A SUSTAINABLE FUTURE FOR THE HUMBER ESTUARY

HUMBER ESTUARY ENVIRONMENTAL QUALITY

ENVIRONMENT AGENCY

EA Anglian

HUMBER ESTUARY

QUALITY REPORT 1994

A Report from the
Humber Management Group
of the
Environment Agency

Comprising the Anglian, Midland, and North East Regions of the Environment Agency

QUALITY OF THE HUMBER ESTUARY 1994

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PREFACE

This report was produced on behalf of the Humber Management Group of the Environment Agency. The data utilised were collected during the lifetime of the Agency's predecessor, the National Rivers Authority, on behalf of the Humber Estuary Committee. This report is the last to be produced in the HEC format: future reports on the Estuary will be made as part of the annual review of the Humber Action Plan.

Marion Justice
Humber Technical Secretary
October 1996

SUMMARY

The Environment Agency's Humber Management Group (HMG), through its Humber Environmental Quality Project Board (EQPB), co-ordinate Agency monitoring of the Estuary. Non-statutory Environmental Quality Objectives (EQOs), designed to protect existing and potential uses of Estuary waters, are used as reference points for comparison of results and trend analysis. Routine monitoring programmes of the whole Estuary, aided by intensive special surveys of smaller areas, provide data on the quality of the Humber including its tidal tributaries and freshwater rivers, its industrial and sewage inputs, accumulation of substances in its sediments and organisms, and the nature and diversity of its invertebrate fauna and micro-organisms.

FRESHWATER FLOWS

The influence of the dry spring was reflected in the rapid loss of flows during the later part of April. Flows remained low throughout the summer, only beginning to increase again in late October and early November.

CHEMICAL QUALITY

There was continued improvement in dissolved oxygen levels in the tidal waters, with only two sites failing the Environmental Quality Standard (EQS) and even these showing an improvement on previous years. Levels of ammonia also reduced, with all sites complying with the EQS. Levels of all List I and List II metals complied with their respective EQSs except copper, which is an ongoing problem in the Estuary. Levels of synthetic organic compounds complied with the EQSs with the exception of Lindane on the River Aire at Snaith.

Metal loads entering the Humber system via the non-tidal rivers, industrial and sewage discharges were all below the five-year mean and were generally lower than those reported in the previous year.

The concentrations of metals in the tidal river and intertidal estuarine sediments were generally lower than the five-year mean. The majority of metals results for subtidal sediments were below the five-year mean with the exceptions of mercury and zinc, which averaged about 30% above the five-year mean at half the sites. In addition, three sites showed levels higher than the five-year mean for most metals. This continued accumulation of metals could be a result of the deposition of dredge-spoil combined with the effects of sediment mobility and mudbank accretion.

The concentrations of metals in the tissues of ragworms and seaweed showed no clear pattern, with some sites being below and others above the five-year mean. Similarly for brown shrimp no clear pattern emerged although all the results were within the normal range.

BIOLOGICAL QUALITY

The biological quality of the tidal rivers remained similar to previous years suggesting no significant improvements in water quality.

There was little significant change in the intertidal fauna of the Estuary, which remained of good quality. Changes were attributed to natural population surges and reductions, specific pollution events and sediment disturbances. At one site, Grimsby, the continued faunal improvement is confidently attributed to the abatement of a sewage discharge.

Subtidal biology of the Estuary suggests a continued state of organic enrichment in the middle and upper reaches and poor environmental conditions near the main channels of the lower reaches due to mobile sediments.

Microbiological tests on sediment samples were carried out for the first time in 1994. The intertidal results suggested sewage contamination of the mudflats in the outermost part of the Estuary, particularly around the Cleethorpes sewage outfall. The subtidal results showed peaks of bacterial contamination coinciding with the confluence of the main tributaries and with the main sewage outfalls from Hull and Grimsby.

The abundance and species richness of the fish community in the Estuary were generally comparable with or better than recent years.

SECTION 1
THE QUALITY OF THE HUMBER ESTUARY 1994

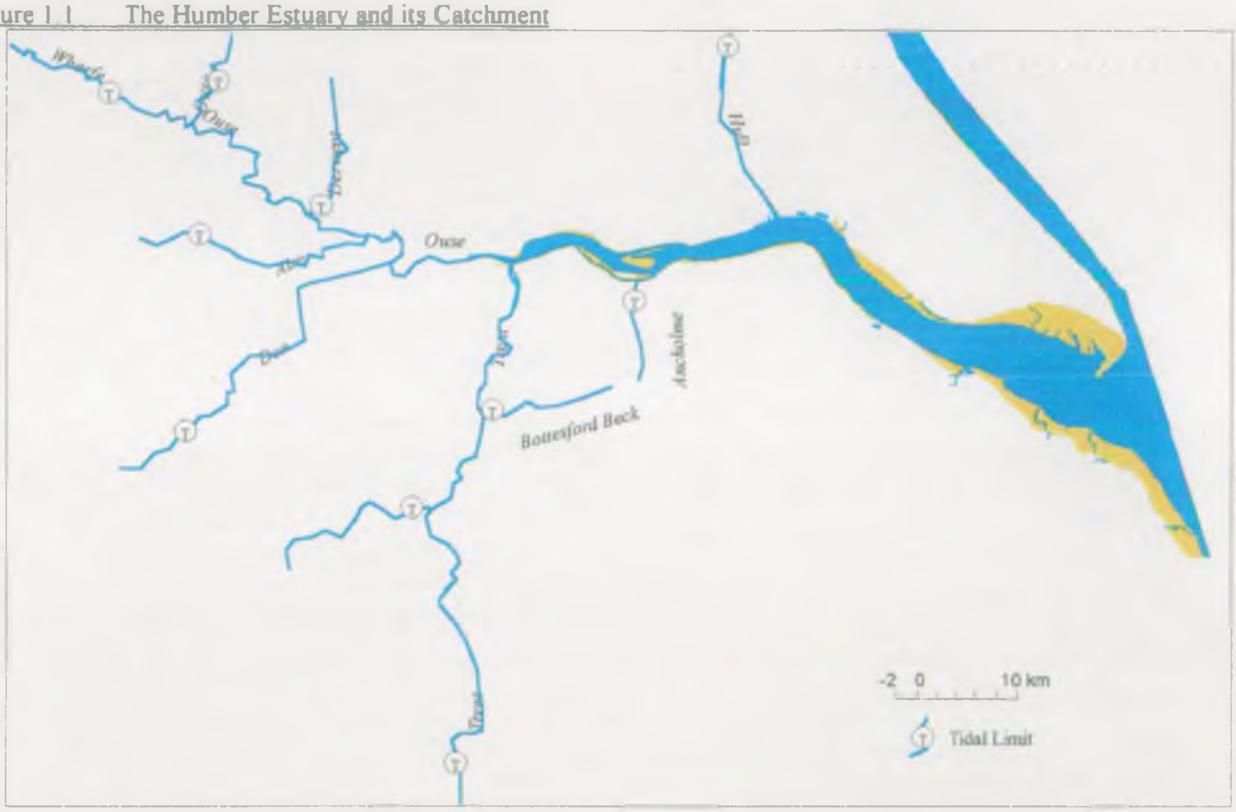
1.1 INTRODUCTION

The Humber Estuary is the largest estuary in the United Kingdom, with a catchment draining over 24 000 sq km, one fifth of the area of England (Figure 1.1). Much of the country's coal output, electricity generating capacity and manufacturing industry is located within the Humber catchment and 11 million people live in the area.

The Estuary is also one of the main freshwater inputs to the North Sea with the catchment generating an average of 250 cubic metres of freshwater per second. This freshwater is derived from two major river systems, the Trent and the Yorkshire Ouse. The Estuary has a tidal range of 6.5 metres at its mouth rising at Saltend to a maximum of 7.2 metres, which is the largest range on the East coast of Britain. A typical spring tide can move the water in the Estuary upstream by 5 km (depending on freshwater flow, location and wind), reversing the river flows. This energetic system results in large amounts of both riverine and marine sediments suspended in the water, giving the Estuary its characteristic brown colour. The sediment gradually settles out, forming the productive mud-flats which line the Estuary shores.

In the past, industries were allowed to discharge large quantities of substances directly into the Estuary without restriction. Many of these substances are now trapped within the sediments and can be released in areas where the Estuary bed or banks are eroding. Current industrial discharges to the Estuary are controlled and the quantities of contaminants discharged are decreasing.

Figure 1.1 The Humber Estuary and its Catchment



Despite historical use, the Estuary is biologically very productive and supports internationally important numbers of over-wintering birds. Between Trent Falls and Donna Nook, for example, the Humber Flats and Marshes are recognised as internationally important with counts of approximately 14 000 wildfowl and 77 000 waders. Large areas of the shoreline are designated as Sites of Special Scientific Interest (SSSIs) and there are also several nature reserves managed by the RSPB and other conservation bodies.

The Estuary is an important nursery area for flatfish such as plaice, *Pleuronectes platessa*. It is also a spawning area for sole, *Solea solea*, and 25 fish species have recently been recorded in the Estuary (section 4.7.4).

The management of the quality of the Humber Estuary was, until 1996, the responsibility of three NRA regions: Anglian, Severn-Trent, and Northumbria & Yorkshire, co-ordinated by the Humber Estuary Committee (HEC). It now comes under the jurisdiction of the equivalent Environment Agency Regions (Anglian, Midland and North East) and is co-ordinated by the Humber Management Group (HMG). The monitoring programme undertaken by the HMG each year enables the Agency to assess the amounts of substances discharged into the tidal rivers and Estuary, and the concentrations in the river and Estuary water. These are then compared to the Environmental Quality Standards (EQSs) to determine compliance for specific substances. These mandatory standards are given for toxic, persistent and bioaccumulative substances on List I of Directive 76/464/EEC on 'Pollution caused by Certain Dangerous Substances Discharged into the Aquatic Environment'. National standards are set for List II substances of the same Directive which are considered less dangerous than those of List I. Discharges of these substances are controlled by the Agency through the issuing of discharge consents and authorisations.

1.2 REPORT ON THE QUALITY OF THE HUMBER ESTUARY 1980 - 1990

In July 1993, the NRA produced a report on the 'Quality of the Humber Estuary 1980 - 1990', which reviewed the results of ten years of monitoring on the Humber including freshwater inputs, chemical and biological quality and fish populations.

The report showed that pollution loads to the tidal rivers and Estuary have decreased and that most substances were well within the EQSs. This was achieved by reductions in effluent inputs via efficient pollution control measures and the closure of Capper Pass smelting works near Brough. Within the ten year period, the estuarine faunal communities remained relatively stable and the Humber continues to be a very productive Estuary. In certain areas there was also a decrease in the accumulation of metals in sentinel species, such as ragworms, providing further evidence of general improvements in environmental quality.

Migratory salmon (*Salmo salar*) were sighted in the Wharfe, Ouse, Trent and Don catchments , but it is not known if salmon stocks were increasing in line with the water quality improvements noted during the decade.

Industries along the Estuary are now strictly regulated and more environmentally aware. They are installing more efficient treatment plants and employing manufacturing techniques which produce less waste. Sewage treatment works in the inland catchment are also improving and the implementation of the Urban Wastewater Treatment Directive (UWWTD) should require at least secondary treatment to be introduced for all major sewage discharges to the Humber. With this combined effort, the improvements in water quality between 1980 and 1990 are expected to continue through the present decade.

1.3 CATCHMENT MANAGEMENT PLANS

The majority of the Catchment Management Plans (CMPs) for the Humber and related rivers were published in 1995/96. The relevant CMPs include:

- Humber Estuary
- Hull and Coast
- Don, Rother and Dearne
- Derwent
- Swale, Ure and Ouse
- Nidd and Wharfe
- Grimsby
- Ancholme

With the formation of the Environment Agency in 1996, the scope of CMPs will be widened to take account of the integrated nature of the EA. CMPs will be replaced by Local Environment Action Plans (LEAPs) and will include issues relating to air quality and waste regulation. The Lower Trent LEAP is due for publication in 1998. To avoid confusion between the many different plans and initiatives on the Humber area, the Agency has agreed to integrate its Humber CMP with the Humber Estuary Management Strategy (HEMS).

SECTION 2
FRESHWATER FLOWS

2.1 INTRODUCTION

The major flows of freshwater into the Humber Estuary are from the Trent and Ouse Catchments. Minor components include the catchments of the Hull, Foulness, Mires Beck and the Ancholme.

The Ouse Catchment flows are derived mainly from the Rivers Don, Aire, Wharfe, Derwent and upper Ouse. The upper Ouse flows reflect the inputs from the Rivers Swale, Ure and Nidd which drain from North Yorkshire. Within the Ouse catchment the following flow measurement gauging stations are used:

River Don	Doncaster
River Aire	Beal
River Wharfe	Tadcaster
River Derwent	Buttercrambe
River Ouse	Skelton

There are secondary flows to the Ouse catchment through the Don from the River Went at Walden Stubbs and through the Ouse from the River Foss in York.

The flows in the River Trent are measured at North Muskham where the gauging station is currently being improved

Flows in the minor catchments are also measured. However, the measurement of flows in the River Hull is problematic and, at present, flow data are not available.

There are a number of large abstractions on most of the principal rivers flowing to the Estuary. Water is abstracted, under licence from the Agency, for agricultural and industrial purposes as well as public water supply. The majority of abstracted water is returned to the river, although up to 40% may be lost by evaporative cooling at power stations such as Ferrybridge and Drax. Water is diverted from the River Aire at Beal and from the River Don at Long Sandall near Doncaster into the British Waterways Board's canal system. This diverted water re-enters the Estuary via Goole docks.

2.2 FRESHWATER FLOWS TO THE HUMBER IN 1994

Freshwater flows to the Estuary between January and May show the effect of storms (see Figure 2.1) although winter peak flows did not represent particularly significant flood events in the long-term record. The influence of the dry spring can be seen in the rapid loss of flow during the later part of April. Flows remained low throughout the summer and only began to pick up in late October and early November.

Figure 2.1 Flows to the Humber in 1994

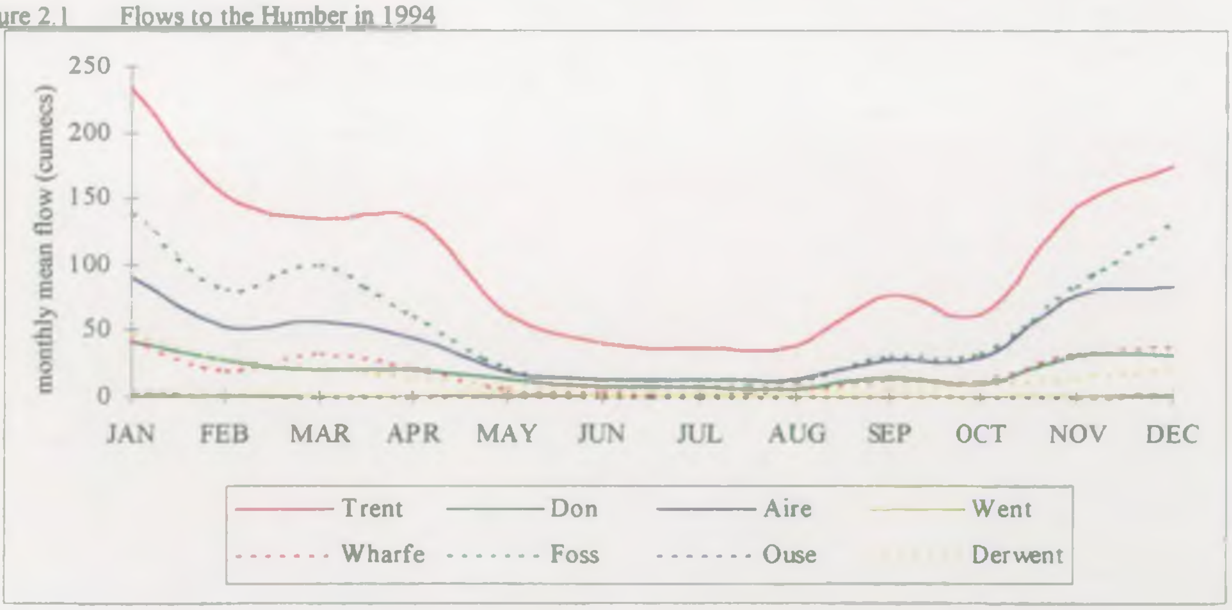


Figure 2.2 Contributions to the Flow of the Humber

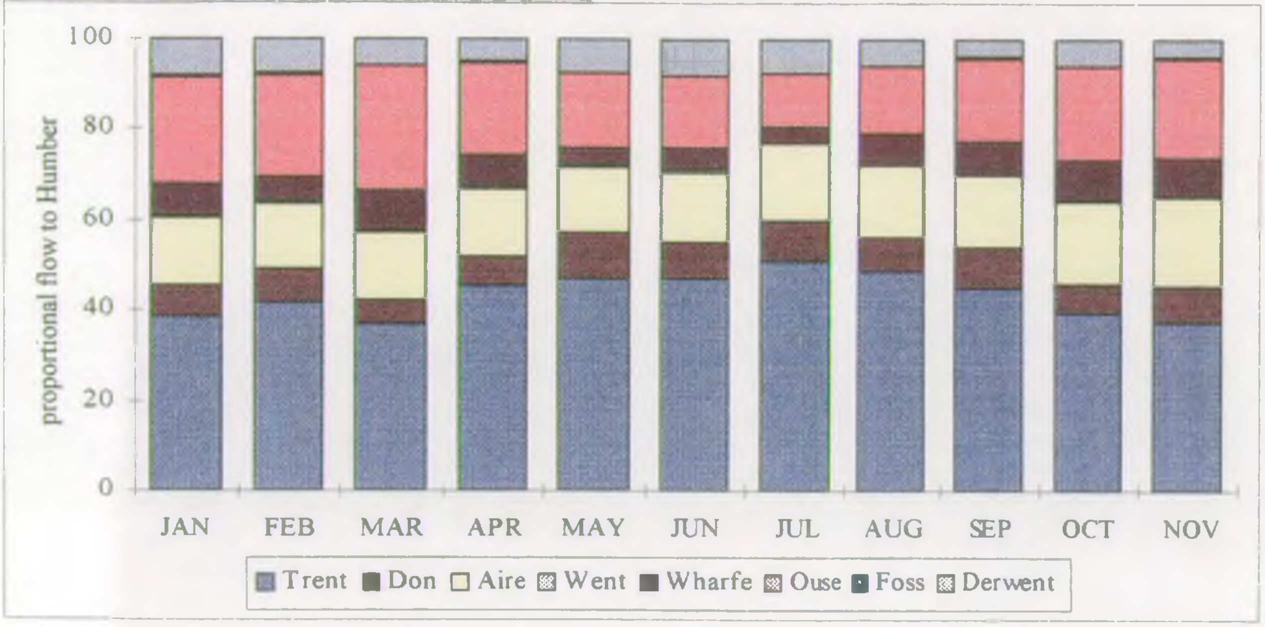


Figure 2.2 shows that the largest single contribution to freshwater flow comes from the River Trent. This is particularly so during the summer months when flows from the other principal rivers (Don, Aire, Ouse) are similar to each other. During the winter months the contribution from the Ouse increases significantly and, in some storm events, can equal that of the Trent. (The data has been corrected for the two large public water supply abstractions on the Derwent).

The Rivers Went and Foss are generally insignificant in their contribution to the Humber.

It is important to emphasise that these flows represent the total input to the Estuary and not the flow that might be measured within the Estuary. Tidal influences will tend to block freshwater flow at high tide and cause a flow surge at low tide. Within the Estuary, daily maximum flows following spring tides may considerably exceed the freshwater inputs.

SECTION 3
CHEMICAL QUALITY

3.1 INTRODUCTION

The chemical monitoring programme aims to measure the levels of metals, organic compounds, dissolved oxygen and other determinands in the tidal rivers and Estuary and entering the system via effluent discharges. Water samples are collected from twelve sites along the five tidal rivers and six sites in the Estuary (Figure 3.1). The analytical results are compared to the relevant Environmental Quality Standards (EQSs) (Appendix 1). These standards apply only to concentrations of substances in the water column since no EQSs have yet been set for sediments or biota. Typical standards are:

- annual mean e.g. metals,
- percentiles e.g. dissolved oxygen, ammonia,
- ranges e.g. pH,
- maximum permitted levels e.g. Endrin.

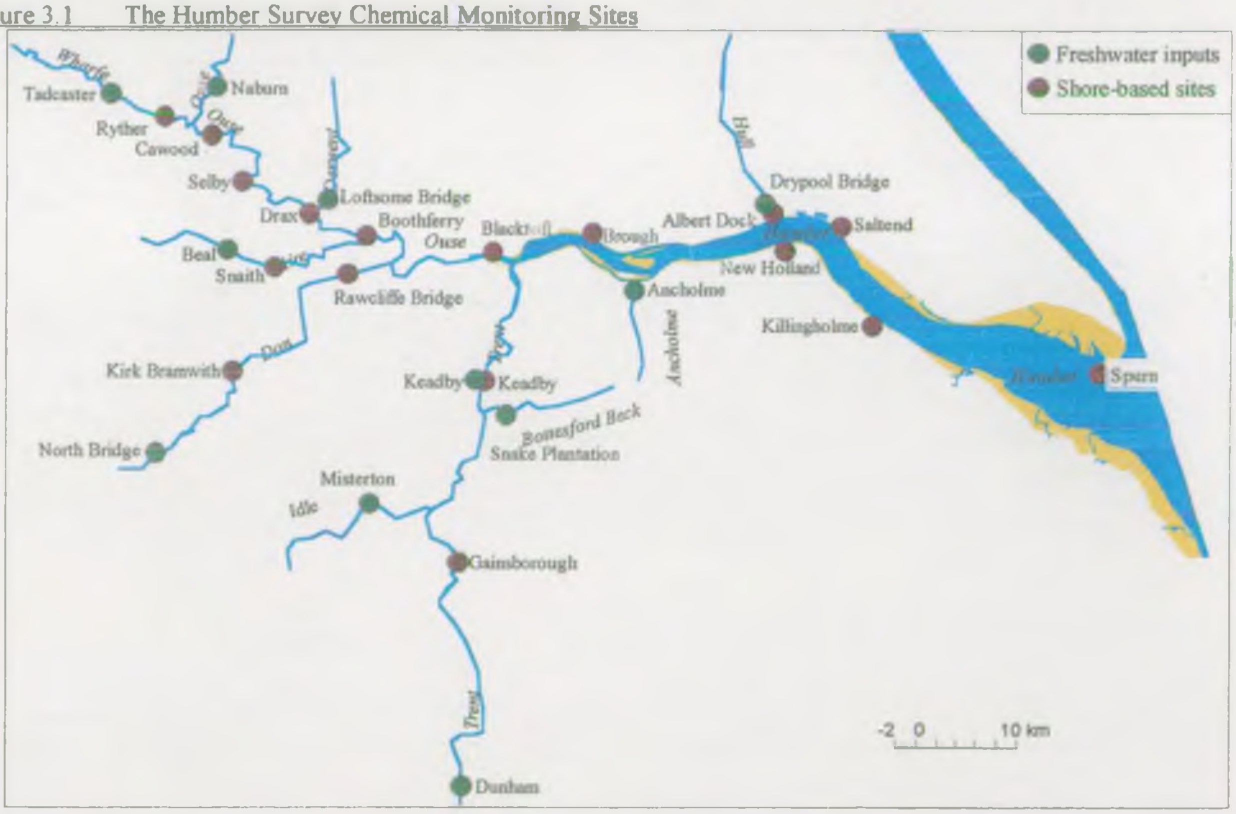
The annual mean is calculated using all the results obtained for the Humber Survey during the calendar year. In some cases, the chemical analysis may not detect a particular substance because its concentration in the sample is below the lowest limit that the current method of analysis can detect i.e. the 'limit of detection' (LOD). In such cases, a 'less than' (<) value is reported e.g. <0.05 µg /l where the LOD is 0.05 µg/l. In order to include these values in the calculation of the mean, the 'less than' figure is taken at half the actual value. For instance, if the limit of detection for a particular substance is 1 µg/l, the true level of that substance in a sample which indicates 0 µg/l could be anywhere between 0 µg/l and 1 µg/l. Half the LOD in this case would be 0.5 µg/l, and this estimate would be used in the calculations. An alternative would be to calculate the mean taking the 'less than' figures as equal to zero and as equal to the LOD, thereby giving the lowest and highest means (see section 3.4.2).

Percentiles (%iles) are used where levels of substances either below or above a particular value are of concern. The most commonly used are the 95 and 5 %iles. For example, the EQS for dissolved oxygen in tidal rivers is a 5 %ile of 40% saturation. This means that the dissolved oxygen level in the rivers should be at least 40% for 95% of the time, or, should not fall below 40% for more than 5% of the time.

Ranges are used for determinands such as pH, where both high and low levels can be harmful to aquatic life.

Maximum permitted levels, like some percentiles, are used where the concentration of a substance above a specific level is of concern.

Figure 3.1 The Humber Survey Chemical Monitoring Sites



3.2 CHEMICAL QUALITY OF TRIBUTARIES UPSTREAM OF THE TIDAL LIMITS

The 1994 results for biochemical oxygen demand (BOD), ammonia and unionised ammonia at the sites immediately upstream of the tidal limits of the Humber tributaries are compared to the 1993 results in Table 3.1.

Table 3.1 Freshwater Results 1994

STATION	BOD (ATU) mg/l				AMMONIA (mg/l - N)				UNIONISED AMMONIA (mg/l)			
	MEAN		95 %ile		MEAN		95 %ile		MEAN		95 %ile	
	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994	1993	1994
Ouse at Naburn	2.21	2.39	5.00	3.85	0.30	0.24	0.82	0.53	0.004	0.004	0.244	0.008
Wharfe at Tadcaster	2.10	1.60	3.60	1.96	0.11	0.08	0.36	0.14	0.001	0.002	0.039	0.004
Aire at Beal	5.67	5.77	11.20	10.88	1.81	0.97	3.36	1.69	0.009	0.040	0.104	0.125
Don at North Br	4.04	2.94	8.40	4.16	2.24	1.04	5.64	1.59	0.012	0.007	0.040	0.015
Trent at Dunham*	4.22	2.29	6.56	3.35	0.29	0.00	0.83	0.01		0.182	0.017	0.289
Derwent at Loftsome Br	1.47	1.41	3.80	2.09	0.11	0.06	0.85	0.13	0.001	0.001	0.051	0.003
Idle at Misterton	4.25	3.00	6.49	5.50	0.15	0.12	0.47	0.33		0.002	0.102	0.004
Bottesford Beck at Snake Plantation	5.68	6.08	8.74	11.88	8.39	5.28	12.26	11.03		0.088	0.253	0.197
Three Rivers at Keadby	3.33	3.07	6.27	5.60	0.34	0.84	1.52	2.06		0.007	0.010	0.016
Hull at Drypool Br	2.21	2.10	5.00	2.63	1.49	0.22	0.82	0.37	0.007	0.003	0.024	0.006

* 1993 values are for the Trent at Winthorpe Bridge: the sampling site has now been shifted to Dunham.

3.3 COMPLIANCE WITH EQSs IN TIDAL WATERS

Compliance with EQSs in the tidal reaches of the Humber Estuary are summarised in Table 3.2. More detail on compliance is shown in Appendix 2 (Tables A2.1 to A2.8).

Table 3.2 EOS Passes/Fails 1994

STATION	Temp	DO	pH	Amm	As	Cd	Cr	Cu	Fe	Hg	Pb	Ni	Zn	B	V	TCB	HCH	DDT tot	DDT PP	PCP	CTC	Drins tot	Endrin	TCE	DCE	PER
TIDAL RIVERS																										
OUSE																										
Cawood	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Selby	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Drax	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	FAIL	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Boothferry	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	FAIL	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Blacktoft	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	FAIL	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
AIRE																										
Snaith	Pass	FAIL	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	*	FAIL	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass
DON																										
Kirk Bramwith	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	*	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	*
Rawcliffe	Pass	FAIL	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
TRENT																										
Dunham	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	*	*	Pass	Pass	*	*	*
Gainsborough	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	*	*	Pass	Pass	*	*	*
Keadby	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	*	*	Pass	Pass	*	*	*
WHARFE																										
Ryther	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	*
ESTUARY																										
Brough	Pass	Pass	Pass	Pass	Pass	Pass	Pass	FAIL	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
New Holland	Pass	Pass	Pass	*	Pass	Pass	Pass	FAIL	Pass	Pass	Pass	Pass	Pass	*	*	*	Pass	Pass	Pass	Pass	*	Pass	Pass	*	*	*
Albert Dock	Pass	Pass	Pass	Pass	Pass	Pass	Pass	FAIL	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Saltend	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Killingholme	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	*	*	Pass	Pass	Pass	Pass	*	Pass	Pass	*	*	*
Spurn	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	*	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

* No data available

3.3.1 Temperature

The EQS for temperature was not exceeded at any site during 1994.

3.3.2 Dissolved Oxygen

The improvement in dissolved oxygen concentrations seen in 1993 continued in 1994 with only two sites (the Aire at Snaith and the Don at Rawcliffe Bridge) failing the EQS. Even the Rawcliffe Bridge site showed some improvement with the 5 %ile dissolved oxygen concentration at 38% compared with 33% in the previous year.

3.3.3 Unionised Ammonia

All sites complied with the ammonia EQS in 1994, including the Aire at Snaith, which failed in the previous year.

3.3.4 pH

All sites on both the tidal rivers and the Estuary complied with the pH EQS.

3.3.5 Metals

EQSs for metals are set as the annual average concentration of either the total or the dissolved fraction.

3.3.5.1 LIST I METALS

The List I metals, cadmium and mercury, are considered the most toxic due to their tendency to accumulate in living tissues and cause physiological harm. The EQSs for both are set for total metal in the tidal rivers and for dissolved metal in the Estuary.

All sites complied with the EQSs for both cadmium and mercury in 1994, although cadmium levels were slightly higher than in 1993.

3.3.5.2 LIST II METALS

Arsenic levels during 1994 were similar to those of 1993 and all sites complied with the EQS. Two tidal river sites, at Selby and Drax on the Ouse, did show considerable increases in arsenic levels compared to the previous year (5.4 ug/l and 6.1 ug/l respectively compared to 3.76 ug/l and 2.98 ug/l).

Chromium levels on both the tidal rivers and the Estuary met the EQS in 1994 with levels similar to those of 1993.

Copper levels at all the tidal river sites complied with the EQS in 1994 despite generally higher levels than in 1993. The Estuary sites failed, although by only a very small margin, at all but one site. Work by the Water Research Centre (WRc 1990) has suggested that less than 1% of copper in saline water is in the non-complexed form and is readily bio-available. Therefore the copper failures are not considered to be of serious concern.

Nickel levels at most sites showed a decrease in 1994 and all sites complied with the EQS.

Lead levels at all sites complied with the EQS in 1994.

Zinc levels complied with the EQS at all sites in 1994.

Iron levels in 1994 were similar to those for 1993 and all sites complied with the EQS.

3.3.5.3 BORON & VANADIUM

Levels of boron and vanadium were first reported for the 1992 Humber Survey. It was hoped that Anglian Region would include these metals in the 1994 programme but this was not possible. The results from the other Regions indicated failures of the EQS for boron on the River Ouse at Blacktoft Jetty and for vanadium at Drax and Boothferry Bridge.

3.3.6 Synthetic Organic Compounds

3.3.6.1 CHLORINATED SOLVENTS

Chlorinated solvents such as trichloroethylene (TCE) were reported as part of the Humber Survey for the first time in 1993 to comply with amendments to Annex II of the Dangerous Substances Directive (86/280/EEC). Other chlorinated solvents also added to the Humber Survey and reported for the first time in 1994 included:

trichlorobenzene (TCB)
tetrachloroethylene (PER)
1,2,dichloroethane (DCE).

Levels of TCE were slightly higher than in 1993 but still well below the EQS of 10 ug/l. No data were available for TCB but both PER and DCE were also well within the 10 ug/l EQS.

3.3.6.2 HCH (Lindane & other isomers) & THE 'DRINS

One tidal river site, the Aire at Snaith, failed the EQS for HCH in 1994 but this is unlikely to be representative since the mean was based on only two sample results. All other sites on both the tidal rivers and the Estuary were well within the EQS, with mean levels all less than one third of the EQS and only two maximum results greater than the EQS.

The 'drins include Isodrin, Dieldrin, Aldrin and Endrin. All sites complied with the EQS for both total 'drins and Endrin (which has an individual EQS), and all the Endrin results were below the limit of detection.

3.3.6.3 DDT (OP & PP)

EQSs are set for both total DDT (which includes the OP and PP isomers) and for the PP isomer alone. In both cases, all sites complied with both EQSs and for the PP isomer all but one result was below the limit of detection.

3.4 LOADS DISCHARGED TO THE HUMBER ESTUARY

3.4.1 Introduction

EQSs prescribe the maximum concentration of specific substances permitted in the water column, but information is also required on the total quantities discharged to watercourses (i.e. the 'loads'). The advantage of a calculated load is that it estimates the amount of a substance entering a water body (and therefore available for deposition into the sediment or release into the sea), rather than the concentration at any given point. This is particularly important for industrial effluents where the effect may be related more to the actual amount discharged than to the concentration of that discharge. (The concentration may be high but with little impact because of a low overall volume).

