



ROYAL COMMISSION
ON
ENVIRONMENTAL
POLLUTION

CHAIRMAN: SIR ERIC ASHBY

THIRD REPORT

POLLUTION IN SOME BRITISH ESTUARIES
AND COASTAL WATERS

Presented to Parliament by Command of Her Majesty

September 1972

LONDON

HER MAJESTY'S STATIONERY OFFICE

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THIRD REPORT

To the Queen's Most Excellent Majesty

MAY IT PLEASE YOUR MAJESTY

We, the undersigned Commissioners, having been appointed "to advise on matters, both national and international, concerning the pollution of the environment; on the adequacy of research in this field; and the future possibilities of danger to the environment";

And to enquire into any such matters referred to us by one of Your Majesty's Secretaries of State or by one of Your Majesty's Ministers, or any other such matters on which we ourselves shall deem it expedient to advise:

HUMBLY SUBMIT TO YOUR MAJESTY THE FOLLOWING REPORT.

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CHAPTER I

INTRODUCTION: A POLICY FOR ESTUARIES

Introduction

1. Between the coastline and the open seas round Britain there are the so-called tidal waters: shallow, close to towns and to industry, and used not only for fishing and recreation but as a convenient and cheap sink for domestic and industrial wastes. Of particular importance are the big estuaries, where tidal waters run up the rivers and are diluted with fresh water on its way to the sea. Some of these estuaries have become great centres of industry. They are not subject to all the legislation and surveillance which exists to control pollution in rivers and some of them are grossly polluted. It is for this reason that we concentrate upon estuaries in this, our Third Report, as one of the topics which we listed in our First Report as in need of further study⁽¹⁾. Our treatment of the subject obliges us to say something about the control of pollution in rivers, along coasts, and in the sea within the continental shelf; but our main emphasis is upon industrialised estuaries.

2. The pattern of the Report is as follows. After an introductory essay in Chapter I we set out conclusions and recommendations in Chapter II. The rest of the Report supports these introductory chapters: it includes chapters on the causes of pollution and its significance for estuaries and coastal waters; on the present pattern, soon to be changed, of legislative and administrative control; on the need for monitoring and research; on questions of economics, and on a possible means of abating pollution by charges rather than by control and consent. The appendices include a review of the common pollutants discharged into estuaries and coastal waters, a summary of international agreements and activities concerned with marine pollution and a list of those whom we consulted. We have also commissioned case-studies, which will be published separately, of four industrial estuaries.

3. It is never our intention to duplicate work already being done by other bodies, but rather to bring to public notice material in technical reports which do not have a wide circulation. So we make it clear at the outset that although our assessment of the pollution problems of estuaries is entirely our own, we have drawn on data given to us or published by other bodies, supplemented by our own visits to seven of the more industrialised estuaries (Clyde, Forth, Humber, Mersey, Tees, Severn, Southampton Water). We did not visit the Thames estuary because this has been extensively studied already⁽²⁾. We referred in our First Report⁽¹⁾ to the improvements brought about in this estuary and it provides an excellent example of how the scientific study of an estuary can be used to pinpoint the action required to clean up pollution.

4. Pollution is only one theme in the debate which is going on about the future of the environment. We are charged to concentrate upon this theme but

we realise—and we want our readers to realise—that control of pollution alone will not preserve the environment for future generations. Other themes, such as population growth and the availability of natural resources, are equally important. There are, however, advantages in considering pollution separately: it needs to be abated whatever view is taken on these other issues; much progress has been made in Britain toward controlling it; techniques for measuring traces of polluting substances have become more refined; and there is every expectation of continued progress, provided the public understand the issues and governments are prepared to act.

5. In considering pollution in estuaries and coastal waters we frequently met the assumption that pollution is not a hazard unless it directly endangers human health. We therefore emphasise that danger to other forms of life may be no less serious. For example, if it were ever to become the case that a pollutant which inhibited the capacity of micro-organisms in the sea to convert carbon dioxide to oxygen, or to break down organic matter, became widespread, this could be a menace. Concern for the eventual impact on man of the ecological cycle which ultimately sustains life is sometimes misinformed, but this concern is not mere sentimentality.

The state of some estuaries

6. A great deal of pollution ends in the sea. Some of it is discharged through sewers direct into tidal waters; some reaches the sea through rivers; some is carried into the air and brought down to the sea with rain; and some, including some very toxic wastes, is dumped in containers from ships. The sea is a powerful and effective scavenger of many pollutants but recently biologists have become apprehensive about its capacity to deal indefinitely with the waste materials being put into it. There has already been enough degradation of the environment to justify this apprehension, notably in enclosed seas like the Baltic and the Mediterranean, which have very little tidal rise and fall.

7. Britain is fortunate in being surrounded by seas which are subject to strong currents, in addition to a relatively high tidal rise and fall. Nevertheless, very large quantities of effluent are discharged to sea, the North Sea also receiving pollutants from the industrialised and densely populated areas of the continent of Europe. In the North Sea the strong currents, the high winds and the shallow waters together give a high degree of aeration and good mixing, which provide good conditions for the assimilation of degradable effluents such as domestic sewage and certain industrial wastes. On the other hand, its shallowness and partially enclosed nature give grounds for concern that persistent substances, such as heavy metals, may be accumulating.

8. Figures 1–3 give an impression of the amount of waste which flows into the seas round our coasts. More details are given in Appendix A. To mention quantities is little more than guesswork at present. We know that many millions of gallons of liquid wastes are discharged into the coastal and estuarine regions of the North Sea alone from this country. (One million gallons a day is roughly equal to half the volume of water which flows at three miles per hour in a channel

one foot wide and one foot deep in the course of a day.) What we do not know is at what levels the volume and composition of this waste would upset the capacity of the sea to render it harmless. Already harm is being done locally, especially in some estuaries of large rivers.

9. A sample of the evidence for this is to be found in the Department of the Environment's recent river pollution survey⁽³⁾. The report contains reassuring evidence that the state of non-tidal rivers is improving. But the mileage of tidal rivers in urgent need of improvement has slightly increased over the last 12 years. Detailed data for the more heavily polluted estuaries (Table 1) give no ground for complacency.

TABLE 1

State of some tidal rivers (estuaries) grouped by river authority areas where concentrations of population and industry occur

(Data from reference (3))

<i>River authority area</i>		<i>Total length</i>	<i>Unpolluted</i>	<i>Doubtful, needing improvement</i>	<i>Poor, urgently needing improvement</i>	<i>Grossly polluted</i>
Northumbrian	miles	83	17	12	22	32
	km	133	27	19	35	52
	%	100	20.4	14.5	26.5	38.6
Yorkshire	miles	124	48	4	56	16
	km	200	78	6	90	26
	%	100	38.7	3.2	45.2	12.9
Trent	miles	52	0	26	0	26
	km	84	0	42	0	42
	%	100	0	50	0	50
Hampshire	miles	55	35	15	2	3
	km	89	52	24	3	5
	%	100	63.7	27.2	3.6	5.5
Glamorgan	miles	36	2	4	16	14
	km	58	3	6	26	22
	%	100	5.6	11.1	44.4	38.9
Mersey and Weaver	miles	67	1	3	40	23
	km	108	2	5	64	37
	%	100	1.5	4.5	59.7	34.3
Port of London	miles	78	0	14	64	0.3
	km	126	0	22	103	0.5
	%	100	0	17.9	81.8	0.4

10. On the one hand, gross pollution of estuaries does obvious harm to the natural environment. Birds and sea mammals may be affected. It prevents the

passage of migratory fish and so interferes with their life cycle. It brings to an end the commercial use of shellfish. It looks unpleasant and may at times stink. It may poison the nursery waters of some fish. The water may become so deprived of oxygen that it can no longer support the bacteria which purify organic waste. There may be more sinister though less obvious consequences of estuarial pollution. Contrary to popular assumption the scour of the tides does not immediately dispose of wastes into the sea, where great dilution might render them innocuous. Some potentially dangerous substances, mercury for instance, accumulate in the bottom mud⁽⁴⁾. They may remain there, inert; or they may be absorbed by living organisms. These dangers cannot be satisfactorily assessed in scientific terms, let alone be costed in money, and some people regard them as too insubstantial to be balanced against the great value which estuaries offer to industry. The trouble is that there could be points of no return in the deterioration of water.

11. On the other hand, as is evident from facts we summarise in Chapter III, estuaries are of great benefit to the economy. They offer shelter and access for large vessels which can bring raw materials and carry away products. They provide vast quantities of cooling water, free of charge. And they are a cheap and convenient sink for the disposal of wastes, both from the industries themselves and from the populations serving the industries. Consequently there has been a notable migration of industry to some estuaries in recent years. On Teesside, for instance, the number of people employed in major industrial groups increased from about 82,000 in 1931 to 194,000 in 1969. Moreover, the nature of the industries located on some estuaries has changed. This has been partly as a result of deliberate government policy to create employment in certain localities. As traditional trades, like shipbuilding, have declined in some areas, newer industries, such as those refining oil and making petro-chemicals, have taken their place. Thus, in 1945 the capacity in Britain for refining crude oil was of the order of two million tons* a year. It is now about 120 million tons and is expected to reach 180 million tons by 1980; and all refineries in this country are on estuaries, none is inland. Because of the general but unjustified belief that estuaries disperse all that is put into them, they have received too little protection by Parliament against the wastes from industries attracted to estuaries by the double lure of a cheap sink and easy access to and from the sea.

12. Two attitudes to the problems of pollution in estuaries now confront the public. Contamination is without any doubt taking place and some estuaries are, by general consent, highly objectionable. Impressive quantities of offensive and in some cases potentially dangerous substances are being put into them and out into the sea (Chapter IV and Appendix A). Evidence is available to show that these discharges may damage or destroy shellfish, birds and fish. The immediate emotional reaction is to urge that this contamination should be stopped and stopped at once before it is too late to reverse the process of destruction.

* The imperial ton is virtually the same in quantity as the equivalent metric unit: 1·016 tonnes = 1 imperial ton.

13. The opposing attitude is to play down the harm that is being caused and to point out, with every justification, that the discharge of sewage and industrial effluent into the estuaries reduces the costs of industry by a considerable amount. Those who hold this attitude point out correctly that to eliminate entirely these discharges would throw a heavy burden on certain of the industries concerned and generally on the local community, sufficient in some cases to cause some enterprises to be abandoned and people to be thrown out of work. Simultaneously they argue that the tangible benefits to be gained, which can actually be costed, are minimal, amounting to little more than what would be saved by reducing damage to inshore fisheries. They claim that no damage to human health has resulted from these discharges nor has any long-term danger been proved to exist. Granted that many people are offended by the squalid condition of some estuaries; that does not justify putting local government and industry to vast cost to remove the offence.

14. The Commission's conclusion is that the truth lies somewhere between these two sets of views. However desirable it would be to remove contamination from estuaries, there is a practical limit to the burden which should be placed on the community to achieve this aim. This limit can be defined as the point beyond which the marginal cost of abating pollution exceeds the marginal cost of the damage being done by pollution. But the inputs for this sort of calculation are rarely at hand; so in practice arbitrary constraints have to be put on the amount of pollution. This does not only mean the tangible measurable damage such as the loss of fishery production, but includes any loss of welfare that the community may suffer as a result of the pollution. In addition, it may be some time, even years, before the damage caused by certain forms of pollution becomes apparent.

15. However, the case for cleaning up the estuaries will not be determined solely on economic arguments. The aphorism "no votes in sewage" is no longer true; some local authorities can now depend on public support for ambitious schemes to clean up rivers and estuaries. A striking example of this is on Teesside. In a report prepared for the County Borough⁽⁶⁾ there occurs this passage:

The declared intention of the Council is the improvement of the River Tees and a reasonable definition of the ultimate objective which would be acceptable to the Northumbrian River Authority is the attainment of a river quality which would support the passage of migratory fish at all states of the tide and freshwater flow.

This intention will cost the local authority alone, quite apart from the costs to industry, some £19 million at present prices. It is an example of a growing concern, among people who are relieved of the elemental anxieties of danger and poverty, to pay for preserving the quality of the environment, even if this does not obviously benefit human beings. In addition—though this may not be widely recognised—twentieth century man is still as dependent upon biological cycles as were his neolithic ancestors; and to preserve the quality of the environment is to safeguard the integrity of these cycles.

16. Secondly, the Government are giving publicity to the view that "the polluter must pay for his pollution". In this climate of opinion it is important that industries enjoying the benefits of estuaries should share the responsibility for keeping them clean. On some estuaries this share will be heavy. Industry's contribution of pollution into the Tees, for instance, comes to some 87 per cent, expressed as biochemical oxygen demand (BOD) (paragraph 73); domestic sewage contributes only 13 per cent. We were impressed with the way some industries are responding to this need, by spending large sums on anti-pollution equipment and by co-operating with local authorities and river authorities in making long-range plans to deal with pollution. Where it has been practicable to increase the size of plant, or to modernise equipment, or to adopt new techniques of production, there have been notable reductions of the amount of pollution per unit of product (the "pollution index"). A sample of these is given in Table 2 and further examples are to be found in Chapter III.

TABLE 2
Effect of new plant on the pollution index

Process	Pollution index as BOD			
	lb per ton of product		kg per tonne of product	
	Old plant (1960)	New plant (1970)	Old plant (1960)	New plant (1970)
Methanol	29	3.1	13	1.4
Terephthalic acid	28	3.3	13	1.5
Ethylene	2.8	0.49	1.3	0.22
Ammonia	8.3	0.73	3.8	0.33

17. A third and different reason for the need to give attention to pollution in estuaries is that far too little effort is being made to measure and record the extent to which pollution is affecting them. The river authorities do monitor some of the common ingredients of pollution, and for some estuaries teams are engaged on scientific investigations and the preparation of mathematical models. But monitoring requires more continuity than teams of this kind can, or should be expected to, provide. Estuaries are critical places in the British environment and it is a serious gap in knowledge that not nearly enough is known about their hydrology or their biology for predictions to be made about their future. We elaborate upon these arguments in Chapter VI.

The danger of time-lag

18. The present concern for preserving the environment is generating vigorous action in Britain, both by government and industry. Welcome decisions have already been taken on issues mentioned in our First Report, for example, the

Government's proposals to reform the organisation of water services, announced on 2 December 1971, and to bring under statutory control the dumping of waste at sea, together with their agreement to an international convention to keep surveillance over dumping in the North East Atlantic, which was signed at Oslo on 15 February 1972. Britain has succeeded more than most countries in taking effective and practical steps—sometimes by voluntary arrangement with industry, sometimes by legislation—to abate pollution of rivers, estuaries and the sea.

19. Despite this progress estuaries remain more vulnerable to pollution than any other part of the British environment. We know that the Government are taking steps to remedy this weakness, but we are concerned at the delays which are likely to come between decision and action. The cause of the delays is understandable. Legislation to reorganise local government and water services in England and Wales is not likely to be enacted before 1974. Thereafter, the new authorities will need time to mobilise their resources, and after that industries and local authorities discharging unacceptable effluents into rivers and estuaries are likely to ask for generous adaptation periods before they comply with stricter conditions of consent. It might therefore be up to ten years before estuaries reap the full benefit from reformed controls. In our view this time-lag would be dangerously long. Accordingly, we hope that the Government will urge existing local authorities and river authorities to take action under present legislation to improve the condition of some of the more seriously polluted estuaries, and that industry will not wait until the new legislation before doing its share.

A policy for estuaries

20. One reason for the migration of industries to estuaries is that they can dispose of their wastes without restraint from some of the statutory controls which operate upstream. Indeed, the anticipation of controls over estuaries is one factor which is prompting some firms to consider diverting their discharges from the estuary, by pipeline to the open sea. It would not be a satisfactory policy to transfer waste from one part of the environment to another solely to avoid statutory controls. Our first general point, therefore, is that control of pollution in estuaries must be part of a national integrated policy for waste disposal, which determines that waste shall be put where it will do least harm, not just where it is under least control.

21. Some pollutants are rendered harmless by natural processes but others, liable to accumulate in bottom mud or to be concentrated in living organisms, are not. These ought to be removed from the effluent, and since the more a pollutant is diluted, the more difficult it is to remove it, the most efficient place to abate pollutants of this kind is at their source. Our second general point is to urge that pollutants which are not likely to be rendered harmless by natural processes in estuaries should be abated before discharge into rivers or tidal waters.

22. One of the practical difficulties in the administration of pollution control is the multiplicity of authorities responsible for it. Estuaries suffer particularly

from this difficulty because they are frequently the dividing line between authorities. Thus, to give one example, action about an oil spill on the Humber is the responsibility of the Department of Trade and Industry if the estuary is more than two miles wide; where its width is less, the responsibility lies with local authorities in Yorkshire or Lincolnshire, depending where the spill occurs. Another example comes also from Humberside. One industry wants to discharge its effluents by pipeline into the estuary. Permission to do this rests in the first instance with the river authority where the effluent originates. This river authority consented; but the effluent would be discharged in territory under the jurisdiction of another river authority, which opposes the plan. On some estuaries these conflicting interests are resolved through consultative committees; but consultative status may not always suffice; and even under the proposed local government reorganisation some estuaries would not come under unified control. Our third general point is that problems of pollution in estuaries which are important centres for industry must be dealt with by one authority—if necessary an *ad hoc* one for a particular estuary—which has more than consultative status.

23. Another practical difficulty in the administration of pollution control is to determine how much cleaning up ought to be done in an estuary used by industry. There are two simple biological criteria for the management of estuarial waters: (a) ability to support on the mud bottom the fauna essential for sustaining sea fisheries, and (b) ability to allow the passage of migratory fish at all states of the tide. This would do for estuaries what the miner's canary did for mines. Given the considerations set out in paragraphs 15 and 16 we think that the aim of pollution control should be, where practicable, to comply with these two criteria.

CHAPTER II

CONCLUSIONS AND RECOMMENDATIONS

Recommendations on administration: England and Wales

24. The present administrative arrangements are summarised in Chapter V. They will be changed when local government is reorganised and river authorities are replaced by multi-purpose regional water authorities. But (as we pointed out in paragraph 19) these changes may be some way ahead, and their benefits to estuaries even more distant in time. Accordingly, we make a number of recommendations which could be adopted under present legislation. These are:

- (a) the Department of the Environment should encourage river authorities to give notice to local authorities and industries whose effluents are at present regarded as "unacceptable", (and there are many of these, even though they are being accepted), that the standard of acceptability will be raised, on the assumption that the regional water authorities will inherit and enforce the new conditions;
- (b) the Department of the Environment should pursue with industry the advice we gave in our Second Report issued in March 1972⁽⁶⁾, namely, to reach voluntary agreement that, subject to certain reservations set out in the Report, the nature and quantities of effluents put into rivers and estuaries should be more widely disclosed than at present; this would not, of course, involve a repeal of Section 12 of the Rivers (Prevention of Pollution) Act 1961, because the discretion for disclosure would remain with industry;
- (c) pending the amended legislation proposed in paragraph 27, this voluntary disclosure should include pre-1960 discharges into estuaries;
- (d) some local authorities which discharge untreated sewage into estuaries or into the sea accept industrial wastes into their sewers without knowing what pollutants may be present; we recommend that, pending legislation covering these discharges, local authorities should seek co-operation from industry over disclosure of the nature of these pollutants; it is essential that every local authority should possess an inventory of them;
- (e) it would be a serious delay to await reorganisation of river management before introducing more systematic monitoring of certain critical substances discharged into estuaries; we recommend that river authorities which have in their jurisdiction industrialised estuaries should at once take responsibility for the monitoring of certain critical substances (to be decided by each authority); this recommendation will undoubtedly require the recruitment of additional technical staff;

- (f) based on the monitoring data there should be "pollution budgets" for each major industrialised estuary, with (say) ten-year plans for the control of pollution agreed by joint committees of river authorities (or their successors), local authorities and industry; the plans should be administered by the river authorities (or their successors); we suggest that the general aims of the plans should be (i) to exploit the estuary for waste disposal up to a level which does not endanger aquatic life, or transgress the standard of amenity which the public need and are prepared to pay for; and (ii) to ensure, by controlling the standards, that exploitation of the estuary does not exceed this level; and
- (g) this policy of planned pollution budgets will require a closer co-operation between planning authorities and river authorities (or their successors) than exists in some areas at present; until statutory changes are made (paragraph 30) planning authorities should, as a moral obligation, consult river authorities before passing any plan which would increase the effluent load on an estuary.

Recommendations on legislation: England and Wales

25. In Chapter V we set out the main provisions of legislation in England and Wales for controlling pollution in tidal rivers, estuaries and coastal waters. We endorse the conclusion reached by the 1970 Report of the Working Party on Sewage Disposal(?) that the time has come to remove, after reasonable notice, the distinction made in this legislation between the control of pollution of inland waters and of tidal rivers and estuaries. Discharges to inland waters are automatically controlled by the relevant Acts; pre-1960 discharges to tidal and estuarine areas ("controlled waters") are controlled only to the extent that river authorities have sought orders by the Minister in each case after public local inquiry. The latter power has not been used to control pollution of any major estuaries, except Milford Haven.

26. Valuable and patient work has been done by river authorities to fill this gap by persuasion and voluntary arrangements with local authorities and industry. In our view, however, these efforts now require the backing of statutory powers automatically conferred by central government legislation and not by Ministerial order after public local inquiry. To the extent that local co-operation has been developed on a voluntary basis, local authorities and industry will be prepared for statutory control within a shorter period than would otherwise be needed.

27. We therefore recommend the following changes in the law in England and Wales:

- (a) the existing statutory powers to control all industrial and sewage effluent discharges to rivers should be extended to "controlled waters", as defined in the Clean Rivers (Estuaries and Tidal Waters) Act 1960, in order to bring pre-1960 discharges to "controlled waters" under automatic control by the main legislation;

- (b) given the progress made by river authorities, local authorities and industry to apply a measure of voluntary control to pre-1960 discharges, and the present weight of local opinion in favour of cleaning up the estuaries (paragraph 15), we recommend that the period of notice of the operation of these proposed changes in the law should be no more than 12 months from the commencement of the amending legislation or from July 1974, whichever is the earlier;
- (c) the amending legislation should remove the present exemption from control of discharges of sewage from all vessels, including naval vessels, in "controlled waters";
- (d) the legislation which will define the powers of the new regional water authorities should provide that all discharges to sewers become subject to control, that industry be charged the full cost of treating and disposing of its wastes, and that authorities be empowered to take samples from private sewers from trade premises; and
- (e) legislation to implement the Oslo Convention on the Control of Marine Pollution by Dumping from Ships and Aircraft in the North East Atlantic should be introduced as a matter of priority.

28. A useful effect of one of the proposed changes in the law will be to remove the present gap in the existing control which has arisen from the interpretation in practice of "new" discharges. Under the Clean Rivers (Estuaries and Tidal Waters) Act 1960, pre-1960 discharges which are "substantially a continuation of a previous discharge made within the preceding twelve months" are exempt from control. It was represented to us on more than one occasion that an increase of ten per cent of effluent should be accepted as a continuation of a previous discharge; an annual increase of this size would double the volume of effluent in less than eight years.

29. It is because practices of this kind are likely to continue until new legislation is operating, and because this operation is likely to be delayed, that we would recommend river authorities to seek Ministerial orders under existing legislation when they think an estuary is at risk. We know that such orders are tiresome to secure and are likely to be opposed by some local interests. Nevertheless, we believe that the protection of estuaries justifies the trouble involved.

30. After the reorganisation of water management in England and Wales the regional water authorities should, in our view, have powers to control all discharges into rivers and estuaries, and coastal waters. We also recommend that there should be a statutory obligation for the regional water authorities to be consulted by planning authorities before consent is given to any development which would substantially increase the effluent load discharged into rivers, estuaries, or coastal waters.

31. The present powers and responsibilities of sea fisheries committees are summarised in Chapter V. We have the impression that their powers are not adequate to their responsibilities. For example, they have no jurisdiction over

Chapter II

discharges by local authorities direct into the sea; and any intervention on their part has to be based not on evidence of the existence of pollution in the sea but on proven detriment to sea fish.

32. Although we think that the responsibilities of the new regional water authorities should include all discharges along the coastlines, the importance to fisheries and fishermen of keeping their waters free from pollution requires special recognition. We assume that the Minister of Agriculture, Fisheries and Food will retain his responsibilities for supporting and protecting fisheries and fishing and that he will wish to maintain organisations under his aegis representing the fishery interests. We recommend that:

- (a) sea fisheries committees should be retained, though we suggest that they should be less unwieldy than the present committees; they should also be empowered to concern themselves with pollution of fisheries in those waters up to six miles from the coast in which exclusive British fishing interests are maintained under the Fisheries Limits Act 1964;
- (b) the committees should have the right to make representations to the regional water authorities on any pollution problems affecting fisheries and should be enabled to press their representations at a hearing before those authorities; and
- (c) in any matter in which they consider that the rejection of their representations involves any considerable risk of damage to fisheries, the committees should have the right of appeal to the Minister of Agriculture, Fisheries and Food and the Secretary of State for the Environment.

Recommendations on administration and legislation in Scotland

33. In Scotland the pollution of rivers and estuaries in the more densely populated areas is controlled by river purification boards whose powers differ from those of the river authorities in England and Wales. The differences are summarised in Chapter V. We hope that the administrative adjustments we propose in paragraph 24 above will also be adopted, where practicable, in Scotland.

34. As we indicate at paragraph 114 the Government have announced their proposals to unify, under the new regional authorities of local government in Scotland, the functions of water supply, sewerage and sewage disposal, and river purification. For the reasons we give in Chapter V we consider it would be a retrograde step to include river purification within the functions of the new local government authorities. Local authorities are among the worst polluters and the proposals could lead to a return to the situation which existed up to 1951 and have a detrimental effect on the quality of Scottish rivers. We recommend that the river purification boards should be retained as separate authorities.

35. As in England and Wales we recommend that legislation should provide for there to be a statutory obligation for the river purification boards to be

consulted by planning authorities of local government, so that there can be adequate consideration of new development which will substantially increase the effluent load on any major industrial estuary.

