]·

Results for the major water quality descriptors are shown in Figures 4.16 and 4.17. Annual averages are shown in Table 4.5.

Ammonia (Figure 4.16)

Apart from one relatively high result in 1992 (1.8 mg/l), which elevated the annual mean, the level of ammonia has remained relatively constant at around 0.25 mg/l.

Dissolved Oxygen (Figure 4.16)

The annual mean Dissolved Oxygen has remained relatively constant at around 78% since 1987. Values as low as 45% saturation are recorded from this section of the estuary and are believed to be a result of industrial and sewage effluents containing high organic loads. In contrast to the Witham and Welland estuaries there are no high DO results, indicating the absence of significant algal blooms within the estuary.

TABLE 4.5 THE GREAT OUSE AT THE POINT : ANNUAL AVERAGES

	DO (% saturation)			NH3 (mg/l)		
year	n	ave	sd	n	ave	sd
1987	10	85.7	7.8	8	0.31	0.3
1988	10	79.4	15.8	11	0.18	0.13
1989	14	77.6	10.4	14	0.28	0.23
1990	12	72.3	13.1	12	0.29	0.2
1991	13	75.6	12.5	11	0.22	0.11
1992	12	79	16	11	0.45	0.51
	BOD (mg/l)			Chlorpyriphos (ug/l)		
year	n	ave	sd	n	ave	sd
1987	-	-	-	-	-	-
1988	-	-	-	-	-	-
1989	-	-	-	1	0.01	-
1990	9	3.25	2	6	0.04	0.08
1991	11	3.2	2.3	10	0.03	0.04
1992	13	3.4	1.6	12	0.02	0.02

	TON (mg/l)		
year	n	ave	sd
1987	7	3.8	3.6
1988	11	4.1	4.4
1989	14	2.2	2.8
1990	12	1.4	2.7
1991	11	4.1	3.5
1992	11	7	4.5

n = no. samples ave = average sd = standard deviation

BOD (Figure 4.16)

BOD levels are low, averaging around 3.2 mg/l.

TON (Figure 4.17)

As with the other estuaries TON appears to vary according to season, with higher results in the winter months. The annual average of TON in 1992 was higher than usual at 7mg/l.

Chlorophyll-a (Figure 4.18)

Several high chlorophyll results were recorded from the estuary in 1988, but since then levels have been low. Since the beginning of 1991 chlorophyll values have not usually exceeded 40 ug/l.

4.4.7 The Wash

4.4.7.1 Introduction

The only site routinely monitored in the Wash is at Cork Hole, and is actually sampled as part of the Great Ouse surveys.

In August 1992 a large scale water quality survey was carried out.

4.4.7.2 Water Quality in The Wash Estuary.

4.4.7.2.1 Introduction

During August 1992 the Sea Vigil carried out a water column nutrient survey of the Wash estuary using an on-board auto-analyser. Tidal constraints resulted in each survey starting and finishing around high water. As a consequence, the southwestern Wash was mostly sampled above half-tide with the outer and eastern Wash sampled below half-tide. Sampling of the northwest edge of the Wash and the southwest corner were restricted due to the presence of military aircraft bombing ranges and sandbanks.

Water was collected from the surface layer of the sea, at sites previously designated for the benthic grid survey (see Part II, Figure 1 for site details). Samples were immediately filtered and entered into the auto-analyser. The methods employed contained built-in Analytical Quality Control procedures and have satisfactorily passed special marine AQC exercises, particularly the stringent ones prepared for ICES (International Council for the Exploration of the Seas).

The nutrient data reported are from water column samples, filtered after collection through 0.45μm membrane filters and therefore termed "dissolved nutrients". All results are in microgrammes per litre (μg/l).

August is one of the peak months in the year for planktonic growth and consequently dissolved nutrients are expected to be at minimum concentrations. Nutrients in coastal waters are very low in comparison to estuaries.

4.4.7.2.2 Results of the August 1992 Wash Nutrient Survey

Ammonia (Figure 4.18)

Ammonia concentrations diminish much as expected away from the estuaries. There is a 'tongue' of higher ammonia levels in the centre of the Wash. This may reflect the higher ammonia content of the Nene (evident from the estuary data in section 4.6.1) as well as the possibility of poor mixing.

Phosphate (Figure 4.19)

Again, concentrations diminish as expected away from the estuaries down to nearly undetectable levels in the Wash embayment. However there is a 'tongue' of higher phosphate levels, which appears to originate from the Great Ouse estuary. Estuary data suggests that phosphate levels in the Nene and Great Ouse are similar, although the greater flows of the Great Ouse would result in a larger influence from this estuary.

Silicate (figure 4.20)

Concentrations diminish as expected away from the estuaries. The combined effects of the Nene and Great Ouse appear to dominate the profile. This is surprising since silicate levels are generally similar in all four tributary estuaries.

Nitrate (TON) (Figure 4.21)

This is the most abundant of the nutrients measured. Whilst concentrations diminish away from the estuaries, as expected, the influence of the Great Ouse overrides all other trends. The data strongly suggests that "nitrates" in the Great Ouse are very substantially higher than in any of the other estuaries. These findings are consistant with the data collected for Paris Commission purposes, which suggest that loadings from the Great Ouse are nearly an order of magnitude greater than the other estuaries.

Dissolved Oxygen (Figure 4.22)

Dissolved Oxygen concentrations ranged between 89 and 110% saturation. This is a wider range than might normally be expected for offshore water. The lowest values were at Sites 15, 16 and 22, all of which are significantly influenced by the outer Nene estuary.

The highest values were off the Norfolk coast part of the Wash, suggesting that this area is influenced more by the North Sea than by the Wash itself.

It would appear from the data that the effects of the reduced DO in the estuaries are not dissipated until water reaches the outer Wash.

Salinity and Temperature.

During the survey period, measured temperatures ranged between 16.8°C and 18.0°C. Salinity was measured in the range of 30.0‰ to 32.3‰.

However, it would appear that the coolest water is off the Norfolk coast part of the Wash and is similar to the area of highest dissolved oxygen. This is interesting because it is suspected that young mussel growth is positively influenced by cold water and it appears that this part of the Wash coincides with a good mussel growing area. However, much more data needs to be collected in order to verify this.

4.4.7.3 THE WASH AT CORK HOLE

[NRA site code R02BI62M09]

Results for the principal water quality descriptors are shown in Figures 4.23 and 4.24 with annual averages given in Table 4.6. A full summary of water quality data collected during 1990-1992 is presented in Appendix C.

Ammonia (Figure 4.23)

Ammonia levels are quite low and have remained relatively constant at around 0.1 mg/l since 1987. Ammonia concentrations are lower at Cork Hole than in all of the tributary estuaries and fluctuate much less widely.

TON (Figure 4.23)

Up until July 1992 no TON concentrations above 1.5 mg/l were recorded (indeed the vast majority of results were below the level of detection). Towards the end of 1992 TON concentrations were seen to increase to around 2.5 mg/l with one result at 7 mg/l. Even given the relatively large increase in TON concentration the results are still much lower than in the tributary estuaries.

Dissolved Oxygen (Figure 4.23)

DO concentrations have remained relatively high and relatively constant since 1987, although there were two notable exceptions to this. A result of over 140% recorded in June 1992 may indicate algal activity (although it is the only evidence of any such algal activity in the whole period). There is no obvious explanation for the other notable exception, a result below 20% saturation was recorded in August 1991 (this may be due to an analytical error).

As mentioned above, there is little evidence of algal activity in this part of the Wash. Due to the nature of the tides in this area high water samples are usually collected during the night, or early morning, and low water samples during the day. Given this sampling regime any algal activity would be characterised by low DO values at high water and the converse at low water. There is no evidence at all to suggest that this is the case.

BOD (Figure 4.24)

BOD levels have remained constant, and quite low (averaging about 2 mg/l). There was one high result in June 1992 and as the corresponding chlorophyll sample was also twice as high as usual this may indicate some algal activity. However both the BOD and chlorophyll results were still low (7mg/l and 50 ug/l respectively).

Chlorophyll-a (Figure 4.24)

Chlorophyll-a concentrations at Cork Hole are low, not usually exceeding 20 ug/l. Since 1987 only three results have exceeded 40ug/l, the highest of these being 100 ug/l in November 1990. As chlorophyll is a measure of phytoplankton abundance these results would suggest that there is no significant algal activity within the Wash.

TABLE 4.6 THE WASH AT CORK HOLE : ANNUAL AVERAGES

	HCH (ng/l)			DO (% saturation)		
year	n	ave	sd	n	ave	sd
1987	-	-	-	6	92.7	11.7
1988	-	-	-	9	84.2	18.8
1989	6	2.77	1.9	14	78.2	7.9
1990	8	4.08	1.3	12	90.8	10.3
1991	10	3.02	1.6	12	79.2	22.2
1992	11	1.4	5.2	11	104.2	17.2
	NH3 (mg/l)			**TON (mg/l)**		
year	n	ave	sd	n	ave	sd
1987	4	0.26	0.2	4	0.05	0
1988	10	0.42	1	10	0.17	0.4
1989	14	0.07	0.04	14	0.33	0.28
1990	12	0.1	0.09	12	0.31	0.2
1991	12	0.1	0.1	12	0.55	0.27
1992	11	0.07	0.07	11	1.48	2.1
	Chlorophyll-a (ug/l)					
year	n	ave	sd			
1987	4	16.4	15.8			
1988	10	7.7	6.8			
1989	13	3.8	3.2			
1990	12	25.4	28.6			
1991	12	11.7	10.4			
1992	11	10.2	13.4			

n = no. samples ave = average sd = standard deviation

4.5 HEAVY METAL CONCENTRATIONS IN SEDIMENTS.

4.5.1 Introduction

To date no quality standards have been derived in the UK for chemicals and metals in sediments (although it is becoming widely recognised that EQS limits for sediments are required). Even if such standards did exist there are two main problems associated with interpreting results from sediment samples, namely;

- the physical characteristics of the sediment (ie particle size, organic carbon content etc) influence the biological availability of the contaminants present.

- contaminants in sediments are not transitory (unlike contaminants in water) and concentrations may reflect inputs over many years, or large single inputs that occurred years previously.

To some extent both of these problems may be overcome, by analysing a range of physical characteristics and by only taking surface sediment samples, but care should be exercised when interpreting any results.

In the absence of any EQS for sediments, results may be interpreted by reference to other estuaries and to the USA EPA (Environmental Protection Agency) Sediment Quality standards. Both of these options have been utilised in the following sections (See Table 4.8). (Note the NRA analyse the <63um sediment fraction, the USA analyse all the sediment.)

Investigations into heavy metal concentrations in sediments were carried out in the Wash in 1991 (as part of the subtidal benthic survey) and in the Great Ouse and the southeast Wash in 1992 (as part of the Great Ouse Intertidal Survey). The results from the 1991 Wash subtidal survey are presented in Part II of the report.

4.5.2 Heavy Metals in Sediments in the Great Ouse Estuary

Sediment samples collected during the 1992 Great Ouse routine intertidal survey were analysed for a range of heavy metals. The sample sites are shown on a map of the area in Figure 4.25. Results from the survey are shown in Figures 4.26 and 4.27. The average values for the estuary are shown in Table 4.7 and are compared to the Humber and to the USA EPA standards in Table 4.8.

There was very little variation in metal concentrations throughout the whole of the survey area, with the possible exception of site 23, Ferrier sands in the Wash (see Figure 4.25), at which the highest values for most metals were recorded.

Given the uniformity of the results it seems appropriate to average the data over the survey area, which covers the estuary between Kings Lynn and the sandbanks in the SE Wash. Average concentrations for the metals analysed are presented in Table 4.7.

Copper (Figure 4.25)

Given the concern expressed about levels of copper in the water column, the copper levels in the sediments are reassuringly low. An average concentration of 24.6 mg/Kg is below the USA EPA standards (34 mg/kg chronic, 54 mg/kg acute) and falls well down the league table of metals in UK estuaries (Bryan and Langston, 1992). The Copper concentrations are about half those recorded in the Humber (NRA 1993b).

TABLE 4.7 GREAT OUSE 1992 : HEAVY METAL CONCENTRATION IN SEDIMENTS

Metal	AVE	SD	MIN	MAX
Cu	25	3.51	16.8	32.1
As	20	5.18	14.6	39.5
Ni	36	8.02	23.8	64.6
Zn	151	26.34	102	228
Cd	1.14	0.24	0.726	1.57
Hg	0.19	0.03	0.142	0.278
Fe	34635	5510	23000	48200
Cr	75	15.69	48	127
Pb	76	25.48	53.3	176

Data represents mg/Kg
Ave = Average value for all sites (see Figure 4.33 for site details)
sd = standard deviation

TABLE 4.8 COMPARISON OF HEAVY METAL LEVELS IN THE GREAT OUSE ESTUARY WITH THE HUMBER ESTUARY AND THE USA EPA STANDARDS

Metal	Gt. Ouse	Humber	USA-EPA
Cu	25	54	34
As	20	48	8.25
Ni	36	45	40
Zn	151	279	190
Cd	1.14	0.5	7.75
Hg	0.19	0.7	0.80
Fe	34635	-	-
Cr	75	110	115
Pb	76	114	33(1)

Data represents mg/Kg
USA EPA values represent the chronic standard (Acute standards are higher)
(1) The acute standard for Pb is much higher at 840 mg/kg.
Humber data taken from NRA (1993b)

4.5.3 Heavy Metals in Wash Sediments

Heavy metal concentrations from subtidal sediment samples are presented in Figures 4.28 to 4.33 and are tabulated in Part II (Table 2) of this report. Relatively low concentrations of all metals were usually recorded.

4.6 JoNuS Project

NRA DATA SUMMARY JULY 1990 - DECEMBER 1992

4.6.1 Introduction

The JoNuS (Joint Nutrient Study) Project was set up in response to international pressure to limit the risks of pollution due to excess nutrients entering the North Sea. The full plan was aimed at understanding nutrient behaviour in the Humber, Wash and Thames estuaries; the major U.K. sources of inputs to the North Sea. The JoNuS Group includes MAFF, Universities of East Anglia and Essex, Plymouth Marine Laboratory, National Rivers Authority and Unicomarine Ltd. Sponsors of the project were MAFF, DoE and NRA.

Due to a lack of funding, surveys started on a limited scale in July 1990 with the fully funded programme commencing towards the end of 1992. There were four surveys in 1992 and monthly surveys in 1993.

The data summarised here relate to surface samples collected by salinity band (at intervals of 2 ‰) throughout the full salinity range of the four tributary estuaries.

The nutrient data reported is from water column samples, filtered after collection through 0.45µm membrane filters and therefore termed "dissolved nutrients". All results are in microgrammes per litre (µg/l).

4.6.2 Conservative vs Non-Conservative Behaviour.

In general, nutrient concentrations are highest upstream, towards the freshwater limit, with the lowest values at the seaward end. If the parameters are conservative, the profile of salinity versus nutrient would be a straight line, i.e. of constant negative gradient. This would occur if perfect mixing and dilution of the saline water with the freshwater input at the upper tidal limit were taking place within the estuary, assuming there were no other inputs.

Very few of the nutrient profiles exhibit true conservative behaviour, indicating that there are many other competing processes within the estuarine system. These include known (and unknown) nutrient inputs throughout each estuary, biological productivity within the water column and sedimentation or release processes within the estuary sediments. The phosphate data for the Welland and Witham estuaries reflect this, with maximum levels often found in the middle estuary, possibly influenced by the location of sewage works.

4.6.3 Results of JoNuS Surveys

Ammonia (Figure 4.34)

In all four tributary estuaries ammonia concentrations were highest in April 1991 and lowest during July 1990.

Ammonia concentrations in the Nene were by far the highest, around three times those in the Welland and Witham and ten times those in the Great Ouse. This could be explained by a combination of poor mixing/dispersion in the Nene estuary and high levels of ammonia from discharges to the Nene system, e.g. incompletely treated sewage effluents.

Similar ammonia values were recorded in the Welland and Witham estuaries. The very high ammonia levels at the freshwater end in July 1990 suggests a direct input that was rapidly "taken out" by biological activity as it was carried down the estuary, in addition to the usual dilution processes.

Ammonia concentrations in the Great Ouse estuary were the lowest of all estuaries, with a flat profile, suggesting there were no significant inputs of ammonia to the estuary. During the July 1990 there was a relative rise in ammonia levels in the middle to lower estuary, but the actual levels were still low. There appear to be biological and sediment processes within the estuary combining to control ammonia levels at a low, relatively constant level. The data for April 1991 were unusually high and did not follow the pattern of the other data, leading to a confusing profile, possibly affected by inputs in the upper and lower estuary.

Phosphate (Figure 4.35)

Phosphate concentrations were highest in October, November and January, with April and July concentrations being noticeably lower. Phosphate is often considered to be the biologically limiting nutrient in freshwaters because of its low levels relative to nitrate and silicate (plankton require a balance of nutrients, amongst other things, so when one is almost fully consumed, this limits further growth). There is no evidence that phosphate is the limiting nutrient in these estuaries.

All estuaries show reasonably conservative behaviour, although the limited data set for the Witham indicates a significant phosphate input midway down the estuary, possibly as the result of sewage input. There is also evidence of a smaller phosphate input to the Welland estuary.

The phosphate levels in the Nene and Great Ouse estuaries were approximately 5 times higher than those in the Welland and Witham estuaries.

Silicate (Figure 4.36)

Silicate levels were very similar in all Wash estuaries. Silicate concentrations were highest in January, most notably in the Great Ouse estuary. With the exception of the Great Ouse estuary, silicate levels were very depleted in July 1990 and substantially depleted in Spring April 1991, suggesting biological consumption of this nutrient by significant diatom populations. Silicate may, therefore, become a limiting nutrient in the Wash estuaries, for a period. Phytoplankton data collected during the JoNuS surveys will help to identify the biological processes involved.

An unusual observation is that silicate levels are significantly different between January 1991 and January 1992 (approximately a factor of two higher). An explanation is difficult, although there were abnormal winter conditions during the period of these surveys, in particular with temperature and freshwater river flows. The former would affect biological growth and the latter would affect the supply of nutrients at a time of expected maximum concentrations.

Nitrate (TON) (Figure 4.37)

Nitrate was shown to be the most abundant of the nutrients at a level around twice the silicate concentration and would therefore not normally be considered to be a limiting factor in plankton growth.

Nitrate concentrations were lowest in July 1990 at < 100 µg/l, when biological activity is known to be high (an algal bloom was observed at the time). Levels in November 1990 had risen to about 200 µg/l and levels exceeded 1,000 µg/l in January 1991, the expected peak period for nutrient concentrations. However levels were higher still in April 1991, at about 2,000 µg/l. It is possible that the turbidity of the Wash estuaries causes a seasonal lag in nitrate uptake. Alternatively, the input of nitrate from the freshwater runoff may have been at a maximum at this time.

Unusually, the Witham estuary showed the highest levels for this nutrient, approximately twice those of the other estuaries. The lowest nitrate levels were recorded from the Great Ouse estuary .

Data from April 1991 for the Nene, Great Ouse and Welland estuaries showed major deviations from the anticipated pattern, with apparent nitrate loss at the freshwater end and apparent inputs of nitrate at the seawater end. One explanation could be that nitrate was taken up by freshwater phytoplankton.

Nitrite (Figure 4.38)

The nitrite profiles for the Great Ouse estuary are different to those of the other three estuaries. Nitrite levels in the Great Ouse estuary were lowest in November 1990 whilst they were lowest in the Nene and Welland estuaries in January. Conversely, maximum nitrite concentrations in the Great Ouse were in January 1991 at a level approximately seven times that of the other three estuaries. With this exception, the Nene appears to contain significantly higher levels of nitrite than the other estuaries, probably caused by the poor dissolved oxygen levels within this estuary which would inhibit the oxidising of Nitrite to Nitrate.

Dissolved Oxygen (Figure 4.39)

The Welland, Witham and Great Ouse estuaries have dissolved oxygen profiles much as expected. Dissolved Oxygen is mostly between 80% and 100% saturation with a sag frequently evident in the mid-salinity band, possibly as a result of sewage effluent inputs. The saline end of each estuary appears to maintain a reasonably constant level at around 100% saturation.

Low dissolved oxygen levels were recorded in the Nene in all but one of the JoNuS surveys to date, as shown below:

	Minimum D.O. (% sat)	Salinity (‰)
JoNuS 2 - July 1990.	7	0.6
JoNuS 3 - November 1990.	31	2.1
JoNuS 4 - January 1991.	41	0.8
JoNuS 5 - April 1991.	37	7.9
JoNuS 6 - October 1991.	20	3.0
JoNuS 7 - January 1992.	67	1.9
JoNuS 8 - February 1992.	25	4.0

During the July 1990 survey, when an algal bloom was evident in both the Wash and its estuaries, some high levels of dissolved oxygen were measured. In particular, a value of 180% saturation was measured in the upper Welland estuary, near Spalding. This was obviously super-saturation, resulting from algal photosynthetic activities.

4.6.3 FUTURE JONUS SURVEYS.

During 1993, the JoNuS programme will sample the Wash and its estuaries each month. After 1993, the sampling effort ceases and about two years will be required to work up the data and produce a mathematical model of the Wash system. This will attempt to integrate the biogeochemical processes within a hydrodynamic model.

4.7 WASH WATER QUALITY MODELS

4.7.1 Existing Models

To date water quality models have been developed for the Nene and Great Ouse estuaries. Although vertical stratification of the estuaries is likely one dimensional models were considered adequate to meet the objectives of the models.

Three models were developed for the **Great Ouse**;

- a hydrodynamic model to predict water levels and water movement

- a water quality model to predict (among others) dissolved oxygen

- a salinity model to predict salinity under low fresh water flow conditions.

The model was calibrated and validated using water level data from July 1984 and water quality data collected during 1983-1985.

The model is used to estimate consent conditions for the estuarine discharges. A full explanation of the model and its validation can be found in the 1986 WRc report 'Mathematical Models of the Great Ouse estuary'.

Two models were developed for the Nene estuary:

-a hydrodynamic model to predict water levels and water movement

- a dissolved oxygen model.

The model was calibrated and validated using data from six water quality surveys carried out over the summer of 1988.

The model was again developed by WRc and is used to estimate consent conditions in statistical terms.

Two models have been developed for the **Wash.** The first of these was produced by Hydraulics Research Station in 1977 as part of the Wash Water Storage Scheme Feasibility Study and was designed to predict current and sedimentation patterns.

A second model, produced by WRc in 1988, was produced for the sole purpose of predicting bacterial dispersal and decay within the Wash. The model is used by Anglian Water to predict and assess the impact from its sewage treatment works at Kings Lynn and Heacham.

4.7.2 Models in Preparation

The NRA have recently commissioned a new model of the Wash and its tributary estuaries. The model will provide a management tool for assessing the impact of polluting loads, identifying the scope for implementing control procedures and will aid the setting of discharge consents. The model, which is due to be completed by summer 1994, will also provide the NRA with the ability to investigate a range of water quality scenarios. The model will extend to pick up contributions from the Humber and will calculate contributions from the Wash system to the North Sea.

The specific objectives of the proposed model are:

i) To predict the numbers of micro-organisms in shell fisheries and areas where there is direct human contact, such as bathing waters.

ii) To provide information on nutrient concentrations within the system in order to investigate:

- the extent to which major sources contribute to nutrient levels
- the potential for eutrophication (incorporating the growth and decay of phytoplankton).
- the extent to which control measures can limit nutrient levels.

iii) To establish the most appropriate discharge consents to achieve EQS compliance.

iv) To simulate the transport of contaminants within the system.

4.7.3 Future Models

The Wash and its estuaries were sampled in each month of 1993 as part of the JoNus Project. The data collected from the project will be used by MAFF to produce a mathematical model of the Wash system. The model should be available in 1996.

5.0 Bacteriological Quality

5.1 Introduction

Sewage from humans and animals may contain a whole range of harmful pathogenic (disease causing) bacteria and there are obvious health risks associated with sewage polluted waters.

For many reasons monitoring for specific pathogens is impractical and as these pathogens are usually vastly outnumbered by commensal intestinal bacteria (which are much easier to isolate and identify) it is this latter group of bacteria that are normally monitored. The presence of these commensal bacteria is taken to indicate that more harmful pathogens may be present and may pose a health risk. Escherichia coli is the most abundant commensal bacterium in the bird and mammalian intestine, present in numbers approaching 1000 million per gramme of fresh faeces (HMSO, 1987). E.coli is, however, rarely found in soil, water or vegetation and is therefore an excellent indicator of faecal contamination and is widely used to monitor sewage pollution. Faecal streptococci are more resistant to environmental stress than E.coli and survive for longer periods outside the intestine. Faecal streptococci are usually monitored along with E.coli. Clostridia bacteria are present in the intestine in fewer numbers than E.coli but can produce spores which can survive for long periods of time in the environment. The presence of clostridia generally implies a remote (both spatially and temporally) or intermittent pollution.

Bacterial monitoring in the Wash is carried out in areas where sewage pollution may pose a health risk, i.e. bathing waters and shellfish harvesting areas. 'Presumptive' numbers of coliforms are usually reported for EC purposes, i.e. the coliforms isolated are presumed to be faecal coliforms. A further test is required to confirm that this is actually the case but because such tests usually show at least 95% confimation they are not carried out routinely.

E.coli is just one type of faecal coliform bacterium but because it is present in vastly greater numbers than other species the term 'faecal coliforms' and E.coli can be regarded as being synonymous for the purposes of this report. In strict terms the NRA test for the presence of faecal coliforms, a further test is required to identify the exact proportion of E.coli.

5.2 Bacterial Quality of Bathing Waters

Bathing waters are monitored by the NRA under directive 76/160/EEC. There are 33 bathing waters identified under the directive within the Anglian region of the NRA, two of which are in the Wash (Hunstanton Beach and Heacham North Beach).

Monitoring of the Wash bathing waters is carried out regularly between May and September at the two EC designated bathing waters as well as at six other beaches.

The locations of the monitored bathing beaches are shown in figure 5.1. In accordance with the Directive, at each site the 20 samples taken over the five month period were analysed for total coliforms, E.coli (faecal coliforms) and faecal streptococci. Salmonella analysis was carried out on two samples from each site annually (Before 1991 only samples from the EC designated bathing waters were analysed for salmonella). Analysis is carried out using standard membrane filtration techniques (HMSO, 1987; NRA, 1992).

The monitoring results, summarised in table 5.1, show compliance with the directive's mandatory standards of 10,000 total coliforms and 2,000 E.coli per 100ml of seawater. In order for a site to pass it can only exceed each of these standards once per season (i.e two values exceeding 10,000 coliforms or two values exceeding 2,000 E.coli will result in a failure). Figures 5.2 and 5.3 show median values for total coliforms and E.coli at each site from 1987 to 1992.

TABLE 5.1 BATHING WATER MONITORING RESULTS 1987 - 1992

	BATHING WATER	1987	1988	1989	1990	1991	1992
1	Old Hunstanton (EC)	Pass	Fail	**Pass***	Pass	**Pass**	Pass
2	Hunstanton North	Pass*	Fail	Pass*	Fail	Pass*	Pass
3	Hunstanton Main	Pass	Pass	Pass	Pass*	Pass	Pass
4	Hunstanton South	Pass	Pass	Pass	Pass	Pass	Pass
5	Heacham North (EC)	**Fail**	Fail	**Pass***	Pass*	**Pass***	Pass
6	Heacham South	Pass	Fail	Pass	Pass	Fail	Pass*
7	Heacham last house	Pass	Fail	Pass	Pass	**Pass**	Pass
8	Snettisham	Fail	Fail	Pass	Pass	**Pass**	Pass

(EC) = Bathing Water recognised under Directive 76/160/EEC
*** Denotes site which included one sample failure**
Bold type indicates Salmonella was detected

The EC designated waters have complied with the directive since 1989. Of the remaining bathing waters, Hunstanton North failed in 1990 and Heacham South failed in 1991. All other bathing waters complied with the directive in all years, although some exceeded one of the mandatory values (these are marked with an asterisk in table 5.1).

Bacterial levels at the bathing waters have been decreasing since 1989, as have the number of EC parameter failures (In 1990 there were 6 failures, 1991 4 failures and 1992 only one EC parameter failure). In addition the fact that salmonella was not detected in any samples in 1992 further emphasises the improvements seen since 1989.

Improvements in bacterial quality of the bathing waters is also seen with reference to the median values of total coliforms and E.coli at each site (Figures 5.2 and 5.3). Median values provide a good indication of general water quality and all eight sites show a decrease in bacterial levels since 1987/88.

The demonstrable improvement in bacterial quality is a result of the decommissioning of the S.T.W. outfall pipe at Hunstanton and the subsequent diversion of sewage to Heacham STW, where it undergoes tertiary treatment before finally entering the Wash via the Heacham river. Sewage was diverted from Hunstanton in 1990 and the only bathing water failure after this date occurred at Heacham South beach in 1991. This failure was attributed to engineering work at Heacham S.T.W., during which effluent from the works could not be fully treated.

5.3 Water Column Bacteriological Surveys

Up until the end of 1992 the only water column bacteriological survey was carried out by the NRA in the Great Ouse estuary in 1991. Water samples were collected during the Great Ouse chemical surveys (see Figure 5.4 for site details) and were analysed for total coliforms, E.coli and faecal streptococci using standard membrane filtration techniques (HMSO 1987, NRA, 1992).

The results for the estuary samples are summarised in figures 5.5 to 5.7 and results for trade effluent and Kings Lynn STW samples are shown in table 5.2.

The presumptive numbers of bacteria in the estuary were variable throughout the year with maximum levels for E.coli ranging from 2,400 per 100ml in November to 80,000 per 100ml in July. Although the numbers were variable the general pattern of distribution in the estuary was very similar in each survey. High concentrations of bacteria were present near to Kings Lynn STW, downstream on the ebb tide and upstream on the flood tide. Table 5.2 shows the STW to be the major source of bacteria into the Great Ouse (more than 10 million E.coli per 100ml) and the effluent from the works is responsible for the peak in bacterial numbers.

The overall number of bacteria in the estuary was generally higher at low water because the STW only discharges on the ebb tide and dilution and die-off of the bacteria occur on the flood tide.

TABLE 5.2 BACTERIAL CONTENT OF EFFLUENTS DISCHARGED TO THE GREAT OUSE ESTUARY (1991 data)

MONTH	DETERMINAND	KINGS LYNN STW	BRITISH SUGAR	DOW CHEMICALS	PORVAIR
JAN	Total Coliforms	56,000,000	2,400	100	3,800
	E.coli	27,000,000	300	10	330
	F.Streptococci	2,900,000	10,000	10	40
APRIL	Total Coliforms	62,000,000	200,000	1,500	120
	E.coli	60,000,000	200,000	10	130
	F.Streptococci	180,000	4,000	10	10
JULY	Total Coliforms	10,000,000	100,000	1,200	100,000
	E.coli	10,000,000	100,000	520	5,900
	F.Streptococci	450,000	4,800	50	40
AUG	Total Coliforms	100,000,000	30,000	0	700
	E.coli	51,000,000	25,000	0	30
	F.Streptococci	650,000	35,000	0	40
DEC	Total Coliforms	190,000,000	160,000	0	1,360
	E.coli	36,000,000	3,500	0	10
	F.Streptococci	470,000	100	0	0

Data represents numbers per 100ml of effluent

TABLE 5.3 GREAT OUSE INTERTIDAL SEDIMENT BACTERIOLOGICAL SURVEY : SEPTEMBER 1992

SITE NUMBER	SITE NAME	TOTAL COLIFORMS	E.COLI	FAECAL STREPS
1	TAIL SLUICE	200,000	71,000	3,000
2	DOWNSTREAM BRITISH SUGAR OUTFALL	200,000	99,000	4,100
4	RIVER NAR CONFLUENCE	200,000	81,000	630
5	SOUTH QUAY	150,000	51,000	4,200
6	COMMON STAITHE QUAY	200,000	124,000	4,600
7	FERRY STEPS WEST BANK	15,000	2,000	7,600
8	FISHER FLEET DOCK	2,000,000	260,000	55,000
9	BABINGLEY CONFLUENCE	1,300,000	260,000	21,000
10	WEST BANK BEACON	3,200,000	930,000	93,000
11	OPPOSITE WEST BANK BEACON-EAST BANK	560,000	160,000	7,000
12	BEACON E	1,800,000	1,000,000	88,000
13	BEACON D	510,000	280,000	10,000
14	BEACON C	960,000	70,000	8,000
15	BEACON B- WEST BANK	1,600,000	730,000	52,000
16	BEACON B- EAST BANK	600,000	93,000	13,000
17	BEACON A	460,000	122,000	7,000
18	WEST STONES BEACON	610,000	130,000	9,000
	SHELLFISH BED-'E' OLD WEST CHANNEL	22,000	2,000	5,000
19	BULL DOG SANDS	17,000	5,000	1,000
22	PANDORA SANDS	219,000	73,000	17,000
25	PETER BLACK SANDS	2,000	<1000	<1000
28	STYLEMANS MIDDLE	<1000	<1000	<1000
31	FERRIER SANDS	<1000	<1000	<1000

Data represents numbers per 100ml sediment
refer to Figure 4.33 for site location details.

5.4 Sediment Bacteriological Surveys

5.4.1 Introduction

Sediment bacteriological surveys were carried out by the NRA in the Wash in 1991 (as part of the subtidal benthic survey) and in the Great Ouse estuary in 1992.

Sediment samples were analysed for total coliforms, E.coli and faecal streptococci using standard membrane filtration techniques (HMSO 1987, Ayres 1977).

5.4.2 The Wash

Bacterial results from the 1991 Wash subtidal benthic survey are shown in Figure 7 of Part II and Figure4.31 (Clostridia only). E.coli was only present in any significant density at 6 of the 66 sites sampled and only exceeded 2000 100ml of sediment at two sites (W51 and W43). Both of these sites are located in the SW corner of the Wash and bacteriological work carried out in this area as part of the Great Ouse surveys would suggest that Kings Lynn STW is implicated in these high results.

Clostridia were present at most sites and in relatively high numbers in the central and eastern Wash (see Figure 4.40). Clostridia spores can survive for long periods in seawater and would be distributed throughout the Wash by the prevailing currents. The higher densities in the eastern Wash could be explained by the water circulation system in the Wash, which runs in an anticlockwise direction (and could carry bacteria from the Witham, Welland and Nene) and by the sewage inputs to this area.

5.4.3 The Great Ouse

Bacterial results from the routine intertidal benthic survey of 1992 are shown in Table 5.3.

Bacterial contamination of the sediments in the Great Ouse is high, with highest densities (1 million E.coli per 100ml of sediment) being found at West Bank Beacon and Beacon E, justdownstream of the STW (see figure 4.33 for site details).

At the seaward end of the training wall bacterial numbers are much reduced, but still very high at around 120,000 per 100ml of sediment. Bacterial contamination of the sandbanks in the south west Wash appears to be variable, with the only obvious trend being a further reduction in contamination at the more seaward sample sites. There are obvious implications for the shellfish beds in this area, these are discussed in section 5.5 below.

It is apparent from the data that the effluent from the STW 'hugs' the west bank of the Great Ouse and is not evenly dispersed throughout the estuary. Samples taken from the training wall (on the west bank of the estuary, where the STW effluent enters) show E.coli to be present in densities an order of magnitude higher than at corresponding sites on the east bank.

5.5 Shellfish Hygiene Monitoring

The shellfish beds in the Wash are not covered by the Shellfish Waters Directive (79/923/EEC) but are sampled at monthly intervals in accordance with the Shellfish hygiene Directive (91/942/EEC). This latter directive classifies harvesting areas according to the degree of bacterial contamination in the shellfish flesh and liquor. The classification scheme is detailed in Table 5.4.

Monitoring under the shellfish hygiene directive is carried out principally by the local Environmental Health Offices, although through a local agreement the NRA undertake the analyses on two occasions each year.

Sampling at the 18 shellfish sites shown in Figure 5.8 began in December 1989. Results between this date and December 1992 are summarised in Figure 5.9, with full results appearing in Appendix A (Data courtesy of KLWNBC Environmental Health Office).

On two occasions each year the NRA undertake the bacterial analysis of shellfish tissue and also test for the presence of salmonella. In November 1991 Salmonella montevideo was detected at South Daseleys, Stylemans Middle and the Training wall (sites E, H and G respectively). In March 1992 no salmonellae were detected and in November 1992 Salmonella mbandaka was present at South Daseleys, Stylemans Middle and the Training wall.

Figure 5.9 clearly shows that shellfish in the north and west of the Wash contain the lowest numbers of bacteria and the shellfish beds are usually categorised within class A or B. The heaviest bacterial contamination of shellfish occurs in and around the mouth of the Great Ouse estuary. The shellfish beds in this area are designated as being class C/D, except site G (the Training wall) where harvesting is prohibited. Kings Lynn STW is clearly implicated in these results.

TABLE 5.4 CLASSIFICATION OF SHELLFISH HARVESTING AREAS UNDER THE SHELLFISH HYGIENE DIRECTIVE (91/492/EEC)

CATEGORY	CRITERIA	MARKETING IMPLICATIONS
CLASS A	<230 E.coli/100g flesh <300 faecal coliforms	May go for direct human consumption
CLASS B	<4600 E.coli/100g flesh <6000 faecal coliforms (in 90% samples)	Must be depurated, heat treated or relaid to meet Category A
CLASS C	<60000 faecal coliforms/ 100g flesh	Must be relayed for at least 2 months to meet Category A o B. Or may be heat treated
CLASS D	>60000 faecal coliforms/100g flesh	Harvesting Prohibited

6. Biological Quality

6.1 Benthic Invertebrate Surveys

6.1.1 Introduction

Both Subtidal and Intertidal surveys have been carried out in the Wash and its tributary estuaries in order to assess general ecological quality and to identify any impacts on biological communities from trade and sewage inputs.

6.1.2 The Wash

6.1.2.1 Introduction

There have been two extensive studies on the intertidal invertebrates of the Wash embayment by Corlett and Salkfield in 1976 and by ITE in 1988. The former study was carried out by IMER as part of the Wash water storage feasibility scheme, the latter with a view to examining interactions of invertebrate and bird communities. A comparison of the two studies revealed how little the intertidal invertebrate communities have altered over the period 1974-1986.

The earliest subtidal benthic invertebrate studies of the Wash embayment were carried out for the NCC (now English Nature) by Dipper et al in 1983, 1985 and 1986. These studies, although only covering part of the Wash, indicated a highly diverse benthic community.

A large subtidal benthic grab survey, the first of its kind in the Wash, was carried out by the NRA in 1991. The findings of the NRA survey are summarised in section 6.1.2.2 below and a full report of this survey is presented as Part II of this report.

6.1.2.2 The Wash Subtidal Benthic Survey, August 1991.

The following section summarises the benthic survey of the Wash that was carried out by the NRA (Anglian Region) in August 1991.Part II of this report presents the full results and interprets the findings with reference to the physical characteristics of the area.

A total of 66 sample points were visited using the survey vessel 'Sea Vigil'. Three grab samples were taken at each point for the determination of the macro-invertebrate fauna; additional samples were collected for the analysis of a number of physical, chemical and microbiological parameters.

Analysis of the biological data showed the Wash to support a diverse fauna. A total of 300 different species were recorded from the sites and animal densities ranged from 60 to 30,000 individuals per square metre. Multivariate statistical analysis of the data revealed two major divisions within the biological communities, which appeared to relate to water depth; the divide between the two different areas appeared to be the 10m depth contour. The deeper water sites tended to support a greater number of individuals and a more diverse fauna. Further subgroups of sites within these two major divisions were also evident and appeared to be related to the sediment characteristics of the sites. There was some evidence of a possible disturbance of the fauna at sites in the immediate vicinity of the Great Ouse estuary. However it is known that this part of the Wash offers a relatively hostile environment to the benthic fauna and it is not possible to be sure if the differences in the fauna were natural or the result of some polluting influence.

6.1.3 The Tributary Estuaries

6.1.3.1 Introduction

In the **Witham** and **Welland** estuaries eight subtidal benthic and two intertidal benthic surveys were carried out during 1989-91 as part of the Ecological Study. The study report (NRA, 1993) compares data from these surveys with work carried out by IMER in 1973 as part of the Wash barrage scheme, and found similar patterns of faunal distribution some 17 years on.

A similar number of surveys were carried out in the **Nene** estuary between 1985 and 1987 (see Dyer and Grist, 1989). A follow-up survey of a selected number of sites in the Nene was conducted in 1991 (Dyer and Grist, 1991a). The 1989 report compared the 1987 results to the IMER surveys carried out in the vicinity of the Nene in 1973 and 1974 and as with the Witham and Welland found very similar faunal distributions.

Intertidal benthic surveys in the **Great Ouse** were undertaken by IMER in 1973 and repeated by WRc in 1984 as part of the Great Ouse Ecological Study. Comparisons between the two surveys showed greatest changes on the training wall and cited accretion and an increase in organic content as a possible explanation of the differences observed (see Gould et al (1986) for a comparison of the two surveys). Since 1988 the NRA have undertaken annual intertidal surveys in the Great Ouse, with findings being published in NRA (1989) and NRA (1993c).

An extensive subtidal benthic survey was carried out in the Great Ouse in 1983-84 by Unicomarine (Dyer and Grist, 1986). Partial repeats of this survey were undertaken in 1990 by Unicomarine (sampling 5 sites) and in 1992 by the NRA (sampling 10 sites).

In 1990, as part of the National Estuaries Survey, a small number of intertidal benthic samples were taken from the **Babingley** and **Ingol** estuaries (Dyer and Grist, 1991b).

6.1.3.2 Comparisons between the tributary estuaries

The hydrographical and physical features of each tributary estuary would appear to be very similar. These similarities are reflected in the benthic populations usually encountered and the summary that follows is largely applicable to all four estuaries.

The estuaries are canalised throughout most of their length and the restricted volumes, together with a high proportion of freshwater in the system result in harsh (very variable) salinity regimes. The salinity regime would appear to largely govern the benthic fauna found in each estuary.

The upper reaches are almost exclusively dominated by oligochaete worms, which are often present in very high densities. These sites may only occasionally experience saline intrusion and oligochaete densities appear to be largely governed by sediment type, with higher numbers being found in soft muds.

Further downstream, at the saline interface, population densities fall dramatically, resulting in a very sparse benthic fauna. Although the restricted habitats that result from the canalisation of the estuaries may play a part, the paucity of the fauna in these areas is largely a consequence of the harsh salinity regime.

Towards the seaward end of the estuaries the number of species and number of individuals gradually increase as the salinity regime becomes increasingly favourable. At the seaward end a rich benthic fauna is usually encountered.

To enable a better comparison of the tributary estuaries, cluster analysis was carried out on a combined data set from the subtidal sites of all four estuaries. Cluster analysis is a multivariate statistical procedure that groups together sites that have similar faunal characteristics.

Data from the July 1990 Witham and Welland survey, the July 1987 Nene survey and the August 1992 Great Ouse survey were combined for the exercise. The outcome of the cluster analysis is presented in the form of a dendrogram in Figure 6.1 and the cluster patterns are shown on a map of the area in Figure 6.2. The dendrogram has been split into four main cluster groups, designated A,B,C and D. This split corresponds to the 30% level of similarity.

Group A contains sites located towards the seaward end of the sampling lines. The fauna at these sites is varied (approximately 100 taxa were recorded in total) and many of the species are restricted to fully marine conditions.

Sites clustered within group B have a less diverse fauna than those within group A, with 36 different taxa being recorded. Juvenile Nephtys sp. were common, as in group A, but the next two dominant species were Tubificoides benedeni and Hydrobia ulvae, both common species in muddy sediments and tolerant of reduced salinities.

Group C contains sites which support a low number of species (13 taxa were recorded in total) and probably reflect a harsher physico-chemical environment. The dominant species is again Hydrobia, and all other species recorded were present in extremely low numbers.

The species recorded at sites within cluster group D were clearly the result of lower salinities. The five most common species were all tubificid oligochaetes and all the other species recorded were present in very low numbers.

Overall, the sites have been grouped according to their location relative to the Wash, rather than necessarily with other sites from the same river. This reflects the basic changes in the natural environmental conditions, particularly salinity, and the influence these have upon the fauna.

The above analysis has shown the faunal communities in each tributary estuary to be very similar and to be largely influenced by prevailing environmental conditions rather than any differences in general water quality (except for stretches of the Nene, see section 6.1.3.4). Such findings are not too surprising given the relatively harsh (and therefore over-riding) salinity regime of the estuaries.

In order to assess whether water quality is affecting the distribution of faunal communities data from several surveys needs to be examined in order to build a general picture of the estuaries and to make year on year comparisons. Given that each estuary was surveyed in different years and often at different times of year, this examination is best carried out by looking at the estuaries separately.

6.1.3.3 The Witham and Welland Estuaries

Eight subtidal surveys and two intertidal surveys were conducted between July 1989 and June 1991 as part of the Witham and Welland Ecological Study (NRA,1993). A total of 21 sites were routinely sampled, the locations of which are given in Figure 6.2.

The study showed that, with the exception of the outer Witham, the substratum of both estuaries was similar and that the faunal distribution patterns were governed by the large salinity range. The highest populations densities, and the lowest species diversities were encountered in the upper reaches of the estuaries, where large numbers of oligochaete worms were found in the soft mud substrata. Species diversity increased downstream and was highest at sites in the outer estuaries. The Witham estuary was shown to be more diverse in terms of species, especially the outer canalised section which was shown to be particularly species rich (largely due to a favourable shell substratum).

Generally speaking the benthic fauna of both estuaries was found to be broadly consistent with the prevailing physical and hydrographical features. One site on the Witham (site 15) supported a fewer number of species than either of its neighbouring sites. This site is influenced by freshwater inputs from the Hob Hole drain and is situated close to Boston STW. The reduced species variety at site 15 could also be a possible consequence of an unstable substratum as this was the only site where 'mega-ripples' were encountered.

6.1.3.4 The Nene Estuary

Eight subtidal surveys were carried out in the Nene between 1986 and 1987 as part of the Nene Estuary Ecological Study (Dyer and Grist,1989). The estuary was divided into two sections, upstream of Wisbech to the Dog-in-a-Doublet sluice (sites 1 to 12) and downstream of Wisbech to the Wash (sites 13 to 26). The locations of sites 14 to 26 are shown in Figure 6.2.

The section upstream of Wisbech was dominated by large numbers of freshwater oligochaetes, with very little other benthic fauna being encountered. Dyer and Grist (1989) concluded that the populations found in this section of the estuary were likely to be reflective of poor water quality.

In the section downstream of Wisbech high oligochaete densities were only encountered at site 13. These results were not surprising as site 13 had very similar physical characteristics to the more upstream sites.

Sites 14 to 18 were shown to support low numbers of individuals and species and their paucity was attributed to unstable sediments and a severe salinity regime. Downstream of site 18 the number of individuals and number of species generally increased but only at sites 25 and 26, in the Wash, were stable marine communities encountered.

An intertidal survey of the Nene conducted in 1987, found only oligochaetes upstream of Sutton Bridge (sites 1-16) and no infauna at site 15. Further studies to investigate this area indicated that West Walton STW may be implicated in these findings. Dyer and Grist (1989) compared the intertidal results with similar data from the Witham, Welland and Great Ouse and found that the Nene generally supported fewer species. The paucity of the intertidal fauna was attributed to poor water quality, especially the low dissolved oxygen conditions that were encountered in the summer months.

6.1.3.5 The Great Ouse Estuary

The 1986 Great Ouse report (Gould et al. 1986) showed that physical conditions in the estuary were quite severe. The canalisation of the estuary and the large freshwater input to it resulted in high current speeds and led to a scouring of the estuary bed. In addition to scour, the benthic fauna also had to contend with a very harsh salinity regime and the result was a very restricted communities. Given these conditions it was thought unlikely that the subtidal benthos would provide a suitable means of monitoring any effects of pollution. Consequently, intertidal benthic surveys have been carried out annually since 1988.

Surveys are carried out in September and the locations of the sampling sites are shown in Figure 4.25. Results of surveys carried out between 1989 and 1992 are given in NRA, 1989 and NRA 1993c.

The surveys carried out during this period saw quite marked changes in faunal distributions which were attributed to the low freshwater flows during the drought period of 1989-1991. The drought started in 1989, following what had been a prolonged period of high freshwater flow, and low freshwater flows were prevalent until August 1992.

In 1988 and 1989 species variety at virtually all sites was low and many sites were devoid of life. In 1990 there was a dramatic increase in abundance at sites on the training wall (sites 12-18) with invertebrate densities rising from around 4,000/m^2 to around 50,000/ m^2. These changes were largely attributable to an increase in the densities of the oligochaete Tubificoides benedeni but also to the polychaete Pygospio elegans. At the same time mollusc populations declined almost as dramatically. T.benedeni is often associated with organic enrichment (Barnett, 1983).

The results suggested that the reduction in freshwater flow was allowing the accretion of fine sediments (and a large amount of organic effluent from the nearby STW) onto the training wall. Organic pollution typically results in a large increase in the abundance of tolerant organisms together with a decline in species variety and this was the observed effect at sites on the training wall. Due to an amelioration of the very harsh salinity regime species variety increased at sites both upstream and downstream of the training wall, but at sites 12-18 species variety either declined or remained constant.

The 1991 and 1992 surveys showed that T.benedeni was still dominant at most sites on the training wall suggesting that these sites are still being impacted by organic pollution.

6.2 Plankton Surveys

6.2.1 Introduction

Plankton sampling was incorporated into the third and all subsequent JoNuS surveys, and was thus carried out at regular salinity intervals (every $2^{o}/_{oo}$) in each of the four tributary estuaries. However, no conclusions can yet be drawn from this work as only a few of the samples collected have been analysed.

6.2.2 Phytoplankton

The NRA only carry out routine phytoplankton surveys in the Great Ouse estuary, although phytoplankton sampling was incorporated into the third JoNuS survey and has been carried out on all subsequent surveys. Each month samples are collected at salinity intervals of $2^{o}/_{oo}$ from all four tributary estuaries. The majority of JoNuS samples are still to be analysed, but data from JoNuS 5 is available for the Witham, Welland and Nene estuaries.

In addition to these surveys, samples were collected in the Nene, Witham and Welland as part of the Estuary Ecological Studies. Results from these surveys can be found in the reports of these studies (Dyer and Grist, 1989 and NRA, 1993 respectively).

Comparing the results from each estuary, huge differences between the Great Ouse and the other estuaries are immediately apparent. Analysis of the JoNuS and Nene study samples revealed extremely low numbers of all phytoplankton species, with phytoplankton densities rarely exceeding 40 cells per 20ml. This is in complete contrast to the Great Ouse where densities above 10,000 cells per 20 ml are commonly recorded

Some of the observed differences are probably due to the fact that the samples were taken at different times of year, but the main reason for the the large differences would appear to be due to different analytical techniques being employed by different workers. (The differences may in fact only reflect very different techniques employed in sub-sampling large volumes of water and algae). Because of these analytical problems direct comparison between estuaries is difficult. However, even allowing for the analytical discrepancies mentioned above, it would appear that the Great Ouse supports a more diverse and more numerous phytoplankton community than any of the other estuaries. Without comparing samples taken at the same time of year it is not possible to estimate to what extent these findings reflect natural seasonal variation and clearly all the JoNuS samples need to be analysed before any meaningful comparisons between the estuaries can be made.

Results of phytoplankton surveys carried out in all tributary estuaries are given in Appendix B.

6.2.3 Zooplankton

Zooplankton surveys have been undertaken in all of the tributary estuaries.

Zooplanktonic studies were first carried out in 1986 as part of the Nene estuary ecological study (Dyer and Grist, 1989), push net studies were made in 1991 and 1992.

The zooplankton community in the Nene is low in diversity, copepod dominated, and even in the upper estuary has an extremely low incidence of freshwater species. The low species diversity in the Nene may be attributable to the poor water quality prevalent in this estuary (see section 5.3).

The only zooplankton surveys of the Witham and Welland were carried out in 1991 and 1992, they showed both estuaries supported a diverse plankton population. There was only a small difference in the zooplankton communities of the two estuaries.

Annual zooplankton trawls have been undertaken in the Great Ouse estuary at high and low water. The results of these surveys have shown the plankton to be restricted within the channel depending on the salinity and were very useful indicators of the changing salinity regime during the drought years (NRA ,1993c). Plankton data from the Great Ouse are included within Appendix B.

6.3 Fish

6.3.1 Fish Surveys

Since 1975 MAFF has collected the only data on the Wash embayment fish communities. The data has not yet been analysed but a species list for the period 1985 to 1991 is shown in Appendix B.

The NRA has trawled the Great Ouse estuary, using a 2m beam trawl, annually since 1988. The trawl sites and the results for 1989 to 1990 are shown in tables Appendix B. The estuarine fish species composed two thirds the total species found in the Wash trawl surveys by MAFF (1975-1991).

Fish trawls were undertaken in the Witham and Welland as part of the Ecological Study (NRA, 1993). Fish catches were generally low and comparable with the catches for the Nene. The results of the surveys can be found in NRA (1993). Push Net samples were taken in August 1991 and 1992, the results of these surveys (and site locations) are given in Appendix B.

Trawling was carried out in the Nene in 1985, with results reported in Dyer and Grist (1989). Catches were generally poor. Push Net samples were taken in August 1991 and 1992, the results of these surveys (and site locations) are given in Appendix B.

6.3.2 Fish Health

Fish health checks are carried out on a subsample of the catches made during the Great Ouse epibenthic trawls. To date the results have indicated the fish to be in good health, with no abnormalities that could be related to acute or chronic water quality problems (see NRA, 1993c for full results).

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List of Abbreviations used

BOD	Biochemical oxygen demand
CMP	Catchment Management Plan
DO	Dissolved Oxygen
DoE	Department of the Environment
EC	European Commission
E. coli	Escherichia coli
EN	English Nature
ESFJC	Eastern Sea Fisheries Joint Committee
EQO	Environmental Quality Objective
EQS	Environmental Quality Standard
HCH	Hexachlorocyclohexane
HMSO	Her Majesty's Stationary Office
ICES	International Council for the Exploration of the Seas
ITE	Institute of Terrestrial Ecology
IMER	Institute of Marine Environmental Research
JoNuS	Joint Nutrient Study
KLWNBC	Kings Lynn and West Norfolk Borough Council
LC50	Lethal Concentration required to induce a 50% mortality
MAFF	Ministry for Agriculture, Fisheries and Food
µg/l	Microgrammes per litre
mg/l	Milligrammes per litre
MPN	Most Probable Number
NCC	Nature Conservancy Council (Now English Nature)
NRA	National Rivers Authority
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PHLS	Public Health Laboratory Service
SSSI	Site of Special Scientific Interest
SSO	Storm Sewage Outfall
SPA	Special Protection Area
STW	Sewage Treatment Works
tcmd	thousand cubic metres per day
TON	Total oxidised Nitrogen

NRA

National Rivers Authority
Anglian Region

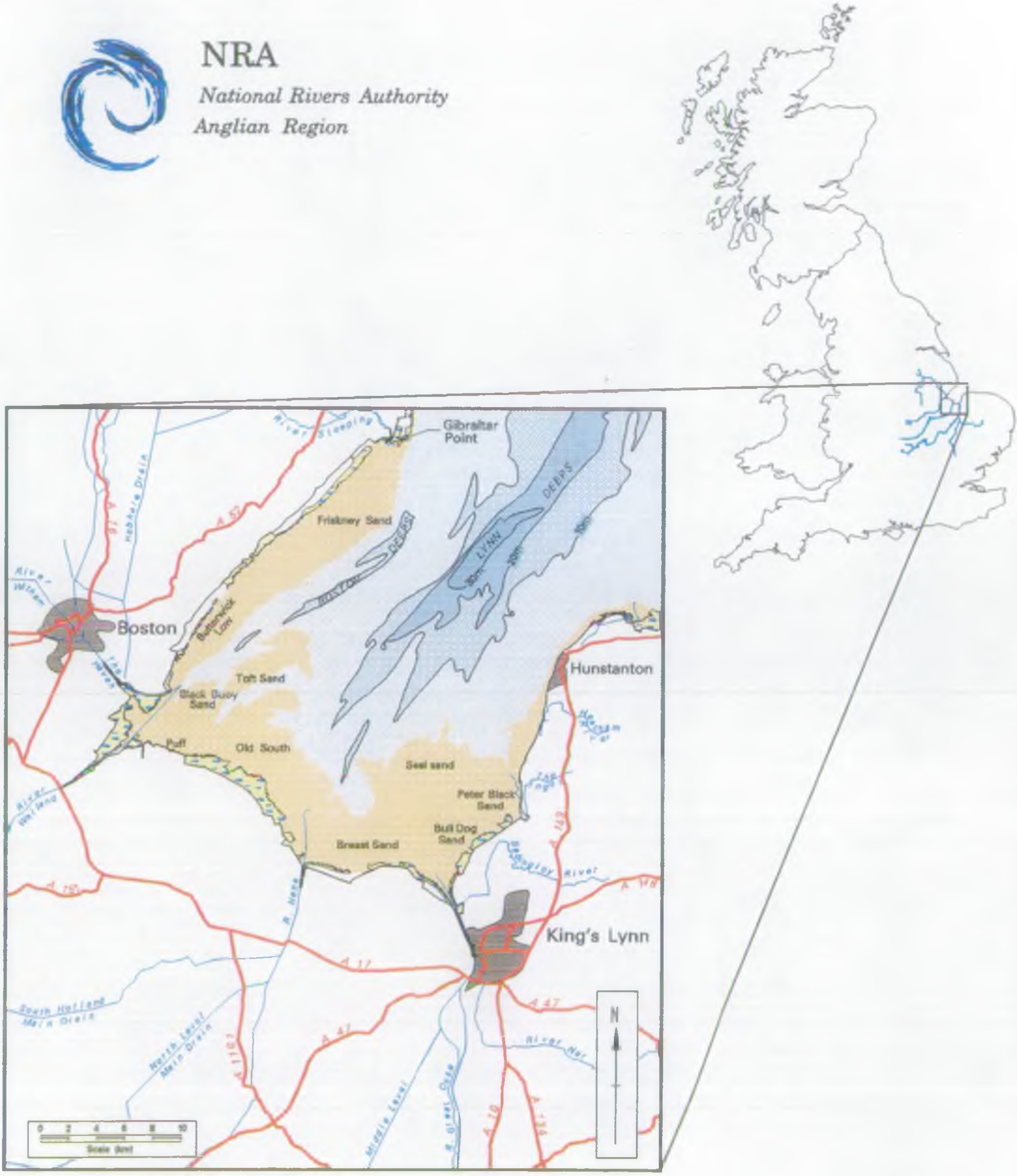


Figure 2.1 The Wash study area

Figure 3.1 Annual Shellfish Landings at Wash Ports

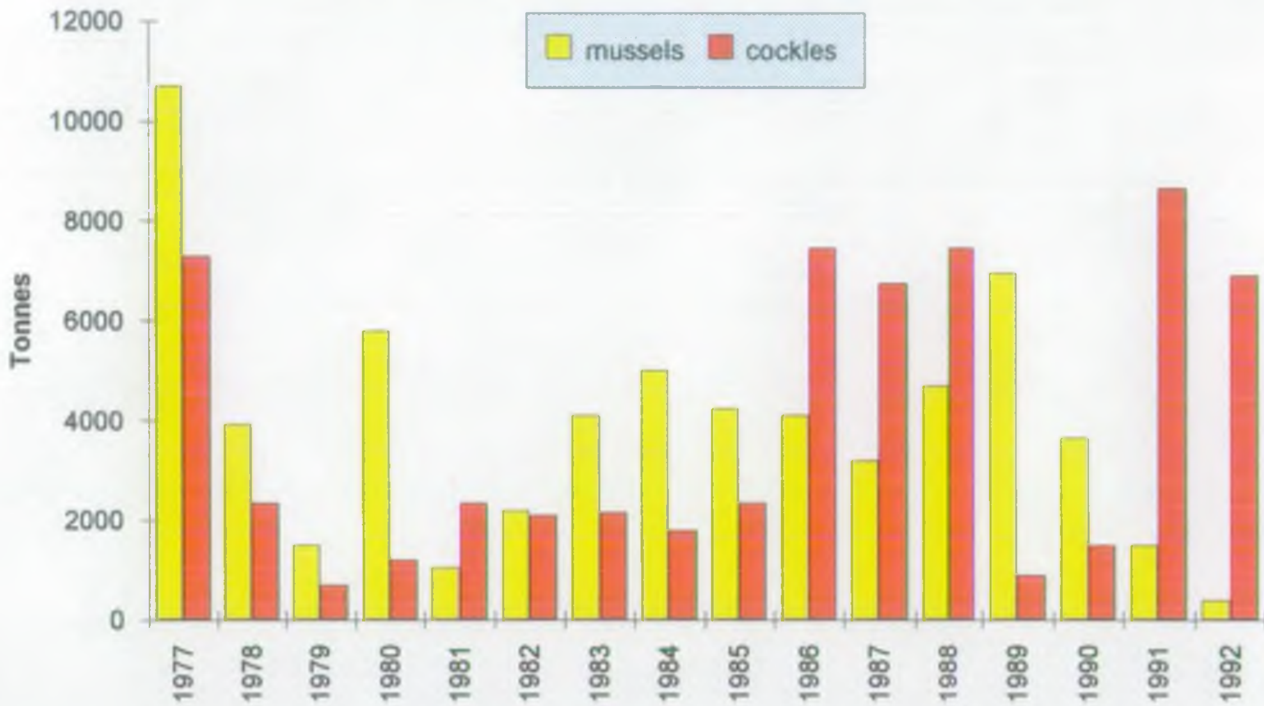
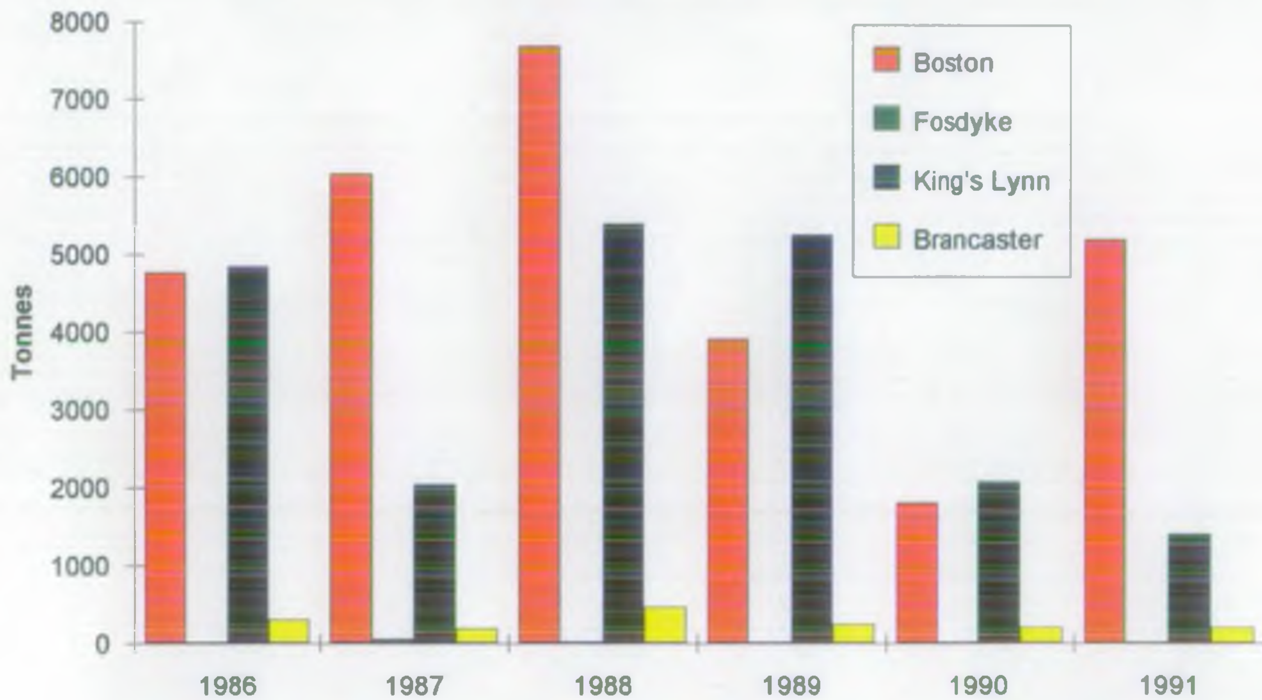


