CONTROLLING THE INPUTS OF PERSISTENT CHEMICALS TO MARINE WATERS FROM LAND-BASED SOURCES

DR R J PENTREATH
CHIEF SCIENTIST
NATIONAL RIVERS AUTHORITY

Introduction

In order to prevent pollution of the aquatic environment it is necessary to control the discharge of many substances simply because of their immediate effect on the receiving water, such as that of lowering the oxygen concentration or of making the water turbid. Other substances, however, have to be controlled because they are persistent and toxic to aquatic life over various timescales because of their accumulation into their tissues, or because they affect the relative abundance of different forms of plant life. Such substances are carried down rivers into estuaries, and hence to the sea, as well as being directly discharged - often from industrial plants sited on estuarine shores - or simply arising from many and varied diffuse sources because of their general use.

There are a number of current initiatives which address the need to reduce the input of such chemicals from point sources. At the same time, however, it is necessary to assess their total input from the land to the sea such that greater control and reduction can be effectively achieved. In order to do so, a programme is in hand - which also provides data in relation to a number of international commitments - to make such large scale assessments. These data are being obtained by all ten of the NRA regions in England and Wales, and collated by staff in the NRA's Anglian region.

What are the Persistent Chemicals?

The definitions and regulations relating to the discharge of certain chemicals variously described as persistent, noxious, hazardous, or even dangerous, are somewhat varied and invariably complicated. Such distinctions between them were first introduced at an international level as a result of the London Convention on the Prevention of Marine

Pollution by Dumping of Wastes and Other Matter (the 'London Dumping Convention'), and the more geographically limited Oslo Convention, both of which related to the dumping of materials from ships and aircraft, and both of which were drawn up in 1972. Both conventions also produced 'black', 'grey' and 'white' lists of substances in relation to dumping practices. A further convention, the Paris Convention, was drawn up in 1974; this related to discharges from land based sources and identified four categories of substances relating to discharge control. For the UK, the London and Oslo Conventions entered into force in 1974, and the Paris Convention in 1978. Between these two dates the EC, too, had produced its own lists in relation to certain 'dangerous substances' and this legislation, in particular, has been effective in determining environmental standards and the discharge controls required to meet them.

The situation, however, continues to develop and for the purposes of this paper such chemicals are identified as:

- List I (Black) or List II (Grey) substances for the purposes of the EC Dangerous Substances Directives;
- Priority UK Red List substances;
- Priority Hazardous substances as agreed by the Third International Conference on the Protection of the North Sea; and
- Prescribed substances as identified for the purposes of Integrated Pollution Control (IPC) under the Environmental Protection Act 1990 (EPA '90).

As to be expected, there is a good deal of commonality between them: indeed all essentially have a common origin and some are sub-sets, or variations of, others.

When the EC produced the initial framework Dangerous Substances Directive in 1976 (76/464/EEC) its aim was to improve the quality of waters by seeking to eliminate pollution caused by the discharge of the most dangerous substances - as determined essentially by a knowledge of their persistence, toxicity and bioaccumulation - and by reducing the input of others. Those in the first category (List I or 'Black' List substances) were either specifically identified or generally characterised, and their inputs to the environment were to be regulated across the European Community on the basis either of limit values (fixed emission standards) applied to the discharges, or by the use of Environmental Quality Standards (EQSs) applied

to the receiving waters. In order to select substances for List I status, some 4,500 were initially identified; these were then reduced to a 'short' list of 129 priority candidate Black List substances by taking into account the quantities of each produced per year within the Community. Of these, 17 have since been made the subject of daughter Directives and thus specifically controlled as List I substances.

The 76/464/EEC Directive also identified a number of List II (or 'Grey' List) substances, the discharge of which was to be reduced by steps to be determined at a national level. Of the 112 substances remaining from the 129 priority candidate Black List substances, 5 have since been transferred to List II status and the remainder, plus an additional 3, are to be regarded and treated as List II substances until otherwise determined.

Other lists specific to the marine environment have been compiled, notably for the United Nations Environment Programme (UNEP) since 1981; but that which has been of practical significance is the UK's Priority Red List, first proposed in 1988, which formed the basis for action to implement that part of the 1987 Ministerial Declaration of the 2nd International Conference on the Protection of the North Sea (NSC-2) which was concerned with the reduction of substances entering the North Sea via discharges from land. The list contained substances which occur in both EC Lists I and II, plus PCBs and several pesticides - 23 substances in total.

At the 3rd International Conference on the Protection of the North Sea (NSC-3) in 1990, a list of 36 substances was identified for priority action; this included all of those in the UK Priority Red List, with the exception of PCBs, all the current EC List I substances, 6 metals and organotin compounds from List II, plus additional pesticides and dioxins.

More recently, following the introduction of IPC under the EPA '90, a list of prescribed substances has been identified for specific control within England and Wales. This list is essentially the same as that of the UK Priority Red List except that it referred specifically to all isomers of hexachlorocyclohexane (HCH), DDT, trichlorobenzene (TCB), and to compounds of pentachlorophenol (PCP).

A compilation of these substances variously included in the Black, Grey, Red and other lists is given in Appendix A.

In addition to these substances, which are considered to have a potential 'toxic' effect when present in sufficient quantities, either to man or to some form of aquatic life, there are other substances such as nutrient chemicals which are persistent and can potentially alter the ecology of the receiving waters. Control is thus increasingly being brought to bear on their discharge and both the EC Urban Waste Water Treatment Directive (91/271/EEC) and the Nitrate Pollution Directive (91/676/EEC) require measures to be taken with regard to the protection of estuarine and coastal - as well as inland - waters which are deemed 'sensitive' or 'vulnerable' to eutrophication resulting from an excess input of nutrients.

Basis of Current Regulation

Under the Water Act 1989 (WA '89), since consolidated into the Water Resources Act 1991 (WRA '91), it is an offence to discharge any poisonous, noxious or polluting matter into controlled waters - which include coastal waters to a distance of three nautical miles from certain territorial baselines - unless such action is covered by a defence, one of which is that of the possession of a discharge consent issued by the NRA. Consents are issued such that site specific or general water quality objectives (WQOs), as determined by reference to relevant water quality standards, are met. A new scheme for setting WQOs on a statutory basis is soon to be introduced, but WQOs in relation to List I substances are already formalised via water quality standards in Regulations introduced under the 1989 and 1991 Acts respectively.