International legislation

36. By international legislation we mean agreement by the Government to concordats over pollution abatement in the sea, and the steps which the Government will take to observe these concordats. The present state of these concordats is summarised in Appendix B.

37. A prerequisite of an effective international concordat to protect the seas around our coasts is agreement to publish: (a) data on monitoring, and (b) estimates of the masses of certain pollutants (such as organic wastes, mercury, lead, cadmium, zinc, chlorinated organic compounds) which are being put into the sea from estuaries and direct discharges from coasts, are being transported by the atmosphere, are being dumped from ships and from aircraft, or which result from accidental loss by spillage or sinking. We recommend that the Government should take a lead in reaching such agreement.

38. Data on pollutants reaching the sea depend on suitable monitoring (to which we refer elsewhere in the Report); and dumping at sea, so far as the UK is concerned, should eventually be covered by the Oslo Convention to which we refer in paragraph 136. Seaborne trade in chemicals and other hazardous cargoes is increasing rapidly and we recommend the preparation of specific contingency plans, of which the appropriate sectors of industry would be made aware, to deal with any accident that might affect our coastline. Such plans must take into account the increasing proportion of such cargoes carried in bulk and also the need to attempt to salvage, particularly in cases where persistent products, for example, certain pesticides, are involved. Another important problem in this context is the lack of knowledge of the content of ships' cargoes, such as individual drums as they are washed ashore, and we recommend the following action at international level:

- (a) in the case of sinking or stranding, the ship's manifest should be immediately made available by the flag State to countries whose coasts are likely to be affected;
- (b) similarly, reporting the loss of deck cargo is also imperative since hazardous chemicals have frequently to be carried in this way;
- (c) although there has been considerable progress in labelling dangerous cargoes (and we note the contribution of the Chemical Industries Association to this development in the international field), labels should be such that under the likely practical conditions (drums floating in the sea for several weeks) they do not soak off; and
- (d) when drums or containers are labelled with proprietary or trade names, a reasonable indication of their chemical composition should be given on the label.

We know that the Government appreciate all these points: our concern is with their acceptance at international level.

Recommendations on monitoring

39. In Chapter VI we set out our views on the need for monitoring pollution in estuaries and coastal waters. On the one hand, this is expensive and time-consuming and, to be of any use, needs to be sustained over many years with uniform techniques. On the other hand, it is impossible to prove that pollutants are affecting the environment unless they are monitored. It is therefore essential that the number of substances to be monitored should be kept to a minimum and that great care should be taken in selecting them (for example, heavy metals, chlorinated organic compounds).

40. We recommend that:

- (a) in addition to the essential substances to be monitored, there should be biological monitoring of certain "indicator" species of animals and plants (paragraphs 165-168);
- (b) responsibility for the task of monitoring discharges to estuarine and coastal waters should be assigned to the proposed regional water authorities (paragraph 169); and
- (c) a number of monitoring stations should be set up offshore, both in sensitive areas and in relatively unpolluted waters, to be operated for the UK by an appropriate department of central government (paragraphs 170-172).

Recommendations on research

41. A good deal of research is already being done on problems of pollution in estuaries and coastal waters. In Chapter VI we comment on this research and suggest where the priorities ought to be. Our suggestions are:

- (a) more attention should be given to assessing the toxicity of the most commonly occurring pollutants on aquatic organisms; in particular, the effects of long-term exposure to sub-lethal concentrations and the effects on organisms at different stages of their life history need further examination (paragraph 185);
- (b) more financial resources should be devoted to the development of effective mathematical models of estuaries so as to provide a scientific basis for taking action to reduce pollution (paragraphs 186-188);
- (c) more extensive and detailed knowledge of coastal hydrography is required to study, for example, the dispersal of suspended materials (paragraph 189);

- (d) information is required on the effects of materials which are not broken down in the environment and can accumulate in marine organisms or on muds and sediments in such a way as to present possible hazards to man or other living things; and specifically on the accumulation of materials such as heavy metals and persistent organochlorine compounds in muds and other sediments, and in particular the conditions under which they can be released (paragraph 190); and
- (e) studies should be made of the effects of trace amounts of organochlorine and organomercury compounds on photosynthesis by marine phytoplankton (paragraph 192).

Economic matters

42. In Chapter VII, and in the Minority Report, we consider two major economic issues which arise in implementing the policy which we recommend in this Report. Our conclusions are:

- (a) The capital cost of achieving the target improvements in the quality of rivers in England and Wales by 1980 has been estimated by DOE and the river authorities to be approximately £610m, of which some £250m would be spent on tidal rivers. These estimates, however, exclude the cost of new and replaced sewerage and storm overflows, and of remedial works, other than those required immediately, to improve industrial effluent discharges. But the estimate of £610m is very small by comparison with total national investment (about 0.15 per cent) and with total wage costs (about 0.2 per cent). Even if the most generous additional allowance were made for expenditure required by industry up to 1980, the order of magnitude of the total required over this period would not be significantly increased.
- (b) We have considered the introduction of a system of charges, instead of consents, as a means of controlling the discharge of industrial effluent into rivers and estuaries. None of us are against the use of charges for this purpose but we do not all agree that they should be introduced without further enquiries, which we have not made. Two of us believe that the reorganisation of water services will provide an excellent opportunity for the substitution of a charges system for the present one and wish to make a firm recommendation that work on the detailed implementation of a charging scheme should be started without delay. The majority of us are unable at present to go this far but we do recommend that the Government should forthwith examine the case for adopting a charging system (paragraphs 213 and 214).

CHAPTER III

THE CAUSES OF POLLUTION IN ESTUARIES AND COASTAL WATERS

Introduction

43. In Chapter I we indicate the reasons for the attraction of some industries to estuarine sites (paragraph 11). In this Chapter we give specific examples of the development of certain industries on estuaries and coasts. We also consider the types of discharge from these industries and how technological changes can affect the volume and character of pollution.

Sources of pollution

44. The pollutants discharged into estuaries and their significance are discussed in Chapter IV. They originate from two main sources: industrial discharges of waste effluents and discharges of sewage, which is largely of domestic origin but which may contain industrial discharges into the sewers.

45. Both types of discharge would be expected to increase with growth of industry and population but the increase is not necessarily directly proportional to growth. For example, a town sited on an estuary may change its sewage disposal methods so that the pollution load on the estuary is reduced even though the population is growing. Similarly, expansion of industry does not always lead to increase in pollution load; indeed, the load may diminish: we give some examples later in this Chapter.

46. The relative load of pollution due to industrial effluents and to sewage discharges varies considerably from one estuary to another. On the Tees nearly 90 per cent of the pollution load, in terms of oxygen depletion, comes from industry; in Southampton Water the main load comes from domestic sources. In other estuaries, the Mersey and Humber, for example, the load is more evenly shared (Figures 4 and 5).

Industrial growth

47. Table 3 lists the major industries which discharge effluents into tidal rivers in England and Wales; similar information for Scotland is given in Table 4. The industries responsible for the largest volumes of discharge are the oil industry, the chemical industry, electricity generation, paper and board manufacture and the steel industry. In order to give an impression of the effect which industries are having on estuaries we set out in the following paragraphs some data about the expansion of four of the major industries which have been attracted to estuarine sites over the past 20 years.

TABLE 3

England and Wales—Direct major discharges per day of trade effluents and cooling water to tidal rivers*

(Data from Reference (8))

Thousands of gallons/cubic metres

Type of Industry	Number of discharges		Total volume of trade effluent (excluding cooling water discharged with it)		Total volume of all trade effluents and cooling waters	
	Trade effluent	Cooling water	gallons	cubic metres	gallons	cubic metres
Chemical	91	14	104,261	475	370,899	1,685
Petroleum Refining	29	7	81,429	370	594,665	2,700
Electricity Generation	26	64	73,036	332	8,545,447	38,800
Iron and Steel	9	3	81,926	372	110,319	505
Paper and Board	34	8	71,742	326	201,095	915
Food Processing	38	13	20,855	95	66,890	304
Textiles (Cotton and Synthetics)	6	4	18,745	85	39,825	181
Quarrying	12	0	17,407	79	17,407	79
Gas and Coke Production	7	6	1,118	5.1	33,237	151
Soap and Detergent	17	2	4,491	20	7,243	33
Brewing	7	4	983	4.5	2,159	9.8

* Excluding discharges to the Humber, Wash, Solent, controlled parts of Bristol Channel, Menai Straits and parts of Morecambe Bay.

48. **The oil industry.** In 1946 only 2½ million tons of oil were refined in this country; by 1970 this figure had increased to 109 million tons and is expected to increase to 181 million tons by 1980. All the refineries built during this period are situated on estuaries, as shown by Table 5.

TABLE 4

Scotland—Direct discharges per day of trade effluents to tidal waters* (Data from Reference (9))

Thousands of gallons/cubic metres

River Purification Board Area	CLASSIFICATION											
	Food and Drink Manufacture		Other Organic Effluents		Engineering Industry		Chemical Effluents		Miscellaneous		Totals	
	Gallons	Cubic Metres	Gallons	Cubic Metres	Gallons	Cubic Metres	Gallons	Cubic Metres	Gallons	Cubic Metres	Gallons	Cubic Metres
Ayrshire	430	2.0	—	—	—	—	9,464	43	—	—	9,894	45
Banff, Moray and Nairn ...	380	1.7	—	—	—	—	—	—	—	—	380	1.7
Clyde	5,800	26	3,120	14	386	1.8	—	—	9	0.04	9,315	42
Dee and Don	105	0.5	105	0.5	—	—	—	—	100	0.5	310	1.5
Forth	3,228	15	3,500	16	—	—	12,700	58	3,750	17	23,178	106
Lothians	—	—	—	—	—	—	4,550	21	—	—	4,550	21
Solway	1,422	6.5	—	—	—	—	284	1.3	25	0.1	1,731	7.9
Tay	—	—	200	0.9	—	—	480	2.2	—	—	680	3.1
Tweed	—	—	—	—	—	—	—	—	—	—	—	—
Totals	11,365	52	6,925	31	386	1.8	27,478	126	3,884	18	50,038	229
Percentages	22.7		13.9		0.8		54.8		7.8		100.0	

* Excluding cooling water and mine or pit water, where possible.

TABLE 5
Crude oil refining capacity in major river estuaries
 (Data from U.K. Petroleum Industry Advisory Committee)

<i>Estuary</i>	<i>Refining capacity ('000 tons)</i>			
	1950	1960	1970	1980 (estimated)
Thames	2,100	18,200	27,300	63,600
Milford Haven	—	4,500	16,200	32,500
Southampton Water	1,100	11,500	16,500	19,500
Mersey	1,500	5,800	11,700	21,600
Humber	—	—	11,500	12,500
Tees	—	—	10,500	11,000
Severn	2,900	3,000	8,000	8,200
Forth	1,750	3,100	7,000	19,000
Clyde	150	160	275	275
Total (rounded)	9,500	46,000	109,000	181,000

49. Oil refining requires the separation of crude oil into fractions by distillation and fractional condensation. The evaporation process uses large volumes of steam which becomes contaminated and is therefore discharged as oily water. Refineries built before 1960 also use very large volumes of water for cooling purposes in the condensation stages, frequently on a "once through" basis. Newer refineries increasingly use air coolers (with water cooling towers in some cases); in these the total effluent is mainly the oily water from distillation together with storm water falling in the refinery area.

50. The changes in cooling methods have had a marked effect on the total volume of liquid effluent discharged. The volume ratio of effluent discharged to oil processed can vary from as much as 30:1 in old refineries to as little as 0.2:1 in those constructed more recently.

51. The oil content of a refinery effluent depends on the type of refinery and on the treatment equipment installed. Coastal and estuarine refineries built before 1960, which generally employ "once through" cooling, treat the effluent by gravity separation only. This treatment can be expected to produce an effluent containing 20–50 parts per million (ppm) total oil content, or 10–15 ppm of persistent oil. The oil content of many modern refinery effluents can be as low as 5 ppm.

52. Thus, in most refineries built on estuaries since 1960, there have been reductions both in the volume of effluent discharged and in its oil content. These modern refineries lose less than 22 lb of oil per 1,000 tons (10 kg per 1,000 tonnes) of crude oil processed, compared to the discharge from older refineries of some 220 lb of oil per 1,000 tons (100 kg per 1,000 tonnes) processed. The big expansion in refining capacity has not therefore been accompanied by a corresponding increase in the amount of oil discharged in effluent. Spillages and leakages are another matter which we consider in Appendix A.

53. **Electricity generation.** Because it is cheaper to transport electricity than to transport fuel, coal-fired power stations are usually situated near coalfields, most of which are inland. At these stations cooling towers are used for condenser cooling. Large oil-fired stations take fuel direct from refineries or large sea-going tankers and for that reason are mainly sited on estuaries or the coast where the direct use of water for cooling is most economic. The cost of transporting nuclear fuel is insignificant so that nuclear power stations are sited without regard to their fuel source. They have been built almost exclusively on estuaries and coastal sites (Appendix A, Table 24) because of the Government's nuclear siting policy and the need for large quantities of cooling water. The major discharge from direct-cooled power stations is large quantities of heated water. Other small discharges are permitted, such as treated sewage effluent, and low level radioactive liquids authorised under the Radioactive Substances Act 1960.

54. The growth on estuaries and sea coasts of generating capacity from power stations which are operated by the Central Electricity Generating Board (which is responsible for generation of electricity in bulk for public supply in England and Wales) is quantified in Table 6.

TABLE 6
Growth of electrical generating capacity in estuarine and coastal sites
(Data supplied by Central Electricity Generating Board)

<i>Year</i>	<i>Generating capacity (megawatts)</i>	<i>Estimated daily cooling water circulation</i>	
		<i>million gallons</i>	<i>million cubic metres</i>
1950	3,700	2,800	13
1960	10,700	6,000	27
1970	17,900	12,000	55
1980 (estimated)	40,000	18,000	82

55. Over the past 20 years both the increase in the capacity of individual generating units, and the improvements in their thermal efficiency, have led to a progressive reduction in the heat rejected in relation to the cooling water per unit of production for coal-fired, oil-fired and nuclear power stations. Economic optimisation of generating plant designed over this period has cut down the flow of cooling water per unit of electricity though it has raised the temperature of the cooling water. Table 7 shows that the increased temperature rise of the cooling water is more than offset by the reductions made in the volume of water used. Nevertheless, the growth of generating capacity has meant that the total quantity of heat discharged has increased, even though it is much less than would be expected on a simple proportional basis.

TABLE 7

Cooling water used per unit of power production
(Data supplied by Central Electricity Generating Board)

<i>Year</i>	<i>Temperature rise (°C)</i>	<i>Specific water circulation per kilowatt-hour supplied</i>	
<i>Coal and Oil-Fired Power Stations</i>		<i>gallons</i>	<i>cubic metres</i>
1950	7	47	0·21
1960	9	32	0·15
1970	10	26	0·12
1980 (estimated)	12-14	17-20	0·08-0·09
<i>Nuclear Power Stations</i>			
1962	8	73	0·33
1967	9	53	0·24
1980 (estimated)	12-14	20-30*	0·09-0·14

* The heat rejection and water quantity will depend on the type of nuclear reactor employed.

56. **The steel industry.** Table 8 gives the growth in steel production of those works belonging to the British Steel Corporation which discharge all or part of their effluent to tidal sections of rivers, estuaries and the sea. In the period 1950-1970 crude steel production at these works approximately doubled, compared to an overall increase in UK production of 70 per cent.

TABLE 8

Production of crude steel at BSC works discharging effluent to tidal sections of rivers, estuaries and the sea

(Data supplied by British Steel Corporation)

Year	Crude steel production	
	thousand tons	% of total UK production
1950	5,064	31
1960	9,607	40
1970	10,722	39

57. The manufacture of iron and steel from iron ore to finished product involves many processes and consequently a variety of liquid effluents. The amount, number and variety of the effluents discharged from a particular works depend primarily on the processes and on the method of water conservation. The variety of liquid wastes is greatest in an integrated works, such as a modern strip mill, which includes cokemaking, ironmaking, steelmaking, rolling and a wide range of finishing processes for flat rolled strip.

58. There is often considerable admixture of the various waste liquids before discharge from a particular site. The types of waste discharged into estuarine and coastal waters by the steel industry include the following:

- (a) Coke oven wastes, which amount to about 50 gallons (0.22 cubic metres) per ton of coal carbonised in the coke ovens, and which contain substantial amounts of chlorides and noxious chemicals, such as phenols, thiocyanates, thiosulphates and ammonia.
- (b) Blast furnace gas washing water, which arises from the need to remove entrained grit and dust to very fine limits from the furnace gas before use as a fuel. The normal cleaning systems include wet washers and wet electrostatic precipitators. The water from these picks up substantial quantities of suspended solids (mostly coke, iron ore and sinter). Lagooning and other forms of settlement can be used to reduce the suspended solids in the discharge.
- (c) Wastes from hot rolling mills which use water mainly for scale removal and for cooling the rolled products. The main contaminants picked up are millscale (iron oxide particles), oil, greases and sludges.
- (d) Acid pickling solutions which arise from dilute sulphuric acid used for pickling (a process for removing surface impurities). The solution is discarded when the remaining free acid is too weak for further use.
- (e) Wastes from strip finishing operations, which arise from cleaning, annealing, galvanising, tinning and other coating processes. These operations give rise to a variety of effluents, which may include potentially toxic contaminants such as zinc or tin salts, chromates, phenol sulphonates, alkalis, silicates, phosphates, emulsified oils and acid pickle wastes. Rinse solutions are generally dilute but batch solutions of much higher concentrations require to be disposed of from time to time.

59. Over the past 20 years, major developments in the technology of iron and steel manufacture have not, generally speaking, had a dramatic effect on the types of waste waters arising. The types of raw effluents (that is, before treatment) which arise from cokemaking, ironmaking and rolling of steel into finished products have remained virtually unaltered, although some changes have occurred in effluents from steelmaking and pickling. The volumes of effluents have tended to increase with increased scale of operations over the years. But this trend has been balanced to some extent by a reduction due to increased water conservation. Table 9, which shows the gross volume and mean composition of all the discharges into the Tees river and estuary from the various BSC works, provides an example where increased steel production has been accompanied by a fall in the overall pollution load.

60. **The chemical industry.** Table 10 gives some information on the growth of the chemical industry on estuarine sites. The figures are incomplete because the information for some sectors of the industry is not available but they are sufficient to illustrate the large growth of the industry over the past 20 years. On average there has been a 20-fold increase in the fixed capital investment on

estuarine sites. The increase is magnified by a large inflationary element but the increase in real terms is still large (about 7-fold). The 1970 figure for total fixed capital investment on estuarine sites represented about one-third of the total capital investment of members of the Chemical Industries Association in that year.

TABLE 9
Discharges by steel industry to tidal sections of the Tees
(Data supplied by British Steel Corporation)

	1950 ¹	1960	1970
Number of separate discharges	16	18	17
Daily flow (million gallons)	101.5	99.5	111.5
Daily flow (million cubic metres)	0.46	0.45	0.51
Permanganate value (4 hours) ² (ppm)	18.1	15.9	13.9
Suspended solids (ppm)	185	117	80
Cyanides (as CN) ³ (ppm)	1.2	1.5	1.0
Phenols (as C ₆ H ₅ OH) ³ (ppm)	23.0	19.4	2.5
Free and fixed ammonia (as NH ₃) (ppm)	8.5	12.4	12.3
Crude steel production (million tons)	2.04	2.87	2.74

¹ In some cases estimates have been made for 1950. Where data are not available for 1950 and processes were similar to 1960, the figures for 1960 have been used.

² An empirical measure of the chemically oxidisable substances present in the effluent.

³ Cyanides and phenols are both toxic but treatment of the effluent reduces the concentration of both to a level where they can be discharged without too much danger to fish⁽¹⁰⁾. Dilution in the river reduces the toxicity still further.

61. The figures in Table 10 which refer to the volumes of effluent discharged indicate that, despite the increase in the volume of effluent in the period under review, it has not been in the same proportion as the growth in capital investment. In some instances the quantity of cooling water shows a reduction which is almost certainly due to the application of processes which make more economical use of cooling water.

62. Effluent discharges have not increased in direct proportion with production because, in that part of the chemical manufacturing industry which has been expanding rapidly (primarily the petroleum-based sector), the process equipment is capital-intensive and considerable economies can be achieved by increasing the scale of operation. In the last decade there have been some outstanding increases in the size of manufacturing units for the production of many of the basic commodity chemicals (see Table 11).

63. The polluting effect of a given discharge of waste is closely related to the ease with which the pollutant can be dispersed into the environment. An easily dispersed discharge has less impact on the environment than one which remains concentrated. Large plants tend to concentrate emissions into a small

TABLE 10

Growth of the chemical industry on estuarine sites (Data from Chemical Industries Association)

Note: The returns for some estuaries are incomplete and the figures given therefore represent minimum values.

Estuary	Fixed capital investment million £'s				Volume of direct discharges to tidal estuary (thousand gallons/day)†						Volume of discharges to estuary via local authority sewer (thousand gallons/day)†				
					Process Effluent			Cooling Water			Process Effluent			Cooling Water	
	1950 (original cost)	1950 cost at 1970 values	1970	Ratio	1950	1970	Ratio	1950	1970	Ratio	1950	1970	Ratio	1950	1970
Mersey	9	21.5	166	7.7	9,350	27,700	3	78,500	98,400	1.3	516	1,495	2.9	16	52
Thames	1	2.5	9	3.6	5	8	1.6	47	*	*	123	1,125	9.1	*	*
Severn	3	7	74	10.5	*	5,680	*	*	1,625	*	*	8	*	*	*
Southampton Water	12	29	40	1.4	*	1,605	*	*	252	*	5	274	55	*	*
Humber	1	2.5	40	16	112	8,200	7.3	110	1,180	11	*	*	*	60	41
Tees	49	120	564	4.7	27,900	49,800	1.8	203,000	134,500	0.7	137	137	1	*	*
Clyde	5	12	81	6.8	2,580	5,320	2.1	2,220	1,560	0.7	*	*	*	*	*
Forth	4	9.5	26	2.7	*	4,120	*	*	*	*	1,910	2,580	1.3	716	1,660

† These can be converted into cubic metres by multiplying by 0.00455.

* Not available.

TABLE 11

Increase in size of new chemical plants in the United Kingdom

(Data from Imperial Chemical Industries Ltd.)

Material	Capacity (tons/day) in year of initial operation	
	1960	1970
Ethylene Crackers	150	1,200
Ammonia Plants	300	1,200
Nitric Acid Plants	200	500
Cement Plants	500	1,000

area, so that their development might be expected to increase the impact of pollution on the local environment. This is generally true, whether the discharge is gaseous or liquid. In practice, however, it has been general experience that the introduction of big plants has not had this effect. Indeed, a number of cases can be quoted where the building of a big plant has produced an improvement in the local environment, particularly as its commissioning has frequently been associated with the closure of smaller and older plants.

64. Some examples of improvements in pollution potential per ton of chemical manufactured (the pollution index) which have occurred as a result of building big plants, are given in Table 12. These show that, in some cases, the total pollution entering the environment is reduced, even though the plants are making a greater volume of product. In other cases the total polluting matter in tons per day rises, although the pollution per ton of chemical manufactured has fallen. The notes in the Table show that there is no uniform reason for the improvement but some general principles do emerge.

65. When a big scale-up in size is being considered for an existing chemical process, the opportunity is usually taken of incorporating the latest technological advance in plant design. In many cases this results in a new or modified process which usually discharges less polluting emissions. This is not surprising because many emissions from chemical plants represent the escape of potentially valuable raw materials or products, and the search for greater efficiency must result in a reduction of these in waste discharges. In other cases, where the procedure remains unchanged, the increase in scale of operations makes it economically possible to install more expensive and sophisticated waste recovery systems which reduce pollution potential. Nevertheless, increased size alone does not necessarily guarantee a reduction in pollution.

66. The examples in Table 12 are of large-scale, continuous manufacture of bulk tonnage chemicals. For small-scale chemical manufacture in batch type operations there is not the same economic advantage in increasing the scale of production and the processes themselves are less susceptible to this

TABLE 12
Effect of the installation of new plant on the pollution index
 (Data from Imperial Chemical Industries Ltd.)

Process	Size	Pollution		Pollution Index (Ratio of Columns (1) and (3))	
	Output (tons/ day) (1)	Type (2)	Quantity (tons/day) (3)	lb per ton	kg per tonne
Nitric Acid (old)	490	Acid Gases	10	45	20
(new)	260	Acid Gases	3	25	12
(latest) ¹	500	Acid Gases	3.5	15	7.0
Sulphuric Acid (old)	750	Acid Gases	5	15	6.7
(new) ²	1,000	Acid Gases	2.5	5.5	2.5
Ammonia (old)	400	Ammonia Gas	1.5	8.4	3.8
(new) ¹	3,000	Ammonia Gas	1.5	0.93	0.42
Terephthalic Acid (old)	160	Acetic Acid	0.5	6.8	3.1
(new) ³	330	Gases	1	6.6	3.0
Terephthalic Acid (old)	160	Liquids giving	2 } as	28	13 } as
(new) ⁴	330	a BOD	0.5 } BOD	3.3	1.5 } BOD
Methanol (old)	600	Liquids giving	8 } as	29	13 } as
(new) ⁵	1,100	a BOD	1.5 } BOD	3.1	1.4 } BOD
"Propathene" (old)	55	Liquids giving	0.3 } as	13.2	6 } as
(new) ⁶	80	a BOD	0.1 } BOD	2.75	1.25 } BOD
Ethylene (old)	200	Liquids giving	0.25 } as	2.8	1.3 } as
(new) ⁷	450	a BOD	0.1 } BOD	0.49	0.22 } BOD
Nitrogen Fertilizer (old)	800	Liquids with	3 } as	8.3	3.8 } as
(new) ⁵	1,100	nitrogenous chemical	2.5 } 'N'	5.0	2.3 } 'N'
Ammonia (old)	400	Liquids giving	1.5 } as	8.3	3.8 } as
(new) ⁵	3,000	a BOD	1 } BOD	0.73	0.33 } BOD

¹ The nitric acid and the ammonia plants both retained the same type of process, but in each case modern design gave rise to detailed changes. In the case of the nitric acid "latest" plant, additional equipment was built into the design beyond the economically justified limit in order to reduce the fume emission further. In the case of new ammonia plants, a flare design had to be developed in order to burn waste ammonia gases.