Loads are calculated by multiplying the concentration of a given substance in an effluent or river by the flow at the time of sampling. The loads calculated for this report are those from the major industrial and sewage discharges downstream of the tidal limits and those entering the Humber via the freshwater rivers. It must be noted that the figures reported for the rivers include loads from industrial and sewage discharges upstream of the tidal limits.

The Humber Estuary Report 1992 showed loads of metals such as mercury steadily decreasing over the last ten years, whereas the Contaminants Entering the Sea Report (1995) has shown them increasing. This discrepancy is a consequence of the way that results which are lower than the limit of detection (LOD) are used in the load calculations (see section 3.1).

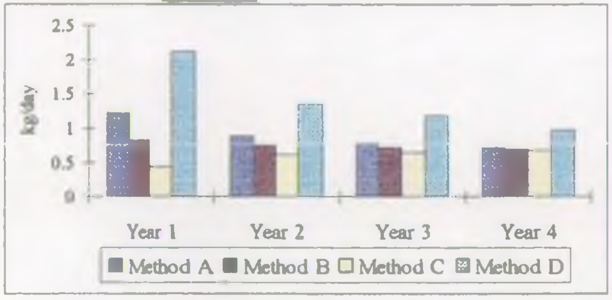
3.4.2 Effects of Different Methods of using LOD Data on Calculated Loads

LOD values can be treated in several ways when working out averages and percentiles:

A. ignore the 'less than' sign and assume the substance to be present at the LOD (often called a 'high load'),
B. divide the LOD by two and use this value in the calculation,
C. assume all 'less than' values to be zero (often called a low load),
D. ignore the 'less than' values and calculate the load using only real values (i.e. a smaller sample is used).

Figure 3.2 shows the results of load calculations on a four-year fictional data set using each of the four methods outlined above. Over the four years the loads almost halve with methods A and D, decrease slightly with method B , and nearly double with method C.

<u>Figure 3.2 Loads Calculated using Four Different Methods</u>



3.4.3 Interpreting Load Data

The example above shows the difficulties in interpreting loads where there are a significant number of 'less than' values in the data set. Loads of BOD, ammonia and TON are much less affected by this mathematical artefact since they are rarely present at levels lower than the LOD. On the test data set, method B (including 'less than' values at half the LOD) provides the most stable result. This is the method generally used when calculating means for EQS compliance and is the method used elsewhere in this report (see section 3.1). However, this does not solve the problem of assessing whether or not metal loads are decreasing. From the measurements of concentration in the water column they seem to be decreasing, but this is not the method used by the Paris Commission in assessing the levels discharged to the North Sea.

The only safe conclusion to draw from the load data is that, as the 'high' and 'low' load calculations converge with improvements in the LOD, we are closer to measuring the real situation. This should result in easier, and better, comparisons over the next ten years.

Since previous Humber Estuary Reports have used method B (including 'less than' values at half the LOD), this is the preferred method for reporting the 1994 data and comparison with the five-year mean (Figure 3.3a - 3.3i). In addition, the Parcom/A1A data are also presented using methods A and C (thereby giving the 'high' and 'low loads') for completeness (Figure 3.4a - 3.4h)[1] and to allow comparison with the North Sea reports. The differences which appear in the two sets of graphs are due mainly to the fact that there is only partial overlap in the sites used in the Humber Routine Survey Programme and those used in the Parcom/A1A programme (see Appendix 3). In addition, the sampling programme for Parcom/A1A is more frequent than the Humber Survey, and this may contribute to the statistical differences.

3.4.4 Cadmium and Mercury

The loads of these two List I metals from all three sources (section 3.4.1) in 1994 were well below the five-year mean (Figures 3.3a & 3.3b). The most substantial differences were in the cadmium loads from industry, which were 0.2 kg/day in 1994 compared to a five-year mean of 2.56 kg/day, and the mercury loads from the rivers, which were 0.18 kg/day in 1994 compared to a five-year mean of 2.46 kg/day. Both metals show a continuation of the decrease first seen in 1989.

Figure 3.4a shows that the calculated 'high' and 'low' loads for cadmium are almost identical because very few 'less than' values were reported, whereas there is a significant difference between the 'high' and 'low' loads for mercury in tidal rivers and sewage effluents - where a substantial proportion of values were reported as 'less thans' (Figure 3.4b).

3.4.5 Other Metals

In 1994, the loads of other metals from all three sources were lower than the five-year mean. Points of particular interest are discussed below.

Arsenic loads in 1994 were substantially lower than the five-year mean (Figure 3.3c), although the rivers load showed an increase on 1993. The decreases in effluent loads were particularly large at 0.6 kg/day in sewage effluents and 0.7 kg/day in trade effluents compared to five-year means of 14.6 kg/day and 360 kg/day respectively and 1993 loads of 2.3 kg/day in both sewage and trade effluents. The huge decrease in trade effluents are thought to be primarily due to the closure of Capper Pass, which was the Estuary's largest source of arsenic.

Copper loads for tidal rivers and sewage were similar to the five-year mean, but were substantially lower for industrial inputs in 1994, at 19 kg/day compared to a five-year mean of 240 kg/day (Figure 3.3d) and 30 kg/day in 1993.

Chromium loads in industrial effluents decreased significantly with levels of 96 kg/day reported in 1994 compared to a five-year mean of 903 kg/day and 240 kg/day in 1993 (Figure 3.3e).

Nickel loads in the tidal rivers were 187 kg/day in 1994 compared to a five-year mean of 245 kg/day and 248 kg/day in 1993 (Figure 3.3f).

Lead loads in the tidal rivers showed a decrease in 1994 to 139 kg/day, which was well below the five-year mean of 284 kg/day (Figure 3.3g) following the very high loads of 454 kg/day reported in 1993.

Zinc loads in sewage effluents showed a similar pattern to lead in tidal rivers, dropping below the five-year mean of 63 kg/day to 25 kg/day in 1994 (Figure 3.3h) after exceeding it in 1993 with levels of 96 kg/day.

Iron loads were not reported in 1993 but in 1994 the highest loads by far were from industrial effluents with a negligible contribution from sewage discharges (Figure 3.3i).

As mentioned above (section 3.4.3) Figures 3.4a - 3.4h show the 'high' and 'low' loads of metals in the tidal rivers, sewage and industrial effluents, for comparison with the Contaminants Entering the Sea Report. In most cases, there was little or no difference between the 'high' and 'low' loads of metals since most of the results for 1994 were above the limit of detection. The exceptions were arsenic loads in the tidal rivers (Figure 3.4c) and mercury loads in the tidal rivers and sewage discharges (Figure 3.4 b).

It is notable that for most metals (cadmium, mercury, arsenic, copper, nickel and lead) the greatest loads entered the Humber system via the freshwater rivers. The highest loads of chromium arose, not surprisingly, from sewage discharges, followed closely by industrial discharges. The highest zinc loads arose from industry.

[1] No graph is provided for 'high' and 'low' loads of iron since it is not included in the Parcom/A1A programme.

Figure 3.3a Cadmium Loads to the Humber

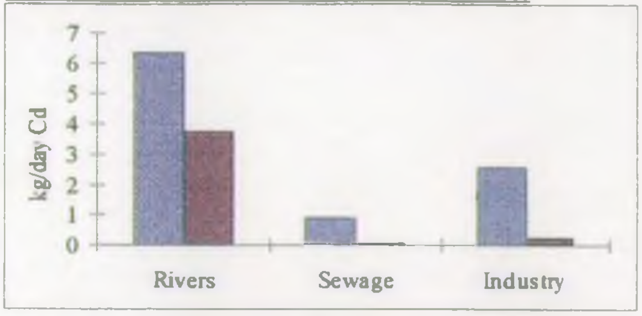


Figure 3.3b Mercury Loads to the Humber

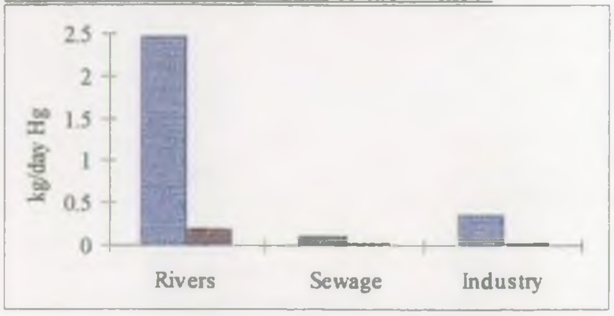


Figure 3.3c Arsenic Loads to the Humber

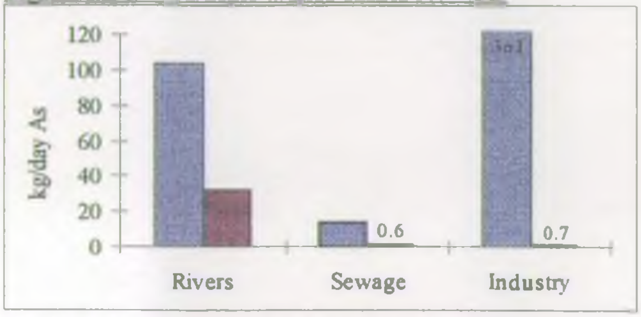


Figure 3.3d Copper Loads to the Humber

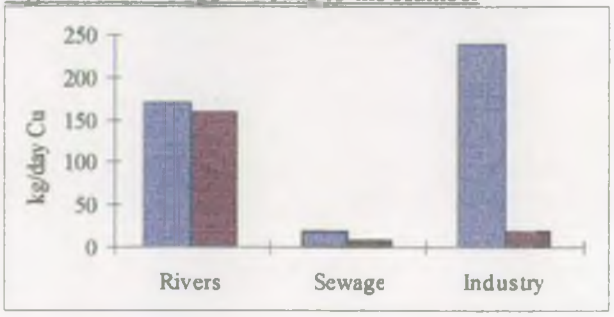


Figure 3.3e Chromium Loads to the Humber

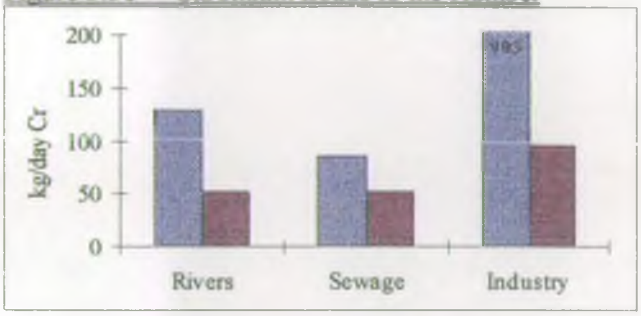


Figure 3.3f Nickel Loads to the Humber

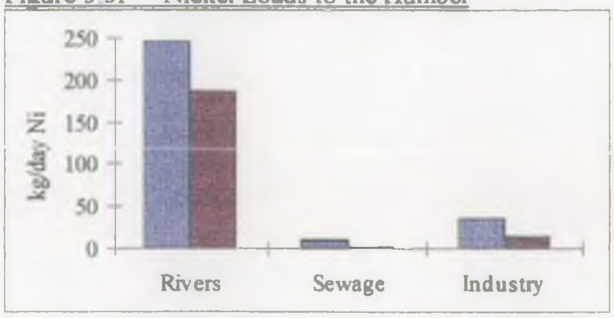


Figure 3.3g Lead Loads to the Humber

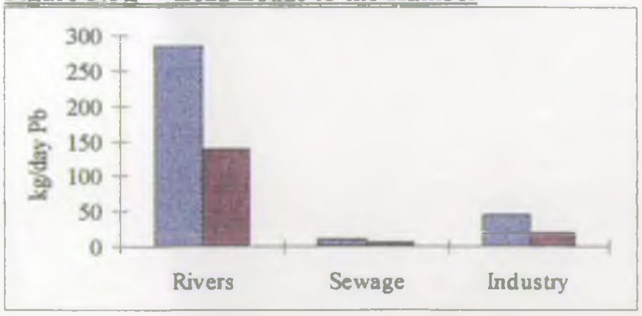


Figure 3.3h Zinc Loads to the Humber

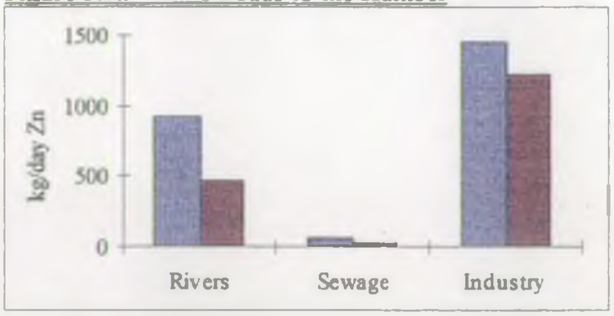


Figure 3.3i Iron Loads to the Humber

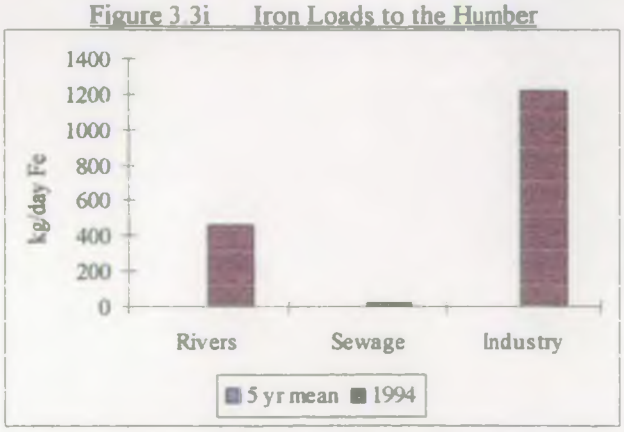


Figure 3.4a High and Low Loads of Cadmium

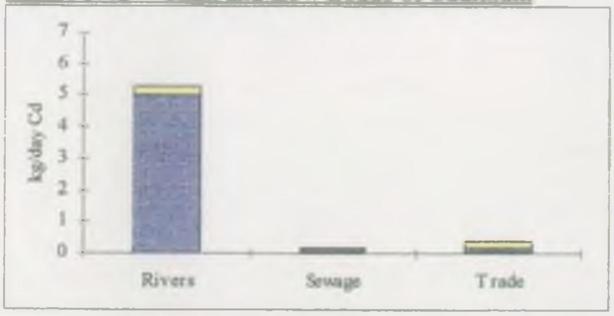


Figure 3.4b High and Low Loads of Mercury

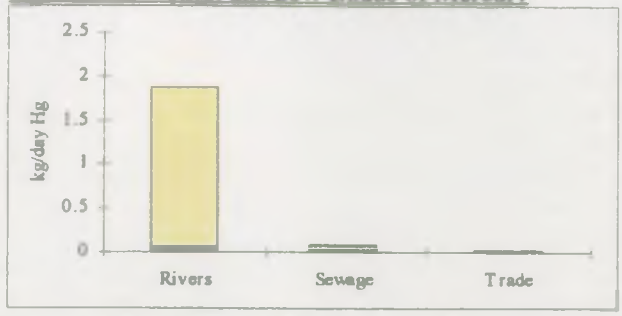


Figure 3.4c High and Low Loads of Arsenic

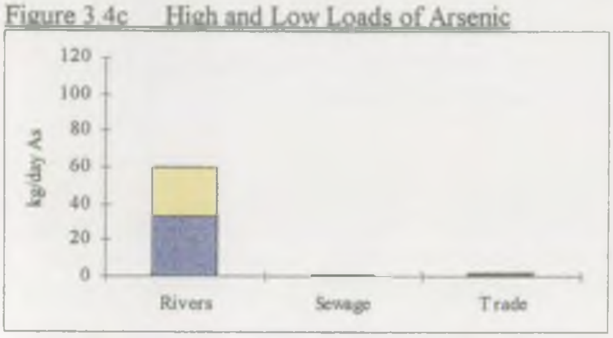


Figure 3.4d High and Low Loads of Copper

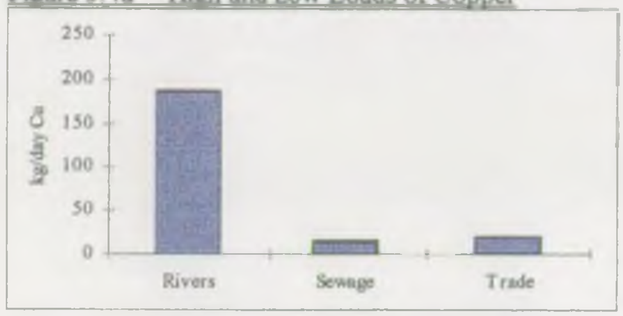


Figure 3.4e High and Low Loads of Chromium

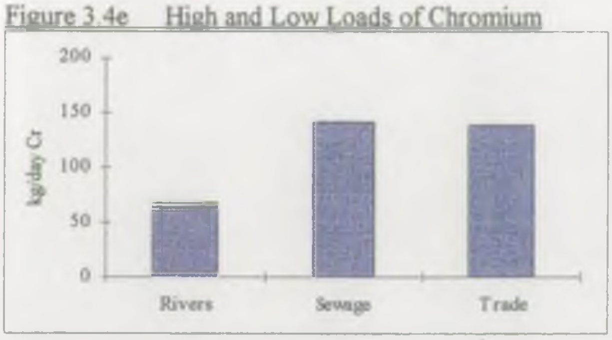


Figure 3.4f High and Low Loads of Nickel

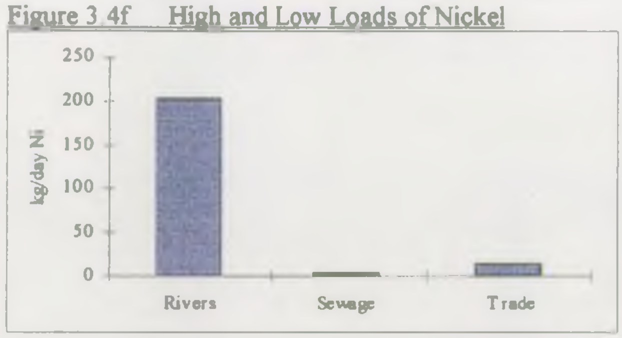


Figure 3.4g High and Low Loads of Lead

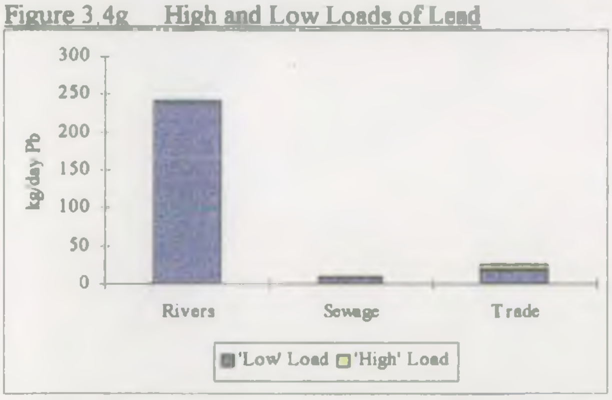
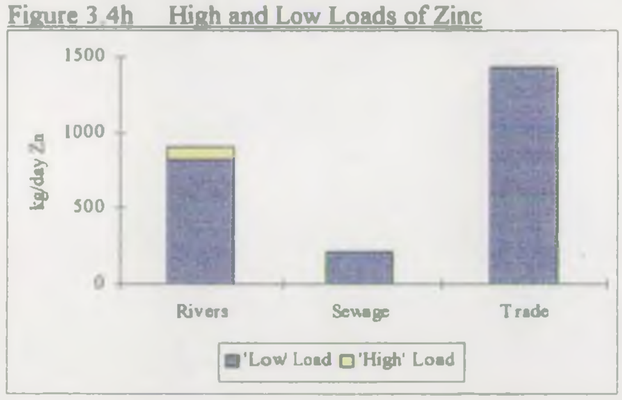


Figure 3.4h High and Low Loads of Zinc



3.5 METALS IN TIDAL RIVER SEDIMENTS

Sediments are collected bi-annually from seven sites on the tidal rivers (Figure 3.5). In general, the levels of metals in the tidal river sediments showed a continuing decrease in 1994 with most sites having levels of most metals lower than the five-year mean (1990 - 1994). The few sites where the 1994 results exceeded the five-year mean are consistent with the downstream migration of historically contaminated sediments (suggested as the cause of the elevated metal levels reported in 1993). Data were not available to allow the calculation of the five-year mean at site TR7.

Arsenic levels in 1994 were below the five-year mean except for a fractionally higher result at TR2 as shown in Figure 3.6a

Mercury levels in 1994 were generally lower than the five-year mean except for negligible increases at two sites (Figure 3.6b). The results from sites TR1 and TR6 were significantly lower than the five-year mean because of substantial reductions on the levels reported in the previous year: the results for both sites fell to about 0.2 mg/kg in 1994 following peaks in 1993 of nearly 3.4 mg/kg at site TR1 and 1.5 mg/kg at site TR6.

Copper levels in 1994 were lower than the five-year mean at all tidal river sites (Figure 3.6c).

Cadmium levels were lower than the five-year mean at all sites in 1994 (Figure 3.6d). Substantial reductions compared to 1993 were reported at sites TR1 (4.0 mg/kg in 1993 to 0.4 mg/kg in 1994), TR4 (3.75 mg/kg to 0.3 mg/kg) and TR6 (3.0 mg/kg to 0.3 mg/kg).

Chromium levels in 1994 were lower than the five-year mean (Figure 3.6e) and all sites showed a decrease compared to 1993.

Nickel levels in 1994 were lower than the five-year mean at all sites (Figure 3.6f).

Lead levels in 1994 were lower than the five-year mean at all sites except TR2 (Figure 3.6g).

Zinc levels in 1994 were lower than the five-year mean at all sites and substantially lower at site TR1 (Figure 3.6h).

Iron levels in 1994 slightly exceeded the five-year mean at sites TR2 and TR5 but were lower at the remaining sites (Figure 3.6i).

Figure 3.5 The Humber Survey Tidal River Sediment Sites

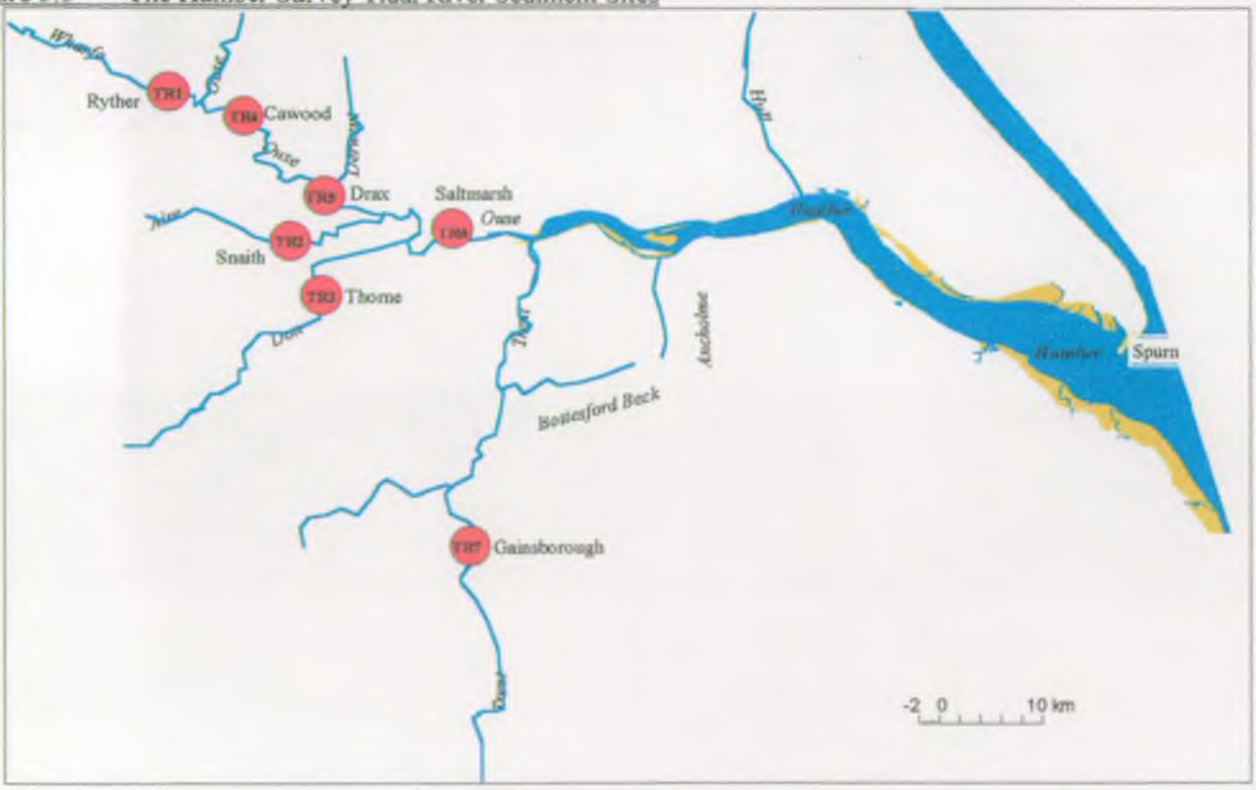


Figure 3.6a Arsenic in Tidal River Sediments

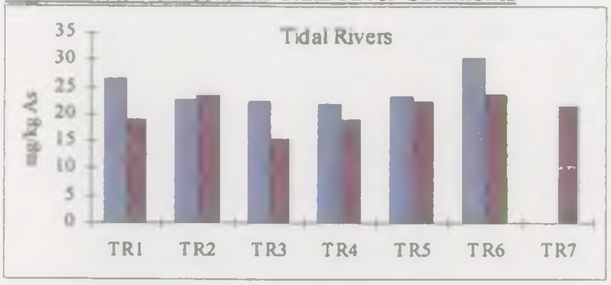


Figure 3.6b Mercury in Tidal River Sediments

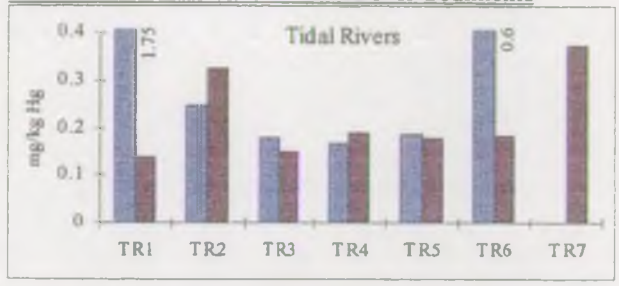


Figure 3.6c Copper in Tidal River Sediments

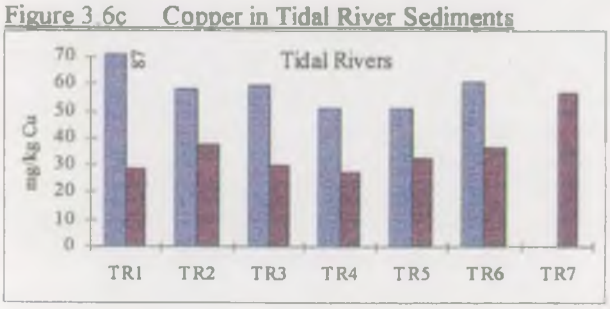


Figure 3.6d Cadmium in Tidal River Sediments

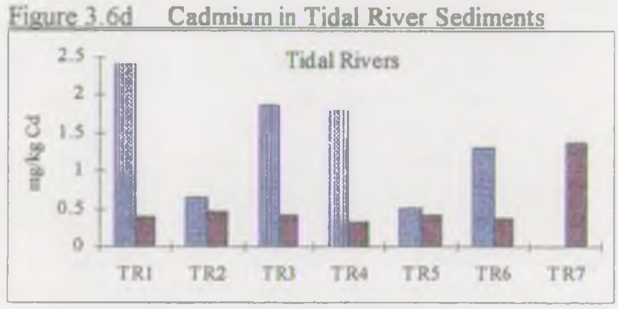


Figure 3.6e Chromium in Tidal River Sediments

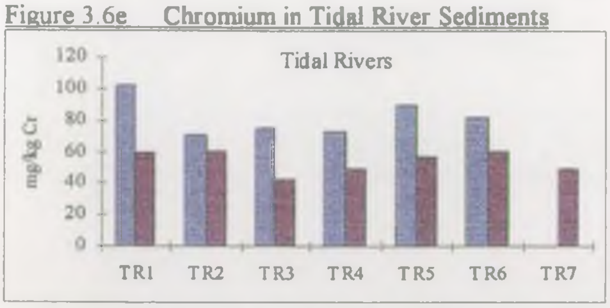


Figure 3.6f Nickel in Tidal River Sediments

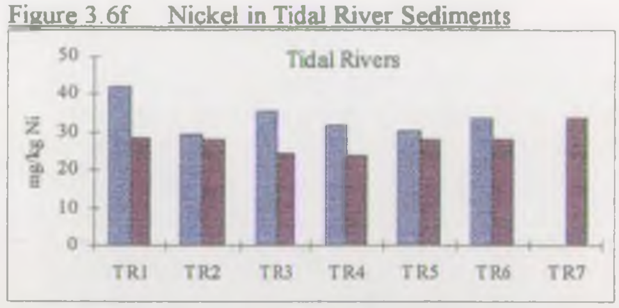


Figure 3.6g Lead in Tidal River Sediments

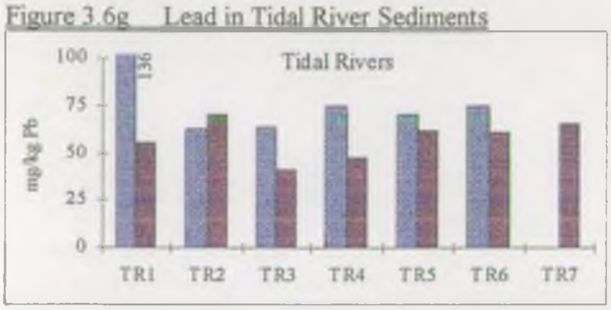


Figure 3.6h Zinc in Tidal River Sediments

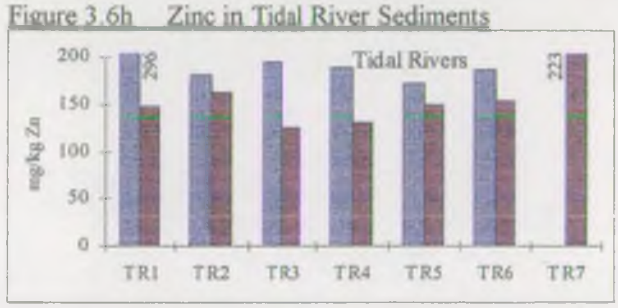
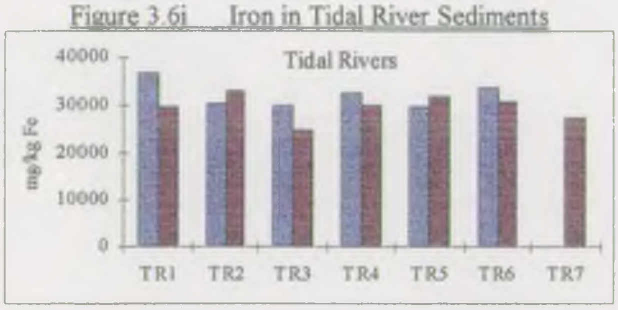


Figure 3.6i Iron in Tidal River Sediments



3.6 METALS IN INTERTIDAL ESTUARY SEDIMENTS

Sediments are collected bi-annually from twenty sites in the Estuary (Figure 3.7). As with the tidal rivers sediments (section 3.5), the levels of metals in the estuarine sediments showed a continuing decrease in 1994 with most sites having levels of most metals lower than the five-year mean (1990 - 1994). For most metals, the 1994 results from the South Bank sites were substantially lower than in 1993. This is possibly a result of a change in the method of processing the sample. Until 1993, sediment samples were wet-sieved then dried but, in 1994, drying prior to sieving was introduced and there is some evidence that this has had a significant effect on the proportion of material of less than 63 μm retained in the sample. The results from the North and South Banks were similar except for arsenic which was slightly higher at the South Bank sites.

Arsenic levels in 1994 were below the five-year mean (Figure 3.8a). In general, the results from the North Bank were slightly lower than those from the South Bank.

Mercury levels in 1994 were generally lower than the five-year mean except for a negligible increase at site N10 (Figure 3.8b). Overall, the levels on both banks of the Estuary were similar.

Copper levels in 1994 were lower than the five-year mean at all sites, although the results from the North Bank remained slightly higher than those from the South Bank (Figure 3.8c)

Cadmium levels in 1994 were below the five-year mean except at sites N9 and S1 (Figure 3.8d). Excluding these two sites, the results for both banks of the Estuary were similar

Chromium levels in 1994 were similar to the five-year mean at sites N1 and N2 but lower elsewhere (Figure 3.8e). All sites showed a decrease compared to 1993. The highest levels were found on the South Bank around the major outfalls.

Nickel levels in 1994 were lower than the five-year mean at all sites (Figure 3.8f).

Lead levels in 1994 were similar to the five-year mean at site N6 and slightly higher at site N2 but lower elsewhere (Figure 3.8g).

Zinc levels in 1994 were generally lower than the five-year mean, particularly on the South Bank (Figure 3.8h). Despite reductions, the highest levels were on the South Bank near the main inputs.

Iron levels in 1994 slightly exceeded the five-year mean at several North Bank sites (Figure 3.8i). There were no comparable exceedences on the South Bank as a result of an historically higher five-year mean. The levels reported for both banks of the Estuary were similar.