Discharges to sewers are made via trade-effluent consents issued by the sewerage undertaker; the deliberate entry into them of List I substances must therefore be specifically consented if it could result in an eventual effect on the receiving water, and must be controlled in order to ensure that the relevant EQS downstream of the final sewage outfall is met as a result of the discharge ultimately from the works, which would be consented by the NRA. Under the WA '89, regulations were introduced such that sewerage undertakers were required to refer to the Secretary of State any applications for new or varied discharges of certain prescribed substances to sewer; the scheduled list consisted of what was essentially the Red List, plus carbon tetrachloride, and thus included all List I substances.

Since the WA '89 was enacted, however, considerable steps have been taken to reduce further the potential discharge of certain substances into the environment. The EPA '90

introduced IPC; for those industries prescribed for such control, and which thus have the greatest potential to pollute, the use of the Best Available Techniques Not Entailing Excessive Cost (BATNEEC) and Best Practical Environmental Option (BPEO) will eventually ensure that certain 'prescribed' substances will be minimised at source as waste products, and that their entry into all sections of the environment will not only be strictly controlled but virtually eliminated or greatly reduced. The body responsible for IPC in England and Wales is Her Majesty's Inspectorate of Pollution (HMIP). Under IPC any direct discharge to the receiving water from a prescribed process will be authorised by HMIP, but only if the NRA is satisfied that EQS values in the receiving water will not be exceeded as a result; trade effluents containing prescribed substances above background levels discharged into sewers have also to be authorised by HMIP. But the discharges from the sewage treatment works into the receiving water, and some discharges from mixed processes and sites, continue to be consented by the NRA under current legislation. And it should also be noted in passing that the dumping of any substances from ships, aircraft, or marine structures into territorial waters have to be licensed by the Ministry of Agriculture, Fisheries and Food, or Secretary of State for Wales as appropriate, under the Food and Environmental Protection Act 1985 (FEPA '85).

Finally, the UK is a signatory to the London Dumping Convention, the Oslo Convention, the Paris Convention, plus the North Sea Conferences, and of these both the Paris Convention and the North Sea Conferences seek to obtain agreed international control, monitoring, and understanding of the input of pollutants from land-based sources; in particular, the latter has sought to reduce by 50% the input of hazardous substances into the North Sea - both directly and indirectly via rivers, estuaries and atmospheric deposition - by 1995 relative to an assumed baseline of 1985 inputs. This is reflected in a UK Action Plan to achieve such reductions.

Sources of Input of Persistent Substances to the Marine Environment

Of the substances variously classified under the national and international lists as being in need of specific regulation in order to reduce their input

- some also occur naturally,
- some are discharged directly to rivers, estuaries or the sea,

- some are discharged to sewer and thus may enter the aquatic environment via liquid effluent from sewage treatment works or from sewage sludge dumped at sea, and
- some, such as pesticides and fertilisers, enter the aquatic environment diffusively because of their use, including atmospheric pathways.

In view of these varied inputs therefore, it is clearly desirable to have a reasonable indication of the relative importance of each source such that regulations and pollution control effort can be used to the greatest effect. Indeed, the control of discharges of persistent and potentially hazardous chemicals, by limits based on concentrations of substances at specific locations in the receiving environment, is not of itself sufficient: account also has to be taken of the total quantities discharged because of the collective potential impact to which the environment is then committed.

Methods of Estimating Inputs

Prior to the introduction of new consenting practices by the NRA, and the introduction of IPC under the EPA '90, discharge consents did not necessarily contain limits on the total quantities of substances which could be discharged. Many of them did have limits on the total volumes of liquid which could be discharged per unit time, plus limits on the maximum concentrations of certain substances in the effluent. These limits were set to protect the receiving water under certain low-flow conditions. In many cases the consents included allowance for site drainage under wet weather conditions and thus it is unlikely that such a site would be discharging under conditions of maximum volume, and maximum concentration, when the receiving water flow was at a minimum. The product of the two values do not therefore usually give a meaningful indication of the actual total 'load' discharged over a sustained period of time, although it is a value which could not be exceeded. Discharge consents are now being set on a different basis where necessary.

A knowledge of such theoretical maxima arising from consented discharges is, in any case, only of limited value in determining the actual quantities entering coastal waters from the land because of the multiplicity of sources; direct estimations are, however, equally difficult to determine. Nevertheless, under the Paris Commission a decision was made in 1988 to undertake a comprehensive annual study of selected inputs to waters covered by the Convention. The substances to be measured were five metals (mercury, cadmium, copper,

zinc, and lead), four nutrients (nitrates, orthophosphates, total nitrogen and total phosphorus), one pesticide (gamma-HCH, also known as lindane), plus suspended particulate matter (spm) and salinity. It was also suggested that seven congeners of PCBs could usefully be measured. An initial study was made in 1990.

The NRA carried out this preliminary work in England and Wales. All the main river systems were studied, being sampled approximately monthly at locations close to, but upstream of, the tidal limit where the uni-directional freshwater flow ceases. All major direct discharges of trade effluent, or of sewage effluent, downstream of the river sampling points were similarly sampled, as were direct major discharges to the coast from such sources. Monthly samples were taken and each total sample analysed for the various substances: the total suspended particulate matter (spm) was also determined (0.45μm) and the flow rate of the sampled water measured.

Estimates were made of the total annual inputs during 1990 of nine substances from the principal land-based sources - 129 rivers, plus 131 main sewage outfalls and 105 industrial outfalls downstream of the riverine freshwater limit - into the coastal waters of England and Wales. The estimates were made on the basis of the arithmetic mean of the twelve 'spot' readings at each site, but comparisons made using mean annual flow rates for one river - the Thames - did not give significantly different results. Nevertheless, it must be noted that the scale of the error relating to the flow-rate information, particularly for rivers, is not precisely known.

The other principal source of error is, of course, that of the analytical determination of the substances themselves. In many cases the analyses were made such that the chemical of interest was less than the limit of detection by the methods used. These also differed from laboratory to laboratory, and hence from region to region. Two choices are then available: either to multiply the flow rates by the values used as the limits of detection, or to assume the concentrations to be zero. Where appropriate, both methods have been used in the total input summations; these are indicated as 'high' and 'low' estimates respectively for copper, cadmium, mercury, and the pesticide gamma-HCH.

Results for 1990

The estimated total annual inputs for 1990 are given in Table 1. As to be expected, the values vary from many tens of thousands of tonnes per year of phosphate and nitrate, and very large quantities of metals such as zinc and copper, to a few tonnes per year of cadmium and mercury, and to fractions of a tonne of the pesticide gamma-HCH. As also to be expected, inputs downstream of the freshwater limits as a result of discharges from industry and from large sewage outfalls are most significant for the metals cadmium and mercury, whereas input from industry in such locations is not of importance for the pesticide gama-HCH, although inputs from sewage outfalls are still of significance.