² In this case there was a complete change of process route. Modern design also helped to reduce the emissions, due to higher pressure operation and an advanced absorber system for the acid fumes.

³ In this case the increase in plant size has brought no change in process, and little detailed change in the equipment.

⁴ The reduction in effluent from the new plant arises wholly from the building of an effluent treatment plant.

⁵ In the cases of ammonia, methanol and fertilizers, the change in scale of operation allowed a change in process design, which gave much less effluent.

⁶ In the case of the "Propathene" plant, the increase in scale of operations made economic a recovery system which greatly reduced the BOD load in the effluent. BOD is defined in paragraph 73.

⁷ The ethylene plant improvement was a result of a special effluent treatment installation. Without this equipment there would have been no reduction in the pollution index.

development. There is therefore less economic incentive to incorporate special waste recovery units in the manufacture of pharmaceuticals, dyes and chemical intermediates. Nevertheless, even in these smaller operations the competitive drive towards better yields will stimulate design to reduce waste of raw materials and product.

Population

67. Table 13 shows the numbers of people living in the local government districts and boroughs bordering eight of the major estuaries in Britain. These figures do not attempt to take account of the larger economic or planning units centred on estuaries or the areas which may contribute effluent to them. The figures should not therefore be interpreted as more than a general guide; all that can be concluded from them is that there has been no dramatic increase in the population bordering estuaries as defined in Table 13.

TABLE 13

Population changes in local government districts and boroughs bordering eight major estuaries
(Figures in 000's compiled from data supplied by the Office of Population Censuses and Surveys and the General Register Office for Scotland)

	1931	1951	1961	1971	<i>Change 1931-71 (%)</i>
Forth	742	811	833	832	+10
Tyne	764	747	740	697	- 9
Tees	304	336	374	395	+30
Humber	618	653	691	728	+18
Southampton Water	621	683	757	848	+36
Severn	923	1,029	1,082	1,119	+21
Mersey	1,427	1,416	1,396	1,295	- 9
Clyde	1,357	1,361	1,336	1,188	-13
Total	6,756	7,036	7,209	7,102	+ 5
Population of England and Wales	39,952	43,758	46,105	48,594	+22
Population of Scotland	4,843	5,096	5,179	5,228	+ 8
Total for Great Britain	44,795	48,854	51,284	53,821	+20

68. Taken together with information on growth of industry in estuaries the population figures show that, with one or two possible exceptions, any increases in pollution during the period 1931–1971 from domestic sewage discharges from the districts covered have not been significant when compared to increased industrial pollution. An important exception to this generalisation was the use of “hard” detergents (not easily biodegradable) in the early 1950s which led to an increase in the polluting capacity of sewage discharges; this was shown to have been responsible for a significant deterioration in the quality of water receiving them. However, the problem was soon largely overcome by the introduction for domestic use of “soft” detergents which readily degrade.

69. An indication of the present pollution from sewage discharges into tidal rivers is given in Table 14. This includes river estuaries, except for those stated, but not discharges from the coast. This Table also contains information on the likely pollution load in 1980 and shows that there should be substantial improvements by then.

TABLE 14
Discharges of sewage to tidal rivers of England and Wales†
(Data from Reference (8))

	<i>Crude sewage</i>	<i>Treated sewage from sewage works</i>
Present position		
Number of discharges	437	306
Number where preliminary treatment is provided	56*	306
Number where effluent is satisfactory	14	187
Total population served (millions)	4.4	10.9
Total served where discharge satisfactory (millions)	0.3	3.2
Dry weather flow (million gallons/day)	263	638
Dry weather flow (million cubic metres/day)	1.2	2.9
1980 estimates		
Number of outlets expected to be still in use	153	291
Number of existing sewage works expected to have closed down	—	39
Number of new sewage works to be built	—	24
Number of sewage works where improved standards will be imposed	—	47
Estimated population (millions)	3.8	13.5

† Excluding discharges to the Humber, Wash, Solent, controlled parts of Bristol Channel, Menai Straits and parts of Morecambe Bay.

* Preliminary treatment in this context relates to screening, comminution or tidal storage.

CHAPTER IV

THE SIGNIFICANCE OF POLLUTION IN ESTUARIES AND COASTAL WATERS

Introduction

70. In Chapter III we outline the common reasons for pollution in estuaries and coastal waters. In this Chapter we discuss what the pollutants are and what happens to them. We deal first with the main types of pollutant discharged into estuarine and coastal waters. We then consider the manner in which the pollutants either degrade or accumulate within the estuary and the extent to which they eventually find their way into the sea.

Pollutants discharged

71. We review in Appendix A the pollutants, the amounts discharged and the effects they may have on the environment. The pollutants listed in the Appendix may be classified into three groups, namely:

(a) **Untreated sewage.** This is important because of the sheer volume of discharges of untreated sewage into estuarine and coastal waters. Except in so far as untreated sewage is a source of heavy metals and organochlorine compounds (from industrial discharges into the sewers), its effects are localised and do not persist. Its chief effect is to lower the oxygen content of the water, thus making some river estuaries uninhabitable for fish. Domestic sewage is of course objectionable if it is visible in the water or deposited on the beach, but according to authoritative medical opinion there is no proof that there is a hazard to human health⁽¹⁾.

(b) **Heavy metals and organochlorine compounds.** These are particularly important owing to their persistence, because some of them are potentially toxic and they may also accumulate in some organisms. They also differ from other pollutants in that their presence in the marine environment is as much a result of their accidental escape as of their deliberate discharge. The concentration effect by some species is the principal cause of concern: both heavy metals and organochlorine compounds may build up within an organism to the extent that a species eating it may be seriously harmed. Many instances of this have been reported. Concentration of organic mercury in marine organisms has led to outbreaks of mercury poisoning in Japan. Breeding failure has occurred in some sea birds because of the effect of organochlorine compounds on egg shell thickness.

(c) **Other pollutants.** Among these are industrial discharges of inorganic and organic chemicals, cooling water, oil and solid wastes, all of which can have serious local effects. Most of them are not persistent: if the discharge ceases their effects may die away and, generally speaking, they do not give rise to the concentration effects occurring with heavy metals and organochlorine compounds.

Dispersal of pollutants in estuaries

72. Water entering an estuary from rivers upstream may already be polluted because of discharges into the rivers inland. If there were no further discharges in the estuary, the water would become less contaminated as it passed through the estuary. The pollution load is decreased largely by biological breakdown of the pollutants and by the diluting effect of the tidal flow. In addition, there are other less obvious factors: for example, some of the pollutants are lost to the air, and the sediments in the estuary are able to adsorb contaminants and to prevent or delay their passage into the sea.

73. Organic pollutants, such as sewage and some industrial discharges, particularly those from food processing, are readily bio-degradable, that is, they are acted upon by bacteria and other micro-organisms, which leads to their oxidation and in many cases complete conversion into carbon dioxide and water. This depletes the water of dissolved oxygen and, if too far depleted, the water will not support normal aquatic life. The capacity to deplete water of oxygen in this way is measured as the so-called "biochemical oxygen demand" (BOD).

74. The water entering the Humber estuary is grossly contaminated, but the BOD becomes less as the river progresses towards the sea with occasional setbacks from discharges made into it. The Tees, on the other hand, is relatively clean as it enters its estuary, but discharges into the estuary itself are such that the water may sometimes become completely de-oxygenated as it progresses towards the sea. However, even in this grossly polluted estuary, by the time the river finally enters the sea much of the organic material has been oxidised and removed.

75. Inorganic materials discharged into an estuary may also become oxidised and thus contribute to the de-oxygenation of the water. Even when oxidised they still remain in the water; for example, the water-soluble ferrous sulphate, which is discharged by some industrial processes, becomes oxidised and hydrolysed to the insoluble ferric hydroxide, which will then itself contribute to the suspended solids in the water.

76. **Dilution by mixing.** The mixing of the river water with the sea in an estuary is brought about by tidal action, river flow, wind and temperature changes. No two estuaries are exactly alike in the manner in which the mixing occurs or in the relative influence of these factors. In addition, the hydrography of the estuary is greatly influenced by its shape and the local geography. The predominating mixing influence is tidal flow on which is superimposed the effect of the river flow in producing a net movement towards the sea.

77. The obvious and rhythmic volume changes of water in an estuary can give the impression that the dilution of a discharge and its passage to the sea would be rapid. This is largely illusory: the water flowing to and fro is substantially the same body of water from one day to the next. For example, in the River Thames the mean distance travelled by a body of water from high slack water to low slack water is nine miles (15 km) at London Bridge⁽²⁾. But the rate of water movement towards the sea is on average no more than about two

miles (3 km) a day and, toward the mouth of the estuary, material discharged may remain in substantially the same place for long periods at times of low water flow (Figure 6).

78. The dispersal of pollutants from an estuary is made more complex by the frequently different rates at which the fresh water and sea-water mix in a longitudinal and a vertical direction. Estuaries may be broadly classified into four groups depending on the vertical distribution of salt in the water⁽¹²⁾:

- (a) In vertically-mixed estuaries there is no measurable difference in the salinity between the water near the surface and that near the bed.
- (b) In slightly stratified estuaries this salinity difference is measurable but small, for example in the Thames estuary (Figure 7).
- (c) In highly stratified estuaries the difference is large and often there is no fresh water near the bed.
- (d) In "salt-wedge" estuaries the sea-water intrudes like a wedge, so that the fresh water flows seaward on top of the salt water, for example in the Tees estuary (Figure 7).

79. Because of the vertical stratification of the water in the estuary, water at different depths may be flowing seaward at different rates with the bottom layer actually moving in the opposite direction up river⁽¹³⁾. Stratification where it occurs can have important consequences for the dispersal of pollutants discharged into an estuary⁽¹⁴⁾: their passage to the sea may be hastened or retarded, depending on whether the effluent has a higher or lower density than the water into which it is discharged and on the level in the estuary at which it is introduced.

80. For example, if an effluent of density greater than, or equal to, that of the water were discharged into the deep layers of a salt-wedge estuary, the effluent would disperse only slowly within the wedge since the currents in the bottom are weak. The waste would then be carried upstream until it reached the tip of the wedge, where it would then diffuse into the surface layers and be carried to the sea. The residence time of the effluent in the estuary would thus be much longer than if the effluent had been discharged into the surface layers.

81. Retention by sediments. Some pollutants, particularly the heavy metals such as mercury, lead and cadmium, do not necessarily pass into the sea. Conditions in the estuary may lead to the precipitation of the metals and this process may carry down with it other compounds which are normally soluble (co-precipitation). In addition, pollutants may be trapped in the sediments in the bottom of the estuary by physico-chemical processes, such as ion-exchange and adsorption on colloidal materials, and by other processes which effectively remove them from solution. They may thus accumulate at the bottom of the estuary and the sediments become a "deposit bank" for heavy metals and other pollutants.

82. Although retention by the sediments can be a valuable buffer between the land and the sea, the pollutants in the sediments do not always remain permanently locked-up and they may be mobilised again if conditions change. Some of

the processes, notably ion-exchange, are reversible and, although the sediments have a greater affinity for ions of heavy metals than for alkali metals, a sudden increase in salinity could release the heavy metals back into solution. Other metals, although precipitated in an insoluble form, may not remain in the sediment, for example, inorganic mercury may become converted to methyl mercury⁽¹⁵⁾. The ability of some animals living in the sediment to absorb and concentrate some pollutants is also an important factor in removing them from the sediment: American hard shell clams in Southampton Water have been shown to concentrate zinc and copper by a factor of 30,000⁽⁴⁾ (Appendix A, paragraph 19).

Pollution of the sea from estuarine and coastal discharges

83. Despite the potential barrier action of the estuaries some of the pollutants in them will eventually flow into the sea. To these will be added direct discharges made into the sea from settlements and industries located on the coast.

84. The discharges of pollutants into the coastal waters of Great Britain do not, however, present the same problems as discharges into estuaries because the potential diluting factor is so much larger. Many of the discharges are common to both coastal and estuarine waters while others, such as those resulting from mining and drilling, are mainly confined to coastal waters. The types of discharge into both estuarine and coastal waters are reviewed in Appendix A.

Conclusions

85. In Chapter III we gave examples to show that the increase in the pollution of estuaries had not increased at the same rate as industrial growth. This is a welcome trend. Nevertheless, although the Thames is a notable exception in having recovered from gross pollution, there has been an increase in the pollution of other estuaries and this has already affected some of them, such as the Tees and the Mersey, to the extent that they no longer support fish and are aesthetically objectionable.

86. It would be both impracticable and unnecessary to require that there should be no pollutants discharged into estuaries at all. Estuaries are able to cope with a certain degree of pollution. The fact that this capacity has been over-estimated and abused is no good reason for going to the other extreme. Each estuary differs in its ability to absorb or disperse pollutants (paragraphs 78-80) so that there can be no universal standards for the amount of pollution that is acceptable; each estuary needs to have its own "pollution budget". This could be done by developing mathematical models for each estuary to predict the distribution of pollutants for given effluent loadings and environmental conditions, as has been done for the Thames⁽²⁾ and other estuaries.

87. Pollution can be accepted if the estuary is able to support on the mud bottom the fauna essential for sustaining fisheries, and if it can also allow the passage of migratory fish (that is, those that move between fresh and salt water)

at all states of the tide and river flow. Insofar as it is practical to meet this criterion discharges of materials which do not persist or accumulate, such as sewage and most chemicals, would be kept under control but not stopped altogether. It would not, however, be an acceptable policy for certain heavy metals (Appendix A, Table 18) and organochlorine compounds, which are persistent and which become concentrated in estuarine muds and some organisms. Stringent control of these is needed and, in particular, their presence in sewage is of concern because at present there is little, if any, control of the amounts of heavy metals that are passed into sewers which discharge direct into estuarine or coastal waters without treatment. Even where the sewage is treated heavy metals accumulate in the sludge (Appendix A, Table 19): whether this is dumped at sea or on land, it can cause undesirably high concentrations of heavy metals in the dumping areas.

CHAPTER V

LEGISLATIVE AND ADMINISTRATIVE CONTROL

Introduction

88. We outline and discuss in this Chapter the framework of legislation and administration which has been built up over the years to control pollution in tidal rivers, estuaries and the seas around the coasts of Britain. We make a number of suggestions for changes, some of which will require new legislation; others can be made by administrative action.

89. A variety of controls are administered by a complex network of Government Departments and local authorities, as well as specialised authorities set up to carry out specific tasks at local level. The control system is supported by government advisory and monitoring services, and by government research, which we consider in Chapter VI.

90. The complex distribution of the main functions and interests in controlling pollution from different sources of tidal waters and the sea is outlined in broad terms in Table 15. We explain later in this Chapter in more detail the extent of these functions and interests.

TABLE 15

Distribution of pollution control functions and interests

<i>Source of Pollution</i>	<i>England and Wales</i>		<i>Scotland</i>	
	<i>Local</i>	<i>Central</i>	<i>Local</i>	<i>Central</i>
Industrial waste and effluent—discharged direct to tidal rivers and estuaries	river authorities	DOE Welsh Office	river purification authorities district salmon fishery boards	SDD DAFS
Sewage from domestic and industrial sources—discharged via sewers to tidal rivers and estuaries	local authorities river authorities	DOE Welsh Office	local authorities river purification authorities	SDD
Discharges into underground strata—by means of wells, boreholes or pipes	river authorities	DOE Welsh Office	—	—

TABLE 15—continued
Distribution of pollution control functions and interests

<i>Source of Pollution</i>	<i>England and Wales</i>		<i>Scotland</i>	
	<i>Local</i>	<i>Central</i>	<i>Local</i>	<i>Central</i>
Wastes—deposited on land	local authorities river authorities	DOE Welsh Office	local authorities river purification boards	SDD
Sewage from domestic and industrial sources—discharged via sewers to coastal waters	local authorities	DOE Welsh Office	local authorities	SDD
Industrial effluents—discharged direct to coastal waters	sea fisheries committees	MAFF	—	DAFS
Wastes dumped at sea outside territorial waters (excluding radioactive waste)	—	MAFF	—	DAFS
Waste deposits or discharges detrimental to: (a) freshwater fish	river authorities	MAFF DOE	district salmon fishery boards (and river purification authorities) (local authorities)	(DAFS) (SDD)
(b) shellfish	local authorities	MAFF	—	DAFS
(c) sea fish within territorial waters	sea fisheries committees	MAFF	—	DAFS
Oil discharged or leaking from ships and shore installations	— (local authorities)	DTI (DOE)	— (local authorities)	DTI (SDD)
Dangerous cargoes escaping from ships	— (local authorities)	DTI (DOE)	— (local authorities)	DTI (SDD)
Radioactive waste disposed of to surface waters and into the sea	(local authorities and sea fisheries committees)	MAFF (with DOE and Welsh Office)	(local authorities)	DAFS (with SDD)
Dredging in estuaries and coastal waters	(local authorities) (port and harbour authorities)	Crown Estate Commissioners DOE DTI	(local authorities) (port and harbour authorities)	Crown Estate Commissioners SDD DTI

DOE—Department of the Environment
SDD—Scottish Development Department
MAFF—Ministry of Agriculture, Fisheries and Food

DAFS—Department of Agriculture and Fisheries for Scotland
DTI —Department of Trade and Industry

91. At the centre the Department of the Environment (DOE) co-ordinates generally the control by government of pollution. In particular, it sets out to ensure that its own activities in carrying out executive functions, and those of other Departments engaged in this work, promote consistently the policy approved by government. The Department, with the Welsh Office, is primarily responsible for legislation promoted to control pollution of tidal waters and estuaries in England and Wales, except for enforcement of legislation relating to pollution by oil and dangerous cargoes. The Department is also responsible, with the Welsh Office and the Scottish Development Department (SDD), for legislation which makes it an offence throughout Great Britain to deposit on land poisonous wastes which, among other things, threaten pollution of surface or underground water supply. Control of the discharge of radioactive substances to surface waters and the sea is the joint responsibility of DOE, and of the Ministry of Agriculture, Fisheries and Food (MAFF) which is also concerned with protection of fisheries and with sea pollution. The Department of Trade and Industry (DTI) is responsible for enforcing legislation for controlling marine pollution caused by oil, for clearing oil at sea which threatens coastal pollution and for regulating the carriage of dangerous cargoes by ships. DOE co-ordinates action to deal with serious cases of hazardous cargoes being washed ashore in large quantities.

92. In Scotland SDD and the Department of Agriculture and Fisheries for Scotland (DAFS) carry out broadly the same functions respectively as DOE and MAFF in England and Wales.

93. At local level anyone discharging or depositing waste of any kind, which may affect tidal and coastal waters or the sea, will find that a variety of different authorities are concerned, according to the type of waste and its destination. It may, for example, be the concern in England and Wales of a river authority if discharged direct to tidal rivers and estuaries, or of a sea fisheries committee if discharged to coastal waters, or of a local authority and the Crown Estate Commissioners if deposited on a beach.

94. On the other hand, no person or authority at present has any statutory powers to control the dumping of wastes at sea beyond the three-mile limit of territorial waters. We refer later in this Chapter to the 1972 Convention on the Control of Marine Pollution by Dumping from Ships and Aircraft, which is intended to control dumping in the whole of the North East Atlantic (paragraph 136).

95. In practice, the arrangements indicated in Table 15 seem to be fairly well understood. A more serious problem lies, however, in the conflict of interest which may arise, on the one hand, between the different kinds of authority with overlapping responsibilities in one area (local and river authorities, or river purification boards and, in England and Wales, sea fisheries committees) and, on the other hand, between the same kinds of authority where responsibility for adjacent parts of tidal or coastal waters is divided between them. Examples of this difficulty are given in paragraph 22. We hope that under the reorganisation of local government and water services information will flow quickly between central and local government.

96. We consider in the rest of this Chapter the administrative controls of pollution and the legislation backing the administration, examining them under the different sources of pollution in the order in which they are identified in Table 15. We start with the control of pollution caused by direct discharges into tidal waters and estuaries.

Direct discharges into tidal waters and estuaries

97. **Control by legislative and administrative action.** The organisation of river pollution control, including tidal rivers and estuaries, has been steadily rationalised throughout Great Britain over the past 20 years under stronger specialised authorities, with functions wider than pollution control and operating over larger areas.

98. **Administrative control in England and Wales.** The last rationalisation in England and Wales was the replacement of the former river boards by the present 27 river authorities* under the **Water Resources Act 1963**. The Act gave the river authorities new functions of management of water resources, in addition to responsibility for pollution, freshwater fisheries and land drainage, and set up the Water Resources Board (WRB) to advise the Minister on the formulation of a national policy for water. Figure 8 shows the areas covered by the respective authorities.

99. Similarly, concern for efficient distribution of water has substantially reduced the number of statutory water undertakers in England and Wales, but local government responsibility for sewerage and sewage disposal has remained fragmented among a large number of authorities throughout Great Britain.

100. In our First Report⁽¹⁾ we endorsed the conclusion of the 1970 report of the Working Party on Sewage Disposal that sewage treatment and disposal ought to be regarded as part of the whole water cycle, together with water conservation and control of the quality and quantity of flow in our waterways⁽⁷⁾. We subsequently expressed the same view to the Secretary of State for the Environment when the Central Advisory Water Committee presented its report in February 1971⁽¹⁶⁾. We therefore welcomed in general, and in the context of our study of estuaries, the proposals announced by the Government on 2 December 1971 for the reorganisation of water services in England and Wales under new multi-purpose regional water authorities⁽¹⁷⁾. In effect, these new water authorities will take over the functions of the river authorities, and most of those of the local authorities relating to sewerage and sewage disposal and of the WRB. The proposed areas of the regional water authorities are shown in Figure 9.

101. We take the view that the implementation of these proposals for England and Wales, which will require legislation, together with the reform of local government, will eventually benefit the administration of pollution control in tidal rivers, estuaries and coastal waters, provided that the powers of the new authorities are strengthened in the ways we have recommended (paragraphs 27 and 30).

* In addition to the Thames Conservancy and the Lee Catchment Board which were given similar powers.

102. Nevertheless, there will be an inevitable time-lag of at least two years in completing consultations and enacting legislation. It will take considerably longer for the new regional water authorities to recruit and train the necessary staff upon whom the implementation of the proposals will depend and to get into full operation, and for industry and the new local authorities themselves to be able to comply with more exacting and comprehensive consent conditions for industrial effluent and sewage discharges. Moreover, there is no assurance, as yet, that the engineering and scientific expertise of the WRB will be maintained. We therefore think it essential—and have recommended—that the Department of the Environment should meanwhile encourage the existing river and local authorities to take administrative action, and to use existing statutory powers to the fullest extent, to improve the condition of the more seriously polluted estuaries (paragraph 24). We also think that industry should not wait for new legislation—or until reorganisation is completed—before doing its share. Indeed, if no positive encouragement is given by the Government on these lines, we believe that there will be a danger of a relaxation of effort pending the introduction of the new organisation.

103. **Statutory powers in England and Wales.** The present statutory control of pollution of both non-tidal rivers, as well as of tidal rivers and estuaries, is based on three Acts passed during the past 20 years: the Rivers (Prevention of Pollution) Act 1951, the Clean Rivers (Estuaries and Tidal Waters) Act 1960 and the Rivers (Prevention of Pollution) Act 1961. The less stringent control so far applied to tidal rivers and estuaries has reflected the policy objective of progressively restoring and maintaining the wholesomeness of non-tidal rivers as a source of public water supply, whilst interfering to the minimum with the industrial development which has been attracted to estuaries⁽¹⁸⁾.

104. The **Clean Rivers (Estuaries and Tidal Waters) Act 1960** gives river authorities a general power to control new or altered outlets, and new or substantially altered discharges, into the tidal waters out to the seaward limit of each estuary of any significance, as defined in the Schedule to the Act. The Schedule lists 95 such "controlled waters". The river authority can impose conditions regarding the point of discharge and the construction of a new or altered outlet and, in the case of a new discharge, conditions as to the nature and composition, temperature, volume or rate of discharge of effluent. The Act requires that the authority shall from time to time review any conditions imposed and may vary such conditions. In laying down conditions for controlled waters river authorities are required to have special regard to the factors arising from the tidal nature of the waters and, in particular, to the dilution due to dispersal by tidal action. The Act also provides that a river authority shall not grant consent to the bringing into use of a new or altered outlet unless they are able to exercise their right to take samples of the effluent.

105. River authorities are not obliged under the 1960 Act to consult sea fisheries committees (paragraphs 140–142) or dock and harbour authorities in exercising their powers in controlled waters, although they were advised to do so in accordance with an undertaking given to Parliament. Authorities were also advised to ensure that immunity from the byelaws of sea fisheries committees

cannot be inferred from the terms of their consents⁽¹⁹⁾. Under the 1961 Act, however, river authorities are required to have special regard to the interests of sea fisheries.

106. The **Rivers (Prevention of Pollution) Acts 1951 and 1961** give the Secretaries of State for the Environment and for Wales power to make "tidal waters orders" giving river authorities full control over existing as well as new discharges. But an order cannot be made except on the application of a river authority or of some other interested person, or without holding a public inquiry. 14 tidal waters orders have been made but, except for Milford Haven, none of them apply to major estuaries. The Thames estuary came under the full control of the Port of London Authority in 1968 under powers in the **Port of London Act 1964**. Five further orders, of which two relate to the Humber and the Severn respectively, are under consideration.