Figure 3.7 The Humber Survey Intertidal Sediment Sites

Figure 3.8a Arsenic in Intertidal Estuary Sediments

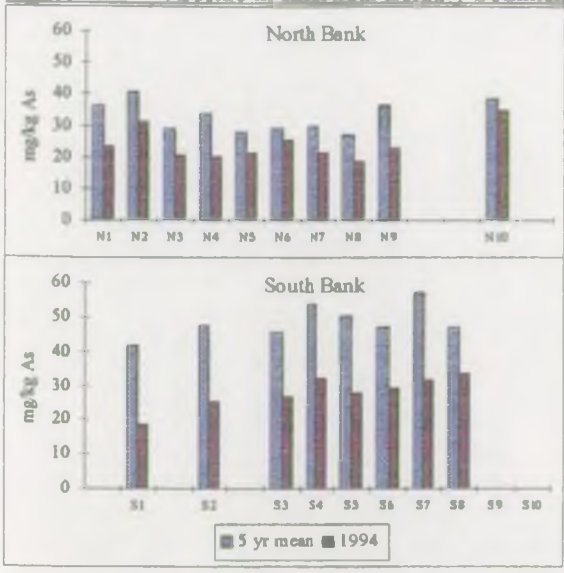


Figure 3.8b Mercury in Intertidal Estuary Sediments

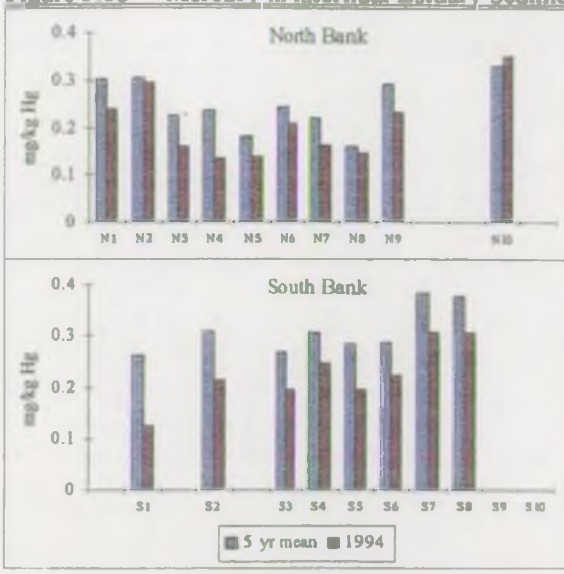


Figure 3.8c Copper in Intertidal Estuary Sediments

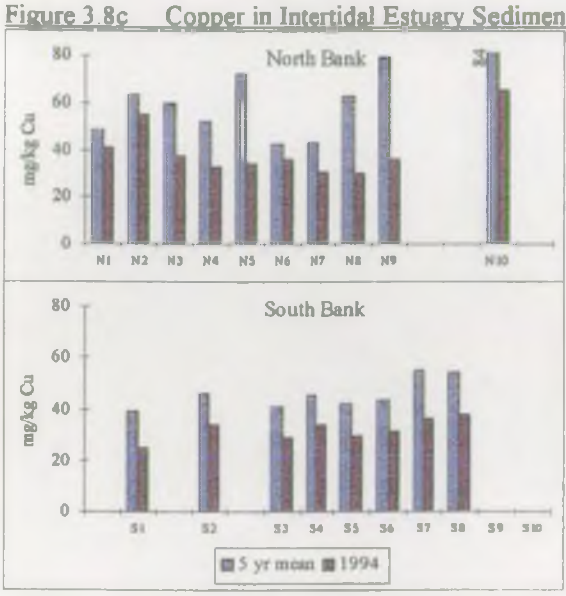


Figure 3.8d Cadmium in Intertidal Estuary Sediments

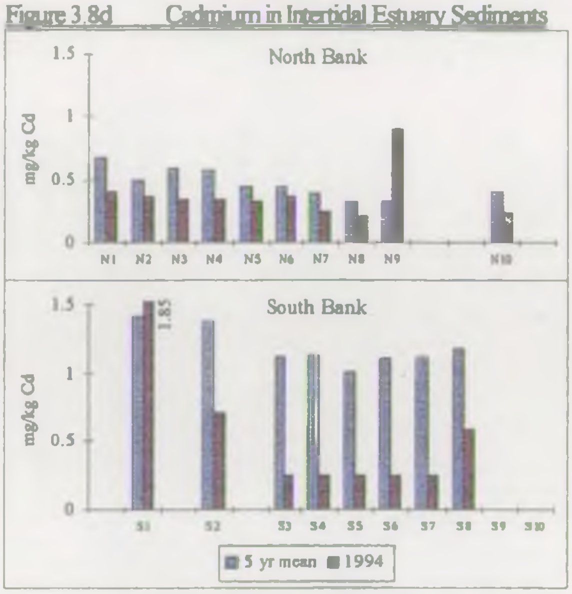


Figure 3.8e Chromium in Intertidal Estuary Sediments

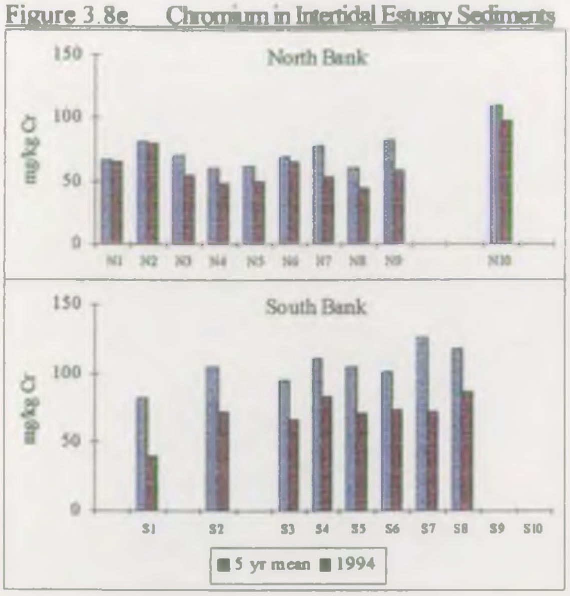


Figure 3.8f Nickel in Intertidal Estuary Sediments

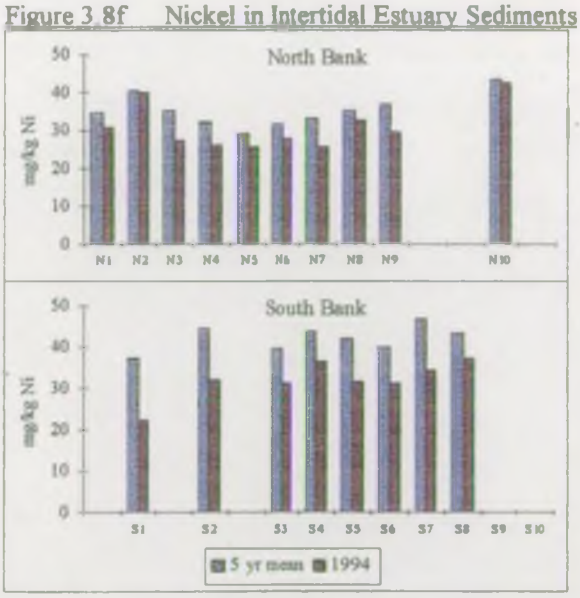


Figure 3.8g Lead in Intertidal Estuary Sediments

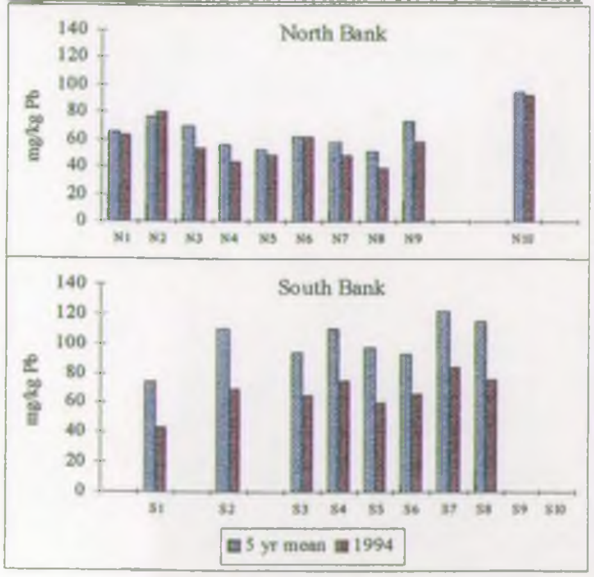


Figure 3.8h Zinc in Intertidal Estuary Sediments

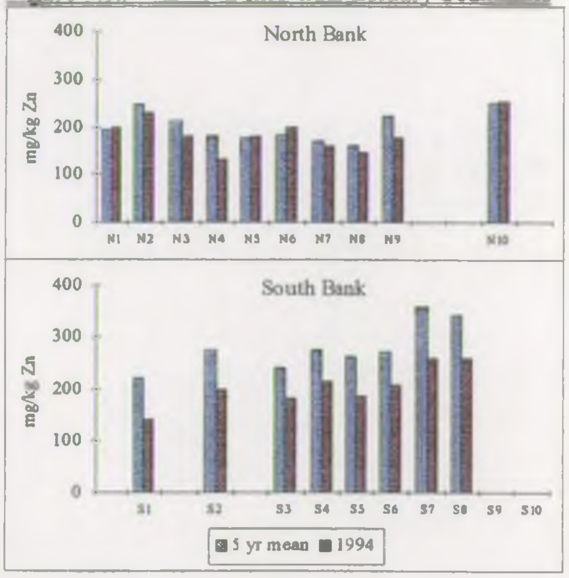


Figure 3.8i Iron in Intertidal Estuary Sediments

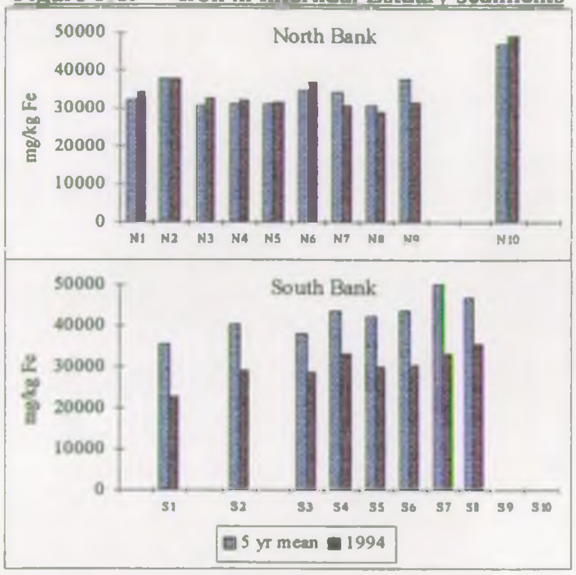


Figure 3.9 The Humber Survey Subtidal Sediment Sites

3.6 METALS IN SUBTIDAL SEDIMENTS

Fourteen subtidal sites on the Humber are sampled annually for metals and some organics in the sediments (see Figure 3.9). The metals results for 1994 are shown in Figures 3.10a-h. All the cadmium results were less than the LOD in 1994 and are therefore not illustrated. The majority of results from 1994 were below the five-year mean for most of the metals, except mercury and zinc for which half the results were greater than the five-year mean. Three sites (ST6, ST7 and ST10) showed levels in 1994 higher than the five-year mean for most metals. It is possible that the continued accumulation of metals at these three sites is a result of the deposition of dredge-spoil in the area combined with the effect of sediment mobility and mudbank accretion. The change in sample processing discussed in section 3.6 above also applies to subtidal samples.

Figure 3.10a Arsenic in Subtidal Sediments

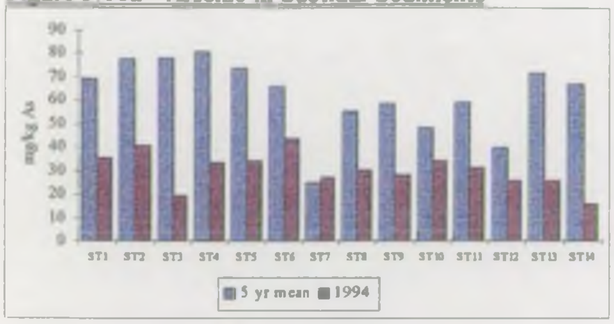


Figure 3.10b Mercury in Subtidal Sediments

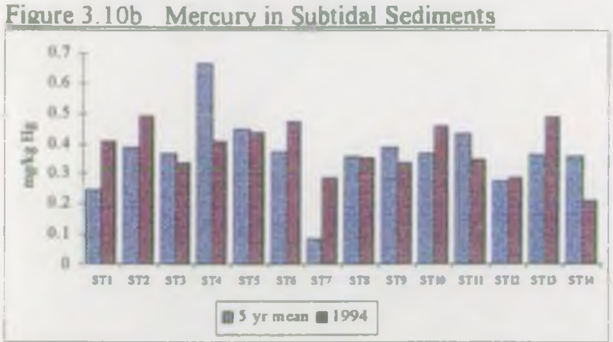


Figure 3.10c Copper in Subtidal Sediments

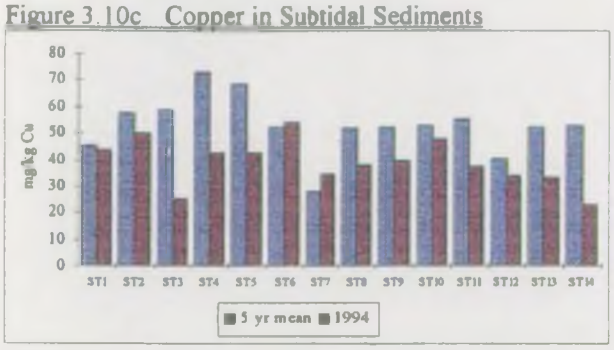


Figure 3.10d Chromium in Subtidal Sediments

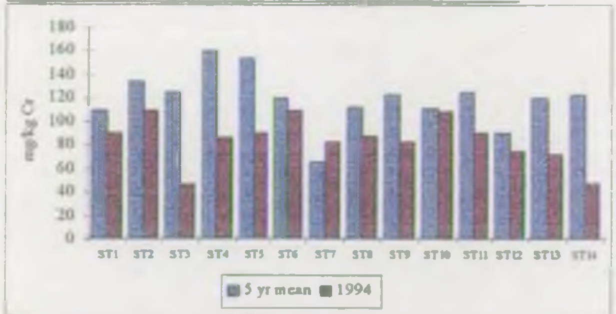


Figure 3.10e Nickel in Subtidal Sediments

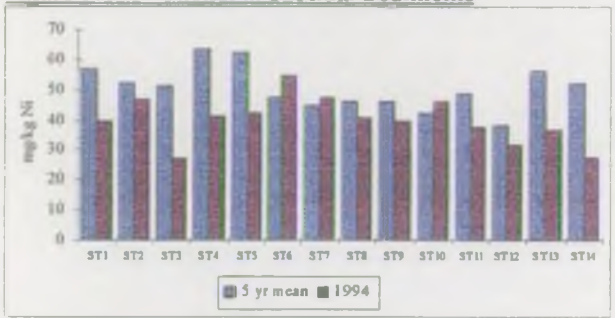


Figure 3.10f Lead in Subtidal Sediments

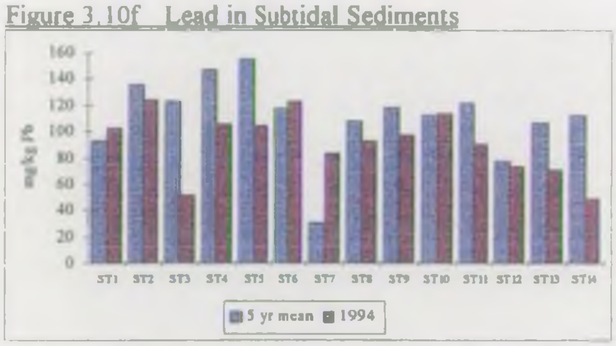


Figure 3.10g Zinc in Subtidal Sediments

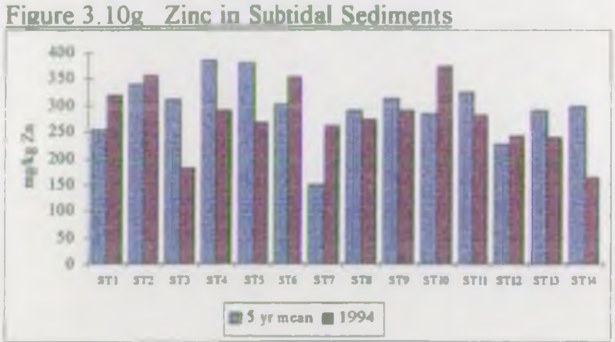
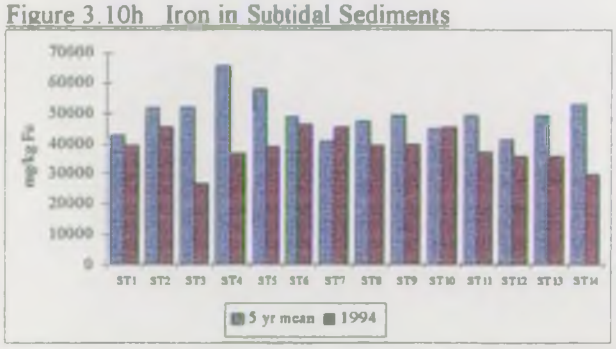


Figure 3.10h Iron in Subtidal Sediments



3.7 BIOACCUMULATION IN ESTUARY ORGANISMS

The levels of certain substances accumulated by some aquatic organisms provide a longer-term view of the chemical quality of the Estuary. Many macroinvertebrates and flora are exposed to the water column either continuously or for a large proportion of their lives, and tend to accumulate certain substances within their tissues. Analysis of these tissues can help to assess the quality of the water column over a longer-time period with the major fluctuations damped. There are twenty-one shore-based and three subtidal sites in the Estuary where organisms are collected for tissue bioaccumulation sampling (Figure 3.11). Changes in water quality are also reflected in the structure of estuarine communities, which is discussed in detail in section 4.

3.7.1 Bioaccumulation in Ragworms

Samples of *Nereis diversicolor* are collected annually and analysed for metals and some organic substances. For 1994, only metal analysis results were available. In most cases, the metal levels were below the limit of analytical detection. This was most pronounced in the results for arsenic, chromium, lead, nickel and vanadium and, therefore, these results are not illustrated. Results for the remaining metals are illustrated in Figures 3.12a-e. The 1994 results were generally higher than the five-year mean at most sites for most metals, the exceptions being mercury and cadmium on the North Bank and iron on the South Bank. Some of the differences between the North and South Bank results appear to be caused by the different analytical methods employed by the separate regions. Mercury levels do, however, appear to be rather higher in the South Bank samples than in the North Bank, and cadmium shows a downward trend moving seawards along both banks.

Mercury levels in 1994 were lower than the five-year mean at all North Bank sites but higher at most South Bank sites, particularly at sites S4 and S8 (Figure 3.12a).

Copper levels in 1994 were higher than the five-year mean at most North Bank and all the South Bank sites, especially at sites N6 and S4 (Figure 3.12b).

Cadmium levels in 1994 were lower than the five-year mean at most North Bank sites but higher at most South Bank sites, particularly at site S4 (Figure 3.12c).

Zinc levels in 1994 were higher than the five-year mean at most North Bank and all the South Bank sites, especially at sites N8, N9 and S10 (Figure 3.12d).

Iron levels in 1994 were higher than the five-year mean at most North Bank sites, especially site N7, but lower at most South Bank sites, particularly at site S8 (Figure 3.12e).

Figure 3.11 The Humber Survey Bioaccumulation Sites

Figure 3.12a Mercury in *Nereis*

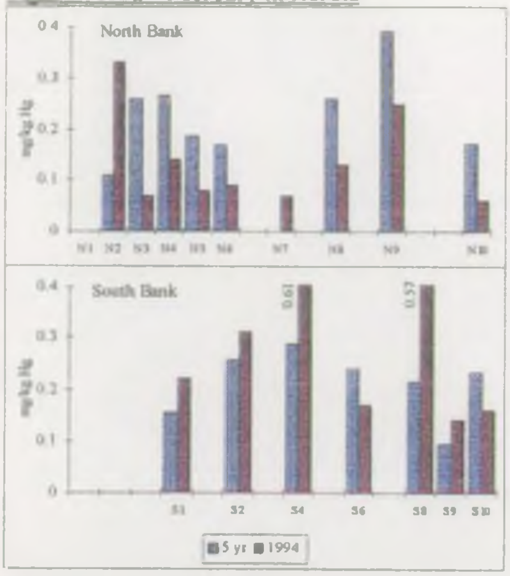


Figure 3.12b Copper in *Nereis*

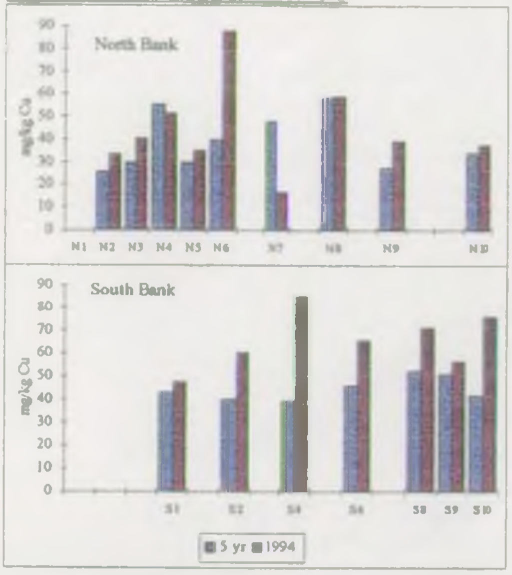


Figure 3.12c Cadmium in *Nereis*

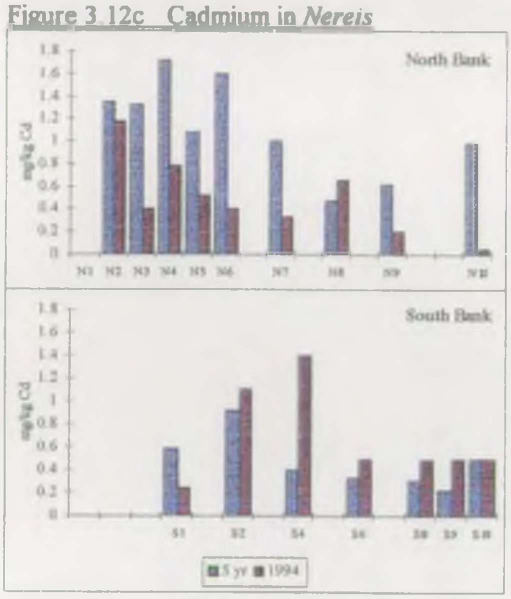


Figure 3.12d Zinc in *Nereis*

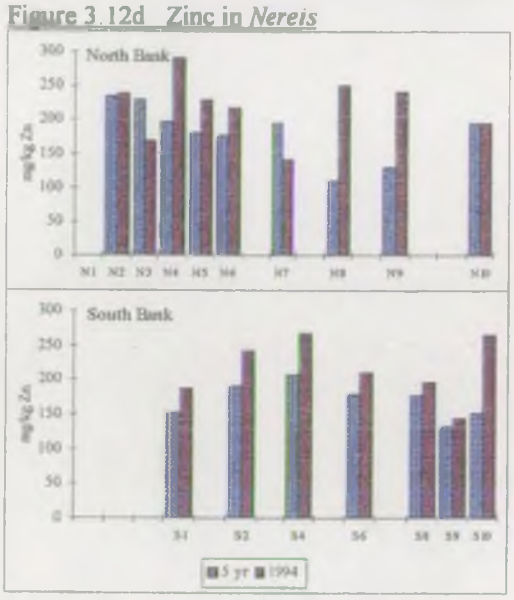
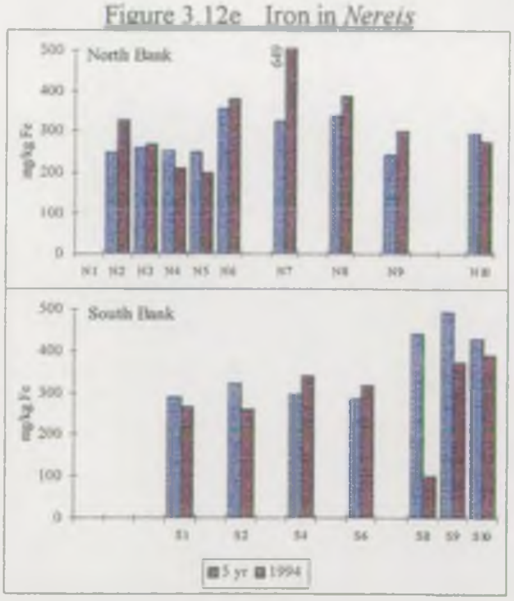


Figure 3.12e Iron in *Nereis*



3.7.2 Bioaccumulation in Seaweed

Fucus vesiculosus samples are collected bi-annually from five North Bank and ten South Bank sites (see Figure 3.11). *Fucus* can take up substances from the environment only passively, i.e. by absorption of metals in solution. The results are shown in Figures 3.13a-d. On the North Bank, just over half of the nickel results were below the limit of detection. No data were available for arsenic and mercury from the South Bank samples. In most cases, particularly cadmium, there is generally a decrease in metal levels moving seawards, with peaks of copper and zinc in the lower Estuary around the main discharges.

Copper levels in 1994 were higher than the five-year mean at most North Bank sites but lower at all the South Bank sites (Figure 3.13a).

Cadmium levels in 1994 were lower than the five-year mean at all the North Bank sites but higher at most of the South Bank sites (Figure 3.13b).

Nickel levels in 1994 were lower than the five-year mean at all the North Bank sites but higher at most of the South Bank sites (Figure 3.13c).

Zinc levels in 1994 were higher than the five-year mean at most North Bank sites and half the South Bank sites (Figure 3.13d).

Figure 3.13a Copper in *Fucus*

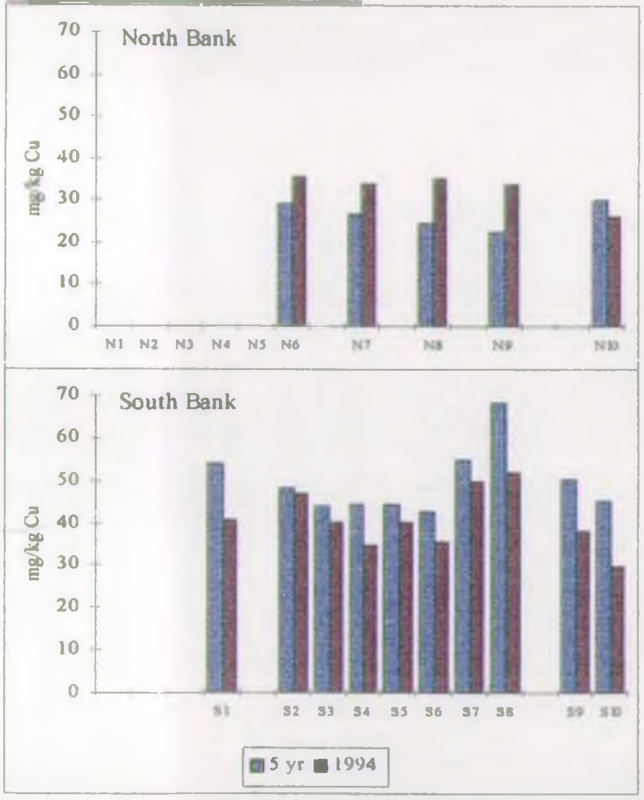


Figure 3.13b Cadmium in *Fucus*

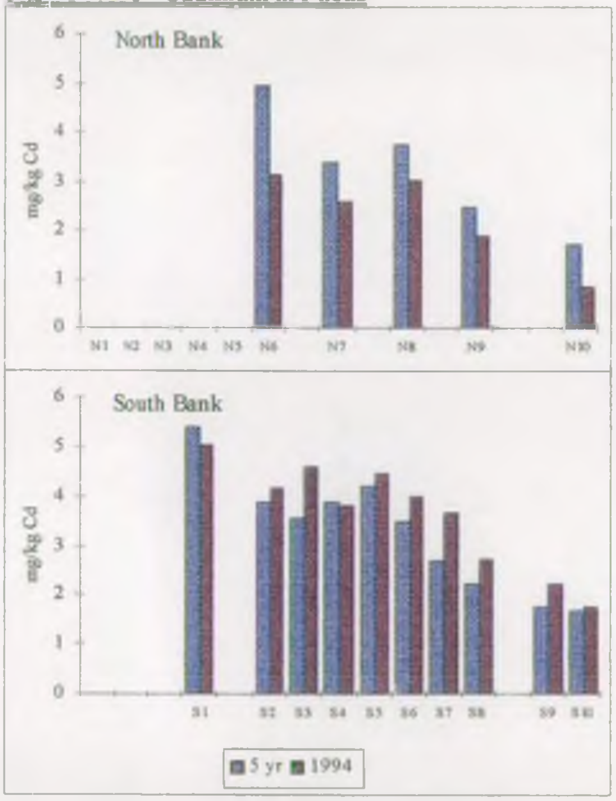


Figure 3.13c Nickel in *Fucus*

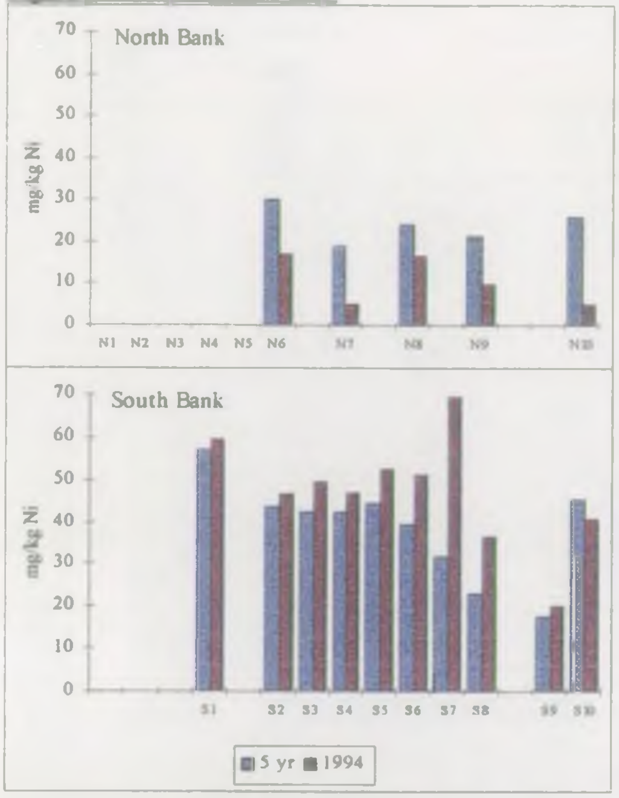
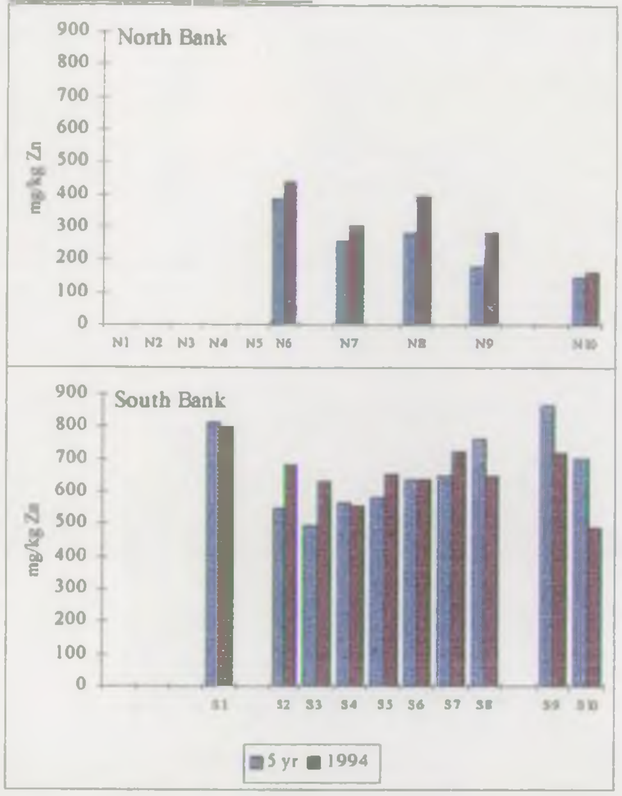


Figure 3.13d Zinc in *Fucus*



3.7.3 Bioaccumulation in Brown Shrimps

Samples of *Crangon crangon* are collected once per year from three subtidal sites in the Estuary and analysed for metals and organics (see Figure 3.11). As with the *Nereis* samples, results were not available for organics during 1994. The wet weight metal results are shown in Figures 3.13a-g. In general, lower levels were recorded in the shrimps collected from the upper estuary.

Arsenic levels in 1994 were considerably lower than the five-year mean, continuing the substantial decrease recorded in 1993 (Figure 3.14a).

Mercury levels in 1994 were similar to or higher than the five-year mean but by such small amounts as to be insignificant (Figure 3.14b).

Copper levels in 1994 were lower than the five-year mean in the upper estuary but higher in the middle and lower estuary. The results were within the normal range following lower levels recorded in 1993 (Figure 3.14c).

Cadmium levels in 1994, like copper, were lower than the five-year mean in the upper estuary and slightly higher in the middle and lower estuary, but still within the expected range (Figure 3.14d).

Chromium levels in 1994 were lower than the five-year mean at all three sites, particularly at site C2, but were still within the normal range (Figure 3.14e).

Zinc levels in 1994 were higher than the five-year mean at all sites but by such a small amount as to be insignificant. The higher results in 1994 followed exceptionally low levels recorded in 1993 (Figure 3.14f).