Figure 3.2 Fish Landing Statistics: Tonnes per year



Data courtesy Eastern Sea Fisheries

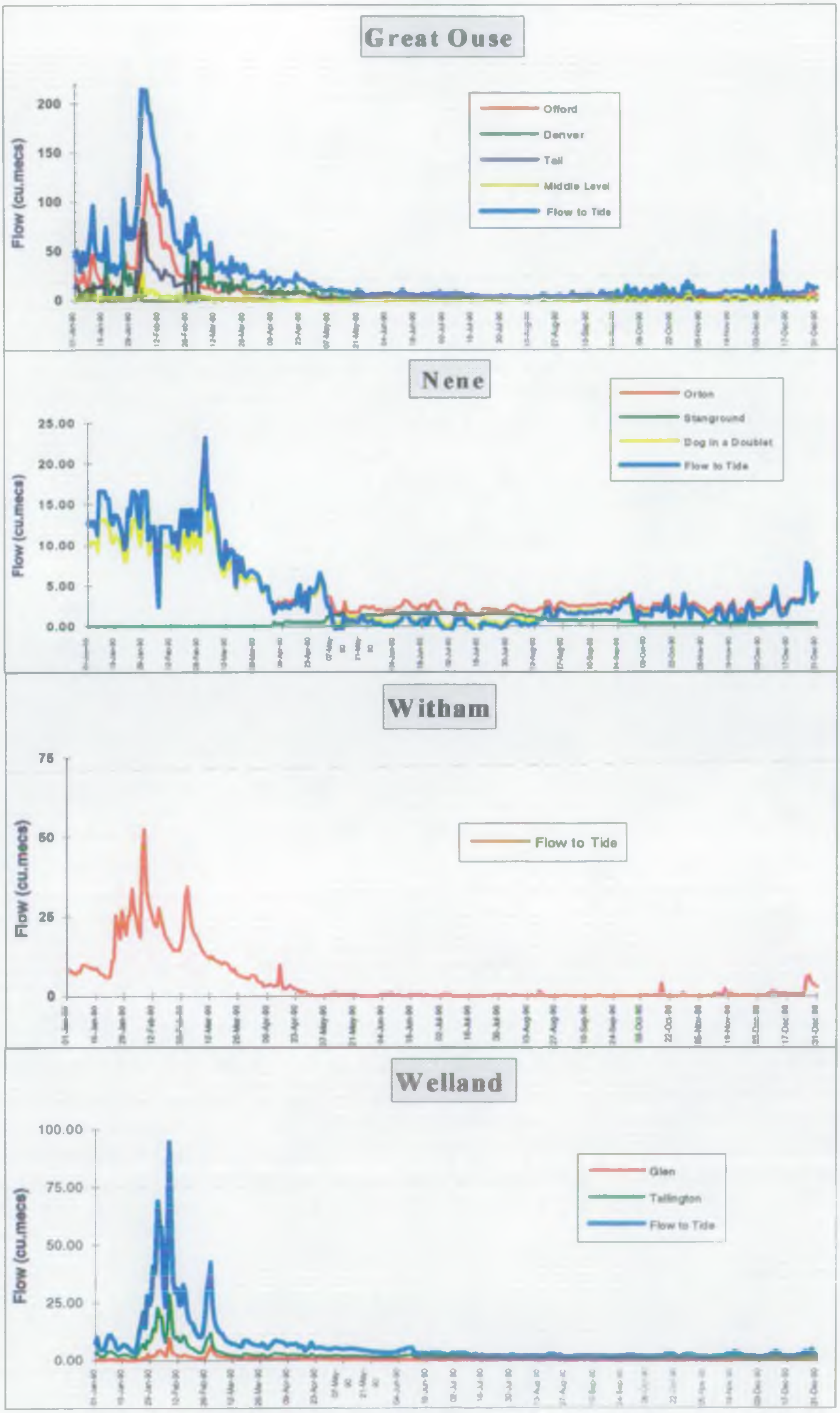


Figure 4.1 Freshwater Flows in the Tributary Estuaries 1990

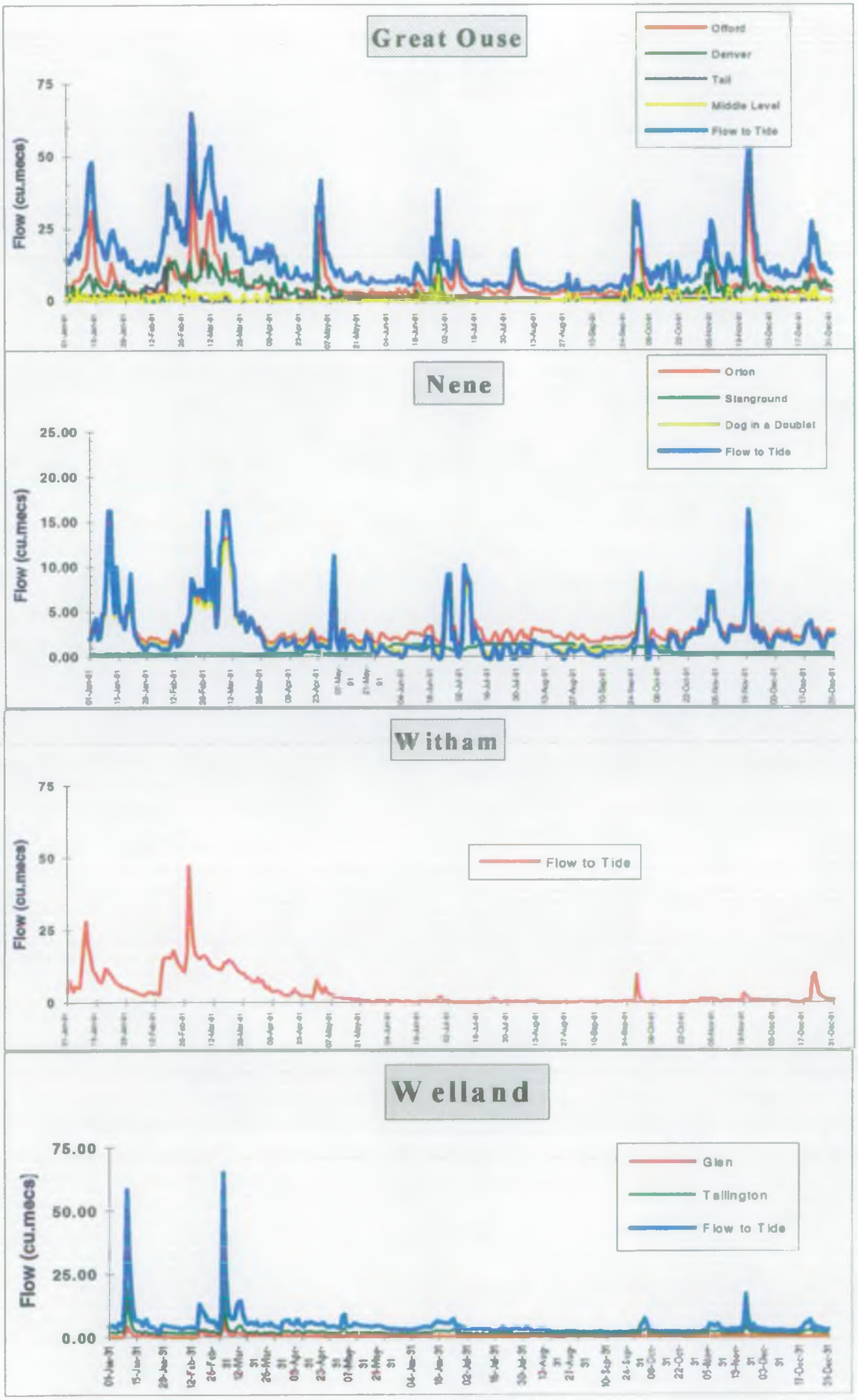


Figure 4.2 Freshwater Flows in the Tributary Estuaries 1991

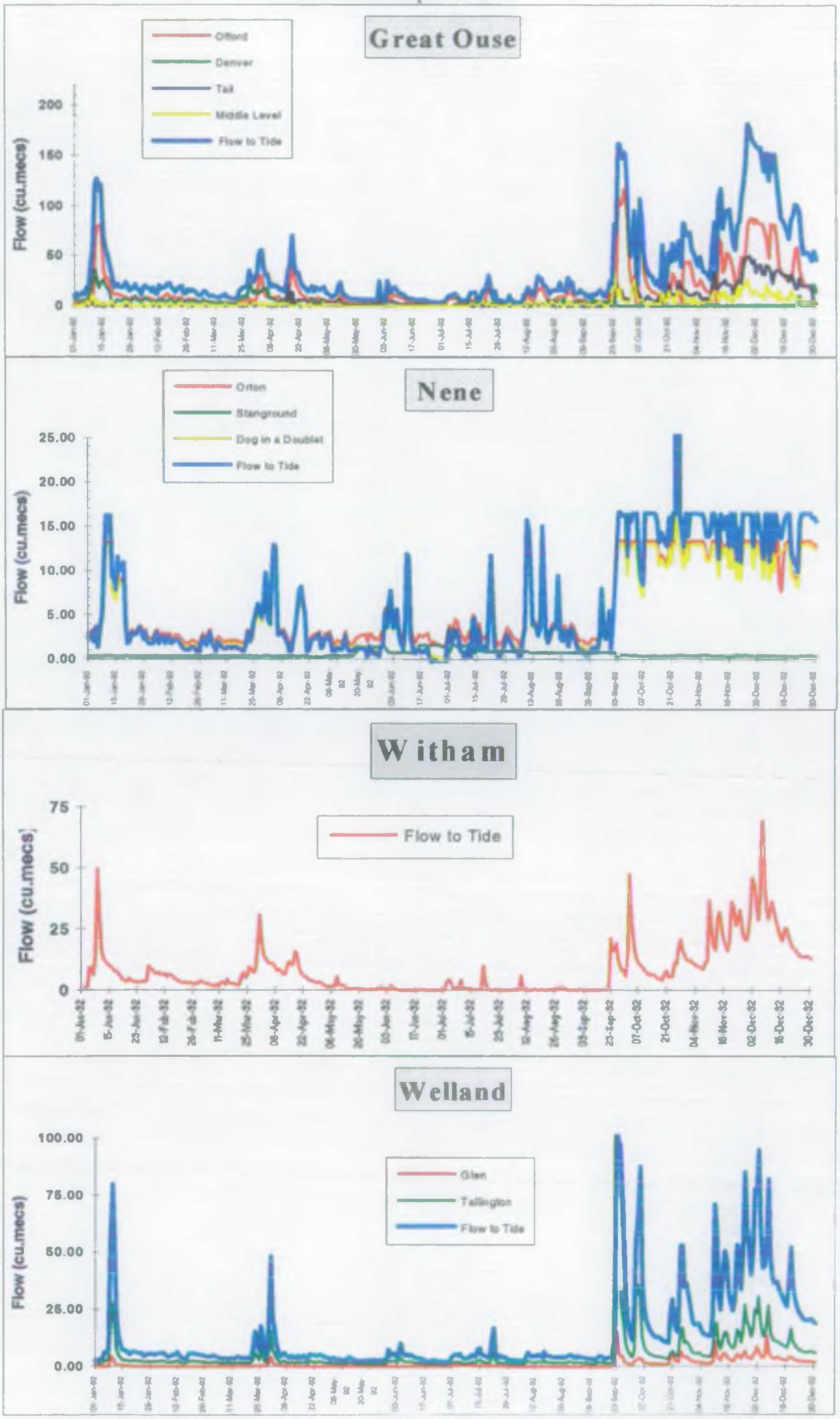


Figure 4.3 Freshwater Flows in the Tributary Estuaries 1992

Figure 4.4 : Inputs to the Welland Estuary

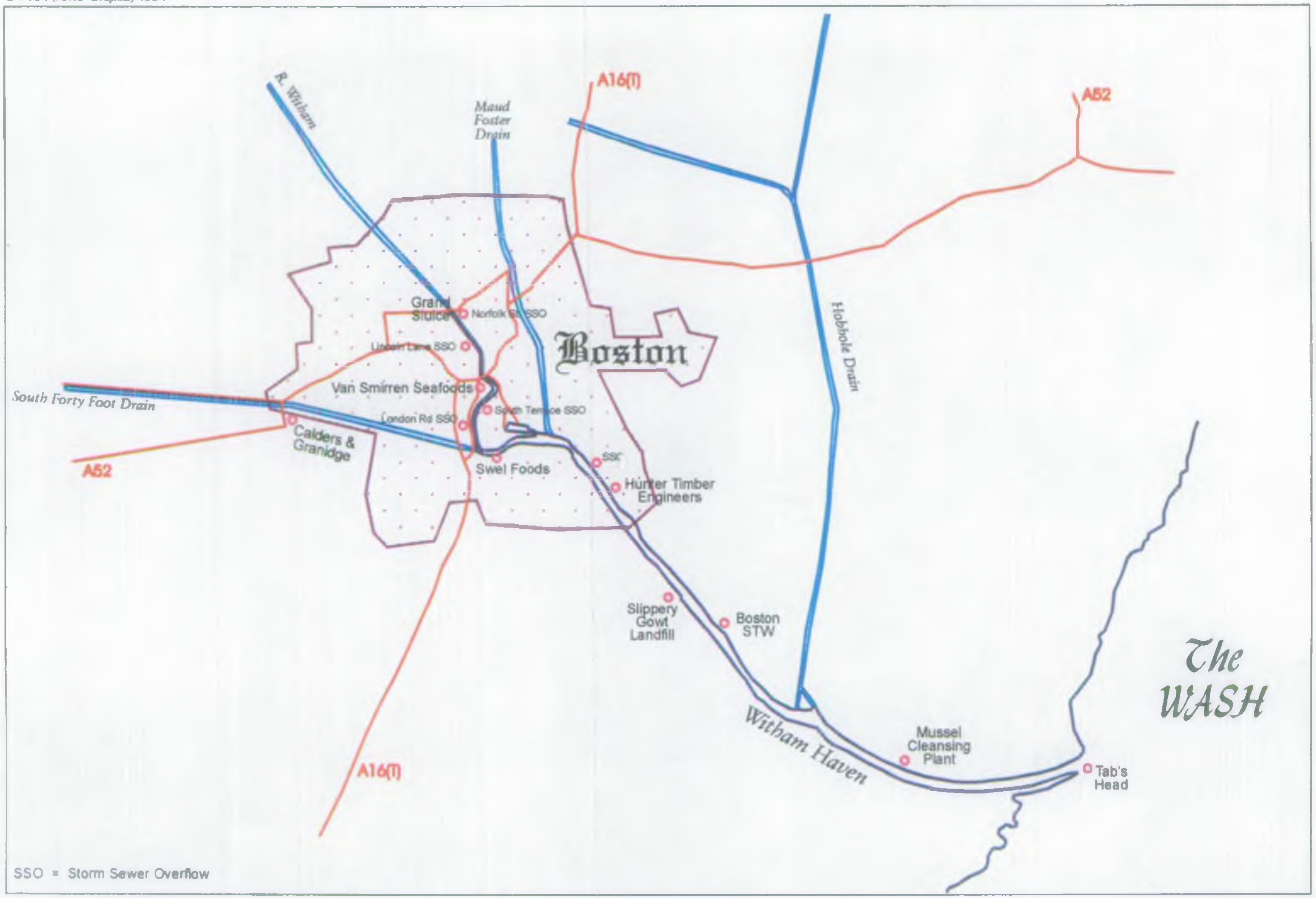


Figure 4.5 : Inputs to the Witham Estuary

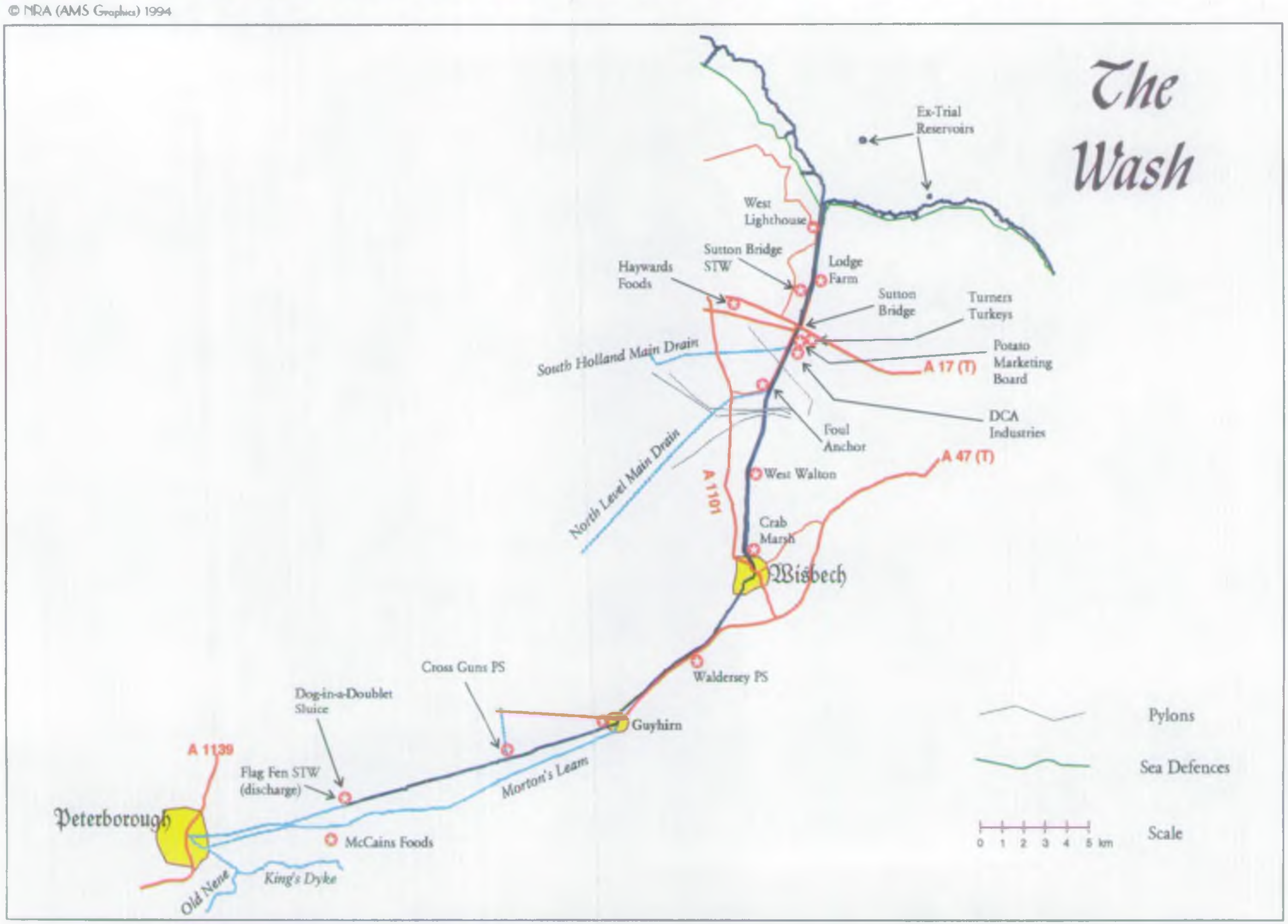


Figure 4.6 : Inputs and Sampling Points for the Nene Estuary

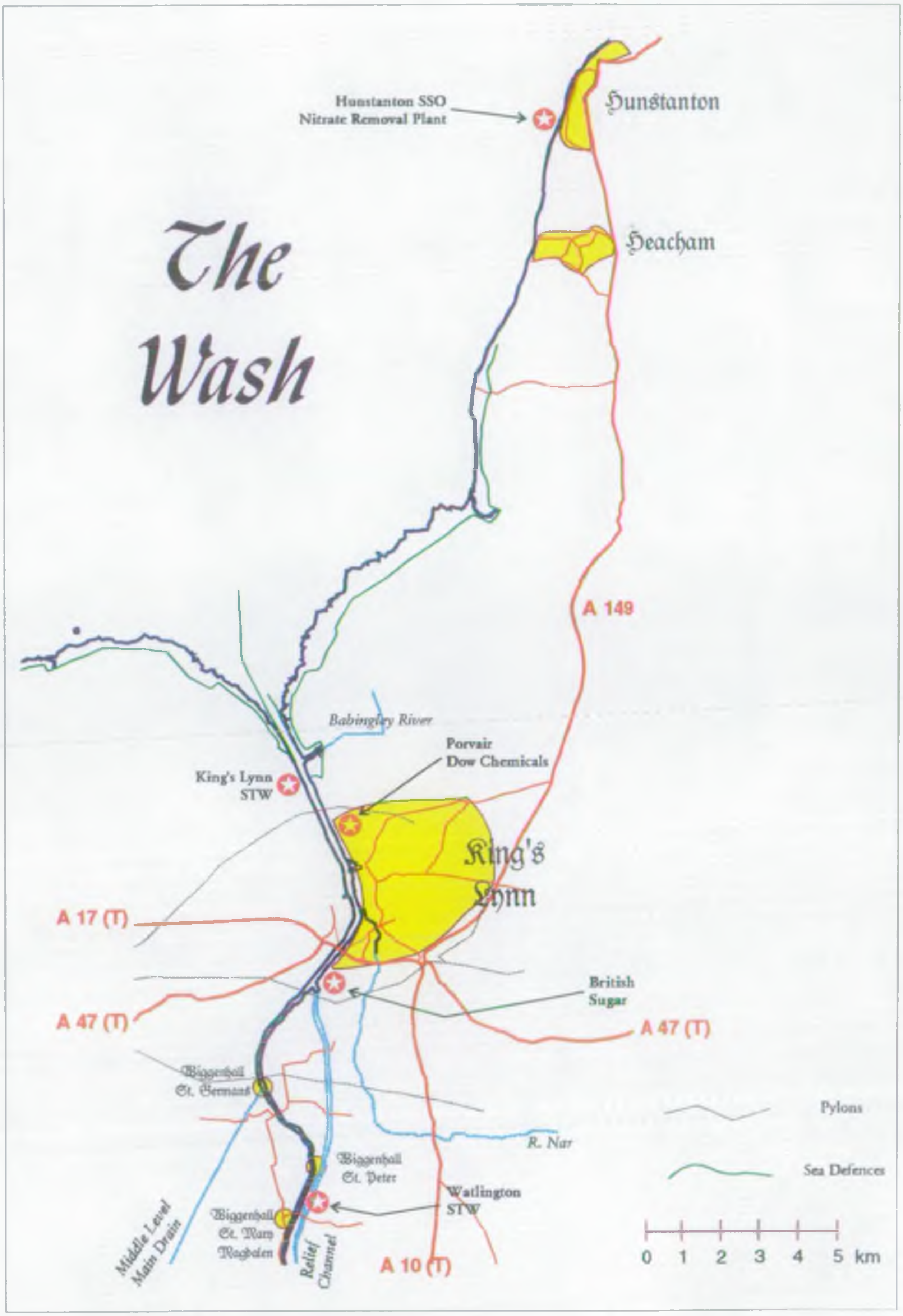


Figure 4.7 : Inputs to the Great Ouse Estuary

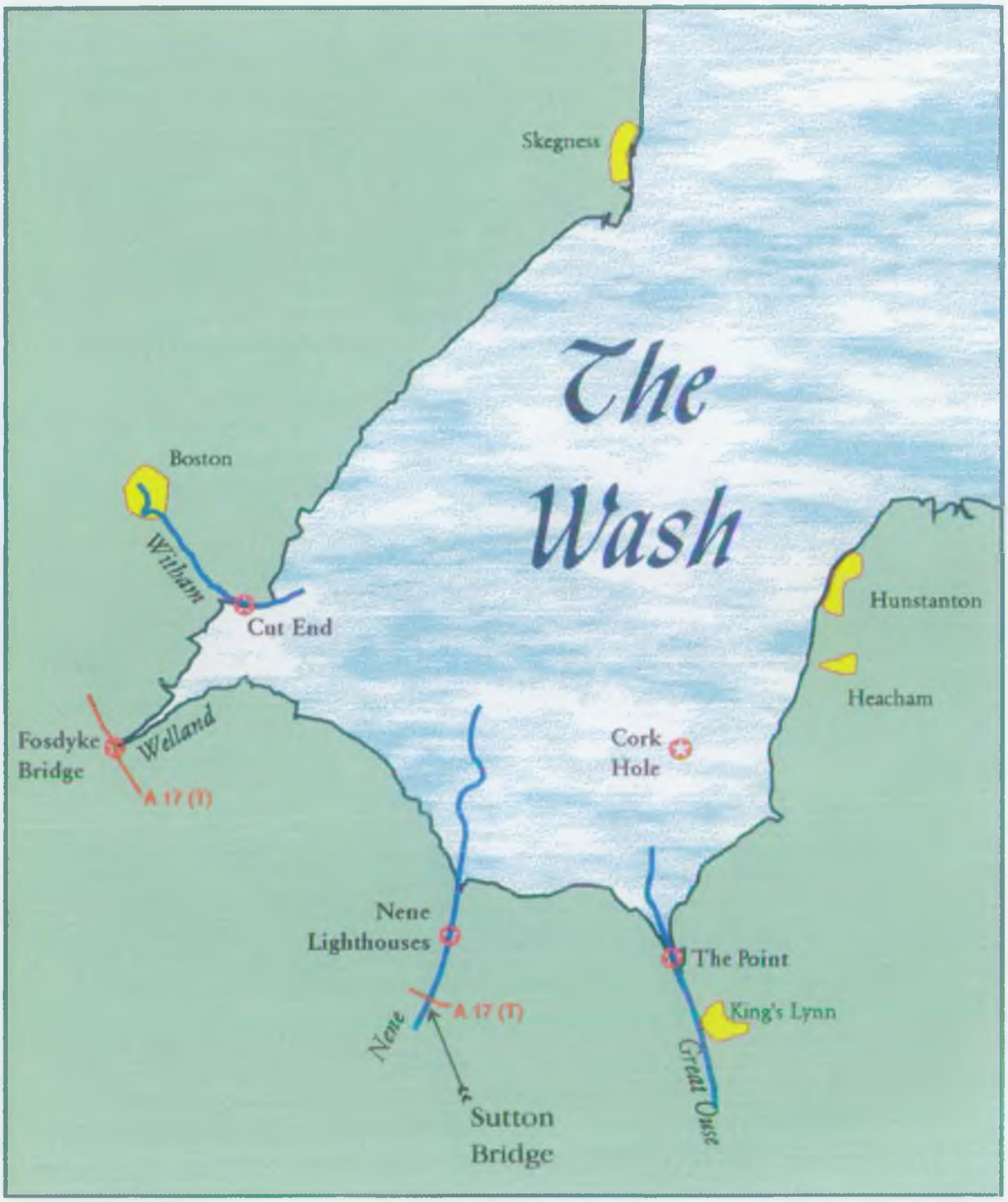
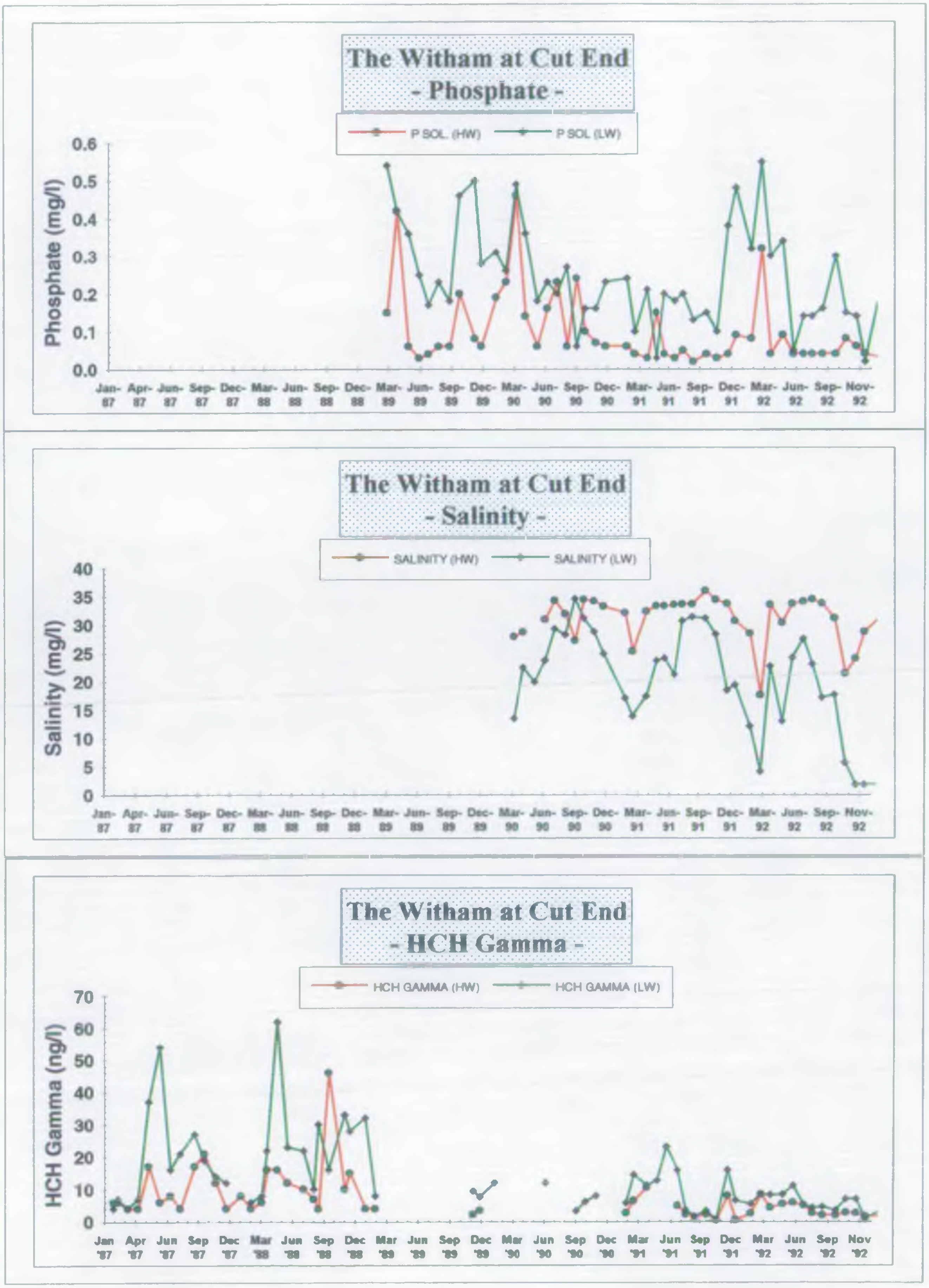


Figure 4.8 :
Location of the Most Downstream Routine Sampling Points

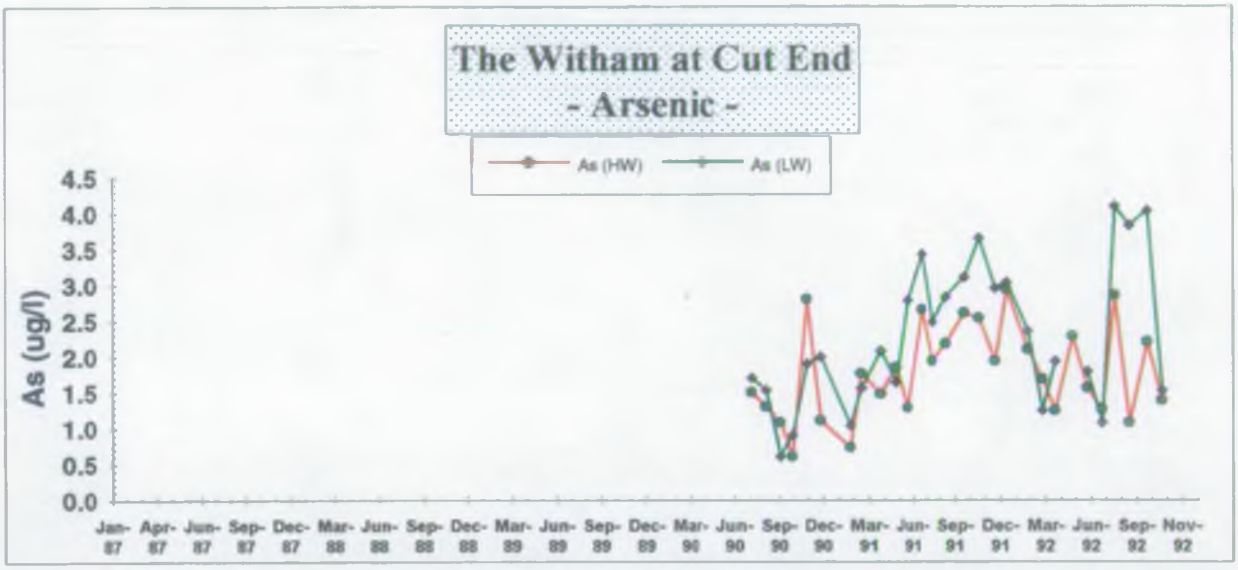

The Witham at Cut End
- D.O. (% Saturation) -
D.O. %SAT (HW)
D.O. %SAT (LW)
D.O. (% SAT)
140
120
100
80
60
40
20
0
Jan-87 Apr-87 Jun-87 Sep-87 Dec-87 Mar-88 Jun-88 Sep-88 Dec-88 Mar-89 Jun-89 Sep-89 Dec-89 Mar-90 Jun-90 Sep-90 Dec-90 Mar-91 Jun-91 Sep-91 Dec-91 Mar-92 Jun-92 Sep-92 Nov-92
The Witham at Cut End
- Ammonia -
AMMONIA (HW)
AMMONIA (LW)
Ammonia (mg/l)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Witham at Cut End
- TON -
TON (HW)
TON (LW)
TON (mg/l)
25
20
15
10
5
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.9



The Witham at Cut End
- Phosphate -
P SOL. (HW)
P SOL (LW)
Phosphate (mg/l)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Jan-87 Apr-87 Jun-87 Sep-87 Dec-87 Mar-88 Jun-88 Sep-88 Dec-88 Mar-89 Jun-89 Sep-89 Dec-89 Mar-90 Jun-90 Sep-90 Dec-90 Mar-91 Jun-91 Sep-91 Dec-91 Mar-92 Jun-92 Sep-92 Nov-92
The Witham at Cut End
- Salinity -
SALINITY (HW)
SALINITY (LW)
Salinity (mg/l)
40
35
30
25
20
15
10
5
0
Jan-87 Apr-87 Jun-87 Sep-87 Dec-87 Mar-88 Jun-88 Sep-88 Dec-88 Mar-89 Jun-89 Sep-89 Dec-89 Mar-90 Jun-90 Sep-90 Dec-90 Mar-91 Jun-91 Sep-91 Dec-91 Mar-92 Jun-92 Sep-92 Nov-92
The Witham at Cut End
- HCH Gamma -
HCH GAMMA (HW)
HCH GAMMA (LW)
HCH Gamma (ng/l)
70
60
50
40
30
20
10
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.10


The Witham at Cut End
- Arsenic -
As (HW)
As (LW)
As (ug/l)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jan-87 Apr-87 Jun-87 Sep-87 Dec-87 Mar-88 Jun-88 Sep-88 Dec-88 Mar-89 Jun-89 Sep-89 Dec-89 Mar-90 Jun-90 Sep-90 Dec-90 Mar-91 Jun-91 Sep-91 Dec-91 Mar-92 Jun-92 Sep-92 Nov-92

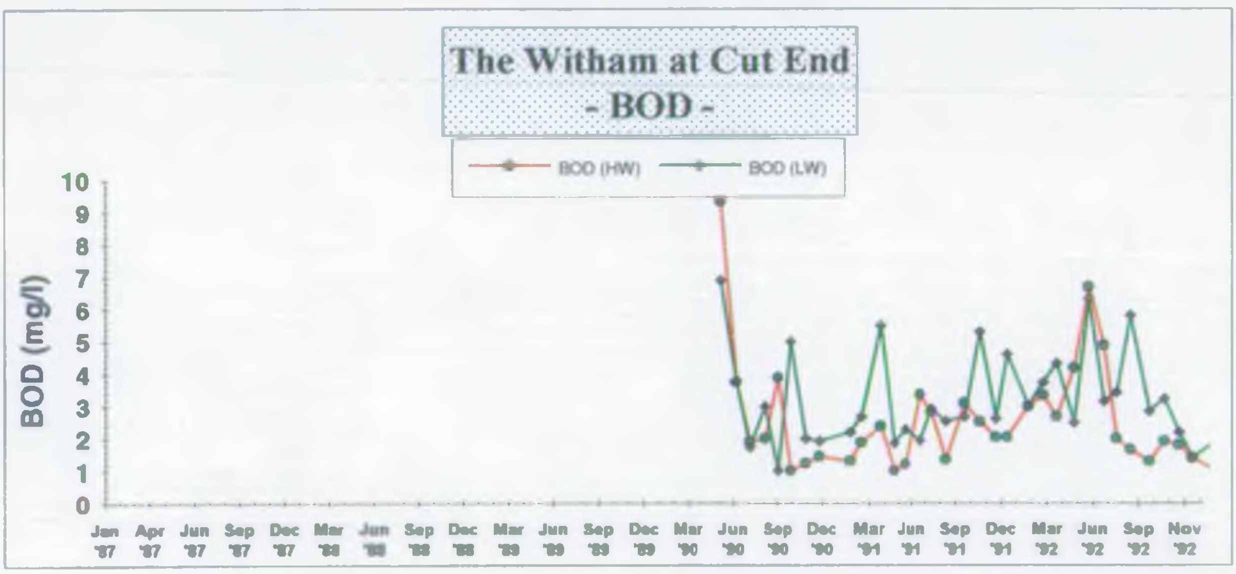

The Witham at Cut End
- BOD -
BOD (HW)
BOD (LW)
BOD (mg/l)
10
9
8
7
6
5
4
3
2
1
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.11

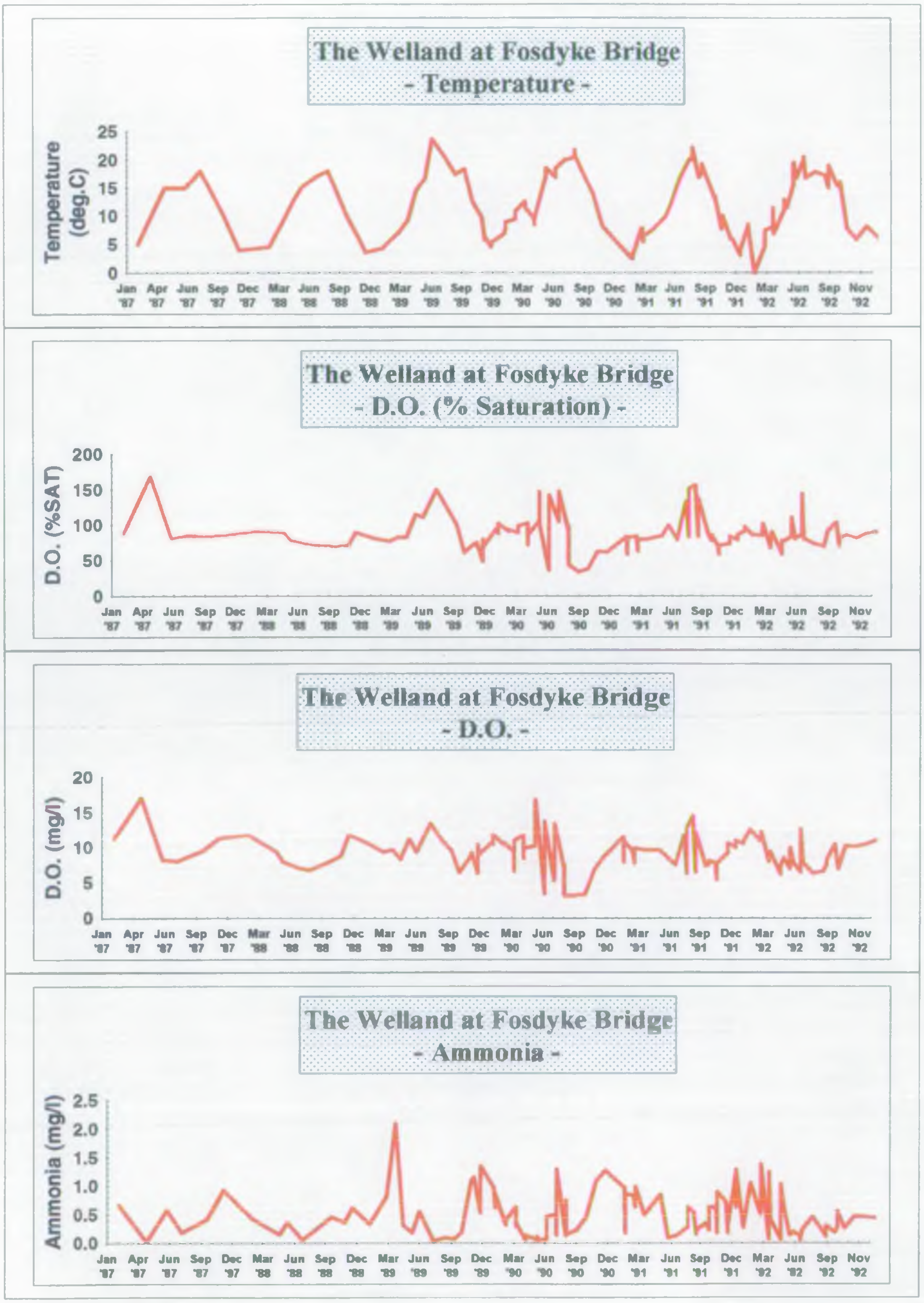

The Welland at Fosdyke Bridge
- Temperature -
Temperature (deg.C)
25
20
15
10
5
0
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92
The Welland at Fosdyke Bridge
- D.O. (% Saturation) -
D.O. (%SAT)
200
150
100
50
0
The Welland at Fosdyke Bridge
- D.O. -
D.O. (mg/l)
20
15
10
5
0
The Welland at Fosdyke Bridge
- Ammonia -
Ammonia (mg/l)
2.5
2.0
1.5
1.0
0.5
0.0

Figure 4.12

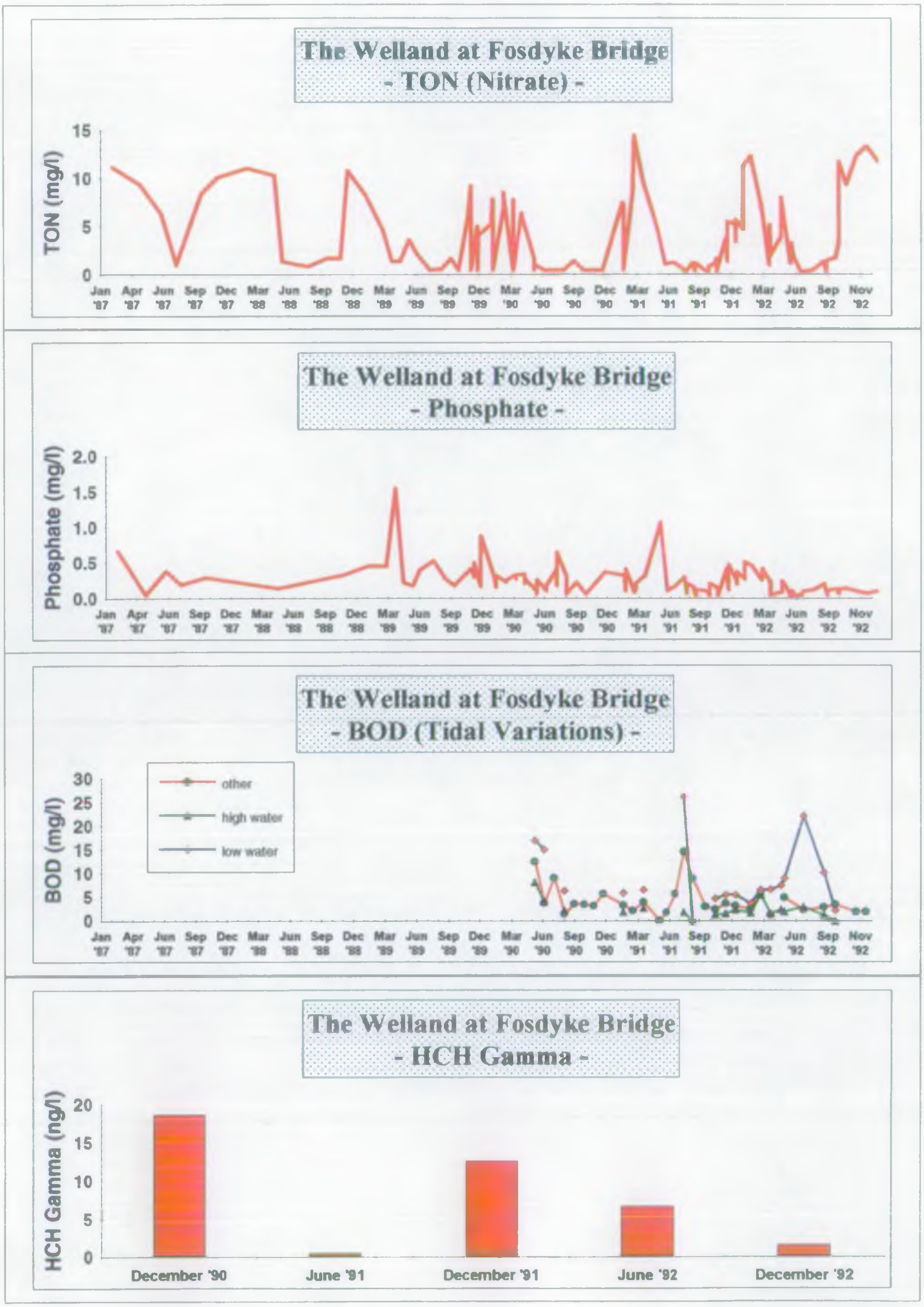
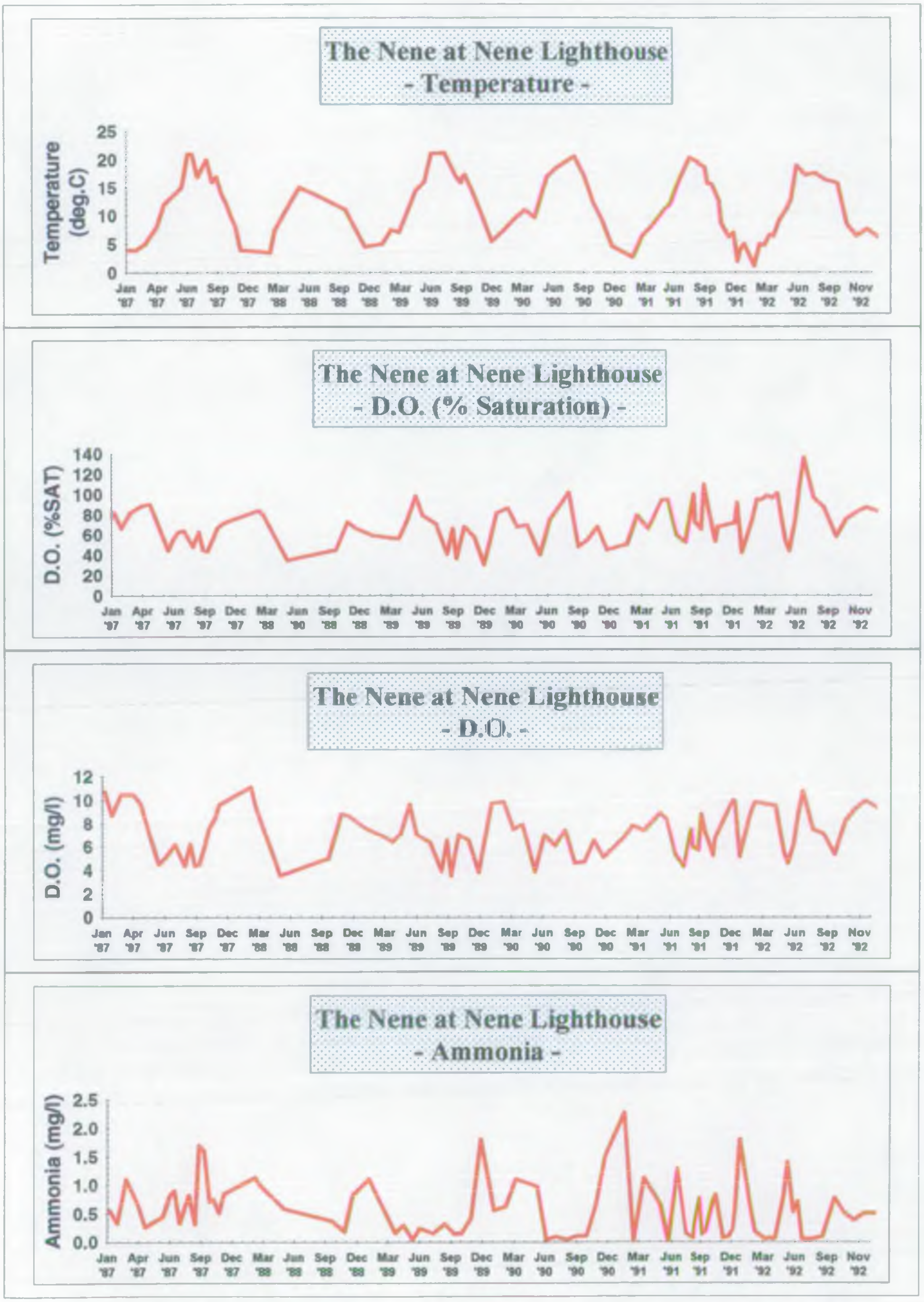

The Welland at Fosdyke Bridge
- TON (Nitrate) -
TON (mg/l)
15
10
5
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Welland at Fosdyke Bridge
- Phosphate -
Phosphate (mg/l)
2.0
1.5
1.0
0.5
0.0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Welland at Fosdyke Bridge
- BOD (Tidal Variations) -
other
high water
low water
BOD (mg/l)
30
25
20
15
10
5
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Welland at Fosdyke Bridge
- HCH Gamma -
HCH Gamma (ng/l)
20
15
10
5
0
December '90
June '91
December '91
June '92
December '92

Figure 4.13



The Nene at Nene Lighthouse
- Temperature -
Temperature (deg.C)
25
20
15
10
5
0
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92
The Nene at Nene Lighthouse
- D.O. (% Saturation) -
D.O. (%SAT)
140
120
100
80
60
40
20
0
The Nene at Nene Lighthouse
- D.O. -
D.O. (mg/l)
12
10
8
6
4
2
0
The Nene at Nene Lighthouse
- Ammonia -
Ammonia (mg/l)
2.5
2.0
1.5
1.0
0.5
0.0

Figure 4.14

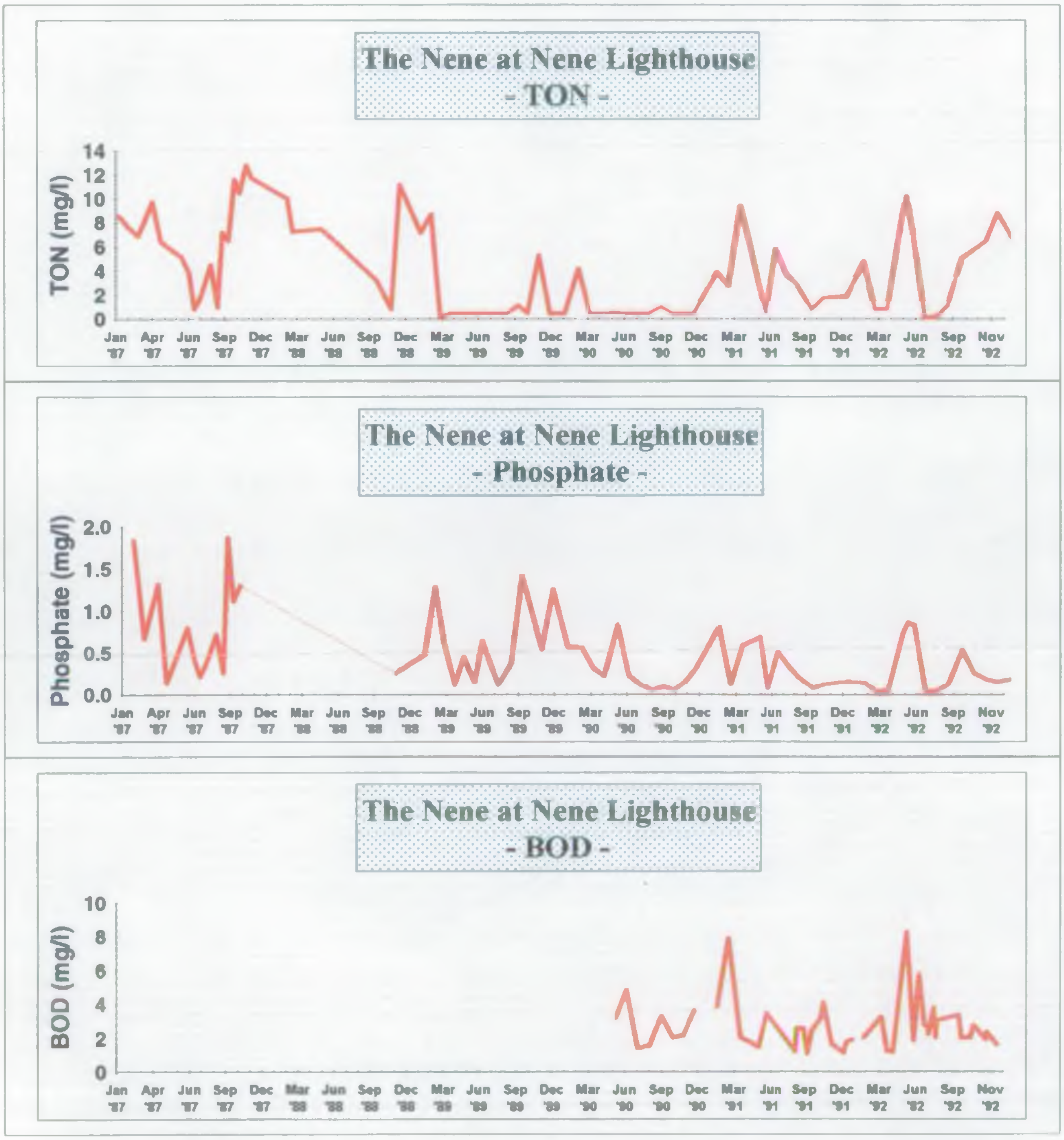

The Nene at Nene Lighthouse
- TON -
TON (mg/l)
0
2
4
6
8
10
12
14
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92
The Nene at Nene Lighthouse
- Phosphate -
Phosphate (mg/l)
0.0
0.5
1.0
1.5
2.0
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92
The Nene at Nene Lighthouse
- BOD -
BOD (mg/l)
0
2
4
6
8
10
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92

Figure 4.15

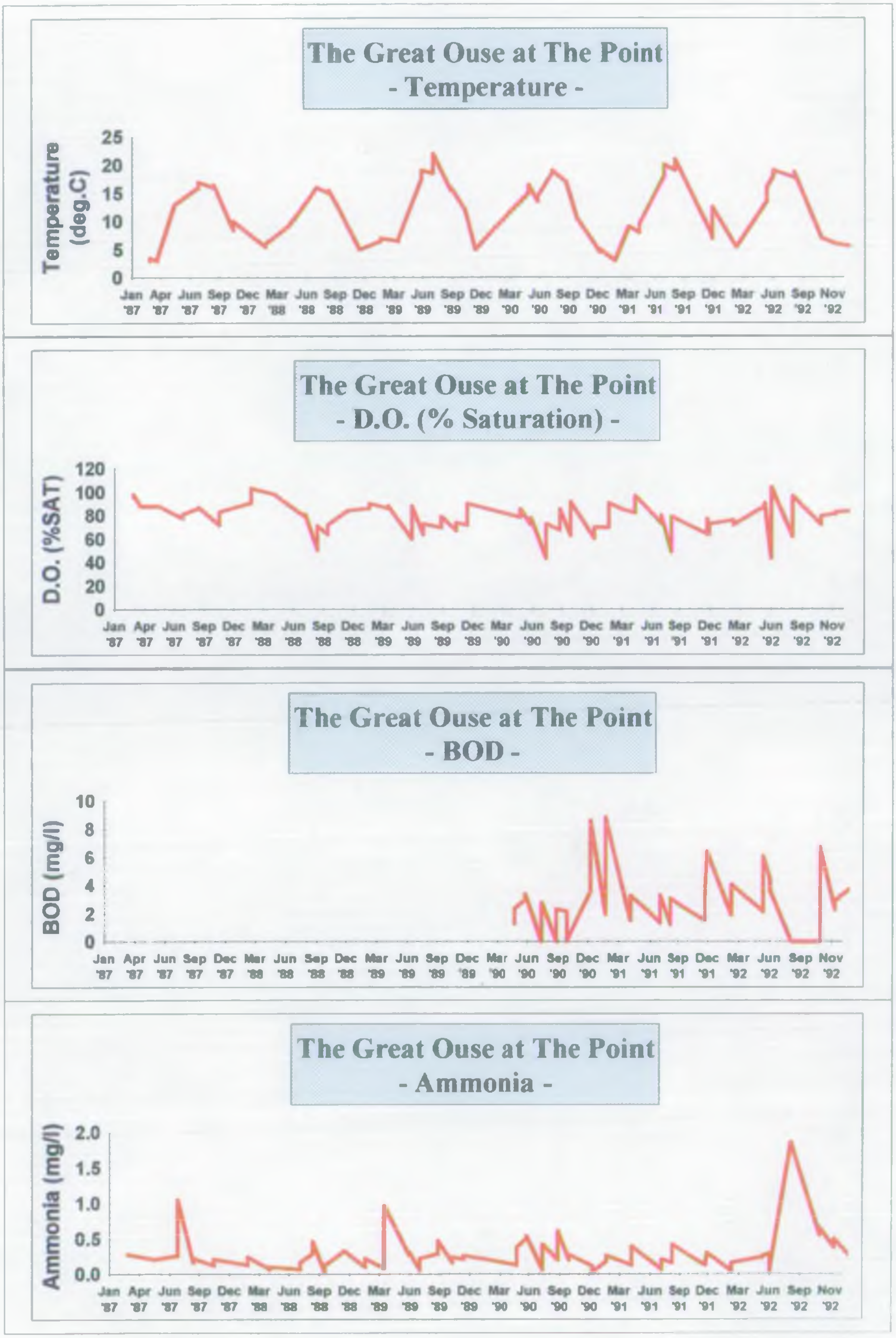

The Great Ouse at The Point
- Temperature -
Temperature (deg.C)
0
5
10
15
20
25
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- D.O. (% Saturation) -
D.O. (%SAT)
0
20
40
60
80
100
120
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- BOD -
BOD (mg/l)
0
2
4
6
8
10
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- Ammonia -
Ammonia (mg/l)
0.0
0.5
1.0
1.5
2.0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.16

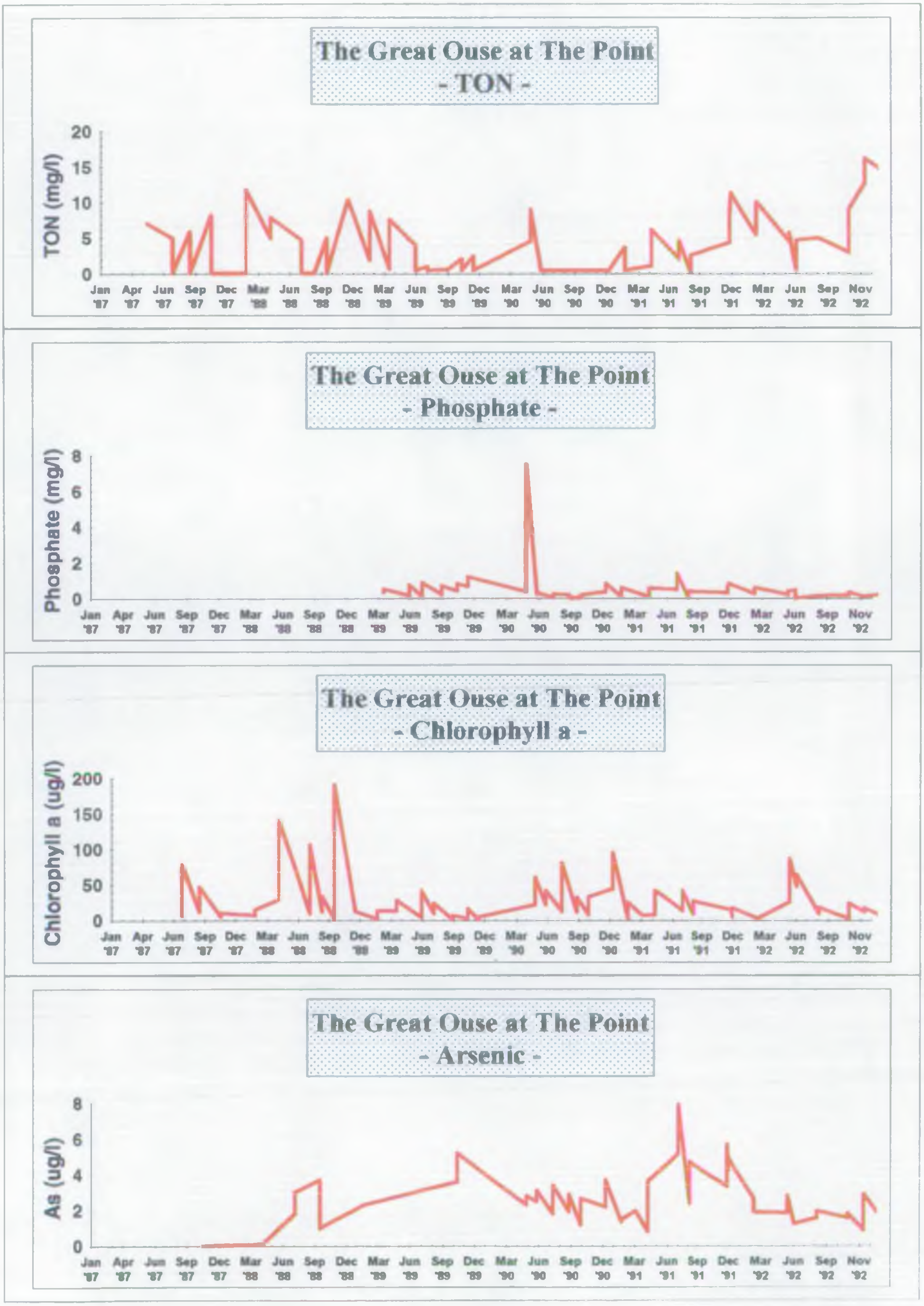
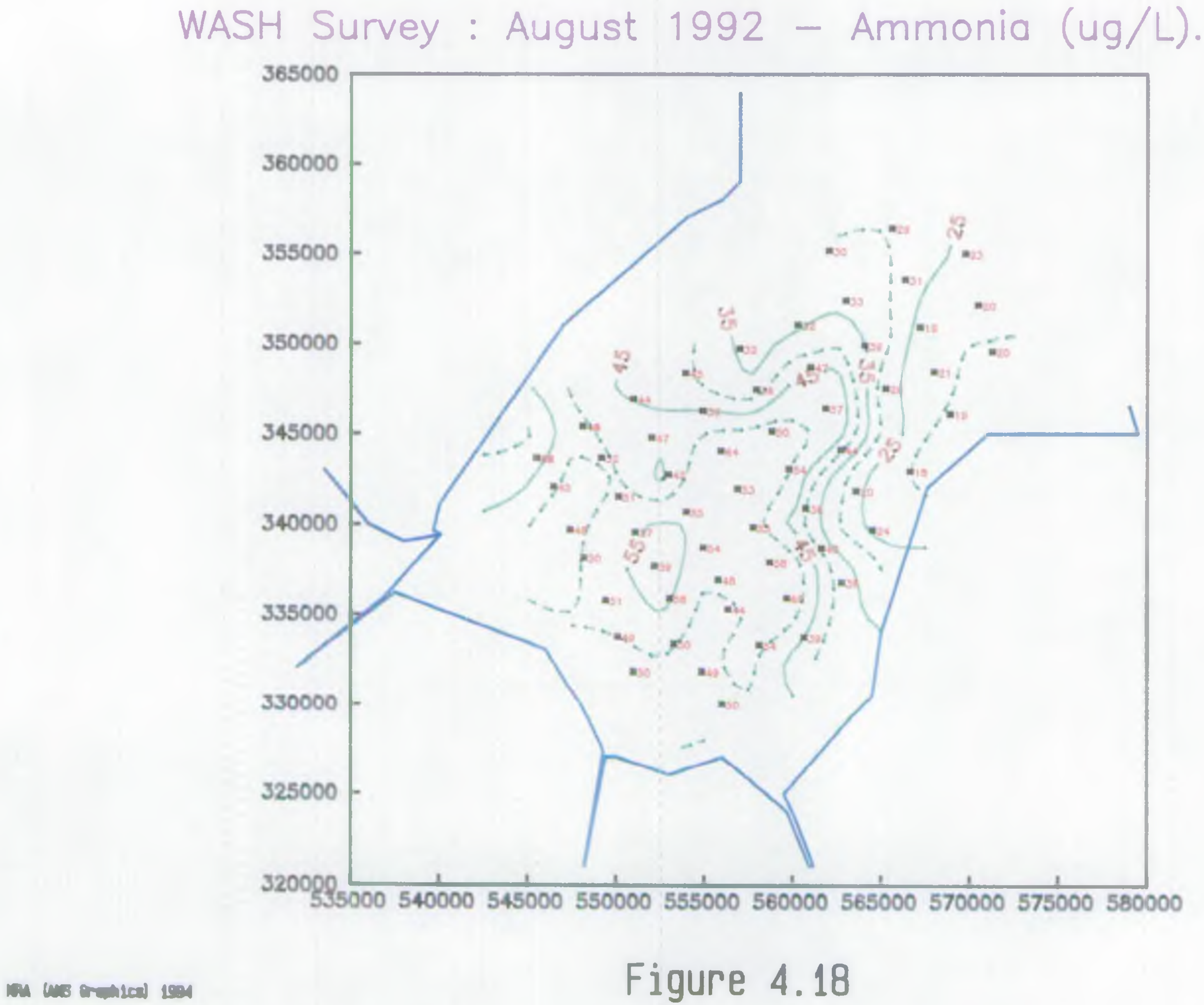

The Great Ouse at The Point
- TON -
TON (mg/l)
20
15
10
5
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- Phosphate -
Phosphate (mg/l)
8
6
4
2
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- Chlorophyll a -
Chlorophyll a (ug/l)
200
150
100
50
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Great Ouse at The Point
- Arsenic -
As (ug/l)
8
6
4
2
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.17



WASH Survey : August 1992 - Ammonia (ug/L).
365000
360000
355000
350000
345000
340000
335000
330000
325000
320000
535000
540000
545000
550000
555000
560000
565000
570000
575000
580000

Figure 4.18

WASH Survey : August 1992 - Phosphate (ug/L).