107. Thus, there is no general control by river authorities over pre-1960 discharges of sewage and industrial effluent to tidal waters and estuaries. We agree with the conclusion of the Working Party on Sewage Disposal in its 1970 Report that the time has come to fill this gap⁽⁷⁾ and we welcome the Government's statement on 8 February 1972 that they accept the Working Party's conclusion⁽²⁰⁾. But we have recommended that this should be done with the minimum statutory period of notice (paragraph 27(b)). Further, we have recommended that, because of the inevitable time-lag, the Government should in the meantime encourage river authorities to seek Ministerial orders to bring all discharges under full control whenever they consider that conditions in an estuary are unacceptable or deteriorating (paragraph 29).

108. River authorities are required to maintain a register containing particulars of the conditions imposed on the outlets and effluents discharged in their area and are required to make the register available to interested persons. On the other hand, Section 12 of the 1961 Act places restrictions on the disclosure of information about effluents which is given to river authorities in administering the control, or from samples taken for this purpose, without the consent of those concerned. There is, however, no restriction on disclosing information from samples taken from the waters into which effluent is discharged. We do not at present consider that Section 12 should be repealed, but we suggested in our Second Report that there should be wider disclosure to persons of responsibility than there is at present of the nature and quantities of industrial effluents put into tidal waters and estuaries⁽⁶⁾.

109. Other weaknesses in the control derive from the division of responsibilities between local and river authorities, which the Government's new proposals for reorganisation of water services will help to resolve (paragraphs 100-101). Provision of sewerage, and of sewage treatment and disposal, has up to now always been the responsibility of local government. Discharges from public sewers to tidal rivers and estuaries are theoretically subject to control by river authorities, though in practice most of them originated before 1960 and escape the present control. In these circumstances an industrial discharge for which consent would be refused by a river authority, could find its way into an estuary via a public sewer if it is not rejected by the local authority on the grounds of

safety to the sewerage system. Some 70 per cent of all industrial effluent in England and Wales is estimated to be discharged to municipal sewerage systems, though there are local variations, and this proportion is likely to increase. Also, in England and Wales 26 per cent of the industrial effluent discharged directly or indirectly to controlled waters is discharged via municipal sewers. Further, the content of present-day domestic sewage is not free from contaminants and toxic materials. We therefore welcome the Government's announcement that local authorities have been recommended to inform river authorities of new discharges into their sewers, which will substantially affect the effluent from the sewage works, in the interval before the legislation to reorganise water services is in operation⁽²⁰⁾.

110. We have recommended that discharges of sewage from ships, including naval vessels, into estuaries and tidal rivers should be statutorily controlled by the regional water authorities. This was recommended by the Working Party on Sewage Disposal⁽⁷⁾ and the Government have announced that they have in mind legislation to make good certain gaps in the powers of river authorities and others to exercise this control⁽²⁰⁾.

111. Full control does not apply to wastes from mines, whether in the form of water drained or raised and discharged in the same condition, or of solid waste accidentally reaching rivers from surface tips. We consider that the Secretary of State for the Environment should consider whether there is need for imposing some form of control in this field when comprehensive legislation for controlling all waste disposal is introduced (paragraph 130).

112. The effectiveness of the limited control over discharges to tidal waters has been further weakened by the definition in the 1951 Act of "new" discharges, that is, those discharges which are not, in various respects including volume, "substantially a continuation of a previous discharge made within the previous twelve months". We have commented on this in paragraph 28. But this defect will be overcome by bringing all discharges under control as the Government now intend to do (paragraph 107).

113. **Administrative control in Scotland.** In Scotland the present nine river purification boards assumed responsibility between 1953 and 1957 for control of discharges to rivers from source to sea in the more populous south and east of Scotland, leaving 12 local authorities with similar functions in the more sparsely populated areas. Figure 10 shows the areas covered by the respective boards.

114. Further rationalisation of the organisation of pollution control and related services is also proposed for Scotland. Following on the lines recommended by the Royal Commission on Local Government in Scotland⁽²¹⁾, the Government have announced their proposals to bring together under unified control, though not under independent authorities as in England and Wales but under new regional authorities of local government, the functions of water supply, sewerage and sewage disposal, and river purification⁽²²⁾. This would mean the winding up of the independent river purification boards. In our view this would have a detrimental effect on pollution control.

115. Although we have not taken evidence specifically on this subject, we have noted the tribute paid during our visits to the Clyde and Forth estuaries to the part played by the boards in the progress that has been achieved since they were set up (paragraph 119). The Confederation of British Industry, representing industrialists in Scotland, argued strongly in their discussions with us for the retention of the boards. The unification of sewage disposal and river purification under the new regional authorities of local government might be argued on the grounds of administrative tidiness and to be consistent in principle with what we have recommended for England and Wales. But local authorities are among the worst offenders; there is a danger that if they are again given responsibility for the control of freshwater pollution, which would make them judges of their own cause as both dischargers of sewage and controllers of the financial budget for pollution and for their other important functions, there would be a considerable slackening-off in the rate of progress of pollution control, even if the regional authorities were subject to increased statutory control by central government of their sewage disposal functions. It would also, in our view, be unfortunate if the authorities responsible for controlling river purification were to lose the valuable contribution at present made by the Secretary of State's nominees to the existing river purification boards as independent representatives of agricultural, fishing and industrial interests.

116. On balance, therefore, while we would have preferred to see in Scotland, as in England and Wales, independent authorities responsible for the whole water cycle, we consider that the advantages of retaining the river purification boards in Scotland, would outweigh the advantages of integrated control under local government, particularly since in Scotland somewhat less emphasis needs to be placed on linking control of sewage disposal and control of water purification in the interest of water supply. We have therefore recommended that the river purification boards should be retained with their present functions (paragraph 34). In addition, it would seem that a good case can be made for the amalgamation of certain of the existing boards.

117. We approve in this context the proposal to maintain a separate administration for specialised fisheries functions in Scotland on the basis of new area boards with a broader constitution and wider powers than the existing district salmon fishery boards, which were set up under legislation in the last century⁽²³⁾. The new boards will have wider areas which will, we understand, be so drawn, so far as possible, that the boundaries do not cross those of the main local government or local purification board areas. The creation of the new area boards will in our view make a valuable contribution to river purification and to preserving amenities.

118. As in England and Wales we have recommended that legislation should provide that there should be a statutory obligation for the river purification boards to be consulted by planning authorities of local government, so that there can be adequate consideration of new development which will substantially increase the effluent load on any major industrial estuary (paragraph 35). Meanwhile, we should like to see greater co-operation straightaway in taking administrative action on a voluntary basis in Scotland, on similar lines as in

England and Wales, between river purification boards, local authorities and industry before new local government legislation is brought into operation (paragraph 102).

119. **Statutory powers in Scotland.** The development of statutory control over pollution of non-tidal and tidal rivers and estuaries in Scotland has been similar to that in England and Wales. The control introduced under the **Rivers (Prevention of Pollution) (Scotland) Act 1951** applied only to new or substantially altered discharges. It could be applied to tidal waters by order of the Secretary of State, who was statutorily required by the Act to make such orders in the case of the Forth and Clyde estuaries. The relevant orders were made in 1960 and 1968 respectively—a not unduly hurried fulfilment of the requirement. Administration and enforcement have remained since 1951 with the nine river purification boards and the local authorities with similar functions (paragraph 113).

120. It was not until the introduction of the **Rivers (Prevention of Pollution) (Scotland) Act 1965**, however, that river purification boards could control all discharges to rivers which existed before the 1951 Act, as well as new discharges to 35 areas of “controlled waters”, which covered all the areas where pollution was most likely to occur and, later, an additional area in Ayrshire. All existing discharges to tidal waters came automatically under control under the 1965 Act where orders had already been made under the 1951 Act, for the Forth in 1960 and for parts of the Solway Firth in 1963. Since 1965 five further orders have been made to bring under control all discharges to eight additional areas of tidal waters, including the Clyde (1968) and the Tay estuary (1970). Further orders are in preparation, by the Dee and Don River Purification Board for all tidal waters in its area controlled at present under the 1965 Act, and by the Forth and Lothians Boards for the outer part of the Forth estuary not covered by the existing order. The statutory control in Scotland of discharges to tidal waters and major estuaries is now more comprehensive than in England and Wales, in that it covers all discharges to the major industrialised estuaries.

Discharges through sewers into tidal waters and estuaries

121. **Local authority control in England and Wales.** The **Public Health (Drainage of Trade Premises) Act 1937** gives occupiers of trade premises in England and Wales the right, subject to certain conditions, to discharge effluent into the public sewer, and the local authority is given varying degrees of control over the discharge. Under the **Public Health Act 1936** certain substances which would endanger the sewerage system, such as petrol, are prohibited. The principal conditions are that due notice must be given to the local authority concerned of the nature and volume of the effluent it is proposed to discharge, and that the discharge complies with the conditions which the authority is authorised to prescribe. Some trade effluents, however, are wholly exempt from control by legislation, including those discharged under a pre-1937 agreement. Other manufacturers are entitled by “prescriptive rights” to discharge the same volume as in 1937, provided that the effluent has not changed since then, a fact which is sometimes difficult to establish.

122. The **Public Health Act 1961** empowers local authorities to make charges for the reception and disposal of pre-1937 discharges and discharges exempt by Section 4 of the 1937 Act. The Act also provides that if there has been no discharge of trade effluent of the nature or composition exempted under the 1937 Act for a period of two years, exemption shall no longer apply. Further, a local authority is enabled to direct that the discharge of effluents exempted under Section 4 of the 1937 Act shall be subject to certain conditions, notably in respect of temperature, acidity and alkalinity.

123. We therefore welcome the Government's announcement on 8 February 1972 that, on the lines recommended in 1970 by the Working Party on Sewage Disposal⁽⁷⁾, all discharges should become subject to control and that industry should be charged the full cost of treating and disposing of its wastes. We hope, however, that local authorities will be given the right, under any new legislation, to refuse to accept certain (nationally agreed) constituents in effluents and that the Government will be able to introduce charges for the treatment and disposal of wastes in less than the three or four years, which is expected to be needed for consultations and the introduction of the new organisation for water services⁽²⁰⁾.

124. Under the 1937 Act the taking of samples of trade effluent is permitted only as it passes, or has passed, into a public sewer. We agree with the Working Party on Sewage Disposal that the consequences of this restriction are too permissive in the case of private premises which discharge mixed effluents into public sewers⁽⁷⁾, and we consider that authorities should be empowered to take samples from private sewers from trade premises.

125. The points noted in paragraphs 121–124 can be met by provisions in the legislation defining the statutory powers of the new regional water authorities, which will combine the present duties of local and river authorities in relation to sewage disposal and pollution control. We have recommended in paragraph 27 that this should be done. We have also recommended that the Act should include a statutory obligation for the regional water authorities to be consulted by planning authorities before consent is given to any new development which will substantially increase the effluent load on a major industrial estuary (paragraph 30). We have also recommended that meanwhile there is a need for greater co-operation in taking administrative action on a voluntary basis between existing river and local authorities and industry in the interval before new legislation is brought into operation (paragraph 24).

126. Effluent from Crown properties is not subject to legislative control, although Crown properties are expected to conform to the requirements of sewage disposal and river authorities. We consider, however, that the Government should take the initiative in repeating and strengthening the directive to all those responsible for Crown premises without waiting, as they propose, for river authorities to bring cases to their notice⁽²⁰⁾.

127. **Local authority control in Scotland.** It is essential in our view that the powers and duties of the existing local authorities, and later the regional authorities of local government, should be strengthened by bringing into force by order of the Secretary of State for Scotland the **Sewerage (Scotland) Act**, which

became law as long ago as 1968. We therefore welcome the Government's announcement on 16 March 1972 that the Act will be brought into operation with effect from 16 May 1973⁽²⁴⁾. This Act includes provisions for dealing with general sewerage matters and with trade effluent discharges to local authority sewers. Industry will have the right to discharge effluent to sewers, subject to meeting conditions prescribed by the local authority, which may include payment of charges for reception and treatment. Existing discharges of industrial effluent to sewers may also be liable in certain circumstances to the imposition of conditions and charges.

Discharges of wastes on land and underground

128. **England and Wales.** River authorities in England and Wales have power under Section 72 of the **Water Resources Act 1963** to control discharges of wastes into underground strata specifically "by means of any well, borehole or pipe", but not generally, for example, into disused mineshafts and quarries or holes, which may contaminate underground water supplies. We think that consideration should be given to strengthening the powers of river authorities to protect underground water as well as to control pollution by discharges on land and underground of tidal waters and estuaries. We have noted that the Government have this in mind⁽²⁰⁾.

129. **Scotland.** It has come to our attention that the present limited powers of river authorities in England and Wales are not available in Scotland to river purification boards. The Clyde River Purification Board has had to obtain powers for controlling discharge of wastes to underground strata under the **Clyde River Purification Board Act 1972**. This indicates a gap in the statutory control in Scotland of pollution of tidal waters and estuaries, as well as of inland rivers, which might merit general legislation.

130. **Tipping on land.** Although the tipping of waste on land is not strictly relevant to the control of pollution in estuaries, we welcome the introduction of the **Deposit of Poisonous Waste Act 1972**, which makes it an offence to deposit on land poisonous wastes which, among other things, threaten pollution of surface or underground water supply. Local authorities in England, Wales and Scotland are made responsible for the enforcement of the Act's provisions generally. River authorities and river purification boards are included in the responsible authorities who must be informed of the movement and deposit of dangerous wastes. We have noted, however, that the 1972 Act is an interim measure, pending the introduction of comprehensive legislation for controlling all waste disposal after the reorganisation of local government in 1974 in England and Wales and in 1975 in Scotland.

Discharges from coasts and sea dumping

131. There are gaps in the control of coastal discharges and dumping at sea which we consider should be filled by specific legislation. In this connection consideration may also need to be given to the pollution problems which could arise if there is a large development of marinas and anchorages in estuaries and along the coast.

132. Coastal discharges. The discharge of sewage into the sea through coastal outfalls in England and Wales is not under statutory control and, where existing arrangements are unsatisfactory, there is no specific power to insist on improvement. In Scotland, control of such discharges is exercised in most cases by river purification boards. However, local authorities have to obtain the sanction of DOE (or the Welsh Office or SDD) for loans required for capital expenditure on new disposal schemes. In England and Wales schemes for coastal discharges, when the proposed expenditure is at least £100,000 or the product of 1p rate in the £1, whichever is higher, require the Secretary of State's specific approval on the basis of a technical examination. In Scotland all schemes require the Secretary of State's approval irrespective of their capital cost. The construction of any new outfall discharging industrial waste directly into the sea is under the jurisdiction of local authorities under the Planning Acts, but there is provision for appeal to the appropriate Secretary of State who may also call in major cases. It has been estimated that the sewage of about six million people in England and Wales is discharged directly to the sea with only partial or no treatment. A wide variety of industrial effluents is also discharged direct to the sea and some coastal local authorities, who do not operate biological treatment works, may receive toxic industrial effluents into their sewers for subsequent discharge through coastal outfalls.

133. We have recommended that all discharges to the sea should be brought under the statutory control of the new regional water authorities in England and Wales (paragraph 30). We note, however, from the announcement of 8 February 1972 that Ministers accept the conclusion to this effect of the Working Party on Sewage Disposal⁽⁷⁾ only to the limited extent of agreeing that "protection of the sea needs to be improved", a subject which is being internationally discussed⁽²⁰⁾.

134. Sewage sludge dumped at sea. Very roughly one-fifth of the total sewage sludge produced from sewage treatment in England and Wales is dumped at sea from purpose-built vessels. Two of the principal cities which dispose of their sludge in this way, London and Manchester, dump annually about five million tons and about half a million tons on a wet weight basis, in the outer Thames estuary and in Liverpool Bay respectively. In addition, a further million tons or so of sludge from a dozen local authorities are dumped annually by Glasgow in the Firth of Clyde. This method of disposal is obviously economically advantageous to those authorities who use it and we understand that there is no evidence that it causes damage to the natural environment in the dumping grounds. But sludge can and does contain polychlorinated biphenyls (PCBs) and other persistent and toxic substances and clearly there are possible dangers, as the presence of PCBs in the vicinity of the Clyde dumping ground indicate. We have noted, however, that a monitoring service for toxic and persistent substances in sludge, including pesticides and heavy metals, has been instituted by the Government and that studies of the effects of dumping of sludge are in progress in different areas. Further guidance on this topic will no doubt be contained in the Report of the DOE Working Party on the Disposal of Sludge in Liverpool Bay which is expected to be published later this year.

135. Waste dumped at sea. The dumping of any substance detrimental to sea fish or sea fishing within the three-mile territorial limit around the coasts of England and Wales is controlled, through statutory byelaws, by sea fisheries committees (paragraphs 140–142). In Scotland DAFS is consulted about major proposals for the dumping of materials in coastal waters. Outside the three-mile limit, however, there is no statutory control, but there are voluntary arrangements under which agreements on suitable methods and areas of disposal are made with firms and other organisations proposing to dump waste. Each application is evaluated by the scientific and technical staff of MAFF (or DAFS) in order to achieve disposal in ways which minimise harm to the marine environment generally. The substances concerned are considered in relation to their toxicity, persistence, solubility and biodegradability, and areas are selected so as to provide suitable dilution and dispersion. Once the waste is dumped a further requirement is for a dumping certificate, in the form of an extract from the ship's log to be supplied to MAFF, showing the area, the method, and the date and time of disposal. For certain toxic wastes, such as sodium cyanide or white phosphorus, MAFF recommends that they be enclosed in sealed containers and dumped in deep water beyond the continental shelf. In addition, the Ministry of Defence arranges for the disposal of some of its surplus conventional ammunition by dumping at sea in areas chosen after consultation between the Hydrographer of the Royal Navy and MAFF, having regard to suitable depth, remoteness from shipping routes, undersea cables and fishery interests. The arrangements for such dumping conform to national policy and statutory regulations, and there is a rigorous form of control involving detailed records and certificates of dumping.

136. We welcome the Government's announcement in December 1971 of their intention to bring in legislation to implement the Oslo Convention on the dumping of wastes in the North East Atlantic and we have already expressed the hope that the legislation will be introduced as a matter of priority⁽⁶⁾. Nevertheless, we consider that the Convention needs to be followed up by early action on the part of the UK and other countries to agree to control all discharges to the sea on a regional basis, whether through rivers and estuaries or from the coasts, and for similar international agreements to be made in other parts of the world.

Discharges detrimental to fisheries in England and Wales

137. In announcing the Government's proposals for the reorganisation of water services in England and Wales the future organisation of fisheries was reserved for further consultations by the Minister of Agriculture, Fisheries and Food.

138. Freshwater fisheries. River authorities have certain jurisdiction under the **Salmon and Freshwater Fisheries Acts 1923 and 1965** over waters, including tidal waters and parts of the sea within their areas, in respect of salmonoid fish, all species of freshwater fish and eels, including power to make and enforce byelaws for the protection, preservation and improvement of fisheries. It is an offence to discharge liquid or solid matter so as to cause the water to be poisonous or injurious to fish or to the spawning grounds, spawn or food of fish. (We have

commented in paragraph 117 on the arrangements for specialised fisheries functions in Scotland.)

139. Shellfish. A large proportion of shellfish-growing areas is liable to pollution by sewage and most of them are subject to some control by the local public health authority under the Public Health (Shellfish) Regulations 1934 and 1948. At the present time over 50 areas are subject to orders made under these Regulations, which enable the authority to place an order on a contaminated bed, either prohibiting the sale of shellfish for human consumption or allowing sale only after the shellfish have been cleansed, sterilised or relaid in clean water.

140. Sea fisheries. The **Sea Fisheries Regulation Act 1966** consolidated earlier legislation for the creation in England and Wales of sea fisheries districts and for local sea fisheries committees to make byelaws for prohibiting or regulating the deposit or discharge within the three-mile limit of territorial waters of any solid or liquid substance detrimental to sea fish or sea fishing. Such byelaws have to be confirmed by the Minister of Agriculture, Fisheries and Food and may also be revoked by him. To enforce their byelaws, the committees can appoint sea fishery officers, who are deemed to have the powers and privileges of a constable and may stop and search any vessel used within the committee district in conveying any substance the deposit or discharge of which is prohibited or regulated. The powers of these officers extend not only to the limits of their districts, but also to "any adjoining sea fisheries district or district under the jurisdiction of a river authority or of a harbour authority".

141. The Act provides for the Minister, in creating a sea fisheries district, to define the limits of the district which can be varied and generally cover the territorial waters adjacent to a particular county or group of counties. Where a sea fisheries district adjoins or overlaps the area of a river authority, a line is drawn by the Minister at, or near, the mouth of every river or estuary within the district limits, and the sea fisheries district does not extend above those limits. But in the case of a river or estuary the river authority may be given the powers of a local fisheries committee. The Minister may also, by order, confer the powers of a local fisheries committee on a river or harbour authority within a defined area.

142. Under these powers 12 committees have been appointed, as committees of county or borough councils, for sea fisheries districts around the coasts, which are shown in Figure 11. The membership of the committees can amount to as many as 86 people. We have the impression, however, that the powers of the committees are not adequate for their responsibilities. For example, they have no power to prevent or control sewage discharges made by local authorities direct into the sea, to which we have referred in paragraphs 132-133. Similarly, the byelaws of the committees do not apply when consents have been issued by river authorities for discharges into estuaries, though river authorities are required to have special regard to the interests of sea fisheries and therefore consult the committees before issuing a consent. Further, the committees' powers, where they apply, limit any intervention on their part to cases where there is firm evidence of detriment to sea fish or sea fishing. The committees are not concerned with water pollution as such for which accepted quality criteria are more readily available.

143. A considerable proportion of the population in certain parts of the country gains its living from inshore fisheries. In addition, there are about 2.8 million anglers in England and Wales, made up of 2.2 million freshwater and 1.3 million sea anglers, with some enjoying both activities⁽²⁵⁾. Fish is an important staple food and the continued presence of fish in the rivers is desirable to provide a biological test of their cleanliness. It could therefore be argued that all these considerations point to retaining the present organisation designed to ensure the special fishery interest in the control of pollution. In our view, however, the overall advantage lies in giving the new regional water authorities undivided jurisdiction and responsibility for the control of all discharges both within the rivers and estuaries and along the coast (paragraph 133).

144. On the other hand, we think the importance to fisheries and fishermen of keeping these waters free from pollution requires special recognition. We assume that the Minister of Agriculture, Fisheries and Food will retain his responsibilities for fisheries research, for regulating fishery practices, and generally for supporting and protecting fisheries and fishing. For this purpose we also assume that he will wish to maintain organisations under his aegis representing the fishery interests. We have recommended in paragraph 32 that the sea fisheries committees should be retained, with some modifications in their powers and responsibilities.

145. We assume that the committees will retain their sea fishery protection and other fishery functions which have been discharged by them in the past, and which will require their services equally in the future. With their duty to keep a watch on pollution problems this should provide an outlet for some of the very able staff in the employment of some of the committees. It will be important to ensure that the technical services of the present MAFF research establishments should be made available to both the regional water authorities and the reconstructed fishery committees.

Other sources of pollution

146. Pollution of tidal rivers, estuaries and coastal waters from certain other specific sources is separately controlled by central government under legislation which implements international conventions.

147. **Oil.** The **Oil in Navigable Waters Acts 1955-71**, which are administered by DTI, provide that there shall be no discharge of oil of any kind from ships of any nationality within UK territorial waters. Outside territorial waters and within specified "prohibited sea areas", UK registered ships are forbidden to discharge persistent oil (crude, fuel, lubricating or heavy diesel oil) or mixtures containing 100 parts per million or more of such oil.

148. When the 1971 Act is brought into full operation, UK registered tankers will be forbidden to discharge any oil from their cargo spaces within 50 miles of land. Outside that limit only such small discharges as have been shown by experiment not to cause lasting pollution will be permitted. The discharge of persistent oil from offshore installations will also be totally prohibited. UK registered ships are required to carry an oil record book, which must be available

for inspection, of certain operations concerning oil which, in the case of tankers, will have to show every movement of oil including loading, transfers and discharges, when the 1971 Act comes into force.

149. The Secretary of State is also empowered by the 1971 Act to take certain action when a shipping casualty within territorial waters threatens large-scale pollution and he has, by Order in Council, provided for the extension of these powers to foreign ships outside UK territorial waters which pose a similar threat.

150. The Government have already put most of the provisions of the 1971 Act into force for British ships. They intend to put the remainder into force as soon as practicable and not to wait for the relevant Convention provisions to come into force internationally. A large amount of oil which enters international trade is carried past our coasts; thus, of the 1,250 million tons of crude oil that is expected to be transported by sea in 1972, more than 350 million tons will go to North West Europe, most of it passing through the English Channel. We urge the Government to continue to put all possible pressure on other countries to implement the Convention, details of which are given in Appendix B, as a matter of high priority.

151. Local authorities around the coasts of Great Britain take action to clear their beaches of oil pollution, and in shallow inshore waters up to about a mile from the coast, for which they receive an extra-statutory grant of 50 per cent of the admissible costs incurred.

152. **Dangerous cargoes.** Internationally agreed safety regulations for the carriage of dangerous goods in ships are set out in the International Convention for the Safety of Life at Sea 1960 of which the Inter-Governmental Maritime Consultative Organisation (IMCO) is the depository. These regulations are in general terms and are primarily concerned with the safety of the ship and its passengers and crew; only incidentally do they protect the environment, though by their nature and through other means, such as navigational aids, a large measure of protection is achieved. The regulations are supplemented by a code which recommends packagings, stowage and general handling precautions for a wide range of dangerous goods which are known to be carried by sea in appreciable quantities. A major IMCO Conference on Marine Pollution is planned to take place late in 1973.

153. Legislative control in the United Kingdom over the carriage of dangerous goods by sea is embodied in the Merchant Shipping (Dangerous Goods) Rules 1965, as amended, which reflect the principles of the Convention. The Rules are supplemented by recommendations in the Report of DTI's Standing Advisory Committee on the Carriage of Dangerous Goods in Ships, which is very similar in content to the IMCO Dangerous Goods Code and is regularly reviewed. Another DTI Committee concerns itself with the design, equipment and operation of ships carrying hazardous cargoes in bulk and with measures which reduce the possibility of marine pollution by, for instance, positioning tanks for dangerous chemicals sufficiently far from the ship's side to reduce substantially the possibility of their release from collision or grounding.