The results in Table 1 give no indication of regional variations. The data can obviously be broken down into different sectors of the English and Welsh coast: for the purposes of the Paris Commission work, this has been done on the basis of 30 coastal zones used by the International Council for the Exploration of the Sea (ICES). In order to give some comparative indication, however, the data have been analysed in relation to different sectors of the coast. These are shown in Figures 1 to 7. The areas are:

- the north, north-east coast;
- the area between, and including, the Tyne and the Tees;
- the east coast down to Spurn Head;
- the Humber;
- the south-east coast around to Dorset;
- the south-west and west coast around and up to the Wirral;
- the Mersey and immediate adjacent coast; and
- the rest of the north-west coast.

As can be seen, the input of nitrate (Figure 1) arises primarily from the southern part of the country, some 25% entering via the Humber. The input of ortho-phosphate (Figure 2) similarly indicates a greater contribution from the south, particularly the south-east. In contrast, the input of the pesticide gamma-HCH (Figure 3), which has been variously used as a cloth and, particularly, as a wood preservative, is largely from the more highly populated south-east, and from the Humber which drains much of the Midlands area of England. And in further contrast, the inputs of the industrially important metals mercury

TABLE 1

Estimated Total Annual Inputs for 1990 into Estuaries and Coastal Waters from Land-based Sources in England and Wales

Substance	Input ($kg\ a^{-1}$)	Source (%) "Estuarine/Coastal"		
		River	Sewage Works	Industry
SPM	**2.1×10^9**	**46**	**11**	**43**
Total N	**2.2×10^8**	**61**	**22**	**17**
Nitrate	**1.4×10^8**	**88**	**9**	**3**
Ortho-P	**3.2×10^7**	**43**	**42**	**15**
Zn	**3.1×10^6**	**50**	**12**	**38**
Cu (low)	**4.4×10^5**	**51**	**22**	**27**
(high)	5.0×10^5	54	22	24
Pb (low)	**3.4×10^5**	**74**	**9**	**17**
(high)	4.3×10^5	73	12	15
Cd (low)	**3.4×10^4**	**17**	**14**	**69**
(high)	4.6×10^4	30	17	53
Hg (low)	**5.5×10^3**	**36**	**4**	**60**
(high)	9.1×10^3	58	4	38
αHCH (low)	**3.0×10^2**	**49**	**50**	**1**
(high)	4.3×10^2	57	38	5

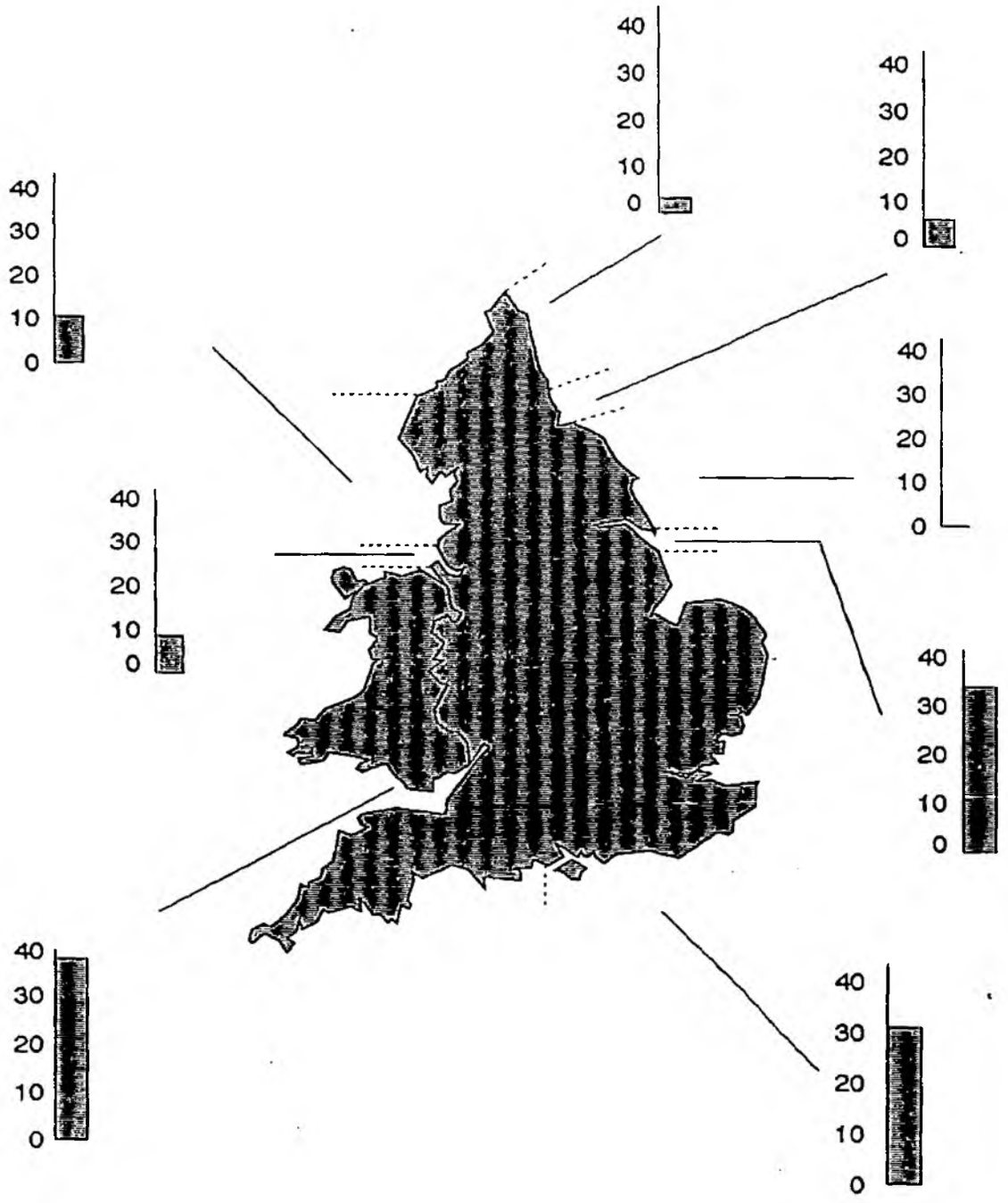

Figure 1 Total quantities (kilo-tonnes per year) of nitrate entering coastal waters from the principal rivers, plus inputs from major industrial and sewage works' discharges downstream of them.

