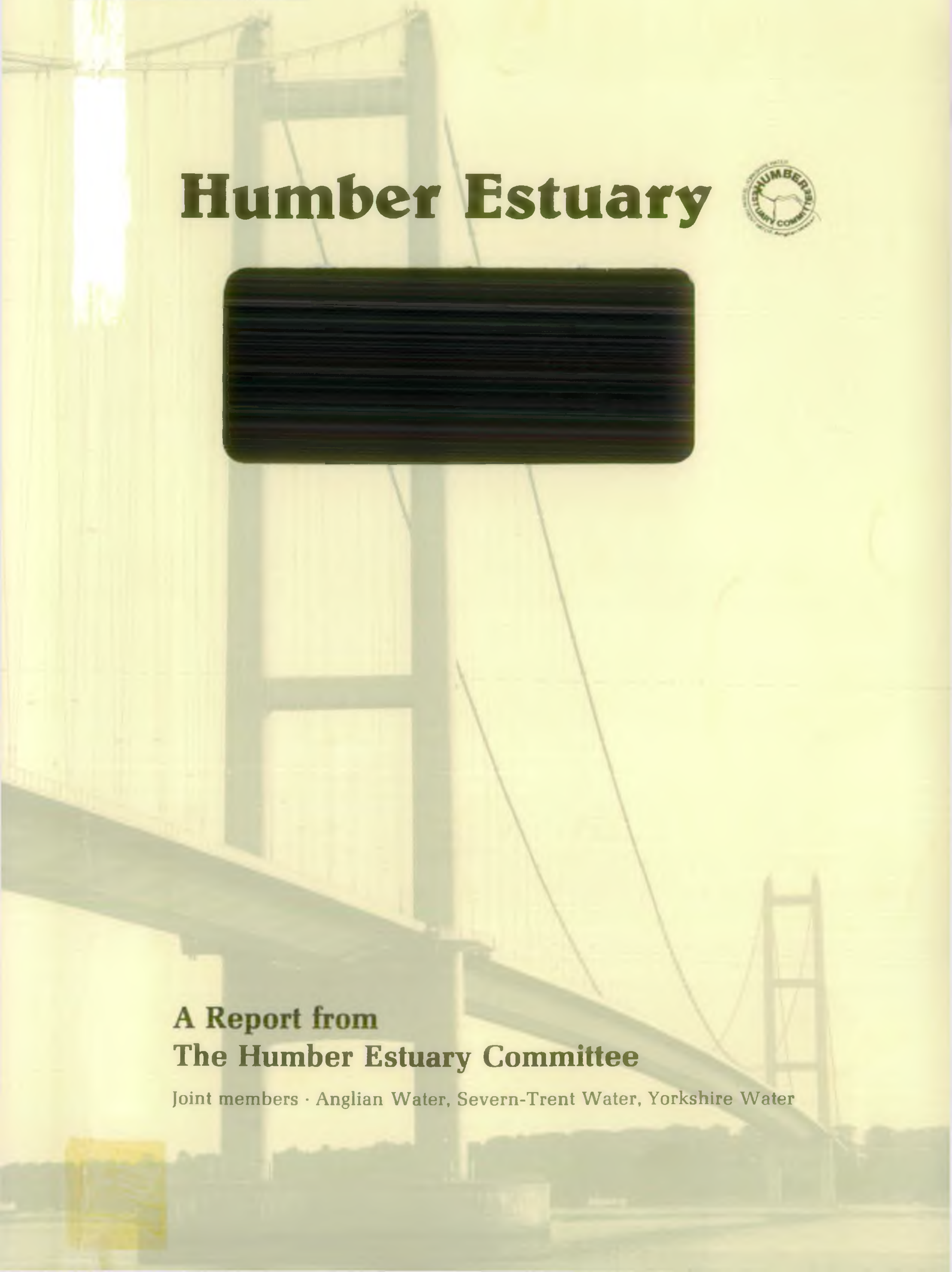

Humber Estuary

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A Report from The Humber Estuary Committee

Joint members · Anglian Water, Severn-Trent Water, Yorkshire Water

[redacted]

THE WATER QUALITY OF THE HUMBER ESTUARY

1986

Report edited for the Humber Estuary Committee
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SUMMARY

The Humber Estuary Committee of the Anglian, Severn-Trent and Yorkshire Water Authorities co-ordinates the water quality management and monitoring of the estuary. Environmental quality objectives based on protecting existing and potential future uses of the water have been established. These are defined by quality standards set for the water column. Routine monitoring programmes, which are supplemented by intensive special surveys, cover the chemical quality of the Humber and its tidal rivers, freshwater river and effluent inputs, metal accumulation in sediments and organisms, and the invertebrate fauna.

The results for 1986 show that the outer Estuary is of high quality with a diverse benthic fauna. The main water quality problem is the depletion of dissolved oxygen levels at times of low freshwater flows in the tidal Ouse, Aire and Don and which also affects the lower Trent and upper Humber. Work is in progress or planned for improvements to sewage treatment works and industrial effluent discharges so that the environmental quality standards are fully met. Action is also well advanced to reduce arsenic levels along the north shore of the upper Estuary.

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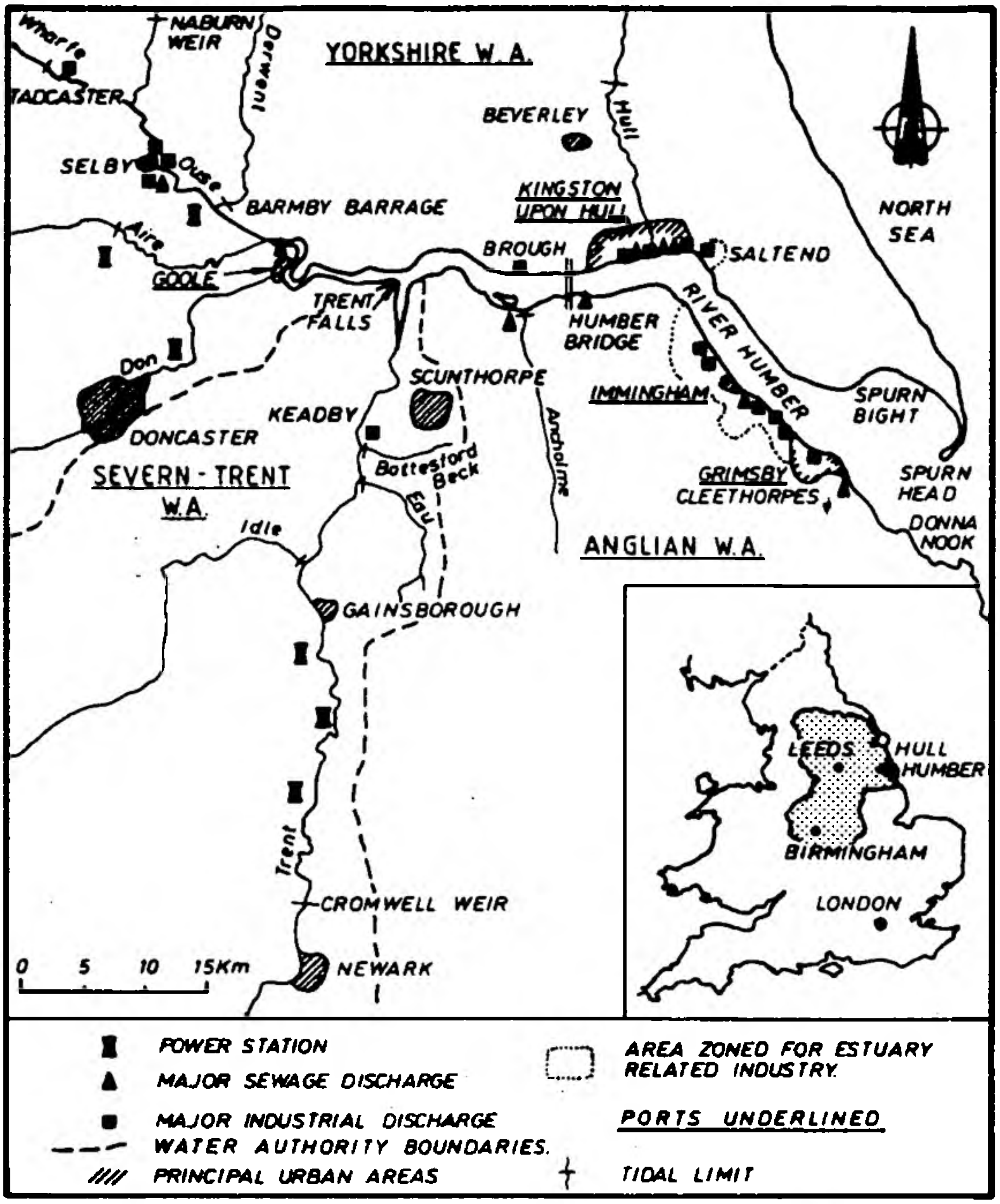


FIG. 1. THE HUMBER ESTUARY & ITS CATCHMENT.

THE WATER QUALITY OF THE HUMBER ESTUARY 1986

1. INTRODUCTION

1.1 The Humber has the largest catchment of any estuary in the U.K. and is the largest single source of freshwater from the country into the North Sea. Co-ordinated monitoring of the Humber and its tidal rivers dates from the early 1960s. This report discusses the results of monitoring for 1986 in the light of the management of water quality undertaken by the Anglian, Severn-Trent and Yorkshire Water Authorities through their Humber Estuary Committee.

The report considers the loads of potentially polluting materials discharged to the estuary, compliance with Environmental Quality Standards for the tidal rivers and estuary, metals in sediments and biota, benthic fauna and recent developments relevent to water quality management and monitoring.

1.2 The Humber Estuary covers the River Humber (62 km long) and its tidal rivers - The Trent, Yorkshire Ouse, Don, Aire, Wharfe and Hull (fig. 1). The total length of the tidal waters of the system is 313 km with the longest tidal run being 147 km from Spurn Head to Cromwell Weir on the Trent. At Immingham the average rise and fall in water level during the tidal cycle is about 5m, ranging from less than 2m to more than 7m at extreme neap and spring tides. The average tidal excursion in the open Humber is about 15 km, which is many times greater than the seaward displacement of the water due to freshwater flow. The estuary receives on average daily runoff of approximately 13,000 m^3 from a catchment area of 24,420 km^2.

1.3 The Humber's catchment has a population of 10.8m, one fifth of the U.K. population, including the cities of Birmingham, Bradford, Derby, Leeds, Leicester, Nottingham, Sheffield and Stoke-on-Trent. It contains 60% of the country's coal production, 40% of crude steel production and 40% of the capacity of the Central Electricity Generating Board. West Yorkshire has the country's largest concentration of wool textile industries. On the banks of the estuary are a non-ferrous metal smelter, two oil refineries (16m tonnes per annum capacity) and several chemical complexes including two plants producing titanium dioxide pigments. Food processing is particularly associated with the ports of Goole, Grimsby, Hull and Immingham. However, the banks of the Humber are not fully urbanised and large, flat sites adjacent to deep water facilities are available for the development of new 'estuary related' industries. There is also much high grade agricultural land beside the Humber.

1.4 The outer Humber supports a sea fishery and fish nursery ground plus a shellfishery. The importance of these has declined during the second half of the century, although angling interest is buoyant in the Humber, tidal Trent, tidal Wharfe and upper part of the tidal Ouse. The marshes and mudflats between Trent Falls and the Humber Bridge and at Spurn Bight include notified Sites of Special Scientific Interest of international importance for their salt marsh communities and for their population of ducks, geese and waders. Cleethorpes is a tourist resort within the esutary with a bathing beach designated under the EC Directive on the Quality of Bathing Waters.

2. MANAGEMENT FRAMEWORK

2.1 The objectives of the Humber Estuary Committee are set out in Appendix 1. The Committee has set environmental quality objectives (EQO) related to water use, based on the recommendations of the third report of the Royal Commission on Environmental Pollution published in 1972. These are:

(i) The protection of all existing defined uses of the estuary system.

(ii) The ability to support on the mud bottom the biota necessary for sustaining sea fisheries.

(iii) The ability to allow the passage of migratory fish at all stages of the tide.

2.2 The environmental quality standards (EQS) set for the water column, which provide numerical values for the quality determinands which define the EQOs, are also given in appendix 1. They include mandatory standards for highly toxic, persistent and bio-accumulative substances on List 1 of Directive 76/464/EEC on "Pollution caused by Certain Dangerous Substances Discharged into the Aquatic Environment of the Community", and the national standards for less dangerous "List 2" substances.

2.3 The Humber Estuary Committee's policy is that any new discharge of trade or sewage effluent should be controlled so that it does not cause the environmental quality standards to be exceeded, except within the defined "mixing zone" around the outfall. Guidelines for setting mixing zones were published by the Water Authorities Association in 1986. The policy for existing discharges is that they should be controlled so that the EQSs are fully met by 1995.

2.4 Co-ordinated monitoring of the Humber system was set up in 1961 and has been modified at intervals since then. The routine programmes now are:

(i) Chemical analysis of water samples from eighteen shore stations at high and low slack water seven times per year.

(ii) Continuous monitoring of dissolved oxygen at a number of locations.

(iii) Chemical analysis of rivers at their tidal limits and of significant effluent discharges to the system. This is co-ordinated with monitoring of the water in the estuary, although additional samples are collected for testing compliance with effluent discharge consent conditions and other purposes.

(iv) Analysis of shore and mid-estuary sediments for metals twice per year.

(v) Analysis of seaweed and ragworms from the shores and shrimps from mid-estuary twice per year to determine the bio-accumulation of metals. Data on metals and toxic organic substances in fish caught in the Humber are provided by the Ministry of Agriculture, Fisheries and Food.

(vi) Community analysis once per year of intertidal and sub-tidal fauna at thirty-one sites.

2.5 In addition, over the years a number of surveys across the estuary and over tidal cycles have been undertaken using boats, helicopters and hovercraft. There has also been fixed station sampling over tidal cycles and intensive surveys to establish the extent of the effluent plumes from some industrial discharges. Surveys of the sub-tidal fauna at up to seventy stations have been undertaken three times since 1977 to supplement the annual, more limited sampling programme.

2.6 A mathematical model of the Humber and tidal rivers is used to investigate the factors affecting dissolved oxygen and to simulate the impact of proposed new discharges. In particular it has been used to plan the strategy to improve the level of dissolved oxygen in the tidal Ouse and upper part of the Humber.

3. CHEMICAL SAMPLING AND ANALYSIS

3.1 In 1986, seven tidal water surveys of the Humber system were carried out as planned, with the main freshwater and effluent inputs being sampled in the seven days prior to each survey. The survey on 16 June was combined with a special intensive survey involving hourly sampling over a tidal cycle. The special survey was designed to examine the behaviour of metals in the estuary and to check the validation of the Humber dissolved oxygen model.

3.2 The location of the routine chemical tidal water sampling stations, along with those for sediments/bio-accumulation and benthic fauna are shown in fig 2 (appended). It was not possible to sample the river Wharfe at Ryther during 1986 as the sampling site is now considered unsafe. Otherwise, 99% of the tidal water samples were taken with good coverage of the chemical parameters in the programme and other data requirements.