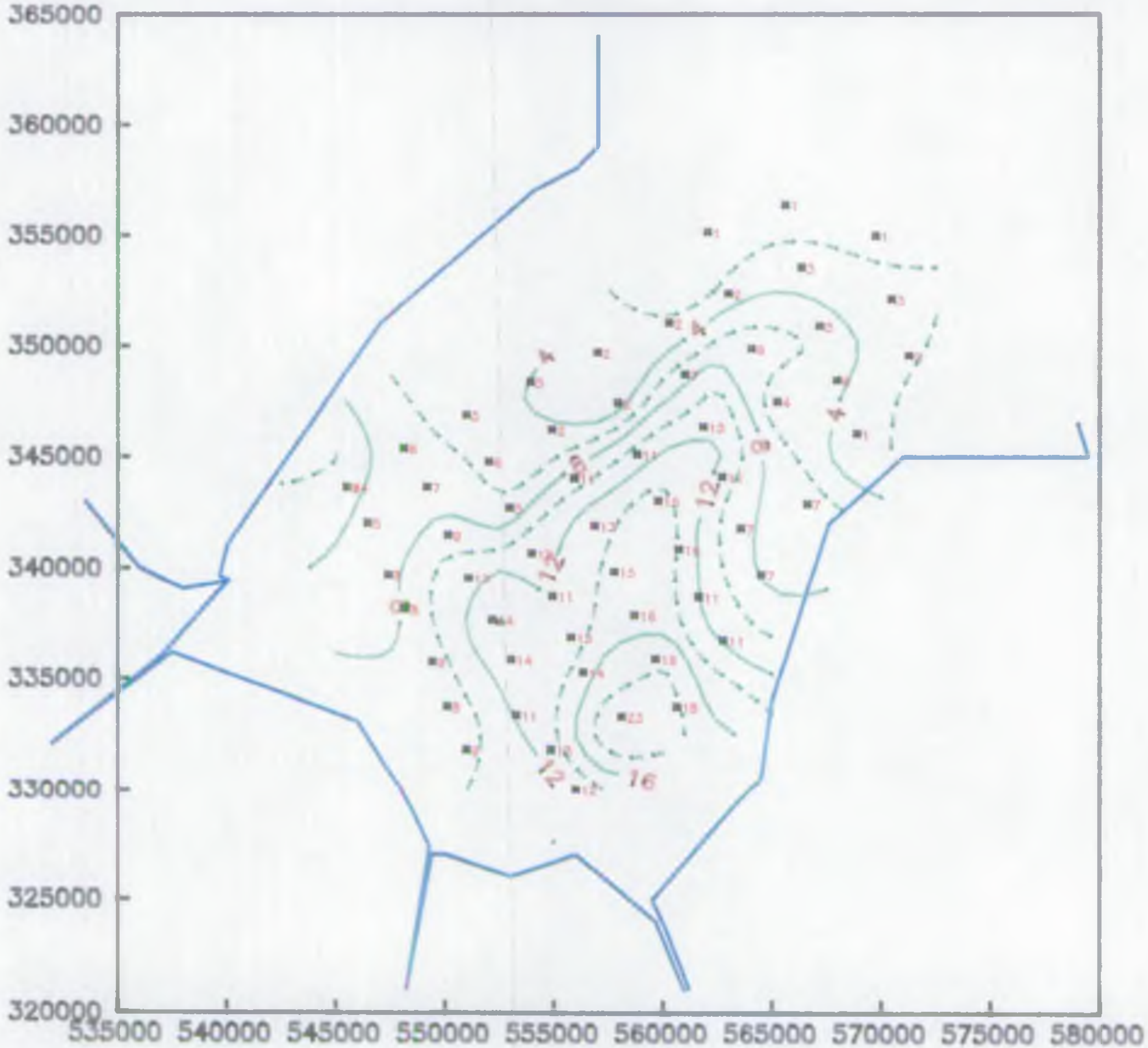
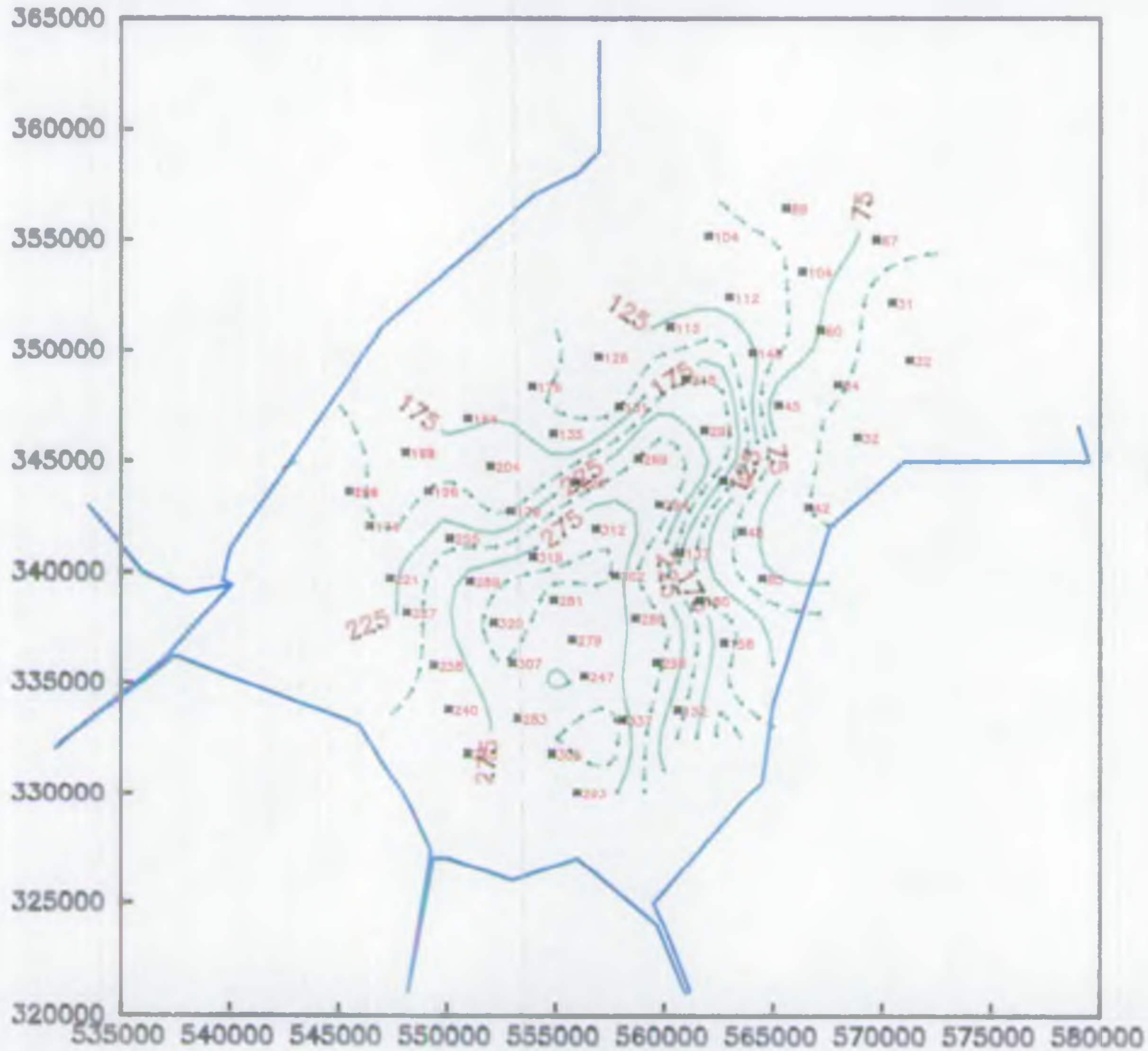


Figure 4.19

NRA (AMS Graphics) 1994

WASH Survey : August 1992 - Silicate (ug/L).



NRA (AMB Graphics) 1984

Figure 4.20

WASH Survey : August 1992 – Nitrate (ug/L).

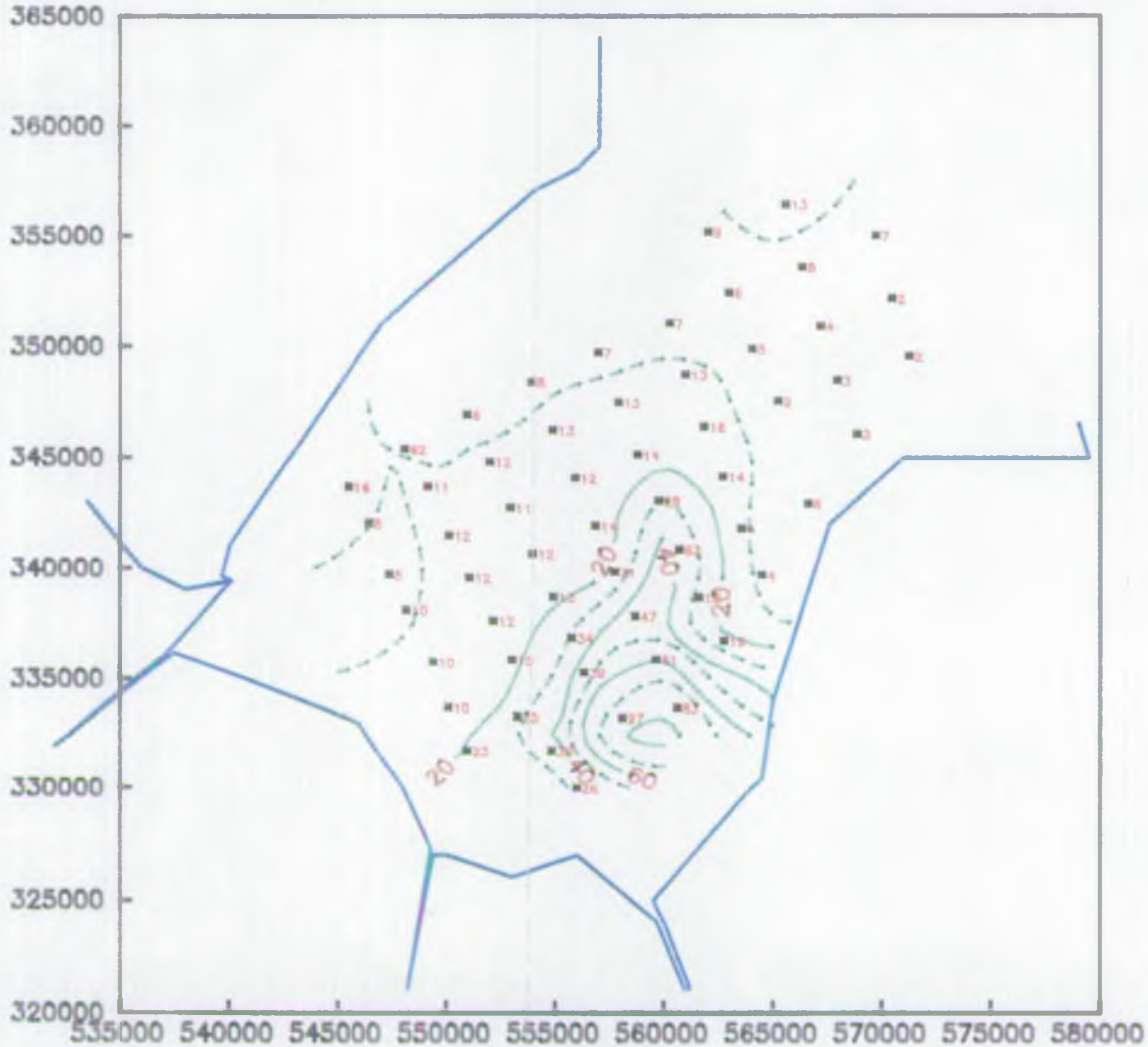
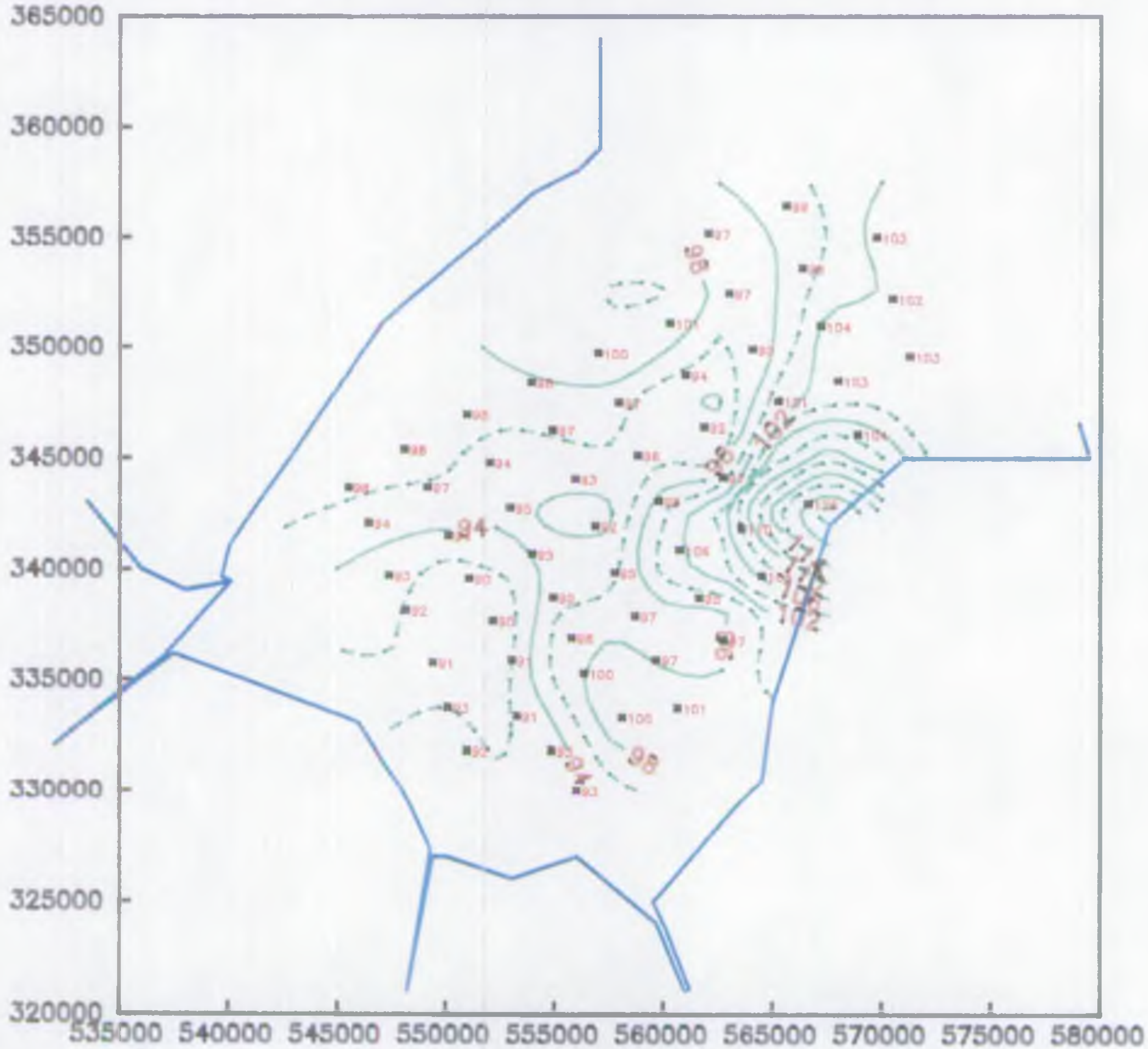


Figure 4.21

NRA (AMS Graphics) 1994

WASH Survey : August 1992 - Dissolved Oxygen (% Sat).



NRA (AMS Graphics) 1994

Figure 4.22

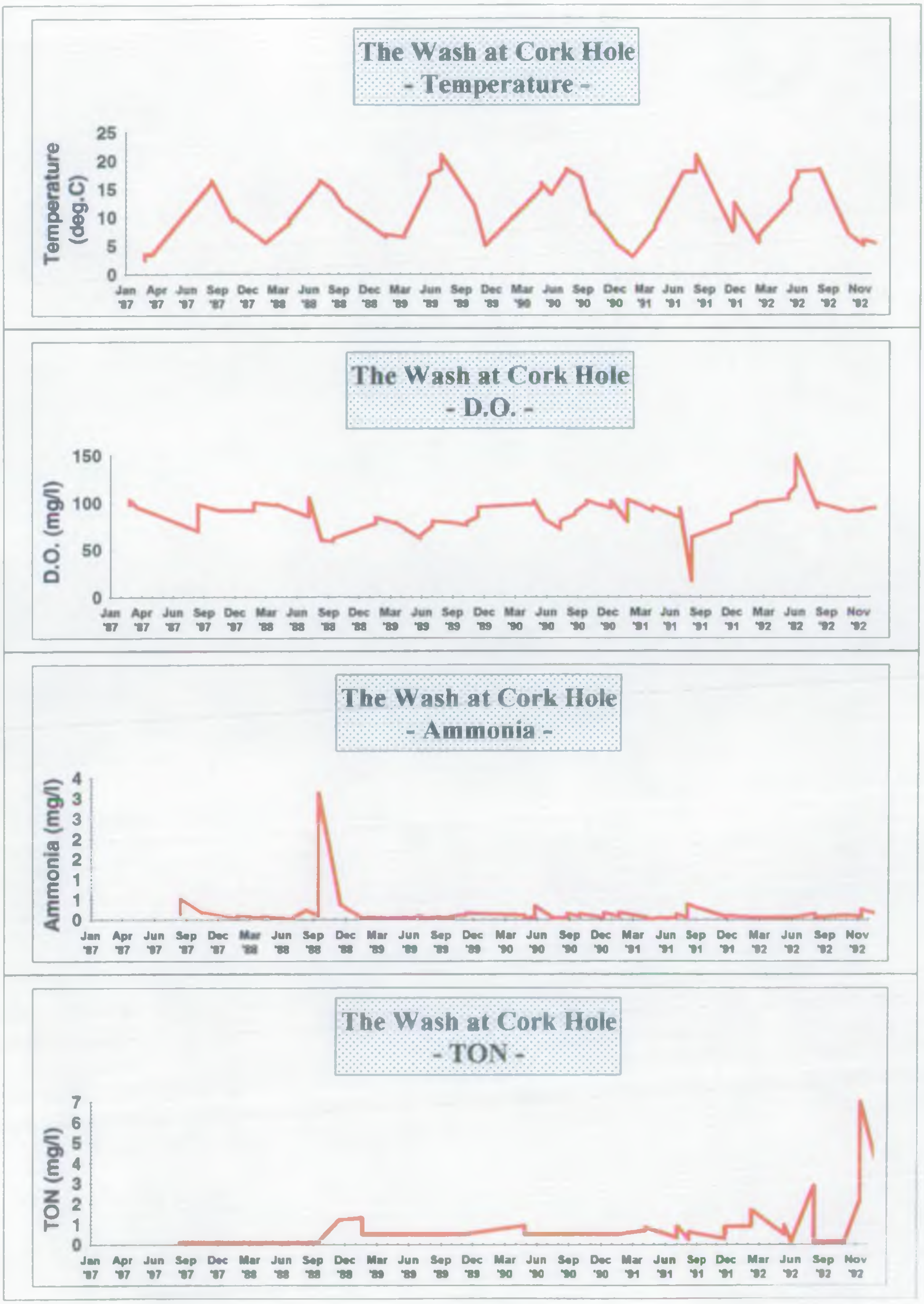

The Wash at Cork Hole
- Temperature -
Temperature (deg.C)
25
20
15
10
5
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Wash at Cork Hole
- D.O. -
D.O. (mg/l)
150
100
50
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Wash at Cork Hole
- Ammonia -
Ammonia (mg/l)
4
3
3
2
2
1
1
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92
The Wash at Cork Hole
- TON -
TON (mg/l)
7
6
5
4
3
2
1
0
Jan '87 Apr '87 Jun '87 Sep '87 Dec '87 Mar '88 Jun '88 Sep '88 Dec '88 Mar '89 Jun '89 Sep '89 Dec '89 Mar '90 Jun '90 Sep '90 Dec '90 Mar '91 Jun '91 Sep '91 Dec '91 Mar '92 Jun '92 Sep '92 Nov '92

Figure 4.23

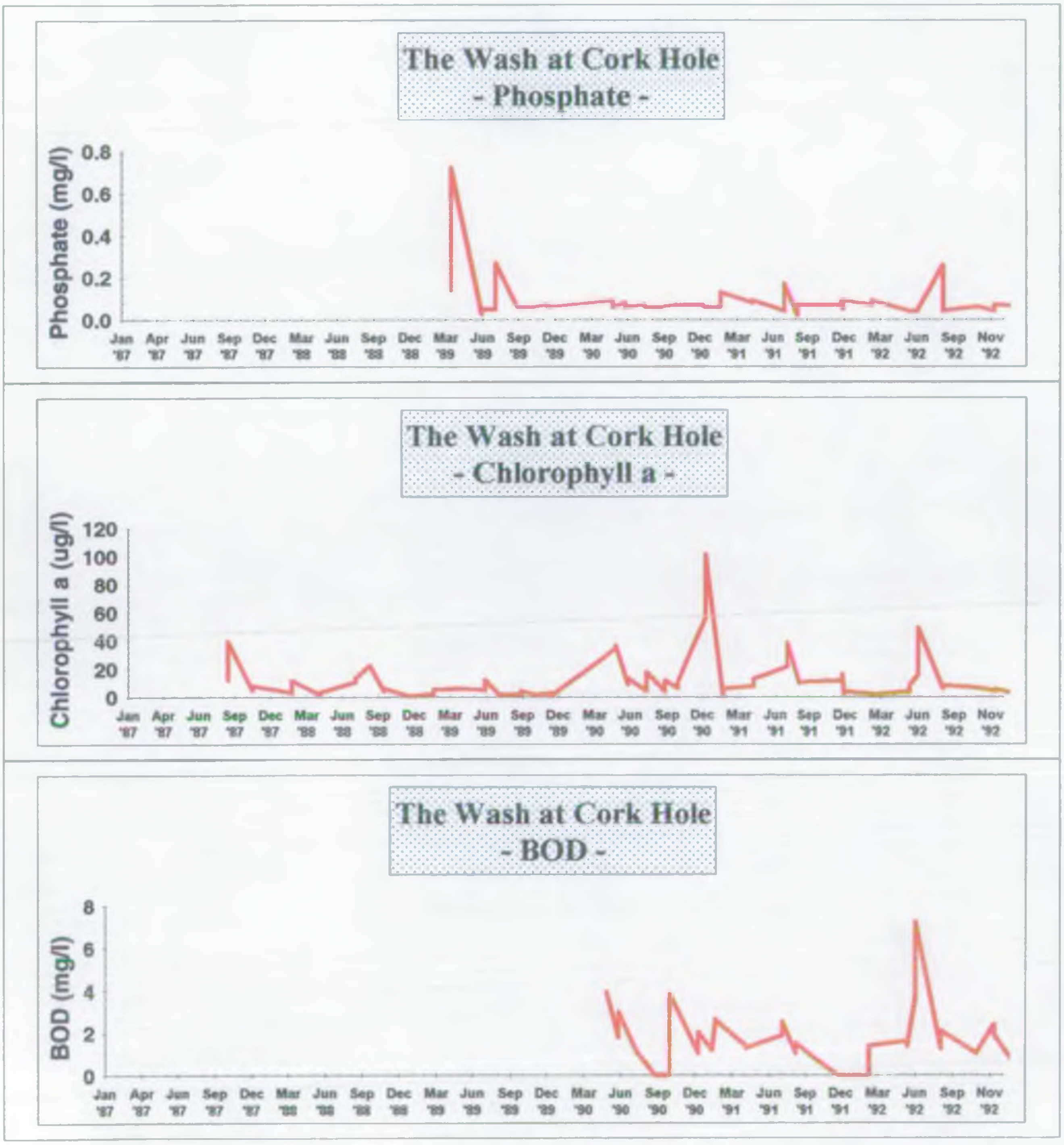

The Wash at Cork Hole
- Phosphate -
Phosphate (mg/l)
0.0
0.2
0.4
0.6
0.8
Jan '87
Apr '87
Jun '87
Sep '87
Dec '87
Mar '88
Jun '88
Sep '88
Dec '88
Mar '89
Jun '89
Sep '89
Dec '89
Mar '90
Jun '90
Sep '90
Dec '90
Mar '91
Jun '91
Sep '91
Dec '91
Mar '92
Jun '92
Sep '92
Nov '92
The Wash at Cork Hole
- Chlorophyll a -
Chlorophyll a (ug/l)
0
20
40
60
80
100
120
The Wash at Cork Hole
- BOD -
BOD (mg/l)
0
2
4
6
8

Figure 4.24

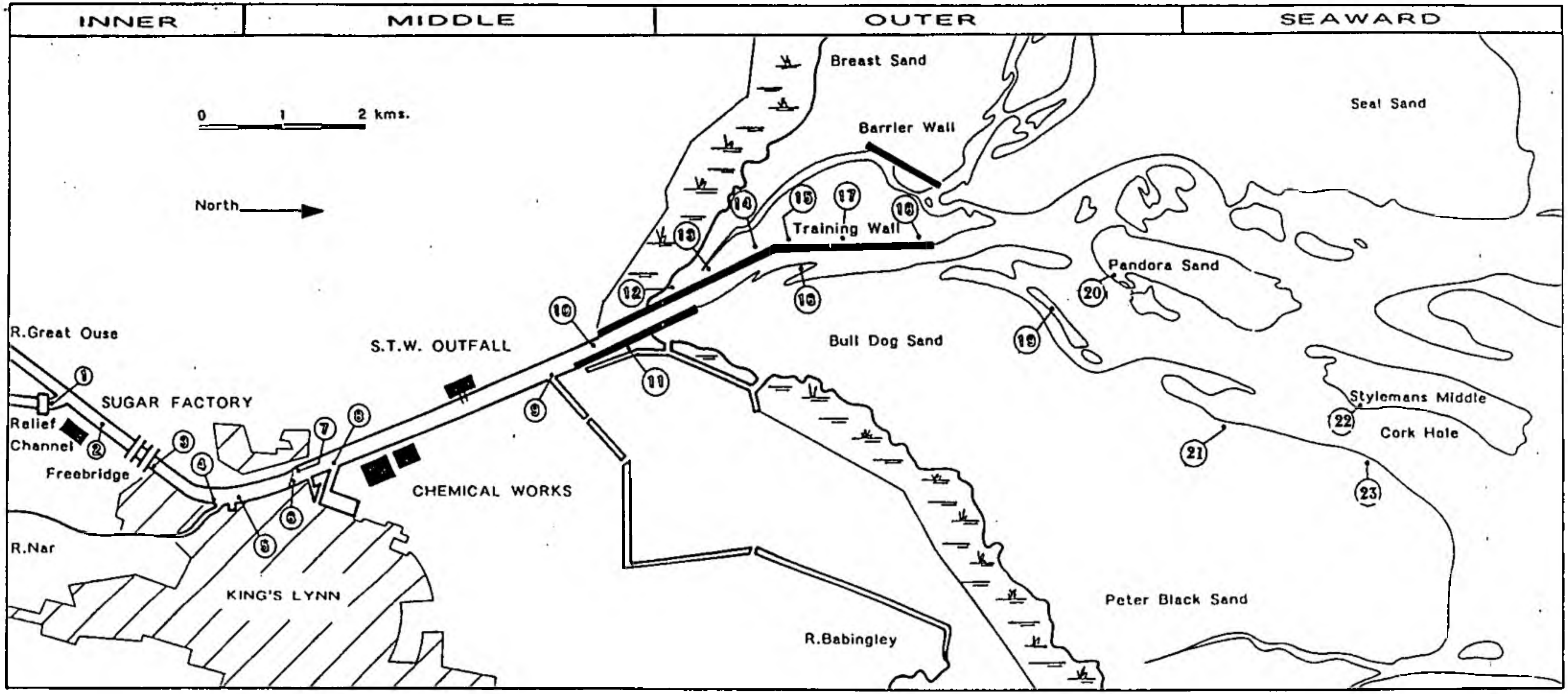


Figure 4.25 NRA Great Ouse Intertidal Sediment Sites

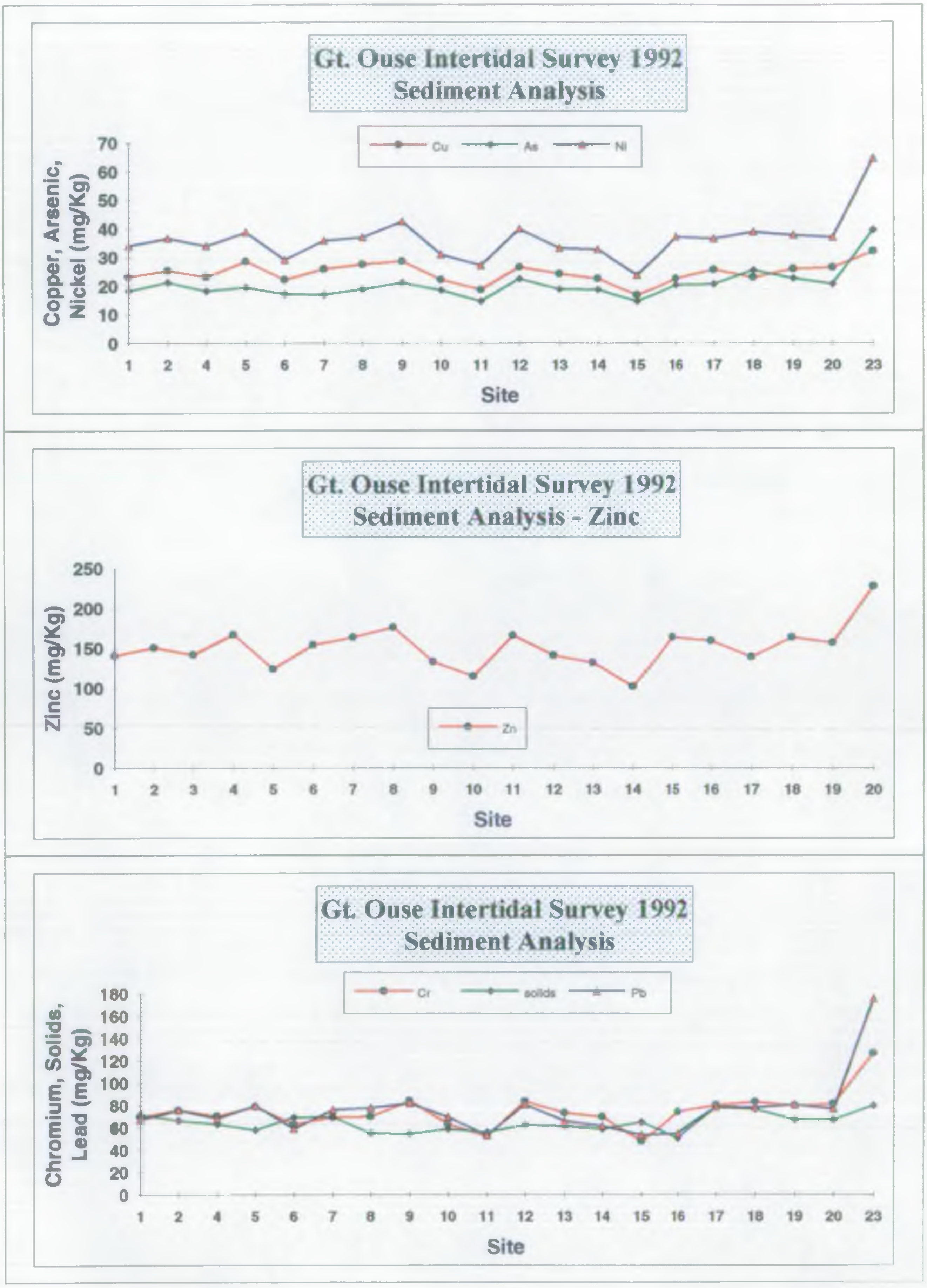
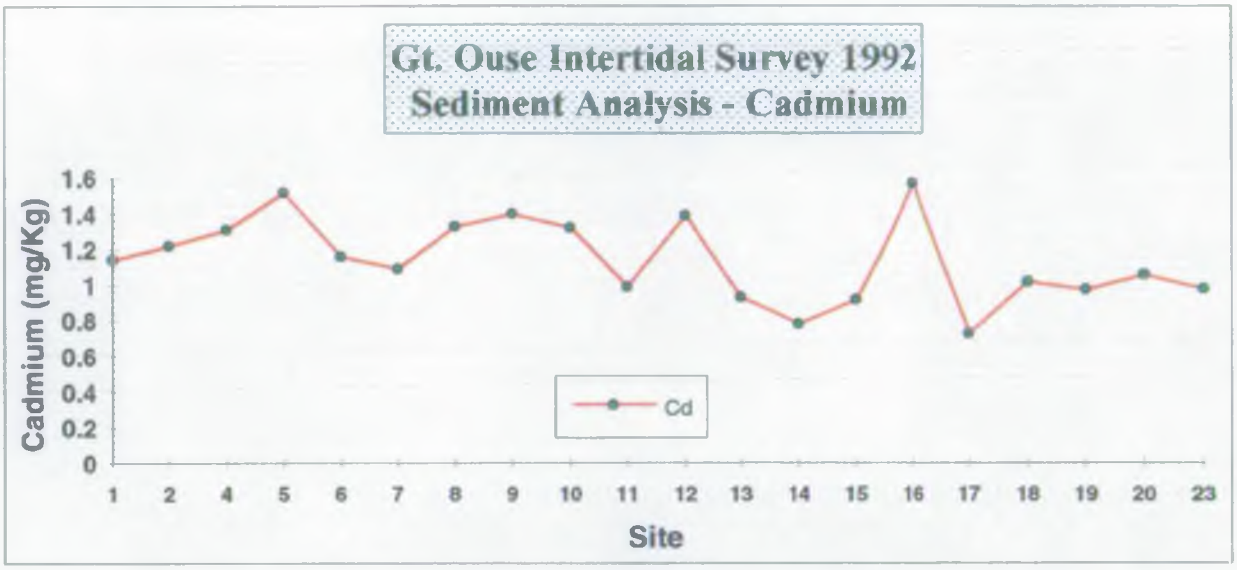
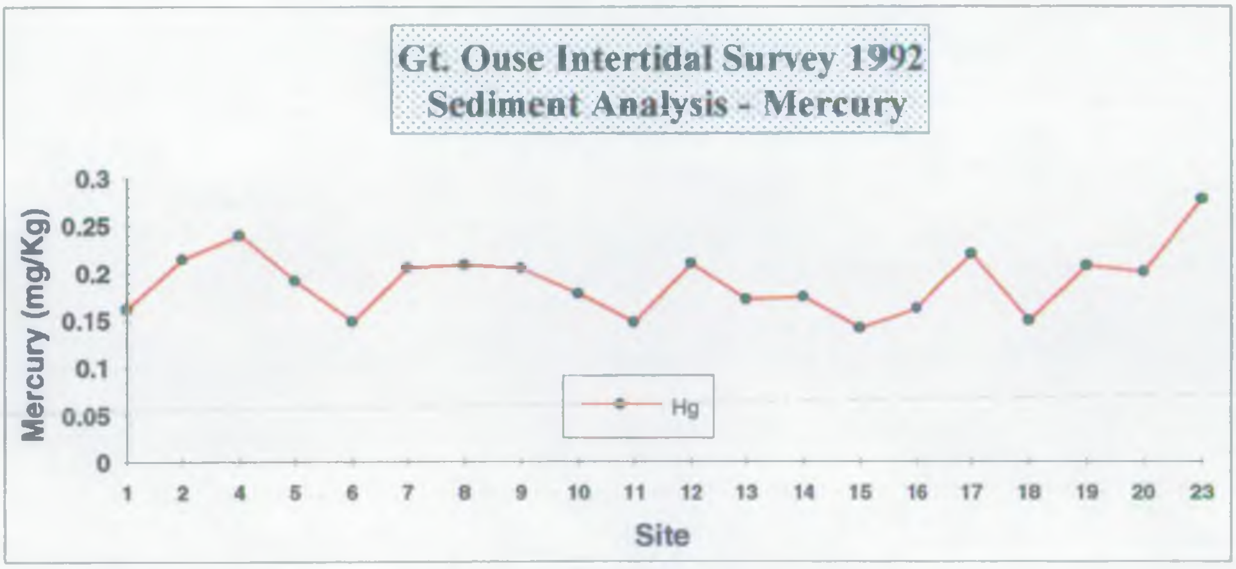


Figure 4.26

See Figure 4.25 for Site Details





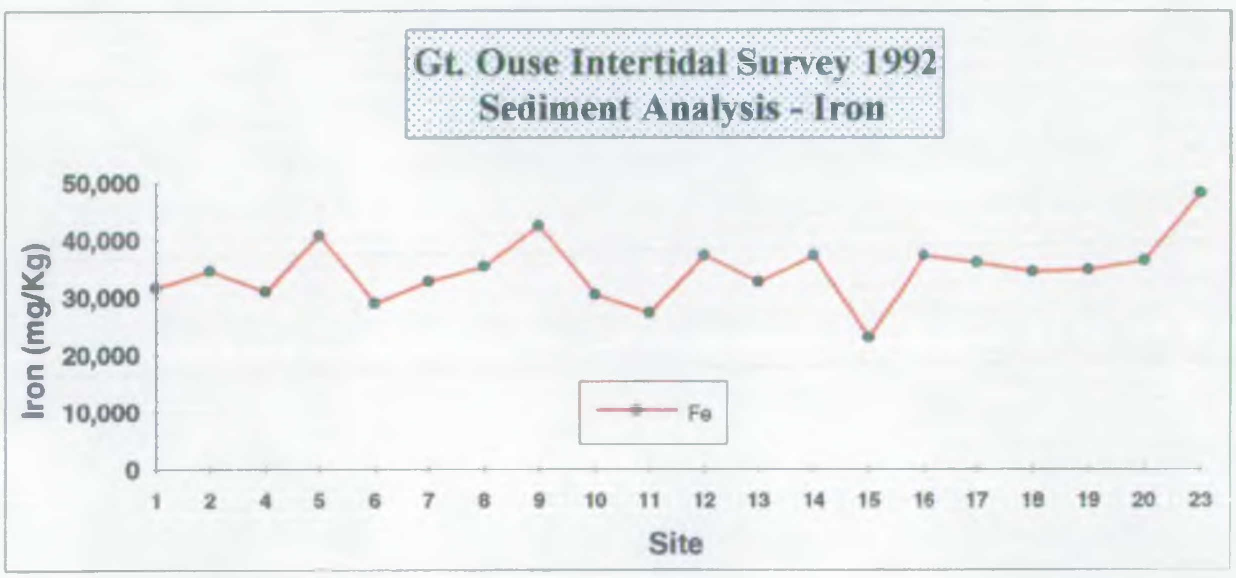
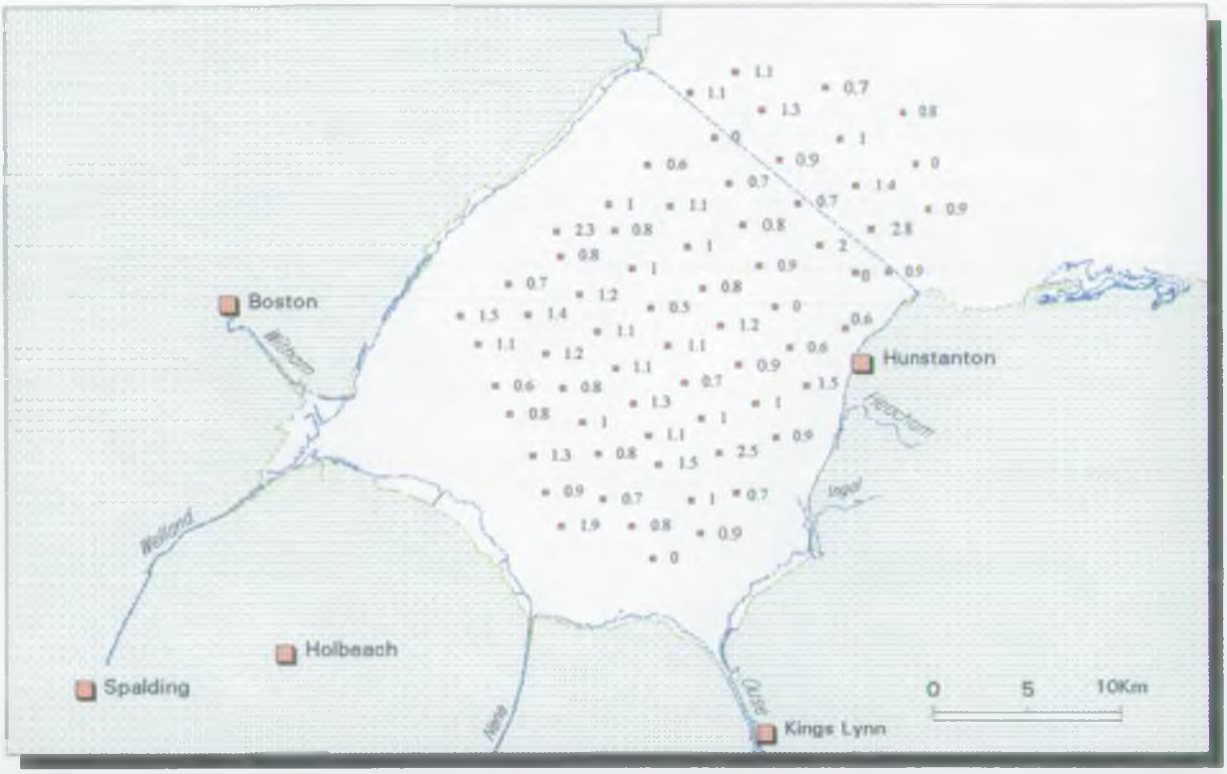


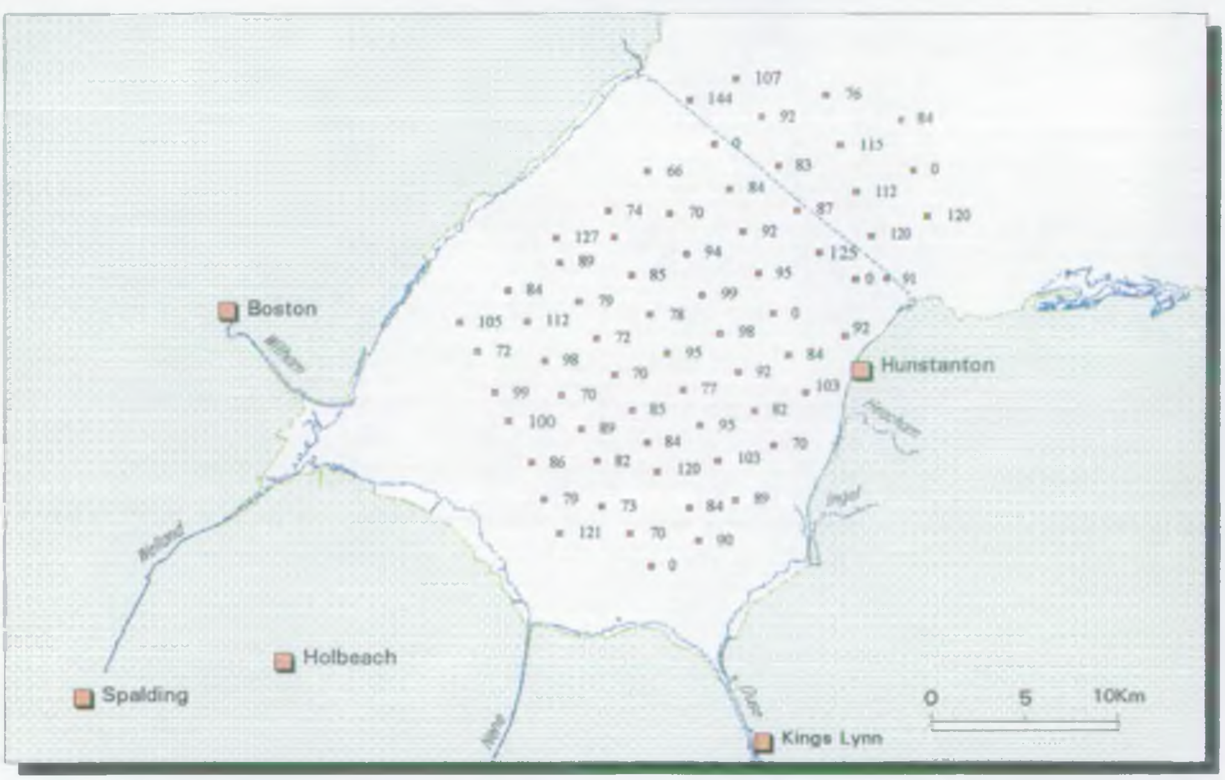
Figure 4.27

See Figure 4.25 for Site Details

Levels of Cadmium in the Wash
(dry weight, mg/kg)



Levels of Vanadium in the Wash
(dry weight, mg/kg)



AMS Graphics 1993

Figure 4.28 Metals in Wash Subtidal Sediments

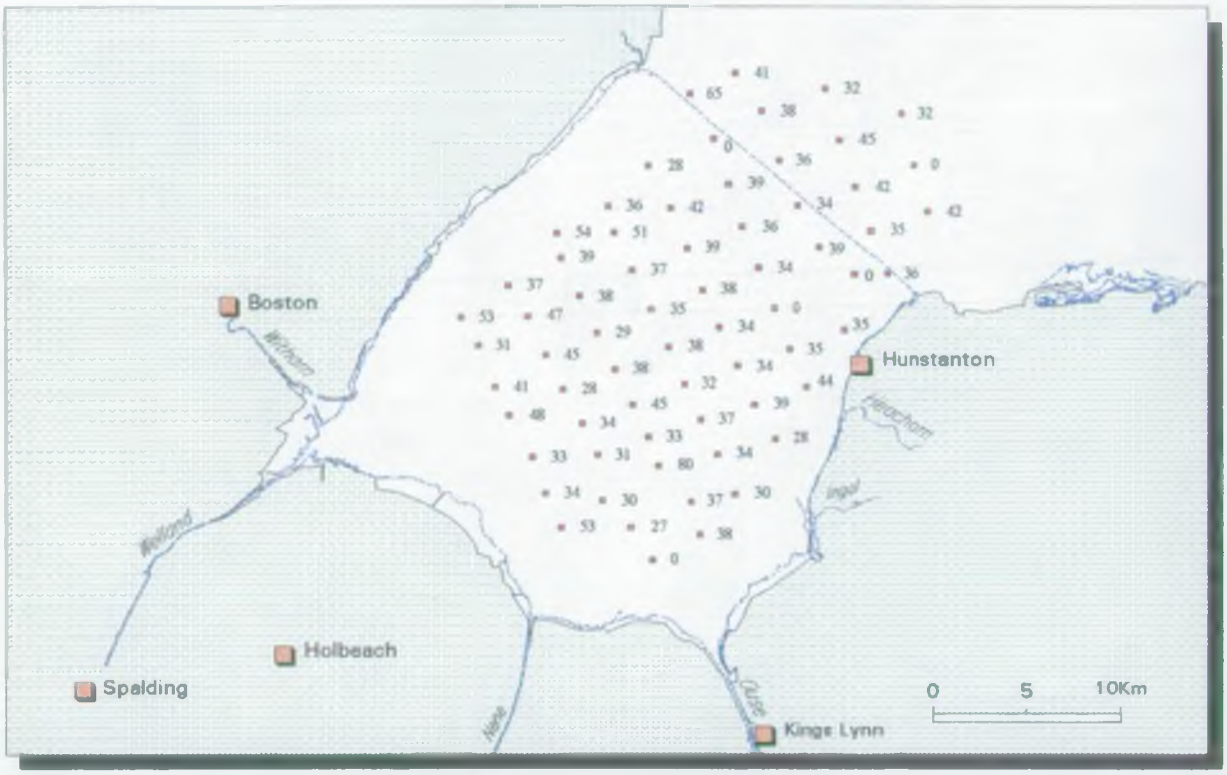
Levels of Mercury in the Wash
(dry weight, mg/kg)

Levels of Titanium in the Wash
(dry weight, mg/kg)

AMS Graphics 1993

Figure 4.29 Metals in Wash Subtidal Sediments

Levels of Nickel in the Wash
(dry weight, mg/kg)



Levels of Arsenic in the Wash
(dry weight, mg/kg)

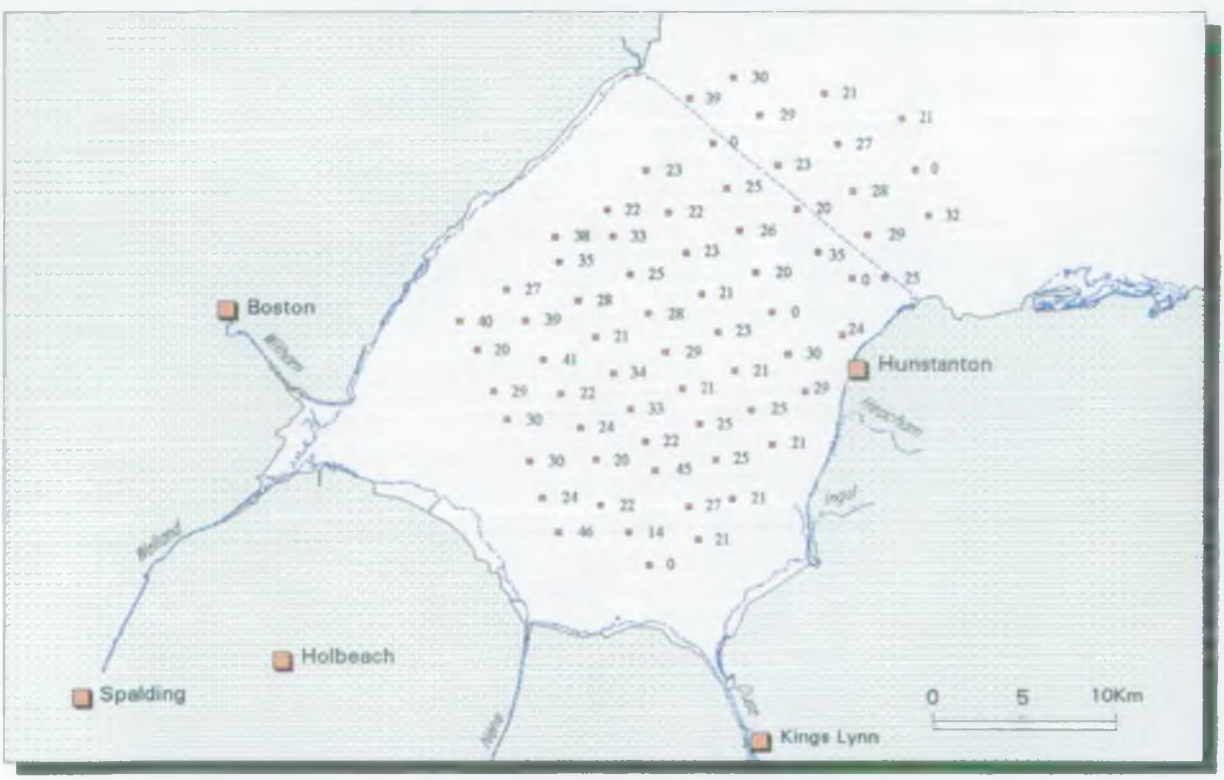


Figure 4.30 Metals in Wash Subtidal Sediments

AMS Graphics 1993

Levels of Clostridia in the Wash
(nos. per 100ml.)

Levels of Lead in the Wash
(dry weight, mg/kg)

Figure 4.31 Metals in Wash Subtidal Sediments

AMS Graphics 1993

Levels of Copper in the Wash
(dry weight, mg/kg)

Levels of Zinc in the Wash
(dry weight, mg/kg)

AMS Graphics 1993

Figure 4.32 Metals in Wash Subtidal Sediments

Levels of Chromium in the Wash
(dry weight, mg/kg)

Levels of Iron in the Wash
(dry weight, mg/kg)

Figure 4.33 Metals in Wash Subtidal Sediments

AMS Graphics 1993

NRA JoNuS Data - July 1990 to April 1992

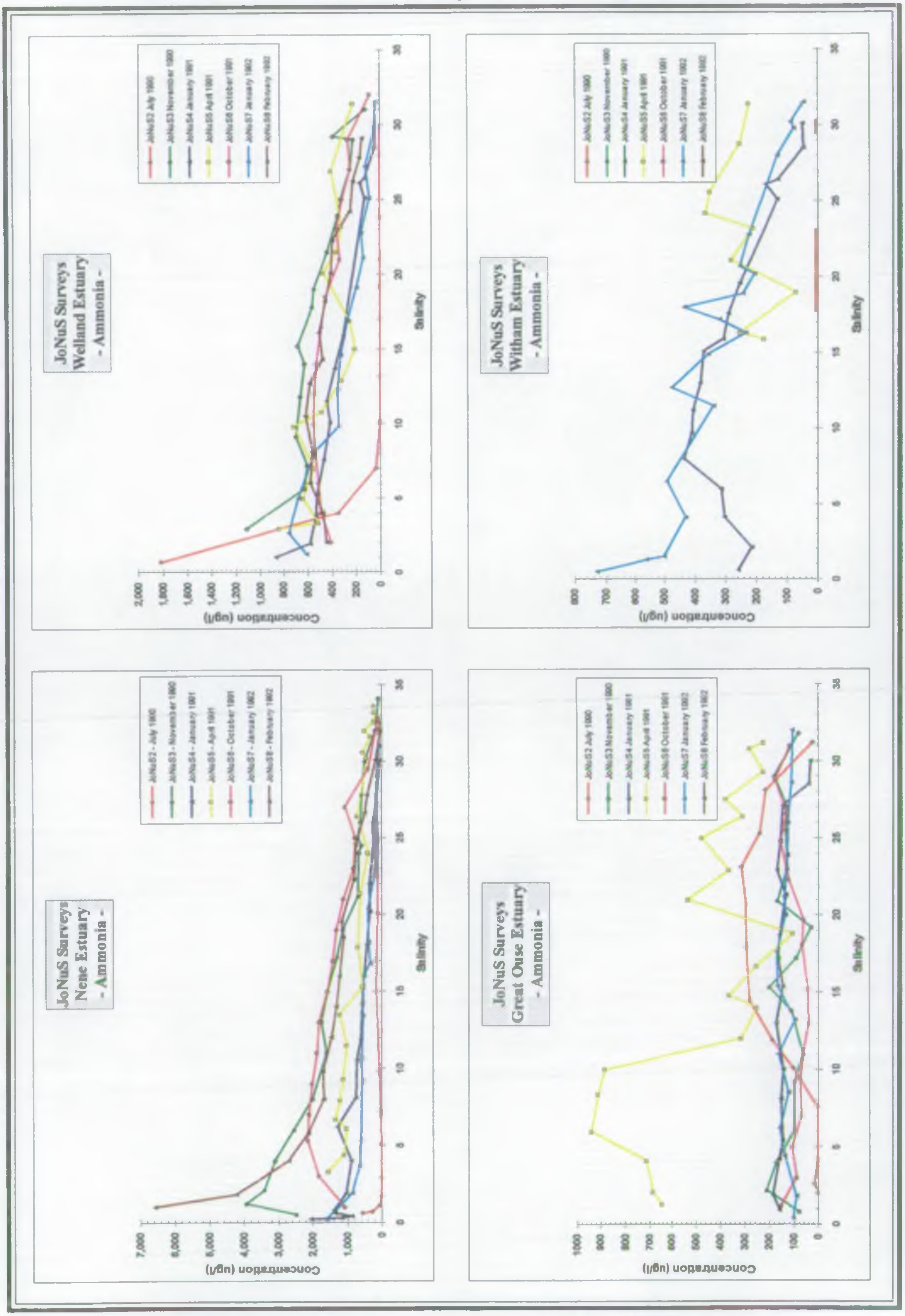


Figure 4.34 : Ammonia for each Estuary.

NRA JoNuS Data - July 1990 to April 1992

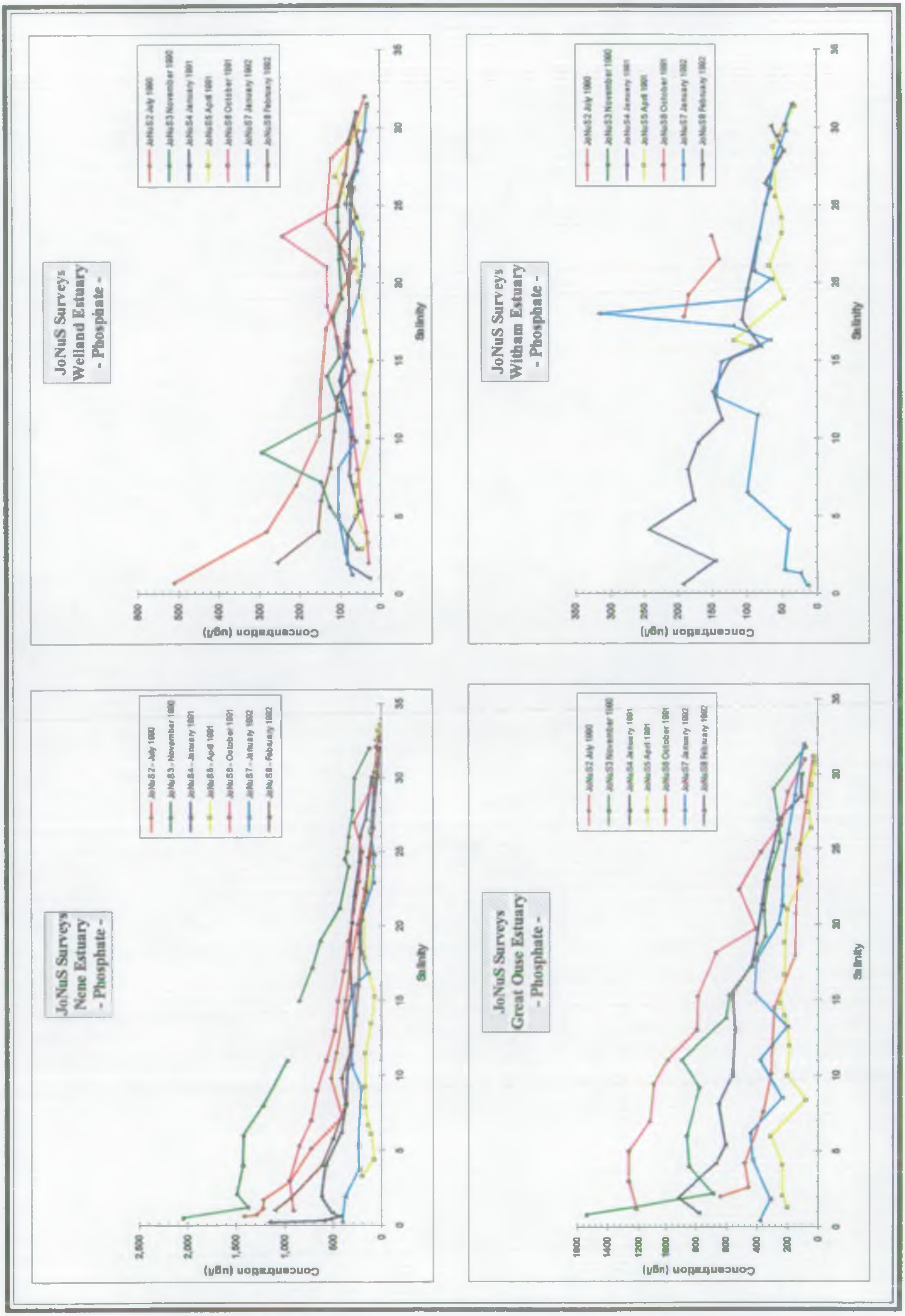


Figure 4.35 : Phosphate for each Estuary.