Iron levels in 1994 were lower than the five-year mean at all three sites, particularly at site C3 (Figure 3.14g).

Figure 3.14a Arsenic in *Crangon*

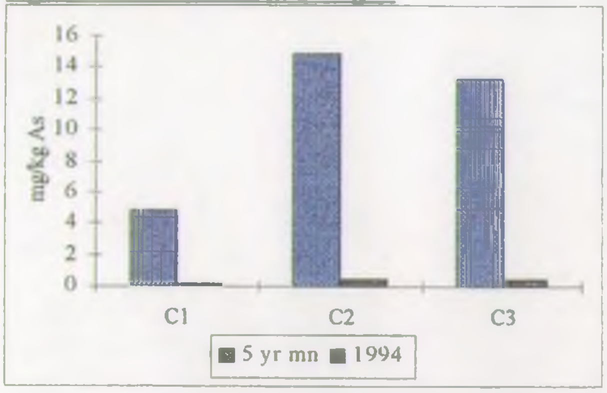


Figure 3.14b Mercury in *Crangon*

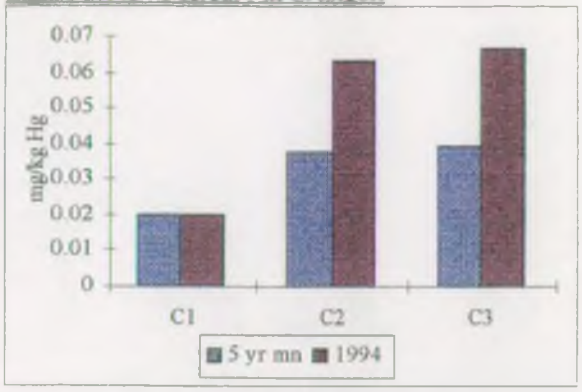


Figure 3.14c Copper in *Crangon*

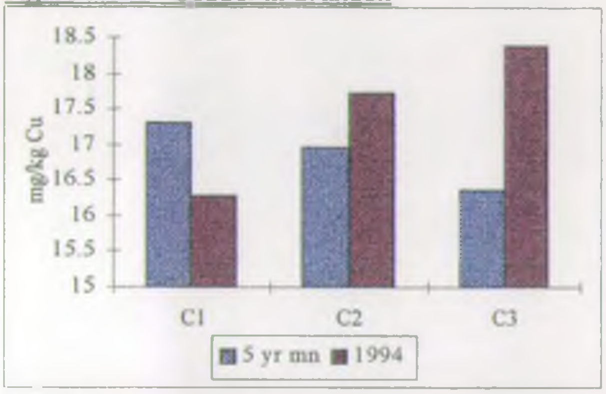


Figure 3.14d Cadmium in *Crangon*

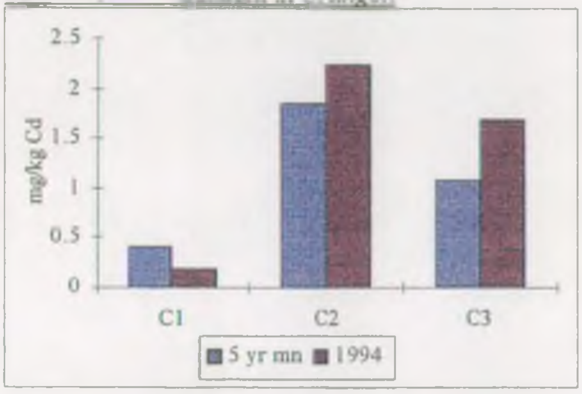


Figure 3.14e Chromium in *Crangon*

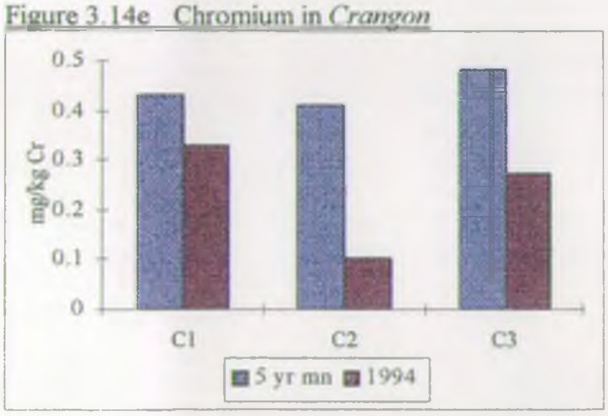


Figure 3.14f Zinc in *Crangon*

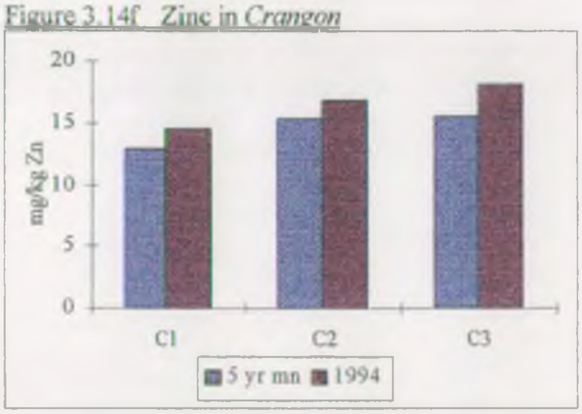


Figure 3.14g Iron in *Crangon*

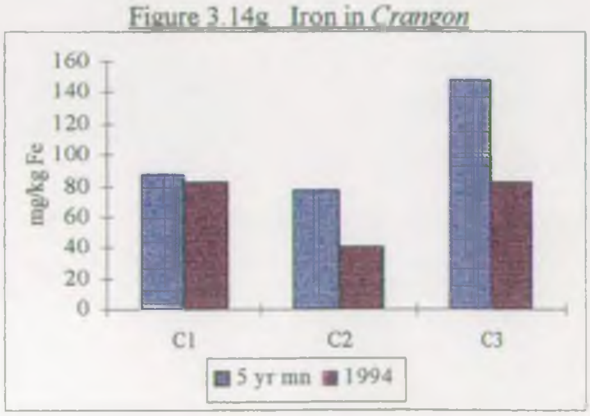
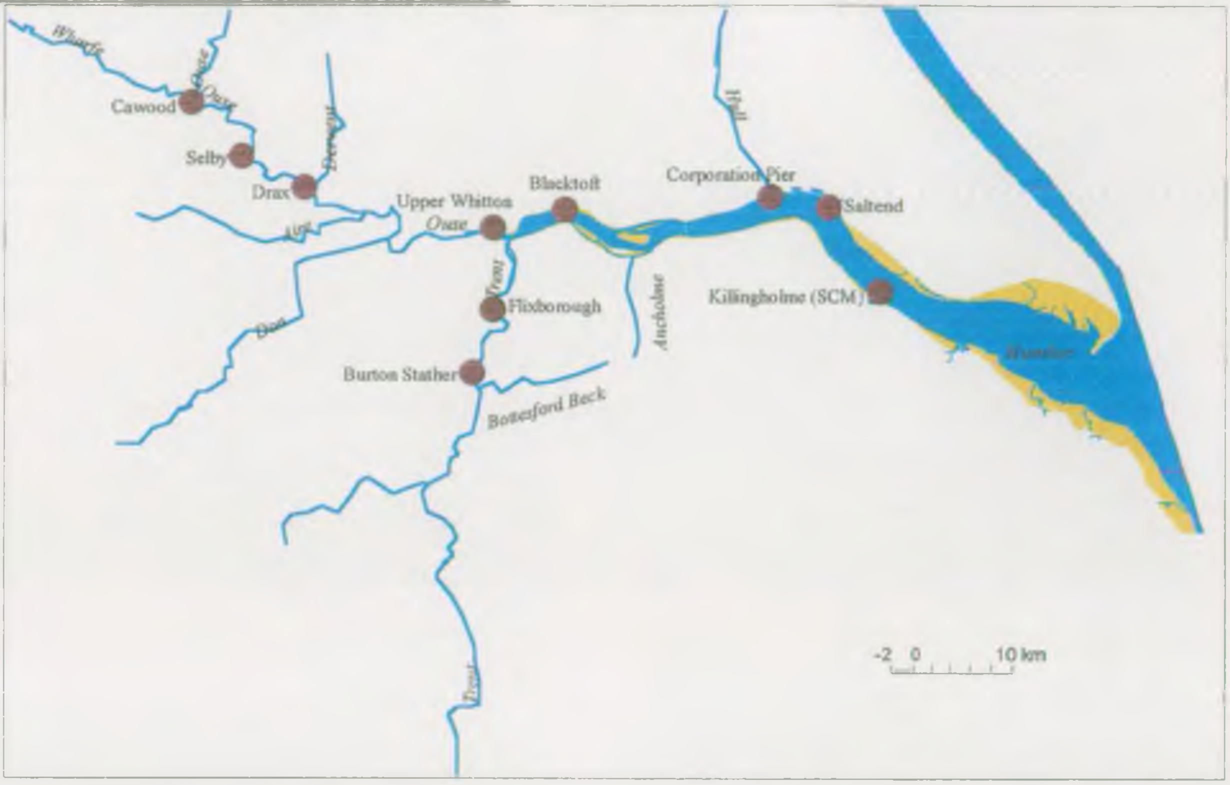


Figure 3.15 Continuous Monitors in the Humber



3.8 CONTINUOUS MONITORS

The Humber Survey requires the continuous monitoring of dissolved oxygen (as % saturation and mg/l) and temperature at several sites in the Humber and its tidal rivers (Figure 3.15) in order to provide a more detailed picture of the estuarine environment. Equipment is permanently in place which monitors (at 15 minute intervals) these determinands plus pH and salinity and, on some tidal rivers, turbidity and ammonia. This data gives a clearer picture of the changing conditions in the Estuary throughout the day, particularly for dissolved oxygen which varies with both the tidal cycle and temperature and is critical in sustaining fish-life.

Some examples of the data recorded by the monitors located at Cawood and Blacktoft on the River Ouse and at Corporation Pier and SCM Jetty on the River Humber are described below.

3.8.1 Downstream Patterns

Figures 3.16a-c show the continuous data readings (at 60 minute intervals) for temperature, dissolved oxygen and salinity during the period between 5th and 24th March 1994 at three of the sites. Comparison of the three sites clearly shows the increase in tidal influence downstream. The Cawood site is freshwater[2] with no visible tidal influence on salinity, Blacktoft Jetty has very low salinity levels with a small amount of tidal influence around the time of the spring tide (12th March 1994), whereas Corporation Pier shows relatively high salinity and strong tidal influences throughout the tidal cycle.

3.8.2 The Ouse at Blacktoft Jetty

Figure 3.17 shows the continuous readings for the ten week period 3 June to 4 August 1994 at Blacktoft Jetty where dissolved oxygen levels are often critical. Dissolved oxygen levels are most likely to fall below the EQS (40 % saturation) when suspended sediment levels and/or temperatures are high. The effects of temperature can be seen throughout this period, particularly between 11th and 15th June and from 24th June onwards. During these periods, low dissolved oxygen levels coincided with increased temperatures and low salinity levels, implying that freshwater moving down the Estuary is at a higher temperature than seawater and is oxygen depleted.

3.8.3 The Humber at SCM Jetty

Figure 3.18 shows the continuous readings for a one week period between 23rd and 29th June 1994 at SCM Jetty. This site is further downstream than those discussed above and shows higher salinity and dissolved oxygen levels, less temperature fluctuation and stronger tidal influence. There is little freshwater influence here and the strong positive relationship between salinity and dissolved oxygen in the lower reaches of the Estuary are clearly illustrated, reflecting the intrusion of well-oxygenated seawater on the incoming tide.

[2] The salinity of sea water is about 35 ‰ and the salinity of freshwater is always less than 0.5 ‰. Therefore, estuarine water has a salinity of between 0.5 ‰ and 35 ‰.

Figure 3.16a Continuous Readings at Cawood 5 - 24 March 1994

Figure 3.16b Continuous Readings at Blacktoft Jetty 5 - 24 March 1994

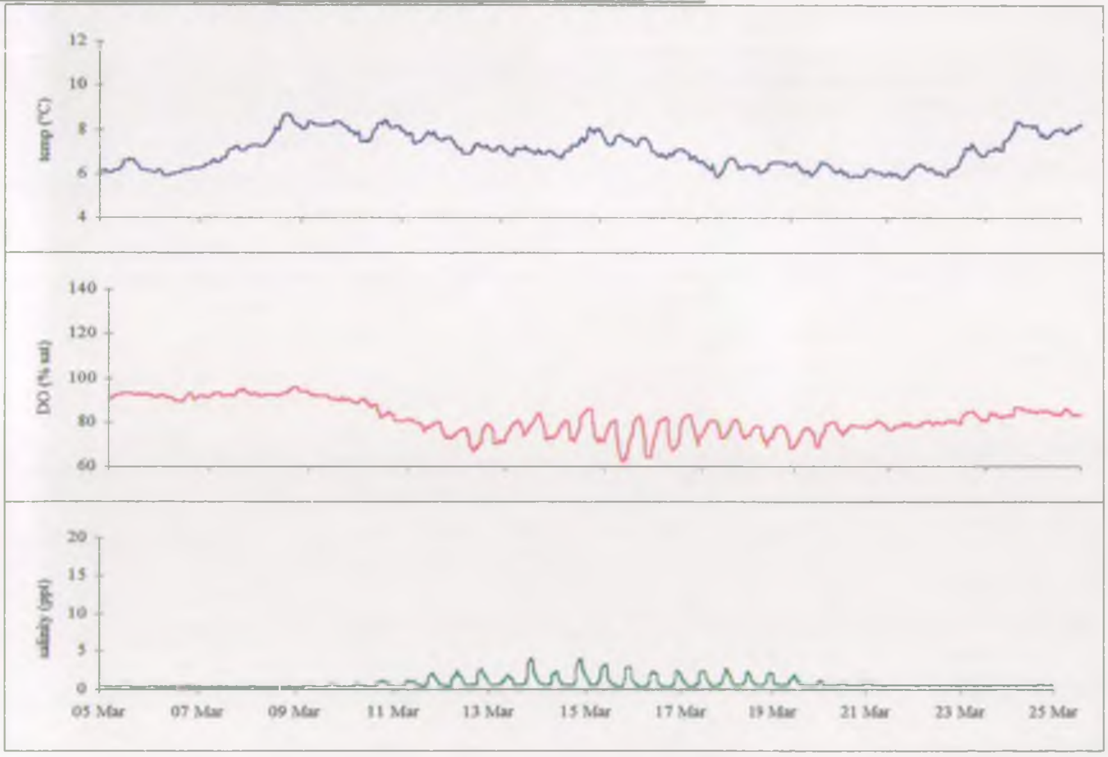


Figure 3.16c Continuous Readings at Corporation Pier 5 - 24 March 1994

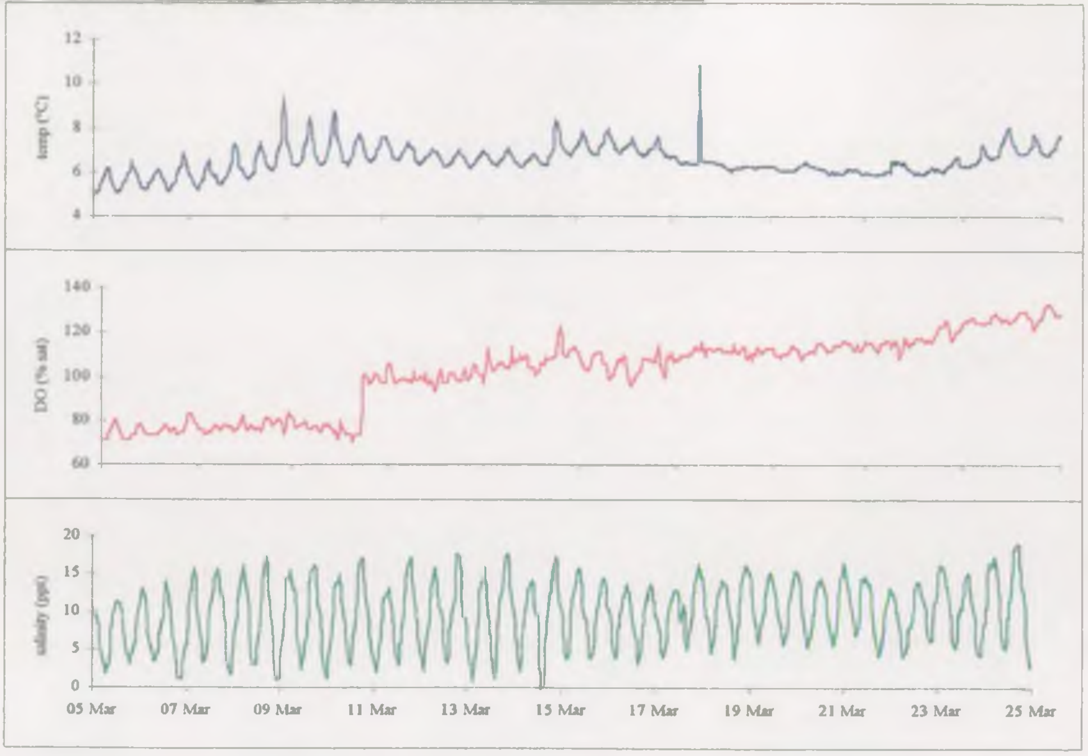


Figure 3.17 Continuous Readings at Blacktoft Jetty 3 June - 4 August 1994

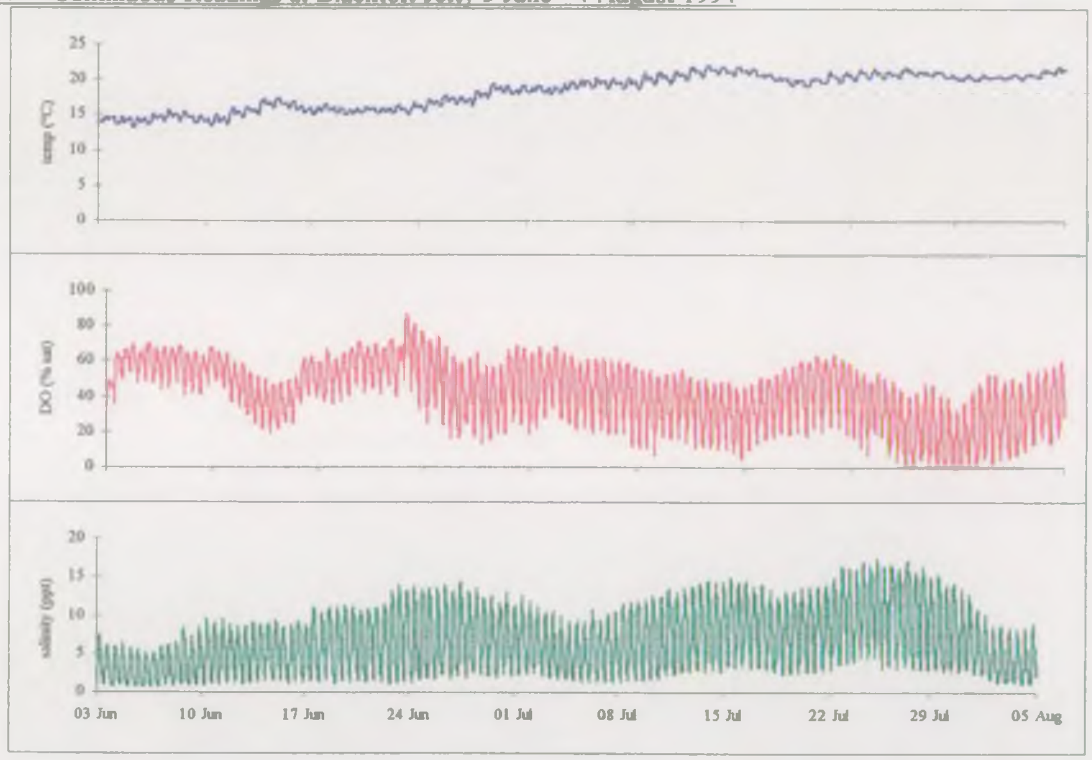
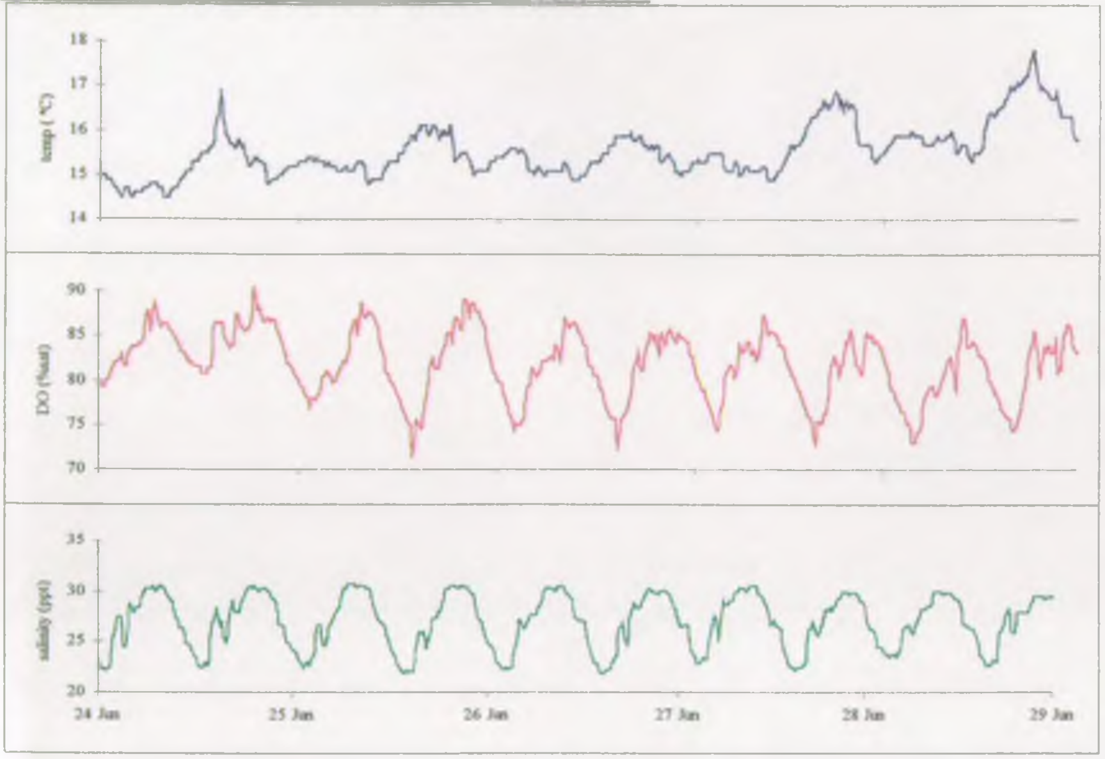


Figure 3.18 Continuous Readings at SCM Jetty 24 - 28 June 1994



SECTION 4
BIOLOGICAL QUALITY

4.1 INTRODUCTION

Monitoring the invertebrate animals and fish living in the tidal rivers and Humber is an important part of assessing the health of the Estuary. Many invertebrates live on or in the mud bottom and are exposed to contaminants in the sediment and/or water column. The variety and abundance of these populations give an indication of the health of the estuarine system. Tidal rivers and estuaries are very harsh environments presenting organisms with soft, shifting sediments, variations in salinity and daily desiccation in the intertidal zones. Human influences such as pollution and reclamation schemes can exacerbate these effects. Analysis of the biological survey data attempts to separate the effects of natural and anthropogenic stresses and to assess the health and productivity of the Estuary.

Faunal abundance is more prone to biological fluctuation than species variety since certain species undergo wide natural population changes. It is also less responsive to pollution effects, although toxic pollution can depress abundance and organic enrichment can cause tolerant species to flourish.

4.2 DATA ANALYSIS

The interpretation of biological data has always been problematic because of the inherent variability of populations and the mobility of certain species such as fish and shrimps.

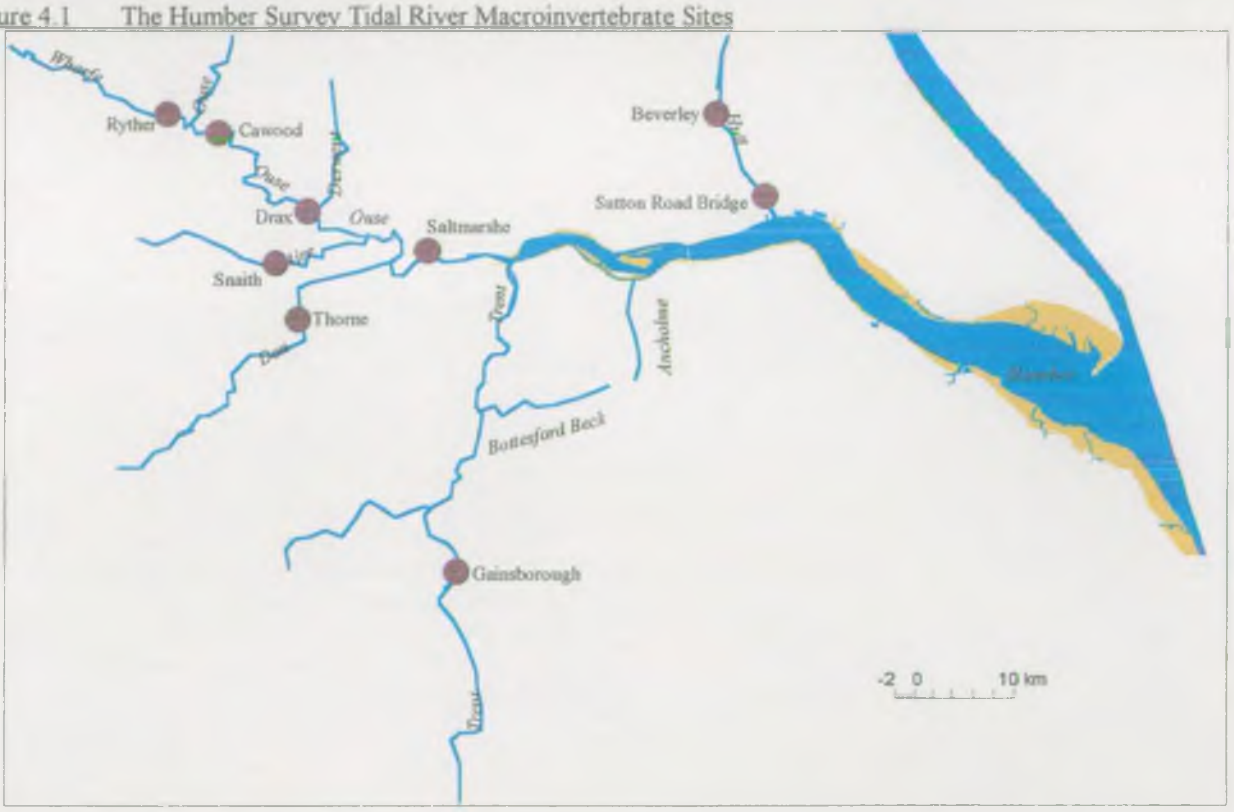
The analysis used here consists mainly of comparing the species variety and abundance to the five-year mean. The presence or absence of particular species and the changes in a population can indicate improvements or deterioration in water quality.

4.3 TIDAL RIVERS INVERTEBRATE BIOLOGY

4.3.1 Introduction

For the first time in 1994, two surveys of the tidal rivers were undertaken: previously, the survey was carried out only once per year. All eight sites on the Rivers Aire, Don, Hull, Ouse and Wharfe were sampled between March and November 1994 (Figure 4.1), including the Ouse at Drax which had not been sampled in 1993 for safety reasons. The Trent site at Gainsborough was not sampled in 1994 for safety reasons.

Figure 4.1 The Humber Survey Tidal River Macroinvertebrate Sites



4.3.2 Methods

Standard Environment Agency sampling methods were used appropriate to each site (sweep, airlift or kick sample). Where possible, organisms were identified to species level, abundances noted and standard biological indices (BMWP & ASPT - see Appendix 4) calculated[3].

4.3.3 Results and Discussion

The results of the 1994 surveys are listed in Appendix 5: summary statistics are shown in Table 4.1 below. As in previous years, the dominant fauna in all the rivers was a variety of worm species and the brackish-water shrimp, *Gammarus zaddachi*.

Table 4.1 Summary Statistics of Tidal Rivers Fauna

Site	89	90	91	92	93	94	94
Aire at Snaith							
BMWP Taxa		3	7	3	3	3	2
BMWP Score		10	24	6	10	7	3
ASPT		3.30	3.43	2.00	3.30	2.33	1.50
Don at Thorne Bridge							
BMWP Taxa		3	4	4	4		4
BMWP Score		10	17	13	13		13
ASPT		3.30	4.25	3.25	3.25		3.25
Wharfe at Ryther							
BMWP Taxa		13	12	12	14	10	18
BMWP Score		63	51	52	61	45	83
ASPT		5.20	4.25	4.33	4.36	4.50	4.61
Hull at Beverley							
BMWP Taxa	12	8	14	6	11	14	9
BMWP Score	43	26	51	18	41	55	31
ASPT	3.58	3.30	3.64	3.00	3.73	3.93	3.44
Hull at Sutton Rd Bridge							
BMWP Taxa	5	3	5	3	4		5
BMWP Score	15	9	18	9	12		15
ASPT	3.00	3.00	3.60	3.00	3.00		3.00
Ouse at Cawood							
BMWP Taxa	3	1	3	4	4		3
BMWP Score	12	1	12	14	12		13
ASPT	4.00	1.00	4.00	3.50	3.00		4.33
Ouse at Drax							
BMWP Taxa			2	1		2	2
BMWP Score			7	1		8	7
ASPT			3.50	1.00		4.00	3.50
Ouse at Saltmarsh							
BMWP Taxa	2	2	4	2	1		3
BMWP Score	7	7	15	7	6		14
ASPT	3.50	3.50	3.75	3.50	6.00		4.66

Ryther is the most upstream site of the survey and, as expected, exhibited the greatest diversity and was dominated by freshwater species. The Hull at Sutton Road Bridge is the most saline site and exhibited the most brackish fauna, composed almost exclusively of the oligochaete worm *Tubifex costatus*. In 1993, the first specimen of *Asellus aquaticus* since 1988 was observed in the sample from the Ouse at Cawood: none were observed in 1994. The Aire at Snaith is the most 'stressed' site and would be expected to yield a large proportion of oligochaete worms. However, in 1994, fewer worms than expected were recorded which may be the result of a change in sampling method from airlift (up to 1993) to sweep sample (in 1994).

The biotic indices and species composition of the tidal rivers remained broadly similar to previous surveys between 1989 and 1993, although some short-term perturbations were noted. The 1994 results from the Wharfe and the Hull at Beverley showed an increase in diversity which has been ongoing since 1992. The Ouse at Saltmarsh returned a slightly higher BMWP Score than in 1993. However, as in the previous two years, this site was not suitable for classification since two of the three scoring families were each represented by only one individual.

The potential causes of the generally poor species diversity in the tidal rivers have been identified in previous reports, and include habitat paucity, tidal scour, salinity fluctuations and pollution from industrial and sewage outfalls. It is often difficult to distinguish the effects of natural events from pollution-induced changes in such stressed environments but the sites exhibiting particularly low diversity coincided with elevated BODs and low dissolved oxygen. This indicates a potential adverse effect from sewage or other organic inputs. On the other hand, the high diversity of the Wharfe seems to be unaffected by the elevated ammonia levels reported in this stretch. The lack of temporal variation in diversity here is probably an indication of the stability of the faunal community.

4.3.4 Conclusions

Biological assessment undertaken as part of the 1994 survey indicated poor quality in tidal rivers, except at the least saline site, Ryther on the Wharfe. Since all sites are subject to natural salinity variations, overall biotic paucity may be due to cumulative effects of upstream input and a naturally stressed environment. While there are some minor indications of biological gain, these do not suggest any significant improvement in water quality.

[3] Although the BMWP Score was designed for use in freshwater, there is currently no similar system for application in estuarine waters. Its use in brackish waters results in very low scores compared to freshwater systems.

Figure 4.2 The Humber Survey Intertidal Macroinvertebrate Sites

4.4 INTERTIDAL INVERTEBRATE BIOLOGY

4.4.1 Introduction

Surveys of the North and South Bank intertidal fauna were carried out in August 1994 at 22 sites (Figure 4.2). The results of these surveys are provided in Appendix 6 for the North Bank and Appendix 7 for the South Bank and are discussed below.

4.4.2 Methods

The standard NRA method for this type of sampling is to take five replicate 10cm diameter cores from each shore level at each site. Following the recommendations of a national working party which recognised that this sampling regime, although adequate for estuarine mud-flats, resulted in undersampling of sandy sediments, enhanced sampling was introduced at sandy sites on the South Bank. Ten replicate cores were therefore taken at each of the sandy sites while five cores continued to be taken at the muddy sites and, although it disrupts the continuity of the data for the (few) sandy stations in the Outer Estuary, this will provide a more realistic assessment of species variety for future interpretation. The samples were washed through a 0.5mm sieve and preserved in formalin for later analysis. Sediment analyses included particle size analysis, organic carbon content and loss on ignition at 400°C and 480°C.