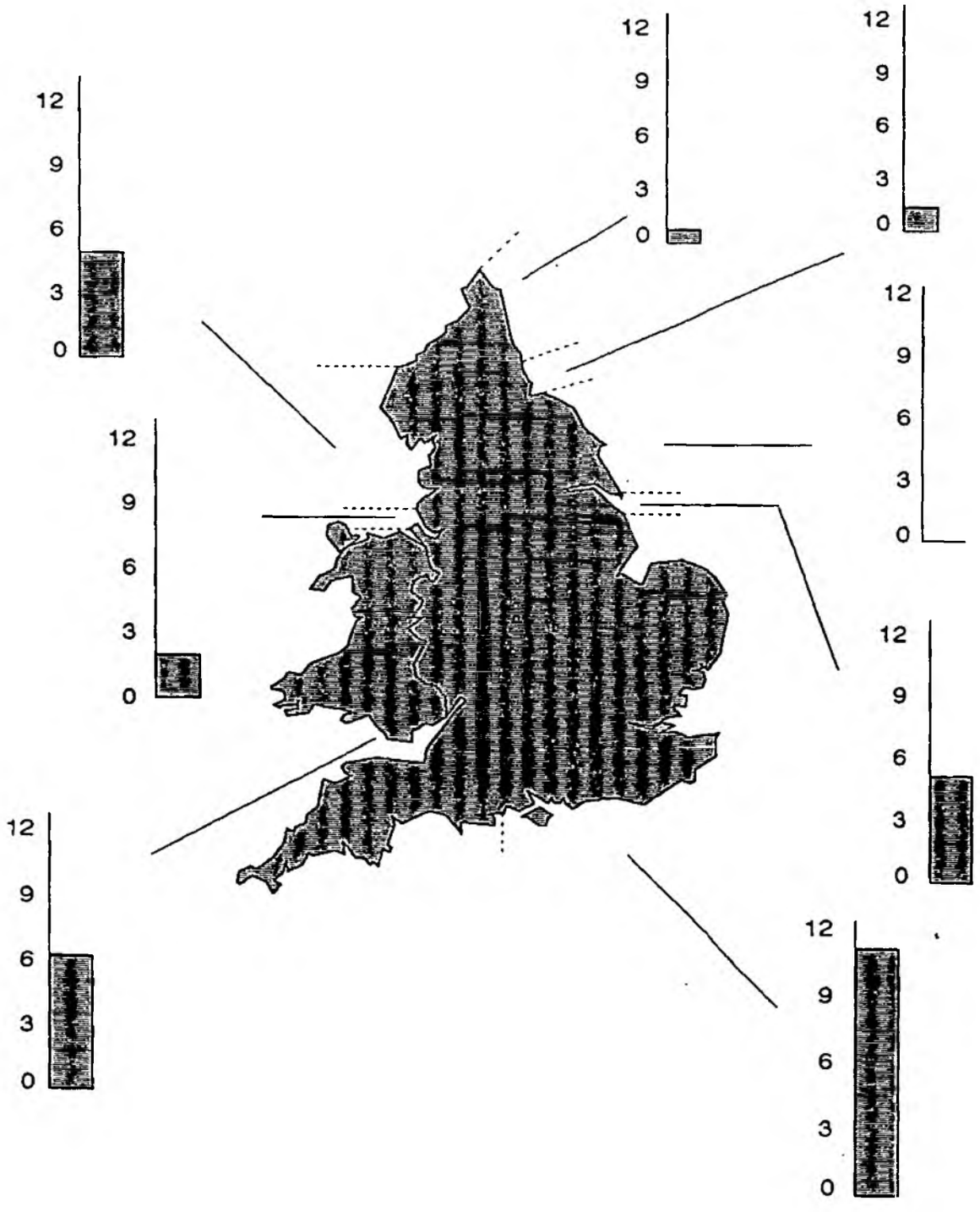

Figure 2 Total quantities (kilo-tonnes per year) of ortho-phosphate entering coastal waters from the principal rivers, plus inputs from major industrial and sewage works' discharges downstream of them.