NRA JoNuS Data - July 1990 to April 1992

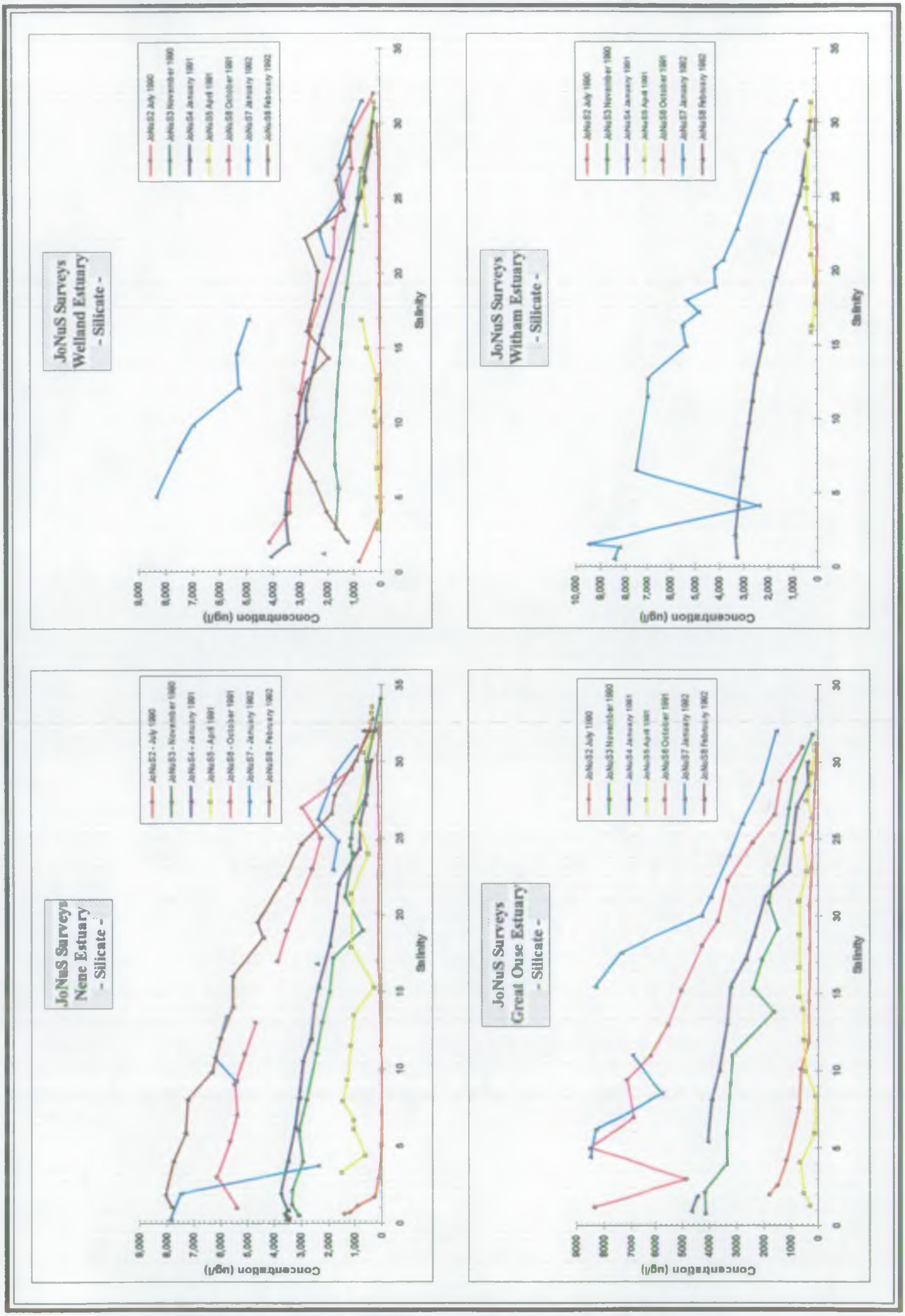


Figure 4.36 : Silicate for each Estuary.

NRA JoNuS Data - July 1990 to April 1992

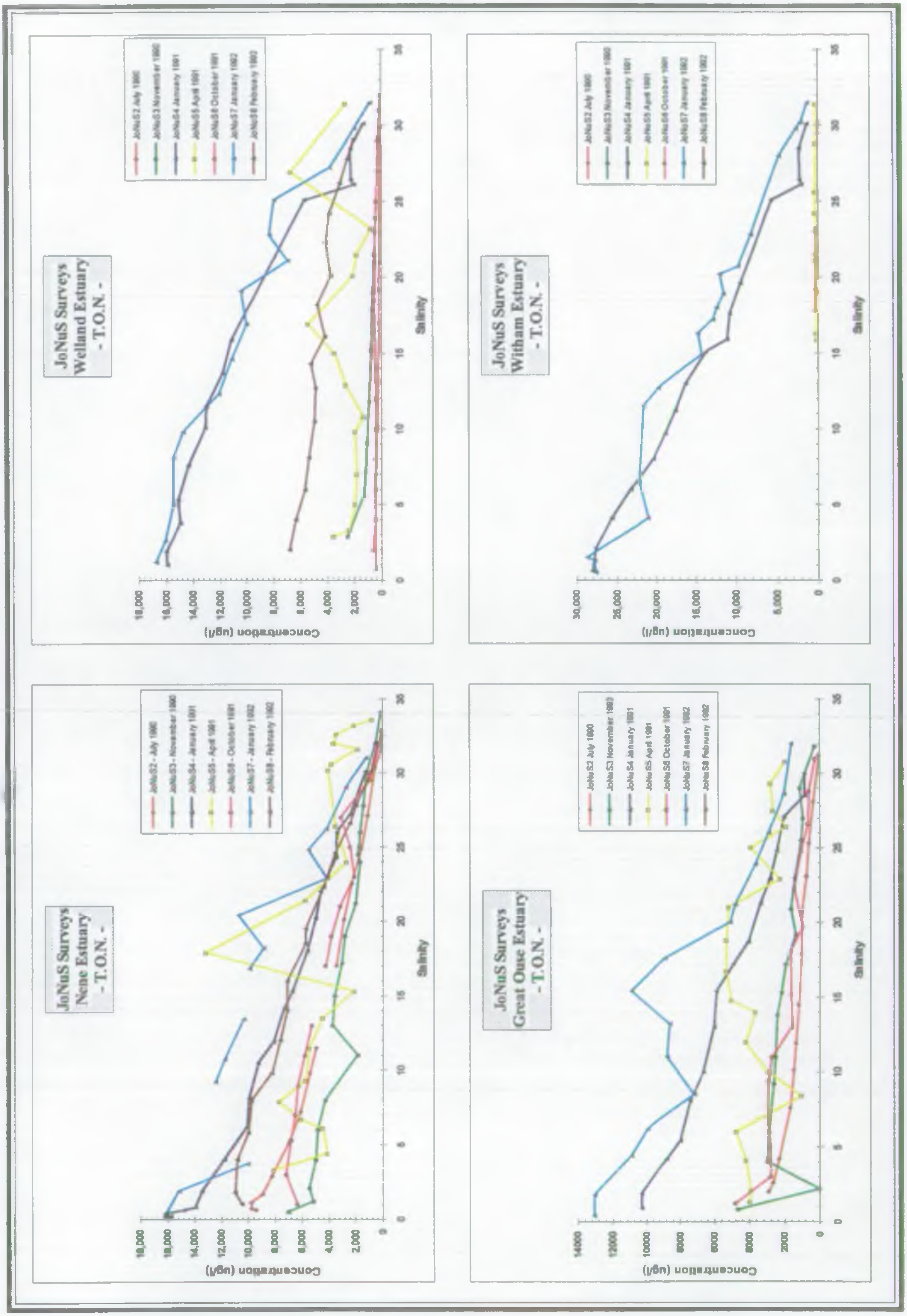


Figure 4.37 : Nitrate for each Estuary.

NRA JoNuS Data - July 1990 to April 1992

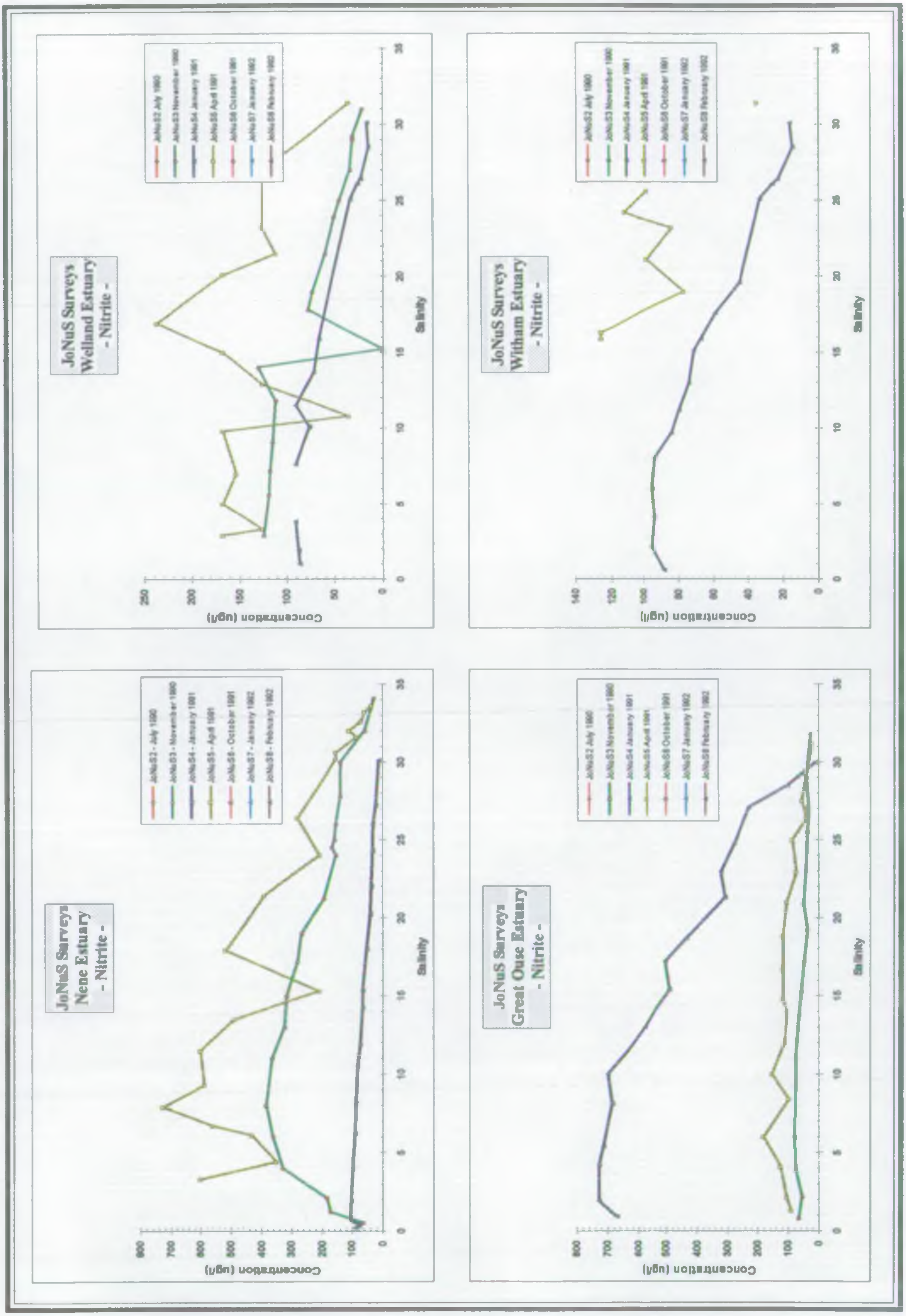


Figure 4.38 : Nitrite for each Estuary.

NRA JoNuS Data - July 1990 to April 1992

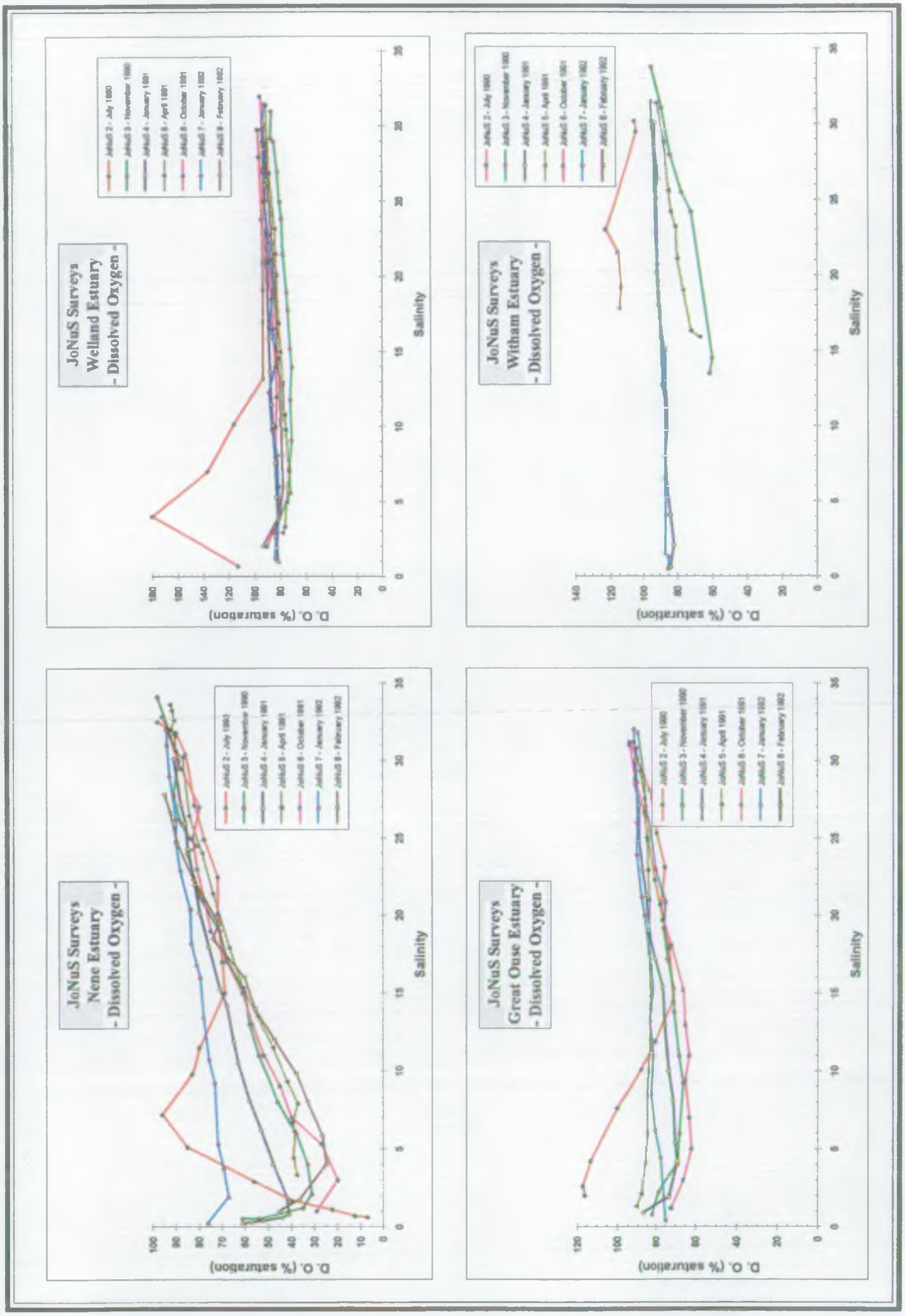


Figure 4.39 : Dissolved Oxygen for each Estuary.

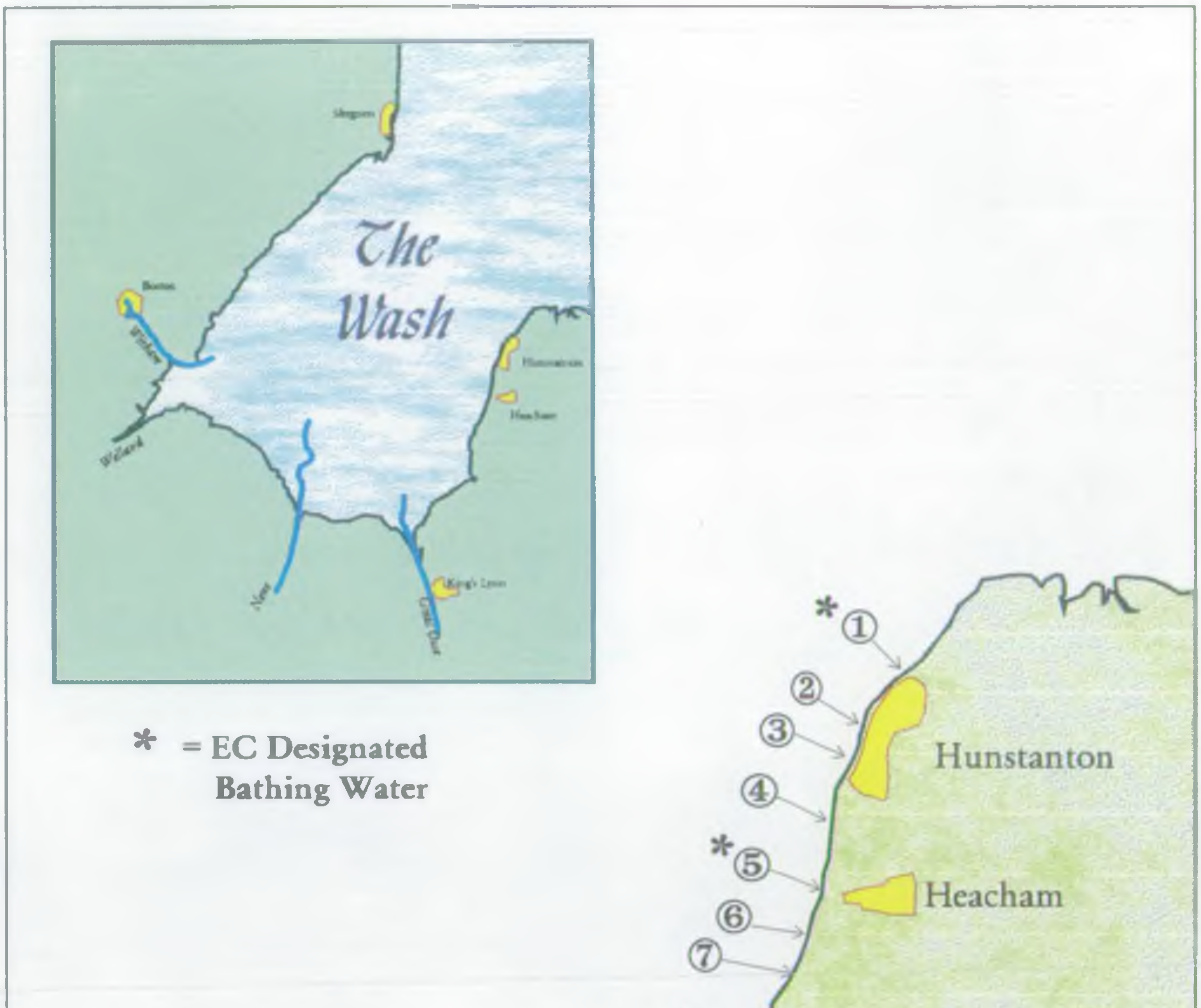


Figure 5.1 : Location of Bathing Water Sampling Sites

Wash Bathing Waters Surveys

Figure 5.2

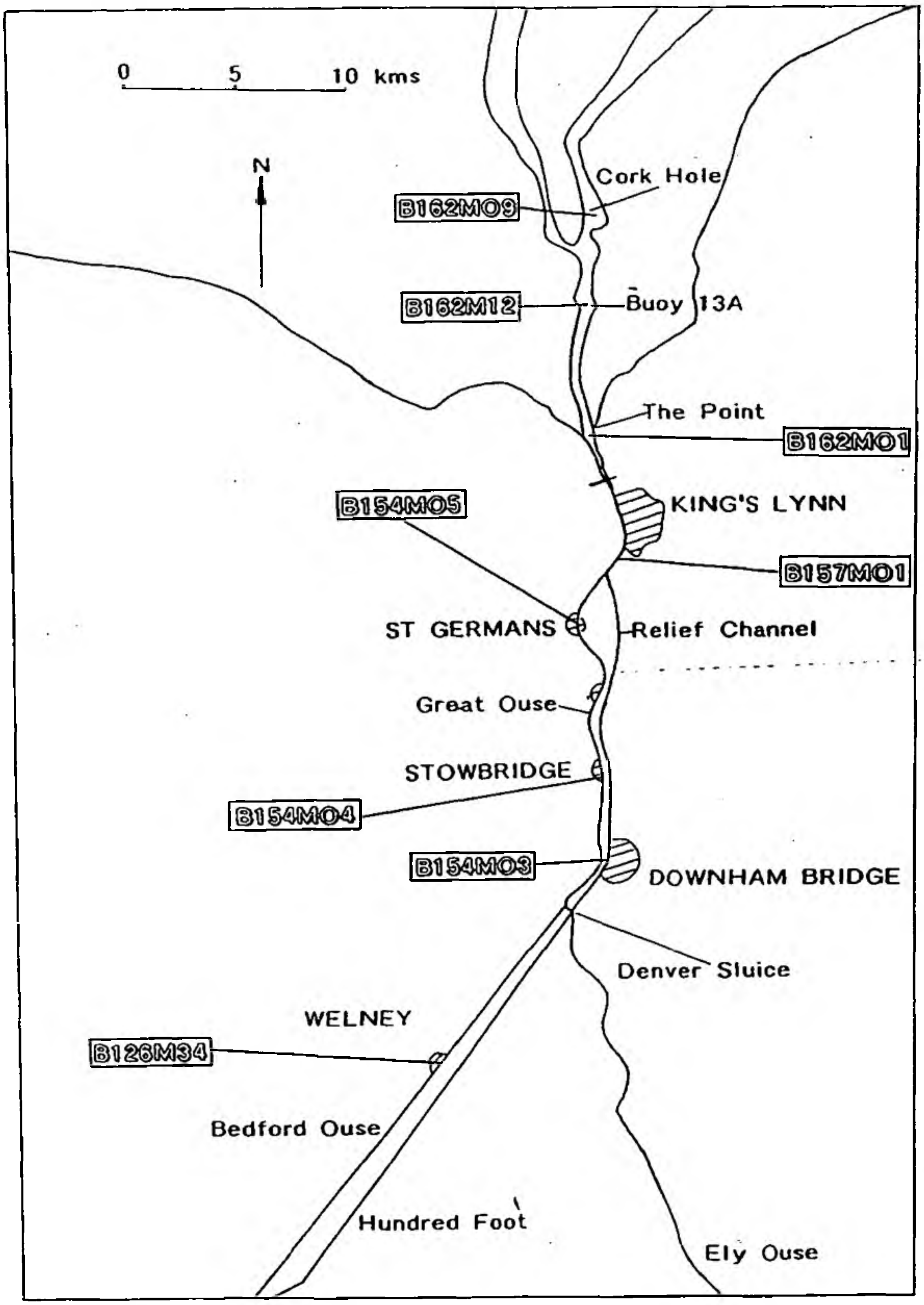
F - Fail
P - Pass

Wash Bathing Waters Surveys

Figure 5.3

F - Fail
P - Pass

Figure 5.4 NRA Great Ouse Chemical Surveys : Locations of Sampling Sites



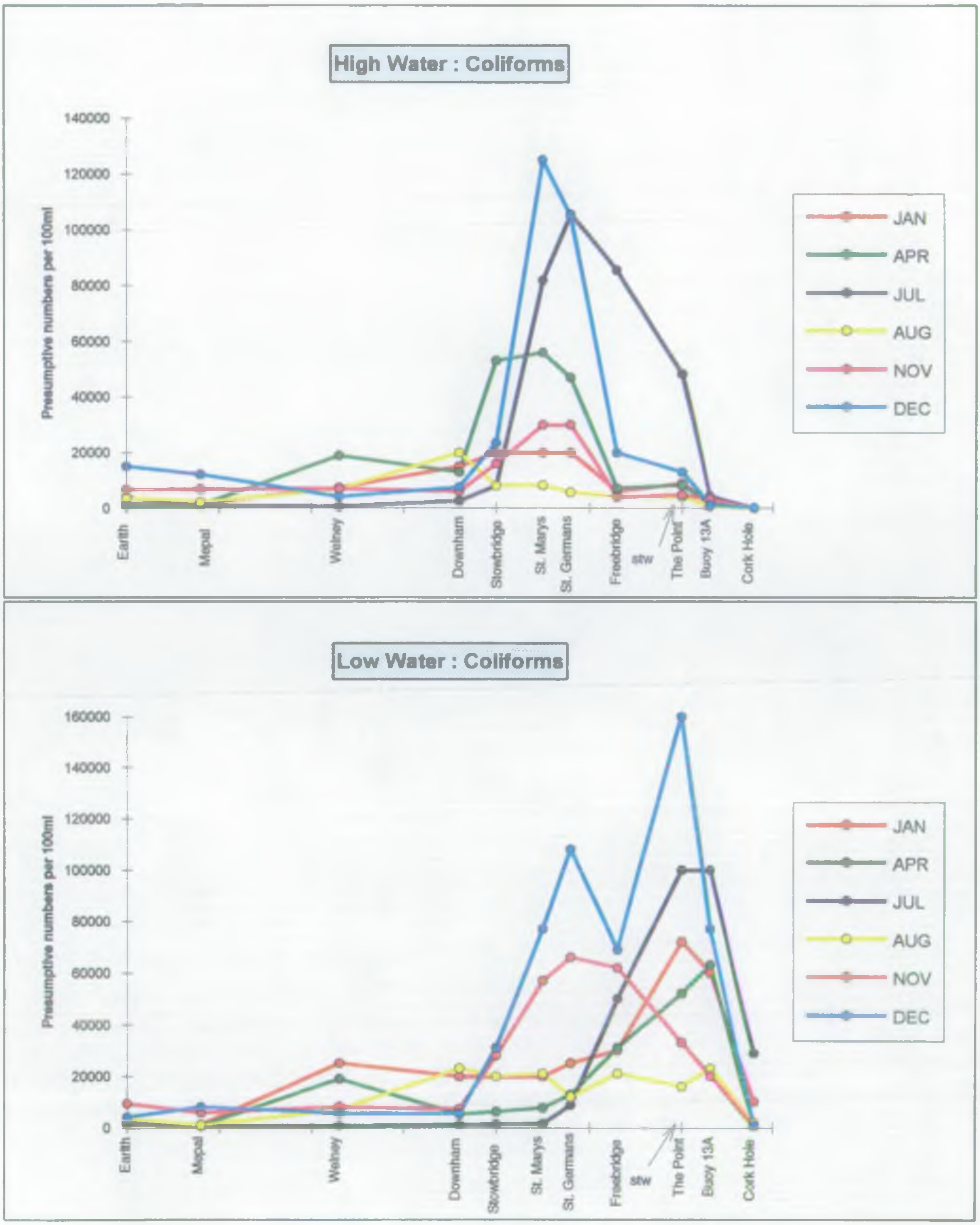


Figure 5.5 Great Ouse Estuary Water Column Bacteriological Survey 1991

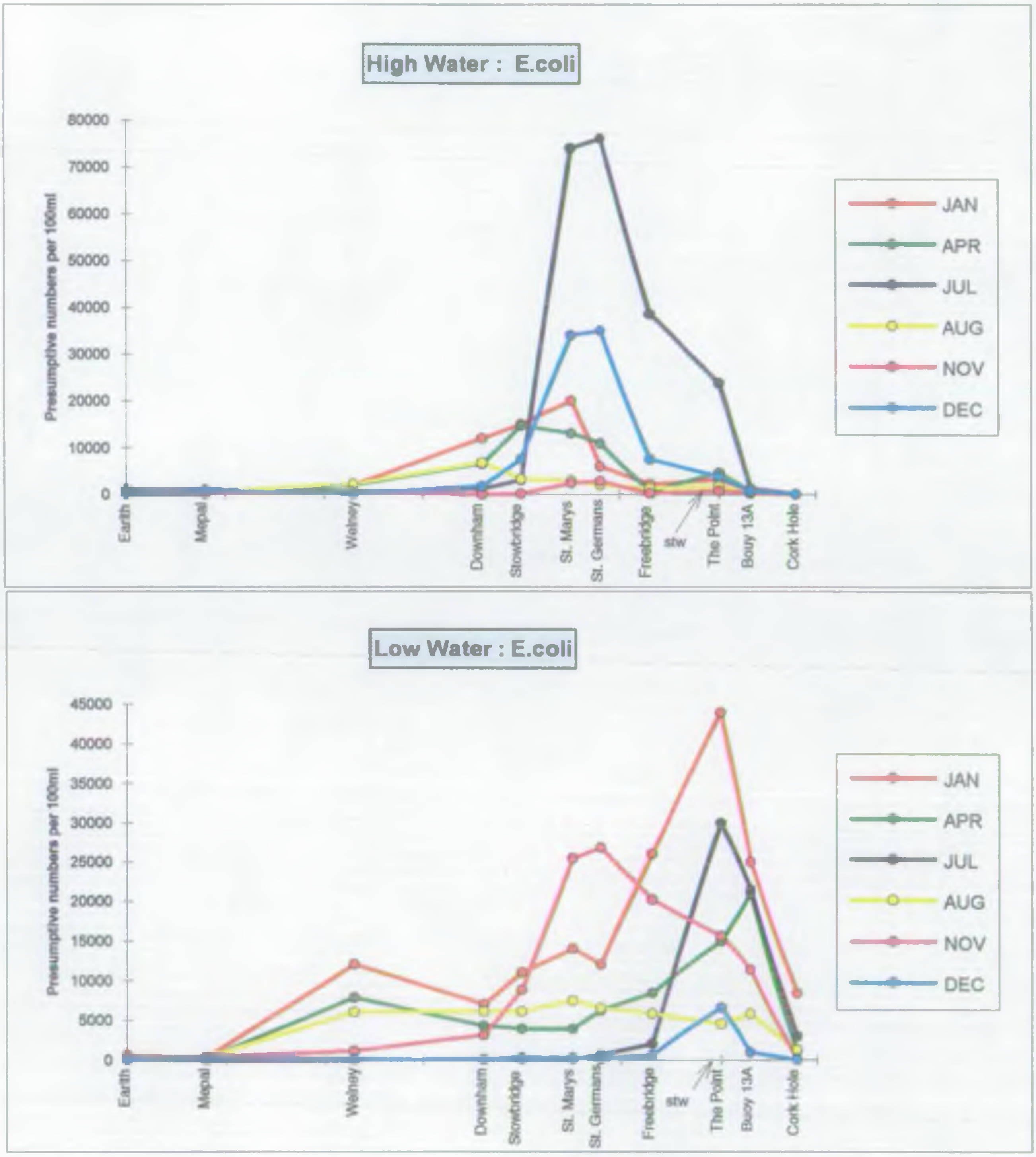
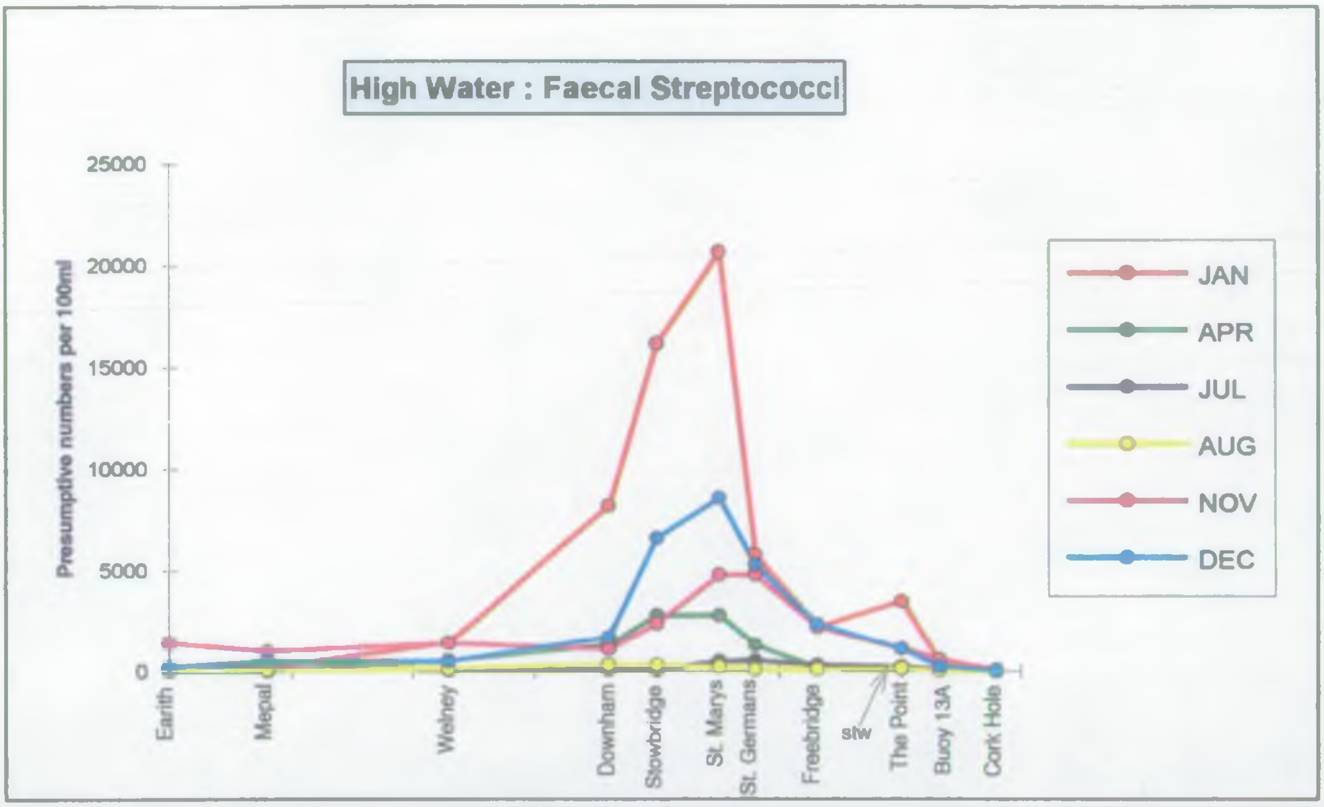


Figure 5.6 Great Ouse Estuary Water Column Bacteriological Surveys 1991



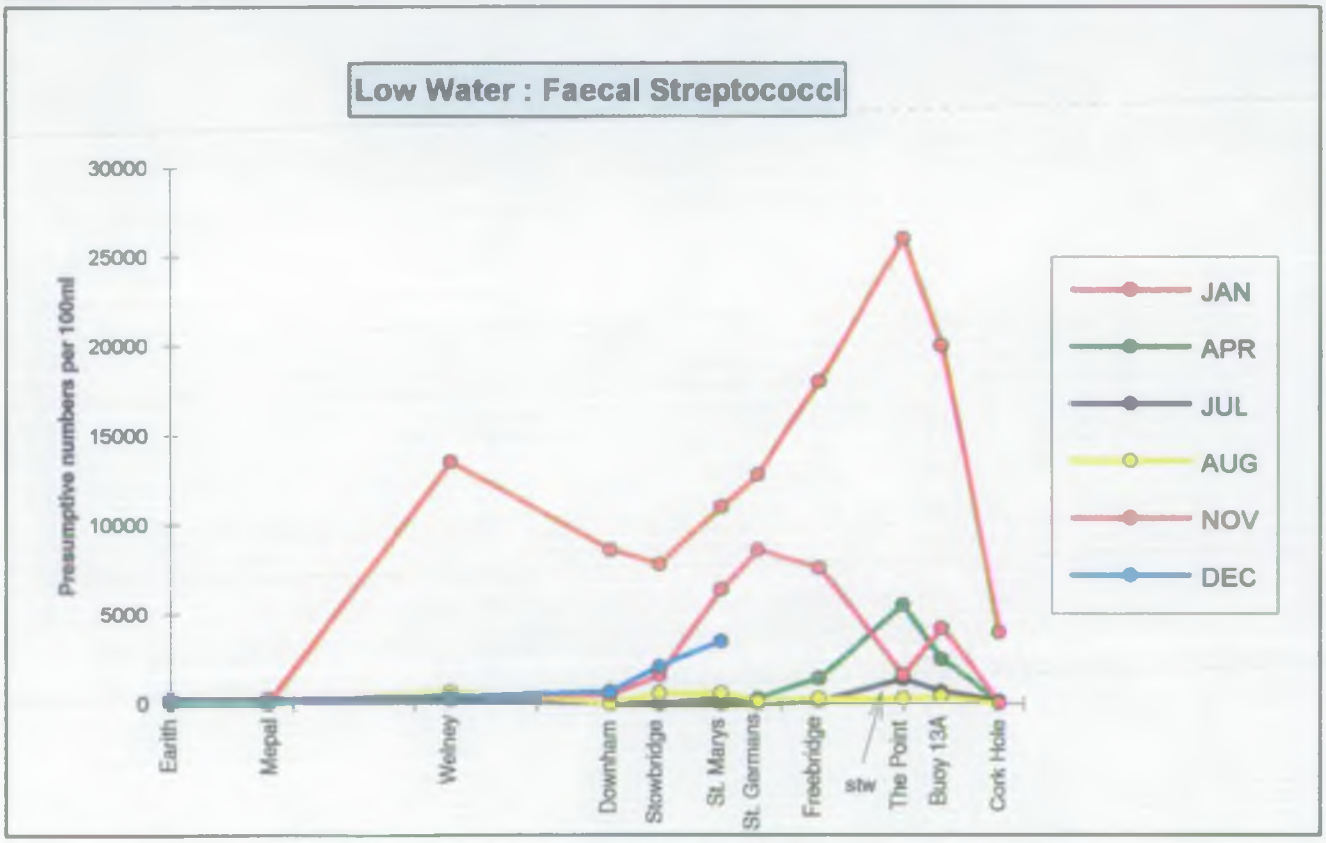


Figure 5.7 Great Ouse Estuary Water Column Bacteriological Surveys 1991

Figure 5.8 Location of Shellfish Beds in the Wash

NO.	SITE	SITE NAME	LATITUDE	LONGITUDE
1	SITE A	W. NENE	52 DEG 52.48 N	0 DEG 13.09 E
2	SITE B	E. NENE	52 DEG 52.83 N	0 DEG 13.47 E
3	SITE C	TOP THIEF	52 DEG 51.71 N	0 DEG 17.62 E
4	SITE D	S THIEF	52 DEG 51.67 N	0 DEG 17.61 E
5	SITE E	S. DASELEY/ROOKS MIDDLE	52 DEG 51.20 N	0 DEG 20.30 E
6	SITE F	DASELEYS / N / RUN	52 DEG 52.02 N	0 DEG 19.20 E
7	SITE G	TR. WALL	52 DEG 49.70 N	0 DEG 21.30 E
8	SITE H	STYLEMANS	52 DEG 52.67 N	0 DEG 22.23 E
9	SITE J	PANDORA	52 DEG 51.89 N	0 DEG 21.91 E
10	SITE K	WITHAMBANK	52 DEG 56.98 N	0 DEG 07.08 E
11	SITE L	TOFTLAYS	52 DEG 56.98 N	0 DEG 08.97 E
12	SITE M	GAT SAND	52 DEG 55.70 N	0 DEG 11.10 E
13	SITE N	MARE TAIL	52 DEG 54.73 N	0 DEG 08.80 E
14	SITE O	FRISKNEY	52 DEG 01.15 N	0 DEG 15.65 E
15	SITE P	BUTTERWICK	52 DEG 58.82 N	0 DEG 09.55 E
16	SITE A	HOLMESIDE	52 DEG 58.82 N	0 DEG 13.09 E
17	SITE A	HEACHAMSIDE	52 DEG 52.48 N	0 DEG 13.09 E
18	SITE A	HUNSTANTON	69 DEG 52.48 N	0 DEG 13.09 E

NRA

Figure 5.9 Results of Shellfish Hygiene Monitoring in the Wash

NO.	SITE		1990	1991	1992
1	SITE A	W. NENE	B	A	B
2	SITE B	E. NENE	B	-	B
3	SITE C	TOP THIEF	B	B/C	-
4	SITE D	S THIEF	B	C	C/D
5	SITE E	S. DASELEY / ROOKS MIDDLE	C	C	C/D
6	SITE F	DASELEYS / N / RUN	B	B	B
7	SITE G	TR. WALL	C	C	C/D
8	SITE H	STYLEMANS	B	C	C/D
9	SITE J	PANDORA	B	C	C
10	SITE K	WITHAMBANK	B/C	B	B
11	SITE L	TOFTLAYS	A	B	B
12	SITE M	GAT SAND	A	B	B
13	SITE N	MARE TAIL	A	A	B
14	SITE O	FRISKNEY	-	-	B
15	SITE P	BUTTERWICK	-	-	B
16	SITE A	HOLMESIDE	-	B	B
17	SITE A	HEACHAMSIDE	-	B	B
18	SITE A	HUNSTANTON	A	B	B

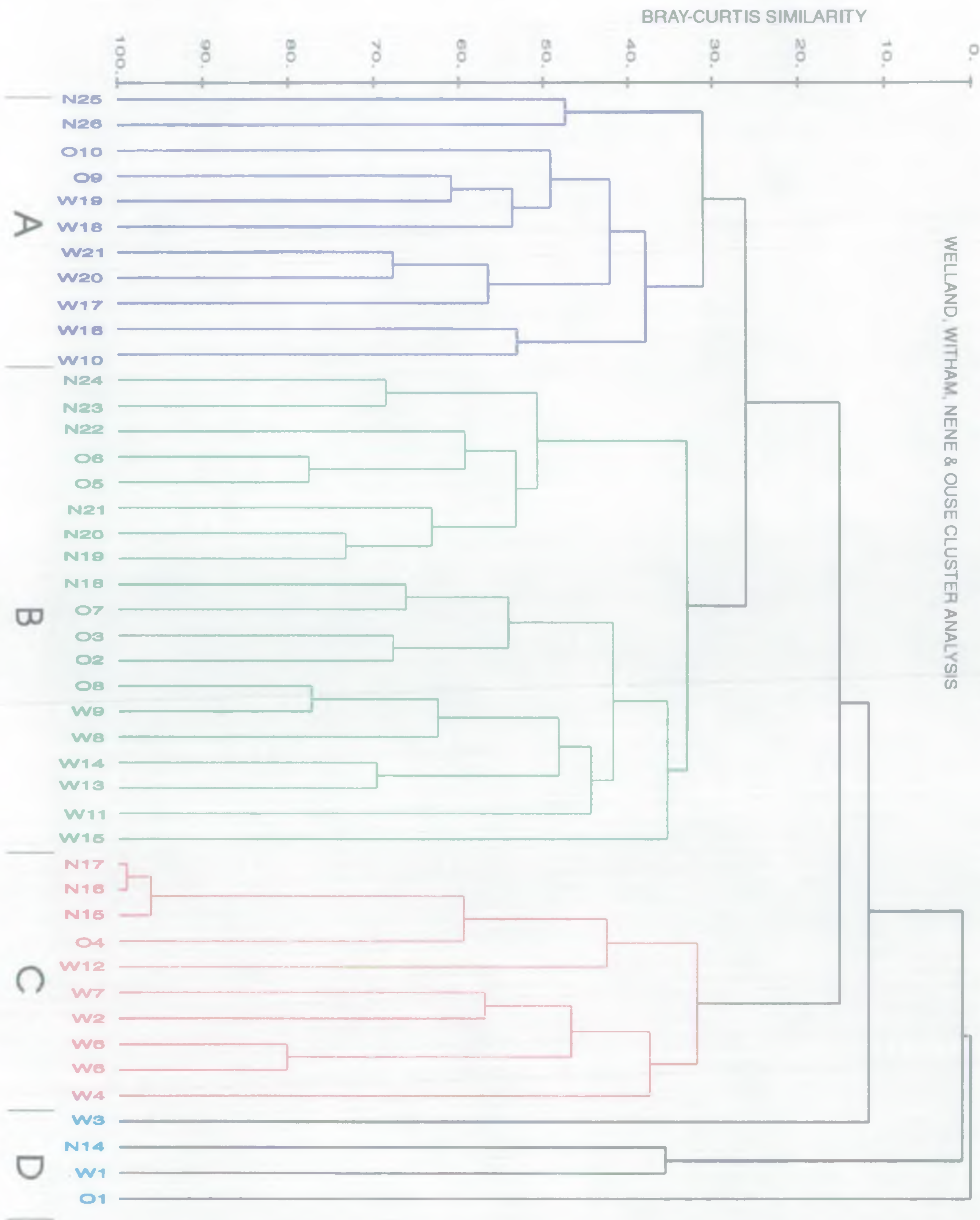
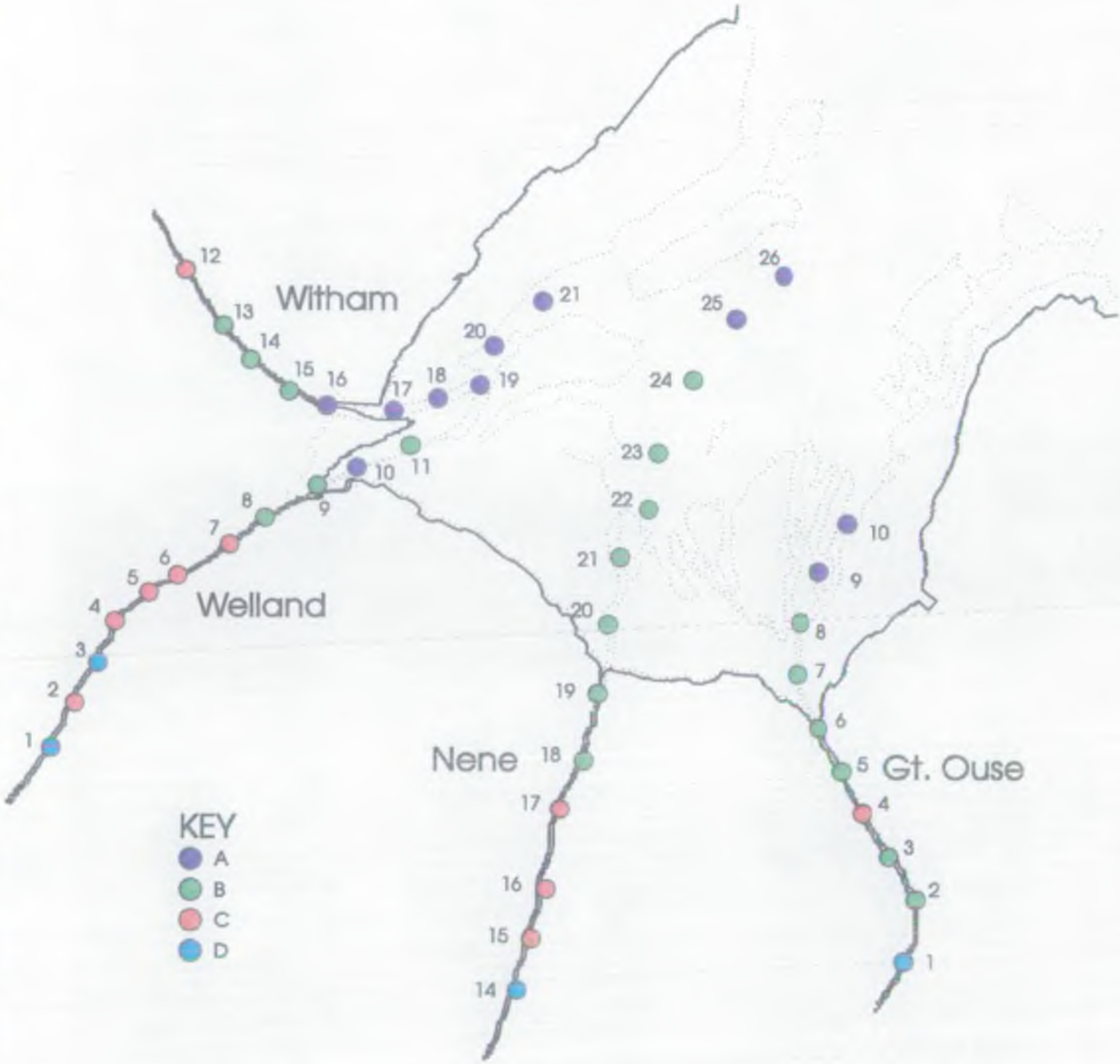


Figure 6.1 Dendrogram from Cluster Analysis of a Combined Data Set of Intertidal Benthos from the Four Tribnutary Estuaries

Figure 6.2 Faunal Associations Identified by Cluster Analysis of a Combined Data Set of Intertidal Benthos from the Four Tributary Estuaries



Wash Zone Report

Part II

Analysis of macroinvertebrate samples from a survey of The Wash in August 1991

REPORT PREPARED FOR THE NRA, PETERBOROUGH

BY

UNICOMARINE LTD.

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Summary

In August 1991 a large scale survey of the Wash was carried out by NRA (Anglian Region) marine scientists. A total of 66 sample points were visited using the survey vessel *'Sea Vigil'*. Grab samples were taken at each point for the determination of the macro-invertebrate fauna; additional samples were collected for the analysis of a number of physical, chemical and microbiological parameters. This report presents the results of the analysis of the 198 biological samples collected, and interprets the findings with reference to the physical characteristics of the area.

The Wash is a shallow bowl, with deeper water towards the centre and north-east. The depth decreases somewhat at the opening of the embayment to the North Sea. The Wash sediments are predominantly sandy, ranging from fine sands with varying admixtures of mud around the periphery, to coarser, less muddy sands in slightly deeper water. A large area of the Wash consists of drying banks of coarser sand. In deeper water (below approximately 10 metres) the sediment is generally more varied, consisting of stones, sand and broken shell, together with mud and silt.

The biological data were analysed using a variety of univariate and multivariate techniques. The fauna was diverse; the number of taxa recorded per site ranged between 11 and 131, and the calculated number of individuals per square metre between 60 and 29400. A total of 301 taxa (including juveniles) were recorded. The value of the Shannon-Wiener diversity index was calculated for each site, and was generally higher at the sites in deeper water. The peripheral sites were somewhat less diverse, and this was reflected in lower values for the index. The lowest values were recorded at sites near to the mouth of the R. Gt. Ouse. The distribution patterns of a number of species were plotted and marked differences between closely related species were demonstrated. In many cases these could be clearly linked to differences in the sediment characteristics between the sites.

Classification and multidimensional scaling analysis of the data indicated that a number of distinct divisions of the fauna could be made. Two major divisions were apparently related to the depth of the site; an approximate dividing line between the two faunistically different regions being the 10 metre contour. Further subgroups of sites within the major divisions were also demonstrated, and were related to the sediment characteristics of the sites. There was some evidence that the degree of sorting of the sediment was important in determining the fauna in some areas.

The analyses did not reveal major areas with an unusually poor or aberrant fauna; where low numbers of species or individuals were found to occur, natural physical stress seemed likely to be involved. There is some evidence for possible disturbance of the fauna found at sites in the immediate vicinity of the R. Gt. Ouse however, particularly those in the channels. The majority of the highest bacterial counts made in the survey were in the same area. It was not possible to be sure if the differences in the fauna of the sites concerned were natural, or the result of a polluting influence. A more specific study of these areas is recommended. The survey provided valuable information on the area, and an important baseline, facilitating future monitoring.

1.Introduction

In August 1991 a large scale survey of the invertebrate fauna of the main body of the Wash was carried out by NRA marine scientists. The survey was undertaken to obtain information on the biology of the major part of the Wash, and to examine the extent to which this was affected and determined by the physical and chemical characteristics of the sediment. An important aim of the survey was to identify, if possible, any areas where anthropogenic factors might be influencing the fauna.

2.Fieldwork

The Wash is approximately rectangular, 20km wide at the mouth increasing to 26km in along the south-west coast, and 28km along the main south-west to north-east axis.

A total of 66 sites were sampled in a broadly rectangular grid pattern aligned with the major axis of the Wash. The sampling points were spaced approximately 3 km apart on the NE-SW axis and 2 km apart on the NW-SE axis. The grid extended some distance beyond the 'bounding-line' drawn between Gibraltar Point and Holme Point, to provide for comparative sampling at a distance from the four major rivers.

Considering only the area within the bounding line described above, approximately 55% of the combined intertidal and subtidal area was sampled at 55 points.

Access to the sites was by boat, the NRA coastal survey vessel *'Sea-Vigil'*. Due to operational depth requirements of the vessel the positioning of certain sites was modified from the planned regular rectangular grid. The location of the 66 sampling points is given in Figure 1. Also indicated in Figure 1 are the locations of the major drying sand-banks, though in view of the dynamic nature of the Wash (certain channels are constantly shifting) these positions should be regarded as approximate.

Peripheral to the area considered in the present study is a large and nationally important area of mud and sand flats, together with salt-marsh in varying stages of development / regression. These areas were not sampled in the present study and any analyses and discussion refers only to the information collected from the 66 positions described above.

2.1Biological Sampling

At each of the 66 sampling points, three Day grab samples were taken for the determination of the fauna present. The Day grab is designed to sample a known surface area of the sea bottom (0.1m²) and is widely used in marine biological survey work. The grab is generally very effective in soft sediments, especially mud and sands, such as occur in the Wash, but it can be prevented from closing correctly if large stones are present. It is not an effective device for the sampling of predominantly rocky substrata. After collection, each of the grab samples was fixed in formaldehyde solution (4%), prior to later processing.

2.2 Laboratory Analysis

Laboratory treatment of the biological samples consisted of differential sieving of the sediment, together with floating-off (elutriation) of the low density material. The minimum mesh size for the sieving was 500µm (0.5mm).The latter included a large proportion of certain groups of animals, especially crustaceans and small polychaetes (worms). This process is valuable in reducing sorting damage to specimens which makes subsequent identification more difficult. The process was followed by sorting of all the remaining sediment in a ring-marked dish under a microscope (x6-x10 magnification), the aim being to extract all of the animals remaining in the sediment. Only 'countable' specimens (those with heads) were extracted from the sediment.

The animals were sorted into the major taxonomic groupings (worms, molluscs, crustacea &c.), identified to species where possible, and counted. If for some reason it was not possible to assign a specimen to a species, then the 'next best' taxonomic level was used (genus, family, order, &c).

Although the majority of samples were fully processed (*ie.* from sorting to identification and enumeration) by Unicomarine Ltd., a proportion were processed directly by the NRA. A drawback of this approach was that a considerable period of time was required to cross-check identifications made by the two laboratories, and to ensure that as far as possible the same taxonomic level was used in each case. The problem was largely a result of the relatively high number of taxa recorded in the survey as a whole. Unicomarine Ltd. carried out the overall checking of the samples, re-examining samples if necessary, and standardising on taxonomy. Consistency of identification (*ie.* assigning the same name to a taxon throughout the sample-set) was maintained by ensuring that the same personnel (within Unicomarine Ltd.) carried out the identification of a group of animals over the entire data set.

2.3 Sediment & Physico-chemical analysis

In addition to the grab samples collected for biological analysis, further samples were taken for the determination of a number of physico-chemical parameters of the sediment. These analyses were carried out by the NRA. Sediment parameters measured included particle size, the organic carbon content and the percentage of clay and silt present. A number of heavy metals were assayed, as were certain pesticides. The values of these, and other determinands measured at each site, are presented in Table 2, together with brief notes on the observed sediment type which was recorded in the field for each sample at the time of sampling. The numbers of three bacterial types were estimated in each sediment sample, and these values are also presented in Table 2. The depth given for each sample is that recorded at the time of sampling, and has not been corrected for tidal height, this varies by up to *c.*7m in the Wash and so this figure should not be taken as necessarily reflecting the true relative depths of the sites (see analysis, section 3.8).

3. Results

The survey covered a large area and generated a large amount of biological and physical data. The present report is concerned primarily with the interpretation of the biological data collected, rather than a detailed examination of the physico-chemical data. However, the two must be viewed together as in general the fauna of an area reflects the physical conditions present.

The approach taken below in the analysis of the results is to consider first the physical environment, and to provide a description of the major regions which may be recognised. The chemical information made available is considered, though most analysis is of the physical sediment parameters. Secondly, the biological data is examined using univariate and multivariate techniques to describe the major components of the fauna and to recognise similarities between sites. Finally, the analysis considers the biological and physical information together, in an attempt to determine the degree to which the former is related to the latter. Selected species are considered where appropriate to illustrate the latter.

3.1 Physical parameters

Consideration of Admiralty charts show the Wash to be a generally shallow region with an average depth (Chart Datum) of approximately 10m. The depth increases from the periphery to the centre with typical depths in the central and outer part of c.20-25m. Towards the outermost part of the area sampled (around points 33 and 34) the depth is in excess of 40m, though further out (around points 35, 50 and 58) the depth again decreases to *c*.15-20m.

In a few areas, particularly towards the mouth of the R. Gt.Ouse and the R. Nene, somewhat greater depths (to around 20m) than otherwise found in the immediate area are recorded. For example to the west of Westmark Knock (South-west of site 21),*c*.16m is recorded and west of Thief Sand (West of site 36) *c*.17m is recorded. Previous survey work in the area has shown that such regions have finer sediments than the surrounding area, with associated biological differences.

The channels between the sand-banks of the Wash are mobile, requiring frequent re-buoying, and the positions of the channels and banks as indicated in Figure 1 must be regarded as approximate.

Presented in Figures 2 and 4 respectively are the median particle size and the percentage of clay and silt in the sediment at each of the sites sampled. In these Figures and in other similar Figures the height of the bars indicates the size of the variable, though the scale for each Figure is different according to the parameter displayed. The degree to which the sediment is sorted is indicated in Figure 3 which shows the distribution of the standard deviation of Phi(o). This value gives a indication of the extent to which the sediment found at a site is uniform in size. The distribution of the major sediment types as observed in the field is presented in Figure 5. Although descriptive, the observations were of entire grab samples rather than smaller sub-samples taken for particle size analysis, as such they may reflect the sediment type, from the macrofaunal viewpoint, better than the latter.

An examination of these Figures together with other data held in Table 2 allows a general description of the Wash sediments to be made. The predominant sediment type is sand with varying admixtures of mud. The sediments of the coastal sites are fine sands or muds, or mixtures of the two; the former apparently more common along the eastern coast. Muds occur in many parts of the study area, and particularly in the outer regions of the channels leading from R. Gt. Ouse, as well as in the deeper parts. In the centre of the Wash, along the NE-SW axis, very mixed sediments are found. Shell, gravel, stones, sand and mud are present in various proportions forming a very diverse sediment when compared with that of the sandbanks., which varies from fine to coarse sand with varying amounts of mud.

3.2 Chemical and microbiological parameters

In addition to the physical parameters described above, information on the levels of 11 metals, 4 organic compounds and 3 bacterial types was recorded and the data are presented in Table 2.

Initial examination of the chemical data has revealed few clear differences between the sampling positions for most of the metals and other chemicals measured. Site 44 was clearly different from the rest in terms of the levels of iron recorded, the levels being an order of magnitude higher than at other sites. There was some evidence that other metals were also elevated at this site. Site 31 had very high levels of nickel, again an order of magnitude higher than at any other site. These two observations should be viewed with caution, and are being examined further. In general the levels of each of the metals measured vary in a similar fashion between sites. A simple illustration of this is given in Figure 6, which displays, for each site, the level of each metal expressed as a proportion of the highest level of that metal recorded at any of the sites. The sites have been sorted in increasing order according to the sum of the standard scores for all 11 metals at the site. It can be seen that there is a rising trend from left to right. No information was available for the five sites indicated to the right of the x-axis.

The other chemical information made available, including that on pesticides, was very scattered and difficult to interpret. The same is true of the microbiological information. Both were based on single samples and, certainly in the case of the latter, wide variations are known to be recorded from individual points on successive occasions. The highest levels of the bacterium *E. coli* were from sites 43 and 51, which are adjacent sites in the western arm of the R. Gt. Ouse channel. This is the minor channel from the Gt. Ouse, and it does not carry major shipping. Levels of *Clostridia* were also high at these two sites, though also present in similarly high numbers at a number of sites across the Wash. The numbers of faecal *Streptococci* were low compared to the other two bacterial forms, and no clear pattern to their distribution was apparent. High numbers were recorded at site 28 towards the mouth of the R. Nene, but also at sites 61 (on the east coast) and 35 (the outermost site sampled). Figure 7 indicates the sites at which the highest values were recorded, for each of the three bacterial types (*E.coli* >900, *Clostridia* > 2800, *Streptococci* > 200, all /100ml). There is a clear tendency for the sites to be concentrated around the south-east corner of the Wash, around the mouth of the R. Gt. Ouse.

3.3 Macroinvertebrate analysis

The results of the identification and enumeration of the animals extracted from each of the 198 Day Grab samples are presented in Table 1. Individual sample results are not included, the values in the table are totals for the three replicate Day grabs taken at each site. To convert the value to a density of animals per metre^2 the number should be multiplied by 3.33.

3.4 Diversity

It is clear from an examination of the data that the Wash supports a diverse fauna; 301 taxa are recorded in the table including juveniles and specimens identified only to genus or above. The taxa are recognised animal groups and are generally species, although higher taxonomic levels (such as the genus or family) have been used when it was not possible to accurately identify further. There were on average 49 taxa recorded at each site, although there were large differences between sites; the range was 11 to 131 taxa. A total of 89302 individuals (all taxa) were recorded in the 198 grab samples; an average of 1353 per site (3 Day Grabs) or approximately 4500 macroinvertebrate animals / metre^2. As for the number of taxa, there were large differences between sites.

The number of taxa and individuals recorded at each site are shown in Figures 8 & 9 respectively. A similar picture emerges from both analyses: the number of taxa and individuals are reduced at the peripheral sites, especially those sites adjacent to, or on, one of the major sandbanks. There is a fairly clear boundary between sites with a large number of species and individuals and this approximates to the line of the 10m depth contour.