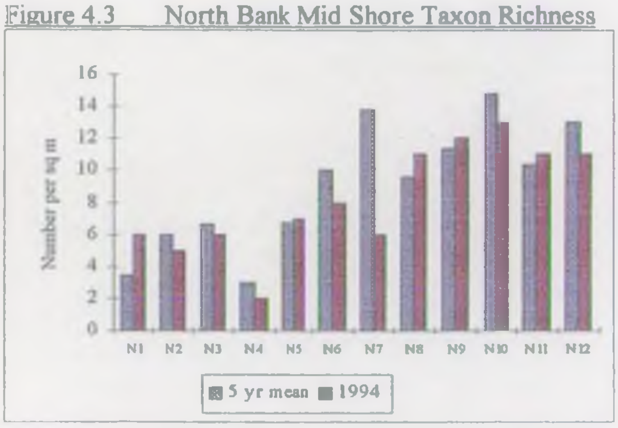
4.4.3 North Bank

4.4.3.1 MID SHORE FAUNAL PATTERNS

4.4.3.1 (a) Taxon Richness[4]

In 1994, the taxon richness was lower than the five-year mean at seven sites and slightly higher at sites N1, N5, N8, N9 and N11 (Figure 4.3). The reduction was not seen at other shore levels and so was unlikely to be caused by deteriorating water quality.

Figure 4.3 North Bank Mid Shore Taxon Richness



The number of taxa reported at site N7 was significantly lower than the five-year mean. This site also showed a decrease since 1993 from eleven to six taxa with the loss of *Paranais*, *Manayunkia*, *Nephtys*, *Streblospio*, and *Retusa*, and with the remaining species reduced in abundance. There are no records of specific pollution incidents which could account for the loss of these species, therefore the change in community structure suggests a general reduction in water quality.

4.4.3.1 (b) Abundance[5]

The total abundance in 1994 was greater than the five-year mean at seven sites but lower at sites N3, N5, N7, N10 and N12 (Figure 4.4).

[4] The number of different species recorded is referred to as 'taxon richness', 'species richness' or 'species variety'.

[5] The total number of individuals of all species is referred to as 'abundance', 'faunal abundance' or 'total abundance'.

Figure 4.4 North Bank Mid Shore Abundance

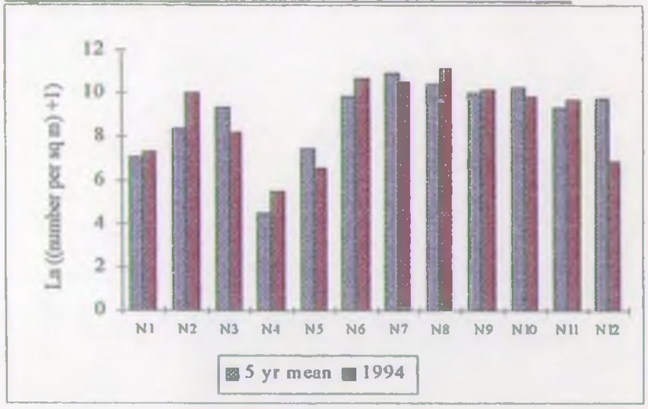
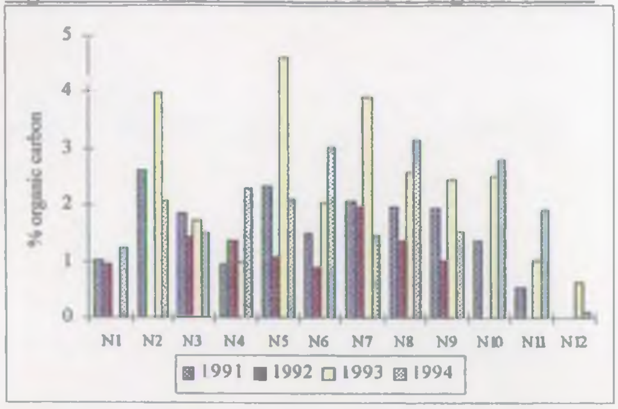


Figure 4.5 North Bank Mid Shore Organic Carbon



The increased total abundance at site N2 was caused by a natural population surge in *Paranais litoralis*. Since this was not evident at other sites, it was probably not related to a recruitment event.

At site N6, a threefold increase in *Corophium* numbers (since 1993) accounted for the increase in total abundance. This increase coupled with the decrease in taxon richness is usually associated with organic contamination but there was no direct evidence of increased organic input at this site.

Site N8 showed a large increase in most species although *Tubificoides benedii*[6] alone increased fourfold from 12 000 per sq m in 1993 to 50 000 per sq m in 1994. This, coupled with the highest level of organic carbon in the Estuary (3.2%) and the presence of the organic pollution indicator species *Capitella capitata*, suggests a decline in water quality at this site[7].

Site N10 showed a decrease in both total abundance and taxon richness. The numbers of *T. benedii*, however, have continued to increase, becoming co-dominant with *Nereis diversicolor*. Both species are pollution-tolerant and the site has shown a slight increase in organic carbon (Figure 4.5) over the last four years, from 1.4% to 2.8%. Recent residential development has lead to increased loading of untreated sewage which may account for the changes.

The decrease in total abundance at site N12 was due to a 99.6% decline *Hydrobia* numbers from 34 000 per sq m in 1993 to 150 per sq m in 1994. Since this was still one of the dominant species, the fluctuations are probably natural rather than a reflection of water quality changes.

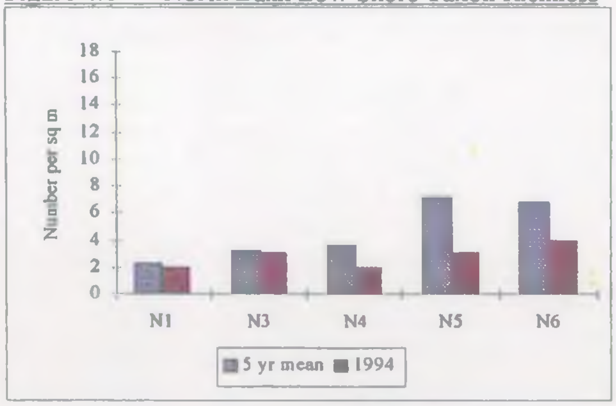
4.4.3.2 LOW SHORE FAUNAL PATTERNS

Only sites N1, N3, N4, N5 and N6 are sampled at the low shore level.

4.4.3.2 (a) Taxon Richness

At sites N4, N5 and N6, the number of taxa was lower than the five-year mean: sites N1 and N3 remained more or less stable (Figure 4.6).

Figure 4.6 North Bank Low Shore Taxon Richness



At sites N4 and N5, the reduction in taxon richness (and in faunal abundance) was probably due to the unstable sediment regimes at both sites. This has been evident at site N4 in previous surveys but has not been recorded before at site N5, although the site notes indicate a 40cm loss in sediment depth since 1993.

Taxa 'lost' from site N6 included *Macoma balthica*, *Hydrobia ulvae*, *Pygospio elegans* and *Nephtys spp.*. These are not pollution-tolerant, and their absence may indicate a decline in water quality. A decrease in species variety is indicative of a stressed community and is commonly associated with an increase in faunal

[6] *Tubificoides benedeni* has been renamed *T. benedii*.

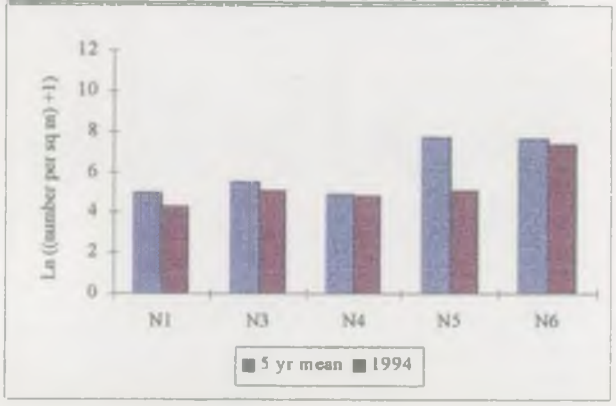
[7] Site N8 is sampled only at mid shore so there are no comparable data from other shore levels.

abundance in organically enriched situations. This pattern was evident at mid shore level although there is no record of any pollution incident which could account for the change. Site notes do, however, indicate the presence of sewage contamination near the sampling site, where organic carbon levels are 1% higher than before.

4.4.3.2 (b) Abundance

The changes in taxon richness were mirrored by lower reported faunal abundance (albeit minor) at all sites compared to the five-year mean (Figure 4.7).

Figure 4.7 North Bank Low Shore Abundance



4.4.3.3 CONCLUSIONS

The overall pattern of intertidal invertebrate macrofauna remained similar to previous years but with a more physically and chemically stressed Upper to Middle and a good quality Outer Estuary fauna. A total of 37 species was recorded in 1994 compared to 47 in 1993, partly a result of reduction in the number of terrestrial and freshwater species. No new taxa were added to the species list. The changes in community structure at sites N6 and N7 may indicate a decline in water quality although no specific pollution events were recorded. Faunal population changes at site N10 may be related to an increase in residential development in the area with a corresponding rise in untreated sewage output.

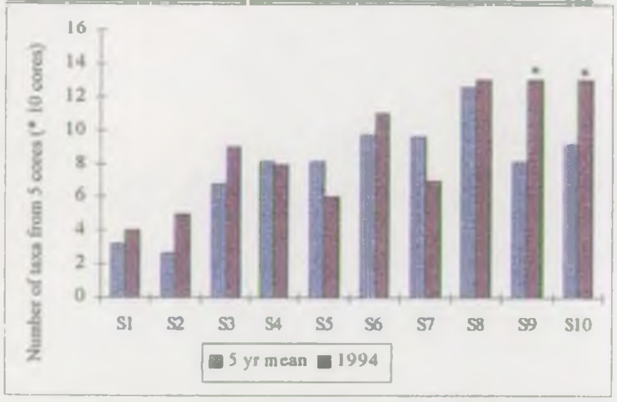
4.4.4 South Bank

4.4.4.1 MID SHORE FAUNAL PATTERNS

4.4.4.1 (a) Taxon Richness

Overall, taxon richness in 1994 was similar to, or higher than, the five-year mean at most sites. Sites S4, S5 and S7 reported lower numbers (Figure 4.8). Only two of these (S5 and S7) showed any appreciable decrease and this was due to natural fluctuation and/or the stability of the sediments.

Figure 4.8 South Bank Mid Shore Taxon Richness



The increases in taxon richness at sites S1 to S3 are not likely to reflect any improvement in water quality. Site S1 was well within the expected range of natural fluctuation and the changes at sites S2 and S3 were probably caused by physical conditions. Site S2 is steeply shelving and physically unstable, whereas the taxon richness at site S3 continued the improvement first noted in 1993 and was ascribed to a combination of possible salinity influences and greater sediment stability (Pethick 1988).

Similarly, the reductions in taxa recorded at sites S5 and S7 were within the range of natural fluctuation and possibly influenced by physical factors. The number of taxa recorded was similar to those of 1990 and 1991 at site S5 and of 1992 at site S7. This supports the suggestion last year that the enhanced species variety was transitory and reflected the recruitment of only a few individuals of 'new' species.

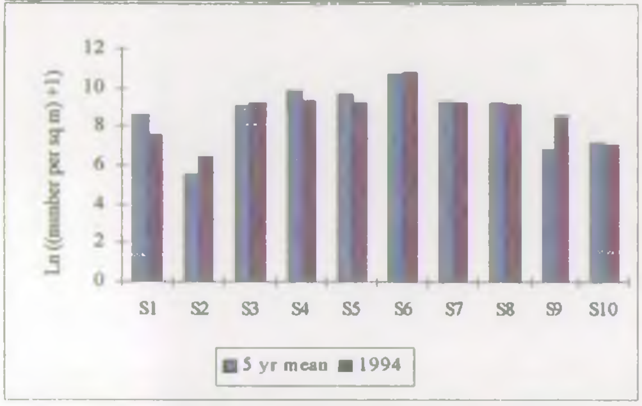
Changes in the fauna at site S7 were, however, more complex, with some of the previously scarce 'new' taxa (e.g. *Pygospio* and *Tharyx*) having apparently consolidated their presence. This site seems prone to fluctuations not directly comparable to other sites. Previous reports have ascribed this variability to sediment instability following construction of a new flood defence revetment on the upper half of the shore. This is supported by visual observations and similar inferences made from the low shore data (see 4.4.4.2 (a)).

At sites S9 and S10, the apparent increases in taxon richness were a result of the enhanced sampling introduced in 1994 rather than real increases in species variety.

4.4.4.1 (b) Abundance

For most sites the 1994 faunal abundance was very similar to the five-year mean and well within the expected range. The exceptions were site S9, which exhibited levels well above the five-year maximum, and sites S1 and S4, which were discernibly below the mean value (Figure 4.9).

Figure 4.9 South Bank Mid Shore Abundance



Although site S9 was subject to enhanced sampling in 1994, the increased abundance was a result of a population surge in *Pygospio*[8]. This spionid characteristically undergoes sizeable fluctuations in density, therefore the increase was unlikely to be associated with any water quality problems.

The low abundance at site S4 compared to the five-year average was attributed to a halving of the local *Corophium* population. Changes by a factor of two are not exceptional for *Corophium* and, since it still occurred in numbers of almost 10 000 per sq m, cannot be regarded as evidence of deteriorating water quality.

The low abundance at site S1 compared to the five-year mean reflected a continuation of the decline in oligochaete worms of the family Tubificidae first reported in 1993. Since the previously substantial populations of these potentially pollution-tolerant worms could not be clearly linked to enrichment, the recent decline cannot be confidently ascribed to a reduction in such pollution. However, the changes at this site are likely to indicate environmental improvement rather than deterioration.

The abundance figures for 1994 were similar to those anticipated from the five-year mean and their pattern along the Estuary was as expected.

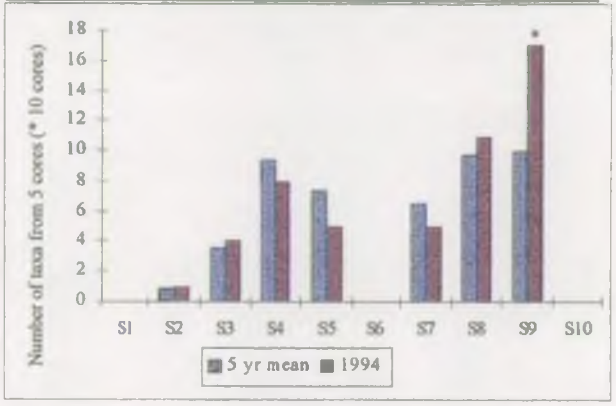
4.4.4.2 LOW SHORE FAUNAL PATTERNS

Sites S1, S6 and S10 are not sampled at low shore.

4.4.4.2 (a) Taxon Richness

In 1994, four sites showed taxon richness higher than the five-year mean and three sites were lower (Figure 4.10).

Figure 4.10 South Bank Low Shore Taxon Richness



At site S9, the apparent increase in species variety was, like the mid shore, a result of enhanced sampling. The number of taxa at site S8 showed an increase on the values of the early nineties rather than of the preceding two years, but did show sustained ecological improvement following abatement of the sewage discharge from Riby Street outfall (Grimsby) in 1986.

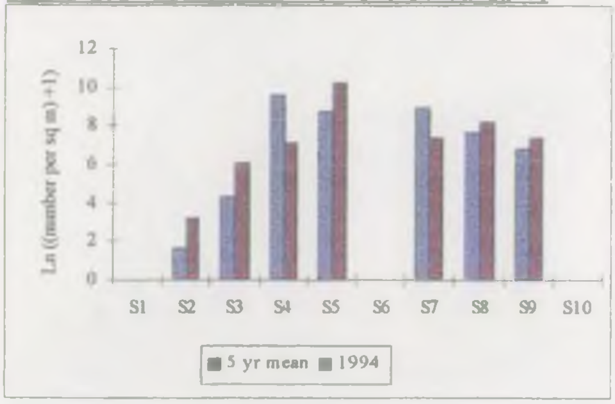
Much of the decline in species variety at sites S4 to S7 was due to the disappearance of taxa previously present in only relatively low numbers. At site S4, the exceptions were *Polydora*, which undergoes appreciable natural population fluctuations, and *Corophium*, which had poor recruitment in 1994. At site S7, the decline in species variety was accompanied by a considerable reduction in total abundance (Figure 4.9), and the number of taxa was exceptionally low compared to recent years. The most notable species losses included *T. benedii* which is generally considered to be pollution-tolerant. Similar observations were reported for the mid shore (4.4.4.1 (a)) where it was suggested that the ecological changes were due to sediment instability resulting from flood defence works. The changes at each of these sites are unlikely to represent any deterioration in water quality.

[8] Site 10 was also subject to enhanced sampling in 1994 but shows no concommitant increase in faunal abundance

4.4.4.2 (b) Abundance

In 1994, five sites showed total abundance higher than the five-year mean and two sites were lower (Figure 4.11).

Figure 4.11 South Bank Low Shore Abundance



The apparent increases in faunal abundance at sites S5 and S8 were, in reality, artefacts of the five-year mean, with numbers actually lower than those of 1993 (and, less so, 1992). The trends at site S5 were dominated by the local *Corophium* population which, as previously observed, can be somewhat erratic. Overall the changes were so small as to be insignificant.

At site S9, the increase to the five-year maximum was accounted for mainly by the polychaete family Spionidae, which can undergo considerable natural population fluctuations.

None of the apparent increases in abundance at the three sites in 1994 (of which only one related to an increase in comparison to 1993) can be considered to indicate any changes in environmental quality and were almost certainly consequences of natural population variability.

The decrease in abundance at site S4 reflected the collapse of the local population of *Corophium*, also observed at mid shore (see 4.4.4.1 (b)). This phenomenon was widespread with a decline of *Corophium* at all sites which previously supported sizeable populations, and was probably related to poor recruitment in 1994 although there was also evidence of scouring at site S4 which would further constrain the recruitment success of the local population. The absence of *Corophium* was not unprecedented and the observed changes were linked to natural phenomena rather than deterioration in water quality.

The recent substantial, and apparently progressive, decline at site S7 was accounted for almost entirely by a substantial reduction in the *Tubificoides swirencoides* population. Although tubificids in general are regarded as reasonably pollution-tolerant, the decline in *T. swirencoides* was unlikely to be a response to any water quality improvement. The most probable cause was physical factors relating to recent flood defence construction work. This is supported by field records which show a recent deepening and decreased viscosity of the soft mud, creating a less favourable habitat for burrowing worms[9].

4.4.4.3 CONCLUSIONS

At most sites, species variety was comparable with or greater than the five-year mean, with a total of 42 taxa recorded in 1994 compared to 42 in 1993 and 40 in 1992. For the outermost sandy sites, enhanced species variety was a function of enhanced sampling. Where species variety fell lower than the five-year mean, the losses consisted mainly of transient species or, at site S7, were due to physical disturbance of the sediment. These results do not suggest either improvement or deterioration in water quality except at site S8, where improvement has continued since the abatement of the discharge from a nearby sewage outfall.

The total number of specimens in 1994 was 5600 (compared to 9500 in 1993 and 12000 in 1992). The two-year decline is attributed to reduced populations of *Hydrobia* in 1993 and of *Corophium* and *T. benedii* in 1994. Fluctuations in *Hydrobia* and *Corophium* populations are not unprecedented and *T. benedii* reductions are associated with environmental improvement. Only at site S7 was the reduced abundance associated with non-biological factors.

4.5 SUBTIDAL INVERTEBRATE BIOLOGY

4.5.1 Methods

Standard Agency methods were followed in the collection, processing and analysis of biological samples. Particle size analysis and determination of organic carbon content of the sediments were carried out by the Institute of Estuarine and Coastal Studies at the University of Hull, and the Public Health Laboratory in Lincoln.

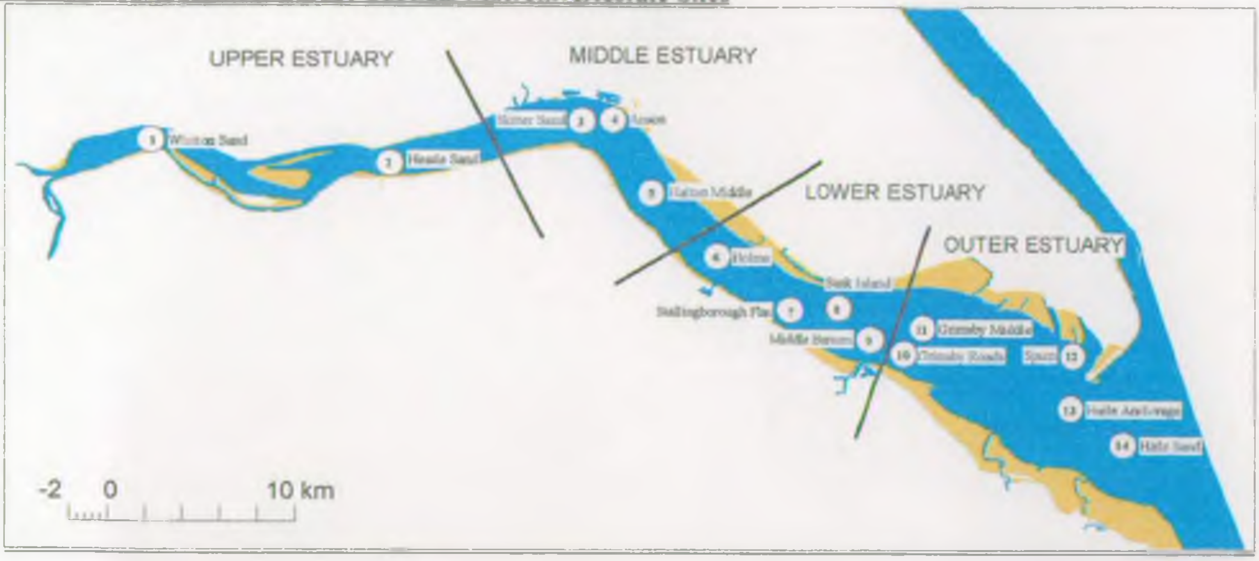
4.5.2 Results

For convenience of discussion, the fourteen subtidal sites (Figure 4.12) are divided into four Estuary sections:

- Upper Estuary (sites 1 - 2)
- Middle Estuary (sites 3 - 5)
- Lower Estuary (sites (6 - 9)
- Outer Estuary (sites 10 - 14)

[9] The situation at site 7 will be further complicated in future by the installation of cooling water pipes for a nearby power station. The trench in which the pipes will be laid passes precisely through the site and, apart from any consequences of site relocation, further sediment disturbance is inevitable.

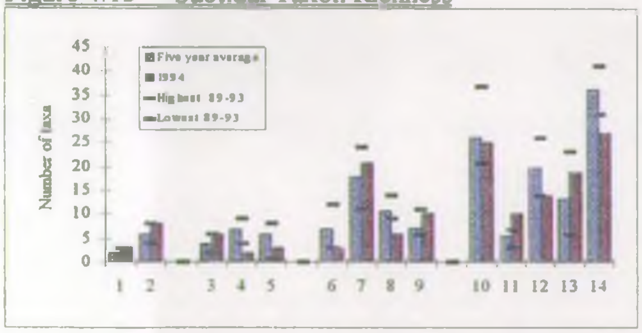
Figure 4.12 The Humber Survey Subtidal Macroinvertebrate Sites



4.5.2.1 UPPER ESTUARY

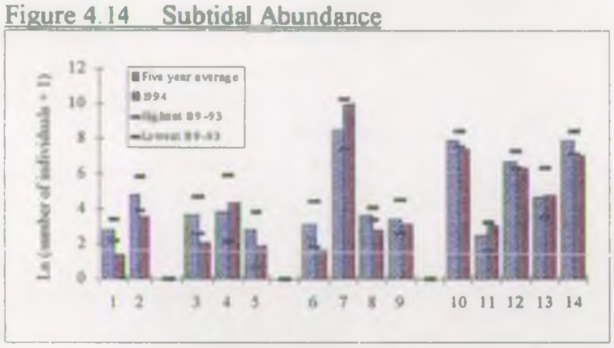
The species richness at the Upper Estuary sites in 1994 was comparable with the five-year average (Figure 4.13). At site 1 the recorded taxa included the rare *Melita pellucida*, while at site 2 *Marenzellaria viridis* was recorded for the first time since 1990.

Figure 4.13 Subtidal Taxon Richness



The total abundance at both sites was lower than recorded over the previous five years (Figure 4.14). Only one specimen of *Neomysis integer* was present in the site 1 grab samples despite this species being normally abundant in the area. This was probably due to changes in the bed sediment at the site which has become muddier during 1993 and 1994. *Neomysis* numbers were not excessively low in the Macer sledge samples taken at this site, which represent all sediment types encountered over a distance of 500 - 1000m (cancelling out any patchiness).

Figure 4.14 Subtidal Abundance



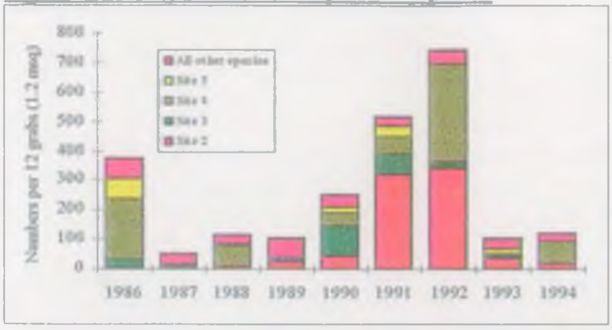
The low total abundance at site 2 was a result of much reduced densities of the polychaete worm *Capitella capitata*, which peaked in 1991 and 1992.

The 1994 results indicate some deterioration in environmental conditions in the Upper Estuary although these are probably related to changes in the sediment regime rather than water quality.

4.5.2.2 MIDDLE ESTUARY

Both species richness and total abundance were below the long-term average in the Middle Estuary, with two exceptions. At site 3 the number of taxa was high compared with the five preceding years, although the total abundance was the lowest for six years - only seven individuals belonging to six taxa were recorded. At site 4 the total abundance slightly exceeded the five-year mean as the density of *Capitella* remained relatively high compared to previous years, whereas its population generally declined in the Middle Estuary (Figure 4.15).

Figure 4.15 Densities of *Capitella capitata*



The Middle Estuary fauna was dominated by *Capitella* which is considered to be indicative of organic enrichment. The fluctuations in density are possibly a result of annual variations in salinity. *Capitella* is rarely found at salinities below 10 ‰ (Wolff 1973) and peak densities in the Middle Estuary (1991 - 1992) follow years of low freshwater flows into the Humber (HEC Water Quality Report 1993). The paucity of other taxa in the Middle Estuary and the continued dominance of *Capitella* indicated generally poor environmental conditions and an ongoing state of organic enrichment.

4.5.2.3 LOWER ESTUARY

At sites 6 and 8 both the taxon richness and total abundance (Figures 4.13 & 4.14) were lower than during the previous five years. This impoverishment has been evident since 1991 at site 6 and since 1989 at site 8, although the decline at the latter site was more marked between 1993 and 1994. A similar long-term trend has also been apparent at site 9, although there was an increase in the number of taxa in 1994. These changes are not fully understood but sediment disturbances are likely to be a major contributor.

Species richness and total abundance at sites 7 and 9 were comparable with the five-year mean.

Sites 6, 8 and 9 are situated in or near main estuarine channels and are subject to stronger tidal currents and more changeable sediment structure than site 5, where the faunal community has remained abundant and species rich.

The results indicate that environmental conditions in much of the Lower Estuary are deteriorating or remaining relatively poor in comparison with previous periods. The most likely reason is the changeable sediment structure of the sector, i.e. periodic scouring and accretion of the bed sediments. Faunal communities near the more sheltered South Bank have remained rich in comparison, reflecting a more stable sediment regime.

4.5.2.4 OUTER ESTUARY

The Outer Estuary showed the same general pattern as in recent years except at site 14, where both the number of taxa and total abundance were below the five-year minima (Figures 4.13 & 4.14). Only 27 taxa were recorded in 1994 compared to 41 in 1992 and 1993. Similarly, the number of individuals in 1994 was only one-third that of the preceding two years. This apparent deterioration is unexplained. Sediment structure was similar to previous years and there was no evidence of elevated contaminant levels in the sediments.

At site 13 the number of taxa and total abundance were low compared to the five-year mean while remaining comparable with the previous three years.

The 1994 results suggest generally unchanged conditions in the Outer Estuary, except in the outermost part where a possible deterioration in environmental conditions is indicated.

4.5.3 Conclusions

The 1994 results suggest a continued state of organic enrichment in the Middle and part of the Upper Estuary. There is evidence for continued poor environmental conditions near the main channels in the Lower Estuary, with the impoverished fauna more likely to be indicative of sediment disturbances related to tidal scouring than to poor water quality. The results indicate some deterioration in environmental conditions in the outermost part of the Estuary.

4.6 MICROBIOLOGICAL SEDIMENT ANALYSIS

Microbiological tests on intertidal sediment samples were carried out for the first time in 1994. The concentrations of faecal bacteria (*Escherichia coli*, faecal *Streptococcus* spp. and *Clostridium* spp.) were determined by the Royal Infirmary in Hull and the Public Health Laboratory in Lincoln. On the North Bank samples were taken from mid shore only, while samples were obtained from both mid and low shore levels for the South Bank. For this year, only mid shore samples are discussed but in 1995 samples from both shore levels on the North Bank will be analysed, allowing better comparison with the South Bank.

4.6.1 Intertidal

The results from both the North and South Banks showed marked fluctuations, especially towards the Outer Estuary (Figures 4.16 & 4.17). This is a reflection of the organisms present in the discharge at the previous high tide (i.e. when the sediment was last covered). The very low concentrations of all three bacteria recorded at site 6 on the South Bank (Figure 4.17) were probably the result of a sampling or analytical error.

Figure 4.16 North Bank Intertidal Microbiology

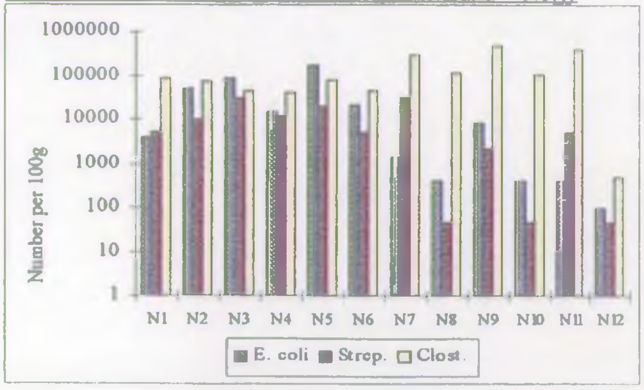
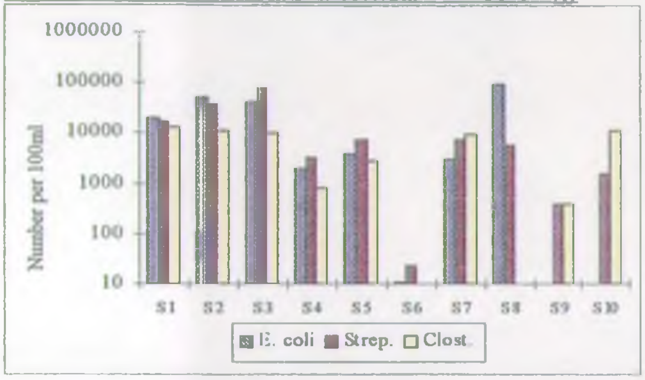


Figure 4.17 South Bank Intertidal Microbiology

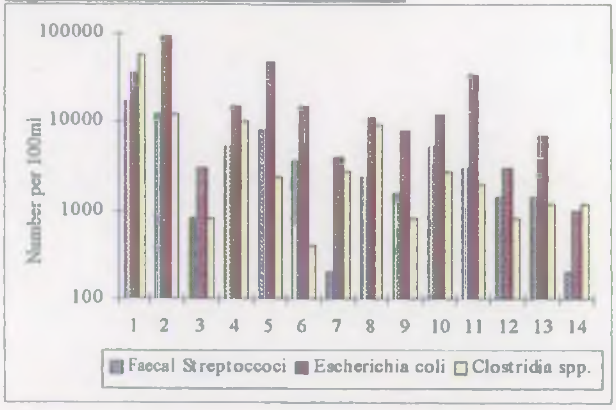


Clostridium perfringens is often used as a long-term indicator of sewage contamination because it produces endospores which have a much longer survival time than vegetative bacterial cells. The presence of this species in the Outer Estuary indicates that sewage is contaminating mud-flats further down the Estuary than would have been expected. The slight rise in *C. perfringens* numbers towards the Outer Estuary may be due to the multiplication of bacterial spores within the sediment, although, on the South Bank, it may be related (along with a similar increase in faecal Streptococci) to the sewage outfall at Cleethorpes.

4.6.2 Subtidal

Figure 4.18 shows the patterns of the three types of bacteria monitored in the subtidal sediments. There was a general decrease in the concentrations of *Streptococcus* spp. and *E. coli* seaward with three fairly consistent peaks. The Upper Estuary peak coincides with the confluence of the main tributaries of the Humber while the other two peaks correspond to the main sewage discharges from Hull and from Grimsby.

Figure 4.18 Subtidal Microbiology



The downstream pattern of *Clostridium* spp. reflects the ability of these organisms, as endospores, to survive longer in the sediments than *Streptococcus* and *E. coli*. The highest concentrations were recorded in the Hull sewage outfall area but also at site 8, which is distant from the major sewage inputs, and moderately high concentrations were recorded seaward to the outermost sites.

4.7 FISH DISTRIBUTION SURVEY

4.7.1 Introduction

A survey of the fish communities of the Humber was carried out in September 1994 in conjunction with MAFF.