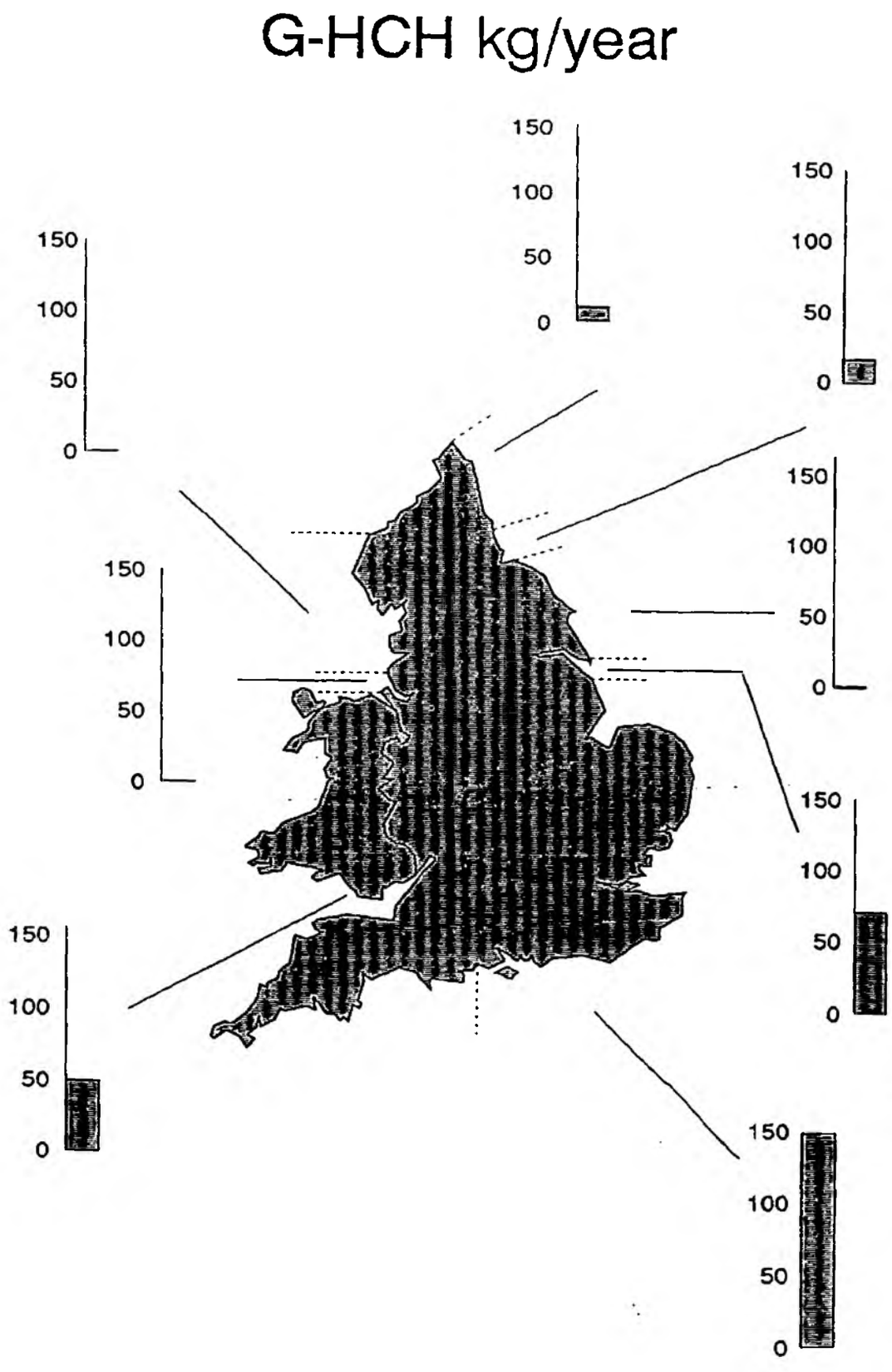

Figure 3 Total quantities (kg per year) of gamma-hexachlorocyclohexane entering coastal waters from the principal rivers, plus inputs from major industrial and sewage works' discharges downstream of them.

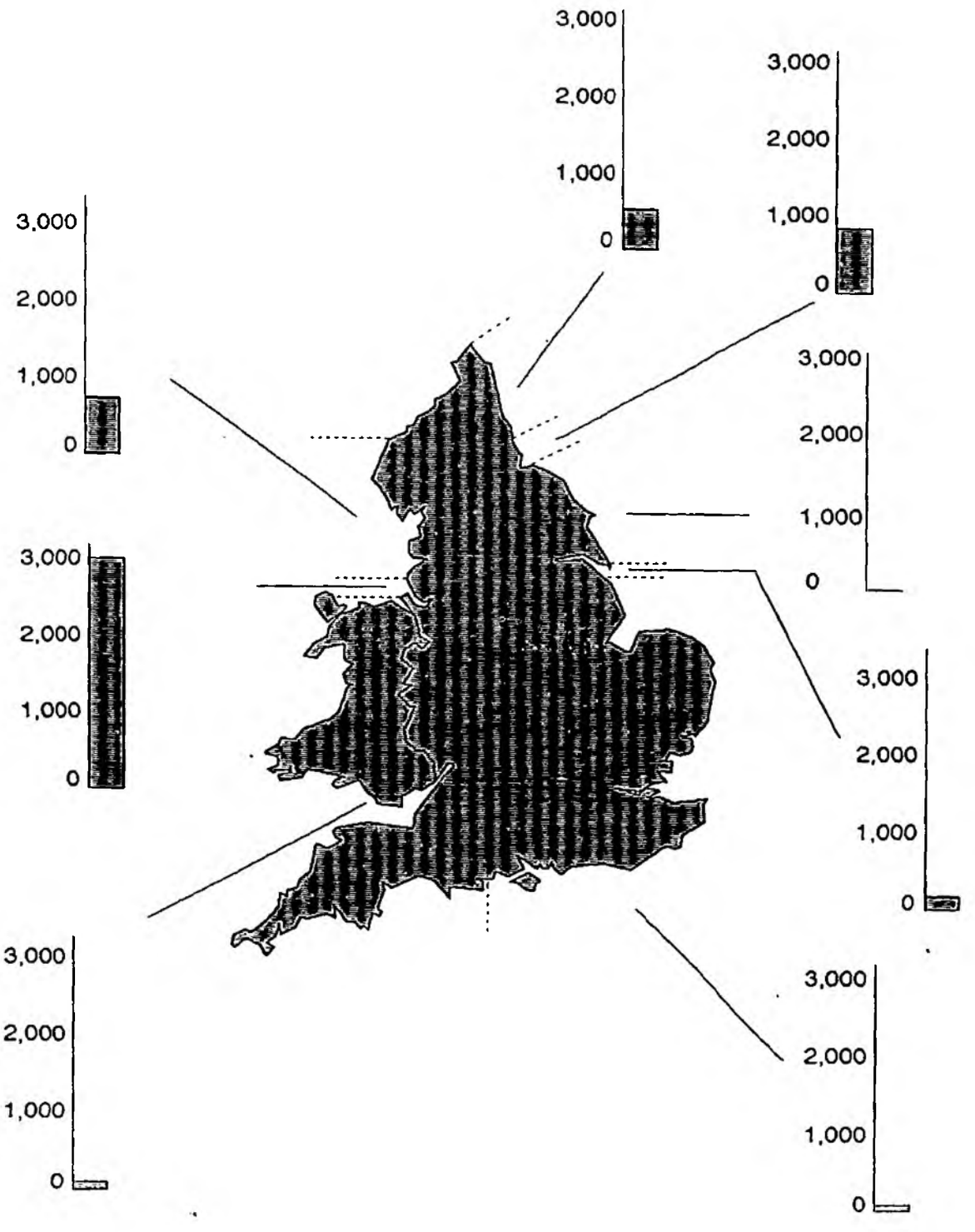

Figure 4 Total quantities (kg per year) of mercury entering coastal waters from the principal rivers, plus inputs from major industrial and sewage works' discharges downstream of them.