3.3 Continuous dissolved oxygen monitoring stations on the tidal Trent at Flixborough and Burton Stather operated reliably throughout the year. On the river Humber, stations operated for limited periods at Blacktoft, Upper Whitton, Hull, Saltend, and the SCM Jetty near Immingham. The new station at the SCM Jetty was installed in June and data were collected until September when equipment problems developed. Problems were also encountered with new equipment installed at Blacktoft and Hull, the detectors proved faulty and had to be returned to the manufacturer.

4. FRESHWATER RIVER AND EFFLUENT INPUT

4.1 The mean freshwater flows for the 1986 surveys are compared with those for the previous years in Table 1; they were the highest for a number of years. Flows were very high during the survey on 21 April, particularly for the Ouse system where the flow of 650 m^3/sec was the highest figure on record during a Humber survey.

Table 2

NON-TIDAL RIVER INPUTS TO THE HUMBER SYSTEM 1986

1985 DATA IN BRACKETS

Station	NWC Classification		Mean Daily Flow m^3/sec	DO% 5%ile
	Present Class	River Quality Objective		
River Ouse at Naburn	1B	1B	56.7 (42.7)	65 (79)
River Wharfe at Tadcaster	1B	1B	21.0 (16.2)	84 (84)
River Aire at Beal	3	2	42.8 (29.0)	50 (54)
River Don at Doncaster	3	2	21.0 (12.3)	77 (72)
River Trent at Winthorpe	2	2	98.8 (81.5)	81 (84)
River Derwent at Loftsome Bridge	1B	1B	18.9 (16.1)	80 (87)
River Idle at Misterton	1B/2	1B	6.3 (5.2)	73 (68)
Bottesford Beck at Snake Plantation	3	3	0.38 (0.32)	58 (58)
Three Rivers at Keadby	2	2	1.24 (1.88)	80+(62+)

Station	BOD + ATU mg/l		Total Ammonia (mg/l-N)		Unionised Ammonia (mg/l-N)
	Mean	95%ile	Mean	95%ile	95%ile
River Ouse at Naburn	2.5 (2.3)	3.9 (3.9)	0.31 (0.32)	0.64 (0.66)	0.015 (0.015)
River Wharfe at Tadcaster	2.1 (1.7)	3.9 (3.9)	0.14 (0.09)	0.42 (0.27)	0.006 (0.006)
River Aire at Beal	6.2 (6.2)	9.2 (10.5)	2.3 (2.6)	4.5 (5.7)	0.034 (0.040)
River Don at Doncaster	6.9 (6.1)	13.3 (9.8)	4.8 (7.3)	8.6 (10.8)	0.107 (0.140)
River Trent at Winthorpe	4.6 (3.1)	8.8 (4.5)	0.7 (0.8)	2.0 (1.3)	0.025 (0.023)
River Derwent at Loftsome Bridge	1.5 (1.7)	2.7 (3.6)	0.12 (0.09)	0.30 (0.24)	0.005 (0.006)
River Idle at Misterton	3.0 (3.6)	5.9 (8.6)	0.4 (0.39)	1.0 (1.2)	0.015 (0.006)
Bottesford Beck at Snake Plantation	5.5 (6.4)	9.3 (11.4)	3.1 (4.4)	4.9 (7.3)	0.113 (0.114)
Three Rivers at Keadby	4.3 (3.3)	8.0+ (6.3+)	0.9 (0.78)	2.2+ (2.2+)	0.015+(0.013+)

+ Maximum/minimum result

Table 1 Mean Annual Freshwater Flows for Humber Surveys (m^3/sec)

(based on the flows over the seven days prior to each survey)

River	Year 1982	1983	1984	1985	1986
Ouse	144	118	121	92	183
Trent	101	88	91	77	116
Total	245	206	212	169	299

4.2 A summary of 1986 quality data for the main freshwater inputs is given in Table 2 (1985 figures are given in brackets). The poor quality of the Aire and Don continues to have a major effect on dissolved oxygen levels in the tidal Ouse. Over the last twelve years the Trent has maintained acceptable quality, while there were significant improvements in the level of ammonia, BOD and dissolved oxygen in the Aire and Don in the middle and late seventies but there has been little change in recent years.

4.3 The BOD and ammonia loads for the major freshwater inputs, calculated from weekly or fortnightly samples, are shown in fig. 3. The figure also shows estimates of the loads of BOD and ammonia in the Aire and the Don when Yorkshire Water's strategy for achieving the quality objectives (RQO) for these rivers is fully implemented. It can be seen that the polluting loads to the estuary will be significantly reduced. The loads of BOD and ammonia from the Trent are high due to the large flow; the river meets its quality objective.

4.4 Yorkshire Water has a programme of capital investment in sewerage systems and sewage treatment works designed to achieve its river quality objectives. This will cost in the order of £250m over 15 to 20 years at current rates of expenditure. However there should be considerable improvement to the Aire and Don at their tidal limits by the mid 1990s. Major Yorkshire Water schemes in progress or planned which will benefit the Humber include:

(i) Reconstruction of Knostrop sewage treatment works, Leeds (cost in the order of £20m).

(ii) Improvements to Huddersfield sewage treatment works.

(iii) Construction of a new bio-aeration system for Blackburn Meadows sewage treatment works, Sheffield (£15m).

(iv) Reconstruction of Old Whittington sewage treatment works, Chesterfield, including provision of capacity to treat strong coal carbonisation liquors which, inter alia, contribute ammonia to the rivers.

In addition, improvements to effluent treatment are being made by industries with direct discharges to the non-tidal rivers of Yorkshire, which will also benefit the estuary.

4.5 The BOD and ammonia loads for the main effluent discharges are shown in fig 4. The BOD loads discharged at Selby have a major effect on the dissolved oxygen levels in the tidal Ouse. The principal trade discharge of BOD to the tidal Ouse has recently become subject to control under the Control of Pollution Act 1974. In 1987 the firm will commission a new treatment plant which will substantially reduce the input.

4.6 For the main freshwater inputs, the levels of cadmium, chromium, copper, iron, nickel, lead, zinc, mercury and arsenic all met the freshwater EQS values. The river Aire was the only freshwater input to exceed the Hexachlorocyclohexane (HCH) standard - the mean level of HCH ($\alpha + \gamma$) at Beal was 0.113 ug/l in 1986 compared to the freshwater standard of 0.10 ug/l; this was a reduction on the previous year. The HCH levels for the river Aire at Beal over the period 1980-1986 are shown in fig. 5. The discharge of HCH occurs mainly through sewage treatment works and surveys to identify sources are in progress. Use of HCH in sheep dips has largely ceased and consequently contamination via textile mills should show progressive reduction. However, it may take some time for contaminated river sediments to be flushed out of the system.

4.7 The loads of List I and List II metals from the main effluent inputs direct to the tidal system (almost entirely to the Humber itself) and the main freshwater inputs are shown in fig. 6 and in table 3. The loads from the non-tidal rivers vary greatly with flow. The average daily input load of total metals (i.e. dissolved plus particulate fractions) for 1984-86 is shown in the figure and table and is compared with the averages for each year for the other two sources. Further work is required to assess the most representative way in which to calculate the freshwater input into the estuary and the precision of the estimates. During 1986 a treatment works was commissioned for the chlor-alkali plant which discharges to the river Rother. This will consequently reduce the amount of mercury coming into the tidal system from the river Don.

4.8 The arsenic load is almost entirely due to a single trade effluent discharge on the North bank of the Humber, the load discharged has increased substantially but is within the existing consented load. Extensive survey and modelling work was carried out by Yorkshire Water in 1986 and the company agreed to install an extended pipeline and other facilities to reduce high concentrations and improve effluent dispersion, thus reducing the size of the mixing zone in which the EQS is exceeded. The new pipeline will be operational in the summer of 1987. Further monitoring work will be carried out by Yorkshire Water in 1987 to check the impact of the discharge.

Table 3 Input of Metals to the Humber (kg/day)

Source	Hg	Cd	Cr	Cu	Ni	Pb	Zn	As
Rivers	2.2	11.1	142	315	373	307	1,068	59
Sewage Effluents	0.8	1.9	91	20	17	22	147	3
Trade Effluents	0.2	7.6	702	102	70	71	1,280	1,080
Total	3.8	20.6	935	437	460	400	2,495	1,142

4.9 It should be noted that the input of substances into the tidal waters of the Humber does not necessarily equate with the input from the Estuary into the North Sea. Much of the metal is likely to be absorbed onto sediments and retained within the system.

5. TIDAL WATER QUALITY

5.1 Unsatisfactory dissolved oxygen conditions were encountered in the surveys on 31 July and 18 September particularly in the tidal Ouse. The worst conditions were encountered in September survey with less than 5% dissolved oxygen at Drax at both low and high water. For this survey temperatures were relatively cool in the tidal Ouse (10-13°C), but the flows were low (less than 10 percentile) and it was a spring tide (6.6m at Immingham). The Humber model has indicated that the combination of low freshwater flows and a spring tide tends to hold back water in the tidal rivers leading to low dissolved oxygen in the tidal Ouse. Average dissolved oxygen profiles in the Ouse-Humber and Trent-Humber for the periods 1976-80 and 1981-86 are shown in fig. 7.

5.2 There are indications of a slight deterioration in the lower Humber and a slight improvement in the upper part of the Ouse although, because of changes in sampling frequency and location, it is doubted whether these are statistically significant. Dissolved oxygen conditions in the lower Ouse were very similar for both periods.

5.3 Unusually high BOD levels and suspended solids levels were encountered in the tidal Aire and Don during survey on 5 March. BOD levels were 30 and 33mg/l at Snaith and 20 and 25 mg/l at Kirk Bramwith at low and high water respectively. Examination of river flow data indicated that both rivers had risen from a low level very rapidly just before the survey. This resulted in substantial scouring of river sediments producing high suspended solids and associated BOD levels.

5.4 The 1986 tidal water data are summarised and compared with EQS values in Table 4. As in previous years, the Ouse, lower Aire and Don failed to comply with respect to dissolved oxygen and the lower Aire and the Ouse at Blacktoft failed to comply with respect to unionised ammonia. The Ouse at Boothferry also failed marginally on unionised ammonia.

5.5 For the metals considered, the only non-compliance was for dissolved arsenic at Brough (high water). The average level was 36 ug/l compared with the EQS of 25 ug/l. Data from the special survey indicated quite high levels of dissolved arsenic in the upper part of the River Humber.

Table 4

1986 HUMBER ROUTINE CHEMICAL SURVEY DATA
COMPARISON WITH ENVIRONMENTAL QUALITY STANDARD

Station	Temp °C 95%ile	DO% 5%ile	pH range	Ammonia Unionised (mg/1 N) 95%ile	Annual Average (μg/1)									
					Cd T	Cr D	Cu D	Ni D	Pb D	Zn T	Hg T	As D	Fe D	HCH T
Tidal River														
OUSE														
Cawood	23	78	7.6-8.0	0.016	0.5	4	4	3	3	59	0.2	2	200	0.008
Selby	20	15Ø	7.4-7.9	0.006	0.5	3	5	4	4	98	0.2	2	200	0.011
Drax	19	3Ø	7.2-7.9	0.011	0.4	3	6	5	3	69	0.2	3	100	0.024
Boothferry	22	18Ø	7.2-7.9	0.023Ø	0.5	4	10	11	4	88	<0.2	4	100	0.031
Blacktoft	19	12Ø	7.3-7.9	0.040Ø	0.6	4	16	10	5	132	0.2	11	100	0.022
AIRE														
Snaith	21	31Ø	7.2-7.8	0.022Ø	0.6	6	11	11	3	84	0.2	5	100	0.092
DON														
Kirk Bramwith	23	50	7.0-7.7	0.123Ø	0.5	<5	13	33	<5	79	0.3		100	0.034
Rawcliffe	20	24Ø	7.2-7.8	0.094Ø	0.9	4	13	22	4	81	0.2	4	100	0.025
TRENT														
Dunham	23+	75+	7.4-7.9	0.015+	0.6	2	9	26	1	83		4	100	0.026
Gainsborough	23	74	7.3-7.9	0.019	0.4	2	15	22	2	57		5	100	0.027
Keadby	20	64	7.4-8.0	0.017	0.5	3	19	16	2	79		9	200	0.020
EQS	25	40	5.5-9.0	0.021	5T	250D	28D	200D	250D	500T	1.0T	50D	1000D	0.100T
					D	D	D	D	D	D	D	D	D	T
Estuary														
HUMBER														
Brough	21+	69+	7.5-7.9	0.005+	0.8T	5		18T	8	20	<0.1	36Ø	100	0.028Ø
New Holland	17	69	7.5-8.0	0.003	0.3		9	6	1	12				0.013
Albert Dock	17	65	7.4-7.8	0.003	0.8	5		6	6	20	<0.1	5	200	0.013
Saltend	16	66	7.4-7.7	0.002	0.6	7		6	5	22	<0.1	4	200	0.018
Killingholme	15	78	6.5-7.9	0.002	0.3		4	7	<1	15				0.010
Spurn	18	87	7.2-8.0	0.003	0.4	9		4	5	23	<0.1	2	400	0.011
EQS	25	55	6.0-8.5	0.021	5D	15D	5D	30D	25D	40D	0.5D	25D	1000D	0.02T

NOTES
- T total, D dissolved
- \+ maximum/minimum result
- Ø non-compliance

Metals and HCH data based on high water samples

At Upper Whitton which is about 1 km upriver of Brough, the average level of dissolved arsenic over a tidal cycle was 18 ug/l in mid channel. As mentioned in paragraph 4.7, the major arsenic discharger is taking measures to reduce the high concentrations found along the shore, but the background levels in the estuary as a whole will have to be carefully monitored.

5.6 Data for cadmium, chromium, nickel, lead, zinc, mercury and iron were well below the EQS at all stations. For copper, there was little reliable routine survey data for the saline stations due to problems with sample preparation and analysis. Copper data from the special survey samples analysed by the Water Research Centre (WRc) indicated dissolved levels in the range 1-10 ug/l. The EQS is 5 ug/l as dissolved inorganic copper, whereas the data reported include the organic complexes as well. It is unlikely that the copper levels in the estuary will give cause for concern although at the present time there are no practicable analytical methods to determine the inorganic species.

5.7 For hexachlorocyclohexane, the only non-compliance was at Brough (high water), this should not be considered significant as confidence limits are wide and the main source is the river Aire catchment, where levels are falling (see 4.5). Analysis for DDT was carried out during 1986 but limits of detection were not always adequate in relation to the EQS. Further work is also required on the recovery of pesticides from samples with high levels of suspended solids. Reliable data were available for the river Trent with average levels of pp DDT of 0.001, 0.001 and 0.003 ug/l respectively at Dunham, Gainsborough and Keadby compared to the standard of 0.01 ug/l. Levels of pp DDT in the Ouse and Aire were reported as $<$0.01 ug/l.