4.7.2 Methods

Standard methods employed by MAFF were used throughout the survey. Fourteen sites, shown in Figure 4.19, were sampled by towing a two metre beam trawl rigged for catching young and small fish. Replicate samples were taken at six sites and additional push net samples were taken at Cleethorpes and Spurn.

4.7.3 Results

The survey results are shown in Tables A8.1 and A8.2 in Appendix 8 and illustrated in Figures 4.19 and 4.20. Results for sites where replicate samples were taken are presented as averages.

A total of seventeen species and up to 108 individuals per catch was recorded, which is comparable with previous surveys in both abundance and species richness.

4.7.3.1 OCCURRENCE OF JUVENILE FISH

Whiting was relatively scarce in 1994, occurring at only two sites. This probably reflects the annual spawning and recruitment patterns of the North Sea stock rather than poor conditions in the Estuary.

Dover sole occurred in numbers comparable with previous years and was recorded as far upstream as Skitter Sand, with highest densities recorded in the Middle and Lower Estuary.

Plaice was less common than previously and the catches at Haile Sand, where the largest numbers are usually recorded, were smaller than usual. This suggests poorer than usual recruitment from the North Sea stock.

Dab was caught in the Outer Estuary and the catches, although small, were comparable to recent years.

Flounder occurred at three sites, which is similar to previous surveys. It has been caught in moderate numbers throughout the Estuary at other times of the year, particularly during spring and summer months (Marshall and Elliott 1993; NRA fish sampling 1992-1995, unpublished records). The majority of the flounder caught are medium to large (10 - 35 cm) and are more likely to escape capture (because of the bow-wave effect of the trawl) than the juveniles for which the survey is intended. Therefore, it is likely to be undersampled in this survey.

4.7.3.2 PUSH NET RESULTS

The push net results are shown in Table A8.2 (Appendix 8). Catch size and species richness at Spurn were comparable with previous records (117 per 1000 m) and included a few turbot and brill as well as a moderately large catch of juvenile plaice.

The catch at Cleethorpes was relatively small compared to previous years both in terms of species richness and total number of fish.

4.7.4 Community Structure

The ability of the Estuary to support fish communities is indicated by the variety of fish species recorded in the surveys, their abundance and distribution. The results of the 1988 to 1994 surveys are summarised in Figure 4.20, showing the number of sites at which each species is found. Of the 25 species recorded, only whiting, sand goby and Dover sole were found at more than half the sampling sites. The remainder were either restricted to the marine conditions in the Lower and Outer Estuary (e.g. dab and sand eel) or were relatively sparse in the Estuary.

The community structure in 1994 compared favourably with previous years. Most of the recorded species were more widespread than in previous years, with the notable exceptions of whiting and plaice.

The species recorded were of a range of ecological types (see classification by Pomfret *et al* 1991). Of the seventeen species recorded in the 1994 survey, there were five estuarine residents (ER), four marine adventurous migrants (MA), three marine juveniles (MJ), two marine seasonal migrants (MS), one diadromous migrant (CA) one freshwater ER (FW/ER), and one ER/MA (Figure 4.20).

4.7.5 Conclusions

Abundance and species richness of the fish community in the Estuary in 1994 were generally comparable with or better than in recent years. Juvenile whiting and plaice were less common than in previous surveys but their apparent paucity is more likely to be a result of annual variations in the recruitment of the North Sea stock rather than the environmental quality of the Estuary.

Figure 4.19 Fish Distribution Survey (September 1994)

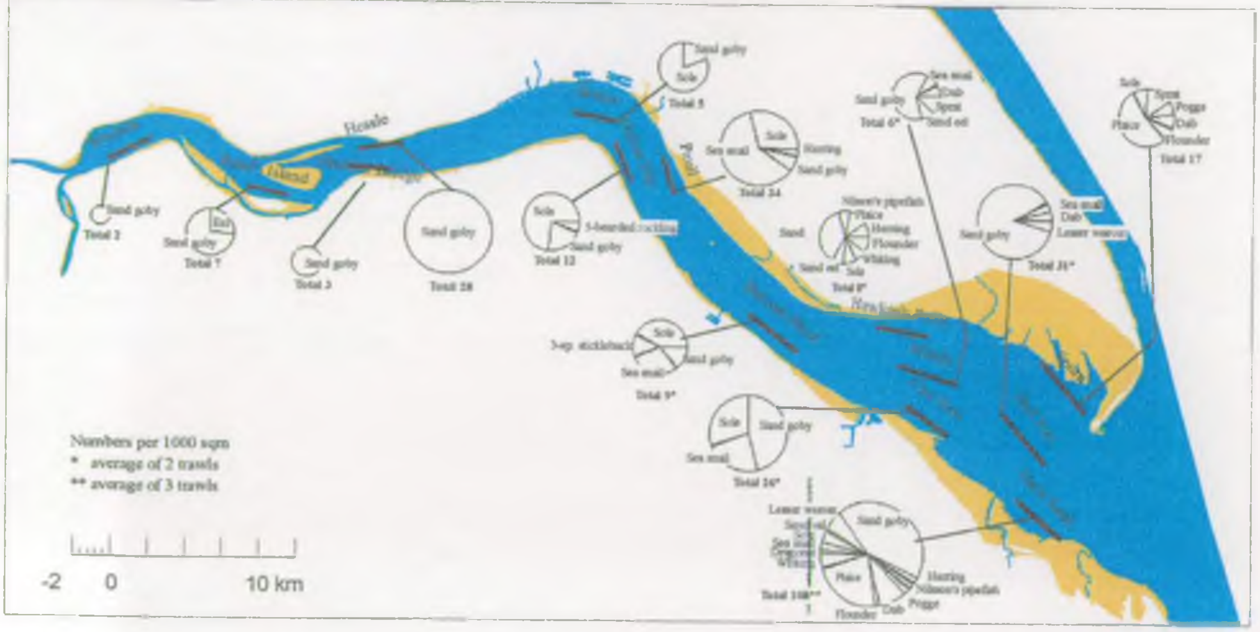
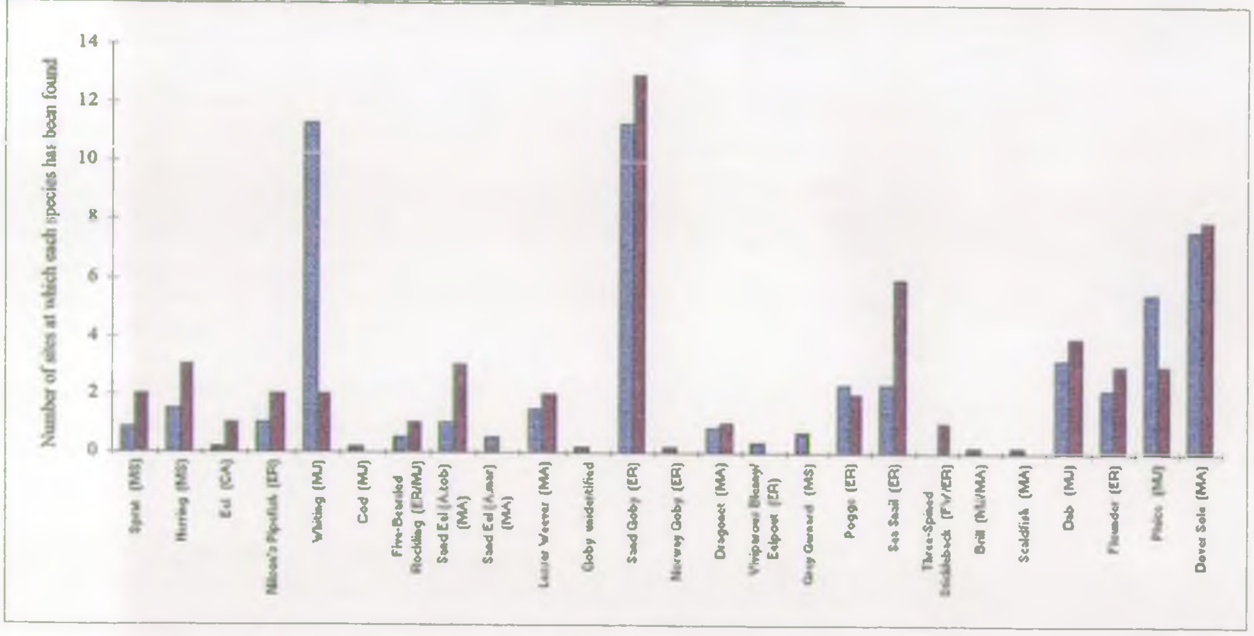


Figure 4.20 Occurrence of Fish Species in September Surveys of the Humber



SECTION 5
CLASSIFICATION OF TIDAL RIVERS AND ESTUARIES

5.1 ESTUARY

The Humber Estuary is classified in accordance with the CEWP Classification Scheme (Appendix 9). This scheme assesses the Estuary in terms of biological, aesthetic and water quality with points awarded for each of the criteria met. In broad terms the Humber Estuary is classified as Class B (fair quality) on the South Bank and west of the Humber Bridge, and as Class A (good quality) along the North Bank (Figure 5.1).

This grading is an average of conditions along the banks of the Estuary and localised areas on either bank may be above or below these grades. For instance, although the North Bank is categorised as Class A, there are localised areas with aesthetic problems, particularly close to the Hull East and West crude sewage outfalls.

The Environment Agency is currently funding investigations and research into a more objective method of classifying estuaries, which could be used in conjunction with the General Quality Assessment (GQA) classification for freshwaters (see section 5.2). Until this is completed and the scheme adopted, estuaries will continue to be classified according to the CEWP scheme.

5.2 FRESHWATER INPUTS

Freshwaters are classified according to the GQA scheme. The basic chemical grade for a river reach is calculated from the BOD, ammonia and dissolved oxygen levels over a three year period. These parameters were selected for use in the scheme because they are indicators of the influence of wastewater discharges and rural land-use runoff including organic, degradable material. It does not take into account contamination by substances included in the EC Dangerous Substances Directive.

Table 5.1 shows details of the GQA classification scheme. Figure 5.1 shows the GQA classification for 1994 and Figure 5.2 indicates the locations of the major industrial and sewage discharges to the Estuary.

Figure 5.1 CEWP Classification Results 1994

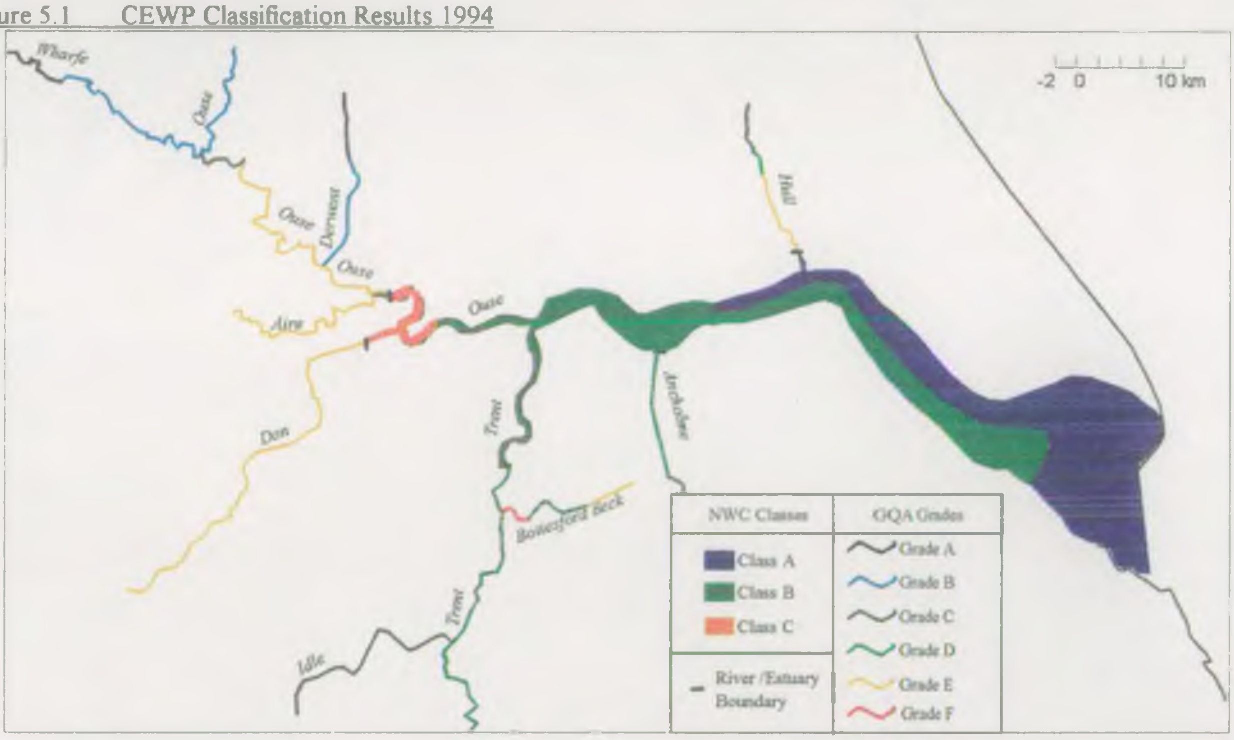


Table 5.1 GQA Chemical Grading for Freshwater Rivers and Canals

Water Quality	Grade	DO (% sat) (10 %ile)	BOD (mg/l) (90 %ile)	Ammonia (mg/l) (90 %ile)
Good	A	80	2.5	0.25
	B	70	4	0.6
Fair	C	60	6	1.3
	D	50	8	2.5
Poor	E	20	15	9
Bad	F	< 20	> 15	> 9
The overall grade assigned to a river or canal reach is determined by the worst grade for each of the three parameters.				

Figure 5.2 Industrial and Sewage Outfalls to the Humber

SECTION 6
MATHEMATICAL MODELLING OF THE HUMBER ESTUARY

6.1 INTRODUCTION

The QUESTS (Quality of Estuaries) suite of water quality models of the Humber system was implemented in 1993 and 1994. These models are now used to help with water quality management of the Humber system, including evaluating the impact of effluent discharges.

6.2 MODEL VERIFICATION

The model provides predictions of water movements and water quality based on information provided on effluent loadings, freshwater flow and tidal conditions. Figure 6.1 shows the locations of the main inputs taken into consideration. Further comparisons were made between observed data from continuous chemical monitors and model predictions, examples are shown in Figure 6.2.

In general, the agreement was quite good but the model had difficulty in closely representing the changing pattern of oxygen levels that occurs over a spring/neap cycle. It is thought that large amounts of bed sediment are re-suspended on a spring and neap tides causing further oxygen depletion. However, there is little data on suspended solids and oxygen uptake to substantiate this mechanism.

6.3 SEDIMENT OXYGEN DEMAND STUDY

Approval is being sought to upgrade some existing continuous monitor sites to measure suspended solids and to carry out measurements of the oxygen uptake of suspended sediments. This will allow the model to be calibrated to provide a better representation of this process.

6.4 AN EXAMINATION OF OXYGEN BALANCE IN THE HUMBER SYSTEM USING THE QUESTS 1D MODEL

6.4.1 Introduction

One of the principal water quality problems in the tidal waters of the Humber is the low dissolved oxygen levels that occur in the lower part of the tidal Ouse during the summer months. This zone of deoxygenation is considered to be very significant in preventing the passage of migratory fish, especially juveniles, and is responsible for the very low catches of salmon and sea trout.

The water quality benefits that would accrue from planned Urban Waste Water Treatment Schemes and possible industrial effluent improvements have been examined using the QUESTS 1D Model of the Humber.

Figure 6.1 Location of Inputs to the Humber used in Model Calibration

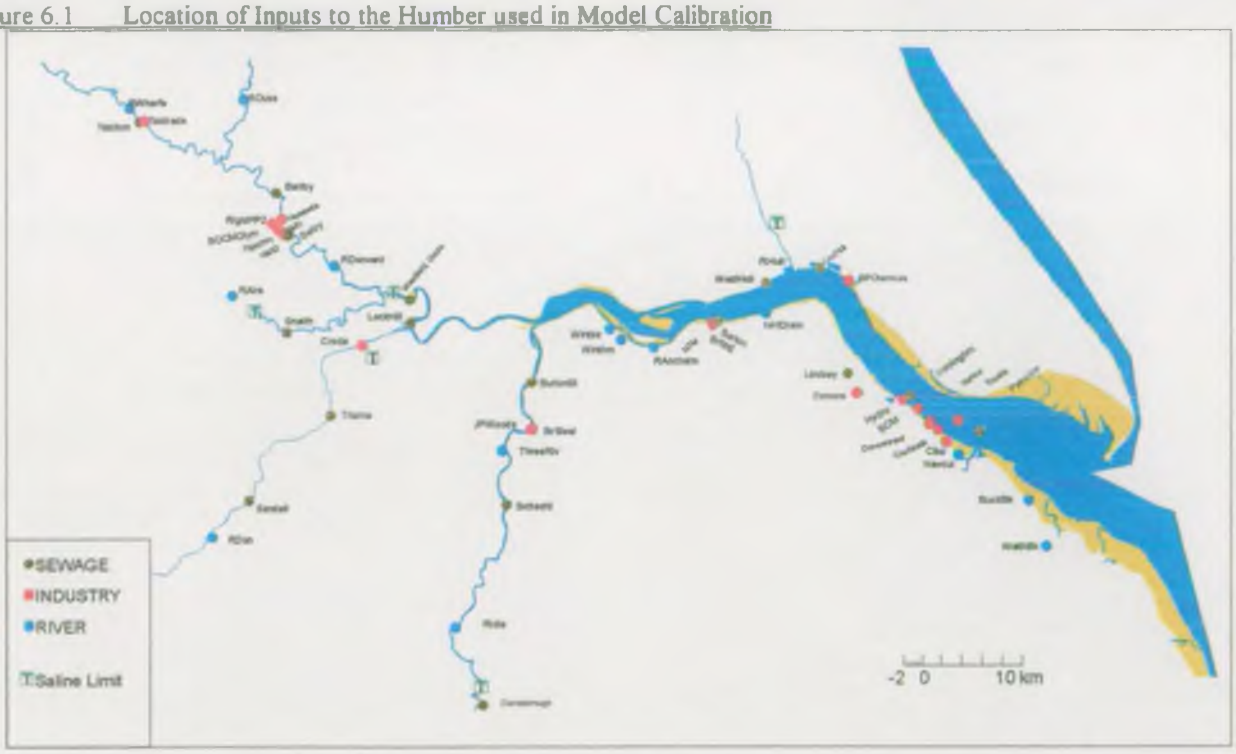
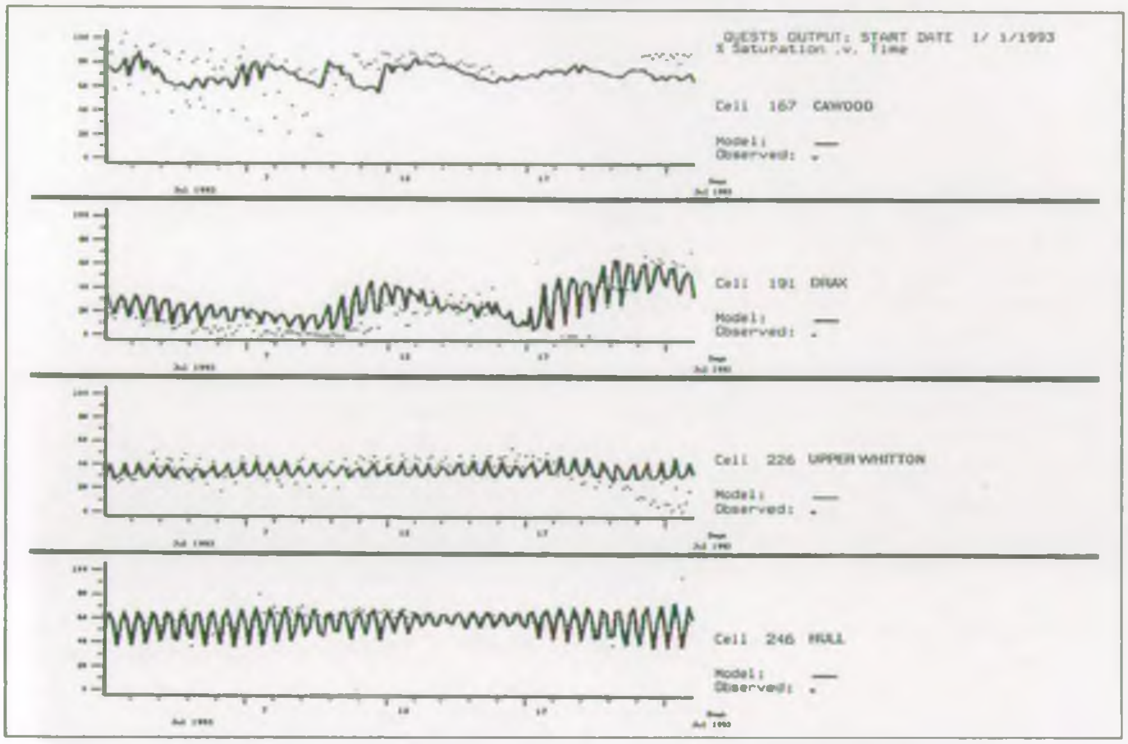


Figure 6.2 Examples of QUESTS Output Compared to Observed Values



The model has been configured to represent the whole of the Humber tidal system including the tidal Trent, Ouse, Wharfe, Don and Aire as well as the River Humber itself. It provides a one-dimensional representation of the system (i.e. complete mixing is assumed across the width and depth of each channel). The model is fully dynamic and can represent changes in water level, flow and quality at an hourly or finer resolution and is quite sophisticated in terms of the processes represented. These include oxidation of carbonaceous material, nitrification, re-aeration, and erosion/deposition of sediment.

6.4.2 Model Simulations

Work with the early Humber Models indicated that the two main factors responsible for deoxygenation were the relatively poor quality of the Aire and Don at their tidal limits and the effluent inputs to the tidal Ouse in the Selby area. Also indicated by earlier work was that Hull crude sewage effluents had only a very small effect on oxygen balance in the tidal Ouse.

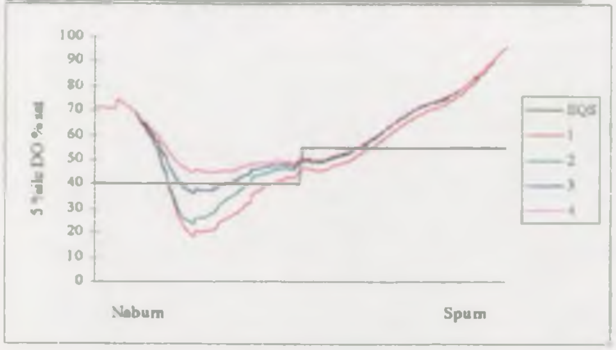
The current model is able to derive statistical summaries of water quality from relatively long model runs. It was found that a period of one calendar year was most practical in terms of model run time (10 hours) and generation of meaningful statistical summaries of water quality. Model simulations are based on 1992, which was chosen as a typical year (neither unusually dry nor wet).

A batch of four main simulations was run:

1. The existing situation. Based on the 1988-92 effluent loads and river quality, except that the quality at the tidal limits of the Aire and Don were improved to 1994 conditions to take into account the marked improvement that has taken place in recent years.
2. As (1) but with UWWTD/AMP2 sewage effluent treatment schemes implemented as follows:
   - All discretionary schemes in the Aire/Calder implemented,
   - Goole, Selby, Thorne and Barlby sewage provided with secondary treatment,
   - Hull, Grimsby and Cleethorpes provided with primary treatment.
3. As (2) but with 50% effluent load reduction from industrial discharges in the Selby area.
4. As (2) but with 90% effluent load reduction from industrial discharges in the Selby area.

A comparison between the oxygen levels in the Ouse-Humber generated by these simulations and the proposed Humber Estuary Committee oxygen standard is made in Figure 6.3.

Figure 6.3 Ouse-Humber DO vs HEC Standards Simulation



A comparison between dissolved oxygen, BOD and ammonia levels, and freshwater GQA standards is given in Figures 6.4a-c.

Figure 6.4a Ouse-Humber DO vs. GQA Simulation

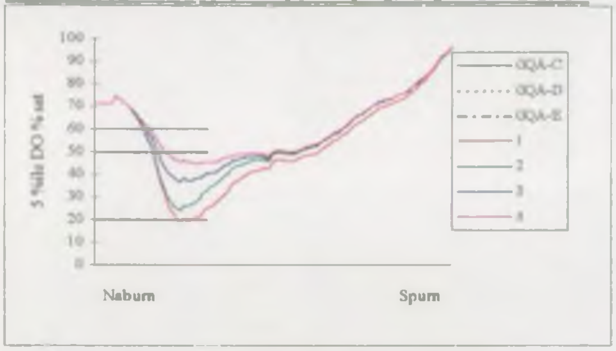


Figure 6.4b Ouse-Humber BOD vs GQA Simulation

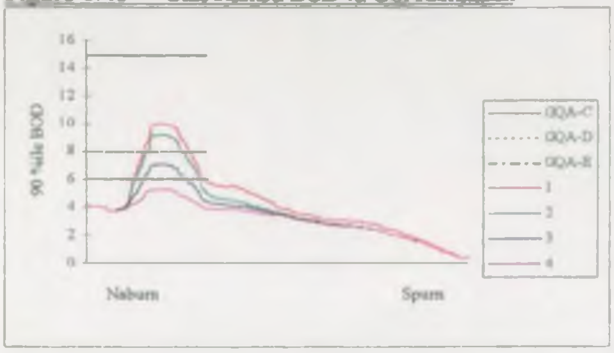
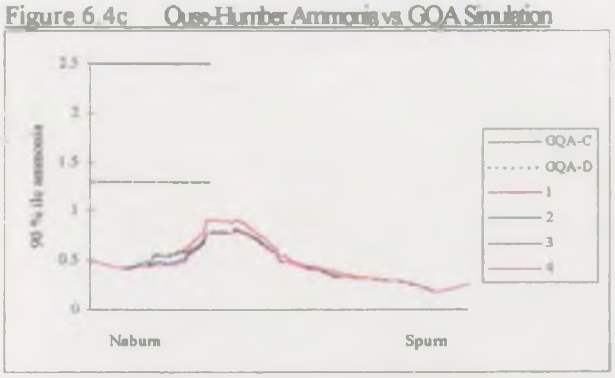


Figure 6.4c Ouse-Humber Ammonia vs GQA Simulation



This work confirms the principal findings of earlier modelling work that the main factors responsible for the deoxygenation in the tidal Ouse are the significant loads of effluent from discharges in the Selby area and the poor quality of the Aire and Don at their tidal limits.

In addition, there is a significant sediment oxygen demand in the lower Ouse and around Trent Falls associated with resuspension of bed sediment. It is suggested that this effect will be reduced somewhat by reductions in polluting loads but will always be significant in this type of estuary.

Significant improvements in the quality of the Aire and Don have been achieved in recent years and there have also been significant reductions in effluent loads to tidal waters.

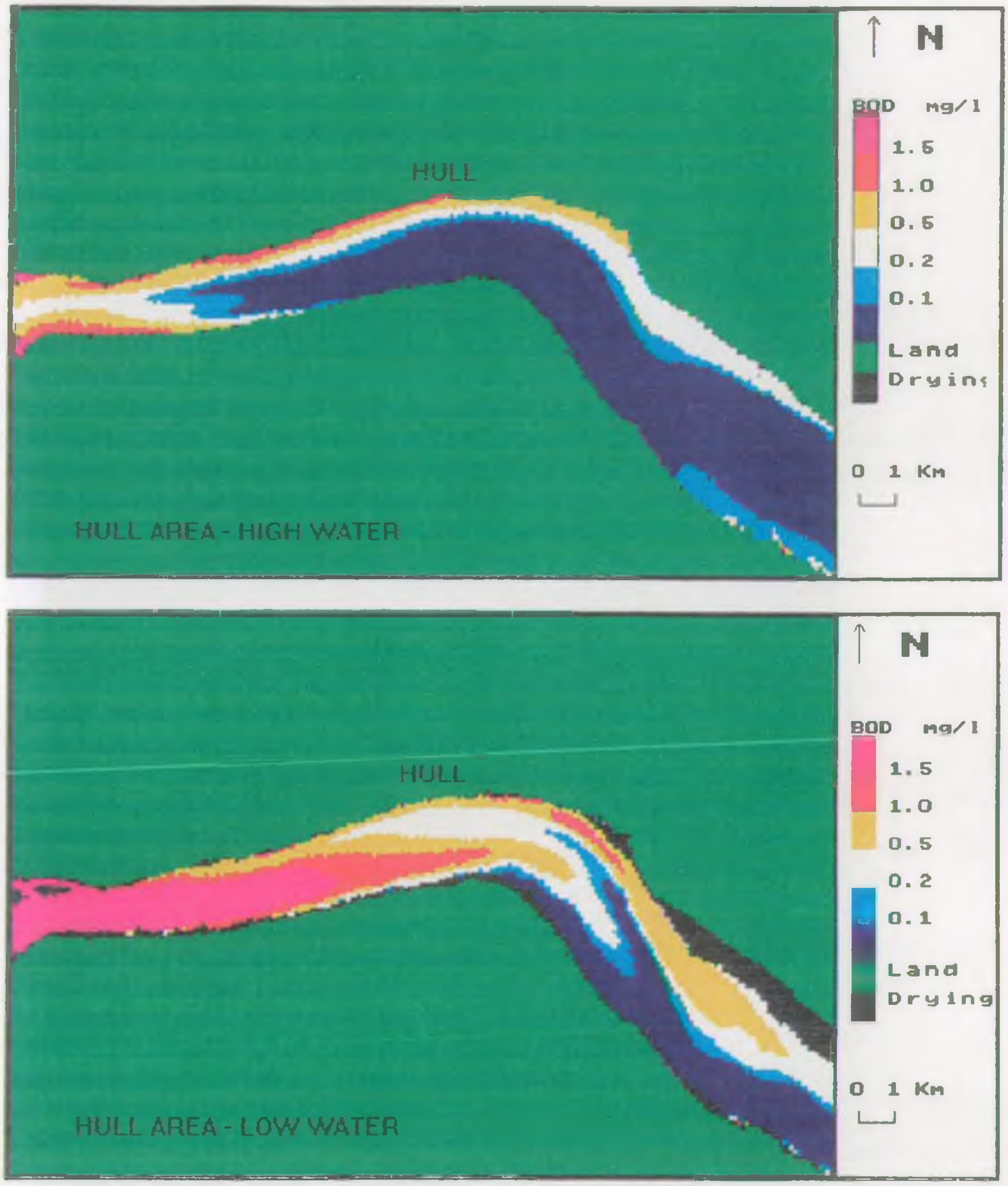
The UWWTD/AMP2 improvements will produce significant water quality benefits in the tidal Don, Ouse and Aire but significant load reductions will be required from industrial discharges in the Selby area in order to approach the dissolved oxygen EQS.

6.5 IMPLEMENTATION OF THE QUESTS 2D MODEL

The 2D Model can provide water movement and water quality predictions based on a 100m or 500m grid, whereas the 1D Model assumes complete mixing across the width of the Estuary. This enables the extent of mixing zones to be established.

The 2D Model was fully implemented towards the end of 1994. One of its first applications will be to produce a range of water quality maps and animations of the Humber to aid understanding of water quality and dispersion processes. Early examples of outputs are illustrated in Figure 6.5.

Figure 6.5 Examples of QUESTS Output



SECTION 7
1994 QUALITY - CONCLUSIONS

☹ River flows during the summer of 1994 were low again after increases in the previous year.

☺ Dissolved oxygen levels in tidal waters have improved, even at sites still failing the EQS.

☺ Ammonia levels in tidal waters have improved and all sites now comply with the EQS.

☺ Levels of List I and List II metals in tidal waters continue to decrease.

☹ Copper continues to be a problem in the Estuary.

☺ Metals loads have generally decreased from all three sources: tidal rivers, industrial and sewage discharges.

☺ Concentrations of most metals in sediments are below the five-year mean.

☹ Some sites for some metals show increasing concentrations in sediments, possibly due to mobile sediments releasing historic metal deposits.

☺ Macroinvertebrate fauna generally remains consistent with previous years.

☺ Macroinvertebrate populations are influenced by natural changes and mobile sediments rather than by pollution or water quality.

☹ Microbiological populations show the influence of localised sewage contamination.

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ACRONYMS

%ile	percentile
A1A	Annex 1A
amm-N	ammoniacal nitrogen
AMP2	Asset Management Plan 2
As	arsenic
ASPT	Average Score Per Taxon
B	boron
BATNEEC	Best Available Technique Not Entailing Excessive Costs
BMWP	Biological Monitoring Working Party
BOD	biochemical oxygen demand
BPEO	Best Practicable Environmental Option
Cd	cadmium
Cl	chloride
CMP	Catchment Management Plan
Cr	chromium
CTC	carbon tetrachloride
Cu	copper
DCE	1,2,dichloroethane
DDT	dichlorodiphenyltrichloroethane
DO	dissolved oxygen
EQO	Environmental Quality Objective
EQPB	Environmental Quality Project Board
EQS	Environmental Quality Standard
Fe	iron
GQA	General Quality Assessment
HCH	hexachlorocyclohexane
HEC	Humber Estuary Committee
HESAC	Humber Estuary Scientific Advisory Committee
Hg	mercury
HMG	Humber Management Group
HMIP	Her Majesty's Inspectorate of Pollution
IPC	Integrated Pollution Control
LEAP	Local Environment Action Plan
LOD	limit of detection
Ni	nickel
NRA	National Rivers Authority
NWC	National Water Council
OP	orthophosphate
Parcom	Paris Commission
Pb	lead
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PER	tetrachloroethylene
QUESTS	Quality of Estuaries
RSPB	Royal Society for the Protection of Birds
SS	suspended solids
SSA	suspended solids, ashed
SSSI	Site of Special Scientific Interest
TCB	trichlorobenzene
TCE	trichloroethylene
TON	total oxidised nitrogen
un-amm	unionised ammonia
UWWTD	Urban Wastewater Treatment Directive
V	vanadium
WRA	Waste Regulatory Authority
WRc	Water Research centre
Zn	zinc

GLOSSARY

N.B. Cross-references are indicated by italic script.