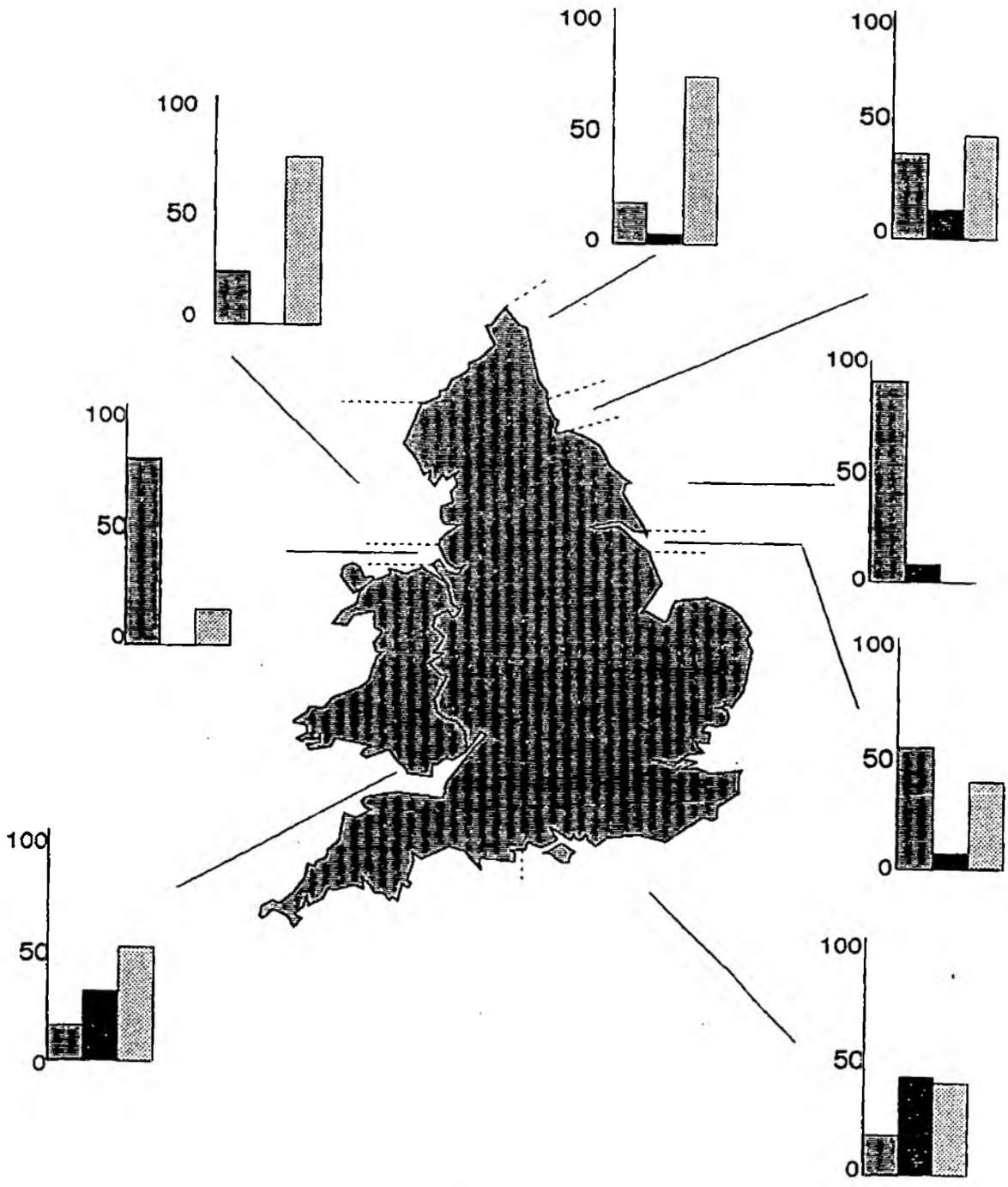

Figure 5 The relative (%) contribution of riverine and downstream industrial and sewage treatment works' discharges of mercury into different sections of the English and Welsh coast.

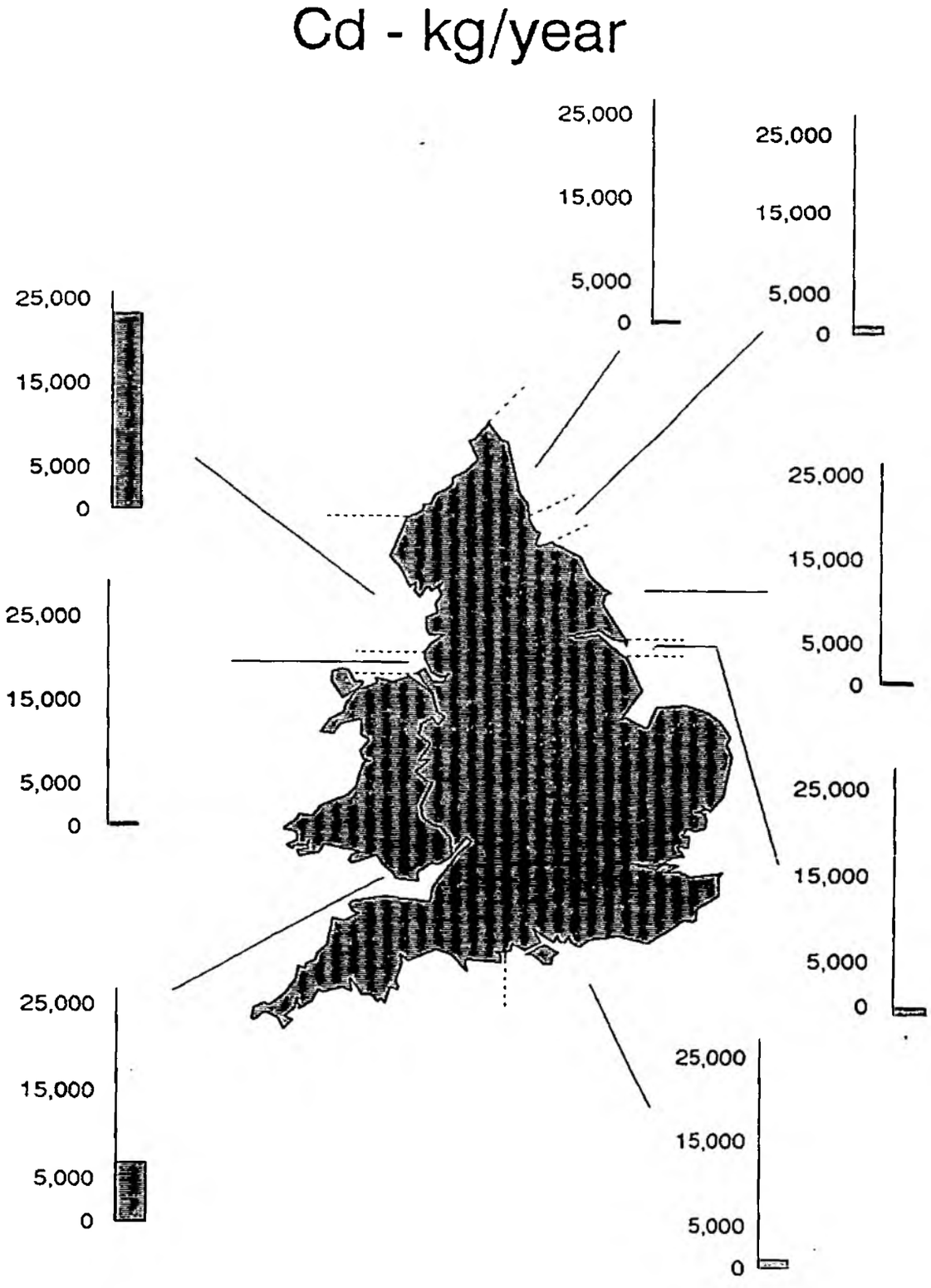

Figure 6 Total quantities (kg per year) of cadmium entering coastal waters from the principal rivers, plus inputs from major industrial and sewage works' discharges downstream of them.