6. 1986 SPECIAL SURVEY

6.1 An intensive chemical survey was carried out on 16 June 1986, in order to investigate the variation in metal concentration across the estuary and over a tidal cycle. Data were also obtained to check the calibration of the mathematical model. Samples were taken over a tidal cycle at a number of routine sampling stations and transects were taken on the Trent at Burton Stather and on the Humber at Upper Whitton, Humber Bridge and Spurn Point. Continuous dissolved oxygen monitors operated at a number of locations during the survey.

6.2 The tide was a typical neap with a range of 3.5 m at Immingham and the freshwater flows at Trent Falls during the week prior to the survey were approximately median. The chemical data indicated that the estuary was generally well mixed, suspended solids levels were lower than average and dissolved oxygen levels were mostly satisfactory with few samples recording less than 40% saturation. The dissolved oxygen profile in the Trent, Ouse and Humber is shown in fig. 8. It should be noted that conditions would have been significantly worse if freshwater flows had been low.

6.3 Data from three of the continuous dissolved oxygen monitors are plotted in fig. 9. The pattern at Burton Stather shows clearly that partially deoxygenated water from the region of Trent Falls is moving to and fro with the tide. Reasonably satisfactory agreement was obtained between observed dissolved oxygen data and the Humber model prediction giving further confidence in the use of the model. Detailed validation of the model is in progress and will be the subject of another report when complete.

6.4 One of the main intentions of the Survey was to obtain reliable dissolved metals data for the saline part of the estuary. The Water Authority laboratories have experienced difficulties with this type of analysis and, thus, WRc were contracted to do some of the determinations. The WRc data for arsenic, nickel, zinc, cadmium, chromium and copper are plotted against salinity in fig 10. As discussed in paragraph 5.6, the dissolved copper results are above the EQs, although this is expressed as an annual average for the inorganic species. Levels of nickel, chromium and copper decrease gradually with increasing salinity due to levels in the freshwater input being substantially higher than in sea water and also, possibly due to absorption onto sediment. For zinc and cadmium, levels are at their highest at intermediate salinity; for zinc this may result from inputs direct to the Humber but there is no ready explanation for the cadmium profile.

6.5 The levels of mercury found were all less than the limit of detection of 0.05 ug/l, which itself was one tenth of the environmental quality standard. The lead results were all close to the limit of detection of 0.7 ug/l. Graphs of these metals with salinity are, thus, not included. It should be noted that the levels of lead and chromium detected during the special survey were substantially less than recorded during the routine surveys, probably reflecting the use of more reliable analytical techniques. The results of the special survey are summarised in table 5.

Table 5 Humber Special Survey 1986 - Summary of Metals Data (WRc analyses)

Station	Dissolved Metals Levels - Average of All Samples Taken (ug/l)							
	Cd	Cr	Cu	Ni	Pb	Zn	Hg	As
Upper Whitton +	0.2	0.9	8.4	8.4	1	13.8	<0.05	17.5
Humber Bridge +	0.2	0.6	6.0	7.1	<1	11.4	<0.05	14.3
Saltend	0.3	0.5	7.3	6.2	1	18.5	<0.05	6.5
Killingholme	0.3	0.2	3.7	5.4	<1	10.8	<0.05	3.0
Spurn +	0.3	0.2	3.1	2.6	<1	8.7	<0.05	1.2
EQS (annual average)	5	15	5	30	25	40	0.5	25

+ mid point of transect

7. METALS IN SEDIMENTS AND BIOTA

7.1 A twice yearly programme to monitor heavy metals in intertidal sediment and biota commenced in October 1981. The main purpose of this work is to determine whether or not metals levels are increasing with time and to help make an overall assessment of metal contamination in the Humber compared with other estuaries. The intertidal sampling stations along the north shore examined regularly between 1981 and 1986 are shown in fig 2.

7.2 The two accumulator organisms examined over the period 1981-1986 were the brown seaweed Fucus vesiculosus and the ragworm, Nereis diversicolor. Because of the low salinity, Fucus is not found in the upper part of the river Humber and to cover this deficiency and provide more information on the estuary it was decided to include also the green alga Enteromorpha. Analysis of Enteromorpha commenced in 1986. From Trent Falls down river these are Weighton Lock, East Clough, Hessle, Alexandra Dock, Paull, Stone Creek and Kilnsea. In 1985 the station at Paull was adversely affected by the construction of sea defences and was replaced by a nearby site at Thorngumbald; in addition an extra site was established at Brough. Special survey work carried out in 1986 indicated that the site at East Clough is affected by the close proximity to the trade discharge. Detailed surveys show that the elevated levels are localised and are not typical of that part of the estuary.

7.3 A summary of metals levels in intertidal sediment and biota from the Humber is given in table 6. These levels generally fall within the range reported for other U.K. estuaries but are higher than 'uncontaminated' estuaries. A comprehensive review of Humber data and comparison with other estuaries has not yet been made, so no firm conclusions can be drawn as to the significance of the levels found.

Table 6 Metal Concentrations (mg/kg) from the North Shore, 1983-86

Metal	Nereis			Fucus			Sediment		
	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.
Zn	90	26	595	85	336	625	140	260	380
Cd	0.5	2.7	15.3	1.1	3.8	6.7	0.2	0.7	4.1
Cu	24	64	184	17.7	29	41	29	49	71
Ni	2.4	5.8	14	9	21	45	21	39	64
Cr	0.3	1.1	5	1	3	8	36	79	156
Pb	0.5	5.2	63	1	3.3	10	46	104	168
As	3.5	21	142	13.3	31	54	24	54	156
Hg	0.04	0.24	1.25	0.02	0.16	0.65	0.08	1.0	5.2

7.4 Levels of cadmium and mercury in Nereis, Fucus and sediments for the period 1983-1986 are shown in figs 11 and 12. For these "List 1" metals, there is a requirement arising from EC Directives 83/513/EEC and 84/156/EEC that the levels in sediment or shellfish must not increase significantly with time. An examination of figure 11 indicates that cadmium levels do not appear to be increasing. The level of cadmium in Nereis at East Clough was substantially higher than at other sites. For mercury, levels in the sediment were substantially higher than in Nereis and Fucus and results were very variable, with particularly high levels being found throughout the estuary in September 1984 and February 1985. The reason for these high levels of mercury remains unclear, there was no known increase from discharges and experimental work suggested that they could not be accounted for by gains or losses during storage. Much lower levels were detected after February 1985.

7.5 Levels of arsenic in Nereis, Fucus and sediments for the period 1983-1986 are shown in fig. 13. The major input to the estuary is from the trade effluent discharging near the East Clough sampling site. The arsenic levels in Nereis and sediment are significantly higher at East Clough than at other sites. The levels vary substantially at each site and no obvious temporal trend can be detected.

7.6 The other metals examined were copper, chromium, iron, lead, nickel and zinc. There were no distinct geographical or temporal trends in the levels of these metals in Nereis, Fucus or sediments.

7.7 The Ministry of Agriculture, Fisheries and Food surveys metal and pesticides in fish and shellfish in the waters around the country*. The report states that the analytical results from samples from the Humber area indicate that levels of contamination for the metals determined (mercury, copper and zinc in fish, with these three plus cadmium and lead in shellfish) give no cause for concern. The concentration of arsenic was also determined in fish because of the known substantial input. The results for 1977 indicated that levels were similar to those in fish collected from areas remote from anthropogenic sources of arsenic, although more work is to be undertaken. Concentrations of PCBs and most organochlorine pesticide residues in fish liver were at low or moderate levels, except for dieldrin, which was found in concentrations considerably higher than the expected range. The levels of dieldrin, however, represent a marked reduction compared with those found previously in the Humber. The use of dieldrin by the Yorkshire textile industry has ceased but it will no doubt be some time before contamination by this persistent substance is eliminated from the system.

8. FAUNAL SAMPLING AND ANALYSIS

8.1 Biological sampling of the Humber tidal system is undertaken annually at thirty-one sampling sites (see fig. 14). There are nine sites in the tidal tributary rivers, eight sub-tidal Humber sites and fourteen intertidal locations (ten on the south shore and four on the north). To avoid the complications of seasonal variations in occurrence of organisms all the samples are collected around August and September. In 1986 all the specified samples were successfully collected except for the Ouse at Cawood, due to adverse tidal conditions, and the Trent at Gainsborough. The varieties of organisms and the numbers found throughout the system are summarised in fig. 14.

Tidal Rivers

8.2 The invertebrate fauna of the tidal rivers reflects the water quality and the physical conditions. The Quality of the Trent is satisfactory whereas part of the Ouse system receives considerable pollution. All the rivers are subject to considerable tidal scouring with the resuspension and deposition of silt, which has severe adverse effects on the fauna. Details of the faunal distributions are given in Appendix 2a.

8.3 Of the tributaries flowing to the Ouse, the Wharfe is of highest biological quality. The sample at Ryther in 1986 produced 1,935 individuals comprising twenty-nine different types of organism. This diverse fauna, although dominated by worms and midge larvae, also contained six types of mayfly, one type of stonefly and four types of

* A. Franklin, 1987, The concentration of metals, organochlorine pesticide and PCB residues in marine fish and shellfish : results of MAFF fish and shellfish monitoring programmes 1977-1984. MAFF Aquatic Enviornment Monitoring Report No. 16.

caddis fly all of which are indicative of clean fresh water. Also present was a shrimp, Gammarus zaddachi, reflecting the tidal influence at this site.

8.4 The fauna of the river Aire at Snaith is influenced by the impact of poor quality freshwater at the tidal limit. Only five taxa were represented amongst the 274 individuals captured. The polluted conditions were indicated by the large numbers of worms and midge larvae present. Similarly in the river Don, where the freshwater is also polluted upstream of the tidal limit, the fauna was again dominated by worms and midge larvae.

8.5 The tidal Ouse was sampled at Drax and Saltmarsh. At both locations only a very few (one or two) worms were found. Such a fauna results from a combination of pollution and natural physical factors. The sites are also difficult to sample adequately and this may affect the numbers captured.

8.6 The river Hull receives clean freshwater at the tidal limit and the first significant effluent input is at Beverley. Improvements to the quality of the sewage effluent in recent years has resulted in a diverse community from which thirty-one taxa were identified from 4,874 animals in 1986, similar to that recorded in 1985. The community was dominated by a mixture of worms, molluscs, shrimps, midge larvae and leeches, mainly a freshwater community with the tidal influence being shown by Gammarus zaddachi. Nearer the estuary, at Sutton Road, the community was reduced to six taxa and 1,158 individuals and was dominated by G. zaddachi, worms, midges and molluscs.

Humber Estuary Sub-tidal Benthic Monitoring

8.7 The improverished fauna of the tidal Ouse extends into the upper Humber but then progressive increases in the diversity and abundance occur seawards to the mouth of the estuary. A total of 110 invertebrate taxa was recorded during the period 1979 to 1986. The benthic data for this period are summarised in table 7 where it can be seen that both the diversity and abundance of organisms fluctuates widely at all sites from year to year. Maximum or minimum values did not, however, occur throughout the estuary in any particular years. Lists of the animals collected in 1986 are given in Appendix 2b.

8.8 At the upper two sites, ghost shrimps (Neomysis) were the only animals regularly collected at both locations and these formed the bulk of the fauna. Gammarid shrimps were also found in most years, and at site 2 small numbers of the worm Capitella were always present. Otherwise only occasional specimens of a variety of species were recorded. Capitella was most abundant at sites 3 and 4, probably reflecting the sewage input from Hull and was the only organism collected on every occasion at these sites.

Table 7 Summary of Humber Sub-tidal Benthic Fauna for 1979-1986

	Site (marked on fig. 14)							
	1	2	3	4	5	6	7	8
Total no.taxa recorded	12	12	20	24	45	37	25	84
Max. no. taxa in any 1 yr	6	6	10	10	25	29	9	44
Min. no. taxa in any 1 yr	2	2	3	5	12	14	5	17
Average no. taxa for 1979-86	3	3.9	5.3	7.8	20.8	20.4	7.1	29.9
Max. no. individs in any 1 year	60	83	262	149	48,312	7,684	26	3,962
Min. no. individs in any 1 year	6	8	4	22	6,172	2,960	10	115
Average no.of individs for 1979-86	27.4	25.3	66.9	76.3	22,147	5,038	19	1,524

Overall total number of invertebrate taxa recorded for the Humber between 1979 and 1986 was 110.

8.9 Abundance of organisms was markedly greater at sites 5 and 6 where the substrata were clay and silt respectively, in contrast to the other sites which were all fine or very fine sands. The clay and silt provide more stable habitats for colonisation and probably provide more abundant food resources. However, organic analyses of the sediments would be required to confirm this latter hypothesis.

8.10 A major change in effluent discharge in the Grimsby area occurred in 1983 when the old intertidal Pyewipe outfall was diverted to a new long outfall. This took the effluent to the edge of the deep water channel. However, no marked changes in fauna occurred at site 6 (e.g. an increase in Capitella) which could be positively linked to the development. Flows from the Riby Street discharge were also diverted to the new outfall in late 1986.

8.11 The seaward trends of increasing diversity and abundance were maintained at site 8 in the outer estuary. At this location a change in the benthic community occurred in 1983 since which time there has been a marked increase in abundance and, to a lesser extent, an increased diversity. These increases correlated with a change to a siltier substratum. Although this increase also coincided with the Pyewipe long sea outfall development a real link between the two appears unlikely given the considerable distance (14 km) of site 8 from the discharge point.

8.12 The fauna at site 7, which was geographically close to site 6, was anomalous in having a low diversity and the lowest abundance figures of any of the routine monitoring sites. Although it might be inferred from these data that toxic discharges may be exerting an influence at site 7 this is not borne out by data from the widespread grid surveys of the estuary carried out in 1977, 1980 and 1985. Rather, the site is typical of large parts of the lower and outer estuary which are affected by tidal scour and which have unstable, sandy bed materials.

8.13 In summary, it can be said that all sites have remained relatively similar from 1979 to 1986. Physical factors appear to have a major influence on the faunal communities but there is evidence of organic enrichment in the middle region of the estuary. There are no indications of deterioration in water quality at any site.

North Shore Intertidal Monitoring

8.14 The four routine sites - Weighton Lock, Hessle, Thorngumbald and Stone Creek - were sampled at mid-shore level as in previous years and the results from 1981 onwards are given in Appendix 2c. The variety and abundance of organisms increased in a seawards direction and, at all sites, worms formed an important component of the community.

8.15 At Weighton Lock and Hessle the fauna was very restricted but has shown no significant change over the years. In this part of the estuary the environment is very harsh from natural factors such as scour and wide salinity fluctuations. The significance of exposure to tidal scour was illustrated further down the estuary by the change of site in 1985 from Paull to Thorngumbald, a distance of only 1km. The original site projected into the estuary and was exposed to tidal currents whereas Thorngumbald is in a sheltered bay. Sediment is deposited in the bay and a very abundant fauna results.

8.16 The fluctuating numerical abundance of the fauna at Stone Creek may have been produced by the oil pollution incident in the Humber in September 1983. Numbers now appear to be settling back to their pre-pollution levels.