154. Certain recommendations are made in paragraphs 37-38, to help overcome the problem caused by lack of knowledge of the contents which can arise following an incident at sea involving hazardous cargoes. The need for these was well illustrated by the sinking of the "Germania" off Guernsey on 21 December 1971 which led to unidentified drums being washed up on the Cornish coast some three weeks later. Enquiries at the ports of loading revealed that a number of dangerous chemicals were among her cargo, although the only chemical known to be washed ashore was ethyl acetate, which was probably carried as deck cargo. Other dangerous goods known to have been carried on board included sodium cyanide, toluene di-isocyanate and an agricultural chemical which is basically a chlorinated hydrocarbon. Identification of the contents of the drums washed up proved difficult since the majority of the markings had been removed during immersion in the sea.

155. During the last decade worldwide production and distribution of chemicals, particularly in liquid form, have increased to such an extent that movement in drums is no longer suitable to meet demand and converted or purpose-built tankers are employed. The contingency plans, which we recommend in paragraph 38, must therefore take into account the increasing proportion of hazardous cargoes carried in bulk and also the need to attempt to salvage, particularly where persistent products, such as certain pesticides, are known to be among the cargo. An enormous variety of products can be involved and action to prevent damage to the environment will depend very much on the degree of specific expertise available in each case. It is therefore essential that the appropriate sectors of industry should be involved in contingency planning, and subsequent action, to ensure that clean-up and salvage operations are undertaken speedily and effectively.

156. **Radioactive waste.** Under the **Radioactive Substances Act 1960**, radioactive waste in England, whether in solid, liquid or gaseous form, can be disposed of only with the authorisation of DOE. In the case of waste from premises used by the United Kingdom Atomic Energy Authority (UKAEA) and from licensed nuclear sites, authorisation must, in addition, be obtained from MAFF. The Act also provides for similar action by the appropriate Departments in Scotland and Wales.

157. Solid radioactive waste is not dumped in the coastal waters of Great Britain. Any dumping at sea is done under carefully controlled conditions at approved sites in the North Atlantic well beyond the edge of the continental shelf. Liquid waste of low activity is discharged from sites operated by the UKAEA, from nuclear power stations and from Ministry of Defence establishments, but the maximum quantities which may be discharged are strictly controlled and there is routine comprehensive monitoring for radioactivity in the coastal waters of the British Isles (Appendix A, paragraphs 47-49).

158. **Dredging.** Most dredging in estuaries is carried out by harbour authorities, who must obtain powers from Parliament to authorise them to dredge below high water mark. Most major authorities have a general power to dredge in order to maintain the harbour as a waterway for ships and dredging powers may also be conferred in connection with the construction of specific works.

The powers authorising dredging generally contain a proviso to the effect that dredgings shall not be deposited below high water mark except in such positions as the Secretary of State for Trade and Industry may approve and subject to such restrictions and conditions as he may impose. DTI is concerned with the safety of navigation. Before deciding where dredgings should be deposited below high water mark, and whether restrictions or conditions should be imposed, the Department also in practice consults MAFF (or DAFS) with regard to fishing interests. When dredging operations are carried out otherwise than under a local Act of Parliament, dredging below low water and the deposit of the spoil below high water mark requires the consent of the Secretary of State for Trade and Industry under the **Coast Protection Act 1949**. The **Crown Estate Act 1961** makes the Crown Estate Commissioners responsible for the management of the foreshore and the seabed, although there is no statutory basis for Crown ownership. The Commissioners license dredging for sand and gravel from the seabed, mostly from areas beyond the limits of territorial waters. The consent of the Secretary of State for Trade and Industry is also required under either the **Coast Protection Act 1949**, or under that Act as extended by the **Continental Shelf Act 1964**, for areas beyond the limit of territorial waters.

159. Authorities responsible for the dumping of dredged spoil should always take appropriate guidance before deciding where the dumping is to take place and no dredging should be authorised before consideration has been given to the effect on the marine environment.

CHAPTER VI

MONITORING AND RESEARCH

Introduction

160. Sea-water is a very complex solution in which most chemical elements can be found, though the majority are present in rarified quantities. One of the difficulties met by research workers is that there are no convenient "baseline measurements" of the concentrations of different chemical compounds made in the pre-industrial era, with which the present concentrations can be compared. The whole of the open seas and oceans are slowly circulating, with currents often going in different directions at different depths. Worldwide mixing is slow, and at any one time concentrations are found to be different at different points. The rate of circulation itself is not constant, but changes seasonally and from year to year, with the result that even the baseline measurement must fluctuate. Just as in studying climate, a long run of oceanographical data is needed in order to show how much change can be attributed to natural variation and how much is man-made, resulting from pollution. Many years of observation may be required to bring out persistent trends, and even large-scale man-made effects may not be distinguishable from natural changes in the short term.

161. Monitoring and research in environmental pollution are therefore carried out for three main purposes: first, to report on the levels of pollution existing in the environment; secondly, to determine the effect of pollutants on living organisms whether or not these can be consumed by man; and thirdly, where necessary, to find practical and economic ways of reducing the amount of pollution. This information is needed as a basis for national and local policy, the ultimate objective being to establish environmental quality standards for marine waters so that we can ensure that:

- (a) no irreversible damage is being done to life-support systems;
- (b) marine food is unquestionably safe for human consumption; and
- (c) waters and beaches are aesthetically acceptable and fit for recreational use.

Monitoring

162. Monitoring in its simplest form requires the repeated measurement of how much of a particular kind of pollutant is present in various parts of the natural environment so that change can be detected. Clearly this is of vital importance: unless we know whether a pollution problem is getting better, or is static, or is deteriorating, we cannot easily decide on our priority for remedial action. Monitoring also allows us to compare the situation in Britain with that in other countries and to assess how relevant their research may be to our conditions.

163. The results of monitoring show whether, in the light of current knowledge, there is a hazard to man or the environment. This provides a basis for any necessary action. Subsequent measurements will show the effect of these actions and whether or not they have been successful in reducing the levels of pollution. Trends detected by monitoring may also indicate future pollution problems which can be remedied before the levels reach unpleasant or harmful concentrations.

164. **Chemical monitoring.** The decision on which substances to control will clearly depend on assessments of the hazards they pose. Nonetheless, because of the obvious size and expense of both the task of control and the monitoring needed to establish its effectiveness, it must be expected that international agreements will in the first instance apply only to a minimum number of persistent substances which are discharged in substantial amounts. In the light of existing concern such substances are likely to include heavy metals and halogenated organic compounds. It is also clearly necessary that all effluents and other disposals of wastes to the sea should be brought under adequate control. Efficient control does not require continuous monitoring of all discharges; random spot checks backed by adequate penalties provide a sufficient deterrent to evasion. However, no control scheme can operate satisfactorily unless monitoring provides a measure of the degree to which it is effective in preserving the environment. To obtain adequate statistics frequent sampling is required over long periods of time at a network of monitoring stations, which must be chosen in order to maintain the best possible picture of the pollutants concerned with the minimum input of manpower and cost.

165. **Biological monitoring.** It is common knowledge that some pollutants are concentrated by living plants and animals within their bodies, among them the organochlorine pesticides and heavy metals such as mercury. These are held in the body by a variety of physical and chemical processes and some like DDT accumulate particularly in body-fat. Consequently, in hard times, when the body's food reserves are mobilised, the concentrated material is brought into circulation and can add dangerously to the individual's distress.

166. Species such as fish, seals and sea birds therefore offer a sensitive index of the presence of cumulative pollutants. Their tissues may on occasion contain a concentration a thousand or even a hundred thousand times greater than that found in the surrounding water and, in fact, sufficient for the chemist to estimate it readily, although the substance may be so dilute in the sea itself as to require the most sophisticated and expensive methods for its analysis.

167. Biological monitoring may also reveal the toxicity of materials previously regarded as harmless or not previously known to exist in the environment. This can be done by searching for the cause of any unusual mortality or morbidity in natural plant and animal life. It was by this means that the widespread occurrence in aquatic life of the organochlorine pesticides, PCBs, and mercury came to light.

168. Consequently, it is valuable to undertake biological monitoring, especially of established "indicator" species of the kind mentioned in paragraph 166. A substantial amount of information on the presence of well-known toxic

substances in animals and plants, sampled for chemical assay, is already being obtained in this country. But the much more complex task of keeping a check on the well-being of selected natural populations and communities, in a search for new or unsuspected effects of pollution, is still in its infancy, especially in the sea. Further development of national and international programmes of this kind of research and surveillance in the marine environment is therefore required.

169. Organisation. The task of monitoring discharges to the sea will be considerable, particularly because of the many substances which might be involved and the length of time it will have to be continued. We therefore think it right to assign responsibility for this work to the new regional water authorities. If their work to reduce pollution is to be successful it will be necessary to ensure that all sources of discharge are known and that effluents are regulated individually at the point of origin.

170. The chemical monitoring of coastal discharges carried out by the regional water authorities will have to be backed up by a chemical and biological monitoring network established by the appropriate government department to deal with offshore monitoring. This would be an extension of work already being undertaken by MAFF and DAFS. Part of this work should entail the regular examination and analysis of suitable "indicator" species of estuarine and marine animals and plants (paragraphs 165-168), particularly those used as food, from which general trends could be determined.

171. The monitoring stations will need to be more concentrated in coastal waters adjacent to major industrial areas or major river discharges than off the open coast, but offshore monitoring stations are also required (a possibility might be on oil or gas production platforms) both in sensitive areas like the southern North Sea and in relatively unpolluted waters, to provide an index of changing pollutant levels in the sea at large. Monitoring is also needed to study the transfer from the air to the sea in the case of certain important pollutants such as mercury, lead and DDT.

172. Such a monitoring system should provide the check required by central government on the activities and efficiency of the regional water authorities in reducing pollution, just as the latter's checks would ensure that industrial premises are observing the conditions prescribed for their discharges. It would also enable the Department responsible for monitoring to integrate the work of its own monitoring stations with those of the regional water authorities. The responsible Department should organise the work to ensure that it met the needs of central government in respect of international obligations; and it would be responsible for evaluating the results and for passing the information to other departments who might, on the basis of what the monitoring revealed, need to review their policies.

173. International commitments. Our responsibilities for monitoring will become even greater as a result of increased international co-operation. Under the terms of the Oslo Convention (paragraph 136), the Government are committed to complementary or joint programmes for monitoring the distribution and effects of pollutants in the area to which this Convention applies. The

signatory nations also agree to use the best practicable means to prevent pollution from other sources such as discharges through rivers, estuaries, outfalls and pipelines. To achieve this the UK will need to be able to identify every substantial discharge of each substance which it agrees to control, and obtain a measure of the output within whatever period may be decided. Fortunately we are well advanced with plans to monitor such discharges through work already carried out by the river authorities and in co-operation with international bodies, such as the International Council for the Exploration of the Sea.

Current research

174. Government research. Research on the pollution of estuarine and coastal waters is carried out in the laboratories of Government Departments, Research Councils (which are administered through the Department of Education and Science (DES)), research associations, universities and public authorities and by nationalised and private industry.

175. The functions and interests of Government Departments in the control of particular forms of pollution are set out in Chapter V. In carrying out these activities the Departments concerned are supported by the work of their own research laboratories and also by work in other laboratories supported from central government funds. The establishments principally concerned are listed in Table 16.

TABLE 16

Government and Research Council establishments undertaking research relevant to the pollution of estuarine and coastal waters

<i>Parent Body</i>	<i>Laboratory</i>
MAFF	Fisheries Laboratories at Lowestoft and Burnham-on-Crouch Fisheries Radiobiological Laboratory, Lowestoft Salmon and Freshwater Fisheries Laboratory, London
DOE	Water Pollution Research Laboratory, Stevenage Hydraulics Research Station, Wallingford
DTI	Warren Spring Laboratory, Stevenage Laboratory of the Government Chemist, London
DAFS	Marine Laboratory, Aberdeen Freshwater Fisheries Laboratory, Pitlochry
NERC (DES)	National Institute of Oceanography, Wormley Institute of Coastal Oceanography and Tides, Liverpool Unit of Coastal Sedimentation, Taunton Institute for Marine Environmental Research, Plymouth Laboratory of the Marine Biological Association, Plymouth Laboratory of the Scottish Marine Biological Association, Oban

176. In addition to the work done in the establishments listed in Table 16 the Departments and Research Councils are empowered to grant-aid appropriate work at centres outside the government organisation and a good deal of pollution research is undertaken in this way, mostly at universities.

177. The Government also contribute towards the cost of the 41 industrial research associations. Each research association is an independent body co-sponsored by government and industry, public authorities or education and research bodies.

178. Government and government-supported research in environmental pollution generally is summarised in a DOE publication⁽²⁶⁾. This publication, together with lists on current research on marine pollution kept by the Marine Pollution Documentation Centre at Plymouth⁽²⁷⁾, can be used to obtain a broad indication of the amount of research which is relevant to estuaries and coastal waters. The numbers of such projects supported from public funds in progress in December 1971 are summarised in Table 17, though the position constantly changes as current projects are completed and new ones started. It has not been practicable to show the relative effort being put into each of the projects, but it is known that they differ considerably in scale.

TABLE 17

Numerical summary of government-supported projects on pollution of estuarine and coastal waters in progress, December 1971

Research Subject	Government and Research Council Laboratories		Research Associations		Universities	
	Institu- tions	Projects	Institu- tions	Projects	Institu- tions	Projects
Sewage discharges	3	18	3	3	3	3
Organochlorine compounds	6	14	—	—	2	3
Heavy metals	6	7	1	1	7	12
Chemical and industrial pollution	4	8	8	8	3	5
Oil pollution	8	3	1	1	2	4
Monitoring	4	5	—	—	2	3
Miscellaneous	7	21	—	—	7	14

179. **Research undertaken by private industry.** In addition, a large amount of research is carried out by industry to assess and reduce the impact of its products

and wastes when they are released into the environment. It would be impracticable to summarise or evaluate the research of this type but examples are:

- (a) The Brixham Laboratory of Imperial Chemical Industries Ltd. which provides, for the divisions of ICI and for outside bodies under contract, a central advisory and investigatory service on the treatment and disposal of liquid wastes and related problems.
- (b) The Marine Biological Laboratory at Fawley, run by the Central Electricity Generating Board, which conducts research on topics such as the effects of discharges of warm water from power stations and on problems arising from the use of salt water as a coolant in power stations.
- (c) The steel industry carries out research on problems associated with the treatment and disposal of its waste products, such as acid pickling solutions and cokeoven wastes which contain substantial amounts of compounds, such as phenols, thiosulphates, chlorides and ammonia.
- (d) The oil companies and the Institute of Petroleum undertake research on the prevention and control of oil pollution. The Institute, with the financial backing of the oil companies, supports the Oil Pollution Research Unit at the Orielton Field Centre (Field Studies Council), which has been studying the ecological effects of marine oil pollution, particularly in the marine life of tidal areas. In the international field funds are provided through CONCAWE (the oil companies' international study group for Conservation of Clean Air and Water Western Europe) to research institutes and similar bodies to develop new knowledge about oil industry pollution and its abatement.

180. Scope of research. Most of the current research on pollution of estuarine and coastal waters is concerned with: either (a) sewage and sewage sludge; or (b) the treatment and purification of effluents; or (c) the dispersal and fate of pollutants reaching the estuaries and the sea; or (d) their effects on various kinds of marine animals and plants.

181. A wide range of materials is under study, including oil, oil dispersants, heavy metals, pesticides, PCBs, sewage sludge, organic trade wastes (from, for example, pulp-mills and distilleries), inorganic wastes of many kinds, inert mineral wastes, and heated water. The range of living organisms investigated is also wide; the greatest emphasis is on fish, molluscs and crustacea, but plankton, bottom fauna and seaweeds are all included. Answers are being sought to such questions as the susceptibility of plants and animals to different kinds of chemical compounds; what concentrations are actually toxic; and what physiological and other effects arise from low-level chronic exposure to pollution. Many studies focus on single species, but some concern whole ecosystems. Much attention is also given to the concentration and accumulation of substances which might prove toxic to living organisms.

182. Inter-disciplinary studies are being made of pollution in specific areas. For example, estuary study groups have been set up in universities on a number of major estuaries. The Institute for Marine Environmental Research has assumed responsibility for these groups for the purpose of pooling knowledge

and co-ordinating research effort between different disciplines in the university departments and research institutes concerned. Another integrated approach is being made by the Working Party set up by the Welsh Office to study pollution in Swansea Bay.

183. A notable exception to the general lack of background information is the survey of ocean plankton made over the North Atlantic Ocean and the North Sea by means of an instrument towed behind commercial ships, known as the Hardy continuous plankton recorder. The survey has recently been taken over by the new Institute for Marine Environmental Research at Plymouth; but it had been running previously for more than 25 years, providing a regular synoptic picture of the changing distribution of plankton organisms, as sampled along the widest possible network of shipping routes. It has shown some very striking long-term trends, but the present view is that they are most likely to be due in the main to naturally-occurring environmental change. The survey has clearly brought out the difficulty of correctly interpreting the causes of even major biological changes in the sea.

Priorities for research

184. The effort devoted to research in estuarine and marine environments has been growing rapidly during the last five years. Nevertheless, we consider it necessary to emphasise the scale on which it needs to be deployed in order to achieve significant results. There are some particularly important subjects which are not at present adequately covered and which need further stimulus.

185. **Effects of pollutants on aquatic life.** Although research is in progress on the toxicity of the most commonly occurring pollutants to aquatic organisms, we think that more effort should be devoted to studying the effects of long-term exposure to sub-lethal concentrations and the effects of pollutants on organisms at different stages in their life history. This research is important because the toxicity levels of different compounds vary enormously from species to species and within a species at different stages in its life cycle. The effects on marine life of heavy discharges of inert materials should also be further investigated.

186. **Development of mathematical models.** One of the most obvious troubles with estuaries is that many of those which drain areas of dense population and industry have been subjected to excessive organic pollution. In some cases this has reduced the concentration of dissolved oxygen sufficiently to eliminate fisheries and to create public nuisances from, for example, foul smells that arise from anaerobic conditions. In other cases fisheries and shell-fisheries have been damaged or eliminated by the directly toxic action of certain pollutants. Trade in shell-fishing has also been prejudiced by contamination of the water with faecal organisms derived from discharges of sewage.

187. Sufficient is probably known about how to achieve the elimination of the principal overt effects of the pollution mentioned above. The studies of the Water Pollution Research Laboratory⁽²⁾, in providing a scientific basis for taking action to clean up the Thames, are a pioneer example of what can be achieved. Work is in hand, and in some cases is well advanced, to develop the

necessary mathematical models for most of the other badly polluted estuaries or those in which pollution can be expected to grow. These models will show what it would cost to restore fisheries in estuaries that are now fishless and they will also permit estimates to be made of the quantities of pollutants exchanged with the open sea.

188. However, much work remains to be done and we recommend that still more financial resources should be devoted to the development of effective mathematical models. In particular, research should be directed to:

- (a) the kinetics of nitrification processes;
- (b) the rates of degradation and removal of the more common substances responsible for poisoning fish;
- (c) the exchange and transport of suspended and deposited matter; and
- (d) exchange of gases and aerosols at the air-water interface.

189. **Hydrography.** More extensive and detailed knowledge of coastal hydrography is required to elucidate the transport of pollutants held in solution or suspension. The results of this work would also be of value for other purposes, for example, the siting of outfalls, coastal protection and gravel extraction.

190. **Possible future hazards.** Over and above the problems of overt pollution there is disquiet about development of more subtle, sometimes delayed, effects arising from the release of materials which are not broken down in the environment and can accumulate in such a way as to produce hazards to man or other living things. In Britain there has not yet been much evidence of significant harm from such releases in fresh water or the sea. But cases have occurred in other countries and the finding, for example, that in British waters there is a gradation in the mercury content of fish, which is related to the proximity of their habitats to estuaries, must clearly receive serious attention. The improvements in control which are being planned in a number of our estuaries will aim to identify the sources and reduce the amount released of the potentially toxic pollutants which are more enduring. But we shall require much more precise information about the present concentrations and trends for these substances and their fate in the estuarine environment before predictions can be made about their likely future effects. This will mean finding answers to some formidable problems, among them the interactions that can take place between pollutants and the mud particles suspended in estuarine water or deposited on the bottom (paragraph 81). The residence time of particular persistent pollutants in estuaries, together with the conditions under which they might be released, will obviously have a direct bearing on the maximum acceptable rates of new discharges. On a wider and ultimately global scale there is the still greater question about how effectively and how fast indestructible substances like mercury are being removed from the biosphere by accumulating and being buried in sedimentary deposits on the ocean floor, and the conditions in which they might be released.

191. We proposed in our Second Report a voluntary "early warning system" for the impact of new products on the environment⁽⁶⁾. As the PCB story shows (Appendix A, paragraph 29), there are no existing means of detecting at an early

stage new pollutants whose large-scale discharge to the environment has been unnoticed. We therefore recommend three lines of action. First, it would be useful to encourage work which is attempting to provide a better theoretical basis for forecasting the kinds of substances which, from their chemical formulations, may be expected to be toxic, persistent and liable to accumulate in living tissues. Secondly, it is essential that data should be available on the quantities of these substances used by industry, and on their discharge, on the basis of spot checks by river authorities and others, and/or by imposing precautionary consent conditions in good time. Thirdly, there is need for continuing review of what should be included in the monitoring programme.

192. Another gap in research which causes us concern is the possibility, that certain organochlorine⁽²⁸⁾ and organomercury⁽²⁹⁾ compounds at great dilution can reduce or eliminate photosynthesis by the marine phytoplankton. These reductions appear to occur at pollution concentrations above those found in the sea; nevertheless, more research in this area seems warranted and it should be linked with the substantial body of existing work on primary production in the sea and the factors affecting it.

193. To summarise, there is a need for research to find out what substances can prove to be harmful, and in what concentrations. There is also a clear need to press ahead faster with monitoring programmes, both physical, chemical and biological, and with experimental investigations on which the mathematical models can be based. Ideally, data should be collected from fixed buoys (or possibly offshore production platforms) to provide a continuous synoptic picture of pollution changes. We consider that this would be desirable both in polluted estuaries and offshore in critical areas such as the southern North Sea and Liverpool Bay. At present only a few useful parameters such as salinity, pH value, suspended solids, current strength, temperature and dissolved oxygen can be measured automatically. Fixed sensors to detect illumination, turbidity or chlorophyll-content need to have their "windows" frequently cleared because they become fouled by the settlement of small organisms and particles. On the other hand, most forms of chemical analysis, and virtually all forms of biological monitoring, require the samples to be collected and brought into the laboratory, where largely automated methods of analysis can often be applied. An alternative to fixed recorders is the use of multi-purpose recorders towed behind ships making regular sea-crossings. Such records based on the continuous plankton recorder (paragraph 183), are under development. However, sensed buoys and "towed bodies" are expensive instruments and their full potential is not at present being realised. In our view more priority should urgently be given to their development.

Conclusions

194. In this Chapter we have considered the research that is needed to identify and deal with damaging and potentially dangerous pollution problems. We have shown that research, whether in estuaries or in inshore and offshore waters, must necessarily be of two kinds. The first consists of synoptic studies in selected areas, which may require many years before they begin to show trends in per-

sistent pollutants, and in ecological effects (revealed, for example, in sea bird breeding colonies), and which may later provide a measure of the success or otherwise of control policies. The second kind of study must be experimental and directed, for instance, towards an understanding of the dynamics of particular forms of pollution in the sea and the chronic effects of pollutants, singly and in combination, on different types of organisms. It is only through careful scientific study that we can ever hope to be forewarned of hitherto unknown dangers that pollution could pose in estuaries or the sea (or indeed, in any part of the environment). And although it has become clear to us that the efforts already deployed by governmental and other agencies have put this country well ahead in marine pollution research, the problems are very urgent and the results are not coming as fast as is required. It would be wrong to conclude that because our contribution is already large we are doing more than our share to solve problems that are basically international in scope. The fact that we already have experience and facilities, makes it all the more important that our research contribution should be the best we can afford.

CHAPTER VII

ECONOMIC CONSIDERATIONS

Introduction

195. As has been explained in the preceding chapters of this Report, various administrative steps need to be taken to ensure that an adequate policy for controlling the pollution of estuaries and coastal waters can be implemented. But two major economic issues arise in connection with the implementation of such policies. First, how much will it cost, and hence what are likely to be the effects on employment in the regions concerned? Secondly, how far should economic incentives such as pollution charges rather than direct regulations, be used to implement policy? For reasons given below, detailed and precise answers to these questions could only be provided with the aid of an immense amount of economics research. However, it is clear to us that general answers already available are all that are needed for the purpose of reaching initial conclusions. These are that: (a) the overall economic impact on the regions concerned will be negligible, and (b) the further use of pollution charges, rather than direct regulation, as a means of controlling pollution in general, should be seriously considered. The system of charging for the treatment of industrial effluent discharged to public sewers will anyway need to be revised in the course of the impending reorganisation of river and water authorities, and it seems an opportune time to consider whether an extended use of pollution charges would be a better means of improving the quality of rivers, estuaries and coastal waters.

The costs of cleaner estuaries

196. How much it costs to clean up an estuary cannot be stated with any precision. The circumstances of each estuary differ and the extent to which it is practicable to comply with the criteria proposed in paragraph 23 will also differ from estuary to estuary. In practice, the only cost data available, in fact, are data on the estimated costs of achieving the particular target improvements that seem appropriate to the various river authorities in the country.