The above two variables, number of taxa and individuals, are both used in the calculation of the Shannon-Wiener diversity index (H'). The value of this index has been calculated for each of the 66 sites, and is presented in Figure 10. One problem with the index is that two quite different situations may lead to the same index. If the fauna of a site is heavily biased towards a single (or few) species, occurring in high numbers, then the index (H') will be low. This will also be the case if the distribution of individuals between taxa is more even, but the overall number of taxa is low. To give an indication of the extent to which sites were dominated by a small number of taxa a second index, Percentage Numerical Dominance (PND) has been calculated and the distribution of values is presented in Figure 11. This index is large if the site is dominated by large numbers of individuals of a small number of taxa, and is small if the distribution of individuals between taxa is more even. In both Figures 10 & 11, the height of the bars indicates the size of the index. Colour coding has been used to allow visual separation of sites with values for the two indices in the following ranges:

Colour of Bar	Shannon-Weiner (H')	Percent Numerical Dominance
Black	< 1.00	0 to 20
Green	1.00 to 2.00	20 to 40
Blue	2.00 to 3.00	40 to 60
Red	> 3.00	60 to 80

No particular significance should be attributed to the particular ranges chosen. It can be seen from the two Figures that in general the higher diversity sites (H' > 2.00) are located towards the centre of the Wash in deeper water away from the sand banks. These sites have generally low values of PND. Sites with particularly high values of PND (>60%) are found towards the periphery, on the north-west and south-east coasts, and also in the channels at the mouth of the R. Gt. Ouse. These sites have low values of H'. The situation is not clear-cut however, and there are many instances of adjacent sites with quite different values of H' and PND.

3.5 Taxonomic composition of the fauna

An analysis of the distribution of taxa and individuals between the major taxonomic groups present has been carried out, and the results for the survey as a whole are presented in Tables 3 & 4 below. The taxa recorded were distributed among the major faunal types as follows:

Table 3. Composition of the Wash fauna by taxa.

Taxonomic Group	Taxa in Group	Percentage of Taxa
Crustacea	97	32%
Echinodermata	12	4%
Mollusca - bivalves	32	11%
Mollusca - others	18	6%
Oligochaeta	6	2%
Polychaeta	119	39%
Others*	17	6%

*This group includes Anthozoa, Nemertea, Pycnogonida, and Tunicata.

Table 4. Composition of the Wash fauna by individuals.

Taxonomic Group	Individuals in Group	Percentage of Individuals
Crustacea	10144	11%
Echinodermata	1582	2%
Mollusca - bivalves	10961	12%
Mollusca - others	1053	1%
Oligochaeta	1404	2%
Polychaeta	58717	66%
Others*	5441	6

*This group includes Anthozoa, Nemertea, Pycnogonida, and Tunicata.

Polychaetes clearly dominate the Wash fauna as sampled, both in terms of the number of taxa and individuals. Next in order of importance by taxa were the crustacea and mollusca. This is a fairly typical finding for a coastal macroinvertebrate survey.

The breakdown into the major taxonomic divisions of the taxa and individuals recorded has been carried out for each of the sampling positions, and the result is presented in Figures 12 & 13. Each column of the small bar charts represents the proportion of taxa in the major group. These are in the sequence; Crustacea (black), bivalve Molluscs (red), other Molluscs (green), Polychaeta (blue), Oligochaeta (cyan), Echinodermata (yellow) and 'others' (magenta). Over the majority of sites the pattern is very similar, with polychaetes representing approximately 40% of the taxa (70% of individuals). In a few instances another group assumes greater importance, such as at site 29 and 52 where molluscs dominate in terms of the number of individuals, and sites 9, 20 and 56 where crustacea are more important. In most cases however, polychaetes are still the dominant group in terms of the number of taxa represented.

It should be remembered that this is an analysis of the fauna as determined from the grab sampling. It would not necessarily reflect the situation for the whole Wash if it was possible to sample its entire fauna. Molluscs (among other taxa) would almost certainly assume a somewhat greater importance, at least in terms of the number of individuals.

No nationally rare species were recorded in the present survey, although as discussed above, only those habitats which were amenable to Day grab sampling were effectively sampled. It is known from dredge samples and samples or photographs collected by divers that, for example, large anemones are found in the deeper parts. These, and other relatively well separated or deep burrowing taxa, have definitely been under-sampled.

3.6 Distribution of selected species.

Certain species, particularly among the polychaeta, were very common and widespread and approximately 10% of taxa were recorded at more than 50% of the sites. This is consistent with the widespread occurrence of the major sediment types described above. Table 5 presents information on the total number of sites at which a taxon was recorded, together with the total number of individuals recorded. It is clear from the data in Tables 1 & 5 however, that many species are apparently restricted in their distribution patterns, although the reason for the restriction may not necessarily be apparent from a consideration of the sediment and other environmental data.

To illustrate such differences, the distribution patterns of a number of species from related taxonomic groups have been plotted. Species have been selected to illustrate particular patterns, not necessarily because of any specific 'indicator-species' status. These distributions are shown in Figures 14 to 26, and are described briefly below.

3.6.1 The polychaete genus *Nephtys*.

Four species of *Nephtys* were recorded in the survey; *N. hombergii*, *N. cirrosa*, *N. caeca* and *N. longosetosa* (in order of decreasing frequency of occurrence) and their distribution patterns are shown in Figures 14 to 17. The genus was recorded at 65 of the 66 sites sampled but it is clear that the individual species are concentrated in certain areas. The two most common species, *Nephtys hombergii* and *N. cirrosa*, have complementary distributions. The former was found in the greatest number at sampling points towards the periphery of the Wash, particularly towards the south around the channels, but away from the immediate vicinity of the sand-banks. The latter species was also most frequent towards the coast, but appears to have a much stronger association with the sandbanks. The remaining two species were much less common, but they too appear to be located in specific regions. *Nephtys caeca* occurs at sites in the centre part of the Wash in generally deeper water, while *N. longosetosa* was recorded at only a small number of sites towards the north-west.

An examination of the sediment data for the sites at which each species was found, including that presented in Figures 2 to 5 reveals that *N. hombergii* occurs at sites having finer sediments with a high proportion of clay and silt, and a correspondingly high organic carbon content. The apparent sediment preferences of *N. cirrosa* are quite different; the species is much more common in coarser sediments, particularly those with a mean particle size of around 200µm. The patterns for *N. caeca* and *N. longosetosa* are less clear, though the former appears to be associated with muddy sediments, like *N. hombergii*, but at those with a larger mean particle size. *Nephtys longosetosa* was found in very small numbers at sandy sites, possibly of coarser grade than *N. cirrosa*

3.6.2 The polychaetes *Lanice conchilega* and *Lagis koreni*.

The situation described for *Nephtys* is notable for the degree to which closely related species occupy different regions of the Wash. A complementary situation is seen in the distribution patterns of two tube-building worms from different families, *Lanice conchilega* (Terebellidae) shown in Figure 18 and *Lagis koreni* (Pectinariidae) in Figure 19. These two species have very similar distributions, in medium / coarse muddy sands away from the immediate edge of the sandbanks *ie*. in deeper water.

3.6.3 The echinoderms *Ophiura albida* and *O. ophiura*.

These two brittlestars are commonly recorded, the former more than the latter. Their distribution patterns (Figures 20 & 21) overlap, though *O. ophiura* is apparently more common closer inshore, possibly in coarser sands than *O. albida*.

3.6.4 The cumaceans *B. scorpioides*, *C. goodsiri* & *P. longicornis*

Cumaceans are small crustaceans occurring at most of the sites sampled. *Pseudocuma longicornis*

(Figure 22) is very widespread, though with higher numbers along the eastern coast, in muddy sands. *Bodotria scorpioides* (Figure 23) is clearly found at the deeper and more centrally placed sites with a more diverse sediment type. The third species in the group *Cumopsis goodsiri* (Figure 24) has a quite different distribution being found in much shallower sites, with coarser sands.

3.6.5The bivalve molluscs *Angulus tenuis* and *Abra alba*

These two small bivalves are further examples of the shallow / deep, sandy / silty division found for many groups. Figure 25 shows the distribution of *A. tenuis*, that of *A. alba* is given in Figure 26.

3.6.6 The polychaete worm *Sabellaria spinulosa.*

One species recorded in the survey, *Sabellaria spinulosa*, has a particular influence upon the fauna of sites where it occurs. This polychaete worm builds reef-like structures from coarse sands, resulting in the creation of a large number of niches for other species. The tube aggregates vary from a patchy covering on rocks to extensive reefs and may be found in areas of high sediment load and water movement. The species is recognised as an important food species for a number of species including fish and shrimps, particularly the pink shrimp which is still fished commercially in the Wash. Sites where *Sabellaria* was found were typically very diverse with more than twice the number of species being recorded compared to sites where *Sabellaria* was not present.

Table 6. Number of taxa and individuals found at sites having *Sabellaria*.

Number of Sabellaria*	Number of sites in category	Average number of Taxa	Average number of individuals**
>100	8	95.9	2670
<100	58	42.6	975

* Total number of *Sabellaria* individuals recorded in the three grab samples taken.
** excludes *Sabellaria*

3.7 Cluster Analysis

In addition to the consideration of the distribution of individual species described above, the data set has been examined using cluster analysis. This multivariate technique compares the taxonomic composition of each site in turn with that of all of the other sites. A matrix of similarity index is calculated and sites (and site-groups) are grouped according to a calculated level of similarity. The results of this analysis are presented in Figure 27 in the form of a dendrogram which shows the progressive linking of sites and site-groups. Sites linked towards the bottom of the dendrogram are more similar than those linked towards the top. For the purposes of the present study the data were fourth root transformed to reduce the excessive influence of highly dominant species. The Bray Curtis similarity index was used and sites were linked according to the group averaging strategy.

The analysis was carried out twice, first as described above, using all of the data. A second analysis was made following removal of uncommon species at each site. These are frequently chance occurrences and are in effect 'noise' which may obscure the main picture. Rather than simply removing all species occurring at only one site, or all singletons in the data-matrix (both commonly utilised reduction strategies) the approach adopted was to consider each site independently and remove those species forming less than 3% of the total number of individuals at that site. The result of this was considerable in terms of the number of taxa in the final data-matrix - a reduction of *c.*70% from 300 to 75 taxa. Repeat analyses with this and other reductions, and comparison with the result obtained from the original matrix were extremely similar. The main difference observed between the resulting dendrograms was a general increase in the similarity between sites in the analysis from the reduced data set, as a result of the removal of 'noise', the actual groupings produced were substantially the same. The dendrogram resulting from analysis of the data set, following the 3% reduction strategy, is that shown in Figure 27.

Determination of what constitutes a 'cluster-group' is to a large extent subjective, and involves an examination of the clusters and the raw data-matrix. For the purposes of the present analysis five main groups of sites have been recognised these have been coded A, B, C, D & E. Sub-groups within A and B have been recognised and are coded A1 & A2, B1, B2 & B3. The division of the sites into these groups has been indicated on Figure 27 by colour coding the groups as follows:

A1-blue; A2-green; B1-red; B2-yellow; B3-orange; C-magenta; D-cyan; E-black

Following examination of the data matrix and analytical results, site 48 has been included in group A2, although it should perhaps best be considered to belong to an 'intermediate' position between A1 and A2.

The spatial location of the eight groups described above is indicated in Figure 28. Sites have been colour coded according to the colour given to the cluster group to which they were assigned by cluster analysis.

The sites belonging to the various cluster groups are clearly spatially related, although the situation is not straightforward. Group A sites are clearly located in the central parts of the Wash with their major axis oriented in a NE - SW direction. Group A1 sites are located towards the seaward end of the axis, while group A2 sites are more central. Group B sites are much more peripherally located, though the three sub-groups are intermixed. Sites in group B1 occur over much of the eastern part of the area, but also around the south and the west. Groups B2 and B3 are more easily located, the former apparently being sites from the sandbanks, possibly some way above LWM. The latter also appear to be associated with banks but rather more towards the periphery of the bank.

Groups A and B and their respective sub-groups are distinct and, within each major group, very similar. The three remaining groups C to E, have lower average within-group similarities. Group C sites are found over the whole study area, on medium / coarse sands. Groups D and E in the main contain sites found towards the mouth of the Gt. Ouse, though one site on the western side of the Wash is also grouped in D.

To aid identification of the taxa characterising the cluster groups the site data from Table 1 have been sorted according to the cluster group to which the sites belong. The average number of individuals of each taxon has been calculated for each cluster group, and these values have been used to sort the taxa within each of the cluster groups. The results of this analysis are presented in Table 5, only the top 40 taxa (where more than 40 were recorded) are shown.

Examination of the taxa lists for sub-groups A1 and A2 shows clear similarities (the groups were linked at approximately 60%), both have high numbers of *Abra* and *Chaetozone*, which are silty-sand species. There are many other similarities within the top 40 taxa. The major difference between the two groups is the presence of high numbers of *Sabellaria* (reef-building polychaete) at sites in group A1.

The three sub-groups of group B are similarly related. Group B1 is more clearly different, with *Abra alba*, *Capitella capitata* and *Nephtys hombergii* being much more common than in sub-groups B2 or B3. The latter species is more common in muddier sediments than *N. cirrosa* which is found in both

B2 and B3. The relative importance of *Spio* sp. and *Spiophanes bombyx* and possibly *Cumopsis goodsiri* and *Pseudocuma longicornis* between the two groups may explain their separation.

Group C sites have a quite different fauna, the top two taxa, *Micropthalmus similis* and *Hesionura elongata* were not recorded in the top forty of any other group, and the numbers of other taxa were generally low. Group D has very few taxa, and this alone probably accounts for its separation from the others, as the few taxa present were recorded elsewhere.

Group E also has a reduced fauna, with juvenile *Nephtys* sp. and *Cerastoderma edule* (cockles) being the two dominant taxa.

Although the situation is not clear-cut, an examination of the sediment characteristics of the sites (see Table 2) reveals that the cluster groups, formed on the basis of the biological similarity of sites, have broadly similar sediment types. This is summarised below:

Group A1 - >15m depth, mixed sediments

Group A2 - <15m depth, mixed sediments

Group B1 - <10m depth, muddy sands

Group B2 - <5m depth, cleaner sand

Group B3 - <10m depth, clean sand

Group C - <10m, coarse sands ?

Group D - <5m ?

Group E - <5m high silt content?

The above descriptions are based on an examination of the information in Table 2, together with Figures 2 to 5. Groups C to E are queried as it is not apparent from this analysis whether there are distinctive sediment differences.

3.8 Nonmetric Multidimensional Scaling (MDS)

Although classification analysis (cluster analysis) is a valuable technique for examining the biological relationships between samples (or, in this case, sites) other techniques exist and may prove useful and may provide further insights into relationships. Non-metric Multidimensional Scaling (MDS) is a particularly valuable technique, making few assumptions about the distribution of the data to be examined, and taking as the starting point a matrix of similarities produced in the same manner as that for cluster analysis (in fact the same matrix has been used in the following analyses). While cluster analysis utilises the absolute levels of similarity between sites (calculated using the Bray-Curtis coefficient as described above) MDS uses only the *relative* similarity of sites (Clarke, 1993)

The technique has been applied to the same similarity matrix produced from the reduced data set described above, in an attempt to determine more precisely the reason for the observed grouping of sites. The output from MDS is displayed not as a dendrogram, but rather as a two-dimensional plan of the similarities between sites. This is not a representation of the spatial distribution of sites, but of the relative similarities between sites. Thus, sites having a similar fauna will have a high similarity coefficient and will appear close together on the MDS plot, whilst less similar sites will appear at increasing distances. The MDS program attempts to place sites in two dimensions such that the best representation of what is in fact a multidimensional situation is obtained. A measure of the success of the program is given as a 'stress' value, where smaller values indicate a more successful result. A value of less than approximately 0.2 indicates that a fair representation of the situation has been achieved. The plots have no scale, and may be viewed in any orientation, though for clarity each of the plots presented here has been oriented in the same manner.

The results of the first MDS analysis of the data set are presented in Figure 29. Also indicated on this Figure are the groupings of sites achieved by cluster analysis. Sites linked at a high similarity by cluster analysis appear closer together than sites less closely linked. A fair degree of concordance between the two techniques can be seen, suggesting that the groups are reflecting 'real' biological differences between the sites. The 'outlier' sites are those assigned to groups C to E and which had a lower similarity than the remaining sites in groups A and B. The latter groups form a major cluster, though the subdivisions have been maintained.

A major difference of the MDS ordination, compared to the dendrogram, is that sites are now arranged in two dimensions and other associations become apparent.

Some indication of the meaning of the spatial distribution in the ordination can be obtained by overlaying the values of the environmental variables measured at each site onto the position of the same site in the MDS plot. This has been carried out for a number of the variables measured, and for a calculated depth category, discussed below. These overlays, each onto the same MDS ordination shown in Figure 29, are shown in Figures 30 to 36. In all of the overlays some values will be so small as to be unclear. Reference should be made to Figure 29, and if a site appears to be missing then the value for variable plotted is to small to show.

The depth category shown in Figure 33, was obtained by examining the position of the site on an Admiralty chart. Sites were classed as (S), where chart depth was < 5m, (I) where depth was between 5 and 10 m and (D) where the depth was greater than 10m. In the main the I and D category sites are located to the top right of the Figure, while the S sites are to the lower left. A test of the groups indicates that the arrangement of sites in categories I and D are not significantly different from each other but that each is significantly different from category S (ANOSIM test $p<1.5\%$).

A number of axes of variation are apparent, though two main trends seem clear. First, considering Figures 30 & 31, there is a general increase in mean and median particle size from the bottom right of the diagram to the top left. The situation is more confused towards the right of the diagram, among those sites assigned to group A1 & A2. This group can be seen to contain only sites classified as I or D (Figures 32 & 33).

The percentage of clay and silt in the sediment at the sites is a complementary plot to Figures 30 & 31. The variables are not independent so this is not unexpected. Following a similar pattern is the organic carbon content, which is strongly related to the percentage of clay and silt, again a reasonable result, considering that fine organic particles will behave in a similar manner to fine silts.

The count of *E. coli* for the sites is given in Figure 36. It is interesting to note that the two sites with very high values (43 & 51) cluster and are ordinated quite separately from the remaining sites.

In attempt to determine the basis for the subdivision of group B into B1, B2 & B3, a second MDS analysis has been made of the sites in these three groups alone. Free from the constraints imposed by the need to consider sites from other groups, MDS will re-position sites to reflect the similarities (and dissimilarities) within the group. The initial MDS plot is presented in Figure 37.

The values of environmental variables have been overlaid as described above. No clear picture emerges, most of the sites have much the same median PS, though four are particularly fine, with high clay silt content (see for example Figure 38, an overlay of median particle size). There is some evidence for an association of the sites with the standard deviation of phi (f) Figure 39. The latter is a measure of particle size (negative logarithm, small values correspond to large sediment size) and the standard deviation is related to sediment sorting *ie.* the degree to which the particles in the sediment are of similar size, regardless of that size. Phi SD varies in the sequence B1>B2>B3 *ie.* the sorting is greater at B3 sites than those of B1. Reference to Figure 3 indicating the position of sites with their associated PhiSD values indicates that those sites with the highest values appear to be located at the edge of sandbanks.

A possible summary of the overall situation in keeping with the observations and analyses described so far would be as follows:

A major biological division of sites into those below 10m (group A) and those above (groups B, C, D & E) is possibly a result of wave action, and associated sedimentological differences. Within group A there is some evidence that more detailed sediment differences result in the split between subgroups A1 and A2, particularly concerning the level of very fine sediments. The remaining sites (groups B, C, D & E) are split by particle size with group C being generally coarse and E being much finer. The reason for the division of groups B and D is less clear. Within group B there is some evidence to suggest that the groups are related to sediment sorting, which is in turn related to the action of water currents.

4. Discussion

The main aim of the survey was to describe the distribution of the fauna, and to identify, if possible, any regions where the fauna was 'unusual' or apparently influenced by anthropogenic 'polluting' factors. The results presented above have shown that the Wash clearly has a diverse fauna, particularly in the deeper waters. Analysis of the distribution of individual species, and groups of species, indicates that biologically distinct regions may be recognised. As discussed, these appear in the main to be related to the physical characteristics of the sediment, although a depth factor is also involved. Sites below approximately 10 metres are more diverse than those in shallower waters, probably due to the more diverse sediment types found. Even within the deeper sites there is evidence for the influence of particle size affecting the fauna.

Sites shallower than 10 metres do not have a uniform fauna however, and though particle size is important, other factors are involved. Sites described above as belonging to group B have generally similar median particle size but different faunal composition. In this case the degree to which the sediment is sorted appears to be important (see MDS of group B with PhiSD overlay, Figure 39; also compare the location of cluster groups B1 to B3 in Figure 28 with the distribution of PhiSD in Figure 3).

Major differences in the fauna of adjacent sites can generally be attributed to differences in the sediment. This is well illustrated in the genus *Nephtys*, as described above. Knowledge of such relationships, and their effect upon the distribution of the fauna is important for a variety of reasons. Major changes in channel position or size, whether natural or man-made, may influence the local fauna as a result of sedimentological changes. Flow changes may also result in changes in the percentage of fine sediment in an area, with possible associated faunal changes. While not necessarily 'harmful', knowledge of the possibility of such changes is important.

There is a close correlation between the organic carbon content of a sediment and the proportion of clay and silt it contains. This is a well known relationship and is of importance given the association of certain species with finer sediments, particularly if it is considered desirable to monitor fauna for heavy metals or pesticides, which are themselves closely related to sediment size.

From the analysis of the data discussed above there do not appear to be major areas with an unusually poor or aberrant fauna; where low numbers of species or individuals do occur, natural physical stress seems likely to be involved. The distribution of the highest bacterial counts made during the survey (Figure 7) suggests that two sources may be involved (presumably King's Lynn STW and possibly Hunstanton). There is some evidence for possible disturbance of the fauna found at sites in the immediate vicinity of the R. Gt. Ouse, particularly those in the channels (Cluster groups D & E). The survey was designed more to provide general descriptive information on the biology of a large area, rather than a detailed study of pollution effects. Accordingly it is difficult to be sure if the differences in the fauna of these sites are natural, or possibly the result of a polluting influence. A more specific study of these areas and with these questions in mind would be worthwhile.

Overall the survey provides extremely valuable data on the area, and other valuable information almost certainly remains within the data. An important baseline has been obtained, which will facilitate future monitoring.

5. References

Clarke, K.R. 1993 *Non-parametric multivariate analyses of changes in community structure.* Austr. J. Ecol. **18**, 117-143

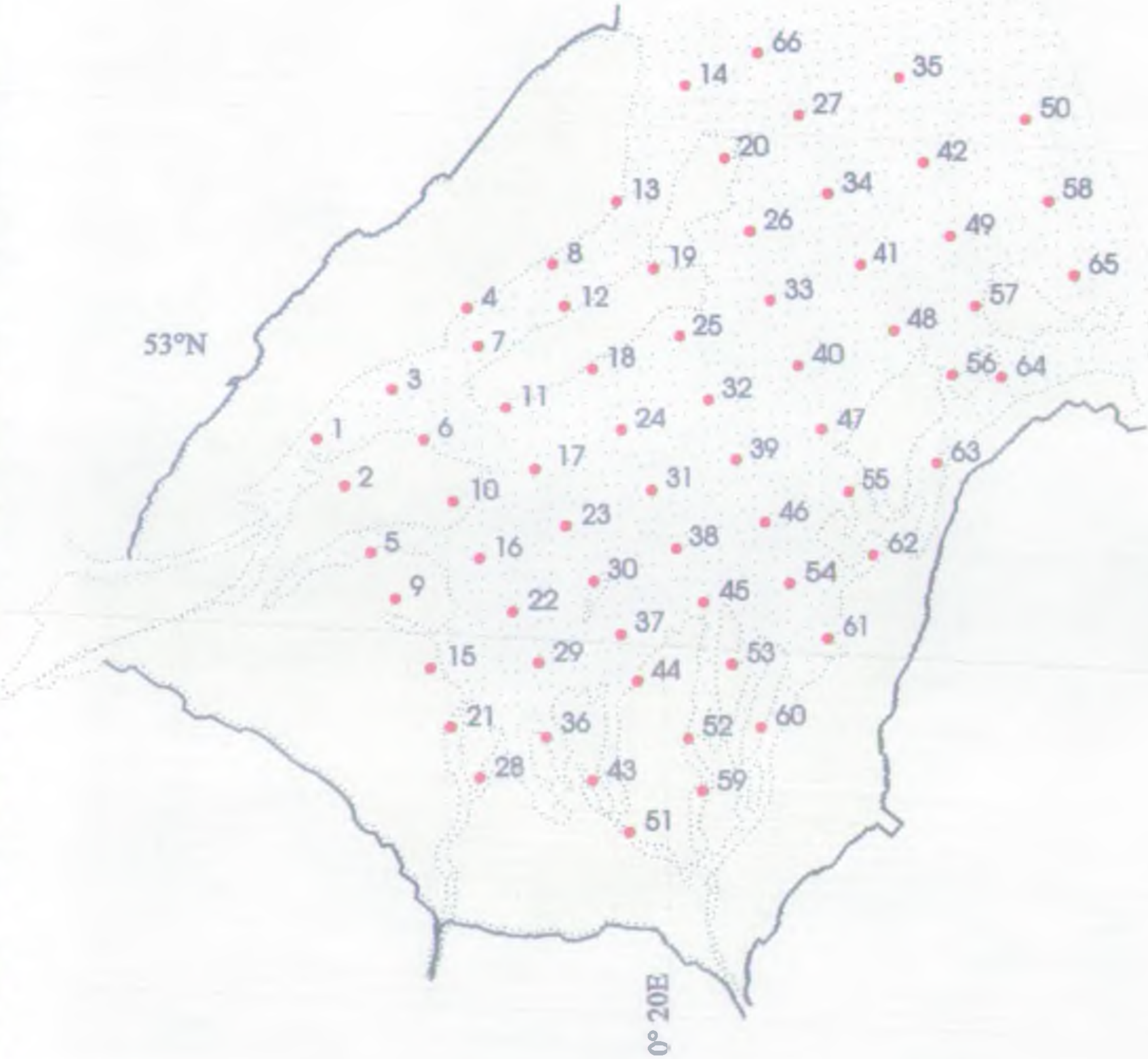

Figure 1. Location of the 66 points sampled. The approximate position of the major sandbanks is indicated.

Figure 2. The median particle size of the sediment recorded at each of the sampling points. Height of bar indicates size (μm). [Max.=1064]

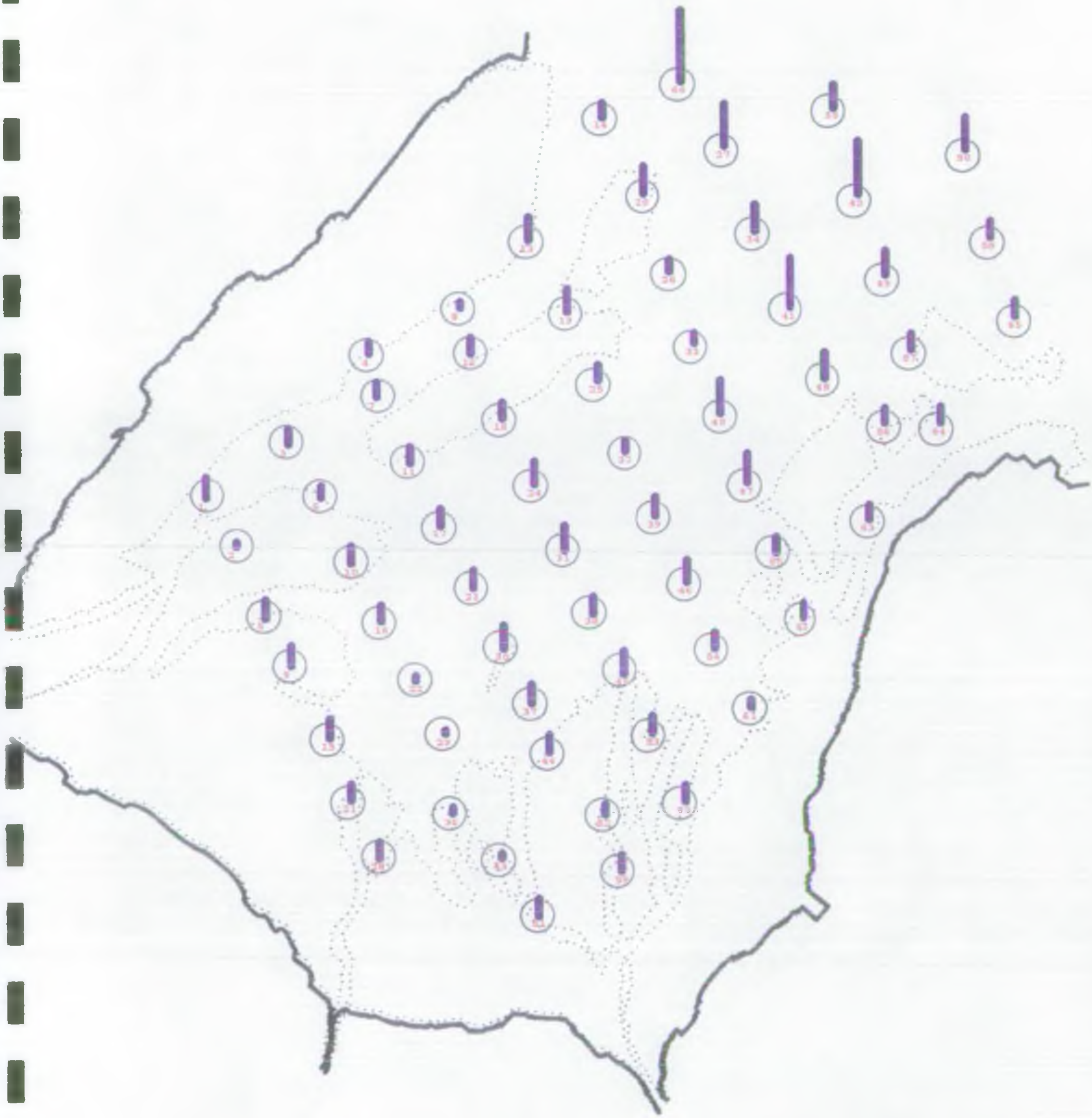

Figure 3. The standard deviation of the phi(ϕ, particle size) value for each of the sampling points. [Max.=3.6]

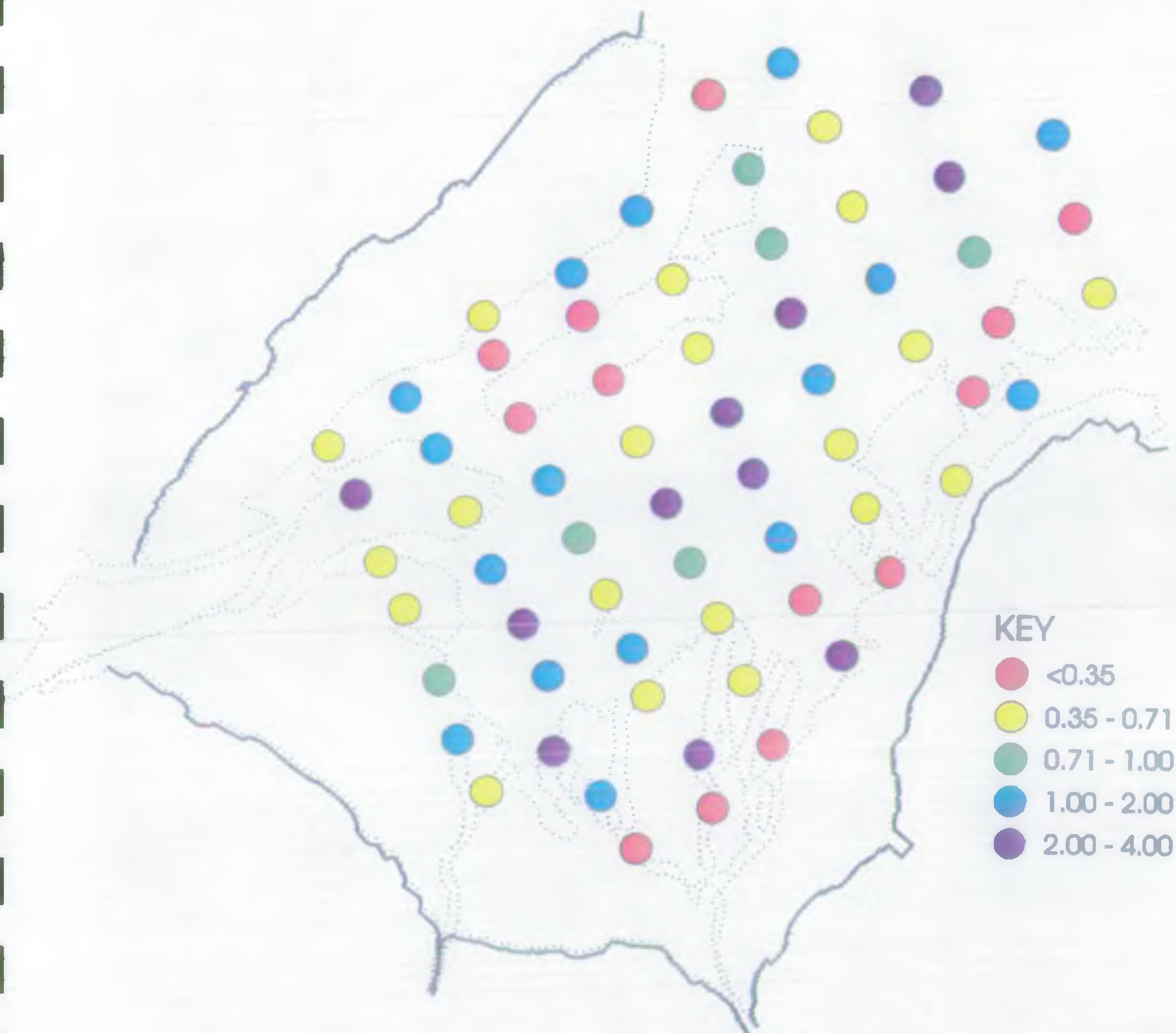

Figure 4. The percentage of clay and silt in the sediment. Height of bar indicates percentage. Blue bars<5%. Red>5%. [Max=73]

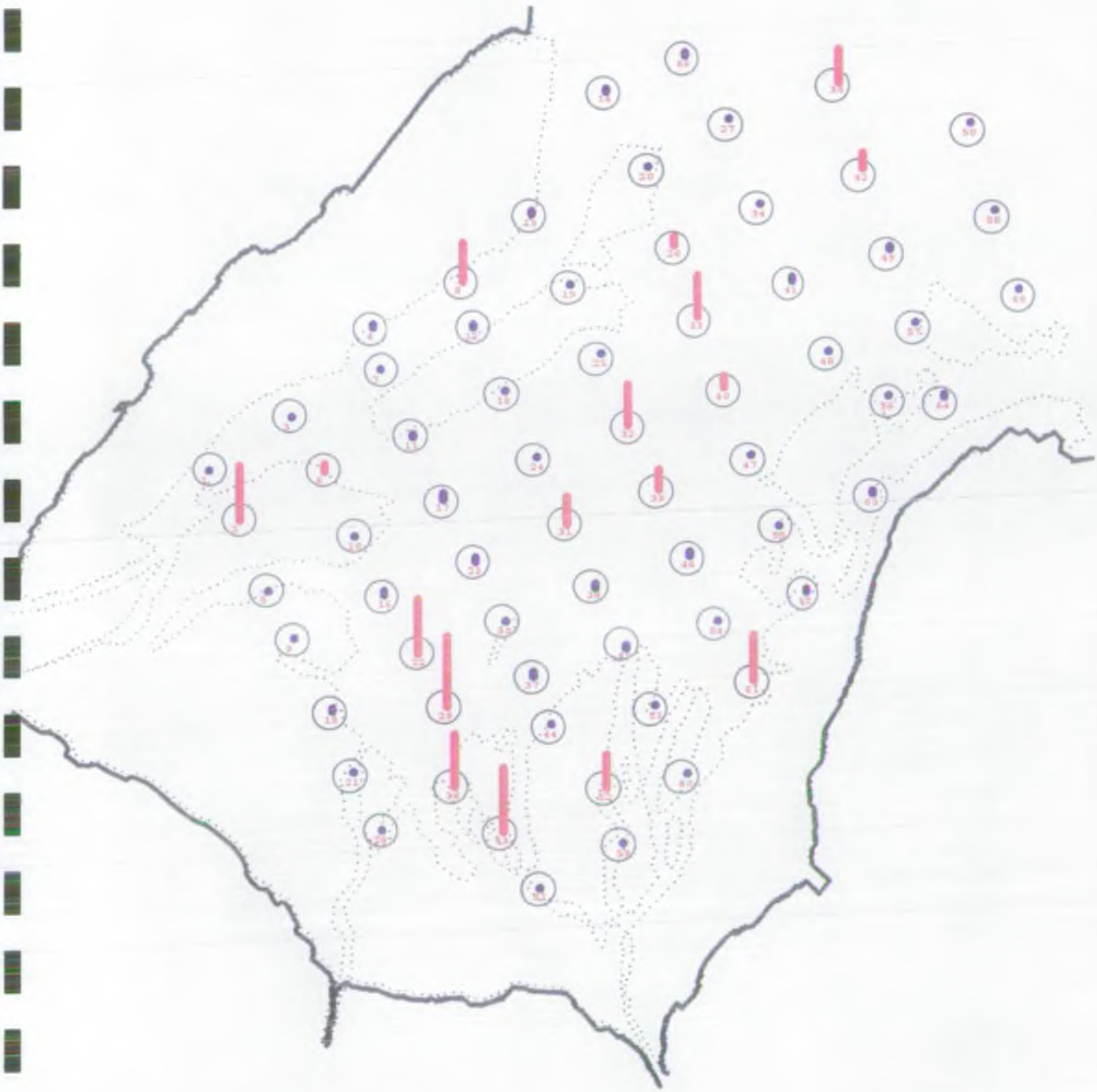

Figure 5. The distribution of the major sediment types in the Wash, as determined from field observations at the 66 sampling positions.

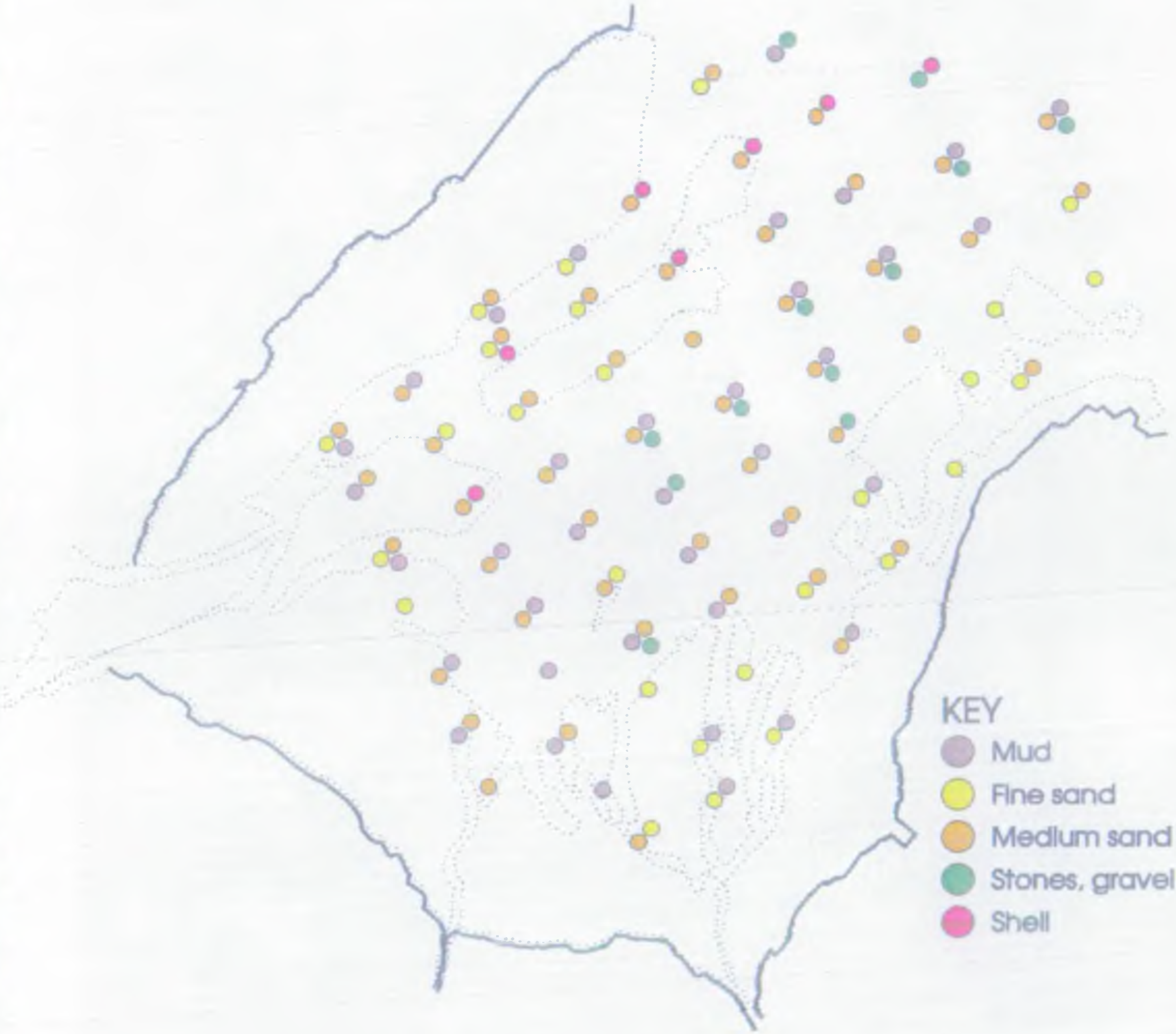

Figure 6. Standardised metal concentrations for each of the 66 sampling sites, sorted in increasing order (see text for further details).

Figure 7. The distribution of the highest counts of each of three bacterial forms.

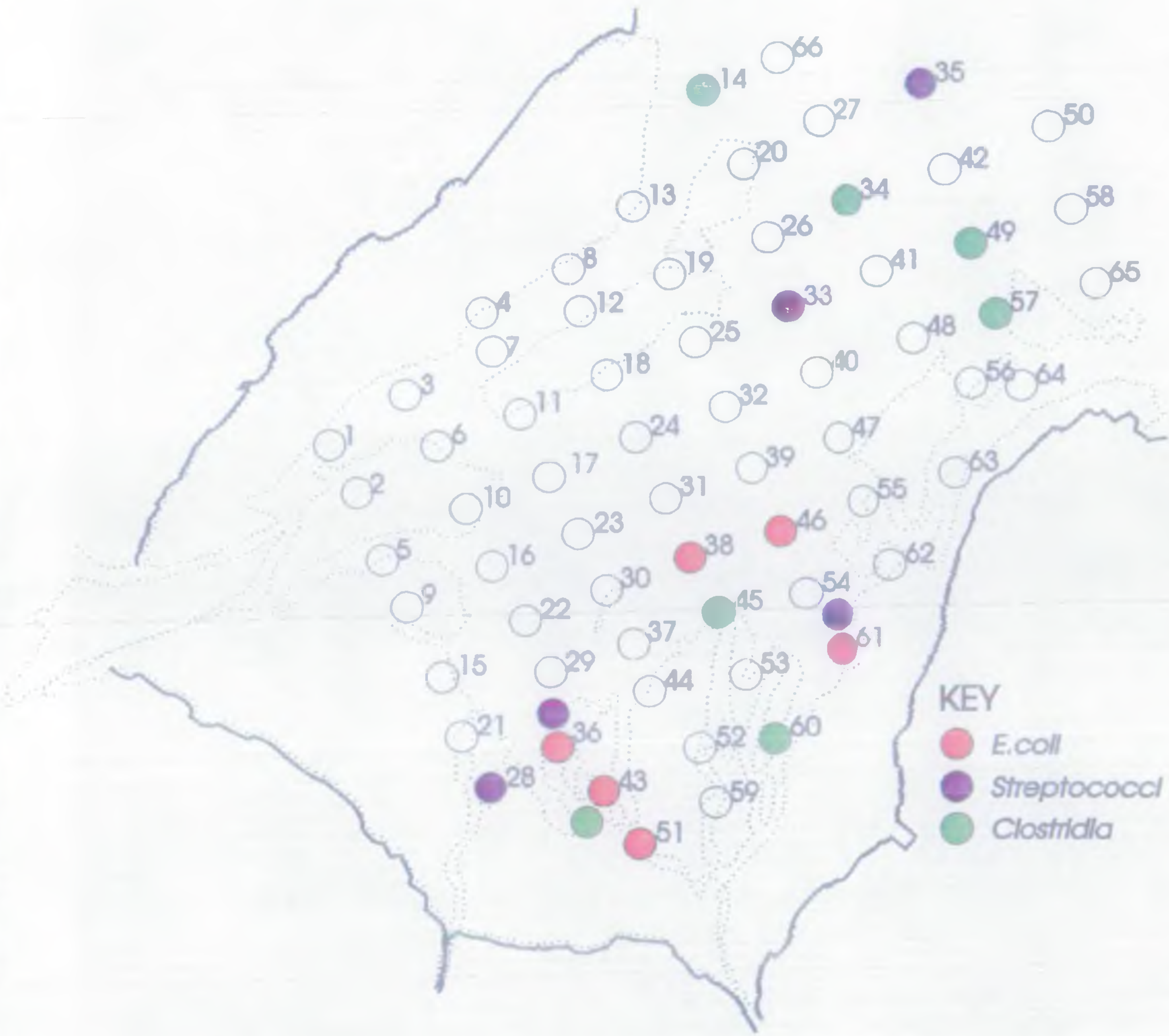

Figure 8 The number of taxa recorded at each of the 66 sampling points [Max.=131]

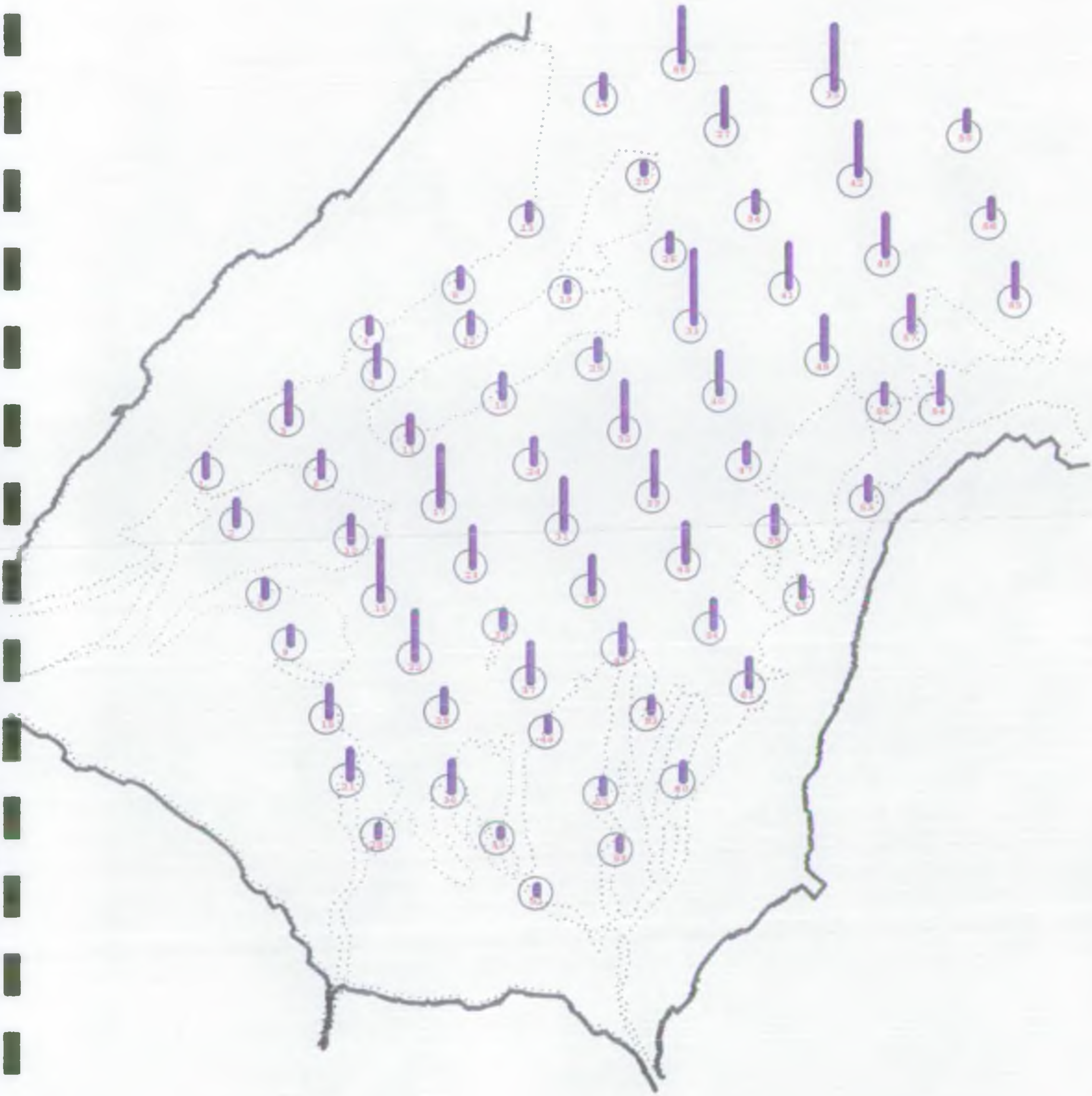

Figure 9. The number of individuals recorded at each of the 66 sampling points.[Max.=8833]

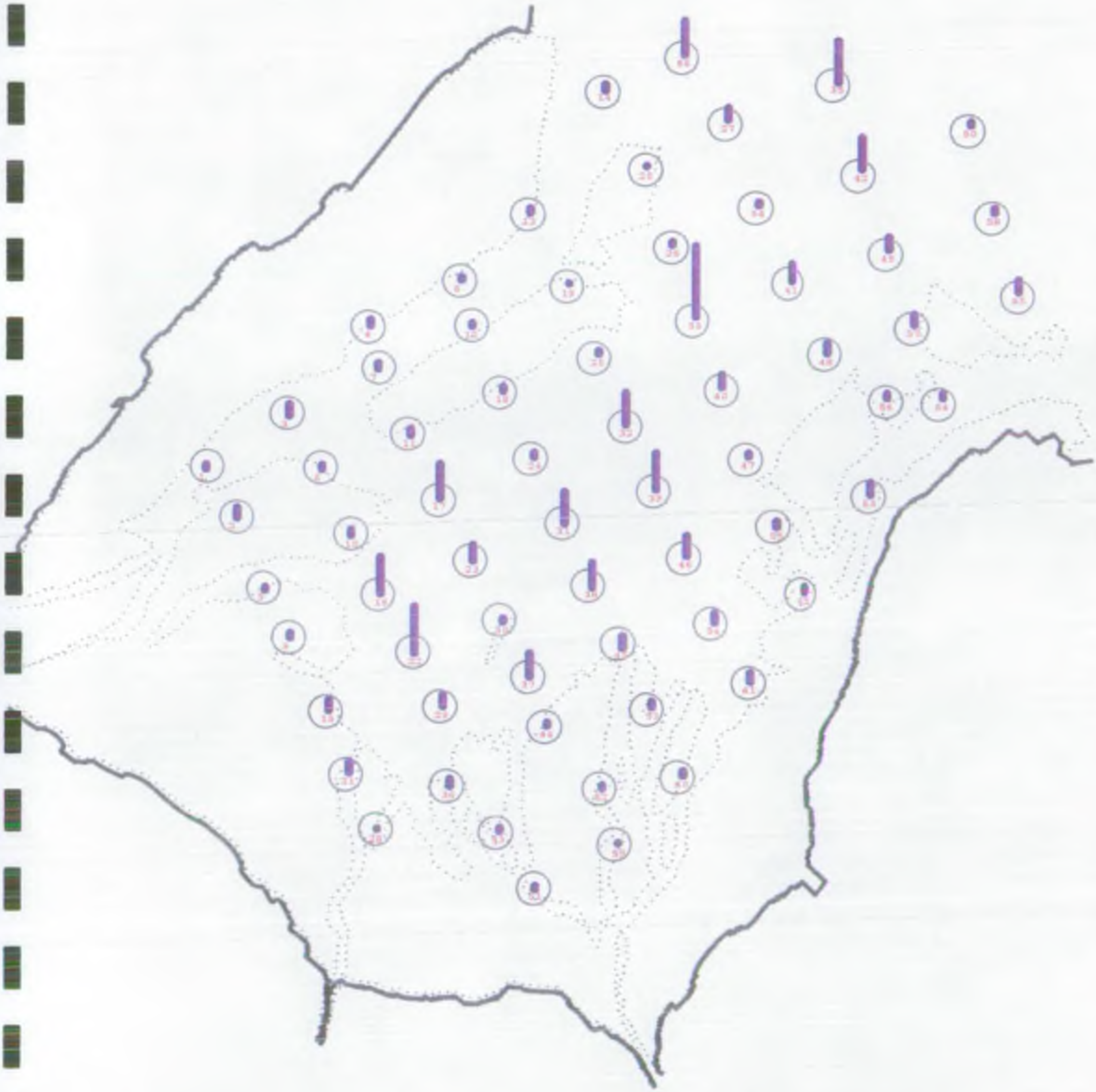

Figure 10. The value of the Shannon-Wiener diversity index for each of the 66 sampling points.[Max.=3.63]

Figure 11. The value of the Percentage Numerical Dominance index for each of the 66 sampling points.[Max.=78.66]

Figure 12. The proportion of taxa in each of seven taxonomic groups recorded at each of the 66 sampling points.
Black-crustacea, Red-bivalve molluscs, Green-other molluscs, Blue-polychaetes, Cyan-oligochaetes, Yellow-echinoderms, Magenta-others

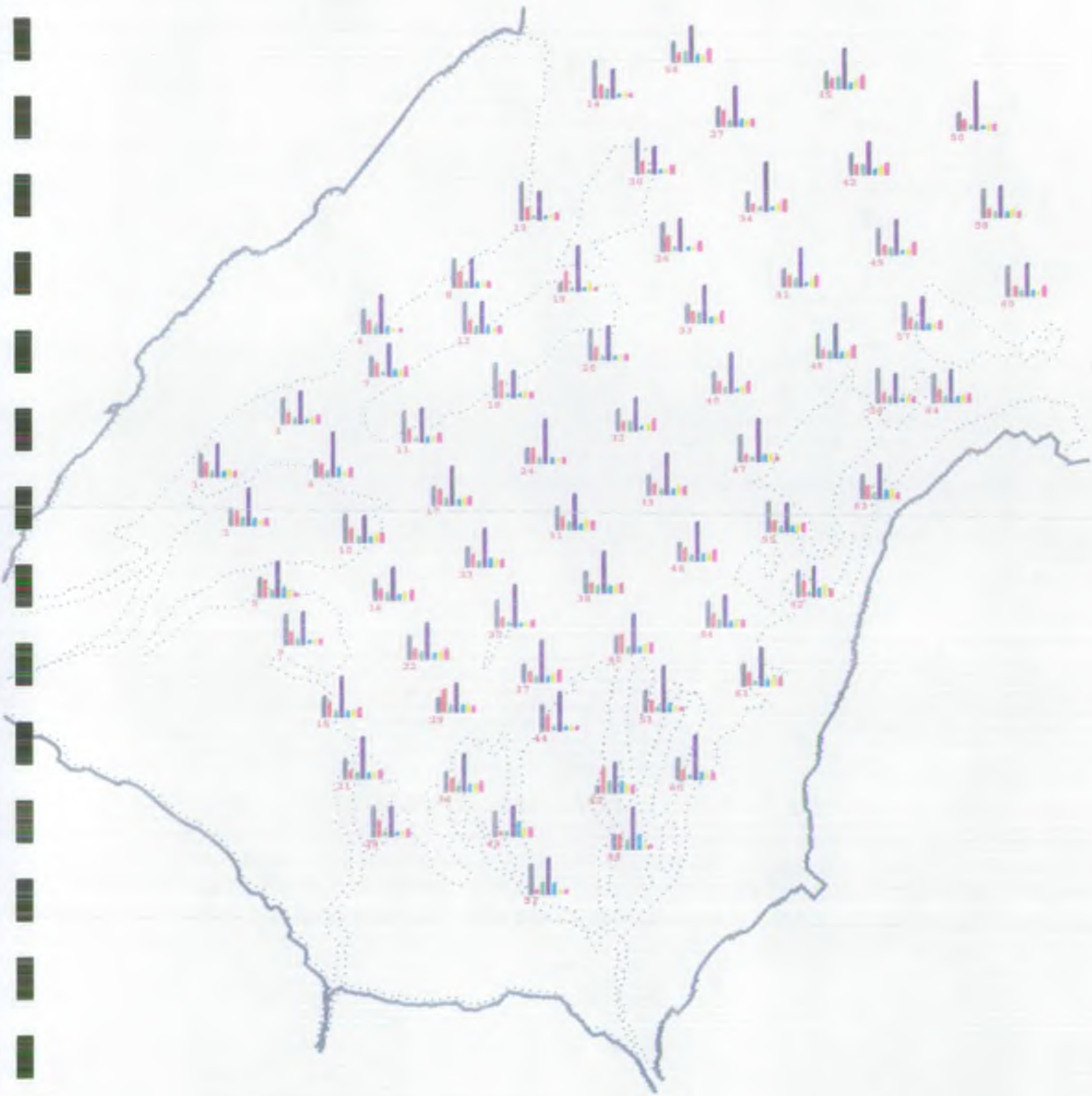

Figure 13. The proportion of individuals in each of seven taxonomic groups recorded at each of the 66 sampling points.
Black-crustacea, Red-bivalve molluscs, Green-other molluscs, Blue-polychaetes, Cyan-oligochaetes, Yellow-echinoderms, Magenta-others

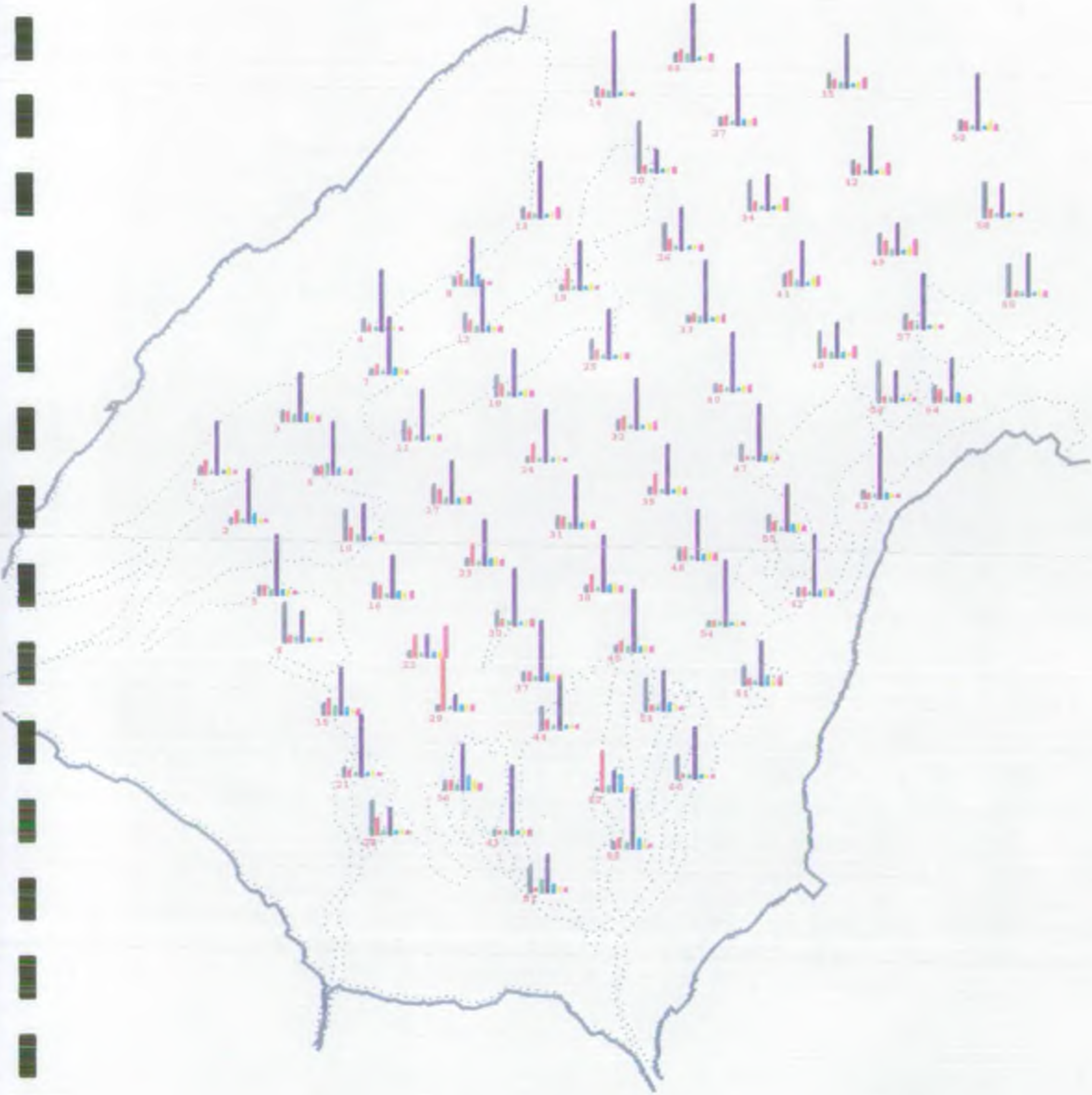

Figure 14. Distribution of the polychaete worm *Nephtys hombergii* [Max.=116]

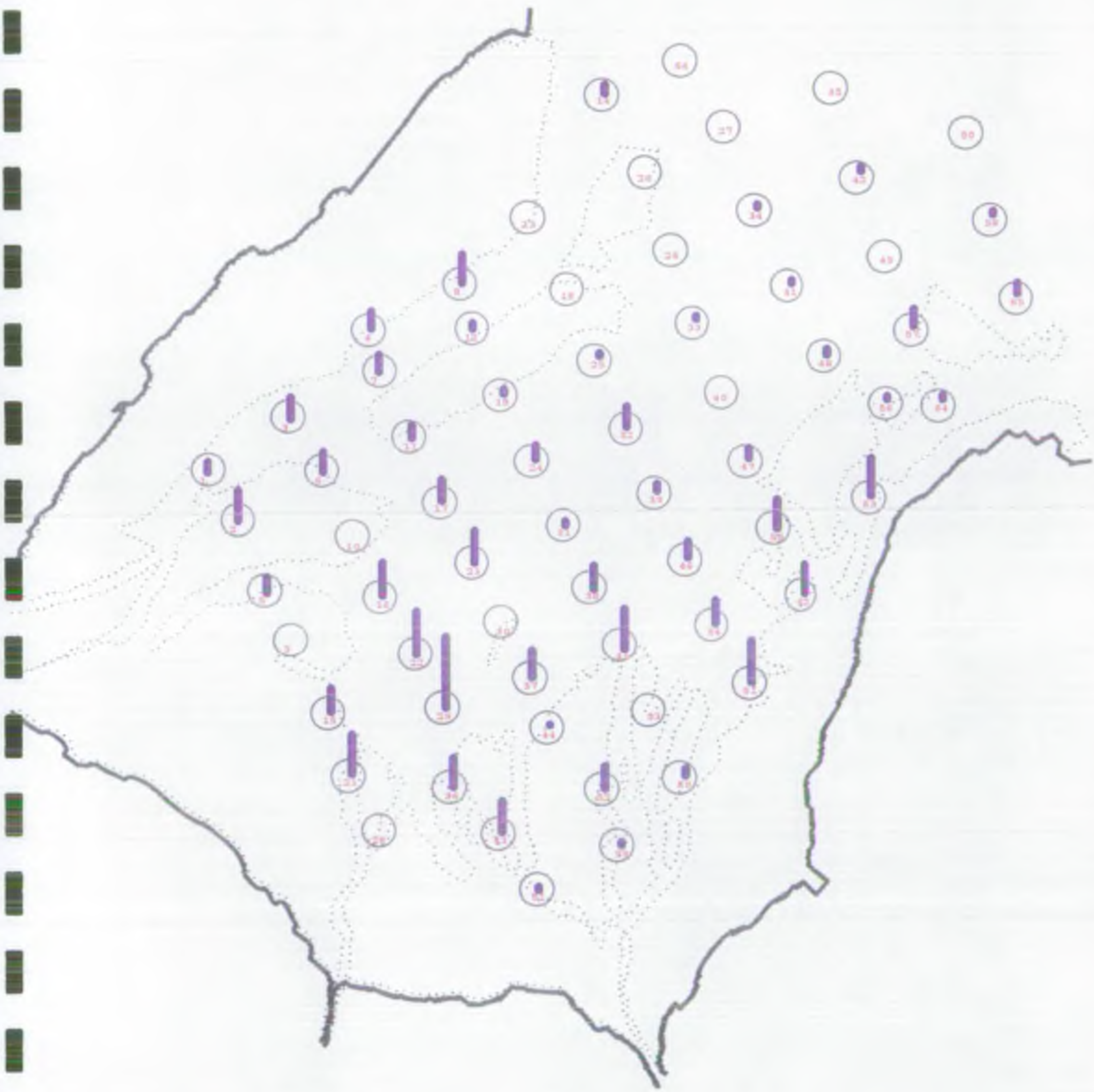

Figure 15. Distribution of the polychaete worm *Nephtys cirrosa* [Max.=93]