Figure 7 The relative (%) contribution of riverine and downstream industrial and sewage treatment works' discharges of cadmium into different sections of the English and Welsh coast.

(Figures 4 and 5) and cadmium (Figures 6 and 7) are dominated by the discharges arising via the Mersey and the north-east coast respectively. Indeed the metal data are well worth examining more closely. It would appear that in the area (Figure 4) where the inputs are largest - the Mersey - the contribution is predominantly that of direct industrial discharges downstream of the freshwater limit (Figure 5). Indeed about a third of the national total arises from industrial discharges into the river Weaver, and hence to the Mersey which receives further discharges from industry. Elsewhere - in the north-east and north-west - the inputs are more varied in their origin. Similarly for cadmium (Figure 6) the input is dominated by a single industrial discharge on the north-west coast, but elsewhere (Figure 7) the sources are considerably varied.

Samples were also analysed for seven congeners of PCB - C28, C52, C101, C118, C138, C153 and C180. Estimates of total inputs were inevitably dominated by a few positive results, essentially from the rivers Humber, Thames, Severn and Mersey, and the most prevalent congeners were C52 and C101 - about 50kg of each - although significant positive results (19kg) for C153 were also detected.

Since these 1990 results were obtained, a second study was made in 1991, the results of which are still being analysed and thus only a preliminary indication of them can be given here. The nutrients appear to be within an order of magnitude of the initial study, as is the estimate of suspended particulate matter. Similarly, the values for zinc, copper, and lead are close to the 1990 data; the mercury and cadmium values are, however, lower at both 'low' and 'high' levels of estimation whereas both these limits for gamma-HCH are higher. With regard to the PCBs, the data indicate generally lower estimates than those made in 1990. Quite clearly, however, further work needs to be done in both analysing existing data and in refining and improving the basis upon which they are derived.

In the latter half of 1990 samples were similarly taken and analysed for a fuller range of Red List substances. The results of this survey, again interpreted as if they represented an annual input, are given in Table 2. As to be expected in the case of such substances, very substantial differences emerge between estimates based on either the 'low' load or 'high' load assumptions: obviously, if a chemical is essentially absent, then taking a positive - though very low - value as the limit of detection in terms of concentration, and then multiplying it

by a large rate of flow, produces a substantially high number. The 'low' value estimates are thus likely to be closer to the real values.

At first glance, therefore, it would appear that notwithstanding the uncertainties in the data, significant quantities of a number of these Red List substances pass from the land into coastal waters: of particular note are total organic tin (TOT), dichloroethane, PCP, simazine, atrazine, and TCB. Their varied sources are also of interest. For several of them - aldrin, dieldrin, trifluralin, TCB, hexachlorobenzene (HCB), hexachlorobutadiene (HCBD), fenitrothian, malathion, atrazine and PCB - the riverine input is dominant, based on the 'low' value estimates. But it must be noted that these riverine inputs, in turn, are likely to have arisen as a result of direct discharges from industry and from sewage treatment works - which also receive discharges from industry and diffuse sources - plus agricultural and surface water run-off, together with atmospheric deposition.

Further studies of the inputs of the substances in Table 2, plus some others, have also been made in 1991 and again the results have not yet been finalised and interpreted; but many of them indicate that the initial survey was again within order-of-magnitude proximity to the full year set.

Table 2

Estimated Total Annual Inputs, Based on Six Months Data Collected in 1990, into Estuaries and Coastal Waters from Land-based Sources in England and Wales

Substance	Input (kg a^{-1})	Source (%)		
		River	Sewage Works	Industry
TOT (low)	1.8×10^4	23	36	41
(high)	5.6×10^4	72	14	14
DDT (low)	3.0	16	84	0
(high)	2.2×10^2	85	11	4
Aldrin (low)	3.3	89	11	0
(high)	1.5×10^2	90	7	3
Dieldrin (low)	1.4×10	63	36	1
(high)	1.5×10^2	88	9	3
Endrin (low)	0.4	14	75	11
(high)	2.1×10^2	85	10	5
Trifluralin (low)	4.0×10	89	1	10
(high)	1.7×10^2	87	7	6
TCB (low)	3.5×10^2	69	29	2
(high)	6.7×10^4	94	6	0
HCB (low)	3.0×10	49	12	39
(high)	1.3×10^2	79	9	12
HCBD (low)	2.6×10	91	7	2
(high)	1.8×10^2	85	9	6
Endosulphan (low)	4.4×10^{-2}	0	0	100
(high)	1.1×10^2	88	9	3
Dichlorvos (low)	3.7×10	38	62	0
(high)	3.8×10^2	78	16	6
Fenitrothion (low)	8.2	61	39	0
(high)	3.1×10^2	75	14	11
Malathion (low)	2.0×10	98	2	0
(high)	2.8×10^2	61	23	16
Azinphosmethyl (low)	9.4×10	4	88	8
(high)	3.7×10^2	58	36	6
Atrazine (low)	2.3×10^3	78	21	1
(high)	4.8×10^4	85	13	2
Simazine (low)	2.4×10^3	40	60	0
(high)	4.8×10^3	72	27	1
PCP (low)	2.6×10^3	58	18	24
(high)	2.3×10^4	94	3	3
Dichloroethane (low)	8.9×10^3	3	3	94
(high)	1.1×10^5	94	1	5

Future Requirements and Developments

Further information relating to the sources, rates of input, and fate of persistent chemicals arising from land based sources via rivers and from direct discharges to estuaries and the open sea is obviously essential for a number of reasons. First of all there are international commitments to carry out current Action Plans for reductions in the input of various listed substances, and to provide information to the Paris Commission, and to the North Sea Conference Secretariat, in order to compile the second quality status report on the North Sea. Such information will be used to assess trends in estimated inputs and, eventually, to determine actual reductions against planned targets. It would be interesting to discuss here, for example, comparative information from other countries, particularly in relation to Red List substances, but such data are often lacking. Compared with the data available in 1990, however, it would appear that the discharge of nutrients such as nitrogen and phosphorus from England and Wales into all of their surrounding seas is less than that of other countries into the North Sea alone, and the same can be said for metals such as copper, zinc and mercury. The second Quality Status Report on the North Sea, due in 1993, will therefore be of particular interest.