197. These data, which have been obtained by DOE in the course of its recent major river pollution survey*, indicate what "remedial" works would be required, in the opinion of the river authorities in England and Wales, immediately and by 1980⁽⁸⁾; but they exclude all expenditure on sewerage, which might as much as double the estimates, and on storm overflows. The full results of this part of the survey will show the changes in the quality of the rivers, including the tidal rivers, associated with these cost estimates. But, for the reason given above the relation between the costs and benefits of the improvements cannot be accurately assessed.

198. Also, there are other major qualifications which have to be noted before any precise conclusions can be drawn. First, the data available distinguish

* Some controlled waters were excluded from the survey.

between tidal and non-tidal reaches, but some of the expenditures on improving the non-tidal rivers will, of course, contribute to improving the state of the estuaries and coastal waters with which we are concerned. Hence it would be wrong to take only the figure for tidal rivers, since in the absence of improvements in non-tidal rivers far greater expenditures on discharges into the tidal rivers would be required in order to achieve any given degree of improvement in the estuaries. On the other hand, it would be wrong to include all the non-tidal expenditures, since many of their benefits are confined to the upper reaches of the rivers, and they would not be carried out if the objective were solely to improve estuaries.

199. Secondly, the estimates do not include the costs of dealing with sea-borne pollution, such as oil discharged accidentally or deliberately, or by some direct discharges into the sea outside the control of any river authorities.

200. Thirdly, the estimates available relate only to the capital costs of the remedial works thought to be necessary. Although this might seem to be the major item as far as most of the works are concerned (since the bulk of the work comprises improved sewage facilities), when these are amortized over the appropriate length of life (also not known) they may not dominate the picture, by comparison with current maintenance costs, as much as they might appear to do in the short run. In other words, the present capitalised value of future operating costs associated with the programme for cleaner rivers may be of the same order of magnitude as the capital expenditures envisaged over the next decade or so.

201. Finally, although the data do distinguish between the expenditure by industry to deal directly with industrial effluent and the expenditure on public sewage facilities, the latter includes most of the costs of dealing with the industrial effluent that is discharged to sewers. The industrial effluent costs, which amount to about £40 million in England and Wales, therefore comprise mainly the costs that would be incurred by industry for remedial works required immediately for treating the effluent before discharge direct to a river or estuary, or the cost of connecting it untreated to the public sewers. They do not include any pre-treatment that the sewage authority might require before accepting the effluent into the sewers, nor do they include all the additional treatment capacity that might be required at the treatment works. Hence the separate estimate of these industrial treatment costs would be an under-estimate of the cost directly borne by industry for treating industrial effluent. It would also be an even bigger under-estimate of the total cost to the community, including all sewage costs, of treating industrial effluent.

202. Furthermore, it would be impossible to say, in the absence of an extremely complex study of individual cases, how far the figures relate to the ultimate burden on local industry of the total costs of effluent treatment in any region. In the first place, much would depend on the extent to which industry contributed to the local rates associated with public sewers, as well as industry's own direct effluent treatment costs. And secondly, the effect in each industry of the various costs, such as the extent to which they would be passed on in higher prices, leading to reduced output and some loss of profits as well as some fall in employ-

ment, at least in the short run, would depend on the particular market conditions in each case. It would be unwise to pretend that the final impact of any cost in a particular case could readily be traced.

203. In view of these many reservations it might seem surprising that it is possible to reach any conclusions at all about the likely incidence of the expenditures deemed to be necessary over the next decade in the main estuaries. But, nevertheless, one important conclusion does emerge clearly from the estimates, namely, that however much one makes allowance for the sort of reservations listed above, the order of magnitude of the costs involved in most (but not all) industries is still very small indeed by comparison with other components of total industrial costs.

204. The data collected in the course of the river pollution survey showed that approximately £610m (at 1970 prices) would be required for remedial works in England and Wales in order to achieve the target improvements by 1980 in the quality of rivers (including tidal rivers and canals): this includes some £425m for discharge of sewage effluent, £145m for discharge of crude sewage, and £40m for discharge of industrial effluent. These figures considerably under-estimate the total cost to industry, because they include for industry only remedial works required immediately, whereas for the other discharges the figures include estimates up to 1980. They also omit expenditure which will be incurred by industry on pre-treatment of their own effluents before discharge to sewers. But even if we make the most generous allowance for expenditure required by industry up to 1980, the order of magnitude of the overall total required over this period would not be significantly increased. Of the total of £610m, some £250m would be spent in all tidal stretches although, as indicated above, the estuaries will benefit from expenditures in the upper reaches. The estimate for industrial expenditure in tidal rivers comes to no more than £16m but this is because it refers only to immediate remedial works and includes no estimates for further work up to 1980. It must be emphasised that these are remedial costs and do not include the cost of new sewerage or of replacing worn-out equipment, nor the environmental component of new industrial capital expansion up to 1980. The latter will vary considerably from industry to industry but in some cases can be significant (and increasingly so). Thus, for a new refinery (likely to be built on an estuary) it can be up to 10 per cent of the total capital cost, perhaps £2m or £3m on pollution abatement equipment in each case. Moreover the very expression "remedial work" under-estimates the desirable expenditure on pollution control in tidal waters, for it implies only the elimination of present dangers to these waters. It does not take into account the fact that damage due to some pollutants may not become apparent for years; so prudence demands that industries should incur expenditure over and above that required for evident remedial work, in order to safeguard tidal waters against unpredictable but nonetheless real dangers of future damage.

205. It is clear, therefore, that one can say little about the final impact of costs on industry in these areas. But even before considering in more detail the relation between these figures and the size of industry in estuarial areas, it is clear that a total national figure of £610m, spread over 10 years, is very small by comparison with total industrial costs or total investment. Total capital

investment (public and private) in the UK amounts to about £8,000m each year and will probably rise to over £10,000m per annum (at 1970 prices) by about the mid-1970s. Remedial capital works may well amount to some £60m per annum in England and Wales, or in our view approaching £75m per annum if allowance is made for all remedial works relating to industrial discharges. But this estimate excludes an unknown expenditure, perhaps as much again, on sewerage to serve these works and on replacements. Excluding this unknown expenditure, remedial capital works would be less than 1 per cent of total investment: no more than about 0.15 per cent of total national product and about 0.2 per cent of wage costs in England and Wales*.

206. Some industries and regions will be affected more than others. Areas bordering on the rivers and estuaries will incur most of the cost and there will also be big variations from one estuarine area to another. Estimates have been prepared of the capital expenditures (excluding the cost of new or replaced sewerage) on tidal stretches of certain river authority areas that can be matched against areas for which corresponding employment statistics are available. In this way the capital costs involved in these particular areas can be compared with the order of magnitude of the wage bills in them. These estimates have been prepared for three such river authority areas, namely: Mersey and Weaver, Northumbrian, and Trent. The total number of employees in these areas of the major tidal stretches of these river authorities is about 560,000 and the estimate of total capital works required in these areas by 1980 for discharges of sewage effluent and crude sewage amounts to about £112m, or £11m per annum, that is, £20 per annum for each employee. This is still only 1.5 per cent of the average wage per head. It is true that allowance should also be made for the costs that will be directly incurred by industry over this period. No satisfactory estimates of this are available, but such data as we have on costs of required remedial works over comparable time periods suggest that the addition to be made to the above estimates in order to allow for costs directly incurred by industry would overall be relatively small. Further, (a) the cost of the public treatment works required which has been used above will by no means fall entirely on local industry, and (b) the length of life of the installations, in most cases, is likely to be substantial, and in terms of annual capital consumption charges (probably the better figure to compare with annual wages) the relative burden would be correspondingly reduced. Although it is impossible to say how far these various corrections would offset each other it is clear that the order of magnitude, of about 1 to 2 per cent of the wage bill for the three areas as a whole over the period up to 1980, would not be significantly changed. There have been far greater changes in wage bills over the years without any effects on employment which could be directly attributed to these changes.

207. Given these orders of magnitude—that is, from about one-fifth of 1 per cent of the average wage bill if only direct industrial costs are included, to about 1 per cent if total costs in the areas concerned are assumed to be borne by local industry one way or another—it is clear that, even on the basis of the most extreme assumptions, the overall impact on industrial costs for the areas as a whole must be minimal compared with total costs.

* If proper allowance could be made for remedial works required in Scotland and Northern Ireland these percentages would still not be increased significantly.

Instruments of policy in the control of pollution

208. The costs of reducing pollution in rivers above the tidal reaches can be set against the benefits of increased amounts of water available for domestic purposes, for industry, and for recreation. The benefits which arise from reducing pollution in tidal waters are much more difficult to evaluate financially, but we hope we have left no doubt that they are just as real. If we allow these tidal waters to deteriorate further severe damage may be done to Britain's environment. So although we do not have any reliable information on the damage done by estuarine pollution, there is a strong *prima facie* reason to believe that, if nothing were done about it, pollution would be likely to remain excessive, and in many of our estuaries it is clear that not enough is being done about it. The reason for assuming that pollution will generally be excessive is, as pointed out in our First Report, that most polluters are not obliged to take account of the full social costs of their pollution in reaching their own decisions about how much to pollute the environment. Since pollution does not usually carry any charge polluters are, in a sense, using a factor of production, namely the facility to pollute, without any financial incentive to economise in its use. They will hence tend to use it wastefully, in a way that they would not do with any other factor of production, such as labour or capital. There tends, therefore, to be a mis-allocation of resources; too much of the scarce resource "clean water" is used up in the course of production.

209. To discharge wastes into estuaries and other tidal waters is a perfectly legitimate use of these resources, provided the biological cycles that go on in them are not thereby endangered. The problem, therefore, is how to control the amounts discharged in such a way that this criterion is fulfilled. There are, broadly, two ways to do this. One is the way we advocate in Chapter II of this Report, namely to empower regional water authorities (and their equivalents in Scotland) to give consents for discharges, with the duty to prosecute anyone who infringes them. Under this system some wastes (for example, certain heavy metals) could be prohibited altogether; consents to discharge other wastes would be controlled so that the total quantities being discharged from all sources are, in the judgment of the regional water authority, safely within the limits which the estuary can absorb and render harmless. The other way is by charges as discussed below (paragraphs 211 to 214).

210. The management of tidal waters in this way is obviously inseparable from the management of the rivers that flow into them. The quality of water reckoned to be desirable will vary not only between river systems, but along different stretches of the same rivers and their estuaries. All this will need sophisticated monitoring and, as new industries apply for consents to discharge wastes into the tidal waters, the consents granted to industries already there may have to be stiffened.

211. We have no reason to believe that this control cannot be exercised effectively under the existing procedures. But it has been represented to us that to control pollution by charges instead of by consents would be a more efficient way of making the polluter pay for his pollution and that it could be done at lower cost for the same level of abatement. Under such a system the regional

water authorities, instead of giving consents up to limited quantities of effluent, would apply a scale of charges rising steeply with the quantity of effluent discharged. The more dangerous substances would be prohibited and, under most circumstances, upper limits would be imposed on the discharge of certain pollutants. These prohibitions and limitations would be enforced by suitably developed monitoring and by prosecuting those who were found to be breaking the rules. The charges would vary from place to place according to the degree of purity of the estuary or river into which they are discharged, and the damage the pollutants might do. If this were done (it is argued) the polluter would have a flexible inducement, namely, to cut down his pollution by any means he chose rather than to pay the charge; and the overall effect of using market forces, rather than fixed standards, to abate pollution would be a higher level of abatement. On the other hand, he could if he chose, pay the charge and discharge without limitation (apart from any limits which may be imposed on certain pollutants).

212. This is not a novel idea: certain kinds of pollution are already subject to charges: for example, some local authorities require payment for the discharge of trade effluent into municipal sewers, and some industrial organisations with their own treatment plants charge individual divisions of the organisation for the use of the plants.

213. The question we have to answer is whether we, as a Commission, recommend without further discussion with those who would have to control water quality, an immediate decision to begin a transition from consents to charges as the main means of controlling pollution in river systems. Although none of us are against charges as one means of controlling pollution, we do not all agree that they should be introduced without further enquiries, which the Commission have not made. Two of us, who subscribe to the Minority Report (page 74), believe that the reorganisation of river management is an excellent opportunity for the substitution of a charges system for the present system, and wish to make a firm recommendation that this should be adopted forthwith as a matter of policy. The rest of us are in favour of the principle that the polluter should not have free use of the environment, but we are unwilling to subscribe to the recommendation in paragraph 6 of the Minority Report because we share all or some of the following reservations:

- (a) We are not convinced that a system of charges would be so effective as consents, to ensure the quality of water in rivers and estuaries. Consents, if properly policed, would guarantee a level of water quality; charges, which put inducements but not obligations upon industries, would not, in our view, offer so effective a guarantee.
- (b) The administration of a system of charges would need an expertise (for example, to fix and adjust the charges on different stretches of water) which we do not believe exists at present; so we would want more consultation with those who would have to manage a charging scheme before we could firmly recommend one; and we would want to see substantial further development in the technique of continuous monitoring. The regional water authorities would, of course, even if a charging system were introduced, have to employ a monitoring and enforcement staff to prevent

the discharge of prohibited substances or any discharges above a certain level. We do not know at this stage whether the same staff or some independent establishment should assess the amounts paid for authorised discharges. It would be a form of taxation and there would have to be provision for appeals. Whether the creation of such machinery would be an efficient use of resources is one of the matters that would have to be examined.

- (c) The fact that there is a limit to how much of a particular pollutant a given stretch of water can accept without detriment, each hour or day or week, has to be taken into account in considering the practicality of a charging system. Many miles of rivers and estuaries in urban and industrial areas are overloaded at present, and any new control measure must reinforce ongoing efforts to restore them to a more acceptable standard. One can visualise as a goal an agreed and acceptable maximum load of pollution, made up of so many arbitrary units which are available for allocation among the bodies having wastes to discharge, namely the adjacent municipalities and industries. But in our view it would not be in the public interest to allow a fixed resource of this kind to be allocated solely according to the users' ability to pay. It might lead to an imbalance between industrial and public needs, or to one kind of industry being put out of business by another because their waste effluents contained the same chargeable ingredient but their financial margins were entirely different. This suggests to us that acceptable pollution control could not be secured by charges alone, without taking political and social considerations into account; and that one could not in practice do away with a system of separate assessments or consents, made by statutory authorities to the individual dischargers.
- (d) There have been some limited experiments in the USA on charging systems for controlling pollution. We have not examined these or obtained from the competent authorities in this country views on their efficiency and practicability.

214. For the above reasons those of us who do not subscribe to the Minority Report certainly recommend that the Government should forthwith examine the case for adopting a charging system; but we do not believe that the case in favour of charges is already so well established as to justify, without further enquiry, a switch from consents to charges as the main device for controlling pollution in rivers and tidal waters.

CHAPTER VIII

SUMMARY

The state of some estuaries

215. (1) A great and increasing volume of pollutants, some of them toxic, reach estuaries partly from rivers and partly from direct discharge. Tidal scour cannot continue indefinitely to break down or disperse all such wastes (*paragraphs 6-9*).
- (2) Gross pollution of estuaries does obvious harm to the natural environment. Estuaries have received too little protection from Parliament against the wastes from industries attracted to them because of their easy access to and from the sea, ample supply of cooling water and ready disposal for waste products (*paragraphs 10-11*).
- (3) Local authorities can now depend on public support for schemes to clean up estuaries. But there is a practical limit to the burden which should be placed on the community and industry must share the responsibility. The case for increased expenditure to reduce pollution cannot be determined solely on economic arguments (*paragraphs 12-17*).

The danger of time-lag

216. An early start is essential in reversing the growth of pollution of tidal waters, if only because it takes so long between the decision to act, the introduction of new powers and changes in organisation, and an actual start to any operation to check the growing damage to the environment (*paragraphs 18-19*).

A policy for estuaries

217. (1) The Government should integrate pollution control of estuaries within a national policy for waste disposal, under which waste products shall be put not where they are under least control, but where they will do least harm (*paragraph 20*).
- (2) In general the law should require the maximum practical abatement before discharge of all pollutants which are unlikely to be rendered harmless by natural processes (*paragraph 21*).
- (3) Steps should be taken to unify or co-ordinate the activities of authorities who are responsible for controlling pollution in estuaries. Only one authority should have executive responsibility (*paragraph 22*).
- (4) The Government should adopt two simple biological criteria for the management of estuarial waters:
- (i) ability to support on the mud bottom the fauna essential for sustaining sea fisheries; and
 - (ii) ability to allow the passage of migratory fish at all states of the tide (*paragraph 23*).

Summary

England and Wales—Recommendations on administration and legislation

218. The law in England and Wales should be amended as soon as possible to give effect to the policy we recommend. Meanwhile the following administrative action should be taken at once:

- (1) The Department of the Environment should encourage river authorities to give notice to those concerned that the standard of acceptability for effluents will be raised (*paragraph 24 (a)*).
- (2) The Department of the Environment should reach voluntary agreement with industry that the nature and quantities of all effluents put into rivers and estuaries should be more widely disclosed (*paragraph 24 (b) and (c)*).
- (3) Local authorities should seek industry's co-operation over the disclosure of wastes discharged into sewers (*paragraph 24 (d)*).
- (4) River authorities should take responsibility for monitoring critical substances in estuaries (*paragraph 24 (e)*).
- (5) "Pollution budgets" for each major industrialised estuary, should be designed so as to exploit the estuary for waste disposal, but only up to a level which does not endanger aquatic life or transgress amenity standards (*paragraph 24 (f)*).
- (6) Planning authorities should consult river authorities before passing any plan which would increase the effluent load on an estuary (*paragraph 24 (g)*).

219. The following changes should be made in the present law:

- (1) All industrial and sewage effluent discharges to tidal waters and estuaries should be statutorily controlled within 12 months from the commencement of the amending legislation or from July 1974, whichever is the earlier (*paragraph 27 (a) and (b)*).
- (2) Discharges of sewage from all vessels, including naval vessels, in tidal waters and estuaries should be brought under statutory control (*paragraph 27 (c)*).
- (3) The legislation setting up the new regional water authorities should provide that all discharges to sewers be controlled; that industry be charged the full cost of waste treatment and disposal; and that authorities may take samples from private sewers from trade premises (*paragraph 27 (d)*).
- (4) Legislation to implement the Oslo Convention on the Control of Marine Pollution by Dumping from Ships and Aircraft in the North East Atlantic should be introduced as a matter of priority (*paragraph 27 (e)*).
- (5) Regional water authorities should have statutory powers to control all discharges into rivers, estuaries and coastal waters (*paragraph 30*).
- (6) Planning authorities should be required by law to consult regional water authorities before permitting any development which would add to the effluent load discharged into rivers, estuaries or coastal waters (*paragraph 30*).

220. Advantage lies in giving the proposed regional water authorities powers to control all discharges along the coasts of England and Wales as well as into estuaries. Nevertheless:

- (1) Sea fisheries committees should be retained, with powers to concern themselves with the effects of pollution on sea fisheries up to six miles from the coast (*paragraph 32 (a)*).
- (2) The committees should have the right to make representations to the regional water authorities on any pollution problems affecting sea fisheries and should also, where appropriate, have the right of appeal to the responsible Ministers (*paragraph 32 (b) and (c)*).

Scotland—Recommendations on administration and legislation

221. In Scotland, the administrative adjustments proposed in paragraph 218 above should be adopted, where practicable. The present river purification boards should be retained as separate bodies outside local government, and the law should require them to be consulted by planning authorities before any development is permitted which would substantially increase the effluent load on any major industrialised estuary (*paragraphs 33–35*).

International action

222. (1) The Government should take a lead in reaching international agreement for the publication of data on monitoring and estimates of the masses of certain pollutants entering the sea (*paragraph 37*).
- (2) Contingency plans should be prepared to deal with any accident at sea involving hazardous cargoes which might affect our coastline (*paragraph 38*).
- (3) Measures should be agreed internationally for the immediate dissemination of details of the type of product involved in any such accident (*paragraph 38*).

Monitoring and research

223. On monitoring:

- (1) Essential substances should be monitored; there should also be biological monitoring of certain “indicator” species (*paragraph 40 (a)*).
- (2) Regional water authorities should be made responsible for monitoring discharges to estuarine and coastal waters (*paragraph 40 (b)*).
- (3) Offshore monitoring stations should be set up and operated for the UK by an appropriate department of central government (*paragraph 40 (c)*).

224. On research:

- (1) More attention should be given to assessing the toxicity of the most common pollutants on aquatic organisms and to examining the effects of their long-term exposure to sub-lethal concentrations (*paragraph 41 (a)*).

Summary

- (2) Greater effort should be devoted to developing effective mathematical models of estuaries (*paragraph 41 (b)*).
- (3) More knowledge of coastal hydrography is required for pollution control purposes (*paragraph 41 (c)*).
- (4) Further studies should be made of the effects of materials which are not broken down in the environment and may present possible hazards to man or other living things, and of their accumulation in muds and sediments and the conditions in which they might be released (*paragraph 41 (d)*).
- (5) Studies should be made of the effects of trace amounts of organochlorine and organomercury compounds on photosynthesis by marine phytoplankton (*paragraph 41 (e)*).

Economic matters

225. (1) The estimated capital cost of achieving the target improvements in the quality of rivers and tidal waters in England and Wales by 1980 is very small by comparison with total national investment or with total wage costs (*paragraph 42 (a)*).
 - (2) The majority of us recommend that the Government should examine the case for adopting a system of charges for the control of pollution. Two of us wish to go further than this and to make a firm recommendation that as a matter of policy a system of charges should be adopted forthwith (*paragraph 42 (b)*).
-

226. We wish to express our gratitude for the help we have received from all the many organisations and individuals whom we consulted in the course of the enquiry.

227. Since we all give our services on a voluntary and part-time basis we depend on our staff for the heavy work involved in preparing a Report which contains as much detail as this one does. It is a pleasure to record our gratitude to three members of the staff without whose indefatigable help the enquiry could not have been conducted, nor the Report written. They are our Secretary, Miss D. M. Wilde; our Assistant Secretary, Mr. A. C. Parsons; and Mr. P. T. Sherwood, who undertook the drafting and checking of all scientific material which has been put into the Report.

ALL OF WHICH WE HUMBLY SUBMIT FOR YOUR MAJESTY'S
GRACIOUS CONSIDERATION.

ERIC ASHBY (*Chairman*)
ZUCKERMAN OF BURNHAM THORPE*
LAUNCELOT FLEMING Bp
JOHN WINNIFRITH
FRANK FRASER DARLING
NEIL ILIFF
AUBREY BUXTON
WILFRED BECKERMAN*
VERO WYNNE-EDWARDS

D. M. WILDE (*Secretary*).

A. C. PARSONS (*Assistant Secretary*).

16th June, 1972

* The only difference of opinion between ourselves and our colleagues is over the best means of achieving the desired degree of pollution abatement in estuaries and coastal waters. We are unwilling to rely on the proposals in Chapter II of the Report and we make alternative recommendations in the Minority Report (page 74).

MINORITY REPORT

by

LORD ZUCKERMAN AND PROFESSOR BECKERMAN

1. This Minority Report sets out in full a case for the control of pollution by charges. We believe that the case is so strong that we make a firm recommendation (paragraph 6) that preparations should be made forthwith to introduce a system of charges for the disposal of wastes into rivers and tidal waters.

The case for pollution charges

2. In our First Report we stated that “. . . pollution should be reduced to the point where the costs of doing so are covered by the benefits from the reduction of pollution”*. The benefits from the reduction of pollution are, of course, the same thing as the elimination of the damage that had hitherto been done by the pollution. For example, society as a whole would lose if, say, £2 were to be spent to eliminate a further unit of pollution that had imposed £1 of damage on society. In saying this, we do not limit the damage to society to any particular forms of damage, such as damage of a purely material kind; and society is free to decide that this damage includes loss of amenity, danger to health, threat to future generations, and so on, as well as more straightforward damage, such as loss of fish resources, cost of cleaning beaches, etc. But, given the valuation placed on the further reduction of pollution it is clearly undesirable to achieve it at a cost that exceeds this valuation. Hence, what is required, ideally, is some incentive to polluters to reduce pollution up to the point where the costs to them of further pollution abatement would be greater than the damage done (at the margin) by the pollution.

3. By and large the price mechanism provides just such an incentive. In the above example, if the polluter were charged £1 per unit of pollution he would have an incentive to reduce pollution, thereby saving himself the payment of pollution charges, only up to the point where it would cost him £1 per unit to achieve a further reduction. For beyond that point, he would have to spend more in pollution abatement costs than he would save through paying less pollution charges. He would tend not to go beyond this point, and so would not incur, say, £2 in abatement costs where the pollution charge (set to equal the gain to society from the further abatement) was only £1. And, conversely, he would have an incentive not to stop short of this optimum point. For if he could reduce pollution at a cost of, say, £0.5 per unit he would have an incentive to incur this cost thereby saving himself a pollution charge of £1 per unit, and he would, in fact, have an incentive to continue reducing pollution up to the point where his abatement costs and hence, roughly speaking, the costs to society, would rise to equal the pollution charge. This is why the ideal means of avoiding excessive pollution at least in principle, is to make the polluter pay

* First Report, paragraph 20.

a charge corresponding to the damage done (at the margin) by his pollution. Who he pays it to does not really matter from the narrow point of view of giving him an incentive to abate pollution, but, in practice, it would usually be necessary for the pollution charge to be determined by, and paid to, a public authority.

4. Almost all taxes, whether on goods, on factors of production, or even on work, tend to mis-allocate resources. By contrast, a pollution charge tends to correct an existing mis-allocation of resources by making polluters bear the true social cost of the clean resources that they are using up. An alternative way of looking at it is to regard the pollution as an undesirable by-product produced in the course of producing some desirable product, such as steel, cement, pulp and paper, and so on. In the same way that the appropriate incentive to produce the goods that confer positive benefits on society is provided by their having a positive price, the disincentive to produce pollution requires, in principle, that it should carry a negative price. A pollution charge is just such a negative price, for the more pollution produced the more the polluter pays.