A

Abstraction	Removal of water from surface or groundwater, usually by pumping.
Abundance	The total number of individual organisms recorded in a sample or at a site. [see also *Faunal Abundance*, *Total Abundance*]
Ammonia	A chemical found in water, often as the result of the discharge of sewage effluents. High levels of ammonia affect fisheries and abstractions for potable water supply.
Amphipod	A small, shrimp-like crustacean.
Anaerobic	Containing no oxygen.
Annex 1A	Following the Second North Sea Conference in 1987, the UK Government issued a list of dangerous substances for control to the North Sea (Red List). The Third North Sea Conference of 1990 modified this list (Annex 1A).
Asset Management Plan	A strategic business plan produced by the water companies for the Office of Water Services (OFWAT) setting out the industry's investment programme for the period 1995 to 2000.
Average Score Per Taxon	A statistical refinement of the BMWP Score.

B

Benthic	Referring to life in or on the sea floor.
Bio-accumulation	A mechanism whereby organisms accumulate, in their body tissues, substances which are present in dilute concentration in sea or freshwater.
Biochemical Oxygen Demand	A standard test for measuring the uptake of dissolved oxygen in water by the microbial decomposition of organic matter.
Bio-concentration	A mechanism whereby organisms concentrate, in their body tissues, substances which are present in dilute concentration in sea or freshwater.
Biological Monitoring Working Party Score	A biological index for indicating the health of a river.
Brackish Water	Water which is saltier than freshwater but less salty than seawater.

C

Catchment	The area of land that drains into a particular river system.
Catchment Management Plan	An NRA plan providing a comprehensive framework for addressing all their functions, including flood defence, within the catchment of a main river. [see also *Local Environment Action Plan*]
Confluence	The point at which two rivers meet.
Consent	A statutory document issued by the NRA under Schedule 10 of the Water Resources Act 1991 to indicate any limits and conditions on the discharge of an effluent to a controlled water.
Cumecs	Cubic metres per second (1 cumec = 1000 litres per second).

D

Dangerous Substances .... Substances defined by the European Commission as in need of special control because of their toxicity, bio-accumulation and persistence. The substances are classified as List I or List II according to the Dangerous Substances Directive.

Dissolved Oxygen .... The amount of oxygen dissolved in water, which is an indication of the 'health' of the water and its ability to support aquatic life. It is part of the system used to classify water quality.

'Drins .... A collective term for the insecticides Dieldrin, Endrin, Aldrin and Isodrin, previously used in the textile industry. Total 'drins are controlled under List I of the Dangerous Substances Directive.

E

Environment Agency .... A Government body responsible for environmental protection, incorporating the *National Rivers Authority*, *Her Majesty's Inspectorate of Pollution* and the *Waste Regulatory Authorities*.

Environmental Quality Standard .... A specific limit for the concentration of a particular substance in water.

Eutrophication .... An increase in nutrients in a body of water, which may lead to extensive algal and weed growth, with undesirable consequences.

F

Faecal Coliforms .... Bacteria found in faeces (e.g. human waste).

Faunal Abundance .... The total number of individual organisms recorded in a sample or at a site. [see also *Abundance*, *Total Abundance*]

G

General Quality Assessment .... A national method of evaluating water quality whereby the rivers in England and Wales have been divided into reaches each with an allocated chemistry sample point. These points are monitored for BOD, dissolved oxygen and total ammonia with GQA grades assigned accordingly. This scheme is replacing the previous *NWC Classification* scheme.

H

High Shore .... Shoreline nearest to land, covered only at high tide.

Her Majesty's Inspectorate of Pollution .... A Government body responsible for pollution control of inland industries. Now incorporated into the *Environment Agency*.

Hydrocarbons .... Compounds of carbon and hydrogen found in petroleum products (e.g. oil).

I

Integrated Pollution Control .... An approach to pollution control in the UK which recognises the need to look at the environment as a while, so that solutions to particular pollution problems take account of potential effects upon all environmental media. IPC deals with releases to air, land and water and uses the principles of BATNEEC (Best Available Technique Not Entailing Excessive Costs) and BPEO (Best Practicable Environmental Option).

Intertidal .... The region of shore that lies between the highest and lowest tides.

Invertebrate .... Animal without a backbone.

L

Local Environment Action Plan .... An Environment Agency plan which provides a comprehensive framework for addressing all its functions within the local environment. These plans replace the NRA's *Catchment Management Plans*.

Lindane .... Gamma HCH: a form of the chemical hexachlorocyclohexane used as a wood preservative and previously used in sheep dip. HCH is controlled under List I of the Dangerous Substances Directive.

Low Shore .... Shoreline uncovered only at very low tides.

M

MAFF .... Ministry of Agriculture, Fisheries and Food.
mg/l .... milligrams per litre (1/1000 of a gram per litre). [see also *ppt*]
Mid Shore .... Shoreline uncovered for short periods at low tide.

N

ng/l .... nanograms per litre (1/100,000,000 of a gram per litre).
NWC Classification .... A national method of evaluating water quality whereby the rivers in England and Wales have been divided into reaches each with an allocated chemistry sample point. These points are monitored for BOD, dissolved oxygen with total ammonia and NWC classes assigned accordingly. This scheme is being replaced by the new *GQA Classification* scheme.
National Rivers Authority .... A Government body responsible for water quality, resources and pollution control. Now incorporated into the *Environment Agency*.

O

Oligochaetes .... Segmented worms related to the common earthworm.
Organic Complex .... A compound formed between, for example, a metal ion and an organic substance such as a protein.

P

Percentile .... A set of data is arranged in descending order and the n %ile is the greatest value of n % of the sorted data set.
Polychaetes .... Segmented bristle worms.
ppt .... Parts per thousand (equivalent to *mg/l*).

R

Recruitment .... The influx of new members into the population by reproduction or immigration.

S

Site of Special Scientific Interest .... A site given statutory designation by English Nature or the Countryside Council for Wales because of its conservation value.
Species Richness .... The number of different species recorded in a sample or at a site. [see also *Species Variety*]
Species Variety .... The number of different species recorded in a sample or at a site. [see also *Species Richness*]
Subtidal .... The area which lies below the low water mark and which is continuously covered by water.
Suspended Solids .... Solid matter in a water sample which is retained by filtration under specified conditions.
Suspended Solids, Ashed .... Solid matter remaining once the material filtered out of a water sample (under specified conditions) has been incinerated at a specified temperature for a specified period of time.

T

Taxon (pl. taxa) .... A grouping of organisms without defining the taxonomic level.
Taxonomic Level .... The precision with which an organism is identified, i.e. species, genus or family.
Taxon Richness .... The number of different taxa recorded in a sample or at a site.
Tidal Range .... The difference in height between the high and low water levels.
Tidal River .... The stretch of a river between the tidal limit and the estuary proper: subject to tides but not saline.
Total Abundance .... The total number of individual organisms recorded in a sample or at a site. [see also *Abundance*, *Faunal Abundance*]

U

ug/l .... Microgrammes per litre (1/1,000,000 of a gram per litre).

W

Waste Regulatory Authority .... A Local Government body responsible for waste regulation. Now incorporated into the *Environment Agency*.

APPENDIX 1
Environmental Quality Standards for the Humber

For the purpose of defining EQOs, the Humber is divided into a tidal rivers section (from the tidal limits to Trent Falls) and an estuary section (from Trent Falls to the seaward limit - a line drawn between Spurn Point and Donna Nook).

DETERMINAND	TIDAL RIVERS	ESTUARY	COMMENT
Temperature	25°C	25°C	95 %ile
Dissolved oxygen	40% saturation	55% saturation	5 %ile
pH	5.5-9.0	6.0-8.5	95 %ile
Unionised ammonia	0.021 mg/l	0.021 mg/l	95 %ile
Mercury	1.0 ug/l T	0.3 ug/l D	annual mean (1)
Cadmium	5.0 ug/l T	2.5 ug/l D	annual mean (1)
Arsenic	50 ug/l D	25 ug/l D	annual mean (3)
Chromium (III + VI)	250 ug/l D	15 ug/l D	annual mean (3)
Copper (II)	28 ug/l D	5.0 ug/l D	annual mean (2,3)
Lead	250 ug/l D	25 ug/l D	annual mean (3)
Nickel	200 ug/l D	30 ug/l D	annual mean (3)
Zinc	500 ug/l T	40 ug/l D	annual mean (3)
Iron	1000 ug/l D	1000 ug/l D	annual mean (3)
Boron	1000 ug/l T	7000 ug/l T	annual mean (1)
Vanadium	60 ug/l T	100 ug/l T	annual mean (1)
HCH	0.1 ug/l	0.02 ug/l	annual mean (1)
DDT (all isomers)	0.025 ug/l	0.025 ug/l	annual mean (1)
DDT (pp isomer)	0.01 ug/l	0.01 ug/l	annual mean (1)
CTC	12 ug/l	12 ug/l	annual mean (1)
PCP	2 ug/l	2 ug/l	annual mean (1)
Total 'drins	0.03 ug/l	0.3 ug/l	annual mean (1)
Endrin	0.005 ug/l	0.005 ug/l	maximum (1)
TCB	0.4 ug/l	0.4 ug/l	annual mean (1)
TCE	10 ug/l	10 ug/l	annual mean (1)
DCE	10 ug/l	10 ug/l	annual mean (1)
PER	10 ug/l	10 ug/l	annual mean (1)

(1) Mandatory: EC Dangerous Substances Directive Environmental Quality Standards for List I Substances.
(2) Higher values acceptable where acclimation expected or copper present in organic complexes.
(3) National List II Environmental Quality Standard.

APPENDIX 2
Results of Humber Routine Survey: Shore-based Water Quality Sampling

Table A2.1 1994 Results vs. EQS: temp, DO, pH, un-amm

STATION	Temperature (° C)						Dissolved oxygen (mg/l)						pH						Unionised ammonia (mg/l)					
	No of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	95 %ile with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	5 %ile with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	95 %ile with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	95 %ile with < at half LOD
TIDAL RIVERS																								
OUSE																								
Cawood	10	0	18.1	4.9	*	16.8	11	0	96.0	76.0	*	81.0	13	0	7.9	4.6	*	7.9	10	0	0.009	0.0002	*	0.009
Selby	12	0	18.6	4.8	*	17.9	10	0	101.0	66.0	*	69.6	14	0	7.8	7.3	*	7.8	12	0	0.014	0.0002	*	0.014
Drax	12	0	18.9	4.6	*	18.1	10	0	96.0	48.0	*	57.0	14	0	7.9	7.2	*	7.8	12	0	0.011	0.0003	*	0.008
Boothferry	13	0	20.0	5.0	*	20.0	7	0	101.0	62.0	*	64.3	13	0	7.7	7.4	*	7.7	13	0	0.035	0.0005	*	0.020
Blacktoft	12	0	22.2	5.6	*	21.0	8	0	92.5	47.0	*	49.8	14	0	7.8	7.1	*	7.8	12	0	0.005	0.0006	*	0.003
AIRE																								
Snaith	3	0	22.0	19.9	*	21.8	3	0	58.7	32.0	*	33.2	3	0	7.5	7.4	*	7.5	3	0	0.013	0.0044	*	0.012
DON																								
Kirk Bramwith	13	0	18.2	6.0	*	18.2	12	0	97.0	51.0	*	56.8	13	0	7.6	7.2	*	7.6	13	0	0.010	0.0024	*	0.010
Rawcliffe	13	0	19.0	5.7	*	18.3	13	0	91.0	32.0	*	38.0	14	0	7.7	7.4	*	7.7	13	0	0.008	0.0007	*	0.007
TRENT																								
Dunham	7	0	20.0	5.0	*	20.0	7	0	94.0	68.0	*	71.6	7	0	8.1	7.8	*	8.1	7	0	0.008	0.0020	*	0.007
Gainsborough	14	0	20.0	6.0	*	19.4	14	0	102.0	67.0	*	76.8	14	0	8.3	7.8	*	8.2	14	0	0.006	0.0020	*	0.005
Keadby	14	0	19.0	5.0	*	19.0	14	0	96.0	46.0	*	52.5	14	0	8.2	7.7	*	8.1	14	0	0.007	0.0010	*	0.007
WHARFE																								
Ryther	11	0	18.4	4.0	*	18.1	8	0	94.0	82.0	*	83.7	14	0	8.0	7.6	*	8.0	11	0	0.003	0.0003	*	0.002
EQS						25 (95 %ile)						40 (5 %ile)						5.5 - 9.0						0.021 (95 %ile)
ESTUARY																								
Brough	6	0	18.0	8.0	*	17.3	5	0	115.0	67.0	*	67.9	7	0	7.8	7.3	*	7.8	6	0	0.006	0.0006	*	0.005
New Holland	14	0	19.0	5.0	*	18.4	10	0	82.0	64.0	*	64.1	14	0	7.8	7.6	*	7.8	*	*	*	*	*	*
Albert Dock	11	0	20.1	6.0	*	20.1	9	0	87.0	66.0	*	67.1	12	0	7.9	7.4	*	7.9	11	0	0.013	0.0006	*	0.011
Saltend	11	0	19.0	5.6	*	18.5	8	0	102.0	58.0	*	61.2	12	0	7.9	7.5	*	7.9	11	0	0.006	0.0006	*	0.004
Killingholme	14	0	19.0	5.0	*	19.0	11	0	81.0	56.0	*	57.5	14	0	7.8	7.6	*	7.8	*	*	*	*	*	*
Spurn	11	0	18.0	5.0	*	17.5	8	0	119.0	73.0	*	74.8	14	0	8.3	7.9	*	8.3	12	0	0.019	0.0012	*	0.012
EQS						25 (95 %ile)						55 (5 %ile)						6.0 - 8.5						0.021 (95 %ile)

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.2 1994 Results vs. EQS: As, Cd, Cr

STATION	Arsenic (ug/l)						Cadmium (ug/l)						Chromium (ug/l)					
	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No of Samples	No of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD
TIDAL RIVERS																		
OUSE																		
Cawood	7	2	6.6	< 1.0	2.2 - 3.6	2.9	7	1	0.6	< 0.1	0.25 - 0.27	0.26	6	5	1.3	< 1.0	0.2 - 1.1	0.6
Selby	7	2	7.0	< 1.4	3.1 - 4.6	3.9	7	0	0.6	0.1	*	0.32	7	4	2.1	< 1.0	0.6 - 1.2	0.9
Drax	6	2	10.6	< 2.2	4.6 - 6.3	5.4	7	0	3.2	0.2	*	0.80	6	2	2.9	< 1.0	1.2 - 1.6	1.4
Boothferry	7	2	11.3	< 3.7	5.4 - 6.8	6.1	5	1	1.7	< 0.1	0.69 - 0.71	0.70	7	1	3.5	< 1.0	1.8 - 1.9	1.8
Blacktoft	7	2	5.9	< 3.5	3.2 - 4.6	3.9	7	0	1.1	0.4	*	0.68	6	1	12.3	< 1.0	4.2 - 4.4	4.3
AIRE																		
Snaith	2	0	13.4	11.9	*	12.7	2	0	1.0	0.1	*	0.54	2	0	4.0	1.7	*	2.8
DON																		
Kirk Bramwith	*	*	*	*	*	*	7	2	0.4	< 0.1	0.13 - 0.16	0.14	7	3	3.2	< 1.0	1.0 - 1.5	1.3
Rawcliffe	4	1	8.0	< 1.4	3.8 - 5.1	4.4	6	0	1.1	0.2	*	0.43	5	3	3.0	< 1.0	0.9 - 1.5	1.2
TRENT																		
Dunham	6	1	3.1	< 1.0	1.9 - 2.0	1.9	7	0	0.4	0.2	*	0.31	7	1	4.6	< 0.5	2.2 - 2.3	2.3
Gainsborough	4	0	11.5	1.4	*	4.7	6	0	0.6	0.3	*	0.37	7	0	4.0	0.6	*	2.0
Keadby	4	0	8.6	2.3	*	6.0	7	0	2.2	0.3	*	0.82	6	0	3.3	0.6	*	1.9
WHARFE																		
Ryther	6	5	2.9	< 1.0	0.5 - 2.6	1.6	7	2	1.3	< 0.1	0.33 - 0.36	0.34	5	3	2.1	< 1.0	0.6 - 1.2	0.9
EQS						50 D						5 T						250 D
ESTUARY																		
Brough	7	2	4.4	< 3.4	2.8 - 4.3	3.5	7	4	0.4	< 0.3	0.13 - 0.27	0.20	7	2	10.2	< 1.0	3.9 - 4.2	4.0
New Holland	6	3	2.3	< 2.0	1.1 - 2.1	1.6	5	1	1.3	< 0.3	0.47 - 0.52	0.49	6	6	< 2.0	< 1.5	0.0 - 1.6	0.8
Albert Dock	7	2	3.4	< 2.3	2.0 - 3.4	2.7	4	1	0.6	< 0.3	0.36 - 0.42	0.39	7	1	14.7	< 1.0	6.2 - 6.3	6.3
Saltend	6	2	2.5	< 1.9	1.4 - 3.1	2.2	4	1	0.5	< 0.3	0.31 - 0.37	0.34	6	1	13.8	< 1.0	6.8 - 7.0	6.9
Killingholme	7	6	1.5	< 1.5	0.2 - 1.9	1.1	1	3	0.6	< 0.6	0.15 - 0.60	0.24	6	5	4.3	< 1.5	0.7 - 2.1	1.4
Spurn	7	4	2.5	< 1.0	0.7 - 2.4	1.5	5	2	0.3	< 0.3	0.19 - 0.29	0.24	7	1	16.1	< 1.0	6.8 - 6.9	6.8
EQS						25 D						2.5 D						15 D

T = Total D = Dissolved

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.3 1994 Results vs. EQS: Cu. Fe. Hg

STATION	Copper (ug/l)						Iron (ug/l)						Mercury (ug/l)					
	No of Samples	No of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No of Samples	No of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD
TIDAL RIVERS																		
OUSE																		
Cawood	7	1	12.3	< 1.0	4.5 - 4.6	4.5	7	0	215.0	58.0	*	121.1	6	5	0.2	< 0.10	0.03 - 0.11	0.07
Selby	7	1	15.5	< 1.0	6.7 - 6.8	6.8	7	0	250.0	55.0	*	114.1	7	5	0.2	< 0.10	0.06 - 0.13	0.10
Drax	6	0	17.6	3.1	*	7.4	6	0	258.0	44.0	*	138.0	7	3	0.2	< 0.10	0.08 - 0.12	0.10
Boothferry	7	1	31.9	< 1.0	11.8 - 11.9	11.8	6	2	222.0	< 40.0	102.0 - 115.3	108.7	7	3	0.4	< 0.10	0.17 - 0.22	0.20
Blacktoft	6	1	23.3	< 1.0	8.6 - 8.8	8.7	7	4	157.0	< 40.0	52.9 - 75.7	64.3	7	1	0.4	< 0.10	0.23 - 0.25	0.24
AIRE																		
Snaith	2	0	19.5	16.3	*	17.9	2	0	88.0	43.0	*	65.5	*	*	*	*	*	*
DON																		
Kirk Bramwith	7	0	14.3	3.3	*	7.4	7	0	192.0	42.0	*	115.6	7	6	0.1	< 0.10	0.02 - 0.10	0.06
Rawcliffe	5	0	15.3	2.1	*	7.3	4	0	178.0	56.0	*	102.5	6	3	0.3	< 0.10	0.11 - 0.16	0.14
TRENT																		
Dunham	7	0	10.4	4.8	*	7.9	7	0	115.0	16.7	*	47.5	7	7	< 0.1	< 0.03	0.00 - 0.04	0.02
Gainsborough	7	0	11.8	5.8	*	8.1	7	1	67.4	< 10.0	36.7 - 38.1	37.4	7	4	0.4	< 0.03	0.07 - 0.10	0.08
Keadby	6	0	10.8	5.1	*	7.8	6	3	83.7	< 10.0	24.2 - 29.2	26.7	7	2	0.3	< 0.03	0.10 - 0.12	0.11
WHARFE																		
Ryther	5	0	11.7	1.0	*	4.2	6	0	133.0	52.0	*	88.7	6	5	0.1	< 0.10	0.02 - 0.10	0.06
EQS						28 D						1000 D						1 T
ESTUARY																		
Brough	3	0	11.9	1.9	*	5.3	7	5	47.0	< 40.0	12.4 - 41.0	26.7	7	6	0.2	< 0.10	0.02 - 0.11	0.07
New Holland	6	0	18.1	2.7	*	9.5	6	6	< 100.0	< 3.0	0.0 - 30.5	15.3	6	5	0.1	< 0.05	0.01 - 0.05	0.03
Albert Dock	1	0	5.1	5.1	*	5.1	7	3	63.0	< 40.0	32.9 - 50.0	41.4	7	7	< 0.1	< 0.10	0.00 - 0.10	0.05
Saltend	*	*	*	*	*	*	6	4	507.0	< 40.0	93.7 - 120.3	107.0	6	6	< 0.1	< 0.10	0.00 - 0.10	0.05
Killingholme	5	0	5.9	1.0	*	3.1	6	3	510.0	< 20.0	100.0 - 123.3	111.7	7	6	0.1	< 0.05	0.01 - 0.05	0.03
Spurn	*	*	*	*	*	*	7	3	62.0	< 40.0	28.0 - 45.1	36.6	7	7	< 0.1	< 0.10	0.00 - 0.10	0.05
EQS						5 D						1000 D						0.3 D

T = Total D = Dissolved

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.4 1994 Results vs. EQS: Pb. Ni. Zn

STATION	Lead (ug/l)						Nickel (ug/l)						Zinc (ug/l)					
	No of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No of Samples	No of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD
TIDAL RIVERS																		
OUSE																		
Cawood	7	2	2.9	< 1.0	1.6 - 1.9	1.75	6	2	4.3	< 1.0	1.6 - 2.0	1.8	7	0	249.0	23.0	*	84.3
Selby	7	4	3.0	< 1.0	0.9 - 1.5	1.21	5	2	7.7	< 1.0	2.3 - 2.7	2.5	7	0	356.0	24.0	*	117.9
Drax	6	4	2.9	< 1.0	0.7 - 1.3	0.99	6	1	8.7	< 1.0	4.6 - 4.7	4.7	7	0	1460.0	30.0	*	309.6
Boothferry	7	4	3.1	< 1.0	1.0 - 1.6	1.27	6	1	10.0	< 3.1	5.7 - 6.5	6.1	4	0	317.0	36.0	*	144.5
Blacktoft	7	4	4.3	< 1.0	1.1 - 1.6	1.36	7	1	10.7	< 5.0	6.8 - 7.5	7.1	7	0	498.0	27.0	*	196.0
AIRE																		
Snaith	2	2	< 1.0	< 1.0	0.0 - 1.0	0.50	2	0	17.2	6.8	*	12.0	2	0	341.0	107.0	*	224.0
DON																		
Kirk Bramwith	7	4	3.4	< 1.0	0.9 - 1.5	1.18	7	0	21.9	10.1	*	17.3	7	0	79.0	30.0	*	45.0
Rawcliffe	5	5	< 1.0	< 1.0	0.0 - 1.0	0.50	5	1	11.0	< 5.0	7.7 - 8.7	8.2	6	0	171.0	32.0	*	104.4
TRENT																		
Dunham	6	0	2.9	0.7	*	1.38	7	0	24.4	9.9	*	17.6	7	0	59.3	28.5	*	38.3
Gainsborough	7	1	2.4	< 0.5	1.0 - 1.1	1.04	7	0	19.6	10.5	*	14.0	7	0	999.0	28.0	*	190.7
Keadby	6	0	2.0	0.6	*	1.00	6	0	14.7	7.3	*	11.3	7	0	784.0	59.2	*	236.6
WHARFE																		
Ryther	5	2	1.8	< 1.0	0.9 - 1.3	1.14	6	2	2.7	< 1.0	1.3 - 1.7	1.5	7	2	268.0	< 20.0	52.9 - 58.6	55.7
EQS						250 D						200 D						500 T
ESTUARY																		
Brough	7	3	3.2	< 1.0	1.0 - 1.4	1.17	7	1	12.2	< 5.0	7.3 - 8.0	7.6	6	3	24.0	< 5.0	9.0 - 16.5	12.8
New Holland	6	6	< 2.5	< 2.5	0.0 - 2.5	1.25	6	0	6.2	4.3	*	4.8	6	0	34.1	10.3	*	22.6
Albert Dock	7	2	4.4	< 1.0	1.6 - 1.9	1.75	7	1	15.3	< 5.0	9.6 - 10.3	10.0	7	3	33.0	< 5.8	12.7 - 21.2	16.9
Saltend	5	1	5.1	< 1.0	2.1 - 2.3	2.18	6	1	16.4	< 5.0	9.1 - 9.9	9.5	6	2	52.8	< 8.2	16.4 - 23.1	19.8
Killingholme	5	5	< 2.5	< 2.5	0.0 - 2.5	1.25	5	0	4.4	3.0	*	3.6	6	0	28.1	5.1	*	13.1
Spurn	7	3	6.0	< 1.0	1.9 - 2.4	2.16	7	1	23.6	< 5.0	11.8 - 12.5	12.2	6	2	74.6	< 5.0	19.7 - 23.8	21.8
EQS						25 D						30 D						40 D

T = Total D = Dissolved

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.5 1994 Results vs. EOS: B. V. TCB. HCH

STATION	Boron (ug/l) No. of Samples	Boron No. of Samples < LOD	Boron Max with < at half LOD	Boron Min with < at half LOD	Boron Range of Mean	Boron Mean with < at half LOD	Vanadium (ug/l) No. of Samples	Vanadium No. of Samples < LOD	Vanadium Max with < at half LOD	Vanadium Min with < at half LOD	Vanadium Range of Mean	Vanadium Mean with < at half LOD
TIDAL RIVERS												
OUSE												
Cawood	7	0	194.0	28.9	*	101.9	7	0	63.7	1.2	*	17.0
Selby	7	0	373.0	29.9	*	153.0	7	0	91.0	1.4	*	26.6
Drax	7	0	806.0	41.5	*	295.2	7	0	354.0	7.4	*	76.8
Boothferry	5	0	948.0	100.0	*	499.0	6	0	168.0	5.0	*	71.9
Blacktoft	7	0	2286.0	201.0	*	1125.7	7	0	140.0	11.5	*	49.7
AIRE												
Snaith	2	0	777.0	686.0	*	731.5	2	0	86.0	23.2	*	54.6
DON												
Kirk Bramwith	*	*	*	*	*	*	*	*	*	*	*	*
Rawcliffe	6	0	1173.0	186.0	*	393.7	6	0	36.5	2.6	*	18.7
TRENT												
Dunham	7	0	613.0	173.0	*	388.1	7	0	7.9	2.5	*	4.0
Gainsborough	7	0	619.0	173.0	*	383.3	7	0	184.0	3.1	*	35.8
Keadby	7	0	979.0	164.0	*	469.4	7	1	94.2	1.0	35.5 - 35.6	35.6
WHARFE												
Ryther	7	0	196.0	27.8	*	94.1	7	4	56.2	1.0	9.6 - 10.2	9.9
EQS						1000 T						60 T
ESTUARY												
Brough	5	0	2342.0	696.0	*	1576.6	6	0	74.5	17.8	*	41.7
New Holland	*	*	*	*	*	*	*	*	*	*	*	*
Albert Dock	6	0	3295.0	1384.0	*	2456.8	6	0	89.6	24.6	*	42.9
Saltend	5	0	3539.0	1979.0	*	2773.4	5	0	29.4	13.9	*	19.1
Killingholme	*	*	*	*	*	*	*	*	*	*	*	*
Spurn	6	0	4525.0	3152.0	*	4087.3	6	0	34.4	5.5	*	14.6
EQS						7000 T						100 T

STATION	Trichlorobenzene (ug/l) No. of Samples	TCB No. of Samples < LOD	TCB Max with < at half LOD	TCB Min with < at half LOD	TCB Range of Mean	TCB Mean with < at half LOD	Hexachlorocyclohexane (ug/l) No. of Samples	HCH No. of Samples < LOD	HCH Max with < at half LOD	HCH Min with < at half LOD	HCH Range of Mean	HCH Mean with < at half LOD
TIDAL RIVERS												
OUSE												
Cawood	*	*	*	*	*	*	6	6	< 0.011	< 0.001	0.0048 - 0.0062	0.0055
Selby	*	*	*	*	*	*	7	5	0.080	< 0.001	0.0190 - 0.0199	0.0194
Drax	*	*	*	*	*	*	7	4	0.066	< 0.001	0.0224 - 0.0231	0.0228
Boothferry	*	*	*	*	*	*	7	3	0.102	< 0.001	0.0297 - 0.0303	0.0300
Blacktoft	*	*	*	*	*	*	7	3	0.021	< 0.001	0.0067 - 0.0079	0.0073
AIRE												
Snaith	*	*	*	*	*	*	2	0	0.125	0.084	*	0.1045
DON												
Kirk Bramwith	*	*	*	*	*	*	6	6	< 0.043	< 0.001	0.0170 - 0.0180	0.0175
Rawcliffe	*	*	*	*	*	*	6	3	0.075	< 0.001	0.0277 - 0.0282	0.0279
TRENT												
Dunham	*	*	*	*	*	*	7	7	< 0.026	< 0.005	0.0060 - 0.0146	0.0103
Gainsborough	*	*	*	*	*	*	6	6	< 0.041	< 0.005	0.0080 - 0.0163	0.0122
Keadby	*	*	*	*	*	*	7	7	< 0.025	< 0.005	0.0043 - 0.0129	0.0086
WHARFE												
Ryther	*	*	*	*	*	*	7	7	< 0.008	< 0.001	0.0023 - 0.0034	0.0029
EQS						0.4 T						0.1 T
ESTUARY												
Brough	*	*	*	*	*	*	7	5	0.022	< 0.001	0.0069 - 0.0076	0.0072
New Holland	*	*	*	*	*	*	6	5	0.003	< 0.002	0.0003 - 0.0044	0.0023
Albert Dock	*	*	*	*	*	*	6	5	0.008	< 0.001	0.0030 - 0.0043	0.0037
Saltend	*	*	*	*	*	*	6	5	0.008	< 0.001	0.0042 - 0.0050	0.0046
Killingholme	*	*	*	*	*	*	7	6	0.003	< 0.002	0.0003 - 0.0045	0.0024
Spurn	*	*	*	*	*	*	7	6	0.006	< 0.001	0.0019 - 0.0031	0.0025
EQS						0.4 T						0.02 T

T = Total D = Dissolved

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.6 1994 Results vs. EOS: DDT. PP. PCP

STATION	Total DDT (ug/l) No. of Samples	Total DDT No. of Samples < LOD	Total DDT Max with < at half LOD	Total DDT Min with < at half LOD	Total DDT Range of Mean	Total DDT Mean with < at half LOD	DDT - PP isomer (ug/l) No. of Samples	DDT-PP No. of Samples < LOD	DDT-PP Max with < at half LOD	DDT-PP Min with < at half LOD	DDT-PP Range of Mean	DDT-PP Mean with < at half LOD
TIDAL RIVERS												
OUSE												
Cawood	6	6	< 0.005	< 0.002	0.000 - 0.005	0.002	6	6	< 0.005	< 0.002	0.000 - 0.003	0.001
Selby	7	7	< 0.010	< 0.002	0.000 - 0.006	0.003	7	7	< 0.010	< 0.002	0.000 - 0.003	0.002
Drax	7	7	< 0.005	< 0.002	0.000 - 0.005	0.003	7	7	< 0.005	< 0.002	0.000 - 0.003	0.001
Boothferry	7	6	0.006	< 0.002	0.000 - 0.005	0.003	6	6	< 0.010	< 0.002	0.000 - 0.003	0.002
Blacktoft	6	6	< 0.002	< 0.002	0.000 - 0.004	0.002	6	6	< 0.002	< 0.002	0.000 - 0.002	0.001
AIRE												
Snaith	2	2	< 0.002	< 0.002	0.000 - 0.004	0.002	2	2	< 0.002	< 0.002	0.000 - 0.002	0.001
DON												
Kirk Bramwith	6	6	< 0.002	< 0.002	0.000 - 0.004	0.002	6	6	< 0.002	< 0.002	0.000 - 0.002	0.001
Rawcliffe	6	6	< 0.002	< 0.002	0.000 - 0.004	0.002	6	6	< 0.002	< 0.002	0.000 - 0.002	0.001
TRENT												
Dunham	7	7	< 0.005	< 0.005	0.000 - 0.010	0.005	7	7	< 0.005	< 0.005	0.000 - 0.005	0.003
Gainsborough	6	6	< 0.005	< 0.005	0.000 - 0.010	0.005	6	6	< 0.005	< 0.005	0.000 - 0.005	0.003
Keadby	7	7	< 0.005	< 0.005	0.000 - 0.010	0.005	7	7	< 0.005	< 0.005	0.000 - 0.005	0.003
WHARFE												
Ryther	7	7	< 0.002	< 0.002	0.000 - 0.004	0.002	7	7	< 0.002	< 0.002	0.000 - 0.002	0.001
EQS						0.025 T						0.01 T
ESTUARY												
Brough	7	7	< 0.002	< 0.002	0.000 - 0.004	0.002	7	7	< 0.002	< 0.002	0.000 - 0.002	0.001
New Holland	6	6	< 0.012	< 0.001	0.002 - 0.009	0.006	6	6	< 0.012	< 0.001	0.002 - 0.006	0.004
Albert Dock	6	6	< 0.005	< 0.002	0.000 - 0.005	0.002	6	6	< 0.005	< 0.002	0.000 - 0.003	0.001
Saltend	6	6	< 0.005	< 0.002	0.000 - 0.004	0.002	6	6	< 0.005	< 0.002	0.000 - 0.003	0.001
Killingholme	7	7	< 0.005	< 0.001	0.000 - 0.008	0.004	7	7	< 0.005	< 0.001	0.000 - 0.004	0.002
Spurn	7	7	< 0.002	< 0.002	0.000 - 0.004	0.002	7	7	< 0.002	< 0.002	0.000 - 0.002	0.001
EQS						0.025 T						0.01 T