South Shore Intertidal Monitoring

8.17 Surveys of the animals living on the intertidal shores of the south bank of the Humber have been conducted in August of each year since 1975. Samples are collected at ten sites at the mid and low shore levels. However, only five key sites have so far been processed for 1986. The result for these five sites from 1983 onwards are presented in Appendix 2d.

8.18 As with the north shore and the subtidal data, the diversity of organisms increases towards the mouth of the estuary. The results also show that a greater variety of animals colonise the more stable mid-shore zone. Numbers have varied from year to year, but show no distinct temporal trend. The total number of individual animals shows a similar pattern. At most sites there was no trend in abundance, but at Barton mid-shore and Grimsby low-shore the numbers have steadily decreased since 1983.

8.19 The overall average abundance for the south shore was highest in 1983 (46,900/m^2) and lowest in 1984 (17,300/m^2) but numbers increased subsequently and in 1986 were 31,200/m^2. This change may be indicative of the effects and recovery from the oil spill which occurred at Immingham immediately after the 1983 survey. However, this increase in numbers only occurred at the mid-shore level. A corresponding recovery was not observed at the low-shore levels and numbers have steadily decreased to their lowest in 1986.

8.20 Further evidence of the impact of the oil spill is suggested by the changes in abundance of several individual species. These are four of the worms (Nereis, Pygospio, Capitella and Paranais) and a bivalve shell (Macoma). The worms all showed decreased numbers after the oil spill followed by recovery in 1985 or 1986, whereas Macoma numbers increased in 1984 from Barton to Killingholme and subsequently returned to their former numbers. The greatest impact was shown at Killingholme, in that all five species were affected and the impact progressively decreased (i.e. fewer species affected) towards Barton and Grimsby.

9. CONCLUSIONS

9.1 Monitoring in 1986 again showed the main water quality problem to be the low dissolved oxygen levels found in the tidal Ouse, Aire and Don and their effect on the lower reach of the Trent and upper part of the Humber. Improvements to sewage treatment works and industrial discharges in Yorkshire are now in progress or will be commenced in the near future in order to combat this problem.

9.2 With the exception of arsenic, metal levels in relation to environmental quality standards give little cause for concern, although more information is required on the speciation of copper. Action is well advanced to reduce the elevated levels of arsenic along the north shore of the upper estuary, although a continuing watch on levels in the system as a whole is required. Work is also in progress to reduce the mixing zones for iron and low pH along the south bank resulting from discharges from the titanium dioxide processing plants. The effectiveness of these schemes will be monitored.

9.3 The EQS for hexachlorocyclohexane is exceeded in the river Aire and upper part of the Humber although concentrations are trending downwards. More information is to be collected on other pesticides and trace organics. Work is also being undertaken to improve the precision of the analytical techniques used for the routine determination of metals in saline waters. An assessment is planned to establish the most representative manner in which to calculate the inputs of substances from the non-tidal rivers bearing in mind their wide variations in flow. Likewise more information is required on the fate of metals and organics in the estuary so that a more accurate estimate of the input into the North Sea can be obtained.

9.4 Water quality in the outer estuary is good and levels of trace metals and organics are generally very much lower than the EQS. However, by its large volume, the Humber is an important input into the North Sea and, thus, its wider impact needs to be kept under scrutiny.

9.5 The monitoring of metals in sediments along the north shore shows a localised area of high concentration relative to the estuary as a whole. There have been no significant trends - upwards or downwards in recent years. Information on metal levels in fish from or off the Humber, published by the Ministry of Agriculture, Fisheries and Food, show no cause for concern. More work is required to compare objectively metals in sediments and organisms in the Humber with other estuaries.

9.6 The restricted fauna of the tidal rivers and upper Humber reflects the harsh environment of scour, widely varying salinity and pollution. In contrast, the outer Humber has a diverse and abundant invertebrate fauna, supporting fish and birdlife, although there are marked variations resulting from the physical nature of the bed of the estuary. The intertidal fauna, particulary along the south shore, still reflects the effects of the major oil spill at Immingham in 1983, although there has now been a substantial recovery.

APPENDIX 1 HUMBER OBJECTIVES AND STANDARDS

Humber Estuary Committee Terms of Reference

To advise the constituent Authorities and other bodies on matters appertaining to their functions relating to the restoration and maintenance of the wholesomeness of the rivers and other waters in the Humber Estuary, and to act as a co-ordinating link between constituent Authorities on matters relating to management of the estuary with particular reference to the objectives laid down for the Committee.

Humber Estuary Committee Objectives

To consider matters concerned with the control, management and use of the Humber Estuary of relevance to the constituent Water Authorities, and in particular:

(i) to restore and maintain the wholesomeness of water in the estuary and to reduce pollution. In particular to restore the wholesomeness of all tributaries and their tidal reaches and to control areas of local pollution east of the Humber Bridge;

(ii) to consider the quality and quantity of the residual flows to the estuary which it is desirable to maintain at the various tidal limits under varying conditions and at different times of the year;

(iii) to undertake a programme to survey and monitor flows and quality conditions in the estuary;

(iv) to monitor and assess the effects of toxic materials carried from the Humber Estuary to the North Sea;

(v) to maintain, improve and develop the indigenous fisheries in the estuary and to allow the passage of migratory fish by improving the quality conditions in the estuary;

(vi) to initiate, co-ordinate and undertake appropriate research on the Humber Tidal System;

(vii) to have regard* for the conservation, in accordance with section 22 of the Water Act 1973, of the flora and fauna, and the geological, physiographical and archaeological features of special interest in, and adjacent to, the estuary;

(viii) to advise on matters in, and adjacent to, the estuary, such as land drainage, amenity, and future development.

Means of Achieving HEC Objectives

(i) New discharges of trade or sewage effluent should be controlled so that they do not cause the environmental quality standards set for the Humber system to be exceeded except in the defined mixing zone around the outfall.

* Following the passing of the Widlife and Countryside Act 1981 Water Authorities have a duty "to further" conservation.

(ii) Existing discharges should continue to be progressively controlled so that by 1995 they also do not cause the environmental quality standards to be exceeded other than within the defined mixing zone.

(iii) The existing suite of mathematical models developed for the Humber system will be used to help determine the consent conditions applied to any discharge of trade or sewage effluent.

(iv) The environmental quality standards, their associated quality objectives and the mathematical models, will be kept under review and revised as and when necessary in the light of advances in scientific information, techniques and legislation.

(v) A co-ordinated programme of physical, chemical and biological monitoring will be carried out on the waters, inputs, sediments, flora and fauna of the estuary system.

(vi) Acceptable mixing zones will be defined for individual discharges by means of local surveys as necessary.

(vii) The Humber Estuary Management Group will co-ordinate work on the estuary and oversee the activities of the Humber Estuary Technical Panel.

Environmental Quality Objectives

The following three general environmental quality objectives have been recognised for the Humber system:-

(i) The protection of all existing defined uses of the estuary system.

(ii) The ability to support on the mud bottom the biota necessary for sustaining sea fisheries.

(iii) The ability to allow the passage of migratory fish at all stages of the tide.

Environmental Quality Standards

The tidal system is divided into fresh water and estuarine water on the basis of the observed biota for the purpose of defining quality standards. The transition between the two zones is at Trent Falls. The seaward limit is the line drawn between Spurn Point and Donna Nook.

Standards for the estuarine section are based on the general quality objectives of the protection of fish, shell fish and other aquatic life, whereas those for the feshwater section are based on NWC Class II river quality criteria and also take account of the metals values for the protection of coarse fish.

Environmental Quality Standards

(Annual Average and ug/l except where stated)

DETERMINAND	TIDAL RIVERS		ESTUARY		COMMENT
Temperature	25°C		25°C		95 percentile
Dissolved Oxygen	40% saturation		55%		5 percentile
pH	5.5 - 9.0		6.0 - 8.5		95 percentile
Ammonia (unionised)	25*		25		*95 percentile (1)
Mercury	1	total	0.5	dissolved	
Cadmium	5	"	5	"	(1)
Arsenic	50	dissolved	25	"	
Chromium (III + VI)	250	"	15	"	
Copper(II)	28	"	5	"	(2)
Lead	250	"	25	"	
Nickel	200	"	30	"	
Zinc	500	total	40	"	
Iron	1000	dissolved	1000	"	(3)
Hexachlorcyclo hexane	0.1	total	0.02	total	(1)
DDT	0.025	"	0.025	"	(1)
DDT (para-para isomer)	0.01	"	0.01	"	(1)
Carbon Tetra-chloride	12	"	12	"	(1)
Pentachloro-phenol	2	"	2	"	(1)

(1) Mandatory - EEC Dangerous Substances Directive Environmental Quality Standards for List 1 Substances.

(2) Higher values acceptable where acclimation expected or copper present in organic complexes.

(3) Subject to review.

Notes:

(a) Standards for most of the metals in freshwater vary according to the water hardness. However, since the average hardness of the tidal rivers varies only between 290 and 350 mg/l standards have been defined in relation to a hardness of 300 mg/l.

(b) No standard has been set for suspended solids in the water column. Local control may be necessary to avoid excessive accumulation of sediment or the deposition of sewage solids.

APPENDIX 2 BENTHIC SPECIES LISTS FOR 1986

Table a. Faunal Distribution at the Tidal River Sampling Sites (Numbers/Sample)

Fauna / River Site	Wharfe Ryther	Aire Snaith	Don Thorne	Ouse Drax	Ouse Saltmarsh	Hull Beverley	Hull Sutton Rd
MOLLUSCS							
Valvata piscinalis						203	
Potamopyrgus jenkinsi	40					500	16
Bythynia tentaculata						30	1
Physa fontinalis						13	
Theodoxus fluviatilis						4	
Lymnaea peregra	5					8	
Lymnaea palustris						1	
Planorbis vortex						2	
Planorbis albus						8	
Ancylus fluviatilis	32	1				7	
Acroloxus lacustris						4	
Sphaeriidae	21					536	
WORMS							
Oligochaeta	664	136	6400	1	2	1722	383
LEECHES							
Glossiphonia complanata	1					61	
Helobdella stagnalis	1					119	
Piscicola geometra						1	
Erpobdella octoculata	1					5	
MITES							
Hydracarina	1					3	
CRUSTACEA							
Asellus aquaticus		16				29	
Asellus meridianus						2	
Gammarus zaddachi	30		20			1352	638
MAYFLIES							
Rhithrogena semicolorata	3						
Heptagenia sulphurea	100						
Ecdyonurus dispar	1						
Ephemerella ignita	136						
Caenis horaria						1	
Caenis macrura/moesta	56						
Caenis rivulorum	36						
STONEFLIES							
Leuctridae	24						

Table a Cont

Fauna	River Site	Wharfe Ryther	Aire Snaith	Don Thorne	Ouse Drax	Ouse Saltmarsh	Hull Beverley	Hull Sutton Rd
BEETLES								
Haliplidae							26	
Dytiscidae		1					6	
Elmidae		20					7	
Corixidae				2				
CADDIS FLIES								
Hydropsyche siltalai		2						
Psychomyia pusilla		6						
Brachycentrus subnubilis		9						
Athripsoides albifrons		4						
Phyryganea sp							1	
Molanna angustata							1	
OTHER FLIES								
Chironomidae		614	120				204	118
Ceratopogonidae		124						
Empididae		2					11	
Simulidae		1						
Psychodidae			1				4	2
Culicidae							3	
Rhamphidia		1						
Tipulidae (unidentified)		1						

Table b. Humber Benthic Species (Numbers/0.3m³)

Sites (Shown on Figure 14)

	1	2	3	4	5	6	7	8
WORMS								
Turbellaria					4			
Nemertini					19			
Pholoe inornata					8			
Eteone longa			1		13	1		2
Anaitides maculata/mucosa					151	6		6
Eumida sanguinea					19			
Proceraea cornuta					40			
Nereis diversicolor				1	4			
Nereis longissima					29	1		2
Nephtys cirrosa							5	39
Nephtys caeca								2
Nephtys hombergii				5		78		59
Nephtys sp (juv)						23	1	93
Sphaerodoridium minutum					4	4		1
Scoloplos armiger						63	1	78
Aricidea minuta		1				13		23
Polydora sp indet				1	8760	21		
Pygospio elegans		1		2	23	41		29
Spio martinensis							3	357
Spiophanes bombyx						1		1924
Streblospio shrubsolii					2	66		
Magelona mirabilis								2
Chaetozone setosa								94
Tharyx sp indet		1	1			614		1
Tharyx vivipara						173		
Scalibregma inflatum								1
Capitella capitata		3	26	68	2	1	2	1
Capitella sp (juv)			2	1	4			64
Mediomastus fragilis						4		
Arenicola marina				7	537	2	1	
Pectinaria koreni						1		4
Ampharete grubei					18	2		2
Amphitrite johnstoni					4			
Lanice conchilega								10
Tubificoides benedeni			2	16	8	98		
Tubificoides swirencoides						1674		
Enchytraeidae indet					304			
Pseudocuma gilsoni								1
Tanaissus lilljeborgii								1

Table b Cont

Sites (Shown on Figure 14)

	1	2	3	4	5	6	7	8
CRUSTACEA								
Gammarus salinus						1		
Gammarus sp indet	3	9	1					
Eurydice pulchra							7	
Bathyporeia elegans								9
Bathyporeia pelagica							3	
Bathyporeia pilosa								4
Pontecrates altamarinus								1
Neomysis integer	18	9						
Schistomysis kervillei			1					2
Crangon crangon		1			2			
Carcinus maenas					2			
Halacaridae					39			
Anoplodactylus pygmaeus					7			
Anoplodactylus sp (juv)					10			
MOLLUSCS								
Hydrobia ulvae							1	
Retusa obtusa								9
Mytilidae (juv)					19			
Mysella bidentata								1
Macoma balthica				2		5		2
Abra alba								1
Abra prismatica								2
Number of Taxa	2	7	6	8	25	22	8	36
Number of Individuals	21	25	34	103	10032	2893	24	2866

Table c Benthic Intertidal Fauna (number/m^2) of the Humber North Shore 1981-86

	August 1981	July 1983	August 1984	August 1985	August 1986
			WEIGHTON LOCK		
Nematoda	66	18	-	18	-
Oligochaeta	966	360	3,618	3,568	3,060
Nereis	78	54	18	72	6
Chironomidae	6	6	6	-	-
Copepoda	-	6	-	6	6
Springtails	-	-	-	48	-
			HESSLE		
Nematoda	6	156	-	12	6
Oligochaeta	156	210	66	12	102
Nereis	84	30	24	18	78
Spionidae	-	6	12	-	-
Phyllodocidae	-	-	60	-	-
Copepoda	-	-	-	-	-
	PAULL			THORNGUMBALD	
Nematoda	306	720	1,254	12,240	12,793
Oligochaeta	48	66	72	18,480	8,713
Nereis	138	378	954	1,296	792
Spionidae	6	30	-	240	4,033
Nephtys	-	6	6	-	-
Phyllodocidae	6	12	654	240	48
Manayunkia	-	-	-	48	24
Macoma - large	30	72	558	168	144
- small	-	66		2,784	4,729
Hydrobia	-	18	18	-	-
			STONE CREEK		
Nematoda	41,165	44,310	28,611	52,008	61,423
Oligochaeta	40,427	50,886	43,325	95,832	68,360
Nereis	1,872	1,416	72	1,104	1,416
Spionidae	6,811	6,457	24	15,288	8,017
Nephtys	30	312	48	216	48
Phyllodocidae	648	408	1,632	1,464	912
Sphaerodoridae	-	-	-	24	-
Macoma - large	1,260	912	9,025	960	2,640
- small	5,395	11,521		22,608	8,521
Hydrobia	90	504	72	432	696
Chironomidae	6	-	-	-	-
Copepoda	6	48		288	24
Carinus	-	48	-	-	24
Isopoda	-	24	-	-	-