5. As indicated in the main body of this Report (paragraph 212) some form of financial disincentive to pollute already exists, up to a point, in this country, namely the charges for the treatment of trade (that is, non-domestic) effluent discharged to municipal sewers. The Public Health (Drainage of Trade Premises) Act 1937 and the Public Health Act 1961, provide drainage authorities with adequate authority to control the discharges into their sewerage systems and to "charge for the reception of the trade effluent into the sewer regard being had to the nature and composition and to the volume and rate of the discharge of the trade effluent so discharged . . ." (Public Health Act 1961). A large number of local authorities do, in fact, charge for trade effluent according to formulae which take account of some indicators of pollution (notably the BOD and the amount of suspended solids in the effluent). In arriving at our conclusion to the effect that greater use should be made of pollution charges rather than direct regulation, we are not, therefore, advocating the introduction of some entirely novel policy instrument on account of purely theoretical considerations. Various bodies and individuals concerned with the practical application of charges have concurred with our view on this matter. For example, the Institute of Water Pollution Control stated many years ago that: "One of the most effective methods of reducing the load caused by trade effluents is to make a charge for their treatment which is based on a sliding scale in accordance with their volume and strength. In this way an incentive can be given to the trader to reduce his discharge of waste from his factory, by re-using water, by making minor modifications in manufacturing processes, by recovering by-products or by some other means. Some remarkable results have been achieved in this way with profit to the trader, and with great advantage to sewage works operation, and with considerable resulting contribution to the national economy"*.

We have also noted with interest the move towards the

* "Memorandum on National Policy on the Discharge of Trade Effluent into Public Sewers", by the (then) Institute of Sewage Purification, 1952. The same advantages for the charging system have been claimed in a paper by Mr. Goodman, Chemical Inspector, Directorate of Water Engineering, Department of the Environment, submitted to the Economic Commission for Europe, January 1972, page 2.

use of pollution charges in the U.S.A., beginning with the imposition of a charge on sulphur oxide emissions announced in the Presidential Message to Congress on 8 February, 1972.

6. In effect, we are advocating that the present rather artificial distinction between the charging practices applied to trade effluent discharged into many municipal sewers and those used to control direct discharges into rivers or estuaries be eliminated as far as the choice between charges and direct regulation are concerned. Subject to certain reservations discussed below, we propose that a charge system be extended to the control of pollution in general, including effluent discharged direct to water courses. We recommend that work on the detailed implementation of such a charging scheme be started without delay as part of the extensive discussions and preparations that are already under way in connection with the reorganisation of water and river authorities and the revision of methods of charging for water consumption and for discharges of effluent to sewers.

7. In making this recommendation we are aware that numerous difficulties and problems arise, and also that the present system of effluent charges is often not an efficient means of achieving the optimum amount of pollution abatement. Also, we appreciate that the choice between pollution charges and direct regulation may appear to some people as one that raises various fundamental issues of principle. Hence, we thought it important that our positive recommendation in favour of the use of pollution charges, subject to certain exceptions, should be accompanied by a discussion of some of these issues.

8. **The general case for pollution charges.** As already indicated, pollution charges do not constitute some entirely novel instrument of control, since some form of financial disincentive to pollution is already embodied in existing trade effluent charges. But, as an instrument of obtaining the optimum amount of pollution abatement, charges are even less novel than trade effluent charges, for they constitute simply the use of the time-honoured price mechanism, rather than direct controls, to determine how society allocates resources between different firms and industries and how society arrives at one pattern of output rather than another. Whilst recognising the many limitations on the price mechanism as a means of achieving all society's objectives, notably those concerned with income distribution or the provision of public goods, as a means of achieving the appropriate levels of output of other goods, (and "bads") the price mechanism is likely to be more efficient, and hence cheaper, than the use of direction. In making a positive recommendation in favour of pollution charges, therefore, we do not feel obliged to be able to report on numerous cases where such a system has already operated successfully. The fact that the price mechanism in general, subject to the qualifications mentioned above, provides a fairly efficient mechanism for resource allocation seems to us to constitute relevant evidence. By contrast, the imposition of production quotas or "norms", according to which different firms are given production targets in the form of direct quantitative regulations is generally unlikely to ensure that goods are produced by the firms best able to do so and by the most economical methods. With certain exceptions, it is not the type of economic policy in-

strument used in this country. The use of direct regulations for the control of pollution amounts precisely to such a system of production quotas and norms.

9. The same forces which tend to make the price mechanism a cheaper means of producing most goods apply to the production of pollution. If a uniform pollution charge is imposed at any particular stretch of river or estuary all polluters will tend to abate their pollution up to the point where it would cost them more to abate further than the charge they pay per unit of pollution. In other words, at the margin, the cost of pollution abatement is equal in all firms, since it is equal to the charge in all firms. Contrast this with the use of some direct control, such as a regulation to the effect that all firms must reduce their pollution by a uniform percentage, or to some uniform amount. This will obviously involve very high marginal costs of pollution abatement for some firms and low marginal costs for others. Clearly, the same total amount of pollution abatement could have been obtained if some of the abatement had been switched from the former firms, where it is costly, to the latter, where it is cheap; and savings of this kind could be made by the switching up to the point where the marginal costs of further abatement were equal for all firms. This is precisely the situation to which the pollution charge system tends to lead. In saying this we are not under any illusions to the effect that all firms are ruthless profit maximisers making careful rational calculations of the optimal degree to which they should reduce pollution. Most firms do not make the theoretically ideal calculations of their investment needs, for example, but even those who are opposed to pollution charges would not argue, on this account, that firms' investment projects should be determined by direct regulation. Hence, our argument no more depends on a very simple view of the way that firms operate than would arguments in favour of using the price mechanism rather than direct regulation to allocate labour and capital and raw materials between different firms rather than allocate supplies to them according to some quantitative plan.

10. It may well be that, to some extent, the excess cost of direct regulation can be mitigated by means of a system such as that used by the Alkali Inspectorate in this country, to relate the amount of pollution abatement in each firm to the costs which that firm would incur in abating pollution. But whilst we feel that, as a matter of general principle, the amount of information needed to ensure that this system is a least-cost system would be far greater than if a simpler pollution charge system were used and firms then left to make their own calculations of how far they abated pollution, and by what means, and how far, instead, they preferred to pay the tax, we have not studied the air pollution problem sufficiently to come to any firm conclusions. Meanwhile as far as the choice between charges and some crude direct regulation system is concerned, such empirical evidence as exists confirms our view that the former must be cheaper and hence impose a smaller burden on the economy*.

11. Direct regulation of pollution also imposes costs on firms, and hence, on society. The great advantage of the charge method is that it enables firms to

* The charges method minimises real costs to the economy and to industry on the assumption that the extra public sector revenue is not allowed to reduce the pressure of demand and hence output. This implies that other taxes must be reduced or public expenditures increased.

find the cheapest means of reducing their pollution*. Some may change their raw material inputs, others may carry out more re-cycling, others may institute more effluent treatment plant inside the firm, and so on. Also, as explained above, a pollution charge allocates total abatement in the cheapest manner between firms.

12. Thus we do not subscribe to the objection set out in paragraph 213(c) above to the effect that the right to pollute will pass into the hands of a few wealthy buyers. On the whole, large firms also tend to employ more labour, capital, and raw materials than do small firms, and this is not generally regarded as a reason for using direct regulation in order to share out available resources of labour, capital and raw materials more evenly. In the same way it should not constitute a reason for not allowing the scarce resource "clean water" to be allocated by any principle other than that which reflects the value placed on its use by different firms. Similarly, more profitable firms are not noticeably less anxious to respond to price incentives than unprofitable firms; if anything the reverse is presumably the case, so there is no reason to fear that very profitable firms will tend to ignore the pollution charge and continue to pollute as much as before. On the whole, firms that find it very costly to reduce pollution considerably will have to pay heavier charges, and those that can easily reduce pollution at relatively low cost will have an incentive to reduce it considerably instead of merely to some maximum level set by a direct regulation. And this is precisely the way that society obtains any given output at lowest cost*.

13. Hence, for these two reasons—firms will be left to find the most economical way of reducing pollution, and total pollution abatement will be distributed between firms in the cheapest way—a given total amount of abatement can be obtained at lower cost*. This is the same as saying that, for a given expenditure, pollution can be reduced further.

14. In a sense, reducing pollution is like increasing the output of some other product, "clean air" or "clean water". Subject to certain limitations, it is more efficient if the distribution of clothing output in the economy is settled by means of the price mechanism rather than by some allocation of quantitative production norms and quotas for everybody. In the same way, it is better to use a price, namely a pollution charge, to ensure the most economical method of allocating scarce resources of clean air, clean water, and so on.

15. Secondly, the introduction of a charge system will require that some body or authority has full-time and permanent responsibility for collecting the necessary information. But with direct regulation there can be some unevenness in the extent to which the regulations are implemented and enforced. In fact, direct regulation is also a form of tax, in the sense that a small fine may be imposed if breaches of the regulations are identified and proved to the satisfaction of the courts. But its incidence is often uncertain, subject to delays, and usually too small anyway. The implementation of direct regulations on pollution may vary with the extent to which pollution happens to be a live, popular and fashionable issue. As a rule, no such vagaries apply to a machinery for collecting charges.

* See footnote on previous page.

16. In view of these two advantages of pollution charges as a means of making the polluter pay for the damage done by his pollution, it may be asked why this method is not used more extensively. It would be out of place to try to discuss all the reasons for this in great detail here, but it is desirable to try to allay some of the more common misgivings over pollution charges that we have encountered and which in the opinion of the signatories of this Minority Report are unfounded.

17. In doing so we shall also try to answer the reasons given by our colleagues for their unwillingness to join us in a positive proposal to implement a charges system in the context of the present Report. We must emphasise, however, that few opponents of a charges scheme subscribe to all the objections discussed below. Some people oppose a charges scheme for reasons which other opponents of the scheme would regard as clearly wrong and irrelevant. To some opponents of a charges scheme, therefore, it will appear as if some of the objections that we take issue with are Aunt Sallys. But what is an irrelevant Aunt Sally to one man is a vital matter of principle to another. Some people support pollution charges in principle but are against it for practical reasons. Others accept that it would work in practice but are against it in principle. Some people think it would be too costly to industry and others think that firms would be indifferent and hence take no action to reduce pollution. Some people think that the scheme would involve a vast army of officials to implement it and others think that the disadvantage of the scheme is that once the charging schedule had been worked out everybody would forget all about it. We do not think we are obliged to discuss every one of the various objections to the charging scheme that we have encountered, however, and have limited ourselves to those that seem to be most common.

18. Is pollution a special case for which the price mechanism is not appropriate? First, it is often argued that pollution charges can have no effect since the polluters will merely pass them on in higher prices. But producers normally try to cover all their costs in their prices—otherwise they would soon go out of business—and one does not, therefore, say that they do not bear the costs of the labour or capital that they employ, and that they are indifferent to how much of it they use. Firms will still try to employ each factor of production up to the point where further use would not add to their revenues more than they add to their costs. In general, it is the more profitable firms that carry out this process more efficiently. To assume that by paying a “licence to pollute” firms have no incentive to economise on pollution is like assuming that firms do not economise in their use of other factors of production. If this were true the whole allocation of resources in the economy would be completely haphazard. It should not be forgotten that a pollution charge would not be like a radio licence, which, once paid, entitles the licence holder to an unlimited amount of listening. A pollution charge would be related to the amount of pollution; the more one pollutes the more one pays, in the same way that the further one travels on a bus the more one pays.

19. Secondly, it is often maintained that a charge scheme is unworkable because we do not have the data needed to decide on the appropriate charge in all cases, making full allowance, for example, for variations in the conditions

(such as, state of river flow, air temperature, tidal conditions) that determine the amount of damage done by effluent at any point in an estuary. This is true, but the same data limitations mean that one does not know the correct amount of pollution abatement to be imposed by direct regulation either. In principle, the data required to identify the correct objective as regards pollution abatement are independent of the methods that might then be used to achieve this objective. For these data relate to the costs of abatement and the damage done to society by the pollution, and are hence the same whatever policy instruments are to be used for abatement purposes. For example, a person might not know whether he will have more sunshine on his holiday if he takes it in Scotland or in Brighton; and he may also have a choice of going to either place by rail or by car. It would be irrational for him to say "since I am not sure which place is best, I shall go by car." The two issues—the correct objective and the means of achieving it—are quite separate in this case, as they are also in connection with pollution abatement. (In fact, for the administrative reasons set out above, it is likely that these data would be built up more rapidly if some authority were responsible for regularly levying charges based on the amount of pollution done than if pollution control is left to direct regulation.)

20. Thirdly, it is often claimed that charges are impracticable because data are not available to permit an accurate calculation of the amount of pollution that should be taxed. For example, it may be feared that monitoring difficulties preclude the observation of the pollution which is to be charged. This is true but, again, precisely the same problems apply to the surveillance and implementation of direct controls. The imposition of direct control implies that whatever is controlled can be measured—otherwise it is pointless to institute the control, since it would be impossible to check whether it is respected. Hence, if whatever is controlled can be measured it can also be made the basis for a tax. For example, if a firm is instructed not to put more than 1 ounce of some heavy metal per day in the river it is unlikely that the check, insofar as there is one, on the amount of the metal contained in its effluent indicates only whether the amount discharged is above or below 1 ounce. A more informative, if not precise, figure would usually be obtained, such as that the amount was 2.8 ounces or 0.7 ounces. The extra information would be virtually free in most cases, and would be adequate for a charging scheme as long as it recognised from the outset that the charging scheme would not be a perfect one.

21. Even where it is not practicable to measure the constituent of the effluent and it is necessary, if any control at all is to be exercised, to lay down consent conditions in terms of, say, the raw material used or the productive process used, this will usually still be related to some quantifiable flow, or characteristic of the raw material or productive process which could then be used as the basis for a charge. For example, suppose it were thought desirable to reduce the amount of some heavy metal flowing into an estuary, but it was impossible to measure the metal concerned at the sort of low concentrations that might be relevant. Direct control, if any, might then take the form of a restriction, in certain productive processes, on the use of some raw material believed to be responsible for the pollution in question. But if the amount of this raw material used can be measured for purposes of ensuring that the direct control is re-

spected, the measurements can be used as a basis for the pollution charge. In some cases, of course, verification difficulties may mean that the calculation of the charge will be inaccurate, but in such cases the check on the observance of direct controls will be equally unreliable. In other cases, the costs of operating a charging system would be excessive in relation to the damage done by the pollution and it may then be thought not worthwhile to impose the charge. But in such cases it will probably be equally undesirable to attempt to monitor how far the direct regulations are respected.

22. Fourthly, it is often believed that the great advantage of the direct regulation is that the regulating authority knows exactly whether or not the abatement target will be achieved, whereas with a charge system they will not know in advance how far firms will respond to the charge and hence how far pollution will be reduced to the optimum amount. This is very much the kind of reservation about the charging scheme raised in paragraph 213 (a) of the main body of this Report. But this objection to the charging scheme is rather like arguing that the great advantage of direct regulation in centrally planned economies is, for example, that they can be sure that the target for clothing output will be produced whereas if they had left it to the market mechanism actual clothing output might have fallen below or above the target. Now this is quite true, but the accuracy with which one hits any target is not, in itself, a desirable objective of policy irrespective of the extent to which it is the appropriate target. The advantage of the price mechanism is precisely that if the output of clothing is too high its price will fall, thereby discouraging its production (and encouraging its consumption) until the correct amount is produced. But with a production quota, and, in addition, no market anyway (as would be the case with pollution), producers would continue to produce the target level of pollution and nobody would know whether or not it is the correct target. By comparison, with the charge method, if the charge failed to produce the level of pollution at which the marginal social damage is equal to the charge, this would itself constitute evidence for the fact that the initial estimate of optimum pollution could not have been correct, so that some adjustment in the charge would be appropriate in due course.

23. **Qualifications and reservations.** In principle the optimum amount of pollution abatement should be that at which the marginal costs of further abatement equal the marginal benefits of further abatement (that is, from the reduction in the damage done by the pollution). The correct charge would be equal to the value of the marginal costs of abatement at this level of abatement, and hence also to the marginal benefits at this level of abatement. But, of course, as indicated in the discussion above, the data required for identifying the optimum charge are not usually available and this, together with certain other practical considerations, will mean that, in general, it would be inappropriate to seek too rigorously to attain the theoretically ideal charge.

24. More particularly, the limitations of data, or the costs of obtaining the requisite data, imply that the following deviations from the theoretical ideal be accepted. First, in some cases, particularly where we are dealing with highly dangerous materials, the optimum amount of pollution that should be tolerated might be thought to be so low that it is pointless to set the appropriate charge,

which might be extremely high, in order to levy it on an extremely small amount of pollution. It would be administratively simpler to ban the pollution outright.

25. Secondly, there is often a non-linear relation between the volume of a pollutant and the damage done by it, so that although the damage done might rise proportionately, or even less than proportionately, to a given rise in pollution over a certain range, beyond a point it begins to rise much more rapidly than the related pollution. This means that, above a certain point, a slight error in the quantity of pollution permitted could lead to a much more than proportionate increase in the damage done. In such cases it would be preferable to set quantitative upper limits to the amount of pollution that can be tolerated. It is true that, even in this case, it would be possible to fix the limit on pollution in quantitative terms and then set up a market in "pollution rights" so that they were allocated, by a price mechanism, in an economically optimum manner. But it is doubtful whether such a solution, however theoretically attractive, would be feasible given the character of the institutions within which pollution policy needs to be implemented in this country.

26. Thirdly, in some cases it might not be worthwhile levying a charge on small polluters since this might require rather more regular monitoring and inspection than would be required by occasional checks to verify that their pollution load has, in fact, remained "small".

27. Fourthly, over the range to which a charging system should be operated, it would be unwise to attempt to charge in a manner that was precisely and continuously related to the pollution load. Quite apart from the fact that there are numerous physical parameters of pollution, including the composition of the effluent, the river flow, the air conditions, the time of the day or night, and so on, the inaccuracies of measurement alone must mean that some sort of "step" method for charging should be adopted.

The role of the authorities

28. Although, for the reasons set out above, we believe that any target level of water quality in our estuaries could be obtained at lower costs by a charging scheme than by direct regulation, it must be recognised that the system of regulation that has operated in this country in the past has succeeded in achieving some improvement in the overall state of our rivers, including tidal rivers, and hence in mitigating some of the deterioration that would otherwise have taken place in some of our estuaries, in spite of (a) a greatly increased potential pollution load from the increase in industrial production, (b) the expansion of certain highly polluting industries, and (c) severe restraint, in the past, on sewage expenditures. And there is little doubt that the expansion of expenditures on sewage that are planned for the next decade would itself have enabled considerable further progress to be made. Thus, it should not be thought that, in advocating an extension and adaptation of a charging system for controlling water pollution, we envisage any reduction in the role played by local authorities and other bodies, such as the river authorities, in the control of pollution in their areas. On the contrary, the extension of the charging system will mean that new duties

will be imposed on the bodies that are to be set up as part of the impending reorganisation of water resources and supplies.

29. In the first place, charges cannot be set nationally; the central government bodies can only lay down general criteria and rules. It is generally recognised that the same applies to the principles underlying the introduction of an extensive system of charging water consumers according to the volume of their consumption, and which is currently under discussion. There is no difference, in principle, between using up the scarce resource "clean water" by drinking it, or watering the garden, or using it for cooling purposes in a factory, or using it up by polluting it. In the same way that charges for water consumption must vary according to local conditions, charges for pollution should vary from place to place to make rough allowance for the costs of abatement and the damage done in each area. The proper level of charges is hence a matter in which the newly constituted regional water authorities and, no doubt, various other public bodies, such as those comprising the technical and scientific services, will have an important role to play. The institution of the regional water authorities is recognition of the fact that water quality is something that should be planned over a wide area, and water quality targets for individual stretches of rivers and estuaries should be planned in a co-ordinated manner, as proposed in Chapter II of this Report.

30. Given the time schedule for the implementation of the various reforms of local government and of environmental services that are due to take effect early in 1974, we think it important that, if the principles of a charging scheme are accepted, the composition and functions of the charging authority be a matter of immediate discussion and decision. The current reorganisation of water administration in this country involves some major changes in the system of charging industry for the services of municipal sewers, as well as the system for charging for water consumption. In our opinion this is the most appropriate time to introduce pollution charges into the system of charges and water quality control that is currently being revised.

31. Finally, it should not be thought that the introduction of a charging scheme would relieve the authorities of their responsibility for ensuring appropriate sewage and water purification facilities, as well as general responsibility for the restoration and protection of the environment. But in most cases it is cheaper, from the overall national point of view, for firms to discharge their effluent to municipal sewers rather than be induced, by a charging scheme, to treat it themselves for direct discharge to water courses. In such cases the required sewerage facilities must be made available, although firms should then pay the correct charge for the use of these facilities.

The main ingredients of a charging scheme

32. It will be obvious that we have only tried here to set out the general case for greater use of pollution charges as a means of obtaining the desired water quality standards in our estuaries. The precise technical details, both concerning the desirable level of charges and also the machinery for their collection, are matters that will require a great deal of work, at a local as well as national level, involving administrative, technical and scientific considerations,

on the one hand, and economic analysis on the other. A lot of work on the former type of consideration is already carried out, as a matter of course, in connection with existing policies, though this work would have to be strengthened, irrespective of the methods used, if a serious effort is to be made to improve standards in the estuaries.

33. All that we can do at this stage is to suggest that the main lines of the scheme should be as follows:

- (i) The regulatory authority, which might well be the regional water authority, should issue licences for the discharge of effluent, both direct to water courses or to municipal sewers, that should indicate the maximum acceptable pollution in each case. Very heavy penalties should be attached to any breach of the maxima stipulated.
- (ii) The licence should also indicate the charge applying to this maximum volume of pollution.
- (iii) The regulatory authority should also decide on the nature and origin of discharges that would be exempt from any charge. Such exemptions would depend partly on the composition of the discharge (for example, there would be a case for exempting discharges that equalled the water quality required in the overall plan for the quality of the stretch of water in question, or that equalled the standard set for sewage discharges at the same point) and partly on the size of the discharge, along the lines discussed in the preceding section.
- (iv) For intermediate levels of pollution a schedule of charges should be provided, indicating how each polluter's charge would vary according to the extent to which he reduced his pollution (or such indicator of pollution that practical monitoring considerations require) below the maximum permissible level. It might also be desirable, in some cases, to institute a negative charge (that is, a payment to firms) in cases where they were able to produce an effluent of better quality than that attracting zero charge; for insofar as they did so the damage done by other effluents would be less. In other words, this would maintain the price mechanism incentive character of a charges system even below the point at which no charge was necessarily levied.
- (v) In some cases it might be found preferable to induce firms to reduce the pollution load they impose on a water course by raising the charges for their water abstraction, thereby providing them with an even greater incentive to recycle their water effluent than that provided by the effluent charge. Whether this is desirable or not depends largely on whether the extra costs of the increased recycling are offset by the savings on monitoring costs. For the main advantage of this procedure would be that it is easier (and hence cheaper) to measure the amount of water abstracted by industrial users than to measure their effluent.

34. In addition to the numerous questions that arise in connection with the administration of a charging scheme and which, as proposed above, should be the subject of early investigation and decision, there are various other economic and financial questions which we have not discussed. These include,

for example, the procedures for identifying the appropriate costs and benefits in each case, and the use to be made of the revenues from any charging scheme*. We have felt, however, that our main task in this connection was to establish the principle that a charging scheme should be adopted and that the practical difficulties which it would no doubt encounter would not necessarily be much greater than those that would be encountered in any alternative scheme for achieving the same degree of improvement in the quality of our estuaries, and would, in addition, achieve any given degree of improvement at a smaller cost burden on industry than an extended system of direct regulation*. We do not deny that a pollution charge will involve difficulties and costs that would not be met if no attempt is made to reduce pollution further. We do not deny that it would involve difficulties and costs that would not be met if we were to be satisfied with a system whereby maximum pollution loads were specified. But a charging scheme provides an incentive to firms to do better than keep within the limits prescribed. The crux of our argument is that **for a given amount of pollution abatement** a charging scheme is cheaper and that, for the reason set out in paragraphs 20-21 above, this conclusion is not likely to be significantly modified, except in a few exceptional cases, by the need to allow for monitoring costs.

35. We would have preferred to accompany our general arguments and proposals by a more concrete and detailed analysis of, for example, the application of a charging scheme to individual cases with an analysis of the likely economies that could be obtained by comparison with direct regulation, given the underlying data on costs and damages. But hardly any of the economics research that would be needed to provide such detailed analysis is being carried out in this country and we regret the lack of progress made in this direction since our First Report. In Chapter VI we discuss the needs for research into the scientific aspects of estuarine pollution. The only reason why this is not accompanied by a similarly detailed survey of the various economic studies that would be needed in order to implement the most economical pollution policy is that there is no person or service in this country with full-time overall responsibility for research into the economic aspects of pollution.

36. Nevertheless, for the many reasons set out above, we believe that the case for introducing a system of pollution charges has already been adequately established. We also believe it is desirable, from an administrative point of view, that the detailed technical problems to which the introduction of such a system will give rise should be tackled now in the context of the current reorganisation of the administrative machinery for controlling rivers and water supplies and of the system of charging for trade effluent discharged to municipal sewers and for water consumption. It seems to us to be unwise to wait until this reorganisation has been completed and then to start changing it all again, insofar as the proposal to introduce a pollution charge is eventually accepted. For these two quite separate reasons we cannot subscribe to the reservations in paragraph 213 of this Report and hence we are unwilling to rely on the proposals in Chapter II of the Report as a means of achieving the desired degree of pollution abatement in our coastal and estuarine waters.

* See also footnote to page 77.