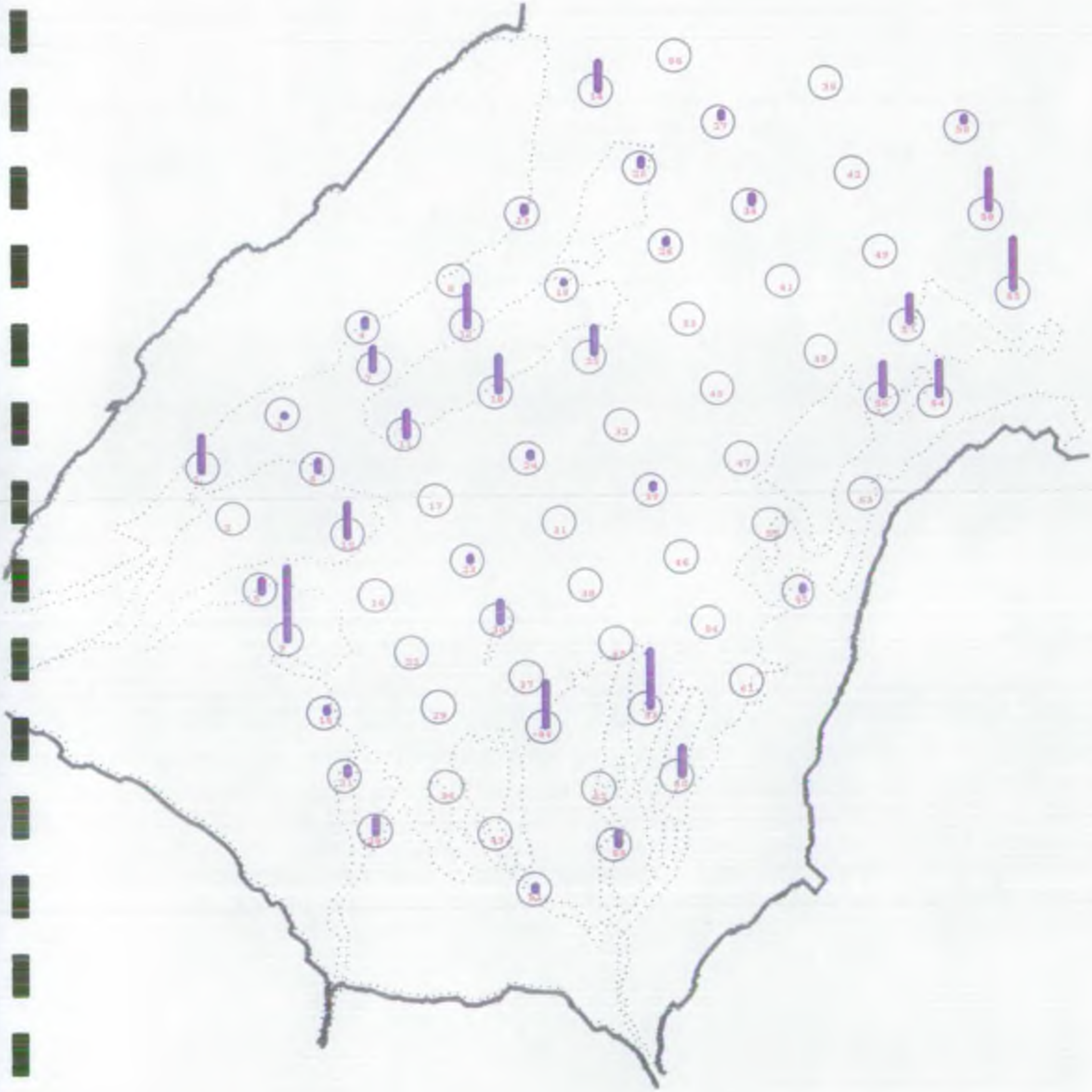

Figure 16. Distribution of the polychaete worm *Nephtys caeca* [Max.=4]

Figure 17. Distribution of the polychaete worm *Nephtys longosetosa* [Max.=2]

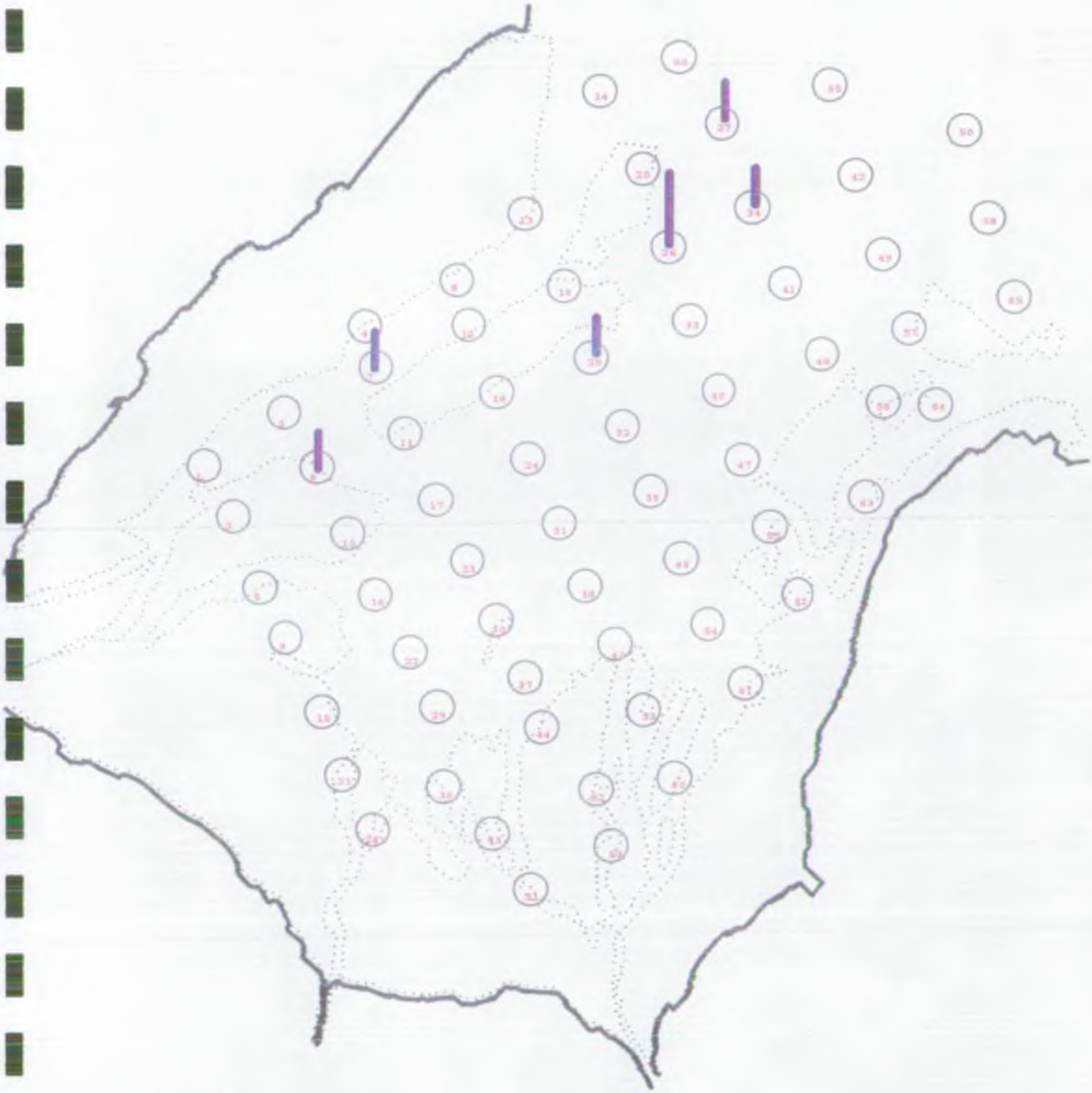

Figure 18. Distribution of the polychaete worm *Lanice conchilega* [Max.=233]

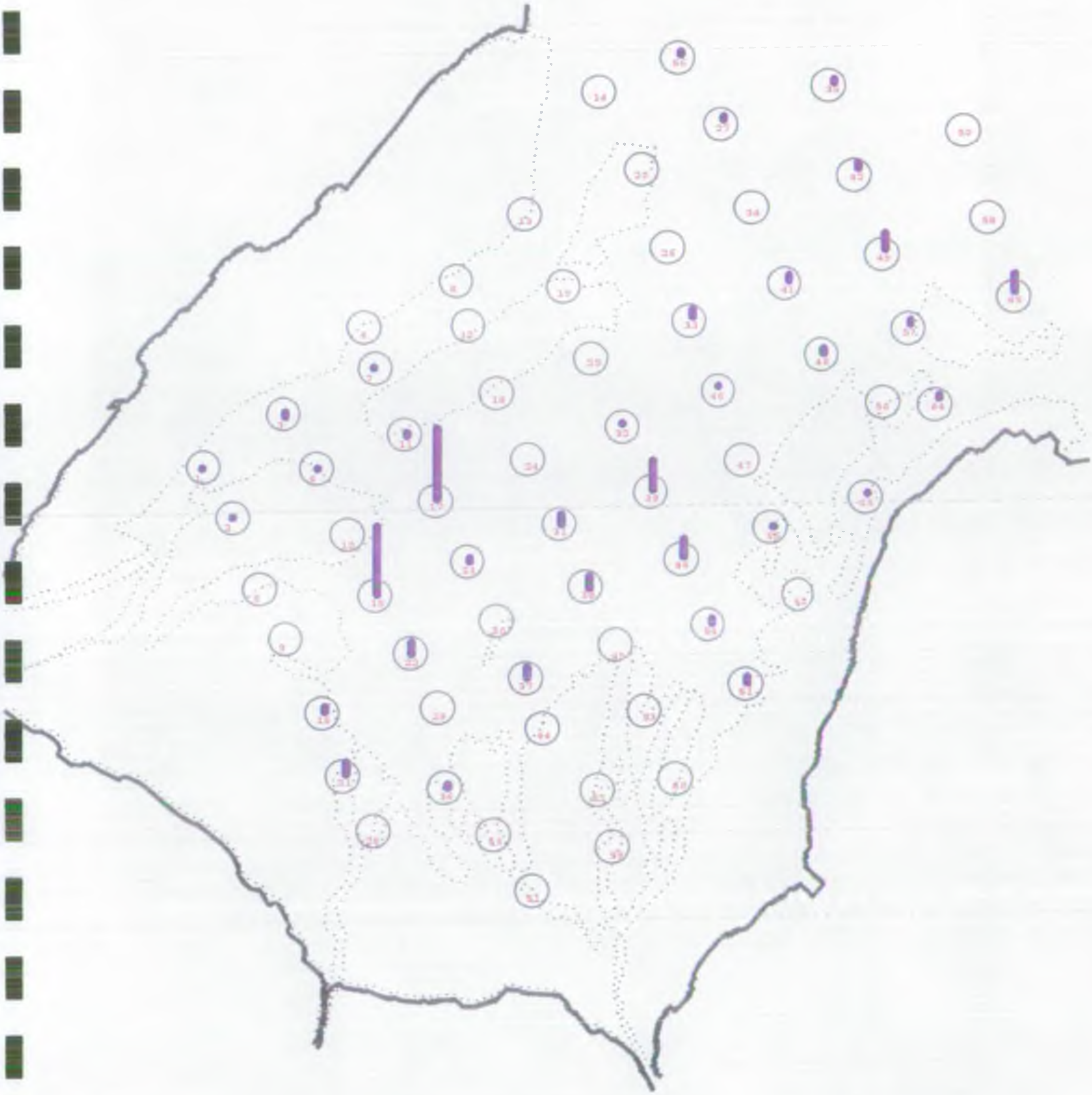

Figure 19. Distribution of the polychaete worm *Lagis koreni* [Max =56]

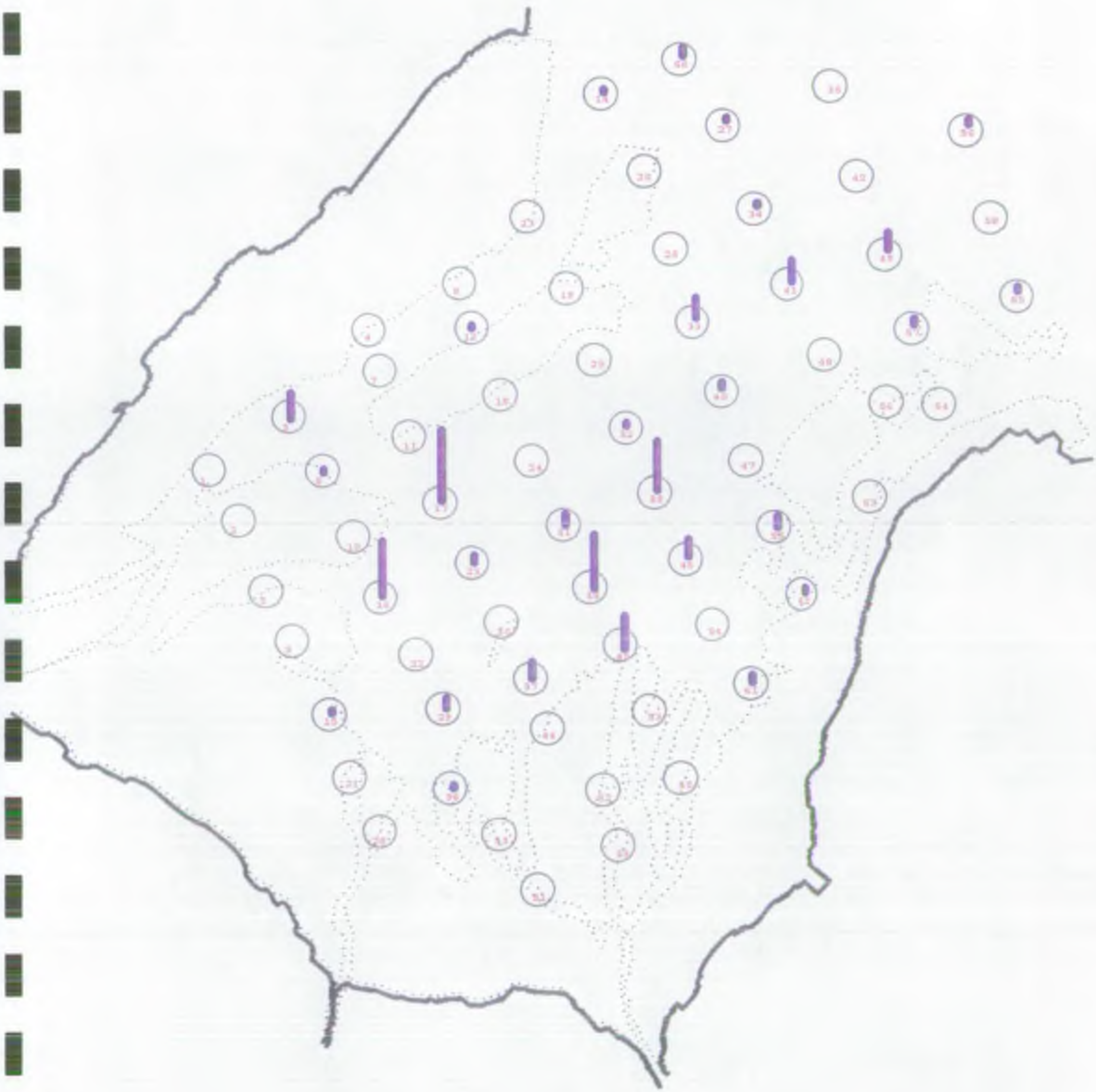

Figure 20 Distribution of the echinoderm *Ophiura albida* [Max.=146]

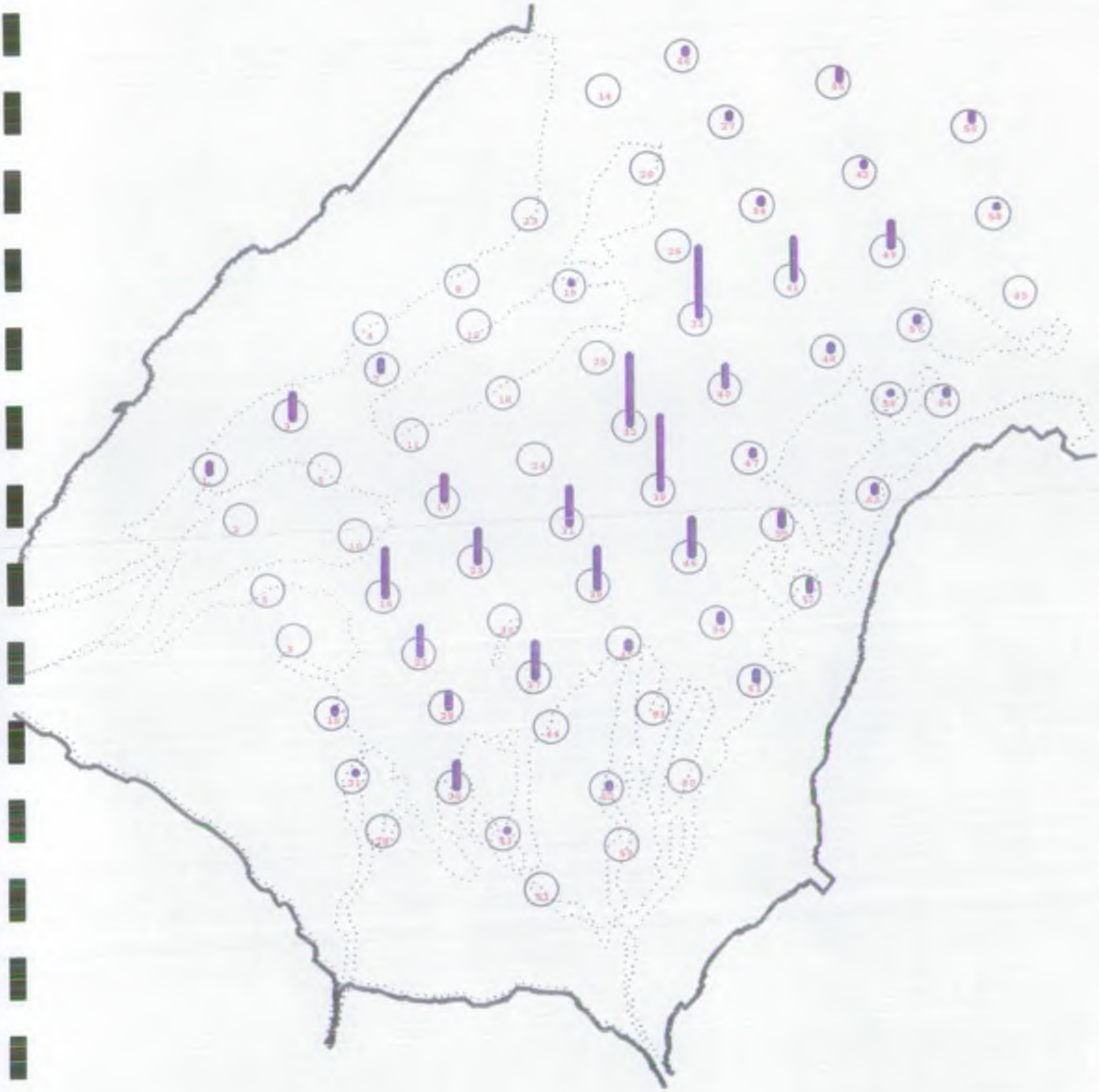

Figure 21. Distribution of the echinoderm *Ophiura ophiura* [Max.=25]

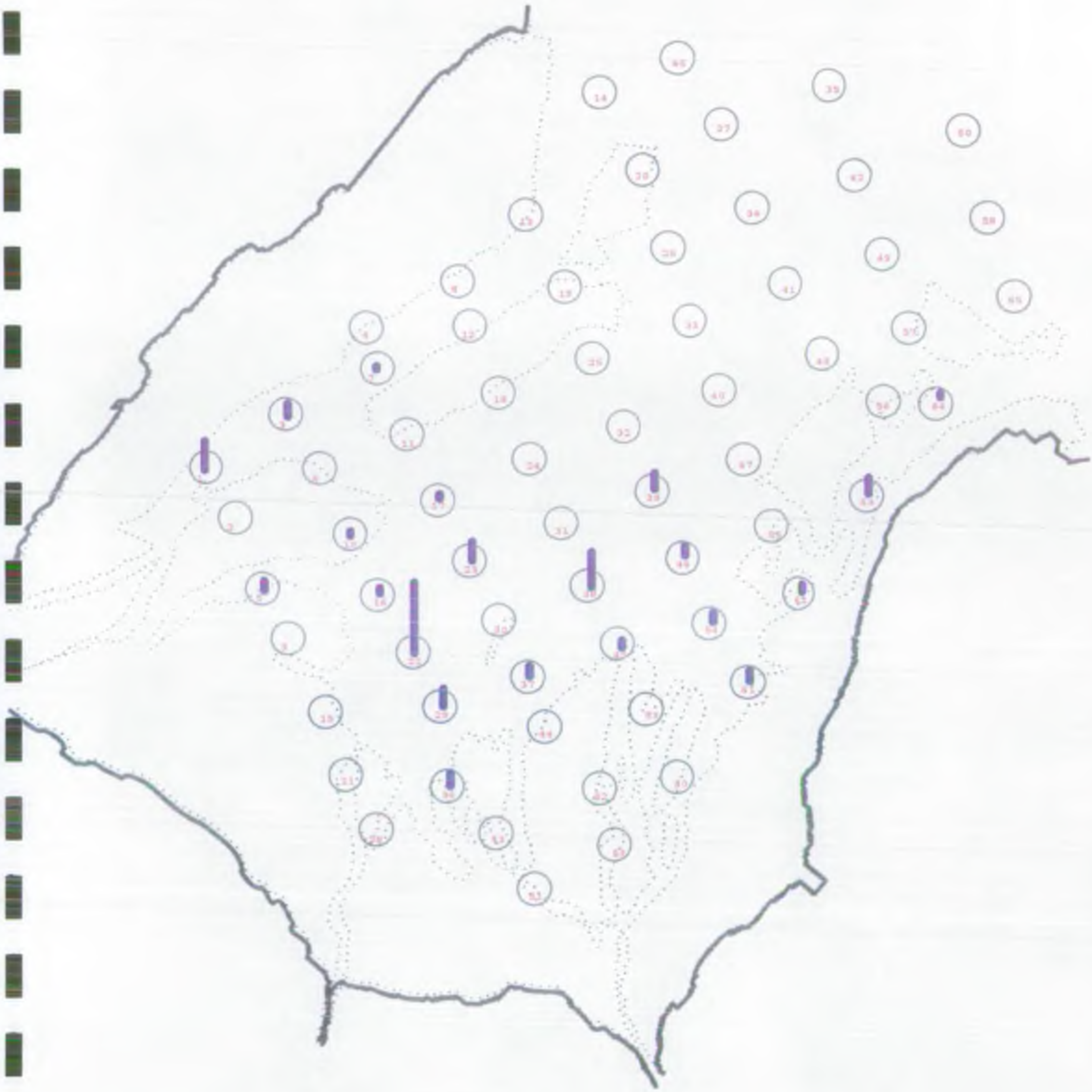

Figure 22. Distribution of the cumacean *Pseudocuma longicornis* [Max.=51]

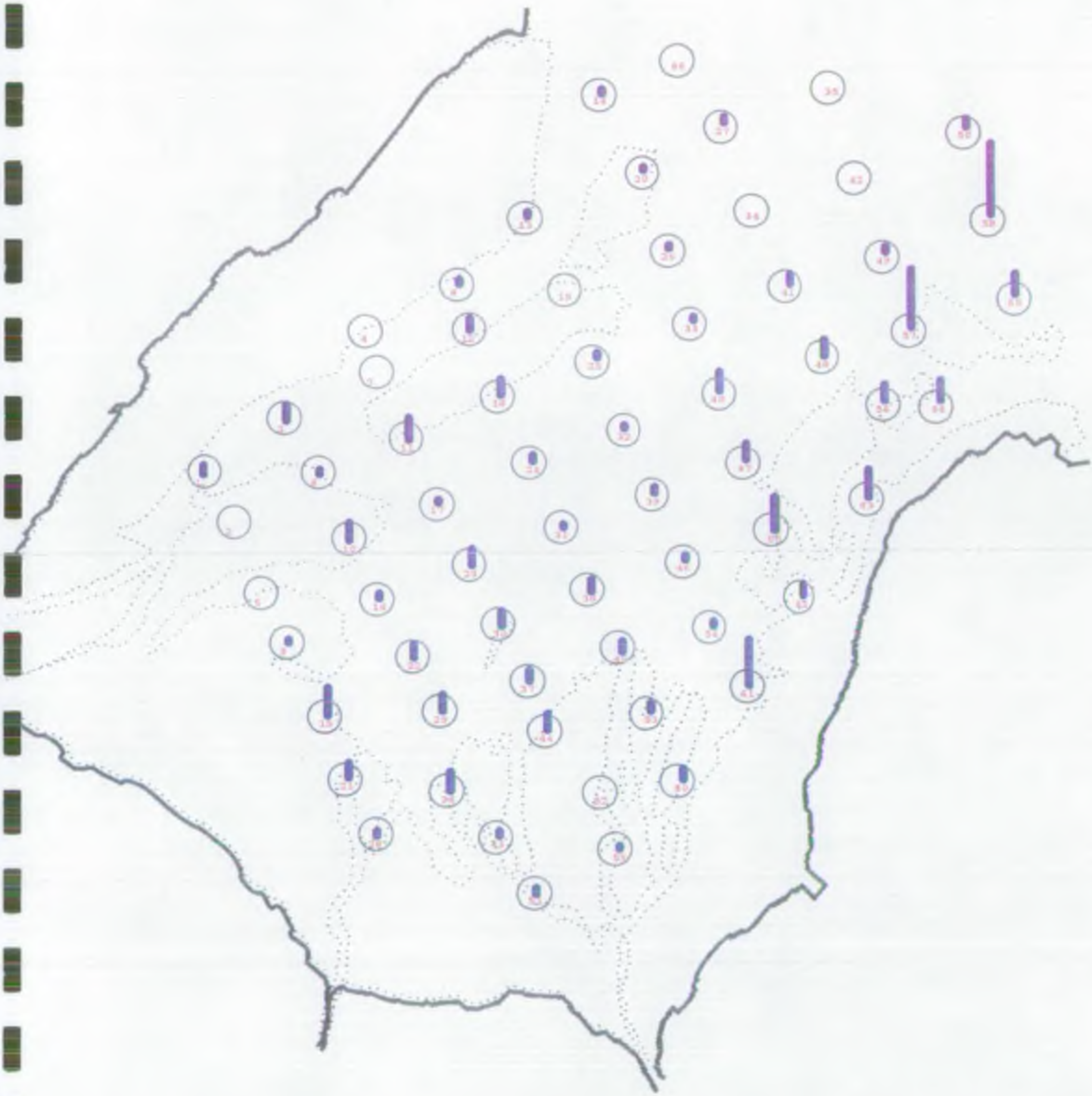

Figure 23 Distribution of the cumacean *Bodotria scorpioides* [Max.=38]

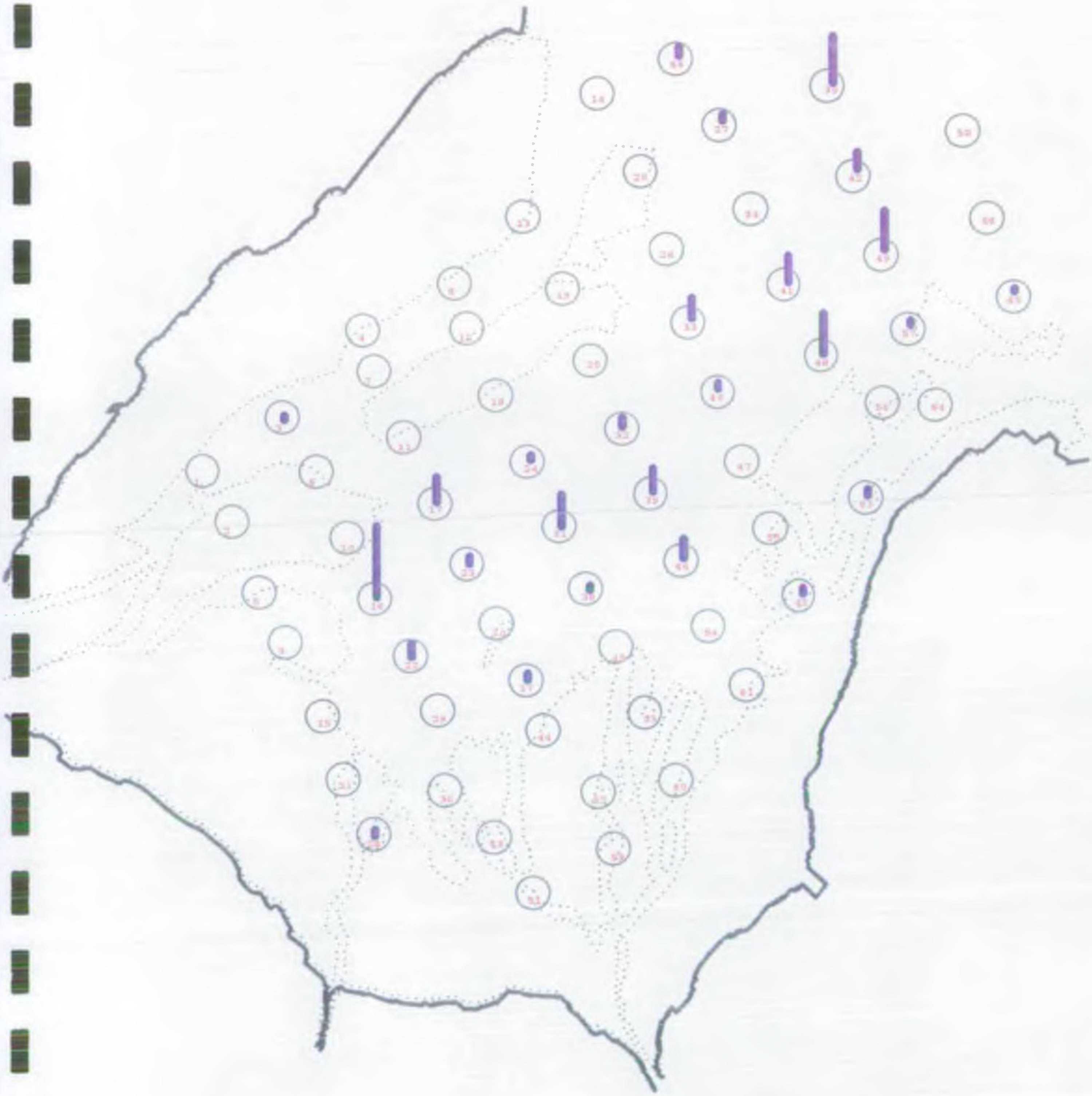

Figure 24. Distribution of the cumacean *Cumopsis goodsiri* [Max.=61]

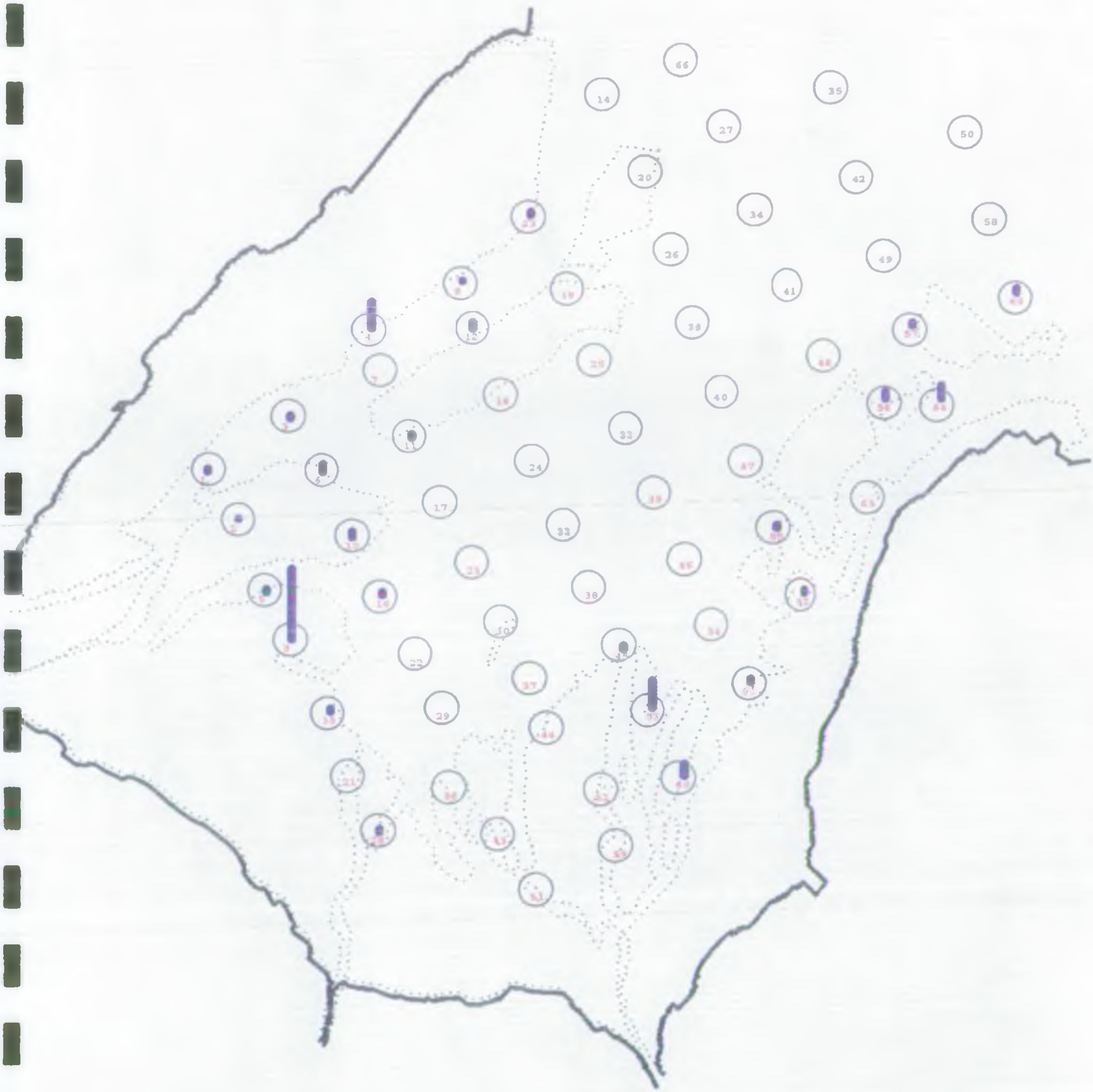

Figure 25. Distribution of the bivalve mollusc *Angulus tenuis* [Max.=48]

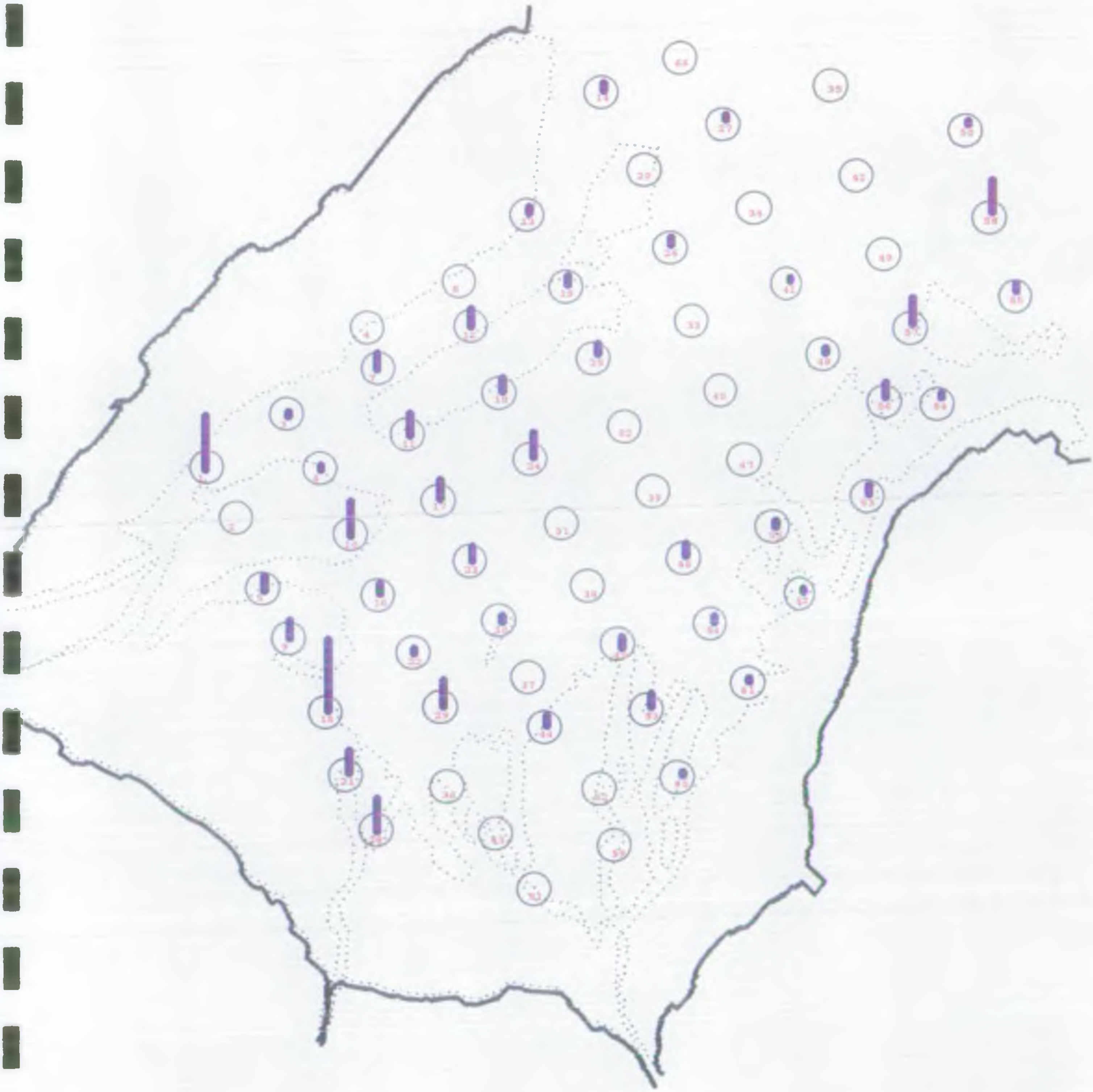

Figure 26. Distribution of the bivalve mollusc *Abra alba* [Max.=1101]

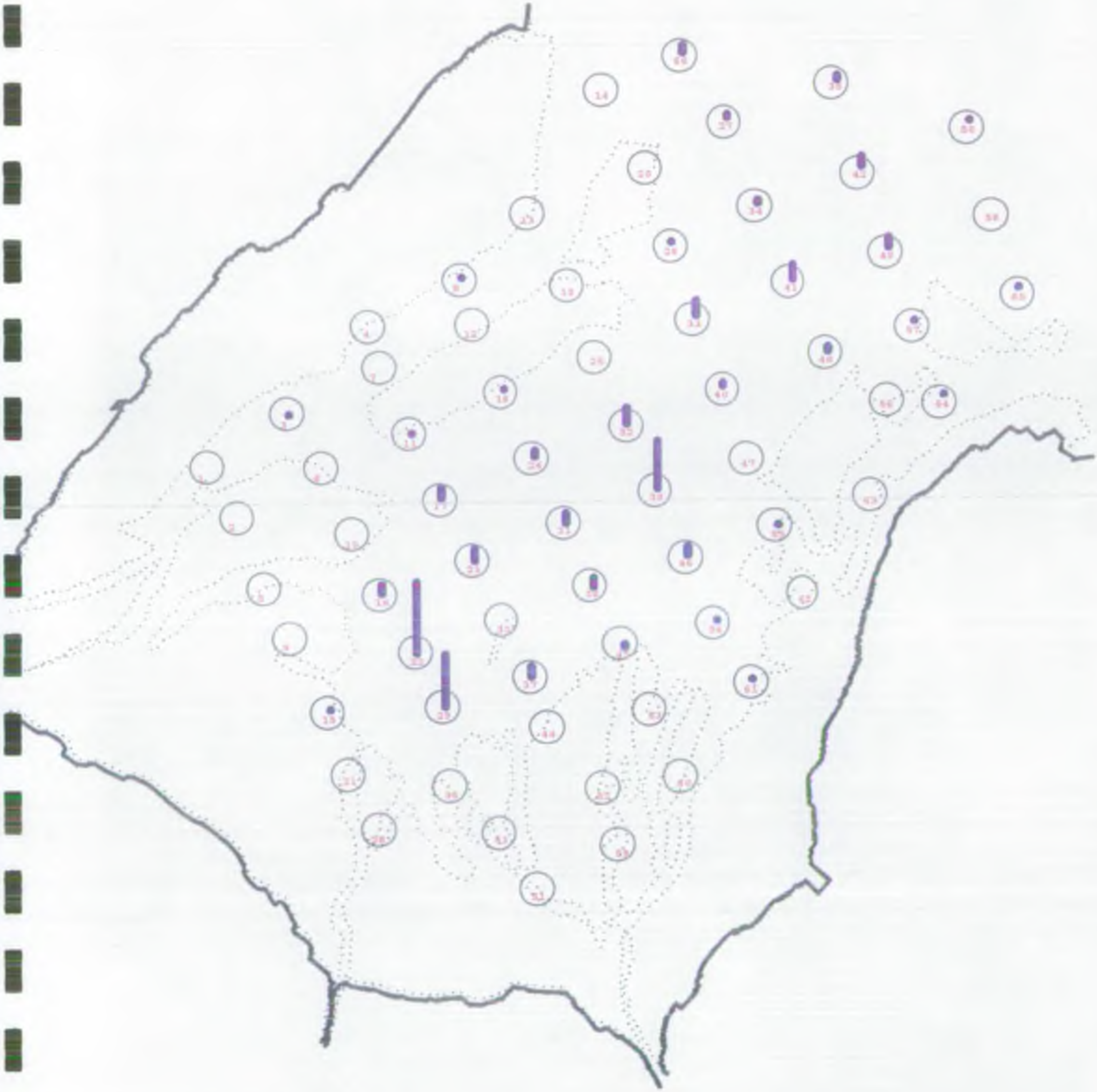

Figure 27. Dendrogram from cluster analysis of the reduced transformed data set

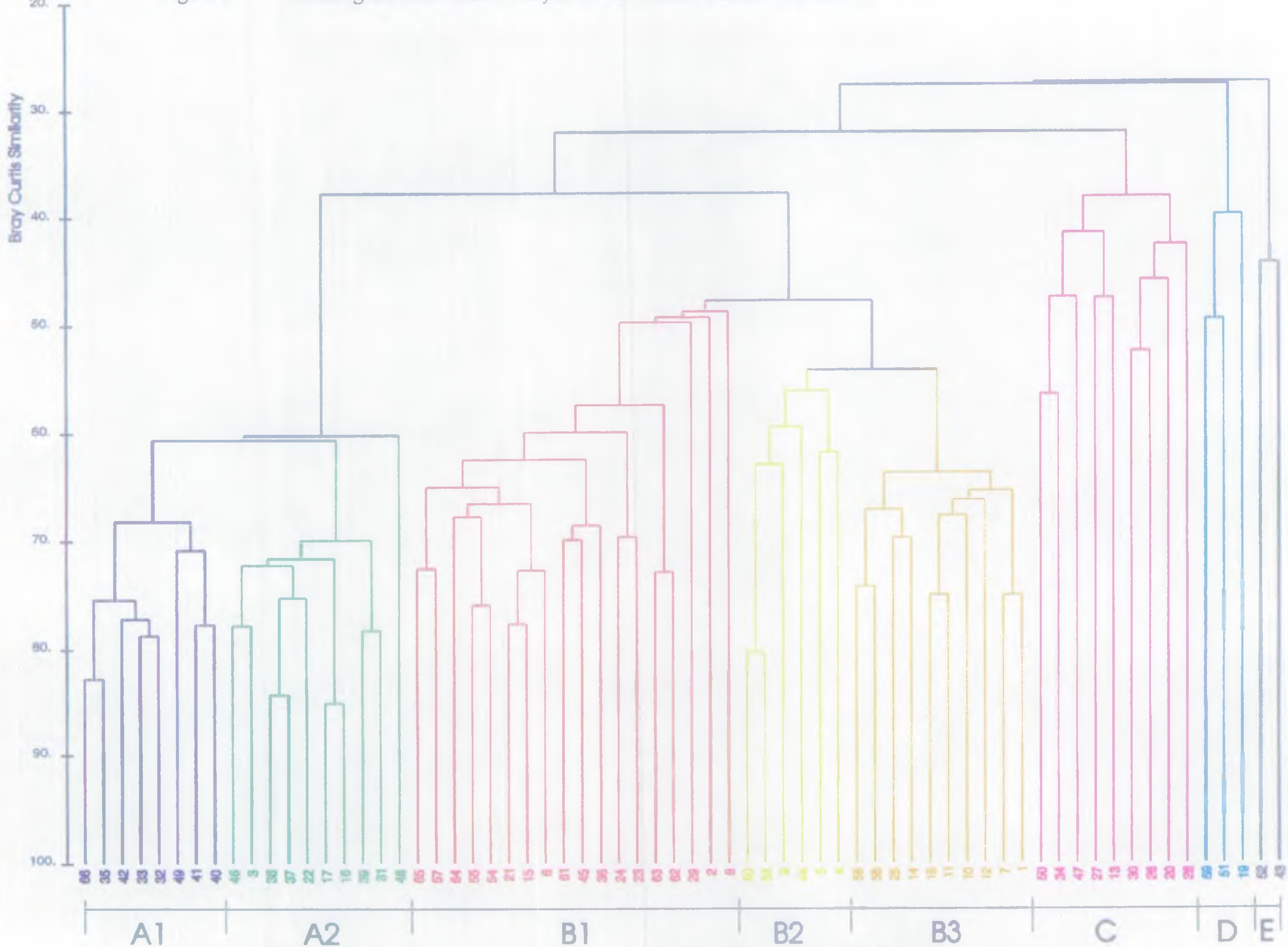

Figure 28. Distribution of the groups resulting from cluster analysis.

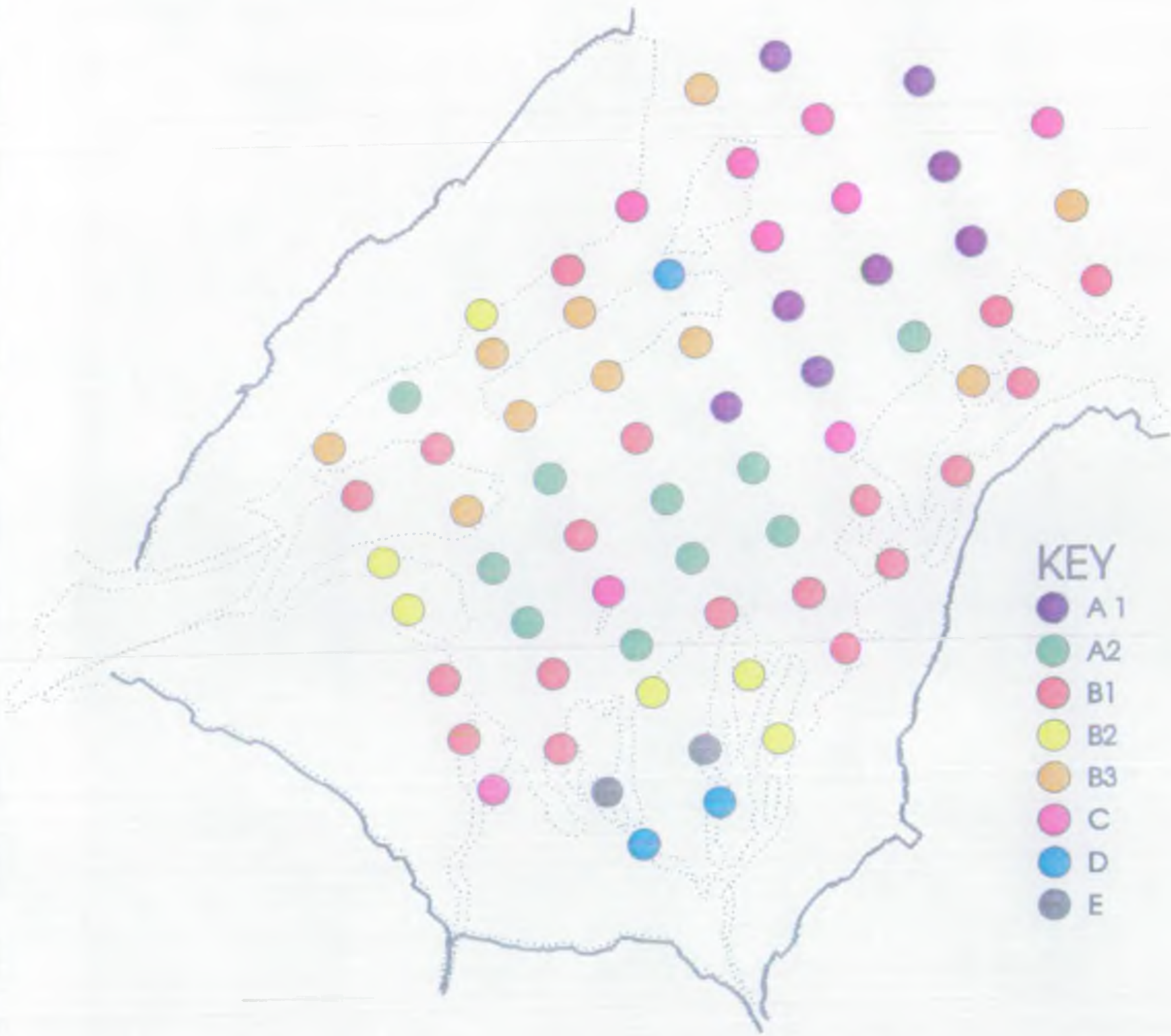

Figure 29. MDS ordination of 66 sampling sites. Cluster analysis groupings are indicated [Stress = 0.135]

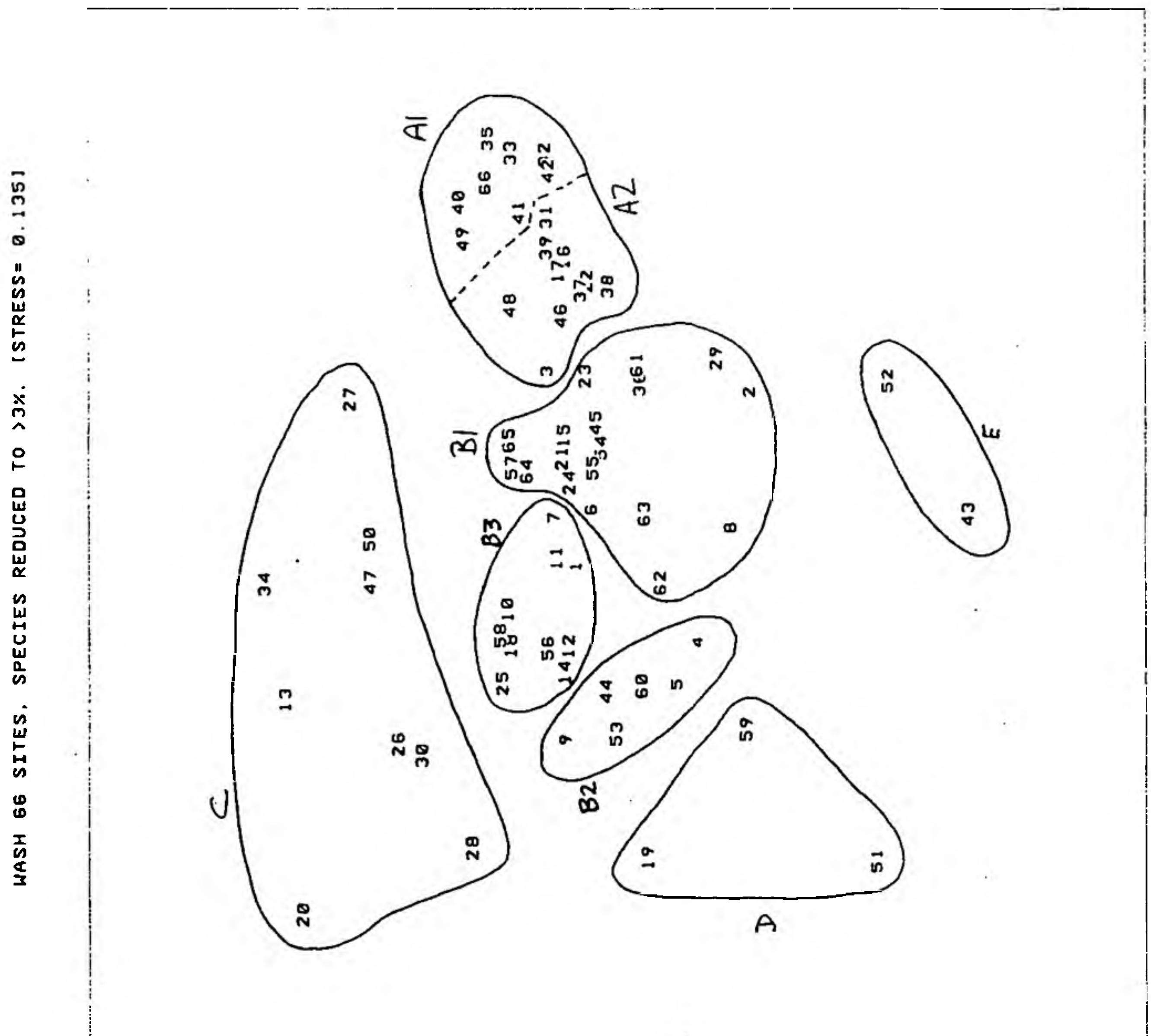

Figure 30. Mean Particle Size overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

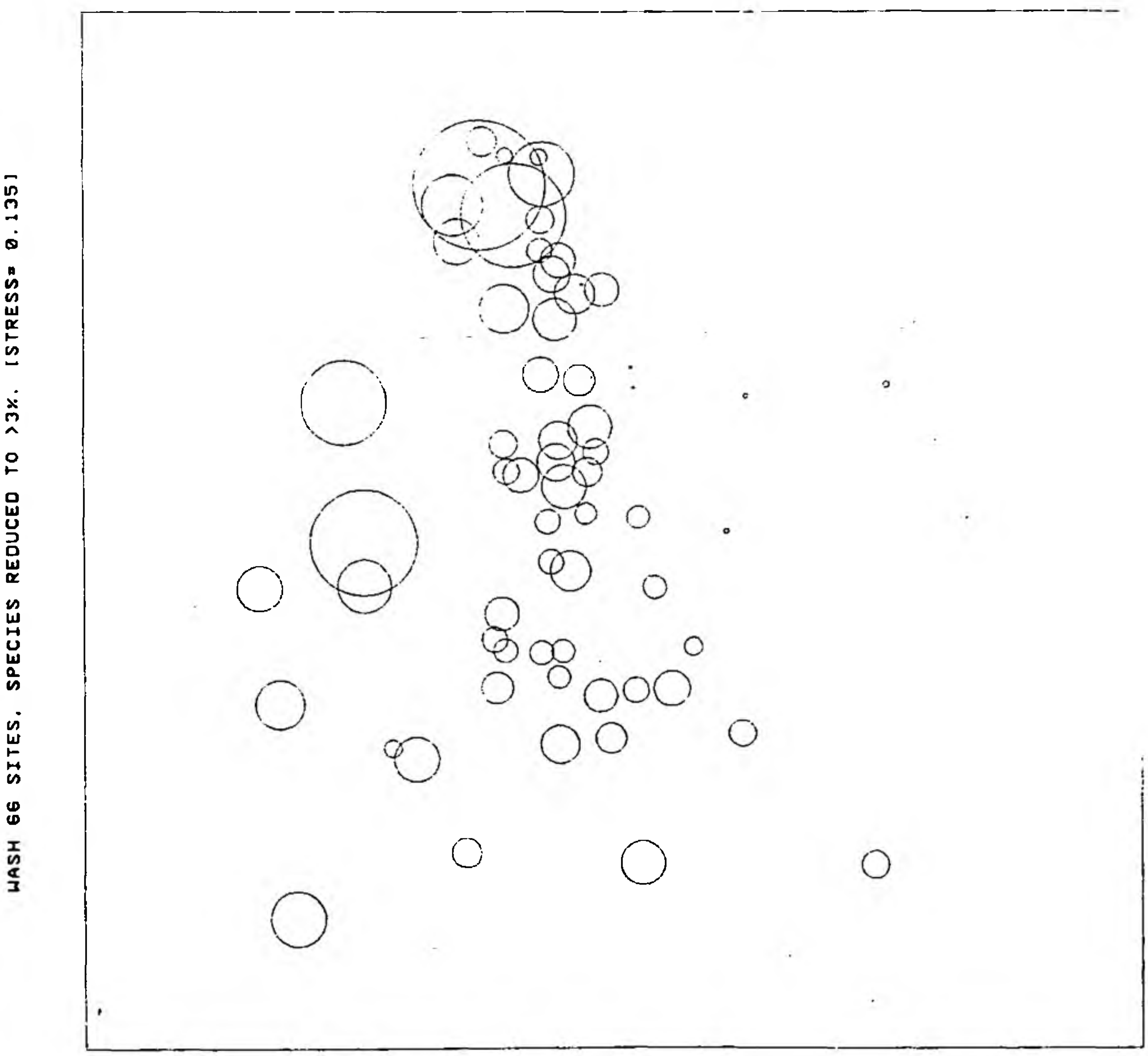

Figure 31. Median Particle Size overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

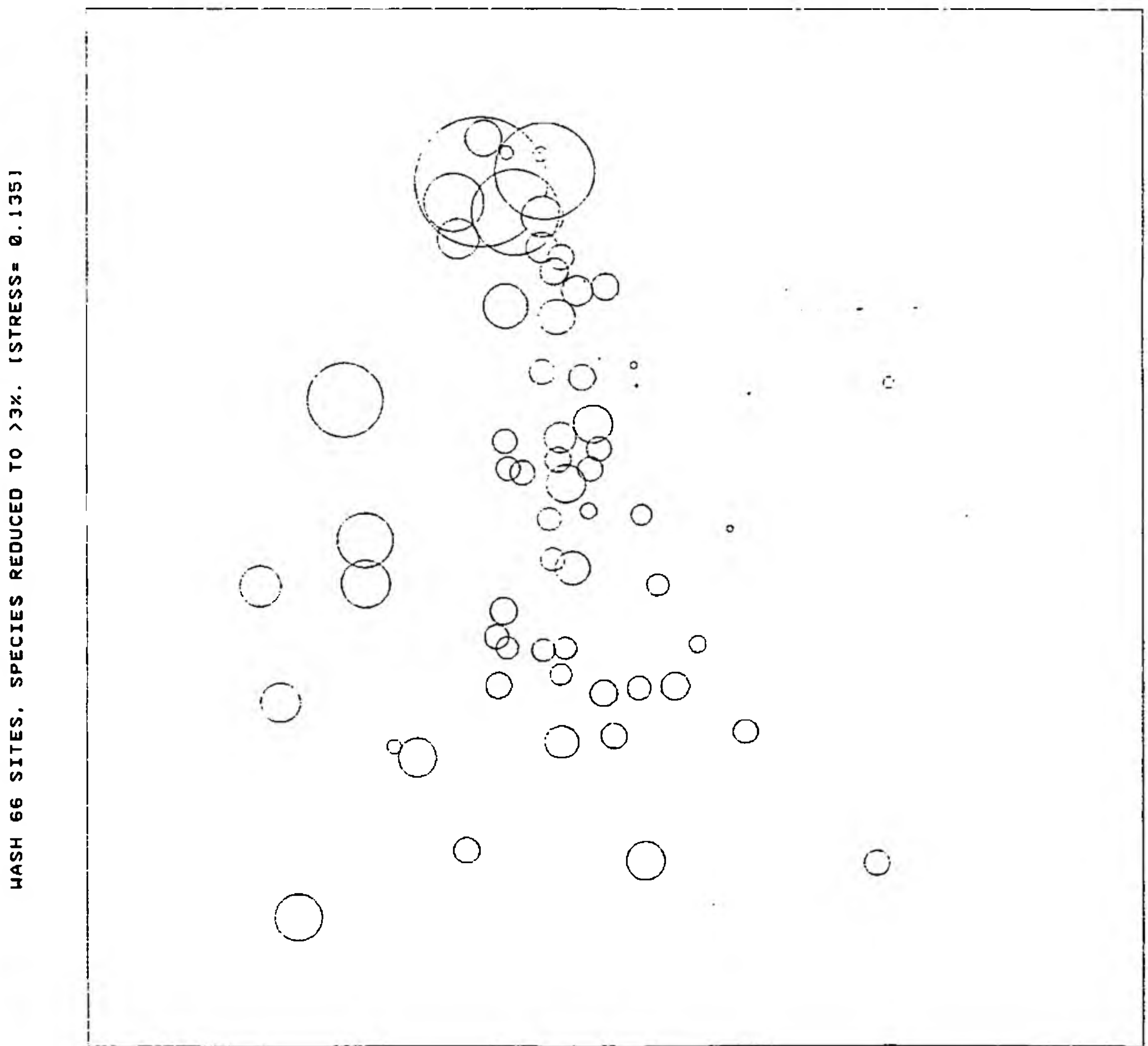

Figure 32. Depth recorded at time of sampling (uncorrected) overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

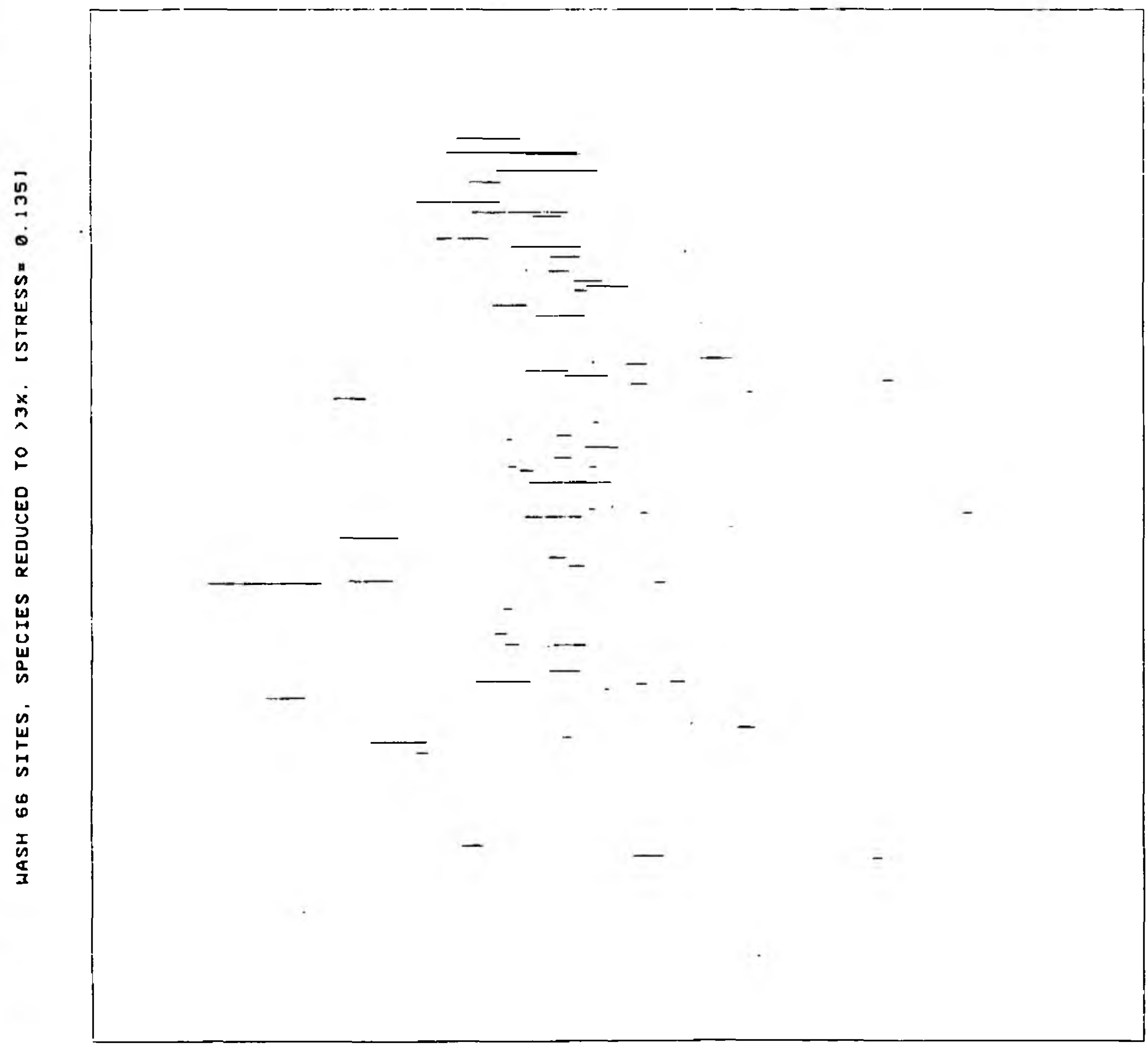

Figure 33. Depth category (see text) overlay on MDS ordination of 66 sampling sites, as shown in Figure 29. S=shallow, I=intermediate, D=deep.