Table d. **Faunal Results for the South Shore 1983-86**

(Number/m^2, mid-share (MS) and low-share (LS))

SPECIES	1983		1984		1985		1986	
	MS	LS	MS	LS	MS	LS	MS	LS
	BARTON ON HUMBER							
Eteone longa			159					
Nereis diversicolor	4938		2804		1501	32	1243	
Polydora sp	32							
Pygospio elegans	96		1370		64	32	64	
Streblospio shrubsolii	414		382		542		32	
Tubifex costatus	350		32		64			
Enchytraeidae	[illegible]	[illegible]				32		
Gammarus sp	[illegible]	[illegible]				32		64
Macoma balthica	[illegible]	[illegible]	478		32		127	
	EAST HALTON							
Eteone longa	[illegible]	[illegible]	1147	127	127			
Nereis diversicolor	[illegible]	[illegible]	414		478		1752	
Nephtys hombergii	[illegible]	[illegible]						32
Polydora sp	[illegible]	[illegible]80	32			1752		
Pygospio elegans	[illegible]	[illegible]027	3951		1211	32	2294	127
Streblospio shrubsolii	[illegible]	860	255		446	64	733	64
Tharyx sp	[illegible]			32				
Capitella capitata	[illegible]			127	64		64	
Arenicola marina	[illegible]	127						
Paranais litoralis	[illegible]				860		1657	
Tubifex costatus	[illegible]						64	
Tubificoides bened[illegible]	[illegible]	573	2294	96	6850	32	9845	605
Enchytraeidae	[illegible]	1434	32			127		
Macoma balthica	[illegible]4		4237		2517	32	1848	127
	SOUTH KILLINGHOLME							
						NO SAMPLE		NO SAMPLE
Eteone longa	96		860	255	127			
Nereis diver[illegible]	287			32	255		191	
Nephtys hom[illegible]	32	127		96				
Polydora sp	32			127	32			
Pygospio e[illegible]	7232	2517	319	10514	2135		5767	
Streblosp[illegible]		1020	32	1211				
Tharyx sp	32	159	32	127				
Capitell[illegible]	446		3823		159		1720	
Paranais lit[illegible]	134513	96			5639		9972	
Tubifex costatus					159			
Tubificoides benedeni	28260	4588	16440	1975	20231		17810	
Tubificoides swirencoides		1179		765				
Macoma balthica	1593	287	5002	64	510		2453	

Table d Cont

SPECIES	1983 MS	1983 LS	1984 MS	1984 LS	1985 MS	1985 LS	1986 MS	1986 LS
				DOVERSTRAND				
Platyhelminths					96	32	159	
Nemerteans					-		32	
Eteone longa	382		1020	32	733		1115	32
Nereis diversicolor			32		32			
Nephtys hombergii	191	96		127	159	127		
Polydora sp		319						
Pygospio elegans	1784	765	32	669	382	1370	14273	605
Tharyx sp	32							32
Capitella capitata	1243		32	64	2644	191	20231	127
Arenicola marina							64	
Paranais litoralis	1338				3536	319	64803	191
Tubificoides benedini	32083	1306	16663	5735	14082	12680	11916	4014
Tubificoides swirencoides		1179	32	1115	32	2390	32	5894
Hydrobia ulvae	64						64	
Macoma balthica	4397	127	7710	32	12202	350	17619	637
				GRIMSBY				
Platyhelminths					1625	64		
Nemerteans		64						
Eteone longa	159		1338				1402	
Anaitides maculata/mucosa			64				191	
Nereis diversicolor	255	1402	382	1306	956	3027	605	9016
Nephtys hombergii	223	319	127		64	446	191	32
Polydora sp	32	382			32	223		
Pygospio elegans	510	287	1848		4046		14815	
Streblospio shrubsolii		32						
Tharyx sp	5161	1243	2963	32	4492	542	1020	
Capitella capitata	127	1211	64		4269	701	15707	1051
Arenicola marina	319				96		223	
Paranais litoralis	159	6404	382	32	446		32	
Tubificoides pseudogaster	7168	669		96	223	64		
Tubificoides benedeni	3791	53780	9271	31000	7965	13923	2390	
Tubificoides swirencoides						32	32	1816
Hydrobia ulvae	90737	478	41705	255	16854	350	21729	191
Mytilus sp juv		32			32			
Cerastoderma sp juv	191	127			159		446	32
Macoma balthica	605	1370	3887	255	8092	1147	8889	319

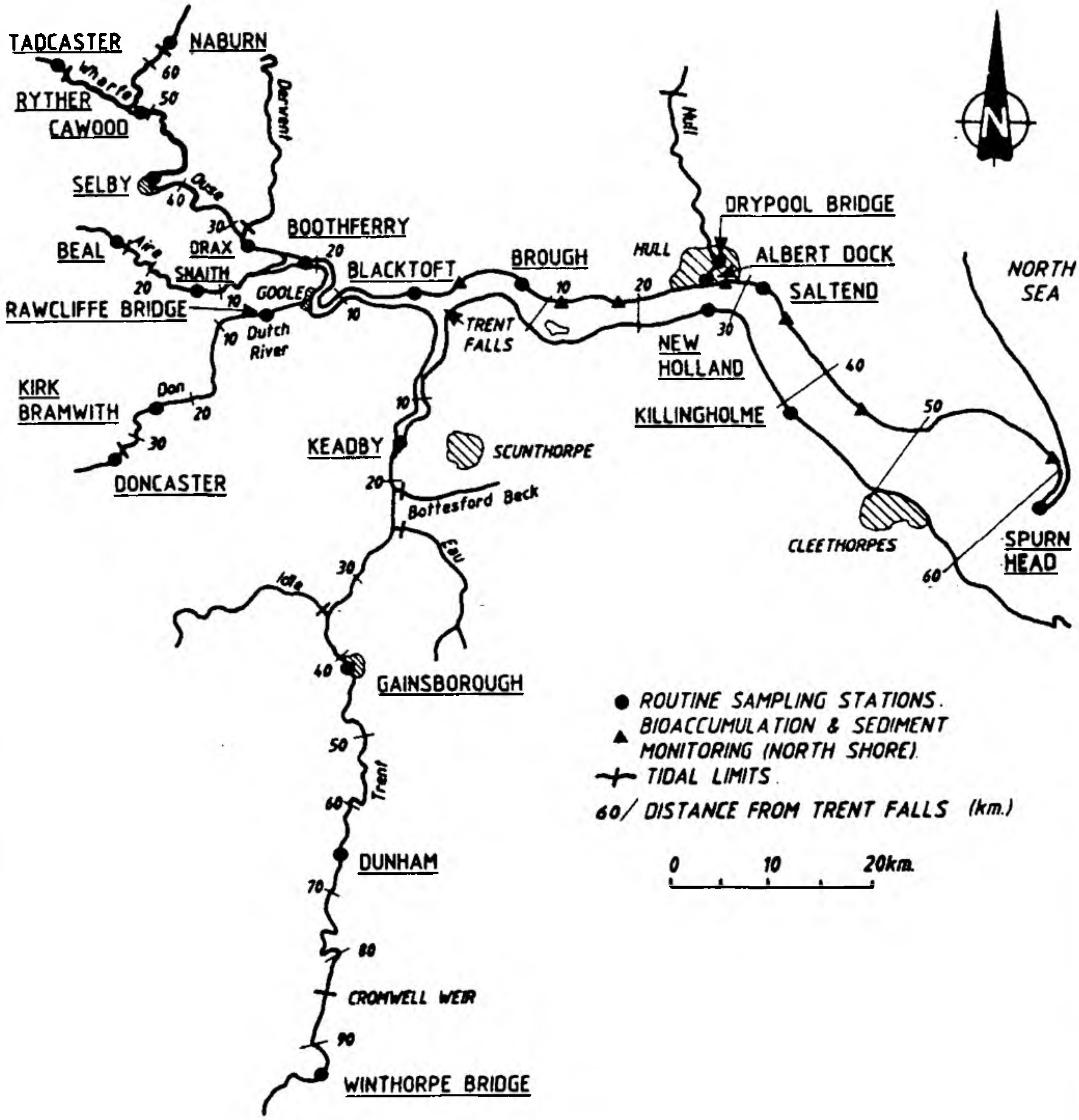


FIG. 2. CHEMICAL MONITORING STATIONS.

FIG. 3 (a) BOD LOADS TO THE HUMBER ESTUARY.

(Load at Tidal Limits of Main Rivers)

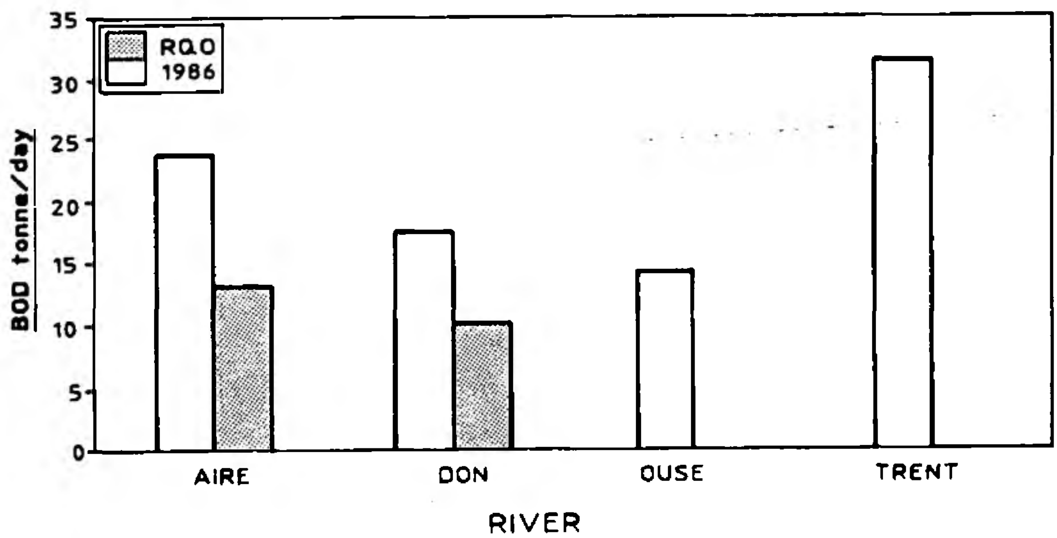
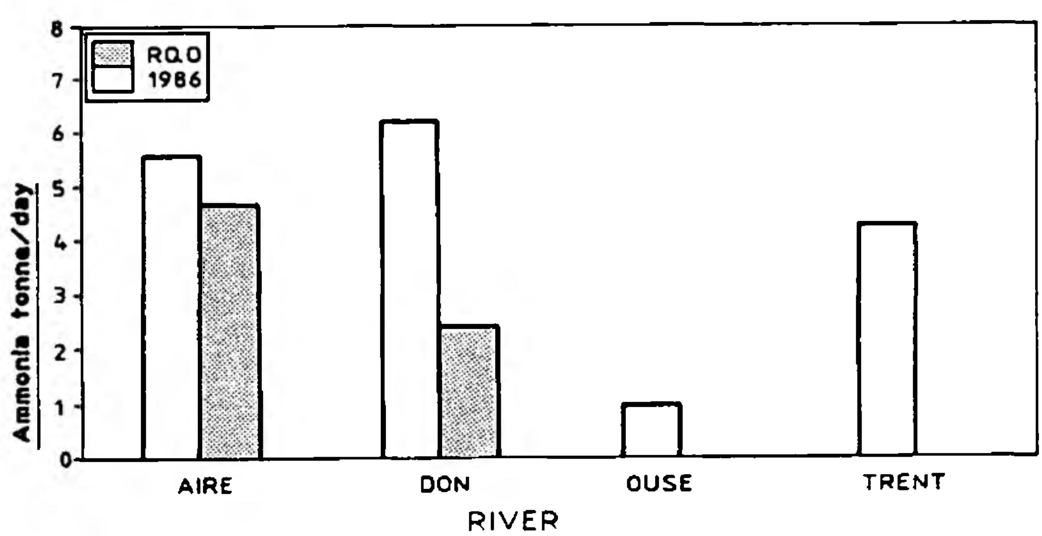


FIG. 3 (b) AMMONIA LOADS TO THE HUMBER ESTUARY.

(Load at Tidal Limits of Major Rivers)