In order to achieve a greater level of control and management over such inputs at a national level, however, it is clearly essential to have high quality environmental information on all the relevant factors. This is particularly important with regard to the setting and revision of discharge consents. Since its formation, the NRA has worked towards the practice of catchment planning, which recognises that successful management of the freshwater environment can only be achieved if all aspects of the activities which affect water within an entire catchment, from source to sink, are taken into account. Within this framework, in order to ensure that various EQSs are met for EC and national purposes, the NRA has therefore had to consider the input of persistent substances from diffuse and point sources. With regard to the latter, the complementary introduction of IPC will do much to reduce the potential input of prescribed substances, by concentrating on the need to reduce or eliminate the production of dangerous substances as waste in prescribed process operations, from the initial design stage through to plant operation. The application of IPC came into effect from 1 April 1991 for all new processes and existing processes undergoing substantial change; controls over other existing processes are being phased in over a five year period. But as can be seen from the information in this paper, many persistent and dangerous chemicals also

arise from more diffuse inputs - which then may enter coastal waters via rivers or via sewage and surface water run-off collecting systems. The need to combine both the work of the NRA and HMIP is thus clearly necessary for longer-term control, and indeed this need has been recognised such that the work of both will be incorporated fully into a new Environment Agency which the UK Government is to set up in the near future to operate within England and Wales. This Agency will also have control over the input of substances from major facilities into the atmosphere - a further pathway to the marine environment from the land - plus control over wastes disposed of direct to land. Further effort will also be needed to reduce unnecessary use, and to ensure adequate precautions are taken with regard to the transport and storage of certain chemicals.

In the shorter term, however, it is necessary for the NRA to consider the consenting of persistent substances both in terms of complying with the relevant EQS values and the total quantities actually liable to be discharged, because it has to be accountable for their long-term as well as short-term potential impacts on the environment. Indeed, such accountability, on a catchment or similar environmentally derived basis, needs to be uppermost in the requirements of the new Agency. It does pre-suppose, however, that the rates of input, fate, and behaviour of the different substances are reasonably well known and can be predicted.

Thus in addition to assessing the sources and inputs of persistent substances, studies have also to be made as to how their distribution and possible effect can be monitored. The three mile coastal water area for which the NRA has water quality responsibilities represents some 8,000 square miles. Its own fleet of four inshore research vessels are now taking part in co-ordinated cruises throughout these waters in order to determine nutrient levels and concentrations of a number of List I substances. The feasibility of using aerial surveillance by deploying a Compact Airborne Spectral Imager has also been examined in order to convert the information obtained by ships on nutrient, chlorophyll and plankton concentrations by travelling in lines along the coast into two-dimensional coverage of the entire three mile wide strip. Modelling, too, will be important. Better models are required, and data will be needed to support large scale national initiatives such as the National Environmental Research Council's major new Land-Ocean Interaction Study (LOIS).

Indeed, one of the questions which still needs to be addressed is the extent to which these varied inputs, particularly of those substances which occur naturally, make a significant

difference to the total annual fluxes of materials through the coastal zones, from both onshore and offshore sources, and thus to their eventual environmental effect. In all of these, and in monitoring studies, continuing emphasis will also have to be placed on analytical quality control procedures if sensible comparisons are to be made.

The greatest requirement, however, is for the reduction in the potential, or risk, of such chemicals being unnecessarily released. This not only includes reduction at source, but minimisation of the likelihood of their entry as a result of inadequate storage facilities and so on. And as controllable point source inputs from active industries are reduced, increasing emphasis will have to be placed on other sources, particularly contaminated land and abandoned mines. There is thus much still to be done. A prerequisite as always, however, is the availability of adequate and relevant data.

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Tables of Dangerous Substances, Quality Standards and Limits of Detection

Comparison of Dangerous Substances included on Specific Lists as at March 1992

Substance	Dangerous Substances (Classification) Regulations 1989 and 1992	List I	List II	Priority UK Red List	Prescribed Substances for Discharge to Water EPA Sch 5	Priority Hazardous Substances
Mercury & its compounds	+	+		+	+	+[1]
Cadmium and its compounds	+	+		+	+	+[1]
Aldrin	+	+		+	+	}
Dieldrin	+	+		+	+	}
Endrin	+	+		+	+	} +[2]
Isodrin	+	+				}
o-HCH	+[3]	+[3]		+	+[3]	+[2]
pp-DDT	} +	+		}	}	}
op-DDT	} +[3]	+		}	}	}
pp-DDE	}	+		} +[2]	} +[3]	} +[2]
pp-TDE	}	+		}	}	}
Pentachlorophenol & its compounds	+	+		+[1]	+	+[1]
Hexachlorobenzene	+	+		+	+	+
Hexachlorobutadiene	+	+		+	+	+
Carbontetrachloride	+	+				+
Chloroform	+	+				+
Trichloroethylene	+	+				+
Tetrachloroethylene	+	+				+
Trichlorobenzene	+	+[3]		+[2]	+[3]	+[2]
1,2-Dichloroethane		+		+	+	+
Arsenic		0	+			+
Chromium			+			+
Copper			+			+
Lead			+			+
Nickel			+			+
Zinc			+			+
Tributyltin compounds		0	+	+	+	+
Triphenyltin compounds		0	+	+	+	+
Boron			+			
Iron			+			
pH			+			
Vanadium			+			
PCSDs[4]			+			
Cyfluthrin[4]			+			
Sulcofuron[4]			+			
Flucofuron[4]			+			
Permethrin[4]			+			
PCBs		0		+	+	
Trifluralin		0		+	+	+
Endosulfan		0		+	+	+
Simazine		0		+	+	+
Atrazine		0		+	+	+
Fenitrothian		0		+	+	+
Malathion		0		+	+	+
Dichlorvos		0		+	+	+
Azinphos-methyl		0		+	+	+
Azinphos-ethyl		0				+
Fenthion		0				+
Parathion		0				+
Parathion-methyl		0				+
Trichloroethane		0				+
Dioxins		0				+

1 - compounds not specified
2 - particular isomers not defined
3 - all isomers
4 - mothproofing agents, see WRc Report No TR261
0 - included on the list of candidate List I substances

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