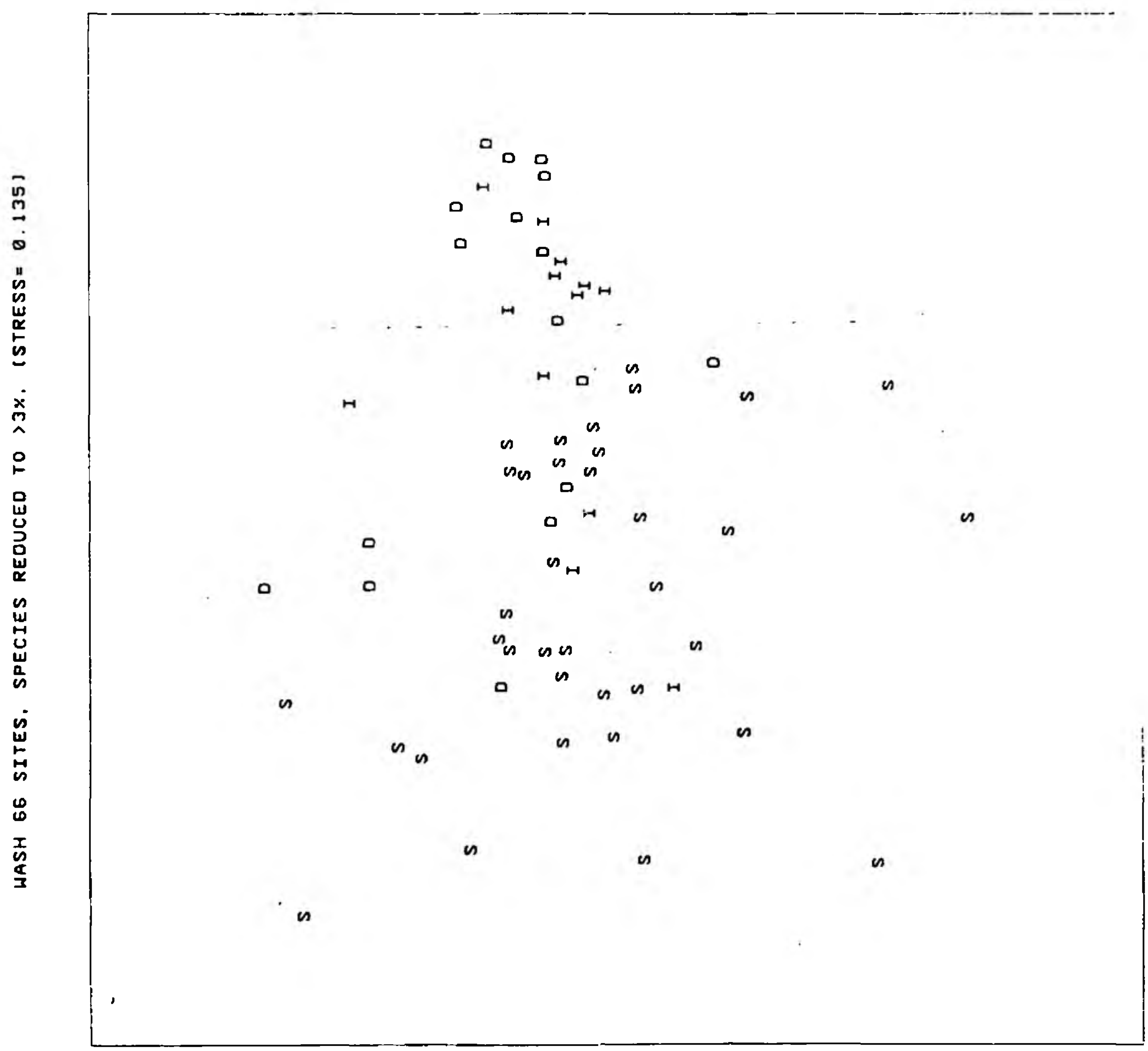

Figure 34. Percentage of Clay Silt overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

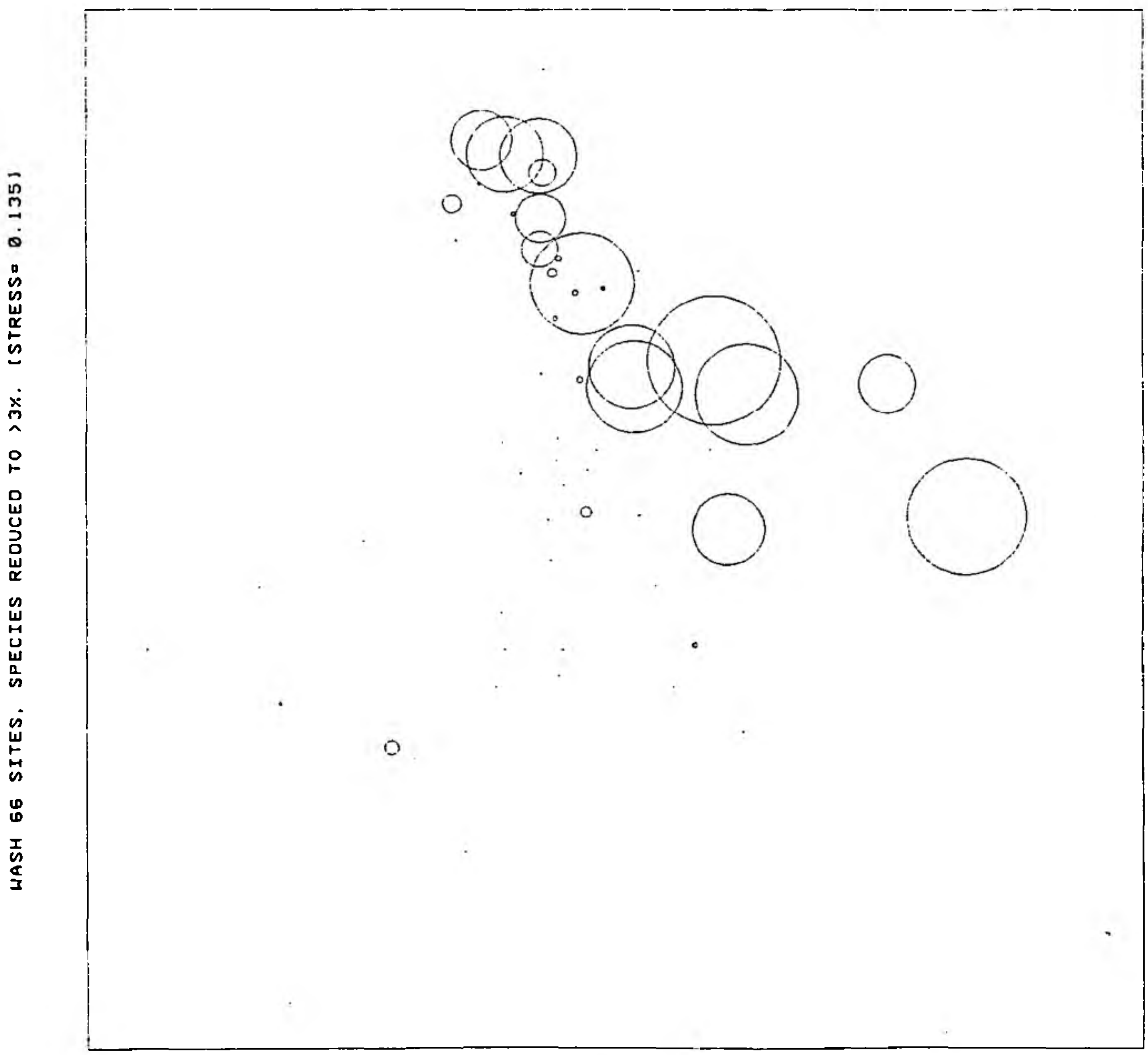

Figure 35. Organic Carbon content overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

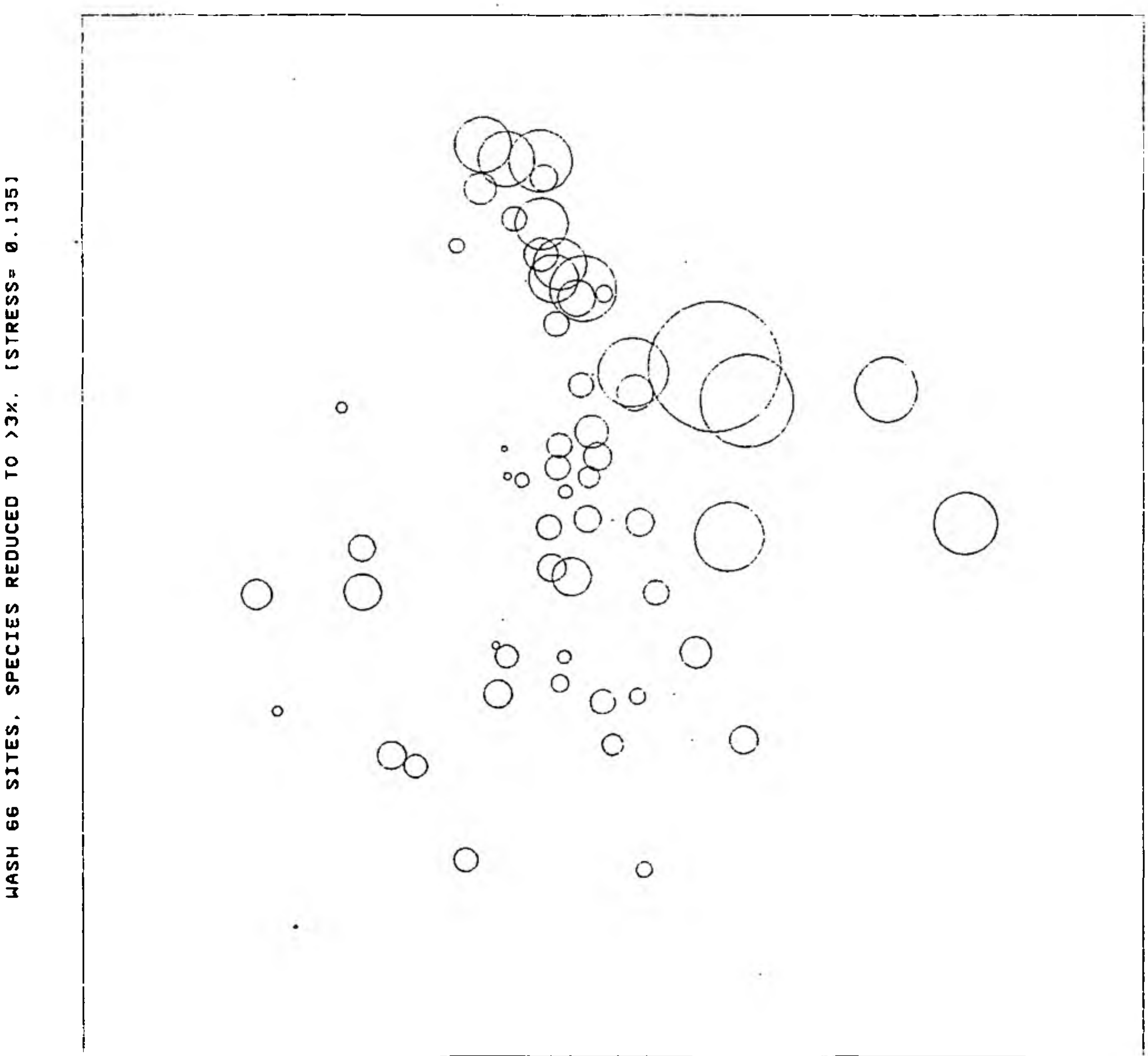

Figure 36. Bacteria (*E. coli*) counts overlay on MDS ordination of 66 sampling sites, as shown in Figure 29.

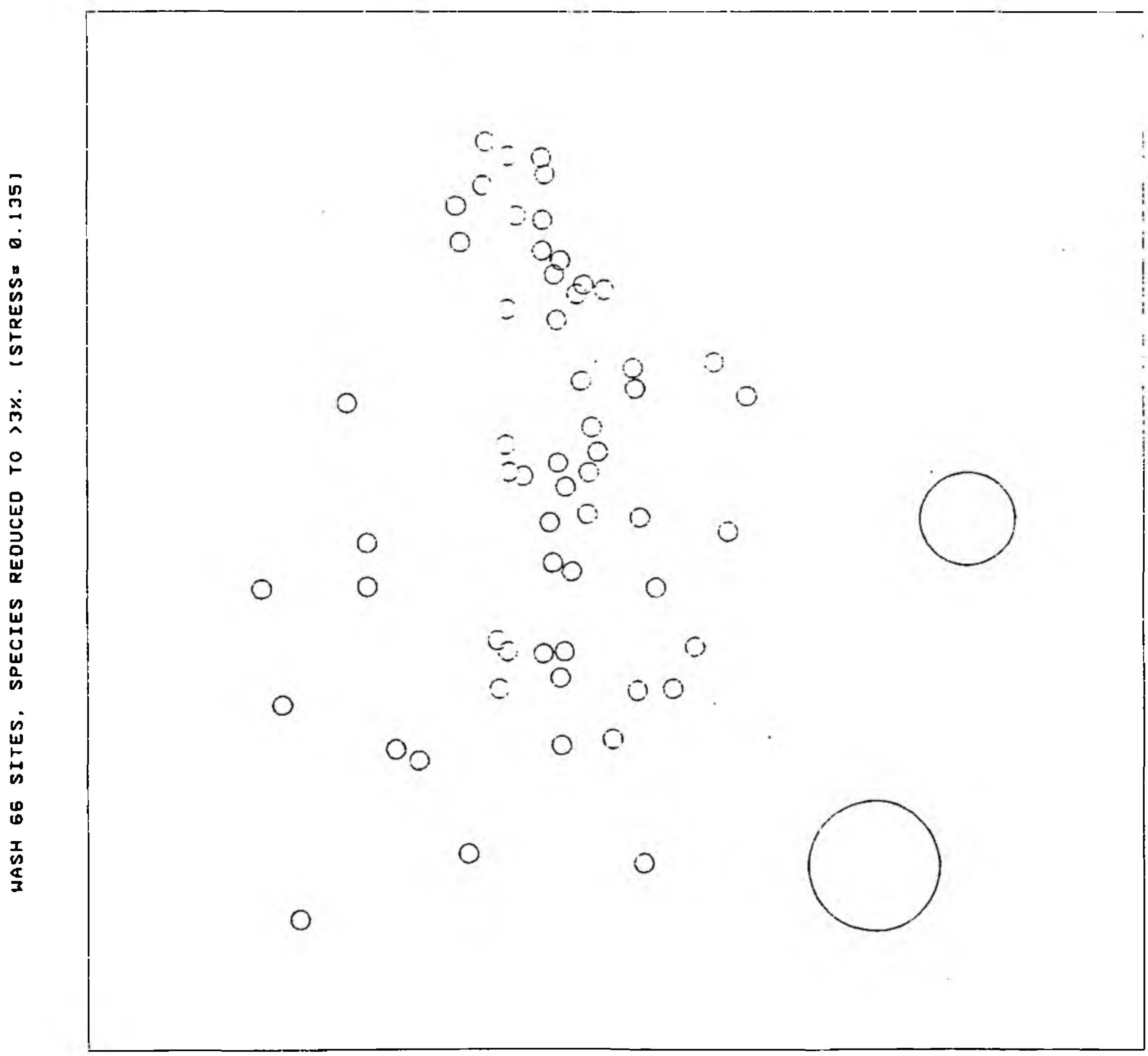

Figure 37. MDS ordination of the sites from cluster groups B1, B2 & B3.[Stress = 0.167].

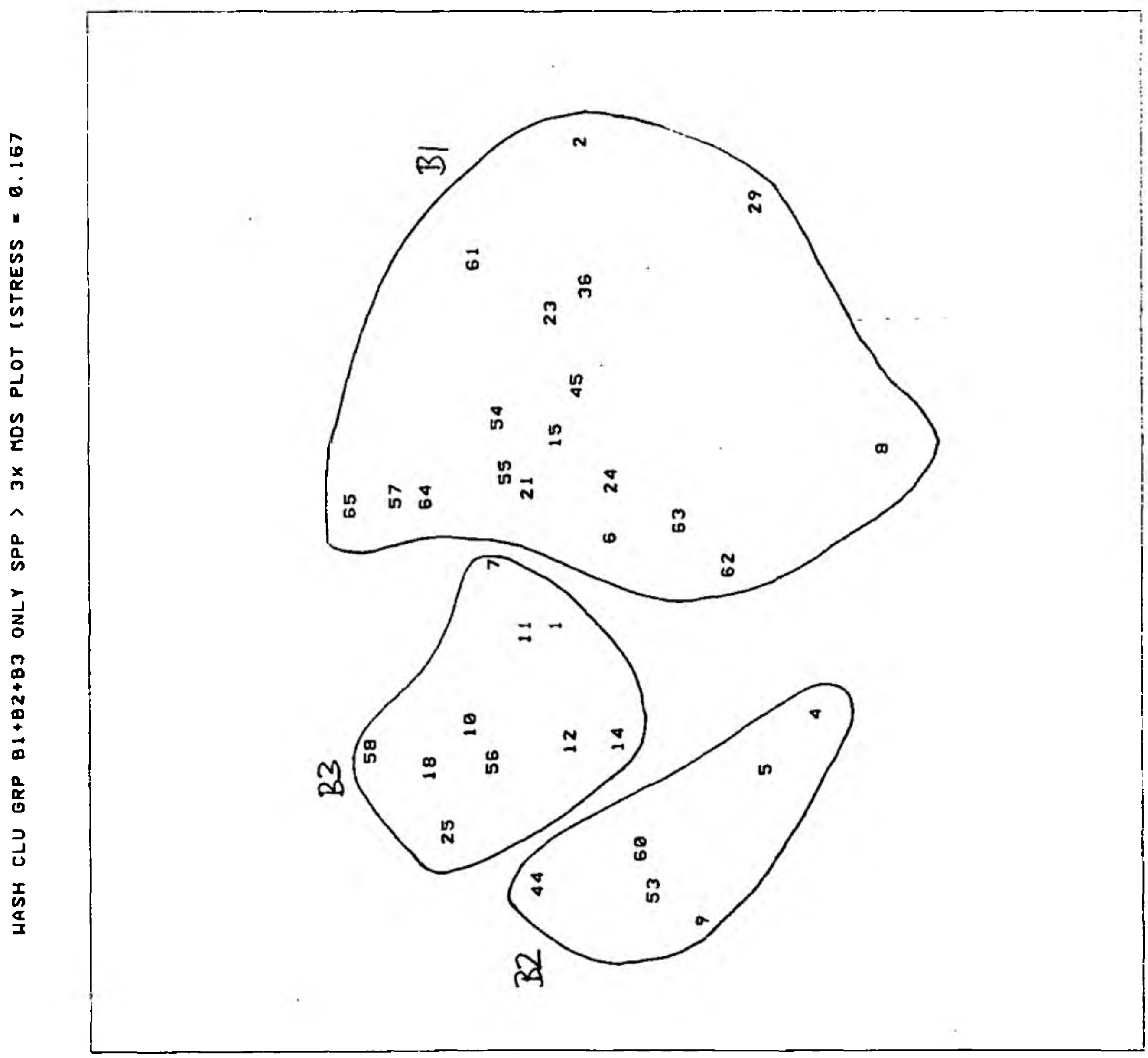

Figure 38. Median Particle Size overlay on MDS ordination of group B sites, as shown in Figure 37.

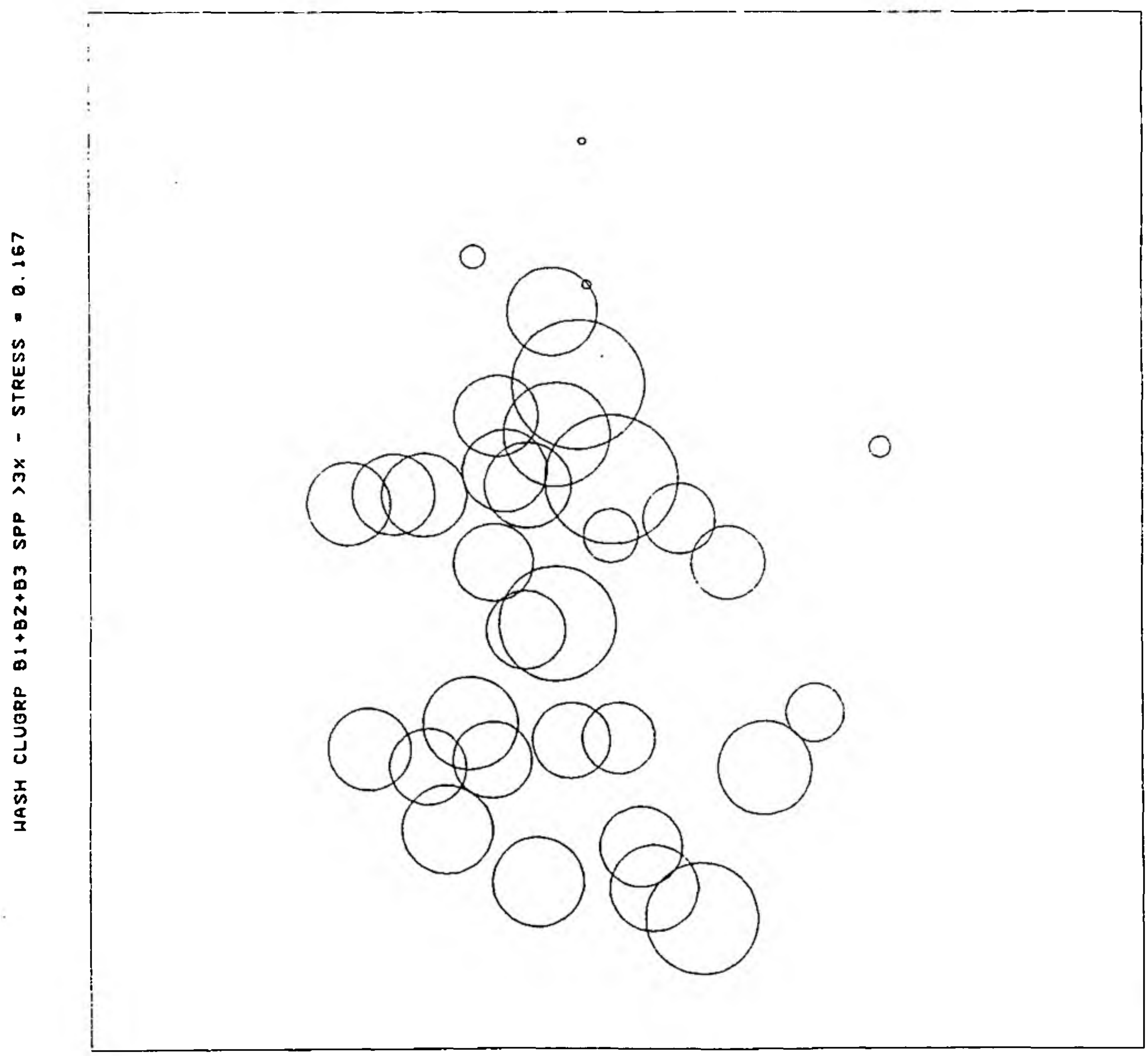

Figure 39. Standard deviation of Phi overlay on MDS ordination of group B sites, as shown in Figure 37.

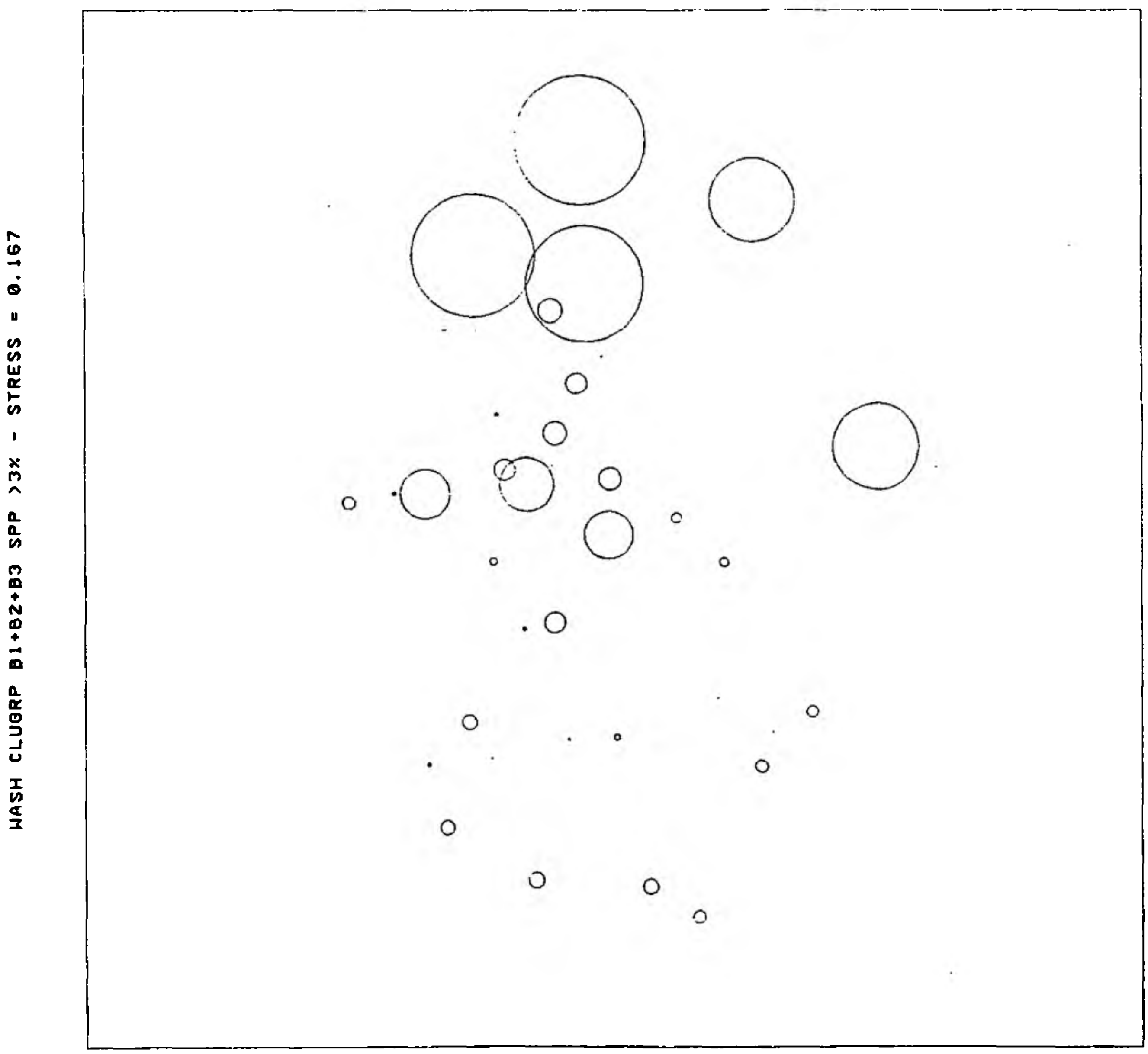

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Actiniidae indet.	D1149	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-
Nemertea indet.	G	-	-	3	-	-	6	1	1	1	2	2	-	31	-	3	13	21	4	-	-	2	5	8	5
Tubulanus superbus	G0047	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sipuncula indet.	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Pisione remota	P0020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphrodita aculeata	P0027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Polynoidae indet.	P0042	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Gattyana cirrosa	P0093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harmothoe sp.	P0097	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	-	-	-	7	4	-	-
Harmothoe impar	P0107	-	-	5	-	-	-	-	-	-	-	1	-	-	-	-	119	32	-	-	-	-	10	-	-
Harmothoe marphysae	P0121	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2	24	-	-	-	13	5	-	-
Lepidonotus squamatus	P0133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Pholoe sp.	P0168	-	10	8	-	2	2	-	-	-	-	1	-	-	-	7	72	166	-	-	-	2	154	15	5
Sthenelais boa	P0187	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-
Phyllodocidae indet.	P0200	-	-	7	-	-	-	1	-	-	-	1	-	-	-	-	118	-	-	-	-	2	18	-	-
Eteone sp.	P0202	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone flava	P0203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone foliosa	P0204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone longa	P0205	-	4	6	1	-	1	2	-	1	1	-	-	-	-	-	5	17	-	-	-	1	3	4	2
Hesionura elongata	P0213	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
Eteone picta	P0224	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Phyllodoce groenlandica	P0253	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10
Phyllodoce mucosa	P0257	-	36	8	-	-	-	-	-	-	-	-	-	-	-	-	26	5	-	1	-	7	-	5	2
Phyllodoce rosea	P0258	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
Eulalia sp.	P0268	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia bilineata	P0270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia viridis	P0277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia ornata	P0280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumida sp.	P0282	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumida bahusiensis	P0283	-	-	46	-	-	1	3	-	-	-	1	-	-	-	11	237	303	-	-	-	19	25	-	1
Phyllodoce sp.	P0311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-
Glycera sp.	P0471	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	3	10	1	-	-	1	-	-	1
Glycera lapidum	P0476	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera oxycephala	P0478	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Glycera tridactyla	P0481	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goniada maculata	P0493	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-
Sphaerodoropsis minuta	P0521	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	10	-
Sphaerodorum gracilis	P0527	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-
Kefersteinia cirrata	P0552	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Micropthalmus similis	P0601	-	-	-	-	-	-	-	-	-	-	-	-	217	-	-	-	-	-	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991 :

		Site								
Taxon	MCS	1	2	3	4	5	6	7	8	9
Syllidae indet.	P0635	-	-	-	-	-	-	-	-	-
Typosyllis armillaris	P0667	-	-	-	-	-	-	-	-	-
Eusyllis blomstrandi	P0686	-	-	-	-	-	-	-	-	-
Streptosyllis websteri	P0723	-	-	-	-	3	3	1	-	1
Exogone hebes	P0744	-	-	-	-	-	-	-	-	-
Exogone naidina	P0745	-	-	-	-	-	-	-	-	-
Exogone verugera	P0746	-	-	-	-	-	-	-	-	-
Sphaerosyllis sp.	P0750	-	-	-	-	-	-	-	-	-
Sphaerosyllis bulbosa	P0751	-	-	-	-	-	-	-	-	-
Autolytus sp.	P0761	-	-	-	-	-	-	-	-	-
Autolytus langerhansi	P0767	1	28	32	-	-	7	3	-	-
Autolytus prolifera	P0771	-	-	-	-	-	-	-	-	-
Proceraea cornuta	P0785	-	-	-	-	-	-	-	-	-
Nereis diversicolor	P0810	-	2	-	-	-	-	1	-	-
Nereis sp.	P0832	-	-	-	-	-	-	-	-	-
Nereis longissima	P0834	-	-	-	-	-	-	-	-	-
Nephtys sp.	P0867	21	40	1	-	2	11	15	-	5
Nephtys caeca	P0868	-	-	1	-	-	-	1	-	-
Nephtys cirrosa	P0870	43	-	1	6	12	9	27	-	93
Nephtys hombergii	P0871	15	49	34	28	22	31	27	46	-
Nephtys longosetosa	P0875	-	-	-	-	-	1	1	-	-
Lumbrineris sp.	P1001	-	-	1	-	-	-	-	-	-
Lumbrineris gracilis	P1008	-	-	-	-	-	-	-	-	-
Lumbrineris latreilli	P1011	-	-	-	-	-	-	-	-	-
Protodorvillea kefersteini	P1104	-	-	-	-	-	-	-	-	-
Scoloplos armiger	P1152	8	12	168	4	1	7	4	29	1
Aricidea minuta	P1158	8	-	35	1	-	15	8	-	-
Poecilochaetus serpens	P1221	-	-	-	-	-	-	-	-	-
Aonides oxycephala	P1227	-	-	-	-	-	-	-	-	-
Aonides paucibranchiata	P1228	-	-	-	-	-	-	-	-	-
Laonice bahusiensis	P1250	-	-	-	-	-	-	-	-	-
Laonice cirrata	P1251	-	-	-	-	-	-	-	-	-
Polydora sp.	P1274	-	1	-	-	-	-	-	2	-
Pseudopolydora pulchra	P1312	-	-	4	-	-	-	-	-	-
Pygospio elegans	P1317	1	342	20	4	-	1	1	-	1
Scolelepis sp.	P1321	-	-	-	-	-	-	-	-	-
Scolelepis mesnili	P1325	-	-	-	-	-	-	-	-	-
Scolelepis squamata	P1326	-	-	-	-	-	-	-	-	-
Spio sp.	P1333	68	8	61	388	84	64	120	45	30
Spiophanes bombyx	P1343	145	2	294	45	1	68	268	9	1

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	-	-	-	-	1	3	6	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	-	-	-	-	-	48	2	-	-	-	-	-	-	-
-	-	2	-	-	1	-	1	-	-	-	1	-	-	-
-	-	-	-	-	5	50	49	-	-	-	-	1	1	1
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
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-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-	-	-	14	221	109	-	1	-	28	139	1	-
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	2	-	-	-	-	-	1	-	1
-	-	-	-	-	-	2	8	-	-	-	-	1	-	-
22	18	-	-	22	9	48	16	15	-	1	27	67	5	7
-	-	-	-	-	-	2	-	-	-	-	2	1	-	-
40	28	49	4	33	2	-	-	42	1	6	7	-	1	3
-	19	6	-	12	35	54	32	4	-	-	64	71	50	23
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	2	1	-	-	-	-	-	-	-
-	3	1	2	2	45	228	138	5	1	-	27	323	77	37
3	9	3	-	-	38	25	68	6	-	-	11	1	61	8
-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	2	1	-	1	-	-	3	-	-
-	-	-	-	-	-	24	76	-	-	-	-	25	2	-
1	-	-	1	-	4	11	9	-	-	-	4	22	7	9
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	93	32	2	294	173	-	1	51	14	6	40	1	38	4
119	75	18	1	78	207	357	105	52	1	1	630	16	376	191

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Streblospio shrubsolii	P1351	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona filiformis	P1363	-	-	-	-	-	-	4	-	-	2	1	-	-	1	-	-	-	4	-	-	-	-	-	1
Magelona mirabilis	P1365	1	-	3	-	2	-	9	4	5	2	21	8	-	13	3	11	10	8	-	-	8	-	11	1
Cirratulidae indet.	P1392	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Caulleriella alata	P1394	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	7	-
Chaetozone setosa	P1403	5	11	27	-	-	6	37	-	-	19	42	5	-	3	13	262	127	39	-	-	5	98	130	18
Cirratulus sp.	P1407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cirriformia tentaculata	P1414	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Dodecaceria concharum	P1420	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tharyx marioni	P1424	1	126	-	1	1	8	-	2	1	-	6	-	-	5	4	1	7	-	-	-	1	10	10	2
Cossura longocirrata	P1465	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flabelligeridae indet.	P1471	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flabelligera affinis	P1484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pherusa plumosa	P1491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Macrochaeta helgolandica	P1504	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capitella capitata	P1531	3	229	8	8	5	21	1	5	-	3	3	2	-	1	19	38	78	2	1	-	43	2	4	1
Heteromastus filiformis	P1553	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Mediomastus fragilis	P1558	-	7	44	1	-	1	-	-	-	-	-	-	-	-	4	69	131	-	-	-	1	124	210	5
Notomastus latericeus	P1563	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	30	-	-	-	-	6	1	-
Arenicola marina	P1576	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Maldanidae indet.	P1591	-	-	-	-	-	1	-	-	1	7	-	1	-	-	1	-	-	-	-	-	-	-	-	-
Ophelia borealis	P1690	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Euzonus flabelligerus	P1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Travisia forbesii	P1706	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelina acuminata	P1719	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	-	-	-	-	-	13	15
Scalibregma inflatum	P1743	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	16	10	-	-	-	-	112	14	8
Owenia fusiformis	P1836	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	13	2	-
Terebellida indet.	P1840	-	-	9	-	-	-	-	-	-	-	-	-	-	-	2	4	2	-	-	-	-	1	-	-
Pectinaria koreni	P1854	-	-	20	-	-	1	-	-	-	-	-	1	-	1	1	44	56	-	-	-	-	-	5	-
Sabellaria sp.	P1874	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabellaria spinulosa	P1876	-	-	6	-	-	-	-	1	-	-	-	1	1	-	3	64	193	-	-	-	1	5	-	-
Melinna cristata	P1883	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Melinna palmata	P1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Ampharete sp.	P1904	-	2	6	-	-	-	-	-	-	-	-	-	-	-	-	64	34	-	-	-	4	34	1	-
Ampharete acutifrons	P1909	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	-	-	-	-	87	-	-
Ampharete lindstroemi	P1910	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	67	164	-	-	-	-	75	12	-
Lanice conchilega	P2031	2	2	11	-	-	1	1	-	-	-	2	-	-	-	8	223	233	-	-	-	33	35	3	-
Neoamphitrite figulus	P2053	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycirrus sp.	P2117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thelepus cincinnatus	P2144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Sabellidae indet.	P2150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Sabella pavonina	P2261	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pomatoceros triqueter	P2304	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1	-	-	-	-	-	-	-
Oligochaeta indet.	P2417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Tubificoides sp.	P2484	-	-	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	-
Tubificoides benedeni	P2487	-	111	-	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	13	-
Tubificoides pseudogaster	P2489	2	5	-	2	1	5	8	25	-	-	1	1	-	-	36	12	36	-	-	-	-	65	24	1
Tubificoides diazi	P2490	-	-	92	-	1	12	-	-	-	1	-	-	-	-	-	169	27	-	-	-	1	1	13	-
Tubificoides swirencoides	P2491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnogonida indet.	Q0001	-	2	5	-	-	-	-	-	-	1	1	-	-	-	-	3	-	-	-	-	-	-	-	-
Nymphon brevirostre	Q0004	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	1	-	-
Nymphon gracile	Q0008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Achelia sp.	Q0016	-	-	3	-	-	-	1	-	-	1	-	-	-	-	1	74	47	-	-	-	1	1	-	-
Endeis spinosa	Q0039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Callipallene brevirostris	Q0045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	-	-	-	-	1	-
Anoplodactylus sp.	Q0060	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-
Anoplodactylus angulatus	Q0061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anoplodactylus petiolatus	Q0062	1	-	13	-	-	-	1	-	-	-	-	1	-	-	3	20	46	-	-	-	14	6	-	-
Anoplodactylus pygmaeus	Q0063	-	4	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-
Pycnogonum littorale	Q0075	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Balanidae indet.	R0100	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysidae indet.	S0048	-	-	-	-	-	-	2	-	-	-	-	-	-	1	1	1	-	-	-	-	1	-	3	-
Gastrosaccus sp.	S0063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus normani	S0065	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Gastrosaccus spinifer	S0067	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1	-	-	-	-	16	-	-	-	-
Erythrops elegans	S0074	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Hemimysis lamornae	S0117	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mesopodopsis slabberi	S0122	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neomysis integer	S0127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis sp.	S0145	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis kervillei	S0146	-	-	1	-	-	-	-	-	3	-	2	-	1	4	-	3	-	-	-	-	-	-	8	-
Schistomysis spiritus	S0149	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	3	-
Amphipoda indet.	S0166	-	-	2	-	-	-	-	1	-	-	-	-	2	-	-	2	-	1	-	-	1	-	-	-
Perioculodes longimanus	S0228	6	-	2	-	-	-	6	-	-	-	1	1	-	-	-	4	-	-	-	-	-	-	4	1
Pontocrates sp.	S0232	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Pontocrates altamarinus	S0233	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Pontocrates arenarius	S0234	10	-	-	-	1	-	1	-	-	6	4	5	-	1	-	-	-	11	-	-	-	-	-	-
Parapleustes bicuspis	S0254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphilochus sp.	S0277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Amphilochus manudens	S0279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9
Amphilochus neapolitanus	S0280	-	-	-	-	-	-	-	1	-
Cressa dubia	S0328	-	-	-	-	-	-	-	-	-
Stenothoe sp.	S0366	-	-	-	-	-	-	-	-	-
Stenothoe marina	S0370	-	-	1	-	-	-	-	-	-
Urothoe sp.	S0427	-	-	-	-	-	-	-	-	2
Urothoe brevicornis	S0428	-	-	-	1	-	-	-	-	2
Urothoe elegans	S0429	-	-	-	-	-	-	-	-	-
Urothoe poseidonis	S0431	1	-	-	-	-	-	1	2	2
Urothoe pulchella	S0432	-	-	-	-	-	-	-	-	-
Harpinia pectinata	S0441	-	-	-	-	-	-	-	-	-
Metaphoxus fultoni	S0447	-	-	-	-	-	-	-	-	-
Phoxocephalus holbolli	S0459	-	-	-	-	-	-	-	-	-
Orchomene nana	S0539	-	-	-	-	-	-	-	-	-
Iphimedia obesa	S0628	-	-	-	-	-	-	-	-	-
Atylus sp.	S0680	-	-	1	-	-	-	-	-	-
Atylus falcatus	S0681	1	-	-	-	-	-	-	-	-
Atylus guttatus	S0682	-	-	7	1	-	-	1	-	-
Atylus swammerdami	S0683	-	-	2	-	-	-	-	-	-
Guernea coalita	S0696	-	-	-	-	-	-	-	-	-
Ampelisca sp.	S0707	-	-	-	-	-	-	-	-	-
Ampelisca brevicornis	S0710	-	-	23	-	-	-	-	-	-
Ampelisca diadema	S0711	-	-	-	-	-	-	1	-	-
Ampelisca spinipes	S0718	-	-	-	-	-	-	-	-	-
Ampelisca typica	S0722	-	-	-	-	-	-	-	-	-
Bathyporeia sp.	S0740	-	-	-	-	-	-	-	-	-
Bathyporeia elegans	S0741	2	-	-	-	-	-	-	-	-
Bathyporeia gracilis	S0742	-	-	-	-	-	-	-	-	-
Bathyporeia guilliamsoniana	S0743	1	-	-	1	1	-	-	-	-
Bathyporeia nana	S0744	-	-	-	-	-	-	-	-	-
Bathyporeia pelagica	S0745	-	-	-	-	-	-	-	-	-
Bathyporeia pilosa	S0746	-	-	-	-	-	-	-	-	-
Bathyporeia sarsi	S0747	4	-	-	4	1	-	1	-	9
Bathyporeia tenuipes	S0748	-	-	-	-	-	-	-	-	1
Haustorius arenarius	S0754	-	-	-	-	-	-	-	-	-
Gammarus sp.	S0768	-	4	-	-	-	-	-	-	-
Megaluropus agilis	S0790	-	-	-	-	-	-	-	-	-
Abludomelita obtusata	S0808	-	-	2	-	-	-	-	-	-
Cheirocratus sp.	S0822	-	-	-	-	-	-	-	-	-
Maerella tenuimana	S0858	-	-	-	-	-	-	-	-	-
Melita sp.	S0862	-	-	1	-	-	-	-	-	-

10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
-	-	-	-	-	-	2	2	-	-	-	-	-	-	-
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3	12	3	-	-	-	-	-	2	-	-	-	-	3	-
5	-	1	-	-	-	5	-	24	-	-	1	-	-	-
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2	4	-	2	-	-	1	7	-	-	-	4	1	6	-
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-	-	-	-	-	19	81	73	1	-	-	1	47	8	-
-	-	-	-	-	-	14	26	1	-	-	-	3	-	-
-	-	-	-	-	-	-	3	-	-	-	-	6	-	-
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3	-	3	1	3	-	-	-	-	-	-	-	-	-	-
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9	6	6	-	4	-	-	-	2	-	-	-	-	-	1
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-	-	-	-	-	-	1	-	-	-	-	-	1	-	-

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Melita palmata	S0865	-	3	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
Gammaropsis sp.	S0896	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megamphopus cornutus	S0912	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microprotopus maculatus	S0918	-	1	39	1	-	1	3	1	-	-	2	2	15	1	44	41	87	-	-	-	40	94	-	-
Photis pollex	S0924	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	17	-	-	-	-	6	-	-
Aora gracilis	S0974	-	-	4	-	-	-	-	1	-	-	-	-	-	-	-	100	31	-	-	-	-	14	-	-
Corophium sp.	S1017	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	3	32	-	-	-	-	1	-	-
Unciola crenatipalma	S1038	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dyopedos monacanthus	S1051	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	11	1	-	-	-	-	-	-	-
Pariambus typicus	S1084	-	-	33	-	2	1	-	-	1	2	1	-	1	-	13	397	630	-	-	-	44	63	5	1
Pseudoprotella phasma	S1101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Isopoda indet.	S1316	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Eurydice pulchra	S1422	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idotea linearis	S1554	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-
Idotea sp.	S1559	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanaidacea indet.	S1868	3	1	-	48	5	14	1	-	108	129	45	3	-	2	-	-	-	24	1	-	6	-	-	-
Cumopsis goodsiri	S1988	1	1	1	22	1	5	-	1	61	4	1	3	1	-	1	2	-	-	-	-	-	-	-	-
Bodotria pulchella	S2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bodotria scorpioides	S2003	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	38	12	-	-	-	-	6	3	2
Eudorella truncatula	S2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	19	-	-
Cumella pygmaea	S2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Pseudocuma longicornis	S2072	6	-	11	-	-	2	-	3	1	11	15	7	2	2	19	3	1	10	-	1	10	8	10	4
Diastylis sp.	S2095	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
Diastylis bradyi	S2096	-	-	5	-	-	-	4	4	-	4	4	2	1	-	3	15	4	1	-	-	2	5	21	6
Diastylis rathkei	S2100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippolyte varians	S2271	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pandalus montagui	S2322	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon sp.	S2329	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon crangon	S2331	-	1	2	-	-	1	-	-	1	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Pisidia longicornis	S2502	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	2	-
Hyas araneus	S2559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Macropodia linaresi	S2584	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Atelecyclus rotundatus	S2626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
Cancer pagurus	S2646	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus sp.	S2666	-	3	3	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus holsatus	S2670	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Pilumnus hirtellus	S2735	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyplacophora indet.	W0050	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptochiton cancellatus	W0056	-	-	-	-	-						-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastropoda indet.	W0092	-	5	2								-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Archaeogastropoda indet.	W0093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Gibbula cineraria	W0193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobia ulvae	W0274	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	2	11	-	-	-	-	-	-	-
Rissoa interrupta	W0284	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	7	22	-	-	-	-	-	-	-
Alvania semistriata	W0318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Onoba semicostata	W0340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysallida indistincta	W0510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Partulida spiralis	W0517	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Noemiamea dolioliformis	W0534	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crepidula fornicata	W0726	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Buccinum undatum	W0844	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Retusa sp.	W1013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Retusa obtusa	W1014	1	-	50	3	2	38	-	6	12	6	-	4	-	5	56	30	30	-	-	-	2	8	11	4
Retusa truncatula	W1017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudibranchia indet.	W1237	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-	-
Pelecypoda indet.	W1612	4	6	33	-	-	-	2	1	-	4	7	1	-	-	5	97	198	1	-	1	-	2	5	-
Nucula sp.	W1616	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nucleus	W1619	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	2	-	-	-	-	10	3	-
Jupiteria minuta	W1631	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Modiolus sp.	W1672	1	28	4	-	-	5	3	17	1	1	3	-	5	2	10	194	37	-	1	1	3	2	1	3
Modiolus modiolus	W1675	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Aequipecten opercularis	W1805	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semierycina nitida	W1880	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Kellia suborbicularis	W1885	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysella bidentata	W1905	5	2	59	2	1	7	16	-	4	4	-	-	1	-	21	85	83	-	-	-	18	370	111	4
Tellimya ferruginosa	W1911	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	5	-	-	-	-	-	-
Cerastoderma edule	W1991	-	108	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula sp.	W2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula elliptica	W2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula solida	W2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solen sp.	W2017	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Ensis americanus	W202-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	1	7	2	-	-	-	-	-	4	-
Ensis sp.	W2022	-	-	2	-	1	1	-	-	-	-	-	-	-	-	-	12	-	1	-	-	-	-	-	-
Tellinidae indet.	W2043	-	-	-	-	-	-	4	-	-	-	-	-	-	5	-	12	2	4	-	-	-	-	-	-
Angulus tenuis	W2046	36	-	2	-	9	2	10	-	11	23	14	11	3	4	48	6	12	8	5	-	14	2	9	16
Fabulina fabula	W2057	20	-	17	1	2	5	29	6	-	24	19	5	-	7	78	111	67	20	2	-	26	-	149	6
Moerella pygmaea	W2063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macoma balthica	W2067	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra sp.	W2101	-	5	-	10	-	-	-	-	-	-	-	1	-	-	-	-	56	-	-	-	-	-	-	1
Abra alba	W2102	-	-	8	-	-	-	-	1	-	-	1	-	-	-	6	114	129	1	-	-	-	1101	159	81

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	Site 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Abra prismatica	W2105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Tapes rhomboides	W2181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Venerupis senegalensis	W2185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
Mya sp.	W2225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	-	-	-	-	-	-
Mya truncata	W2227	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Mya arenaria	W2229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-
Hiatella arctica	W2251	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoronis muelleri	ZA0005	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	77	43	-	-	-	-	2241	9	-
Crossaster papposus	ZB0149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Asterias rubens	ZB0190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiuroidea indet.	ZB0204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-
Ophiothrix fragilis	ZB0235	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphipholis squamata	ZB0300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Ophiura sp.	ZB0311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiura albida	ZB0313	14	-	45	-	-	-	16	-	-	-	-	-	-	-	4	93	43	-	1	-	1	52	60	-
Ophiura ophiura	ZB0315	10	-	4	-	3	-	1	-	-	1	-	-	-	-	-	2	1	-	-	-	-	25	6	-
Psammechinus miliaris	ZB0355	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Echinocardium cordatum	ZB0407	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	5	-	-	-	-	-	-
Holothurioidea indet.	ZB0418	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Thyone fusus	ZB0495	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Tunicata indet.	ZD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	Total Taxa	35	43	72	24	27	40	54	30	29	42	42	33	25	34	52	111	106	37	13	15	51	84	68	42
	Total Individuals	452	1241	1369	584	168	369	681	221	362	488	478	191	301	530	996	4477	4185	369	31	56	1186	5694	1788	495

Numbers are totals / 3 Day Grabs

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Actiniidae indet.	D1149	-	-	2	-	-	-	19	13	16	-	7	-	9	-	3	3	9	3	-	-	-	4	-	56
Nemertea indet.	G	4	1	34	1	-	9	80	23	86	12	49	-	7	4	37	8	15	43	-	-	1	1	-	4
Tubulanus superbus	G0047	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	12
Sipuncula indet.	N	-	-	-	-	-	-	1	-	10	-	41	-	-	-	-	-	-	-	-	-	-	-	-	-
Pisione ramota	P0020	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aphrodita aculeata	P0027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polynoidae indet.	P0042	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gattyana cirrosa	P0093	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harmothoe sp.	P0097	-	-	-	-	-	-	-	-	133	-	28	-	-	-	-	-	-	-	-	-	-	-	-	-
Harmothoe impar	P0107	-	-	1	-	-	-	10	27	370	-	124	-	9	1	55	9	35	199	-	-	-	39	-	8
Harmothoe marphysae	P0121	-	-	-	-	-	-	-	-	2	-	4	1	-	-	-	-	-	4	-	-	-	5	-	-
Lepidonotus squamatus	P0133	-	-	-	-	-	-	-	1	5	-	3	-	-	-	-	-	-	4	-	-	-	-	-	2
Pholoe sp.	P0168	-	-	5	-	4	-	180	197	523	-	318	14	68	71	263	30	100	430	-	2	2	51	-	13
Sthenelais boa	P0187	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	5	-	-	-	-	-	2
Phyllodocidae indet.	P0200	-	-	-	-	-	-	1	-	29	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone sp.	P0202	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone flava	P0203	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Eteone foliosa	P0204	-	-	-	-	-	-	5	-	10	-	-	-	-	-	5	1	2	3	-	-	-	-	-	-
Eteone longa	P0205	-	-	1	-	-	-	5	3	4	-	-	-	-	5	10	2	11	10	-	1	1	8	-	1
Hesionura elongata	P0213	-	-	597	-	-	79	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Eteone picta	P0224	-	-	-	-	-	-	-	-	3	-	8	-	-	-	-	-	-	4	-	-	-	-	-	-
Phyllodoce groenlandica	P0253	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1	1	-	-	-	-	2	-	-
Phyllodoce mucosa	P0257	-	-	-	-	-	-	-	-	-	-	-	3	34	5	1	6	3	-	-	-	1	27	-	-
Phyllodoce rosea	P0258	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Eulalia sp.	P0268	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia bilineata	P0270	-	-	-	-	-	-	-	-	4	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia viridis	P0277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eulalia ornata	P0280	-	-	-	-	-	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumida sp.	P0282	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eumida bahusiensis	P0283	-	-	-	-	-	-	14	-	4	-	1	2	41	13	151	3	15	11	-	-	2	38	-	5
Phyllodoce sp.	P0311	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera sp.	P0471	1	1	49	-	-	-	3	2	-	1	5	2	2	3	4	3	3	-	-	-	-	1	-	2
Glycera lapidum	P0476	-	-	8	-	-	-	2	-	6	1	3	-	-	-	-	3	-	1	-	-	-	1	-	5
Glycera oxycephala	P0478	-	-	2	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glycera tridactyla	P0481	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Goniada maculata	P0493	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Sphaerodoropsis minuta	P0521	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerodorum gracilis	P0527	-	-	-	-	-	-	-	-	[illegible]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kefersteinia cirrata	P0552	-	-	-	-	-	-	11		[illegible]	-	4	-	-	-	-	-	1	33	-	-	-	-	-	-
Micropthalmus similis	P0601	-	-	64	-							-	-	-	-	-	250	-	-	-	-	-	-	36	-

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Syllidae indet.	P0635	-	-	-	-	-	-	-	1	19	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-
Typosyllis armillaris	P0667	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-
Eusyllis blomstrandi	P0686	-	-	-	1	-	-	1	15	10	1	12	-	-	-	-	6	12	11	-	-	-	-	-	80
Streptosyllis websteri	P0723	-	1	1	2	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-
Exogone hebes	P0744	-	-	19	-	-	-	10	1	25	-	14	1	4	17	43	-	-	3	-	-	4	2	-	14
Exogone naidina	P0745	-	-	-	-	-	-	-	-	7	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Exogone verugera	P0746	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerosyllis sp.	P0750	-	-	40	-	-	-	6	3	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Sphaerosyllis bulbosa	P0751	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	71	-	-	-	-	-	-	-	-
Autolytus sp.	P0761	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Autolytus langerhansi	P0767	-	-	-	-	-	-	3	46	125	-	31	8	43	-	43	-	31	27	-	-	2	12	-	51
Autolytus prolifera	P0771	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Proceraea cornuta	P0785	-	-	-	-	-	-	-	-	-	-	3	6	4	8	1	4	5	-	-	-	6	1	-	5
Nereis diversicolor	P0810	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis sp.	P0832	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nereis longissima	P0834	-	-	-	-	-	-	2	6	9	-	2	-	1	3	9	1	3	10	-	-	-	1	-	1
Nephtys sp.	P0867	6	4	1	-	49	15	-	4	-	4	1	136	32	28	-	-	1	3	218	7	15	6	-	1
Nephtys caeca	P0868	1	-	-	-	-	-	1	-	2	1	1	-	4	1	1	2	2	-	-	-	3	2	1	2
Nephtys cirrosa	P0870	31	1	3	16	-	23	-	-	-	6	-	-	-	-	1	-	-	-	-	55	-	-	-	-
Nephtys hombergii	P0871	3	-	-	-	116	-	3	32	3	2	-	44	44	34	9	-	1	5	48	1	63	24	14	8
Nephtys longosetosa	P0875	1	2	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbrineris sp.	P1001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbrineris gracilis	P1008	-	-	-	-	-	-	2	3	9	-	5	-	1	-	1	1	1	3	-	-	-	-	-	-
Lumbrineris latreilli	P1011	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Protodorvillea kefersteini	P1104	-	-	8	-	-	-	44	13	86	-	47	-	-	-	5	12	30	56	-	-	-	-	-	-
Scoloplos armiger	P1152	12	1	-	-	12	2	96	331	206	-	4	55	451	289	353	263	238	183	7	4	107	142	11	121
Aricidea minuta	P1158	-	-	-	2	-	-	32	6	10	3	4	2	61	16	37	3	-	-	-	-	1	66	12	-
Poecilochaetus serpens	P1221	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Aonides oxycephala	P1227	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Aonides paucibranchiata	P1228	-	-	56	-	-	-	20	-	85	-	50	-	1	-	5	8	21	-	-	-	-	-	-	-
Laonice bahusiensis	P1250	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Laonice cirrata	P1251	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Polydora sp.	P1274	-	-	-	-	-	1	-	4	76	-	29	-	1	1	1	32	1	-	-	-	-	1	-	7
Pseudopolydora pulchra	P1312	-	-	-	-	-	-	22	4	2	1	-	-	10	18	49	1	5	4	-	-	-	2	-	18
Pygospio elegans	P1317	1	-	1	-	-	-	4	-	-	-	-	28	107	131	7	18	6	9	2	6	101	649	1	18
Scolelepis sp.	P1321	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scolelepis mesnili	P1325	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Scolelepis squamata	P1326	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spio sp.	P1333	29	7	2	14	-	16	1	-	-	11	-	-	-	-	2	-	-	-	-	-	52	4	7	3
Spiophanes bombyx	P1343	13	20	31	-	3	3	1	-	5	11	-	38	769	387	13	4	7	1	-	29	642	156	17	1