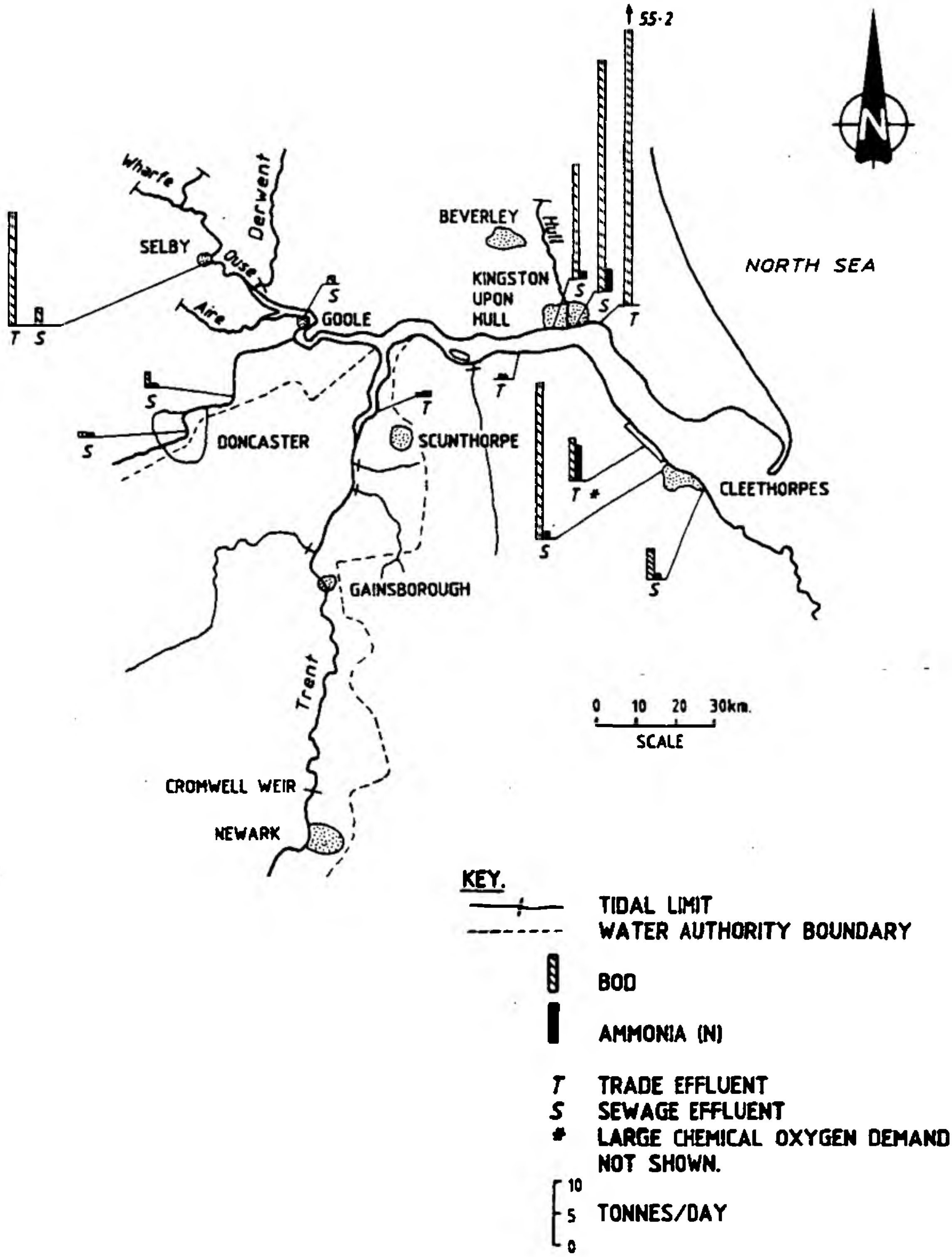
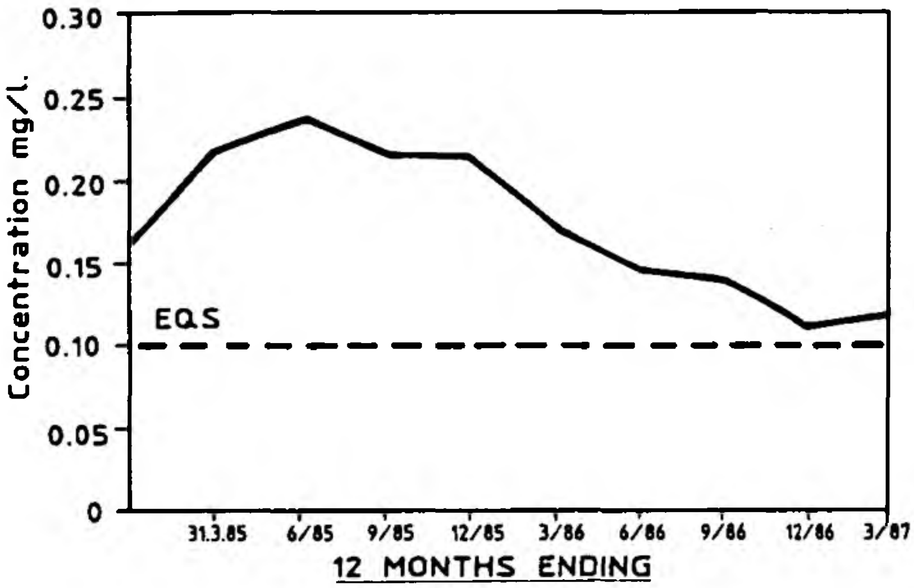
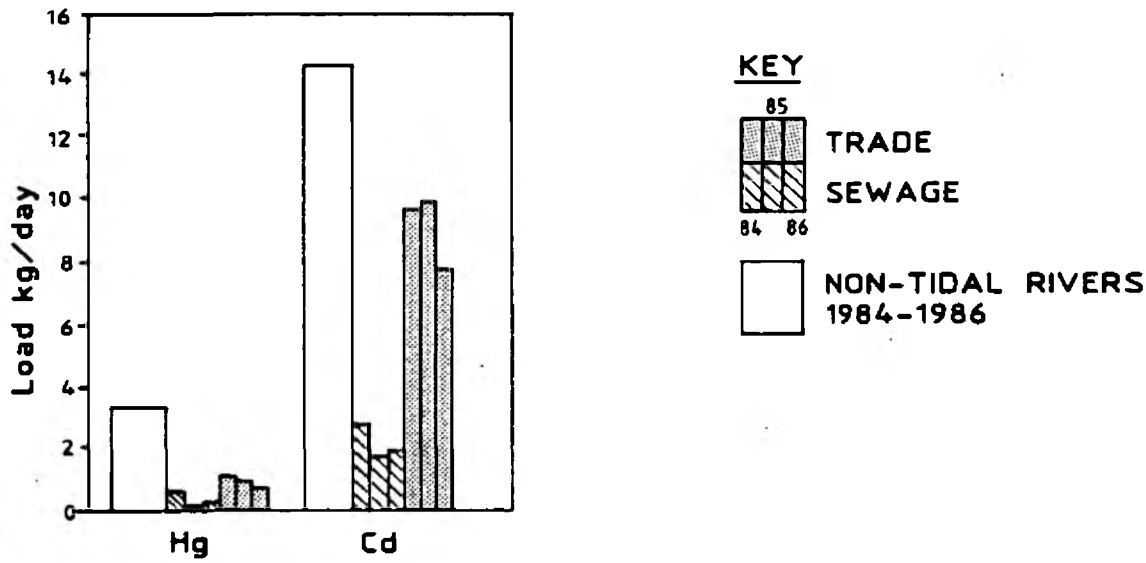


FIG. 4. BOD & AMMONIA LOADS FROM THE MAIN EFFLUENT INPUTS.

FIG. 5. H.C.H. IN THE RIVER AIRE AT BEAL: ROLLING 12 MONTHLY COMPARISON WITH THE ENVIRONMENTAL QUALITY STANDARD.



(a) List 1 Metals.



(b) List 2 Metals

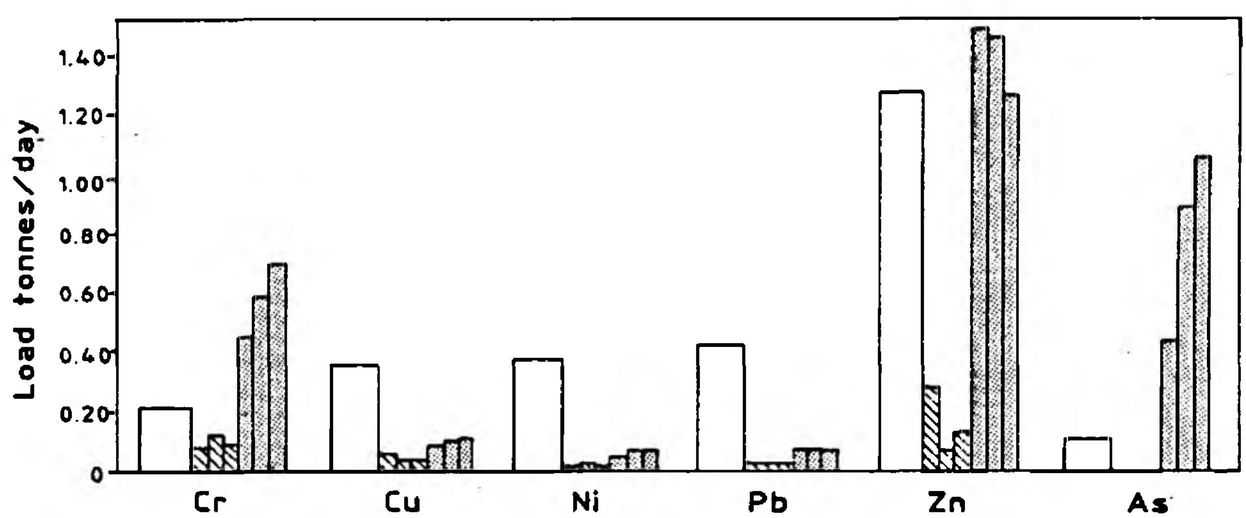


FIG. 6. LOADS OF METAL DISCHARGED TO THE HUMBER SYSTEM

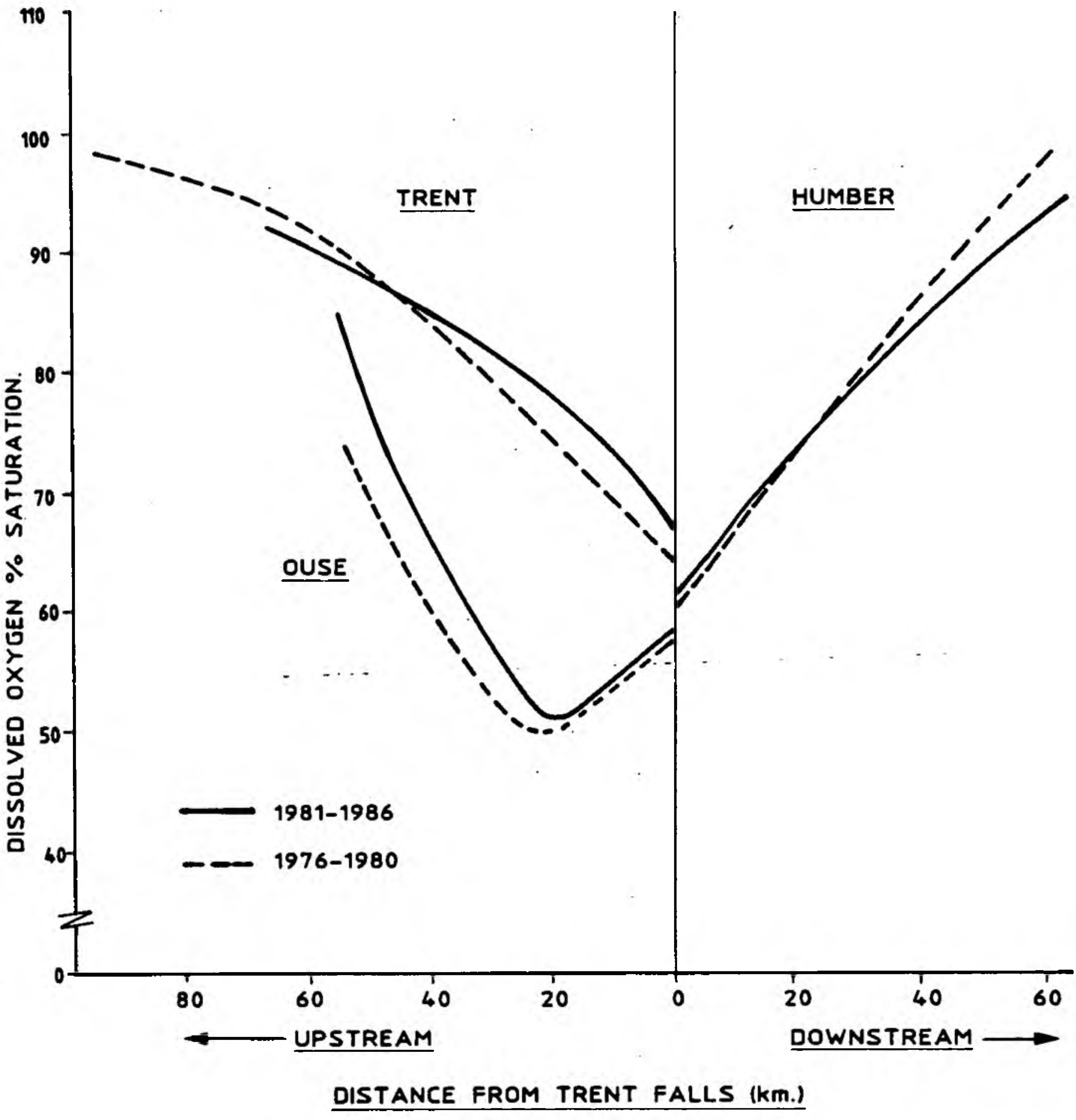
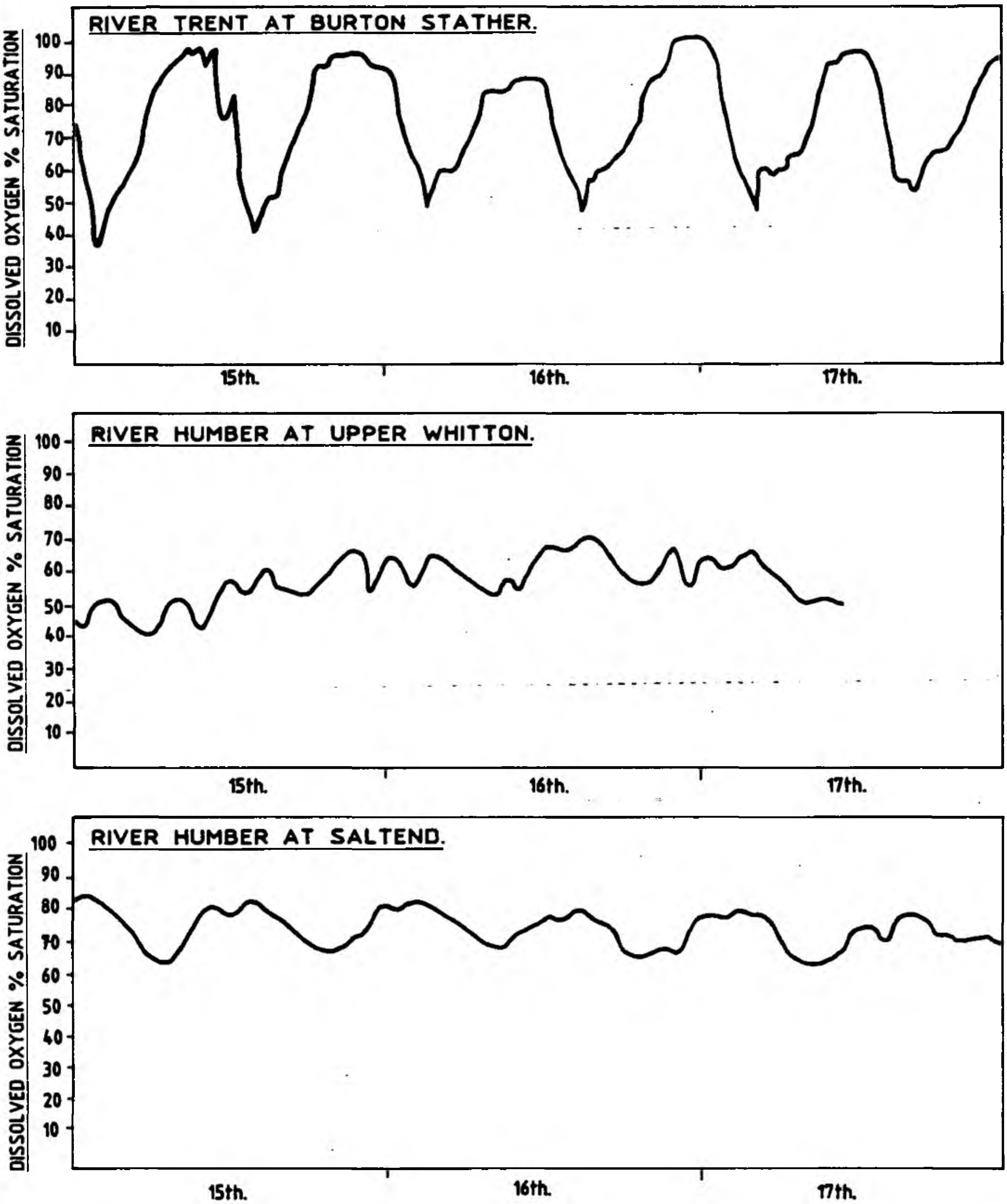


FIG. 7. AVERAGE DISSOLVED OXYGEN LEVELS FOR 1976-1980 & 1981-1986.