STATION	Pentachlorophenol (ug/l) No. of Samples	PCP No. of Samples < LOD	PCP Max with < at half LOD	PCP Min with < at half LOD	PCP Range of Mean	PCP Mean with < at half LOD
TIDAL RIVERS						
OUSE						
Cawood	7	7	< 0.20	< 0.20	0.0 - 0.200	0.1
Selby	7	7	< 0.20	< 0.20	0.0 - 0.200	0.1
Drax	6	5	0.50	< 0.20	0.1 - 0.250	0.2
Boothferry	7	7	< 0.20	< 0.20	0.0 - 0.200	0.1
Blacktoft	7	7	< 0.20	< 0.20	0.0 - 0.200	0.1
AIRE						
Snaith	2	2	< 0.20	< 0.20	0.0 - 0.200	0.1
DON						
Kirk Bramwith	7	5	0.40	< 0.20	0.1 - 0.229	0.2
Rawcliffe	7	6	0.40	< 0.20	0.1 - 0.229	0.1
TRENT						
Dunham	*	*	*	*	*	*
Gainsborough	*	*	*	*	*	*
Keadby	*	*	*	*	*	*
WHARFE						
Ryther	7	7	< 0.20	< 0.20	0.0 - 0.200	0.1
EQS						2 T
ESTUARY						
Brough	6	6	< 0.20	< 0.20	0.000 - 0.200	0.1
New Holland	7	5	0.11	< 0.02	0.028 - 0.042	0.0
Albert Dock	6	6	< 0.20	< 0.20	0.000 - 0.200	0.1
Saltend	4	4	< 0.20	< 0.20	0.000 - 0.200	0.1
Killingholme	7	5	0.15	< 0.02	0.025 - 0.039	0.0
Spurn	7	7	< 0.20	< 0.20	0.000 - 0.200	0.1
EQS						2 T

T = Total D = Dissolved

* No data available

Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.7 1994 Results vs. EQS: CTC. 'drins. Endrin

STATION	Carbon Tetrachloride (ug/l)						Total 'drins (ug/l)						Endrin (ug/l)					
	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD
TIDAL RIVERS																		
OUSE																		
Cawood	7	7	< 0.1	< 0.05	0.0 - 0.093	0.046	6	6	< 0.005	< 0.001	0.0000 - 0.0058	0.0029	6	6	< 0.005	< 0.002	0.0 - 0.0025	0.0013
Selby	6	6	< 0.1	< 0.05	0.0 - 0.092	0.046	7	7	< 0.010	< 0.001	0.0009 - 0.0083	0.0046	7	7	< 0.010	< 0.002	0.0 - 0.0031	0.0016
Drax	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	7	7	< 0.005	< 0.001	0.0007 - 0.0061	0.0034	7	7	< 0.005	< 0.002	0.0 - 0.0024	0.0012
Boothferry	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	7	7	< 0.005	< 0.001	0.0016 - 0.0064	0.0040	7	7	< 0.005	< 0.002	0.0 - 0.0024	0.0012
Blacktoft	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	7	7	< 0.003	< 0.001	0.0014 - 0.0059	0.0036	7	7	< 0.002	< 0.002	0.0 - 0.0020	0.0010
AIRE																		
Snaith	2	2	< 0.1	< 0.10	0.0 - 0.100	0.050	2	2	< 0.005	< 0.001	0.0035 - 0.0075	0.0055	2	2	< 0.002	< 0.002	0.0 - 0.0020	0.0010
DON																		
Kirk Bramwith	6	6	< 0.1	< 0.05	0.0 - 0.092	0.046	6	6	< 0.002	< 0.001	0.0000 - 0.0048	0.0024	6	6	< 0.002	< 0.002	0.0 - 0.0020	0.0010
Rawcliffe	5	5	< 0.2	< 0.05	0.0 - 0.110	0.055	6	6	< 0.003	< 0.001	0.0013 - 0.0058	0.0036	6	6	< 0.002	< 0.002	0.0 - 0.0020	0.0010
TRENT																		
Dunham	*	*	*	*	*	*	7	7	< 0.005	< 0.005	0.0000 - 0.0200	0.0100	7	7	< 0.005	< 0.005	0.0 - 0.0050	0.0025
Gainsborough	*	*	*	*	*	*	6	6	< 0.005	< 0.005	0.0000 - 0.0200	0.0100	6	6	< 0.005	< 0.005	0.0 - 0.0050	0.0025
Keadby	*	*	*	*	*	*	7	7	< 0.005	< 0.005	0.0000 - 0.0200	0.0100	7	7	< 0.005	< 0.005	0.0 - 0.0050	0.0025
WHARFE																		
Ryther	6	6	< 0.1	< 0.05	0.0 - 0.092	0.046	7	7	< 0.002	< 0.001	0.0003 - 0.0050	0.0026	7	7	< 0.002	< 0.002	0.0 - 0.0020	0.0010
EQS						12 T						0.03 T						0.005 T
ESTUARY																		
Brough	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	7	7	< 0.003	< 0.001	0.0013 - 0.0056	0.0034	7	7	< 0.002	< 0.002	0.0 - 0.0020	0.0010
New Holland	*	*	*	*	*	*	6	6	< 0.008	< 0.001	0.0015 - 0.0134	0.0075	6	6	< 0.005	< 0.001	0.0 - 0.0043	0.0022
Albert Dock	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	6	6	< 0.005	< 0.001	0.0005 - 0.0060	0.0033	6	6	< 0.005	< 0.002	0.0 - 0.0025	0.0013
Saltend	4	4	< 0.1	< 0.05	0.0 - 0.088	0.044	6	6	< 0.002	< 0.001	0.0000 - 0.0048	0.0024	6	6	< 0.002	< 0.002	0.0 - 0.0020	0.0010
Killingholme	*	*	*	*	*	*	7	7	< 0.005	< 0.001	0.0001 - 0.0132	0.0067	7	7	< 0.005	< 0.001	0.0 - 0.0044	0.0022
Spurn	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	7	7	< 0.002	< 0.001	0.0000 - 0.0049	0.0024	7	7	< 0.002	< 0.002	0.0 - 0.0020	0.0010
EQS						12 T						0.3 T						0.005 T

T = Total D = Dissolved
* No data available
Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

Table A2.8 1994 Results vs. EQS: TCE. DCE. PER

STATION	Trichloroethylene (ug/l)						1.2.Dichloroethane (ug/l)						Tetrachloroethylene (ug/l)					
	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD	No. of Samples	No. of Samples < LOD	Max with < at half LOD	Min with < at half LOD	Range of Mean	Mean with < at half LOD
TIDAL RIVERS																		
OUSE																		
Cawood	7	7	< 0.1	< 0.05	0.0 - 0.093	0.046	7	6	1.000	< 0.100	0.1129 - 0.5986	0.3557	7	7	< 0.100	< 0.050	0.0000 - 0.0929	0.0464
Selby	6	6	< 0.1	< 0.05	0.0 - 0.092	0.046	6	5	1.000	< 0.100	0.1417 - 0.6917	0.4167	6	5	0.110	< 0.050	0.0183 - 0.0933	0.0558
Drax	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	4	3	1.000	< 0.100	0.2325 - 1.0075	0.6200	5	4	0.170	< 0.050	0.0340 - 0.1040	0.0690
Boothferry	5	5	0.1	< 0.05	0.0 - 0.090	0.045	5	3	1.000	< 0.100	0.2640 - 0.8840	0.5740	5	3	1.500	< 0.060	0.3260 - 0.3780	0.3520
Blacktoft	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	5	4	1.000	< 0.100	0.1920 - 0.8780	0.5350	5	3	0.620	< 0.070	0.1380 - 0.1980	0.1680
AIRE																		
Snaith	2	2	< 0.1	< 0.10	0.0 - 0.100	0.050	*	*	*	*	*	*	2	2	< 0.100	< 0.100	0.0000 - 0.1000	0.0500
DON																		
Kirk Bramwith	6	6	0.1	0.05	0.0 - 0.092	0.046	*	*	*	*	*	*	*	*	*	*	*	*
Rawcliffe	5	5	0.2	< 0.05	0.0 - 0.110	0.055	5	3	1.670	< 0.100	0.5060 - 0.9460	0.7260	5	4	3.530	< 0.050	0.7060 - 0.7760	0.7410
TRENT																		
Dunham	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Gainsborough	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Keadby	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
WHARFE																		
Ryther	6	6	0.1	0.05	0.0 - 0.092	0.046	*	*	*	*	*	*	*	*	*	*	*	*
EQS						10 T						10 T						10 T
ESTUARY																		
Brough	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	5	5	< 2.000	< 0.100	0.0000 - 0.6600	0.3300	5	5	< 0.100	< 0.050	0.0000 - 0.0900	0.0450
New Holland	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Albert Dock	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	5	5	< 2.000	< 0.100	0.0000 - 0.6600	0.3300	4	2	0.110	< 0.080	0.0475 - 0.0975	0.0725
Saltend	4	4	< 0.1	< 0.05	0.0 - 0.088	0.044	4	4	< 2.000	< 0.100	0.0000 - 0.8000	0.4000	4	3	0.120	< 0.050	0.0300 - 0.0925	0.0613
Killingholme	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Spurn	5	5	< 0.1	< 0.05	0.0 - 0.090	0.045	5	5	< 2.000	< 0.100	0.0000 - 0.6600	0.3300	5	4	0.120	< 0.050	0.0240 - 0.0940	0.0590
EQS						10 T						10 T						10 T

T = Total D = Dissolved
* No data available
Range of mean is calculated by taking the 'less than' values as equal to zero for the lower value and as equal to the LOD for the higher value (see section 3.4.2)

APPENDIX 3
Sites Used in Load Calculations

Included in Humber Routine Survey and Parcom/A1A:

Rivers	Sewage	Trade
Ancholme	Pyewipe	Ciba Geigy
Aire @ Beal	Hull East	Courtaulds
Derwent @ Loftsome Bridge	Hull West	Hydro Fertilisers
Ouse @ Naburn Weir		MTM @ Barton
Don @ North Bridge		SCM Chemicals
Wharfe @ Tadcaster		Tioxide UK
		Britag
		British Aerospace
		Croda (Goole)
		Haarmann & Reimer
		BP Chemicals

Included in Humber Routine Survey but not in Parcom/A1A:

Rivers	Sewage	Industry
Idle @ Misterton	Sandall	British Steel
Bottesford Beck @ Snake Plantation	Thorne	Keadby Power Station
Three Rivers @ Keadby		Pilkingtons
Hull @ Drypool		Rigid Paper Products
		BOCM Olympia Mills
		Doverstrand
		Harlow Chemicals

Included in Parcom/A1A but not in Humber Routine Survey:

Rivers	Sewage	Industry
Idle @ Bawtry	Cleethorpes	British Sugar
Hull @ Hempholme Lock	Immingham	Hazelwood
	Louth	Capper Pass
	Beverley	
	Goole	
	Selby	

APPENDIX 4
Biological Monitoring Working Party Score

Following the disappointing results of the 1970 biological classification of rivers, a Biological Monitoring Working Party (BMWP) was set up to recommend a biological classification of river water quality for use in national river pollution surveys. This finally recommended a classification of "...the biological condition of rivers based on a score system." Economic constraints, in terms of resources available for such surveys, dictated that the system should be simple, necessitating a compromise between ecological validity and logistic feasibility. The simple system resulting should, however, satisfy the not-very-demanding requirements of a broad classification system. More ecologically exacting systems can still be used for specific purposes.

The BMWP Score is the sum of the points attributed to different invertebrate families according to their degree of tolerance to organic pollution. Erring on the safe-side, the most tolerant species within each family is used in allocating the points. Each family occurring in a sample is scored only once - no matter how many species are represented.

The Average Score Per Taxon (ASPT) allows comparison between different sampling sites where the varying numbers of organisms may give considerably different BMWP Scores.

FAMILIES	SCORE
Siphlonuridae; Heptageniidae; Leptophlebiidae; Ephemerellidae; Potamanthidae Ephemeridae Taeniopterygidae; Leuctridae; Capniidae; Perlodidae; Perlidae; Chloroperlidae Aphelocheiridae Phryganeidae; Molannidae; Beraeidae; Odontoceridae; Leptoceridae; Goeridae; Lepidostomatidae; Brachycentridae; Sericostomatidae	10
Astacidae Lestidae; Agriidae; Gomphidae; Cordulegasteridae; Aeshnidae; Corduliidae; Libellulidae Psychomyiidae (Ecnomidae) Philopotamidae	8
Caenidae Nemouridae Rhyacophilidae (Glossosomatidae); Polycentropodidae; Limnephilidae	7
Neritidae; Viviparidae; Ancylidae (Acroloxidae) Hydroptilidae Unionidae Corophiidae; Gammaridae (Crangonyctidae) Platycnemididae; Coenagriidae	6
Mesoveliidae; Hydrometridae; Gerridae; Nepidae; Naucoridae; Notonectidae; Pleidae, Corixidae Haliplidae; Hygrobiidae; Dytiscidae (Noteridae) Gyrinidae Hydrophilidae (Hydraenidae) Clambidae; Scirtidae; Dryopidae; Elimidae; Chrysomelidae; Curculionidae Hydrophsychidae Tipulidae; Simuliidae Planariidae (Dugesiidae); Dendrocoelidae	5
Baetidae Sialidae Piscicolidae	4
Valvatidae; Hydrobiidae (Bithyniidae); Lymnaeidae; Physidae; Planorbidae; Spaeridae Glossiphoniidae, Hirudinidae; Erpobdellidae Asellidae	3
Chironomidae	2
Oligochaeta (whole class)	1

APPENDIX 5
Results of Humber Routine Survey: Tidal Rivers Biological Sampling

TAXA	AIRE Snaith		DON Thorne Bridge		WHARFE Ryther		HULL Beverley		HULL Sutton Rd Br		OUSE Cawood		OUSE Drax		OUSE Saltmarsh	
	May	Oct	-	Oct	Aug	Nov	May	Nov	-	Oct	-	Aug	Mar	Aug	Mar	Aug
FLATWORMS																
Planariidae	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
Polycelis torva	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-
Dugesiidae	-	-	-	-	-	3	-	3	-	-	-	-	-	-	-	-
Dendrocoelidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ROUNDWORMS																
Nematoda	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
SNAILS																
Theodoxus fluviatilis	-	-	-	-	40	37	-	-	-	-	-	-	-	-	-	-
Potamopyrgus jenkinsi	-	-	-	-	9	1935	-	-	-	6	-	-	-	-	-	1
Bithynia tentaculata	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-
Lymnaea peregra	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
Physa fontinalis	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Planorbidae	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Ancylus fluviatilis	-	-	-	-	22	8	-	-	-	-	-	1	-	-	-	-
Ancylus lacustris	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-
BIVALVES																
Spaeridae	1	-	-	-	32	175	137	-	-	-	-	-	-	-	-	-
Pisidium sp.	-	-	-	-	-	-	-	24	-	-	-	-	-	-	-	-
WORMS																
OLIGOCHAETA	64	-	-	-	12	408	403	29	-	434	-	-	-	3	-	-
Tibificidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tubifex tubifex	-	1	-	3	-	-	-	-	-	-	-	-	-	-	-	-
Tubifex/*Potamothrix* (indet.)	-	-	-	9	-	-	7	-	-	-	-	-	-	-	-	-
Tubifex costatus	-	-	-	-	-	-	-	-	-	-	-	230	-	-	-	-
Psammoryctes barbatus	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Limnodrilus claparedeanusa	-	-	-	5	-	-	3	-	-	-	-	-	-	-	-	-
L. hoffmeisteri	-	1	-	21	-	-	15	-	-	-	-	-	-	-	-	-
L. cervix	-	1	-	5	-	-	1	-	-	-	-	-	-	-	-	-
L. udekemianus	-	-	-	1	-	-	15	-	-	-	-	-	-	-	-	-
L. profundicola	-	-	-	1	-	-	-	-	-	-	-	3	-	-	-	-
Limnodrilus/*Potamothrix* (indet.)	-	-	-	52	-	-	-	-	-	-	-	25	-	-	-	-
Potamothrix hammoniensis	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-
P. moldaviensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LEECHES																
Glossiphonia complanata	-	-	-	-	-	5	-	4	-	-	-	-	-	-	-	-
Helobdella stagnalis	-	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-
Erpobdellidae	-	-	-	-	8	14	-	-	-	-	-	-	-	-	-	-
Erpobdella octoculata	-	-	-	3	-	-	1	2	-	-	-	-	-	-	-	-
E. testacea	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
CRUSTACEANS																
Asellus aquaticus	1	-	-	21	-	7	4	-	-	-	-	-	-	-	-	-
Gammarus zaddachi	-	-	-	62	1600	39	704	667	-	508	-	53	5	8	-	17
Palaeomonetes varians	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
Daphniidae	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siriella armata	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
MAYFLIES																
Caenis luctuosa	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
STONEFLIES																
Taeniopteryx nebulosa	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
BUGS																
Corixidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
BEETLES																
Haliplidae	-	-	-	-				5	-	-	-	-	-	-	-	-
Dytiscidae	-	-	-	-			1		-	-	-	-	-	-	-	-
Elmis aenea	-	-	-	-	17	51			-	-	-	-	-	-	-	-
Limnius volkmari	-	-	-	-	10	13			-	-	-	-	-	-	-	-
Oulimnius sp.	-	-	-	-	1	19			-	-	-	-	-	-	-	-
CADDIS FLIES																
Limnephilidae	-	-	-	-	-	1	5	-	-	-	-	-	-	-	-	-
Brachycentrus subnubilis	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
FLIES																
Dicronata sp.	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Chironomidae	-	1	-	-	-	-	75	4	-	5	-	-	3	-	-	-
Simuliidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnophora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Psychoptera sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
BMWP SCORE	7	3	-	13	45	83	55	31	-	15	-	13	8	7	-	14
No. scoring taxa	3	2	-	4	10	18	14	9	-	5	-	3	2	2	-	3
ASPT	2.33	1.50	-	3.25	4.50	4.61	3.93	3.44	-	3.00	-	4.33	4.00	3.50	-	4.66
Total taxa	4	4	-	4	12	22	14	9	-	6	-	4	2	2	-	6
Total no. individuals	106	4	-	184	16154	2747	1387	742	-	955	-	339	8	12	-	23
Biological classification	B3-	B4	-	B3-	B2-	B1B	B2	B3-	-	B3	-	B3-	B3-	B3-	-	*

APPENDIX 6
Results of Humber Routine Survey: North Bank Intertidal Biological Sampling

	Low Shore					Mid Shore											
SITE	N1	N3	N4	N5	N6	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12
TAXA (No. per sq m)																	
#*Nemertea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0
#*Nematoda*	48	24	71	24	143	24	214	0	48	119	4284	4546	27156	405	1214	714	690
Paranais litoralis	48	0	0	0	0	857	14804	24	0	71	0	0	0	0	0	0	0
Tubifex costatus	24	95	0	24	0	428	7568	1476	0	48	0	0	0	0	0	0	0
Tubificoides benedii	0	0	0	0	357	24	0	0	0	119	3897	23657	50075	714	8901	24	0
Tubificoides indet	0	0	0	0	0	0	71	0	0	0	0	0	0	0	0	0	0
Lumbriculidae	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0
Enchytraeidae	0	0	0	0	0	0	48	71	0	0	60	0	24	0	0	0	0
Oligochaete sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Syllidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	95
Nereis diversicolor	0	0	0	119	0	48	0	928	48	309	684	762	500	214	3641	238	0
:*Nereis hombergii*	0	0	0	0	0	0	0	0	0	0	0	0	95	452	24	405	71
:*Nephtys kersivalensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
Eteone longa/flava gp	0	0	0	0	24	0	0	0	0	0	30	643	2689	738	1190	428	24
Pygospio elegans	0	24	0	0	0	0	0	0	0	0	0	357	2190	12495	238	8568	95
Spio decorata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48
Streblospio schrubsolii	0	48	48	0	0	0	0	24	0	71	60	0	143	0	119	24	0
Spionid indet	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0
Tharyx sp.	0	0	0	0	0	0	0	0	0	0	0	0	24	0	190	48	0
Mediomastis fragilis	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0
Capitella capitata	0	0	0	0	0	0	0	0	0	0	0	0	119	0	0	0	0
Manayunkia aestuarina	0	0	0	0	0	0	0	0	0	0	60	0	0	0	0	0	0
Polychaete indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	333
Hydrobia ulvae	0	0	0	0	0	0	0	0	0	0	0	500	952	1023	143	405	143
Retusa obtusa	0	0	0	0	0	0	0	0	0	0	0	0	0	785	95	357	0
Cerastoderma edule	0	0	0	0	0	0	0	0	0	0	0	0	0	357	48	405	24
Macoma balthica	0	0	0	0	476	24	0	0	0	24	3392	9520	14613	8044	3475	5022	0
Mytilus edulis	0	0	0	0	0	0	0	0	0	0	0	0	0	48	0	0	0
Bivalvia indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0
Bathyporeia pilosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24
Corophium volutator	0	0	71	24	762	71	95	1023	190	48	35432	0	0	643	262	0	0
Tanaissus lilljeborgi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	71
Amphipoda indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48
Carcinus maenas juv.	0	0	0	0	0	0	0	0	0	0	0	0	0	95	0	0	0
#*Ostracoda*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	119
#*Collembola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
#*Copepoda*	0	0	0	0	0	0	0	0	0	0	0	0	119	0	0	405	24
TOTAL	120	190	190	190	1761	1476	22800	3546	286	809	47897	39984	98771	26013	19588	17041	1833
No. taxa	3	4	3	4	5	7	6	6	3	8	9	7	16	13	15	13	15
* average based on 4 cores only																	
TOTAL	72	167	119	167	1619	1452	22586	3546	238	690	43615	35439	71496	25608	18350	15924	1000
No. taxa excluding #	2	3	2	3	4	6	5	6	2	7	8	6	14	12	13	11	11
: included as one taxa																	

APPENDIX 7
Results of Humber Routine Survey: South Bank Intertidal Biological Sampling

	Low Shore							Mid Shore									
SITE	S2	S3	S4	S5	S7	S8	S9	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
SPECIES (No. per 5 cores - 10 cores at S9 & S10)																	
Nemertea spp.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	14	14
Anaitides mucosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Eteone longa	0	0	1	0	0	0	0	0	0	3	0	1	10	0	13	2	0
Autolytus sp.	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
Nereis diversicolor	0	0	0	0	0	0	0	0	2	44	17	1	36	0	6	0	0
Nereis spp. juv.	0	0	0	0	0	0	0	0	0	3	9	1	0	0	2	0	0
Nephtys hombergii	0	0	0	0	16	17	0	0	0	0	0	0	1	15	2	0	0
Nephtys cirrosa	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	8	3
Nephtys spp. juv.	0	0	0	0	2	5	0	0	0	0	0	0	0	0	0	0	0
Sphaerodoropsis minuta	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	0	0
Glycera sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Scoloplos armiger	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0
Paraonis fulgens	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	5	8
Spio martinensis	0	0	0	0	0	0	31	0	0	0	0	0	0	0	0	40	5
Polydora spp.	0	0	0	167	0	0	0	0	0	0	0	0	0	0	7	0	0
Pygospio elegans	0	0	27	3	0	9	9	0	0	11	1	17	83	25	180	308	14
Spiophanes bombyx	0	0	0	0	0	0	26	0	0	0	0	0	0	0	0	3	0
Streblospio schrubsolii	0	2	14	16	2	32	0	0	0	140	6	0	0	4	0	0	0
Tharyx spp.	0	0	0	0	6	50	0	0	0	0	0	0	0	9	58	0	0
Capitella capitata	0	0	0	0	0	0	2	0	0	0	0	0	3	0	1	0	0
Alkmaria romijni	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Manayunkia aestuarina	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Paranais litoralis	0	0	0	0	0	0	0	8	0	0	1	0	1	0	0	0	0
Enchytraeidae	1	14	0	0	0	0	0	0	1	0	17	0	0	0	0	0	0
Tubifex costatus	0	1	0	1	0	0	0	43	10	3	0	0	0	0	0	0	0
Tubificoides benedii	0	0	1	0	0	5	1	0	2	1	0	1	924	15	0	0	2
Tubificoides swirencoides	0	0	0	0	34	20	0	1	0	0	0	0	0	0	0	0	1
Tubificidae juv.	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
Pontocrates sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Haustorius sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Urothoe sp.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	9	30
Bathyporeia spp.	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	38	8
Gammarus spp.	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corophium volutator	0	0	0	892	0	1	0	22	1	182	353	328	779	0	5	0	0
Eurydice pulchra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4
Cyathura carinata	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanaidacae sp.	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0
Cumacea sp.	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	2
Crangon sp.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Hydrobia ulvae	0	0	0	0	0	4	0	0	0	0	0	0	0	3	60	0	3
Mytilidae juv.	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Cerastoderma juv.	0	0	0	0	0	4	1	0	0	0	0	0	0	0	5	0	0
Macoma balthica 'adult'	0	0	0	0	0	0	0	0	0	2	0	1	12	5	0	1	0
Macoma balthica 'juv.'	0	0	0	0	2	0	0	0	0	3	27	41	18	309	12	0	0
Scrobicularia plana	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Ensis 'spat'	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Mys sp. juv.	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
TOTAL	1	18	50	1079	62	150	123	74	24	393	432	391	1869	385	354	433	97
No. Taxa	1	4	8	5	5	11	17	4	5	9	8	6	11	7	13	13	13

APPENDIX 8
Results of Humber Routine Survey: Fish Sampling

Table A8.1 Fish Distribution in Humber Survey September 1994

Species		Whitton	Read's Island	Humber Bridge	Hessle	Skitter	Paull	Halton Flat	Burcom Shoal A	Burcom Shoal B	Hawkin's Point A	Hawkin's Point B
Sprat	*Sprattus sprattus*											
Herring	*Clupea harengus*						1.1				1.3	
Eel	*Anguilla anguilla*		1.9									
Nilsson's pipefish	*Syngnathus rostellatus*											1.2
Whiting	*Merlanguis merlangus*										1.3	
5-B. Rockling	*Ciliata mustela*							0.8				
Sand eel	*Ammodytes tobianus*											1.2
Lesser weever	*Trachinus vipera*											
Sand goby	*Pomatoschistus minutus*	1.9	5.5	3.1	27.9	0.9	2.2	2.3	1.4		7.9	2.4
Dragonet	*Callionymus lyra*											
Pogge	*Agonus cataphractus*											
Sea snail	*Liparis liparis*						20.6		1.4	3.9		
3-sp. stickleback	*Gasterosteus aculeatus*									1.3		
Dab	*Limanda limanda*											
Flounder	*Platichthys flesus*										1.3	1.2
Plaice	*Pleuronectes platessa*										1.3	2.4
Dover sole	*Solea solea*					3.7	9.8	8.5	1.4	6.5	1.3	
Number of species per trawl		1.0	2.0	1.0	1.0	2.0	4.0	3.0	3.0	3.0	6.0	5.0
Abundance per 1000 sq m		1.9	6.4	3.1	27.9	4.6	33.7	11.6	4.2	11.7	14.4	8.4

Species		Grimsby Middle A	Grimsby Middle B	Clee Ness A	Clee Ness B	Bull Sand Fort A	Bull Sand Fort B	Spurn	Haile Sand A	Haile Sand B	Haile Sand C
Sprat	*Sprattus sprattus*		1.0					2.5			
Herring	*Clupea harengus*									1.4	
Eel	*Anguilla anguilla*										
Nilsson's pipefish	*Syngnathus rostellatus*								2.5		
Whiting	*Merlanguis merlangus*									1.4	7.5
5-B. Rockling	*Ciliata mustela*										
Sand eel	*Ammodytes tobianus*	0.7							1.3		
Lesser weever	*Trachinus vipera*						1.4		8.8	7.1	7.5
Sand goby	*Pomatoschistus minutus*	3.4	6.1	7.5	15.7	44.3	12.6		56.3	74.3	22.5
Dragonet	*Callionymus lyra*									2.9	
Pogge	*Agonus cataphractus*							1.3			2.5
Sea snail	*Liparis liparis*	0.7		6.5	5.2	1.3				2.9	1.3
3-sp. stickleback	*Gasterosteus aculeatus*										
Dab	*Limanda limanda*	0.7					1.4	1.3	10.0	2.9	17.5
Flounder	*Platichthys flesus*							1.3	1.3		
Plaice	*Pleuronectes platessa*							8.8	23.8	50.0	7.5
Dover sole	*Solea solea*			13.1	2.6			1.3		4.3	6.3
Number of species per trawl		4.0	2.0	3.0	3.0	2.0	3.0	6.0	7.0	9.0	8.0
Abundance per 1000 sq m		5.5	7.1	27.1	23.5	45.6	15.4	16.5	104.0	147.2	72.6

Table A8.2 Pushnet Results from Humber Survey September 1989 - 1994

Species		CLEETHORPES 1989	1990	1991	1992	1993	1994	SPURN POINT 1989	1990	1991	1992	1993	1994
Sprat	*Sprattus sprattus*			1.9									
Herring	*Clupea harengus*			2.9	1.0		1.9		1.0	1.0			
Nilsson's pipefish	*Syngnathus rostellatus*	2.0	4.0	1.0	10.5		1.9						
Whiting	*Merlanguis merlangus*				1.0								
Sand eel	*Ammodytes tobianus*			1.0	1.1				1.0	1.9	5.7		
Lesser weever	*Trachinus vipera*			1.9	1.9	1.9				1.9	2.9	1.0	3.8
Sand goby	*Pomatoschistus minutus*	8.0	168.0	82.9	108.6	10.5	74.3		3.0	2.9	4.8	21.9	43.8
Common goby	*P. microps*		5.0	1.0	48.6							2.9	
Painted goby	*P. pictus*	1.0											
Turbot	*Scophthalmus maximus*		1.0	2.9		4.8		9.0	18.0	11.4	3.8	1.0	7.6
Brill	*S. rhombus*				1.9	1.9				3.8	1.0	1.0	1.9
Dab	*Limanda limanda*				1.0	1.0			1.0				
Flounder	*Platichthys flesus*				1.0								
Plaice	*Pleuronectes platessa*	111.0	250.0	33.3	99.0	46.7	31.4	22.0	41.0	34.3	46.7	43.8	59.0
Dover sole	*Solea solea*					12.4					1.9	2.9	1.0
Number of species per trawl		4.0	5.0	8.0	11.0	7.0	4.0	2.0	6.0	7.0	7.0	7.0	6.0
Abundance per 1000 sq m		122.0	428.0	129.0	276.0	79.2	109.5	31.0	65.0	57.0	66.0	74.5	117.1

APPENDIX 9
CEWP Scheme for Classifying Estuaries

DESCRIPTION	Points awarded if the estuary meets this description
Biological Quality (scores under a, b, c and d to be summed)	
a) Allows the passage to and from freshwater of all the relevant species of migratory fish, when this is not prevented by physical barriers	2
b) Supports a resident fish population which is broadly consistent with the physical and hydrographical conditions	2
c) Supports a benthic community which is broadly consistent with the physical and hydrographical conditions	2
d) Absence of substantially elevated levels in the biota of persistent, toxic or tainting substances from whatever source	4
Maximum number of points	10
Aesthetic Quality	
a) Estuaries or zones of estuaries that either do not receive a significant polluting input or which receive inputs that do not cause significant aesthetic pollution	10
b) Estuaries or zones of estuaries that receive inputs which cause a certain amount of pollution but do not seriously interfere with estuary usage	6
c) Estuaries or zones of estuaries that receive inputs which result in aesthetic pollution sufficiently serious to affect estuary usage	3
d) Estuaries or zones of estuaries that receive inputs which cause widespread public nuisance	0
Water Quality (score according to quality)	
Dissolved oxygen exceeds the following saturation levels:	
60%	10
40%	6
30%	5
20%	4
10%	3
below 10%	0

The points awarded under each of the headings (biological quality, aesthetic quality, water quality) are summed. Waters are classified on the following scales:

Class A	Good Quality	24 to 30 points
Class B	Fair Quality	16 to 23 points
Class C	Poor Quality	9 to 15 points
Class D	Bad Quality	0 to 8 points