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Streblospio shrubsolii	P1351	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona filiformis	P1363	5	1	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Magelona mirabilis	P1365	23	3	-	1	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	3	1	-	-	-
Cirratulidae indet.	P1392	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caulleriella alata	P1394	-	-	-	-	-	-	13	9	10	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Chaetozone setosa	P1403	3	-	13	-	5	-	1334	412	325	4	115	11	149	335	730	144	198	129	-	-	6	21	4	-
Cirratulus sp.	P1407	-	-	-	-	-	-	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Cirriformia tentaculata	P1414	-	-	-	-	-	-	-	-	-	-	1	-	1	1	2	2	5	8	-	-	-	-	-	1
Dodecaceria concharum	P1420	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-
Tharyx marioni	P1424	-	1	3	-	17	-	116	146	235	-	110	16	9	21	72	17	64	192	1	-	-	-	-	1
Cossura longocirrata	P1465	-	-	-	-	12	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
Flabelligeridae indet.	P1471	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flabelligera affinis	P1484	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Pherusa plumosa	P1491	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrochaeta helgolandica	P1504	-	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capitella capitata	P1531	2	-	-	4	1	2	1	-	-	1	1	3	3	9	7	-	-	1	-	1	3	-	3	12
Heteromastus filiformis	P1553	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mediomastus fragilis	P1558	-	-	3	-	7	1	349	396	136	-	53	1	175	593	594	31	52	168	-	-	43	171	10	12
Notomastus latericeus	P1563	-	-	-	-	-	-	1	3	2	-	-	1	3	12	8	2	3	-	-	-	1	3	-	-
Arenicola marina	P1576	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
Maldanidae indet.	P1591	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelia borealis	P1690	-	-	1	-	-	9	-	-	-	3	-	-	-	-	-	8	-	1	-	-	-	-	17	-
Euzonus flabelligerus	P1700	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Travisia forbesii	P1706	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophelina acuminata	P1719	-	-	-	-	-	-	2	1	6	-	-	-	2	1	9	2	5	-	-	-	-	-	-	-
Scalibregma inflatum	P1743	-	-	7	-	-	-	17	23	9	1	2	1	33	33	86	22	48	1	-	-	-	15	1	1
Owenia fusiformis	P1838	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	-	-	-	-	-	-	-	-	-
Terebellida indet.	P1840	-	-	2	-	-	-	-	-	1	1	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Pectinaria koreni	P1854	-	-	1	-	6	-	8	2	15	1	-	1	12	42	38	3	16	-	-	-	25	13	-	-
Sabellaria sp.	P1874	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabellaria spinulosa	P1876	-	-	2	-	-	-	55	810	4540	-	2456	-	24	1	1	124	90	690	-	4	-	3	-	15
Melinna cristata	P1883	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Melinna palmata	P1886	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ampharete sp.	P1904	-	-	4	-	3	-	26	56	48	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Ampharete acutifrons	P1909	-	-	-	-	-	-	-	-	-	-	8	-	1	-	1	-	-	-	-	-	-	2	-	-
Ampharete lindstroemi	P1910	-	-	-	-	1	-	167	155	18	-	2	-	55	49	270	34	81	41	-	-	2	10	-	1
Lanice conchilega	P2031	-	-	3	-	-	-	28	1	16	-	1	3	31	30	92	1	14	14	-	-	-	55	-	11
Neoamphitrite figulus	P2053	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycirrus sp.	P2117	-	-	15	-	-	-	1	8	6	-	27	-	-	-	-	-	1	10	-	-	-	-	-	-
Thelepus cincinnatus	P2144	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Sabellidae indet.	P2150	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sabella pavonina	P2261	-	-	-	-	-	-	-	9	25	-	2	-	-	-	4	20	15	1	-	-	-	7	-	49
Pomatoceros triqueter	P2304	-	-	-	-	-	-	40	5	43	-	27	-	-	-	-	1	3	201	-	-	-	-	-	-
Oligochaeta indet.	P2417	-	-	24	-	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubificoides sp.	P2484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubificoides benedeni	P2487	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	1	-	1
Tubificoides pseudogaster	P2489	-	-	1	-	25	-	11	4	5	-	1	82	93	68	15	-	-	4	3	-	7	51	3	25
Tubificoides diazi	P2490	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
Tubificoides swirencoides	P2491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pycnogonida indet.	Q0001	-	-	-	-	-	-	-	3	2	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Nymphon brevirostre	Q0004	-	-	-	-	-	-	-	7	3	-	17	-	-	-	-	-	-	-	-	-	-	-	-	2
Nymphon gracile	Q0006	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	2	5	2	-	-	-	2	-	-
Achelia sp.	Q0016	-	-	-	-	-	-	-	46	69	1	149	10	2	1	6	23	31	100	-	-	4	45	-	18
Endeis spinosa	Q0039	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Callipallene brevirostris	Q0045	-	-	-	-	-	-	-	5	24	-	12	-	-	-	-	-	1	26	-	-	-	-	-	-
Anoplodactylus sp.	Q0060	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anoplodactylus angulatus	Q0061	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anoplodactylus petiolatus	Q0062	-	1	-	-	-	-	1	24	5	-	12	3	5	4	23	19	55	34	-	-	7	19	-	9
Anoplodactylus pygmaeus	Q0063	-	-	-	-	-	-	-	-	3	-	4	3	1	-	-	1	-	2	-	-	-	-	-	2
Pycnogonum littorale	Q0075	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	1
Balanidae indet.	R0100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Mysidae indet.	S0046	-	-	6	-	-	1	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus sp.	S0063	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus normani	S0065	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastrosaccus spinifer	S0067	1	1	7	1	-	3	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erythrops elegans	S0074	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemimysis lamornae	S0117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mesopodopsis slabberi	S0122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neomysis integer	S0127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis sp.	S0145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Schistomysis kervillei	S0146	2	-	-	-	-	-	-	-	1	-	-	1	-	1	-	1	-	-	-	-	1	-	1	-
Schistomysis spiritus	S0149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Amphipoda indet.	S0166	-	-	3	-	-	-	2	4	3	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-
Perioculodes longimanus	S0228	1	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-	3	1	3
Pontocrates sp.	S0232	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pontocrates altamarinus	S0233	1	2	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Pontocrates arenarius	S0234	4	5	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parapleustes bicuspis	S0254	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphilochus sp.	S0277	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphilochus manudens	S0279	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	2	10	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991 :

Taxon	MCS	25	26	27	28	29	30	31	32	33
Amphilochus neapolitanus	S0280	-	-	-	-	-	-	-	3	1
Cressa dubia	S0328	-	-	-	-	-	-	1	7	6
Stenothoe sp.	S0366	-	-	-	-	-	-	-	-	-
Stenothoe marina	S0370	-	-	-	-	-	-	-	3	14
Urothoe sp.	S0427	-	-	-	-	-	-	-	-	-
Urothoe brevicornis	S0428	-	-	-	2	-	-	-	-	-
Urothoe elegans	S0429	-	-	1	-	-	-	-	-	2
Urothoe poseidonis	S0431	-	-	-	-	-	-	-	-	-
Urothoe pulchella	S0432	-	-	-	-	-	-	-	-	-
Harpinia pectinata	S0441	-	-	-	-	-	-	3	-	3
Metaphoxus fultoni	S0447	-	-	-	-	-	-	-	-	3
Phoxocephalus holbolli	S0459	-	-	17	-	-	-	1	-	-
Orchomene nana	S0539	-	-	-	-	-	-	-	-	-
Iphimedia obesa	S0628	-	-	-	-	-	-	-	-	-
Atylus sp.	S0680	-	-	1	-	-	-	-	-	-
Atylus falcatus	S0681	-	-	2	-	-	4	-	-	-
Atylus guttatus	S0682	-	-	13	-	-	-	3	1	-
Atylus swammerdami	S0683	-	-	1	-	-	-	-	1	-
Guernea coalita	S0696	-	-	-	-	-	-	-	-	-
Ampelisca sp.	S0707	-	-	-	-	-	-	2	1	-
Ampelisca brevicornis	S0710	-	-	-	-	12	-	-	-	-
Ampelisca diadema	S0711	1	-	-	-	-	-	46	301	74
Ampelisca spinipes	S0718	-	-	1	-	-	-	5	5	10
Ampelisca typica	S0722	-	-	-	-	-	-	-	-	-
Bathyporeia sp.	S0740	-	-	-	-	-	-	-	-	-
Bathyporeia elegans	S0741	20	11	-	-	-	8	-	-	1
Bathyporeia gracilis	S0742	-	2	-	-	-	-	-	-	-
Bathyporeia guilliamsoniana	S0743	-	-	-	-	-	-	-	-	-
Bathyporeia nana	S0744	-	-	-	-	-	-	-	-	-
Bathyporeia pelagica	S0745	-	-	-	1	-	-	-	-	-
Bathyporeia pilosa	S0746	1	-	-	-	-	-	-	-	-
Bathyporeia sarsi	S0747	6	-	-	-	-	4	-	-	-
Bathyporeia tenuipes	S0748	-	-	-	-	-	-	-	-	-
Haustorius arenarius	S0754	-	-	-	-	-	-	-	-	-
Gammarus sp.	S0768	-	-	-	-	-	-	-	-	-
Megaluropus agilis	S0790	-	1	-	-	-	-	-	-	-
Abludomelita obtusata	S0808	-	-	-	-	-	-	21	2	1
Cheirocratus sp.	S0822	-	-	-	-	-	-	2	1	-
Maerella tenuimana	S0858	-	-	-	-	-	-	2	-	-
Melita sp.	S0862	-	-	-	-	-	-	6	-	-

34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
-	-	-	-	-	2	2	3	2	-	-	-	-	-	2
-	-	-	-	-	-	-	6	17	-	-	-	-	-	19
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	22	-	-	-	-	9	16	14	-	-	-	-	-	50
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-	385	-	-	-	39	11	71	26	-	-	-	-	-	-
-	25	-	-	1	12	-	6	3	-	-	-	-	-	-
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Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Melita palmata	S0865	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Gammaropsis sp.	S0896	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Megamphopus cornutus	S0912	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microprotopus maculatus	S0918	-	-	1	-	-	-	5	-	-	1	-	6	21	25	37	-	-	-	-	-	10	26	1	7
Photis pollex	S0924	-	-	-	-	-	-	15	20	2	-	24	-	11	1	38	4	8	1	-	-	1	-	-	7
Aora gracilis	S0974	-	-	-	-	-	-	4	5	28	2	40	-	6	1	16	34	74	52	-	-	-	3	-	151
Corophium sp.	S1017	-	-	1	-	-	-	2	-	9	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-
Unciola crenatipalma	S1038	-	-	-	-	-	-	-	-	9	-	14	-	-	-	-	4	-	1	-	-	-	-	-	-
Dyopedos monacanthus	S1051	-	-	-	-	-	-	1	1	-	-	5	-	2	-	3	3	-	1	-	-	-	-	-	-
Pariambus typicus	S1084	-	-	-	-	-	-	296	3	-	-	-	2	17	9	23	1	-	1	1	-	2	200	-	11
Pseudoprotella phasma	S1101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Isopoda indet.	S1316	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eurydice pulchra	S1422	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idotea linearis	S1554	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Idotea sp.	S1559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tanaidacea indet.	S1868	5	1	-	40	-	2	-	-	18	-	62	-	-	-	-	-	-	-	-	24	-	-	1	-
Cumopsis goodsiri	S1988	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
Bodotria pulchella	S2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
Bodotria scorpioides	S2003	-	-	2	3	-	-	16	4	10	-	24	-	2	1	12	2	13	9	-	-	-	9	-	21
Eudorella truncatula	S2022	-	-	-	-	3	-	-	-	1	-	-	2	1	-	2	-	-	1	-	-	-	-	-	-
Cumella pygmaea	S2048	-	-	-	-	-	-	-	1	23	-	3	-	-	-	-	-	-	7	-	-	1	-	6	-
Pseudocuma longicornis	S2072	2	1	3	2	11	9	1	1	1	-	-	12	6	7	3	13	6	-	3	11	6	2	11	11
Diastylis sp.	S2095	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diastylis bradyi	S2096	2	1	-	-	5	-	-	1	-	-	-	6	7	6	2	2	1	-	1	-	18	1	-	2
Diastylis rathkei	S2100	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hippolyte varians	S2271	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Pandalus montagui	S2322	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	4	-	-	-	-	-	7
Crangon sp.	S2329	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Crangon crangon	S2331	-	-	-	-	-	-	1	-	-	-	-	-	1	2	2	-	3	-	-	-	-	2	-	1
Pisidia longicornis	S2502	-	-	1	-	-	1	2	1	68	-	32	-	-	-	-	-	-	440	-	-	-	2	-	13
Hyas araneus	S2559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Macropodia linaresi	S2584	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Atelecyclus rotundatus	S2626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cancer pagurus	S2646	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Liocarcinus sp.	S2666	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liocarcinus holsatus	S2670	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	1	-	-	-	-	1	-	7
Pilumnus hirtellus	S2735	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polyplacophora indet.	W0050	-	-	-	-	-	-	2	1	-	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-
Leptochiton cancellatus	W0056	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Gastropoda indet.	W0092	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Archaeogastropoda indet.	W0093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gibbula cineraria	W0193	-	-	-	-	-	-	13	-	1	-	5	-	-	-	-	-	-	12	-	-	-	-	-	3
Hydrobia ulvae	W0274	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	4	9	-	-	-	-	-	13
Rissoa interrupta	W0284	-	-	-	-	-	-	-	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alvania semistriata	W0318	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Onoba semicostata	W0340	-	-	-	-	-	-	-	-	1	-	8	-	-	-	-	-	-	4	-	-	-	-	-	-
Chrysallida indistincta	W0510	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Partulida spiralis	W0517	-	-	-	-	-	-	-	10	163	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-
Noemiamea dolioliformis	W0534	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crepidula fornicata	W0726	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-
Buccinum undatum	W0844	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Retusa sp.	W1013	-	-	-	-	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Retusa obtusa	W1014	-	-	5	-	11	-	61	9	14	-	4	14	4	1	38	2	16	3	-	-	4	11	-	-
Retusa truncatula	W1017	-	-	-	-	-	-	-	1	5	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Nudibranchia indet.	W1237	-	-	-	-	-	-	-	-	1	-	17	-	-	-	-	-	1	2	-	-	-	-	-	1
Pelecypoda indet.	W1612	-	1	13	-	6	-	55	84	50	-	54	9	1	-	35	23	32	98	-	-	13	3	-	-
Nucula sp.	W1616	-	-	-	-	3	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nucula nucleus	W1619	-	-	-	-	2	-	76	137	45	-	47	-	1	10	193	3	17	64	-	-	1	-	-	-
Jupiteria minuta	W1631	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Modiolus sp.	W1672	-	-	28	1	36	6	33	44	90	-	79	15	-	-	-	19	35	9	-	3	22	8	1	33
Modiolus modiolus	W1675	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Aequipecten opercularis	W1805	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Semierycina nitida	W1880	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kellia suborbicularis	W1885	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mysella bidentata	W1905	1	-	2	1	61	-	47	27	22	-	12	7	13	335	34	1	5	20	-	1	73	109	-	5
Tellimya ferruginosa	W1911	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cerastoderma edule	W1991	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula sp.	W2002	-	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spisula elliptica	W2003	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	5	1	-	-	-	-	-	-	-
Spisula solida	W2005	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Solen sp.	W2017	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ensis americanus	W202-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	1	-	-
Ensis sp.	W2022	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tellinidae indet.	W2043	2	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Angulus tenuis	W2046	6	4	2	21	17	3	-	-	-	-	-	-	-	-	-	-	1	-	-	6	6	7	-	2
Fabulina fabula	W2057	6	-	-	-	1	-	-	-	1	-	-	11	13	48	12	1	1	1	-	4	15	41	-	2
Moerella pygmaea	W2063	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macoma balthica	W2067	-	-	-	-	3	-	-		-	-	-	1	1	-	-	-	-	-	-	-	1	1	-	-
Abra sp.	W2101	-	-	8	-	10	-	9		12	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Abra alba	W2102	-	1	19	-	[illegible]		[illegible]	[illegible]	[illegible]	6	26	-	137	110	734	13	208	131	-	-	2	118	-	36

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Abra prismatica	W2105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
Tapes rhomboides	W2181	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Venerupis senegalensis	W2185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mya sp.	W2225	-	-	-	-	-	-	1	7	2	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-
Mya truncata	W2227	-	-	-	-	-	-	-	-	13	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-
Mya arenaria	W2229	-	-	-	-	-	-	1	-	4	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Hiatella arctica	W2251	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phoronis muelleri	ZA0005	-	-	-	-	53	-	22	3	6	-	17	-	8	14	-	-	-	12	6	-	-	1	-	-
Crossaster papposus	ZB0149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
Asterias rubens	ZB0190	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-	-	1	-	-	-	1	-	-
Ophiuroidea indet.	ZB0204	-	-	-	-	-	-	1	-	10	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-
Ophiothrix fragilis	ZB0235	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphipholis squamata	ZB0300	-	-	-	-	-	-	-	4	6	-	1	-	1	-	-	-	6	17	-	-	-	-	-	-
Ophiura sp.	ZB0311	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Ophiura albida	ZB0313	-	-	1	-	26	-	68	140	135	1	15	46	66	74	146	37	79	2	1	-	6	70	4	6
Ophiura ophiura	ZB0315	-	-	-	-	6	-	-	-	-	-	-	4	3	12	5	-	-	-	-	-	2	3	-	-
Psammechinus miliaris	ZB0355	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
Echinocardium cordatum	ZB0407	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Holothurioidea indet.	ZB0418	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Thyone fusus	ZB0495	-	-	-	-	-	-	2	2	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	-
Tunicata indet.	ZD	-	-	-	-	-	-	-	44	182	-	70	-	-	-	-	10	33	180	-	-	-	-	-	4
	Total Taxa	32	26	66	18	38	27	90	88	131	30	113	52	67	61	75	72	76	92	13	22	47	66	30	74
	Total Individuals	197	76	1201	115	1363	217	3735	3990	8833	123	4980	636	2703	2945	4483	1411	1901	3876	293	173	1290	2302	184	1047

Numbers are totals / 3 Day Grabs

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Actiniidae Indet.	D1149	56	-	-	-	-	-	-	-	1	-	-	-	-	-	2	9	1	13	22	230
Nemertea Indet.	G	12	5	-	-	-	2	1	2	1	4	-	-	-	-	-	4	1	50	45	609
Tubulanus superbus	G0047	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	14
Sipuncula Indet.	N	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	53
Pisione remota	P0020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4
Aphrodita aculeata	P0027	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Polynoidae Indet.	P0042	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Gattyana cirrosa	P0093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Harmothoe sp.	P0097	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	7	203
Harmothoe impar	P0107	22	-	-	1	-	11	5	1	4	-	-	1	4	-	-	2	6	20	29	1131
Harmothoe marphysae	P0121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	64
Lepidonotus squamatus	P0133	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	17
Pholoe sp.	P0168	42	-	-	-	-	4	-	-	9	-	-	-	1	-	1	2	7	87	37	2868
Sthenelais boa	P0187	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7	16
Phyllodocidae Indet.	P0200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	10	210
Eteone sp.	P0202	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Eteone flava	P0203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Eteone foliosa	P0204	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	9	29
Eteone longa	P0205	3	1	-	1	22	-	-	-	-	-	-	33	1	-	-	-	2	-	33	173
Hesionura elongata	P0213	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	683
Eteone picta	P0224	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5	17
Phyllodoce groenlandica	P0253	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	8	20
Phyllodoce mucosa	P0257	-	-	1	-	4	3	-	-	1	-	-	18	1	-	2	1	7	-	25	208
Phyllodoce rosea	P0258	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	7
Eulalia sp.	P0268	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Eulalia bilineata	P0270	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	20
Eulalia viridis	P0277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1
Eulalia ornata	P0280	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	6
Eumida sp.	P0282	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12
Eumida bahusiensis	P0283	45	-	-	1	-	8	11	-	24	1	-	-	1	-	-	4	155	2	33	1199
Phyllodoce sp.	P0311	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	8
Glycera sp.	P0471	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	7	25	112
Glycera lapidum	P0476	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	33
Glycera oxycephala	P0478	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5
Glycera tridactyla	P0481	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Goniada maculata	P0493	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	6	8
Sphaerodoropsis minuta	P0521	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	12
Sphaerodorum gracilis	P0527	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	7
Kefersteinia cirrata	P0552	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	9	90
Micropthalmus similis	P0601	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	567

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Syllidae indet.	P0635	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	44
Typosyllis armillaris	P0667	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Eusyllis blomstrandi	P0686	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	59	16	261
Streptosyllis websteri	P0723	3	1	-	-	12	-	-	-	1	-	-	19	-	-	1	-	-	-	19	60
Exogone hebes	P0744	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	22	269
Exogone naidina	P0745	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	9
Exogone verugera	P0746	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7
Sphaerosyllis sp.	P0750	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	58
Sphaerosyllis bulbosa	P0751	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	73
Autolytus sp.	P0761	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4
Autolytus langerhansi	P0767	8	-	-	-	-	4	3	-	1	-	-	1	2	1	5	5	63	50	35	1149
Autolytus prolifera	P0771	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Proceraea cornuta	P0785	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	13	46
Nereis diversicolor	P0810	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Nereis sp.	P0832	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5	8
Nereis longissima	P0834	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2	18	64
Nephtys sp.	P0867	2	2	-	17	12	3	4	18	3	7	3	33	87	-	-	3	20	2	52	1099
Nephtys caeca	P0868	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	22	35
Nephtys cirrosa	P0870	-	2	2	-	72	-	-	39	31	49	14	32	-	2	-	41	61	-	38	888
Nephtys hombergii	P0871	-	-	2	33	-	37	46	4	26	4	2	10	68	45	60	3	14	-	51	1430
Nephtys longosetosa	P0875	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7
Lumbrineris sp.	P1001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Lumbrineris gracilis	P1008	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	11	28
Lumbrineris latreillii	P1011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	9
Protodorvillea kefersteini	P1104	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	13	320
Scoloplos armiger	P1152	70	5	1	1	1	3	4	2	1	2	1	1	170	3	3	4	1	58	61	4342
Aricidea minuta	P1158	4	10	-	-	-	-	-	-	-	1	1	2	1	1	4	36	1	10	41	626
Poecilochaetus serpens	P1221	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Aonides oxycephala	P1227	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Aonides paucibranchiata	P1228	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	9	259
Laonice bahusiensis	P1250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4
Laonice cirrata	P1251	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4
Polydora sp.	P1274	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	15	20	182
Pseudopolydora pulchra	P1312	9	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	20	280
Pygospio elegans	P1317	-	-	-	2	15	55	3	2	15	1	-	16	66	-	7	3	8	-	44	1720
Scolelepis sp.	P1321	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Scolelepis mesnili	P1325	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5
Scolelepis squamata	P1326	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Spio sp.	P1333	2	3	3	-	61	371	202	52	288	6	24	45	-	295	951	36	174	1	51	4290
Spiophanes bombyx	P1343	6	77	-	-	28	419	89	28	90	68	1	14	53	14	26	50	59	-	59	6233

Table 1 : Wash Subtidal Survey 1991 :

Taxon	MCS	49	50	51	52	53	54	55	56
Streblospio shrubsolii	P1351	-	-	-	-	-	-	-	-
Magelona filiformis	P1363	-	-	-	-	-	-	-	-
Magelona mirabilis	P1365	-	-	-	-	5	5	4	4
Cirratulidae indet.	P1392	-	-	-	-	-	-	-	-
Caulleriella alata	P1394	-	-	-	-	-	-	-	-
Chaetozone setosa	P1403	22	6	-	-	-	5	5	5
Cirratulus sp.	P1407	-	-	-	-	-	-	-	-
Cirriformia tentaculata	P1414	2	-	-	-	-	-	-	-
Dodecaceria concharum	P1420	-	-	-	-	-	-	-	-
Tharyx marioni	P1424	6	-	-	-	-	-	-	-
Cossura longocirrata	P1465	-	-	-	-	-	-	-	-
Flabelligeridae indet.	P1471	-	-	-	-	-	-	-	-
Flabelligera affinis	P1484	-	-	-	-	-	-	-	-
Pherusa plumosa	P1491	-	-	-	-	-	-	-	-
Macrochaeta helgolandica	P1504	-	-	-	-	-	-	-	-
Capitella capitata	P1531	1	1	-	-	1	28	2	3
Heteromastus filiformis	P1553	-	-	-	-	-	-	-	-
Mediomastus fragilis	P1558	37	4	-	1	-	1	-	-
Notomastus latericeus	P1563	1	1	-	-	-	-	-	-
Arenicola marina	P1576	-	-	-	-	-	-	-	-
Maldanidae indet.	P1591	-	-	-	-	-	-	-	-
Ophelia borealis	P1690	-	2	-	-	-	-	-	-
Euzonus flabelligerus	P1700	-	-	-	-	-	-	-	-
Travisia forbesii	P1706	-	-	-	-	-	-	-	-
Ophelina acuminata	P1719	-	-	-	-	-	-	-	-
Scalibregma inflatum	P1743	-	1	-	-	-	-	-	-
Owenia fusiformis	P1836	-	-	-	-	-	-	-	-
Terebellida indet.	P1840	-	-	-	-	-	-	-	-
Pectinaria koreni	P1854	12	3	-	-	-	-	8	-
Sabellaria sp.	P1874	-	-	-	-	-	-	-	-
Sabellaria spinulosa	P1876	105	-	-	-	-	-	-	-
Melinna cristata	P1883	-	-	-	-	-	-	-	-
Melinna palmata	P1886	-	-	-	-	-	-	-	-
Ampharete sp.	P1904	-	-	-	-	-	-	-	-
Ampharete acutifrons	P1909	-	-	-	-	-	-	-	-
Ampharete lindstroemi	P1910	23	-	-	-	-	-	-	-
Lanice conchilega	P2031	49	-	-	-	-	10	2	-
Neoamphitrite figulus	P2053	-	-	-	-	-	-	-	-
Polycirrus sp.	P2117	-	-	-	-	-	-	-	-
Thelepus cincinnatus	P2144	-	-	-	-	-	-	-	-

6	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
	-	-	-	-	-	-	-	-	-	-	1	2
	4	-	-	-	-	-	-	-	-	-	10	26
[illegible]	5	4	-	2	-	5	2	-	2	-	33	192
	-	-	-	-	-	-	-	-	-	-	3	7
	-	-	-	-	-	-	-	-	-	15	8	60
5	33	12	-	-	1	-	-	9	20	88	46	4993
	-	-	-	-	-	-	-	-	-	-	2	5
	-	-	-	-	-	-	-	-	-	7	11	31
	-	-	-	-	-	-	-	-	-	-	2	2
	-	2	-	-	-	3	2	-	-	35	37	1255
	-	-	-	-	-	-	-	-	-	-	2	13
	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	-	2	11
	-	-	-	-	-	-	-	-	-	-	1	31
[illegible]	292	-	2	1	13	33	21	-	35	1	51	965
	-	-	-	-	-	-	-	-	-	-	2	3
	-	-	-	-	7	2	-	-	1	28	37	3473
	3	-	-	-	-	-	-	2	3	2	22	90
	-	-	-	-	-	-	-	-	-	-	3	3
	-	-	-	-	-	-	-	-	-	-	5	11
	1	-	-	-	-	-	-	-	-	-	10	44
	-	-	-	-	-	-	-	-	-	-	1	2
	-	-	-	-	-	-	-	-	-	-	1	4
	-	-	-	-	-	-	-	-	-	-	12	64
	-	-	-	-	23	-	-	-	-	-	25	487
	-	-	-	-	-	-	-	-	-	-	7	25
	-	-	-	-	-	-	-	-	-	1	10	31
	4	-	-	-	4	2	-	-	2	6	30	355
	-	-	-	-	-	-	-	-	-	-	2	2
	2	-	-	-	2	-	-	-	1	2454	28	11654
	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	25	14	315
	-	-	-	-	-	-	-	-	-	-	7	125
	-	-	-	-	1	-	-	-	-	34	22	1267
	9	-	-	-	12	-	1	1	51	4	35	993
	-	-	-	-	-	-	-	-	-	-	1	1
	-	-	-	-	-	-	-	-	-	2	8	70
	-	-	-	-	-	-	-	-	-	-	2	2

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Sabellidae indet.	P2150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Sabella pavonina	P2261	7	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	12	143
Pomatoceros triqueter	P2304	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	11	380
Oligochaeta indet.	P2417	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	42
Tubificoides sp.	P2484	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	48
Tubificoides benedeni	P2487	-	-	-	1	-	-	-	-	5	-	1	-	-	-	-	-	-	-	12	142
Tubificoides pseudogaster	P2489	-	-	1	41	26	8	28	-	-	1	4	2	65	3	16	28	1	1	45	847
Tubificoides diazi	P2490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	11	323
Tubificoides swirencoides	P2491	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2	2
Pycnogonida indet.	Q0001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	9	25
Nymphon brevirostre	Q0004	4	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	8	9	53
Nymphon gracile	Q0006	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	7	16
Achelia sp.	Q0016	40	-	-	-	-	2	5	-	-	-	-	1	2	-	-	-	5	28	29	717
Endeis spinosa	Q0039	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	2
Callipallene brevirostris	Q0045	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	8	81
Anoplodactylus sp.	Q0060	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5
Anoplodactylus angulatus	Q0061	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	2	3
Anoplodactylus petiolatus	Q0062	46	-	-	2	-	-	2	-	2	-	-	-	-	-	-	2	4	22	31	406
Anoplodactylus pygmaeus	Q0063	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	14	29
Pycnogonum littorale	Q0075	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4
Balanidae indet.	R0100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	24
Mysidae indet.	S0046	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	19
Gastrosaccus sp.	S0063	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Gastrosaccus normanii	S0065	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	2	9
Gastrosaccus spinifer	S0067	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	73
Erythrops elegans	S0074	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Hemimysis lamornae	S0117	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Mesopodopsis slabberi	S0122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Neomysis integer	S0127	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	2
Schistomysis sp.	S0145	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Schistomysis kervillei	S0146	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	15	32
Schistomysis spiritus	S0149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6
Amphipoda indet.	S0166	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	12	33
Perioculodes longimanus	S0228	-	5	-	-	-	3	1	22	3	3	-	-	-	2	3	-	-	-	23	78
Pontocrates sp.	S0232	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Pontocrates altamarinus	S0233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	9
Pontocrates arenarius	S0234	-	-	-	-	-	1	-	34	3	30	-	-	-	-	-	2	-	-	16	119
Parapleustes bicuspis	S0254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4
Amphilochus sp.	S0277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Amphilochus manudens	S0279	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	14

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Amphilochus neapolitanus	S0280	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	12	25
Cressa dubia	S0328	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	58
Stenothoe sp.	S0366	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	4
Stenothoe marina	S0370	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	13	152
Urothoe sp.	S0427	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Urothoe brevicornis	S0428	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	25
Urothoe elegans	S0429	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	20
Urothoe poseidonis	S0431	-	-	-	-	-	5	-	1	10	-	-	-	-	-	-	-	1	-	13	46
Urothoe pulchella	S0432	-	-	-	-	-	6	2	3	4	4	-	-	-	14	4	-	-	-	13	74
Harpinia pectinata	S0441	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	20
Metaphoxus fultoni	S0447	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	8
Phoxocephalus holbolli	S0459	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	22
Orchomene nana	S0539	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Iphimedia obesa	S0628	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Atylus sp.	S0680	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	6	16
Atylus falcatus	S0681	-	-	-	-	-	1	2	-	-	-	-	-	-	1	-	-	-	-	10	17
Atylus guttatus	S0682	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2	20	25	96
Atylus swammerdami	S0683	-	-	-	-	-	1	5	-	6	-	-	-	2	-	3	1	11	1	18	41
Guernea coalita	S0696	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4
Ampelisca sp.	S0707	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	10
Ampelisca brevicornis	S0710	1	1	-	-	-	-	-	-	4	-	-	-	5	-	-	-	-	-	19	414
Ampelisca diadema	S0711	47	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	17	1048
Ampelisca spinipes	S0718	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	77
Ampelisca typica	S0722	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Bathyporeia sp.	S0740	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	11
Bathyporeia elegans	S0741	-	-	-	-	-	-	-	16	1	7	-	-	-	-	-	2	-	-	13	84
Bathyporeia gracilis	S0742	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Bathyporeia guilliamsoniana	S0743	-	-	-	-	-	-	-	8	-	13	-	1	-	-	-	-	10	-	15	69
Bathyporeia nana	S0744	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4
Bathyporeia pelagica	S0745	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	4	5
Bathyporeia pilosa	S0746	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Bathyporeia sarsi	S0747	-	-	1	-	1	-	-	21	-	16	-	15	-	-	-	-	8	-	17	114
Bathyporeia tenuipes	S0748	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	3	6
Haustorius arenarius	S0754	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1
Gammarus sp.	S0768	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	6
Megaluropus agilis	S0790	-	-	-	-	-	-	1	-	5	24	-	-	-	1	-	1	8	-	10	45
Abludomelita obtusata	S0808	30	-	-	-	-	-	8	-	2	-	-	-	3	-	-	1	5	-	18	121
Cheirocratus sp.	S0822	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4
Maerella tenuimana	S0858	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Melita sp.	S0862	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	9

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Melita palmata	S0865	14	-	-	-	-	-	3	-	2	-	-	-	4	-	-	1	-	-	9	31
Gammaropsis sp.	S0896	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Megamphopus cornutus	S0912	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3
Microprotopus maculatus	S0918	25	1	-	-	-	5	34	-	47	-	-	-	19	-	2	13	336	-	35	994
Photis pollex	S0924	11	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	3	19	182
Aora gracilis	S0974	129	-	1	-	-	1	5	-	-	-	-	-	-	-	-	3	48	186	25	939
Corophium sp.	S1017	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	13	57
Unciola crenatipalma	S1038	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	28
Dyopedos monacanthus	S1051	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	13	34
Pariambus typicus	S1084	9	-	-	-	-	-	7	-	29	-	-	-	122	1	1	8	38	1	35	1976
Pseudoprotella phasma	S1101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Isopoda indet.	S1316	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Eurydice pulchra	S1422	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1
Idotea linearis	S1554	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Idotea sp.	S1559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Tanaidacea indet.	S1868	-	-	-	-	156	-	3	89	12	16	-	66	-	1	25	2	21	27	33	961
Cumopsis goodsiri	S1988	-	-	-	-	22	-	2	5	2	-	-	9	1	1	-	10	2	-	25	162
Bodotria pulchella	S2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3
Bodotria scorpioides	S2003	20	-	-	-	-	-	-	-	2	-	-	-	-	2	2	-	1	4	26	222
Eudorella truncatula	S2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	31
Cumella pygmaea	S2048	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	42
Pseudocuma longicornis	S2072	3	4	3	-	5	2	23	11	42	51	1	6	32	7	19	13	14	-	56	484
Diastylis sp.	S2095	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	8
Diastylis bradyi	S2096	5	-	-	-	-	5	14	1	8	2	-	1	6	-	-	3	9	1	40	191
Diastylis rathkei	S2100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Hippolyte varians	S2271	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Pandalus montagui	S2322	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	2	6	16
Crangon sp.	S2329	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Crangon crangon	S2331	1	-	-	-	-	1	1	1	1	1	2	-	2	2	1	2	2	-	25	36
Pisidia longicornis	S2502	-	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	8	16	583
Hyas araneus	S2559	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Macropodia linearesi	S2584	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Atelecyclus rotundatus	S2626	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	5
Cancer pagurus	S2646	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Liocarcinus sp.	S2666	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	10
Liocarcinus holsatus	S2670	6	-	-	1	-	1	-	-	1	-	-	-	1	-	-	1	1	-	14	25
Pilumnus hirtellus	S2735	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Polyplacophora indet.	W0050	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	9
Leptochiton cancellatus	W0056	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Gastropoda indet.	W0092	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	8

Table 1 : Wash Subtidal Survey 1991 : Taxa recorded in 3 Day Grab Samples

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Archaeogastropoda indet.	W0093	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Gibbula cineraria	W0193	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	38
Hydrobia ulvae	W0274	14	-	2	2	-	1	-	-	1	1	1	-	-	-	-	-	2	14	16	81
Rissoa interrupta	W0284	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	6	49
Alvania semistriata	W0318	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	2	9
Onoba semicostata	W0340	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	13
Chrysallida indistincta	W0510	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Partulida spiralis	W0517	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	52	5	237
Noemiamea dolioliformis	W0534	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Crepidula fornicata	W0726	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5	10
Buccinum undatum	W0844	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2
Retusa sp.	W1013	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	14
Retusa obtusa	W1014	-	-	-	2	-	3	4	2	-	-	-	-	-	-	5	1	-	21	39	503
Retusa truncatula	W1017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10
Nudibranchia indet.	W1237	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	35	9	64
Pelecypoda indet.	W1612	37	-	-	1	-	4	-	-	16	-	-	-	1	-	-	1	7	53	38	964
Nucula sp.	W1616	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	11
Nucula nucleus	W1619	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	616
Jupiteria minuta	W1631	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Modiolus sp.	W1672	24	-	-	17	1	9	1	4	22	-	4	-	5	4	5	30	10	236	51	1156
Modiolus modiolus	W1675	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	3
Aequipecten opercularis	W1805	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Semierycina nitida	W1880	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Kellia suborbicularis	W1885	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	2
Mysella bidentata	W1905	-	2	-	-	-	11	22	-	2	1	-	-	28	1	5	7	-	24	46	1672
Tellimya ferruginosa	W1911	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10
Cerastoderma edule	W1991	-	-	-	92	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	202
Spisula sp.	W2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6
Spisula elliptica	W2003	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	4	9
Spisula solida	W2005	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Solen sp.	W2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5
Ensis americanus	W202-	3	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	12	25
Ensis sp.	W2022	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	27
Tellinidae indet.	W2043	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	31
Angulus tenuis	W2046	-	1	-	-	8	3	3	9	17	21	-	1	1	1	5	2	4	-	44	396
Fabulina fabula	W2057	-	-	-	1	-	8	26	1	6	-	1	-	2	24	12	2	-	-	43	834
Moerella pygmaea	W2063	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Macoma balthica	W2067	-	-	-	5	-	-	-	-	-	-	-	1	-	-	-	-	-	-	8	18
Abra sp.	W2101	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	130
Abra alba	W2102	123	8	-	-	-	3	7	-	2	-	-	-	4	-	-	1	4	79	36	4766

Taxon	MCS	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	Sites	Total Ind.
Abra prismatica	W2105	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3
Tapes rhomboides	W2181	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Venerupis senegalensis	W2185	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2
Mya sp.	W2225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	7	30
Mya truncata	W2227	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	22
Mya arenaria	W2229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	10
Hiatella arctica	W2251	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	5
Phoronis muelleri	ZA0005	-	-	-	-	-	-	-	-	-	-	-	-	55	-	-	-	-	2	17	2571
Crossaster papposus	ZB0149	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	10
Asterias rubens	ZB0190	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	6	6
Ophiuroidea indet.	ZB0204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	17
Ophiothrix fragilis	ZB0235	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Amphipholis squamata	ZB0300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	39
Ophiura sp.	ZB0311	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	3	3
Ophiura albida	ZB0313	44	11	-	2	-	9	22	1	4	2	-	-	13	13	5	1	-	2	42	1381
Ophiura ophiura	ZB0315	-	-	-	-	-	3	-	-	-	-	-	-	3	2	5	1	-	-	21	102
Psammechinus miliaris	ZB0355	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	5
Echinocardium cordatum	ZB0407	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	5	9
Holothurioidea indet.	ZB0418	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Thyone fusus	ZB0495	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	8
Tunicata indet.	ZD	69	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	10	623
	Total Taxa	71	31	11	21	20	47	43	31	59	30	15	27	47	33	35	50	57	94		89302
	Total Individuals	1339	171	18	227	454	1072	630	391	1119	355	62	334	900	491	1209	362	1262	4120	89302	

Numbers are totals / 3 Day Grabs

Table 2. Wash Subtidal Survey 1991 : Physico-Chemical Data

Site	Longitude	Latitude	Depth(m)	Sediment description	Median Particle Size(um)	Mean Particle Size(um)	% Clay & Silt	% Organic Carbon	Clostridia n/100ml.	E. coli n/100ml.	Faecal Streptococci n/100ml.	PCB-C52 ug/kg	Dieldrin (ug/kg)
1	52 58 21	00 10 00	5.6	fine/medium sand some mud	277.6	297.5	0.03	0.91	800	<1000	<200	210	120
2	52 57 31	00 10 82	2.8	sand and mud, anoxic below	51.8	49.3	57.1	2.24	<400	<1000	200	250	-
3	52 59 11	00 12 39	12.6	sand and some mud	245.5	227.4	1.01	0	160	0	200	-	-
4	53 00 66	00 14 82	1.7	fine/medium sand some mud	142.6	167.1	2.58	0.75	2000	<1000	200	-	-
5	52 56 03	00 11 58	4 to 8	fine /medium sand some mud	245.3	247.9	0.12	0	<400	<1000	<200	-	-
6	52 58 16	00 13 27	3	fine medium sand	158.1	157.2	5.82	0.63	<400	<1000	<200	-	-
7	52 59 87	00 15 00	16.4	fine/medium sand ,shell pieces	179.2	211.4	0.41	0.58	400	<1000	<200	-	-
8	53 01 41	00 17 41	2	fine sand/mud	54.6	82.2	39.7	1.66	800	<1000	200	-	-
9	52 55 16	00 12 25	3.9	fine sand	266.3	289.3	0.12	0	<400	<1000	<200	-	-
10	52 56 98	00 14 07	3.7	compacted sand ,shell pieces	236	245.4	0.24	0	800	0	200	-	-
11	52 58 71	00 15 85	6	fine/medium sand	179.7	213.9	0.44	0.66	<400	<1000	<200	-	-
12	53 00 81	00 17 67	10	fine/medium sand, anoxic below	169.8	206.6	0.87	0.31	<400	<1000	<200	-	-
13	53 02 58	00 19 44	11.5	Coarse sand with shells	335.1	340.9	1.55	0.23	<400	<1000	<200	-	-
14	53 04 73	00 21 64	9.5	fine/medium sand	164.9	197	0.46	0.41	3600	<1000	<200	-	-
15	52 53 89	00 13 27	5.3	coarse sand over muddy sand	262.7	273.1	0.63	0.58	<400	0	<200	-	-
16	52 55 91	00 14 86	9.5	sand,some mud	243.1	231.4	2.9	1.24	1600	<1000	<200	-	-
17	52 57 57	00 16 63	7	sand some mud	253.7	244.8	4.74	1.16	<400	<1000	<200	-	-
18	52 59 45	00 18 48	5	fine/medium sand	173.5	208.2	0.42	0.54	400	<1000	<200	-	-
19	53 01 28	00 20 43	9.6	medium coarse sand some shells	299	334	0.14	0.37	<400	<1000	<200	-	-
20	53 03 33	00 22 76	1.8	medium sand with shells	372.1	398.6	0.05	0.08	<400	<1000	<200	-	-
21	52 52 79	00 13 82	6	sand with mud	261.2	229.9	0.25	0.58	<400	<1000	<200	-	-
22	52 54 87	00 15 78	9	coarse sand some mud	39.2	45	56.8	1.58	400	<1000	<200	-	-
23	52 56 48	00 17 48	12.8	muddy sand	222	236.2	3.19	0.58	2000	<1000	<200	-	-
24	52 58 25	00 19 34	23.4	sand, some mud and stones	302.4	330.8	0.23	0.31	2000	<1000	<200	-	-
25	53 00 03	00 21 23	16	medium/coarse sand	224.5	236.6	0.25	0.66	400	<1000	<200	-	-
26	53 01 95	00 23 40	16.5	mud over sand and mud	132.1	143.4	7.61	0.66	2000	<1000	200	-	-
27	53 04 13	00 25 10	10	coarse sand and shells	561.1	624.1	0.07	0.25	<400	<1000	<200	-	-
28	52 71 75	00 14 55	7	medium sand	210.8	231.4	0.25	0.55	<400	<1000	1000	-	-
29	52 53 90	00 16 49	9.8	soft muds, brown over grey	25	34.2	72.9	3.15	<400	<1000	<200	-	-
30	52 55 38	00 18 28	4.2	fine/medium some coarse sand	304.9	338.8	0.02	0.55	<400	<1000	<200	-	-
31	52 57 08	00 20 09	9	gravel and stones plus mud	196.6	352	27.2	1.24	400	<1000	200	-	-
32	52 58 78	00 21 94	20.4	sand and mud with stones/gravel	125.7	146.5	41.8	1.49	<400	<1000	<200	-	-
33	53 00 66	00 24 00	36.5	sand with mud and stones	121.5	138.9	42.1	1.33	<400	<1000	800	-	-
34	53 02 61	00 25 88	32	medium sand over anoxic mud	309.7	359.4	0.26	0.71	1200	<1000	<200	-	-
35	53 04 74	00 28 33	18.5	stones and shells,sabellaria reef	211.6	316.3	33.4	1.33	1200	<1000	400	-	-
36	52 52 51	00 16 63	6	sand with mud	39.4	53.4	52	0.86	400	1000	400	-	-
37	52 54 41	00 18 98	5	sand and mud with stones	276.1	267.1	2.81	0.87	1600	<1000	<200	-	-
38	52 55 95	00 20 84	12.5	sandy mud	238.48	241.99	1.96	0.4	2400	1000	<200	-	-
39	52 57 64	00 22 75	19.9	sandy mud	177	272.5	19.7	0.79	1600	<1000	<200	130	-
40	52 59 41	00 24 69	23.8	stony sand and mud	409.7	495	9.99	0	1600	<1000	<200	-	-

Table 2. Wash Subtidal Survey 1991 : Physico-Chemical Data

Site	Longitude	Latitude	Depth(m)	Sediment description	Median Particle Size(um)	Mean Particle Size(um)	% Clay & Silt	% Organic Carbon	Clostridia n/100ml.	E. coli n/100ml.	Faecal Streptococci n/100ml.	PCB-C52 ug/kg	Dieldrin (ug/kg)
41	53 01 25	00 26 77	27	muddy sand and stones	683.1	714.4	2.06	0.58	800	<1000	<200	-	-
42	53 03 19	00 28 91	28.3	sand with mud and stones	434.1	798.6	14.8	0.63	400	<1000	200	-	-
43	52 51 69	00 18 00	3.6	fine mud	33.8	41.2	65.4	1.5	4800	5000	200	120	130
44	52 53 54	00 19 45	2.5	fine sand	232.3	240	0.06	0.58	0	0	0	-	-
45	52 54 86	00 21 61	3	muddy sand	298.3	332	0.11	0.79	4000	<1000	<200	-	-
46	52 56 48	00 23 57	14.4	muddy sand	293	312	2.25	0.58	400	1000	<200	-	-
47	52 58 16	00 25 38	13.2	medium/coarse sand and gravel	361.7	412.2	0.07	0.87	400	<1000	<200	-	-
48	52 59 95	00 27 74	10.4	medium sand	333.1	381.9	0.03	0	<400	<1000	<200	-	-
49	53 01 75	00 29 58	15.4	sand, some mud	312.6	349.5	1.07	0.33	4800	<1000	<200	-	-
50	53 03 90	00 32 00	17.2	sand some mud and stones	696.7	466.7	0.64	0.62	<400	<1000	<200	-	-
51	52 50 66	00 18 96	3.8	fine/medium sand	199.7	227.4	0.05	0	2400	7000	200	-	-
52	52 52 40	00 20 95	4.4	fine sand/mud	66.3	128.8	33.4	1.58	2000	0	200	-	-
53	52 53 80	00 22 42	1.4	fine sand	215.7	231.8	0.11	0.5	800	<1000	<200	-	-
54	52 55 25	00 24 25	10.2	fine/medium sand	186.1	220.9	0.66	0.66	3600	<1000	<200	-	-
55	52 56 90	00 26 08	3.1	fine sand and mud	207.5	223.1	0.66	0.5	800	<1000	<200	-	-
56	52 59 11	00 29 40	1.8	fine sand	172.9	208.5	0.19	0	<400	<1000	200	-	-
57	52 00 42	00 30 21	3.5	fine sand	184.6	219.4	0.23	0.17	2800	<1000	<200	-	-
58	53 02 34	00 32 56	4.5	fine/medium sand	184	221.8	0.08	0.17	400	<1000	<200	-	-
59	52 51 40	00 21 35	5.9	fine sand/mud	188.9	218.8	0.56	0.66	400	0	200	-	-
60	52 52 59	00 23 20	4.2	fine sand some mud	181.3	218.6	0.13	0.37	2800	<1000	<200	-	-
61	52 54 19	00 25 20	7	sand some mud	44	86.4	46.9	1.66	<400	1000	400	-	120
62	52 55 75	00 26 85	4.3	fine/medium sand	169.4	202.6	0.31	0.58	400	<1000	<200	-	-
63	52 57 42	00 26 84	3.4	fine sand	163.7	195.2	1.18	0.66	<400	<1000	<200	-	-
64	52 59 10	00 30 95	5.2	fine/medium sand	242.9	225.3	0.77	0.33	2000	<1000	<200	-	-
65	53 00 95	00 33 20	2.6	fine sand	198.5	225	0.1	0.12	800	<1000	<200	-	-
66	53 05 30	00 23 94	9.7	mud and gravel	848.1	1064.4	1.33	0.75	2400	<1000	200	-	-

Table 2. Wash Subtidal Survey 1991 :

Site	HCH Gamma (ug/kg)	DDT (PP') (ug/kg)	Cu dry wt. mg/kg	Zn dry wt. mg/kg	Cd dry wt.	Hg dry wt. mg/kg	Tl dry wt. mg/kg
1	-	-	29.4	195	1.46	0.259	592
2	-	-	23	130	1.12	0.476	607
3	-	-	25.2	150	0.694	0.288	679
4	-	-	31.4	189	2.33	0.25	1520
5	-	-	24.6	167	0.628	0.275	683
6	-	-	26.1	172	1.39	0.21	695
7	-	-	26	151	0.752	0.308	688
8	-	360	25.7	142	0.957	0.199	734
9	-	-	29.5	175	0.769	0.267	651
10	-	-	25.3	174	1.23	0.321	753
11	-	-	25.1	145	1.16	0.318	587
12	-	-	27.5	179	0.824	0.235	603
13	-	-	20.6	114	0.644	0.217	606
14	-	-	34.4	213	1.07	0.372	1300
15	-	-	26.6	146	1.3	0.226	699
16	-	-	20.1	116	0.784	0.266	590
17	-	-	20.4	121	1.09	0.232	679
18	-	-	25.5	150	1.02	0.302	695
19	-	-	18.2	103	1.13	0.0987	430
20	-	-	-	-	-	-	-
21	-	-	24.6	144	0.872	0.24	625
22	-	-	26.3	142	1.02	0.286	844
23	-	-	28.3	175	1.1	0.286	699
24	-	-	27	145	0.531	0.265	599
25	-	-	28	163	0.995	0.254	889
26	-	-	25.8	144	0.721	0.207	659
27	-	-	28.2	162	1.27	0.27	870
28	-	-	30	177	<1.89	0.357	989
29	-	-	23.7	126	0.764	0.218	841
30	-	-	30.1	166	<1.29	0.336	768
31	-	-	29.5	166	1.12	0.329	680
32	-	-	30.7	162	0.796	0.311	892
33	-	-	24.7	148	0.76	0.251	790
34	-	-	29.1	142	0.862	0.265	731
35	-	-	23.7	128	0.673	0.233	638
36	-	-	20.8	120	0.692	0.225	708
37	-	-	24.4	137	1.08	0.221	784
38	-	-	26.3	143	0.67	0.266	656
39	110	-	23.1	143	1.23	0.24	963
40	-	-	24.1	139	0.866	0.21	882

Pb dry wt. mg/kg	V dry wt. mg/kg	Cr dry wt. mg/kg	Fe dry wt. mg/kg	Ni dry wt. mg/kg	As total wt. mg/kg
115	105	82	45600	53.2	40.3
68.5	71.8	54.2	31900	30.8	19.9
81.7	84	62.9	35400	36.7	26.7
90.2	127	104	49900	54.1	37.7
96.5	99.4	74.4	35600	40.6	29
107	112	79.1	42700	47	39
76.3	89.3	67.8	37200	39	34.9
67	74.1	62.2	34300	35.5	22
95.4	100	78.5	36900	47.6	30
94	98.4	75.3	36700	44.8	40.5
79.7	79.2	62.1	34500	38.4	27.8
87.7	101	88.2	41200	51	32.8
61.4	65.6	50	29100	27.9	22.5
85.5	144	116	56700	64.5	39.3
102	86.4	59.8	32600	33.4	30.1
61.8	69.5	52.4	27600	28.2	22.4
64	71.9	54.2	28600	29.2	20.5
72.3	84.6	65.2	36700	37.2	24.8
34.6	70	55.2	38600	42	21.9
-	-	-	-	-	-
81.5	78.9	59.3	32200	33.5	24.2
80.3	88.7	65.3	32700	33.9	24
105	69.7	70.2	37500	37.6	34.2
60.1	78.2	59.9	32600	35.2	28
78.9	94.4	71.9	38600	39	23.4
70.9	83.5	63.3	38400	39.4	25
86.6	92.1	66.1	38800	37.5	28.5
108	121	94.2	46000	52.6	46.4
68.3	81.9	61.1	30700	31.3	20.2
114	85.4	70	35700	45.1	33.1
94.8	94.5	71.6	36600	387.7	28.7
87.8	98.7	75.3	34700	37.9	21.3
73.4	91.6	69	34000	36.4	26
79.3	82.8	62.8	32100	35.5	22.6
67.2	76.1	56.5	30900	32.1	21.4
65.3	72.5	53.6	28800	29.6	22.2
71.9	83.5	63.8	32500	32.9	22.4
79	77.4	59.3	31900	31.8	21
71.7	98	71.9	33400	34.1	22.9
73.9	94.7	71.7	32700	33.7	19.6

Table 2. Wash Subtidal Survey 1991 : Physico-Chemical Data

Site	HCH Gamma (ug/kg)	DDT (PP') (ug/kg)	Cu dry wt. mg/kg	Zn dry wt. mg/kg	Cd dry wt.	Hg dry wt. mg/kg	Tl dry wt. mg/kg	Pb dry wt. mg/kg	V dry wt. mg/kg	Cr dry wt. mg/kg	Fe dry wt. mg/kg	Ni dry wt. mg/kg	As total wt. mg/kg
41	-	-	24.9	142	0.739	0.255	725	77.3	86.6	66.8	33000	33.9	19.7
42	-	-	33.5	182	1.03	0.286	1000	95.5	115	86.2	43300	45.3	27.1
43	-	-	20.1	109	0.76	0.161	714	58	69.6	52.9	26700	26.8	14
44	-	-	31.1	197	1.46	0.362	710	135	120	121	442200	80	45.3
45	-	-	27.7	152	1.04	0.238	897	83.4	94.7	70.4	37500	37.1	24.9
46	-	-	24.6	141	0.943	0.27	812	74.1	91.6	68.5	33800	33.6	21.1
47	-	-	-	-	-	-	-	-	-	-	-	-	-
48	-	-	28.1	192	<1.98	0.291	1190	101	125	87.6	43500	38.5	35.4
49	-	-	31	168	1.44	0.327	1030	89.1	112	82.8	42100	42	28.1
50	-	-	23.8	131	0.827	0.212	741	68.9	83.6	64	31300	31.9	20.9
51	-	-	-	-	-	-	-	-	-	-	-	-	-
52	-	-	21.6	150	1.01	0.257	581	69.2	84.2	68.2	34100	36.5	26.6
53	-	-	23.3	159	<2.48	0.421	1020	75.3	103	77.5	34900	33.7	24.9
54	100	-	26	156	0.955	0.314	612	87.4	82.3	65	34800	39.1	24.6
55	-	-	23.9	145	0.647	0.392	679	75.1	83.6	62.6	33700	35	30.2
56	-	-	-	-	-	-	-	-	-	-	-	-	-
57	-	-	21.9	179	<2.81	0.371	1140	57	120	83.7	39900	34.6	29.2
58	-	-	-	-	-	-	-	-	-	-	-	-	-
59	-	-	24	149	0.909	0.267	755	76.4	89.9	70.7	33200	37.8	20.6
60	-	-	19	135	<.709	0.182	738	67.3	88.8	65	30900	29.9	20.5
61	-	-	20.1	119	0.919	0.204	588	64.9	69.9	53.5	29500	28.1	20.9
62	-	-	26.5	172	<1.52	0.402	910	82.2	103	74.5	41500	43.6	29.1
63	-	-	20.8	142	0.638	0.213	830	70.5	92.3	70.5	33600	34.6	23.8
64	-	-	22.5	146	0.873	0.213	721	74.6	90.5	70.6	34000	36.1	24.9
65	-	-	26.4	186	<.949	0.649	1110	82.4	120	87	42300	42.1	31.8
66	-	-	30.1	161	1.14	0.24	1280	82.4	107	77.2	41100	41	30.1

Table 5. The average number of individuals / site for the top 40 taxa in each of the groups recognised from cluster analysis

A1		A2		B1		B2		B3
Taxon		Taxon		Taxon		Taxon		Taxon
Sabellaria spinulosa	1409	Chaetozone setosa	306	Spiophanes bombyx	165	Spio sp.	101	Spiophanes bombyx
Pholoe sp.	216	Abra alba	263	Spio sp.	152	Tanaidacea indet.	68	Spio sp.
Chaetozone setosa	179	Phoronis muelleri	241	Abra alba	60	Nephtys cirrosa	45	Nephtys cirrosa
Scoloplos armiger	169	Scoloplos armiger	231	Nephtys hombergii	46	Spiophanes bombyx	20	Tanaidacea indet.
Abra alba	127	Mediomastus fragilis	226	Capitella capitata	42	Cumopsis goodsiri	19	Chaetozone setosa
Ampelisca diadema	115	Spiophanes bombyx	210	Pygospio elegans	36	Nephtys hombergii	10	Nephtys sp.
Mediomastus fragilis	113	Pariambus typicus	168	Scoloplos armiger	33	Nephtys sp.	10	Angulus tenuis
Harmothoe impar	101	Mysella bidentata	114	Microprotopus maculatus	31	Eteone longa	10	Fabulina fabula
Tharyx marioni	101	Pholoe sp.	105	Nephtys sp.	23	Pygospio elegans	7	Pseudocuma longicornis
Tunicata indet.	77	Pygospio elegans	98	Mysella bidentata	21	Streptosyllis websteri	6	Pontocrates arenarius
Pisidia longicornis	69	Eumida bahusiensis	87	Fabulina fabula	21	Angulus tenuis	6	Nephtys hombergii
Aora gracilis	69	Ampharete lindstroemi	86	Tubificoides pseudogaster	20	Tubificoides pseudogaster	5	Magelona mirabilis
Modiolus sp.	67	Lanice conchilega	75	Mediomastus fragilis	16	Bathyporeia sarsi	5	Bathyporeia sarsi
Achelia sp.	61	Ophiura albida	66	Chaetozone setosa	15	Pseudocuma longicornis	4	Bathyporeia guilliamsoniana
Ophiura albida	57	Autolytus langerhansi	65	Pariambus typicus	15	Phyllodoce mucosa	4	Bathyporeia elegans
Pelecypoda indet.	54	Pelecypoda indet.	42	Eumida bahusiensis	13	Magelona mirabilis	3	Perioculodes longimanus
Ampharete lindstroemi	49	Microprotopus maculatus	38	Pseudocuma longicornis	13	Retusa obtusa	3	Scoloplos armiger
Pomatoceros triqueter	42	Tubificoides pseudogaster	38	Modiolus sp.	13	Capitella capitata	3	Aricidea minuta
Autolytus langerhansi	40	Sabellaria spinulosa	37	Ophiura albida	12	Scoloplos armiger	2	Urothoe pulchella
Nucula nucleus	39	Ampelisca brevicornis	35	Tharyx marioni	11	Abra sp.	2	Ophiura albida
Nemertea indet.	36	Aricidea minuta	34	Aricidea minuta	10	Bathyporeia guilliamsoniana	1	Megaluropus agilis
Protodorvillea kefersteini	33	Aora gracilis	33	Autolytus langerhansi	10	Mysella bidentata	1	Mysella bidentata
Micropthalmus similis	31	Scalibregma inflatum	32	Retusa obtusa	9	Fabulina fabula	1	Urothoe poseidonis
Partulida spiralis	30	Nephtys hombergii	31	Nephtys cirrosa	9	Modiolus sp.	1	Capitella capitata
Anoplodactylus petiolatu	27	Modiolus sp.	31	Angulus tenuis	8	Pholoe sp.	1	Diastylis bradyi
Harmothoe sp.	23	Fabulina fabula	31	Lanice conchilega	8	Sabellaria spinulosa	1	Nemertea indet.
Aonides paucibranchiata	22	Nucula nucleus	29	Tubificoides benedeni	7	Urothoe brevicornis	1	Tubificoides sp.
Polydora sp.	20	Tubificoides diazi	29	Phoronis muelleri	7	Aricidea minuta	1	Pelecypoda indet.
Ampharete sp.	17	Harmothoe impar	29	Diastylis bradyi	6	Tharyx marioni	1	Retusa obtusa
Eusyllis blomstrandi	16	Pseudopolydora pulchra	25	Cerastoderma edule	6	Schistomysis kervillei	1	Magelona filiformis
Actiniidae indet.	15	Tharyx marioni	24	Pholoe sp.	5	Bathyporeia tenuipes	1	Tellinidae indet.
Mysella bidentata	14	Pectinaria koreni	23	Tanaidacea indet.	5	Pariambus typicus	1	Tharyx marioni
Tanaidacea indet.	13	Retusa obtusa	23	Pelecypoda indet.	4	Bodotria pulchella	1	Cumopsis goodsiri
Scalibregma inflatum	13	Nephtys sp.	20	Phyllodoce mucosa	4	Ophiura ophiura	1	Modiolus sp.
Lanice conchilega	13	Achelia sp.	20	Pectinaria koreni	3			Tubificoides pseudogaster
Stenothoe marina	11	Exogone hebes	19	Ampelisca brevicornis	3			Ophiura ophiura
Bodotria scorpioides	11	Nemertea indet.	18	Aora gracilis	3			Bathyporeia sp.
Sabella pavonina	10	Ampharete sp.	18	Magelona mirabilis	3			Maldanidae indet.
Eumida bahusiensis	10	Capitella capitata	18	Scalibregma inflatum	3			Schistomysis kervillei
Kefersteinia cirrata	9	Anoplodactylus petiolatus	15	Anoplodactylus petiolatus	2			Microprotopus maculatus

	C		D		E	
	Taxon		Taxon		Taxon	
86	Hesionura elongata	76	Spio sp.	14	Nephtys sp.	118
76	Micropthalmus similis	35	Nephtys cirrosa	6	Cerastoderma edule	46
38	Spiophanes bombyx	18	Tubificoides pseudogaster	2	Nephtys hombergii	41
32	Nemertea indet.	10	Modiolus sp.	2	Tubificoides pseudogaster	22
17	Gastrosaccus spinifer	8	Angulus tenuis	2	Modiolus sp.	9
14	Spio sp.	8	Nephtys hombergii	1	Scoloplos armiger	4
14	Nephtys cirrosa	7	Pseudocuma longicornis	1	Phoronis muelleri	3
13	Aonides paucibranchiata	6	Nephtys sp.	1	Macoma balthica	3
12	Glycera sp.	6	Scoloplos armiger	1	Pygospio elegans	2
11	Tanaidacea indet.	5	Capitella capitata	1	Pseudocuma longicornis	2
9	Modiolus sp.	5	Hydrobia ulvae	1	Nucula nucleus	2
9	Sphaerosyllis sp.	4	Fabulina fabula	1	Ophiura albida	2
7	Angulus tenuis	4	Phyllodoce mucosa	1	Tubificoides benedeni	1
5	Abra alba	4	Spiophanes bombyx	1	Anoplodactylus petiolatus	1
5	Ophelia borealis	4	Crangon crangon	1	Hydrobia ulvae	1
4	Bathyporeia elegans	4			Retusa obtusa	1
4	Pseudocuma longicornis	4			Harmothoe impar	1
4	Macrochaeta helgolandica	3			Eteone longa	1
4	Chaetozone setosa	3			Eumida bahusiensis	1
3	Nephtys sp.	3			Tharyx marioni	1
3	Aricidea minuta	3			Mediomastus fragilis	1
3	Oligochaeta indet.	3			Schistomysis spiritus	1
2	Scoloplos armiger	2			Pariambus typicus	1
2	Exogone hebes	2			Diastylis bradyi	1
2	Microprotopus maculatus	2			Liocarcinus holsatus	1
2	Mediomastus fragilis	2			Pelecypoda indet.	1
2	Urothoe brevicornis	2			Fabulina fabula	1
2	Phoxocephalus holbolli	2				
2	Ophiura albida	2				
2	Nephtys hombergii	2				
2	Polycirrus sp.	2				
1	Atylus guttatus	2				
1	Pelecypoda indet.	2				
1	Capitella capitata	1				
1	Scalibregma inflatum	1				
1	Atylus falcatus	1				
1	Ensis sp.	1				
1	Glycera lapidum	1				
1	Streptosyllis websteri	1				
1	Protodorvillea kefersteini	1				