FIG. 8. DISSOLVED OXYGEN LEVELS AT SELECTED CONTINUOUS MONITORING STATIONS OVER THE PERIOD 15th. TO 17th. JUNE, 1986.



CONDITIONS FOR SPECIAL SURVEY ON 16th. JUNE, 1986.

TIDAL RANGE AT IMMINGHAM :- 3.5m (NEAP).
FRESHWATER FLOWS AT TRENT :- OUSE 94tcmd.
FALLS IN PREVIOUS WEEK :- TRENT 76 tcmd.

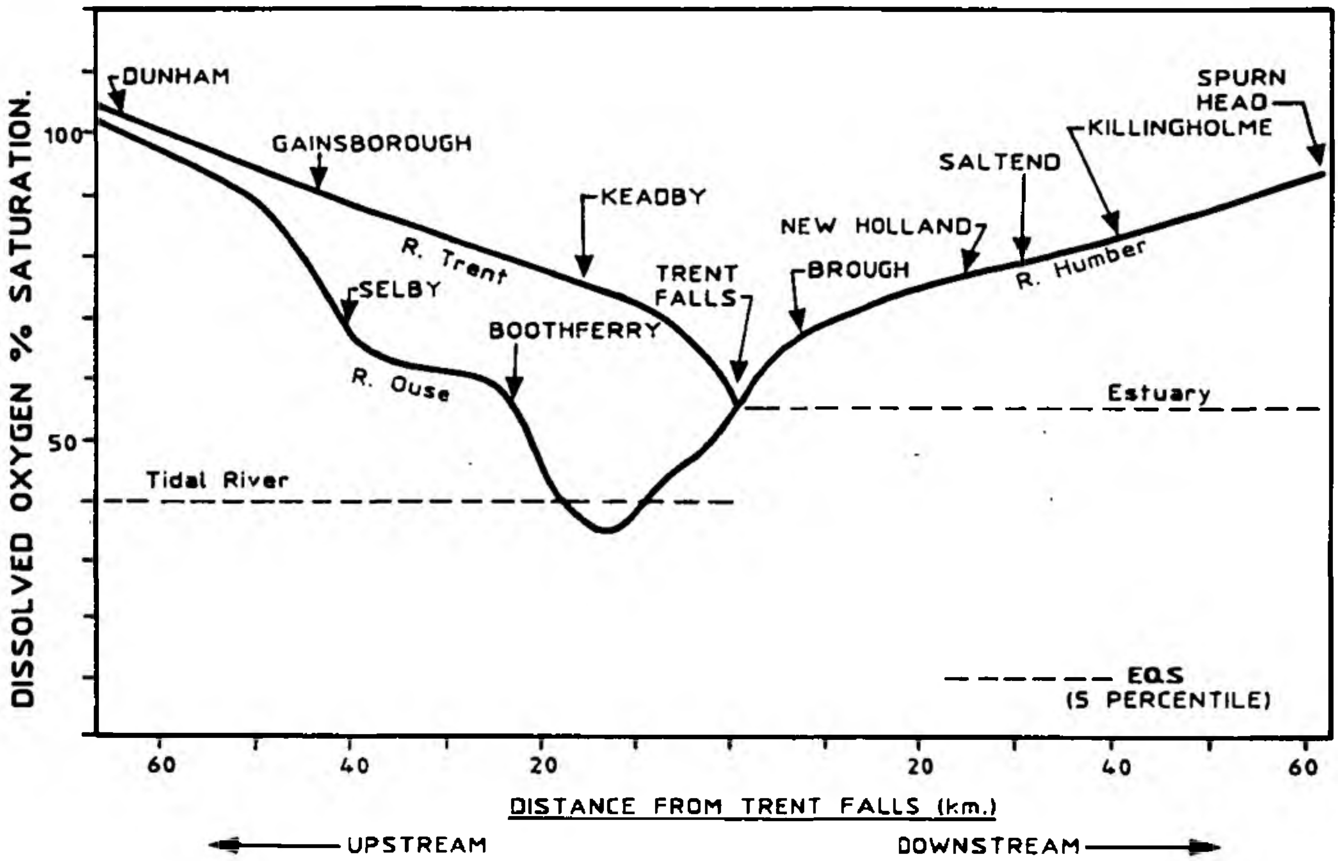


FIG. 9. DISSOLVED OXYGEN PROFILE 16th. JUNE, 1986. (LOW WATER AT SPURN HEAD).

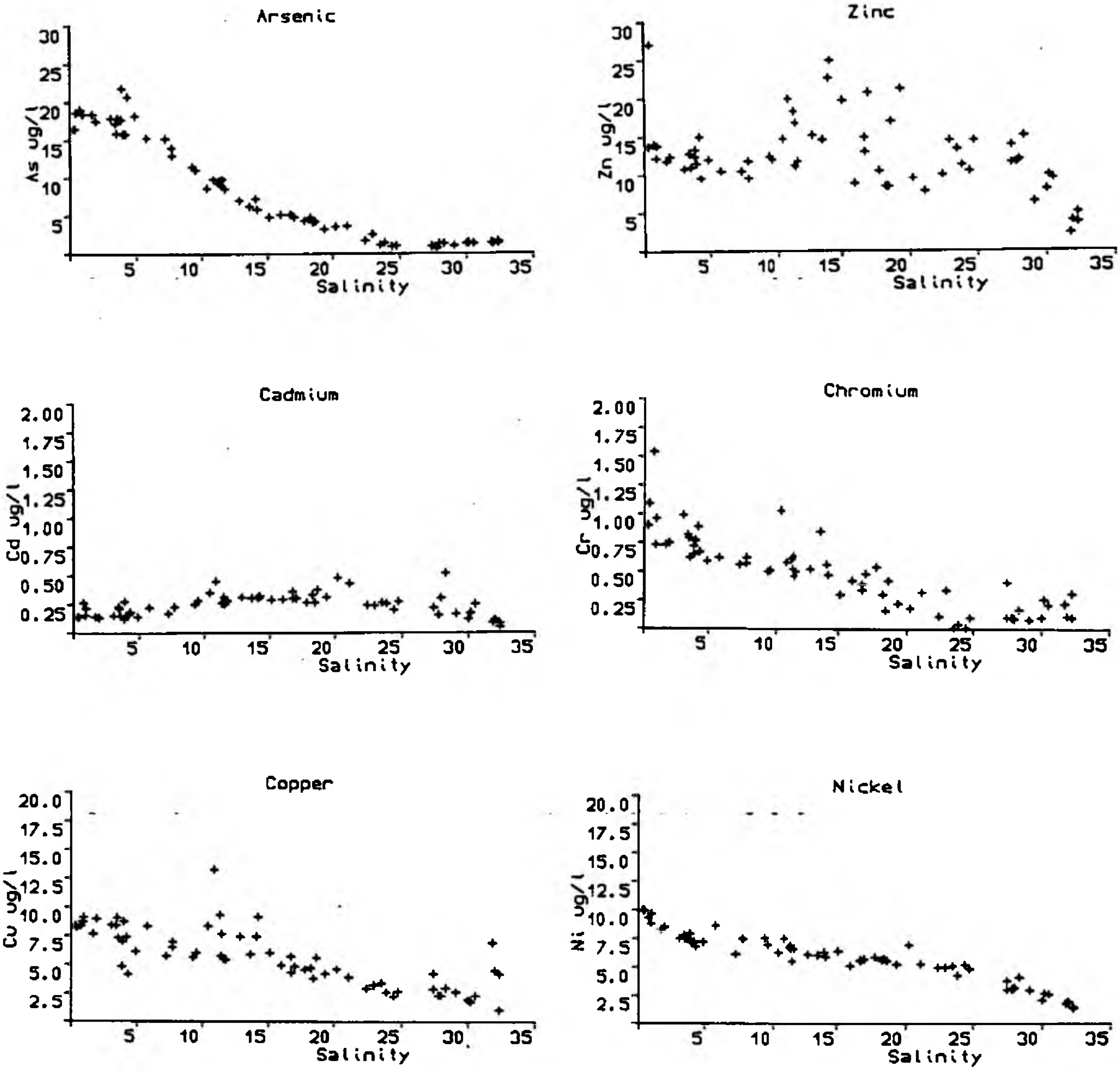
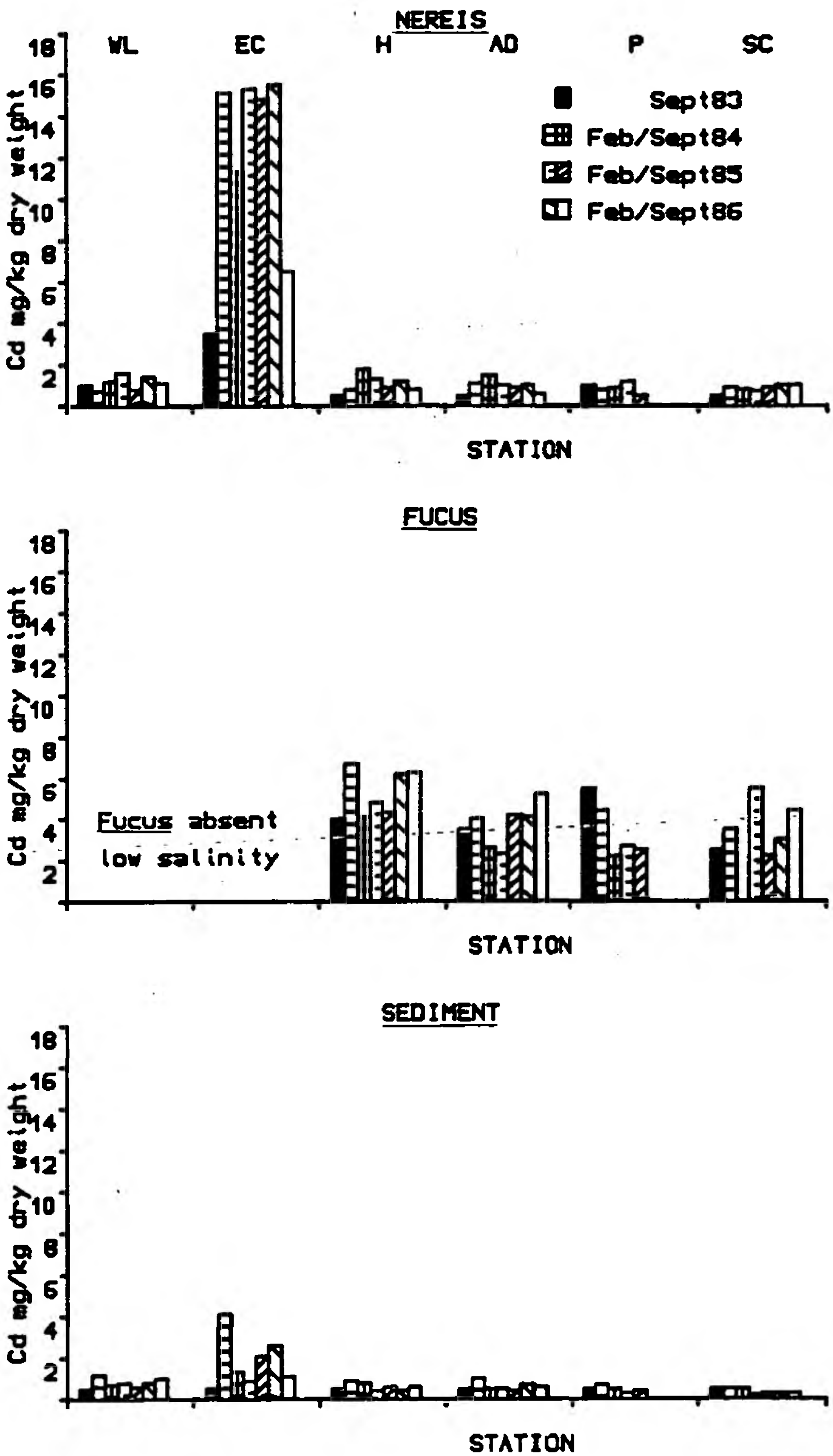


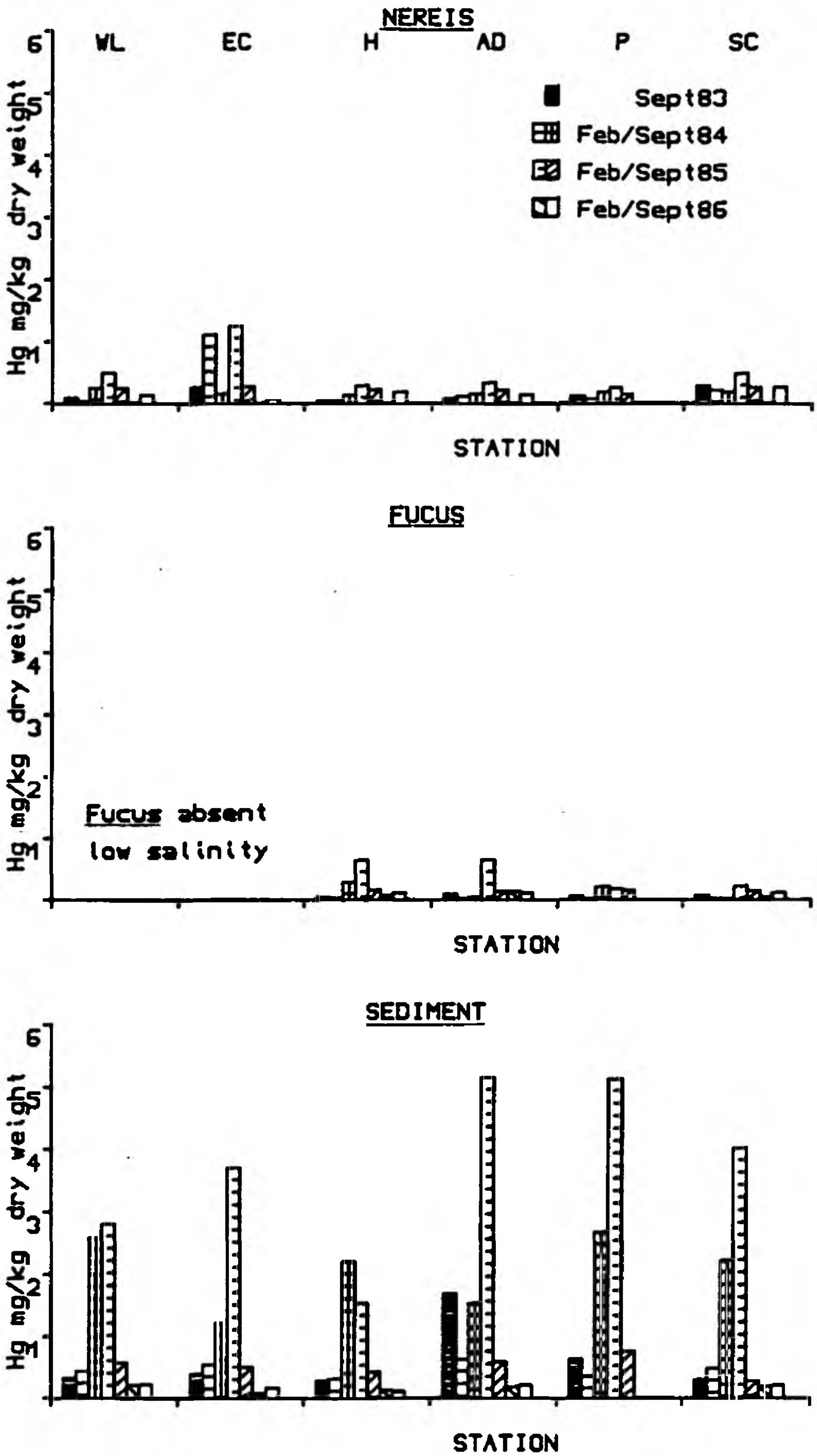
FIG. 10. VARIATION OF THE CONCENTRATION OF DISSOLVED METALS WITH SALINITY

FIG 11 CADMIUM ACCUMULATION 1983-1986



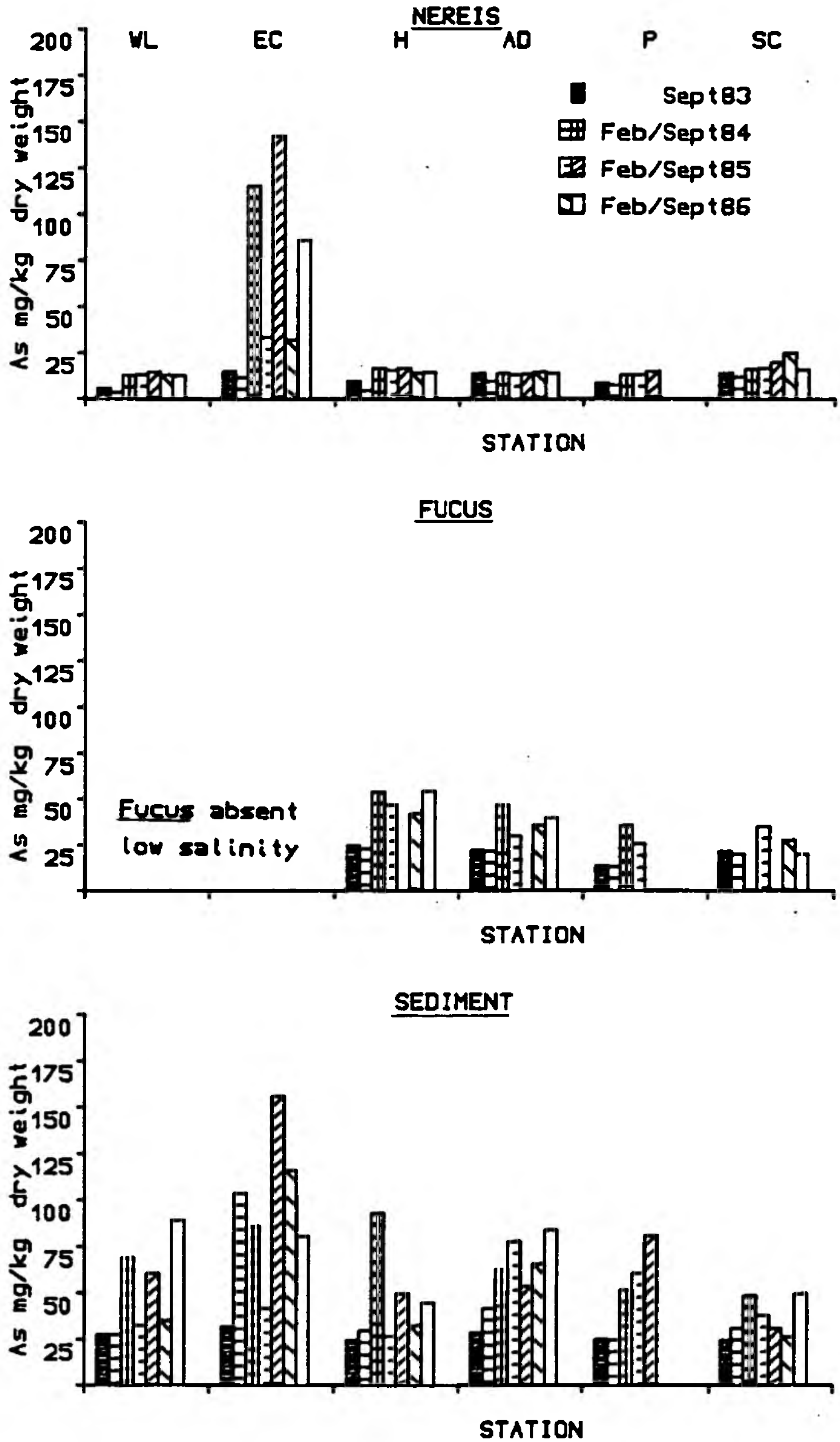
STATIONS
Weighton Lock, East Clough, Hessle
Alexandra Dock, Paull, Stone Creek
(Sampled twice per year)

FIG 12 MERCURY ACCUMULATION 1983-1986



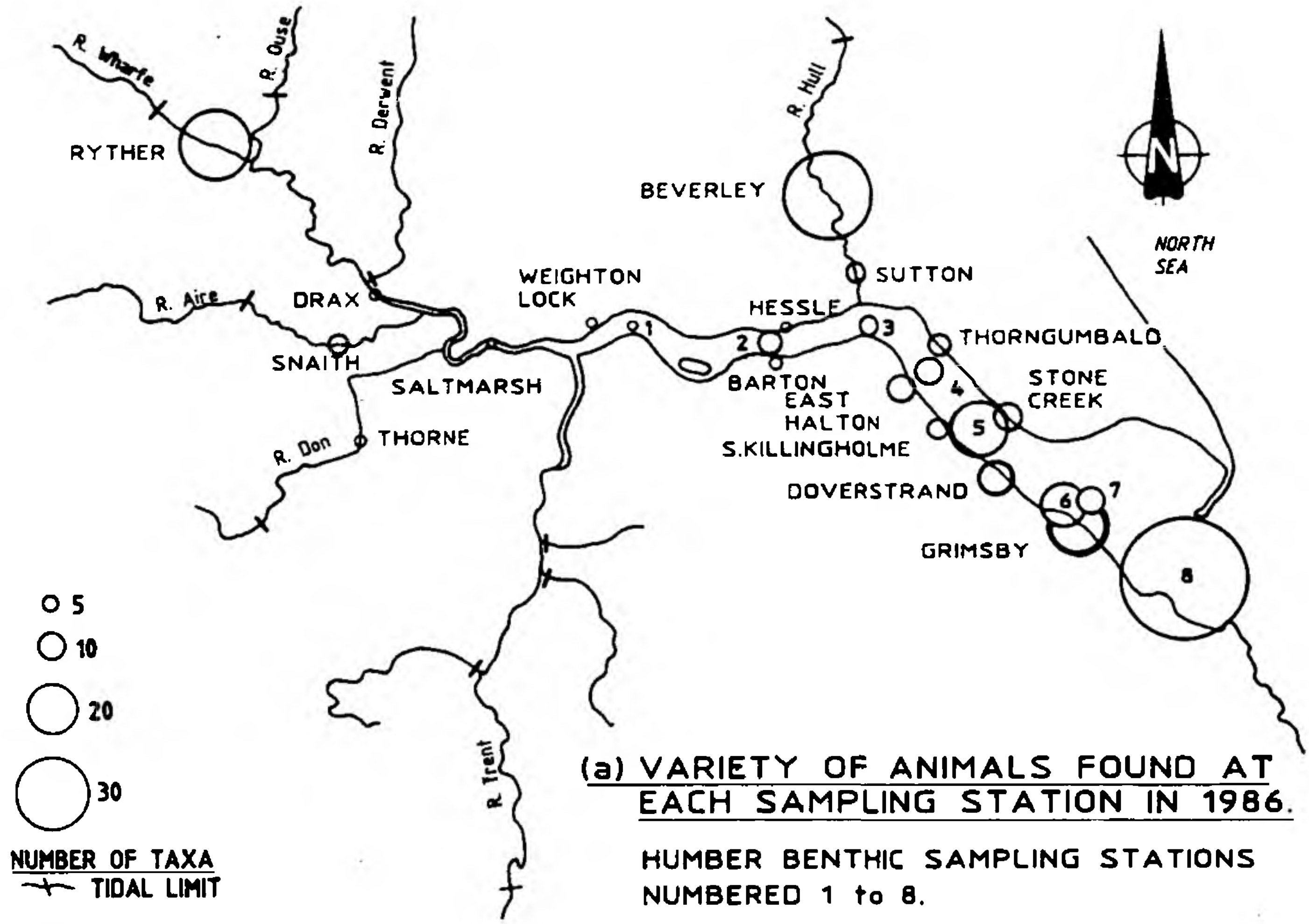
STATIONS
Weighton Lock, East Clough, Hessle
Alexandra Dock, Paull, Stone Creek

FIG 13 ARSENIC ACCUMULATION 1983-1986



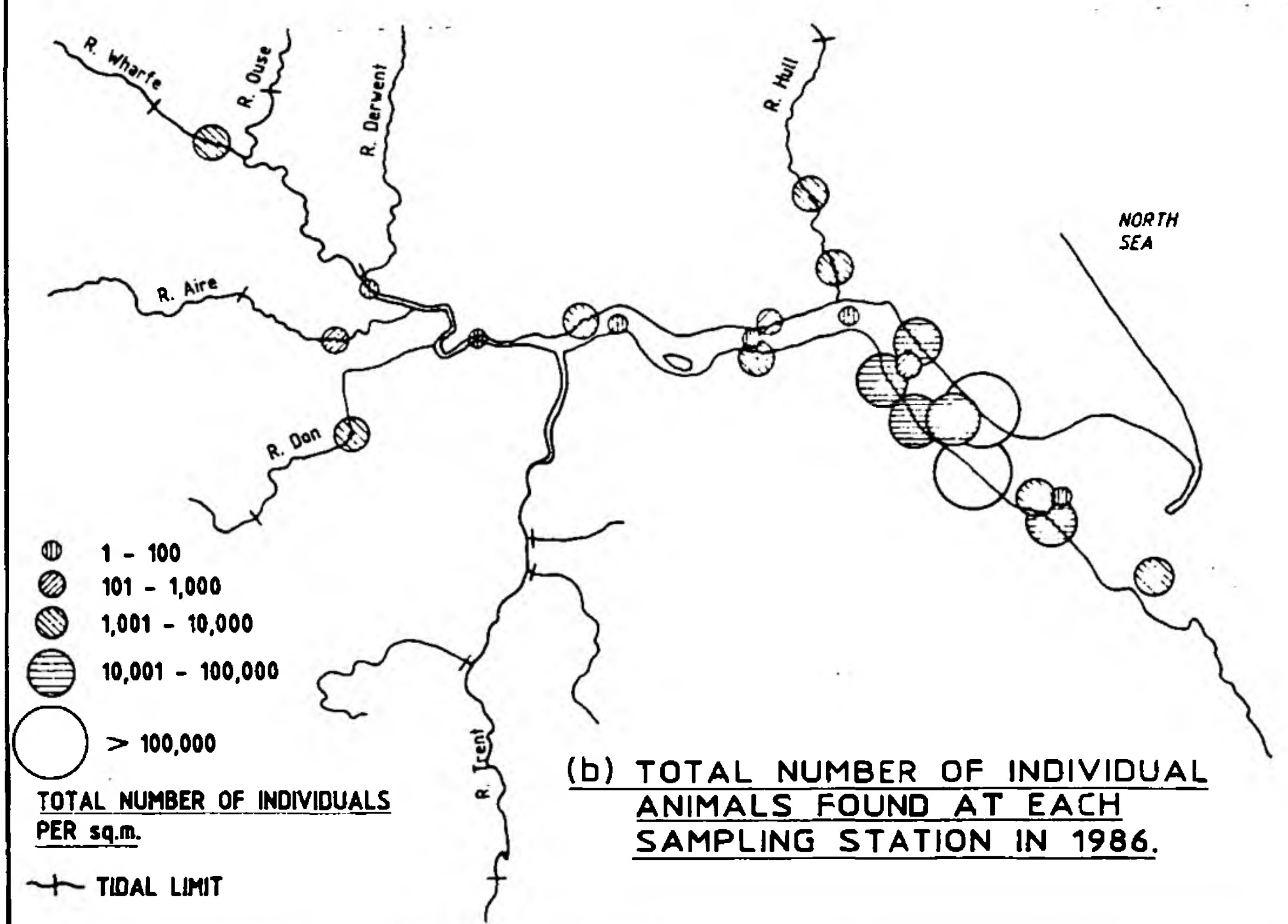
STATIONS
Weighton Lock, East Clough, Hessle
Alexandra Dock, Paull, Stone Creek

FIG. 14. FAUNAL DATA FOR THE HUMBER SYSTEM IN 1986.



(a) VARIETY OF ANIMALS FOUND AT EACH SAMPLING STATION IN 1986.

HUMBER BENTHIC SAMPLING STATIONS NUMBERED 1 to 8.



(b) TOTAL NUMBER OF INDIVIDUAL ANIMALS FOUND AT EACH SAMPLING STATION IN 1986.

PUBLICATIONS CONCERNED WITH THE HUMBER ESTUARY

Edwards, A M C (1985) Humber Estuary Water Quality Management: Review of Development Trends and Water Use. Report to the Humber Estuary Committee, 51pp.

Edwards, A M C and Lai P W (1984) The Effects of the Yorkshire Rivers on Dissolved Oxygen in the Humber Estuary. Water Sci Tech 16, 127-137.

Gameson, A L H (1982) The Quality of the Humber Estuary 1961-1981. Yorkshire Water Authority, 88pp.

Natural Environmental Research Council (1979) The Humber Estuary: A Selection of Reports on the Present Knowledge and its Future Potential Given at Two Symposia Arranged by the Humber Advisory Group and the University of Hull. NERC, Publ Series C, No 20, 33pp.

Porter, E (1973) Pollution of Four Industrialised Estuaries: Four Case Studies Undertaken for the Royal Commission on Environmental Pollution. HMSO, 98pp.

Sayers, D R (1986) Derivation and Application of Environmental Quality Objectives and Standards to Discharges to the Humber Estuary. Water Sci Tech 18, 277-285.

Woodward, G M (1984) Pollution Control in the Humber Estuary. Water Pollution Control, 83, 82-90.

Reports on routine chemical monitoring have been produced annually since 1963 - ones for years prior to 1981 are covered by the publication edited by A L H Gameson. Annual reports on biological monitoring were introduced in 1984.