FIGURE 1

Discharges of sewage to estuarine and coastal waters of England and Wales

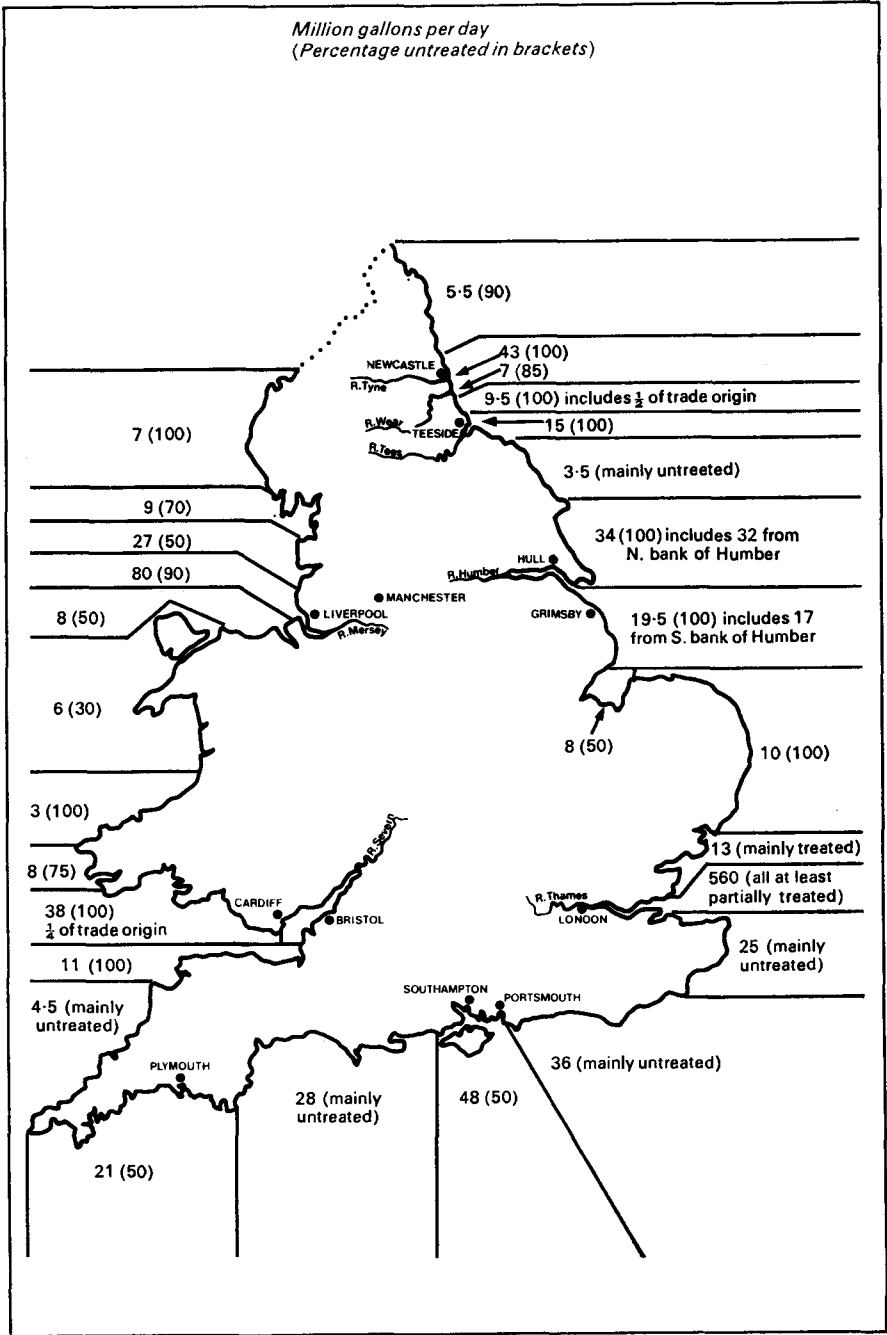
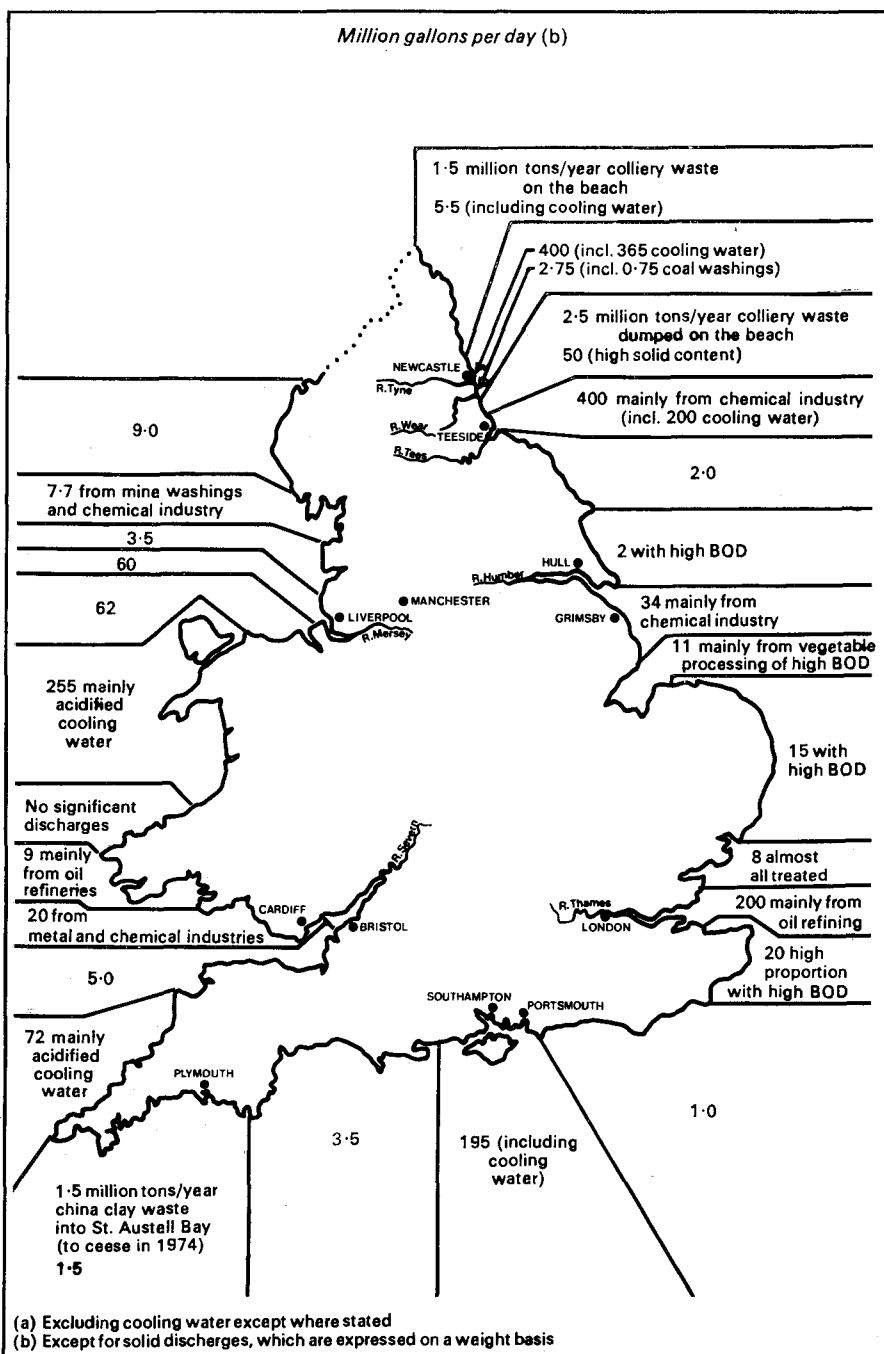


FIGURE 2

Discharges of trade wastes to estuarine and coastal waters of England and Wales (a)



**FIGURE 3 Discharges of domestic sewage (a) and trade wastes (b)
into estuarine and coastal waters of Scotland**

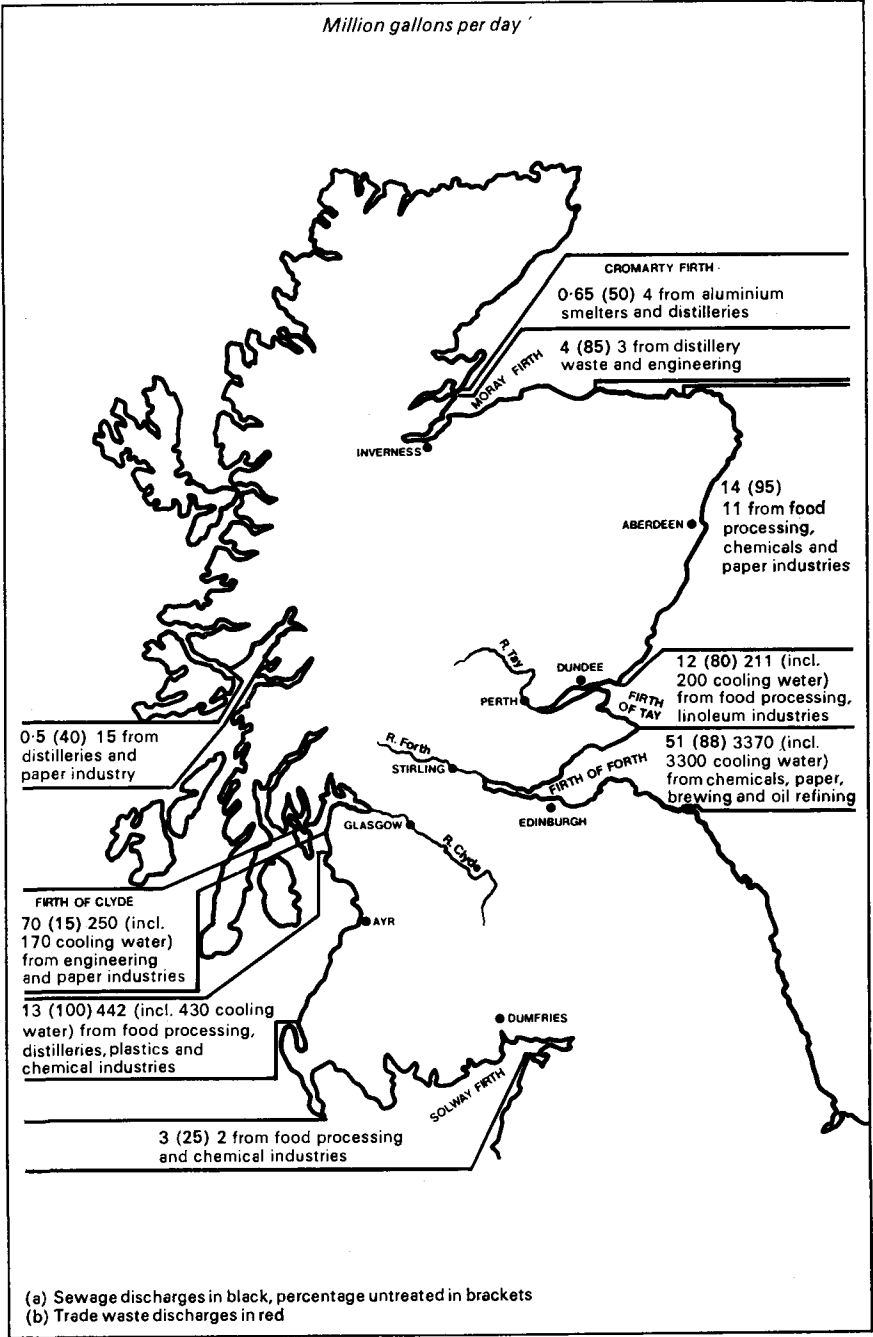


FIGURE 4

Mersey Estuary – Pollution load (lb. BOD/day)

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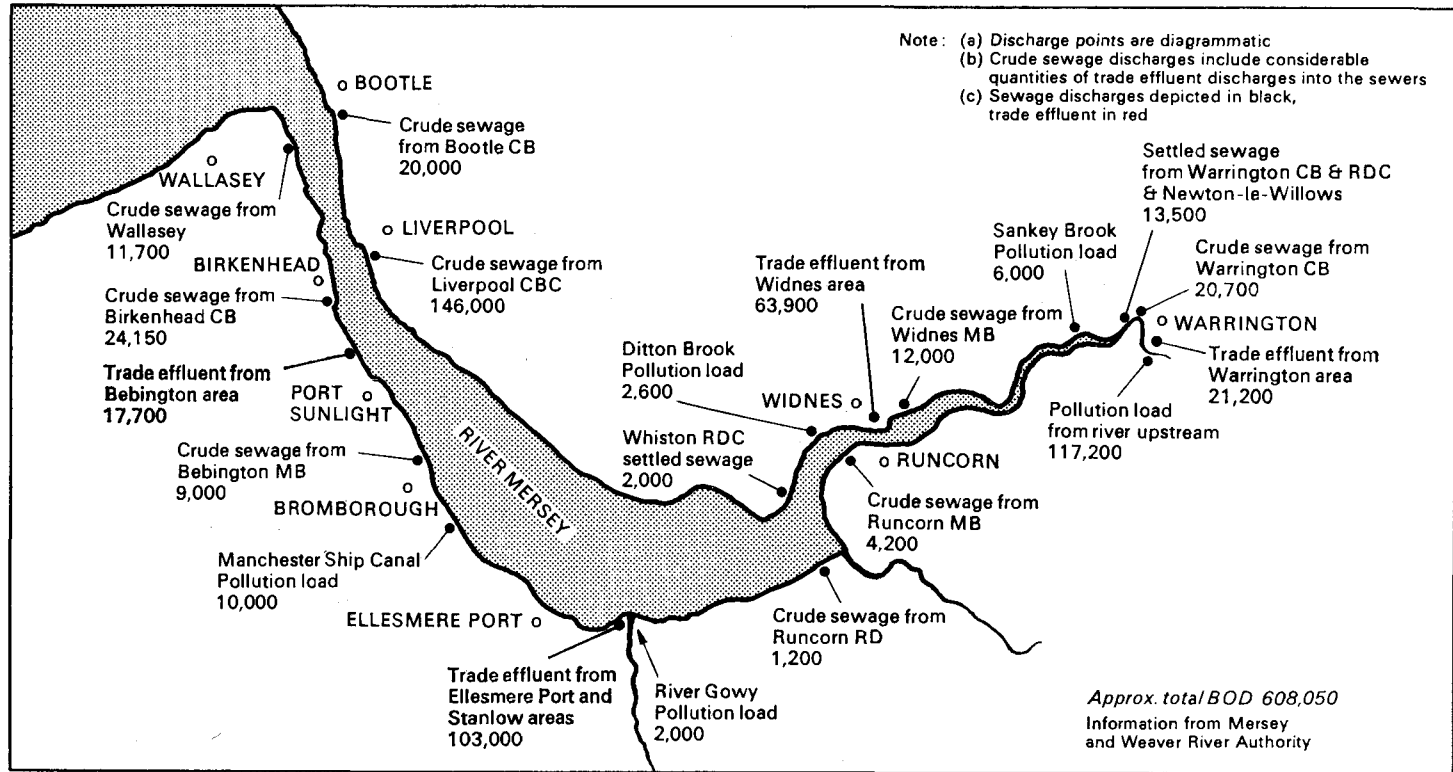


FIGURE 5

Humber Estuary – Pollution load (lb. BOD/day)

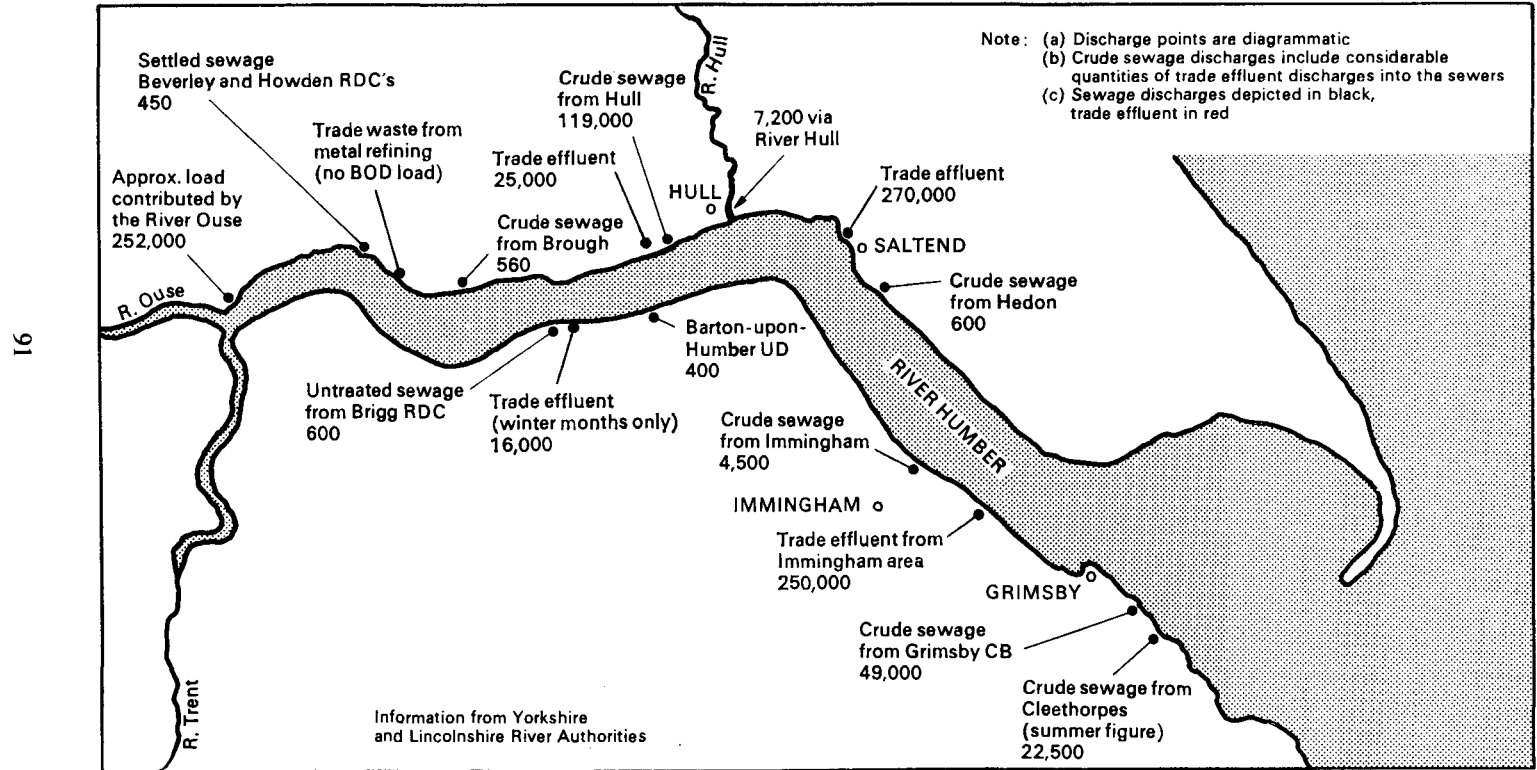


FIGURE 6

Net seaward movement of water in the Thames Estuary*

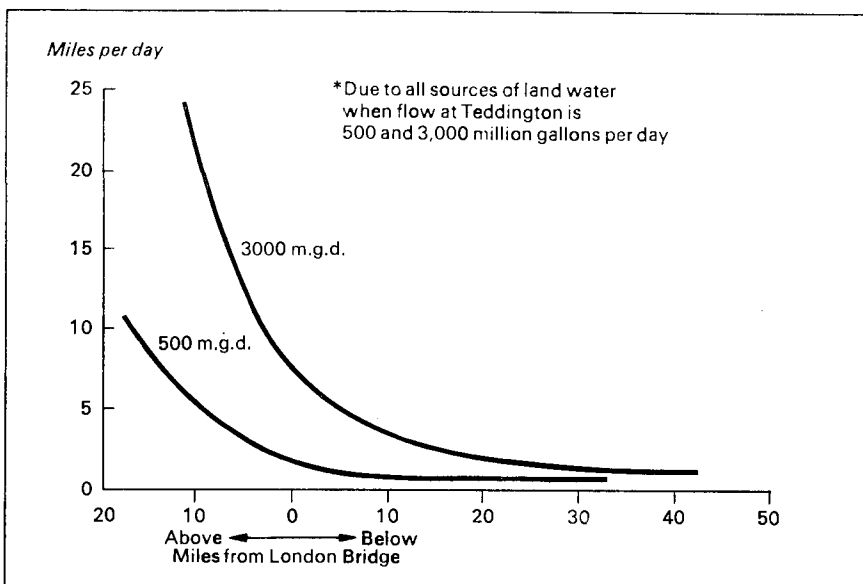


FIGURE 7

Distribution of salinity at high water of spring tide in Tees and Thames Estuaries

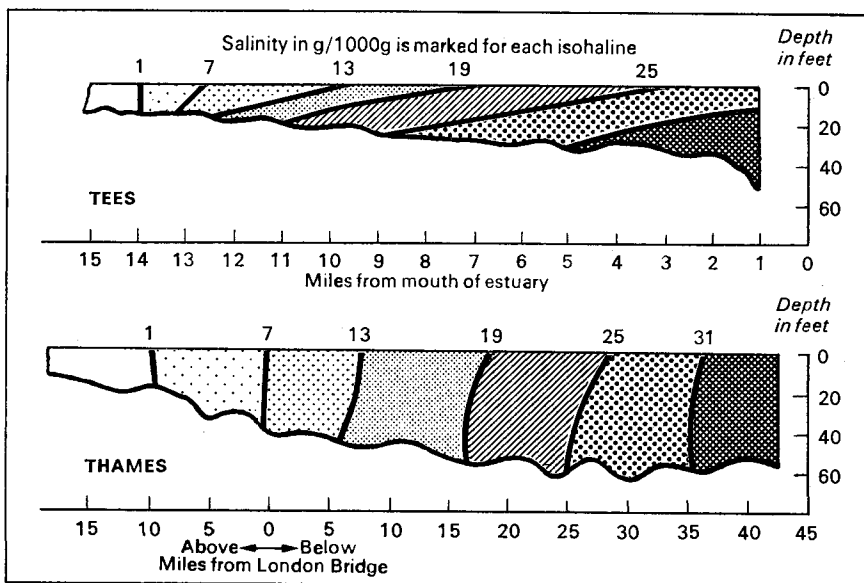


FIGURE 8

River authority areas



FIGURE 9

Proposed regional water authority areas

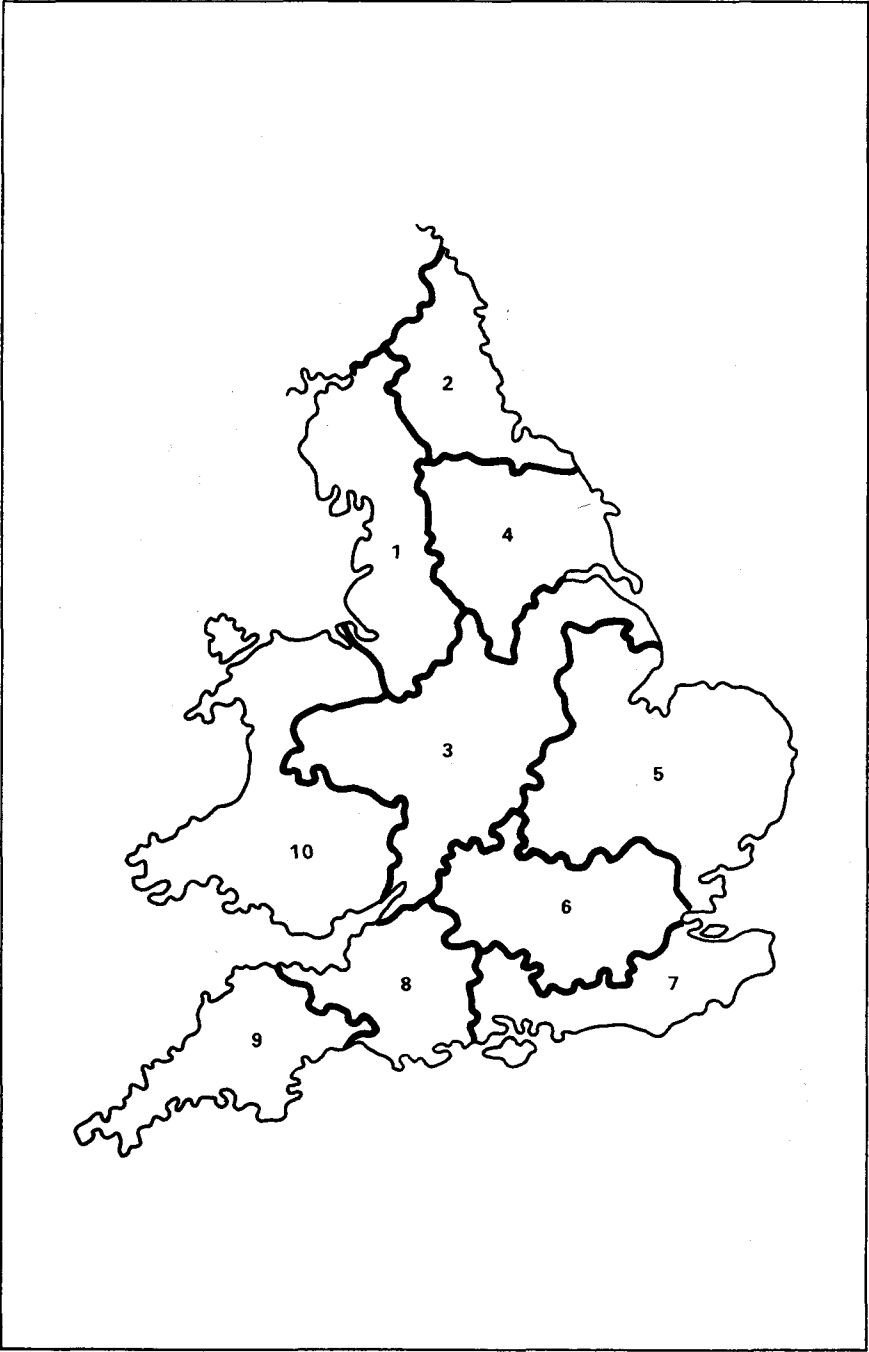


FIGURE 10

River purification board areas

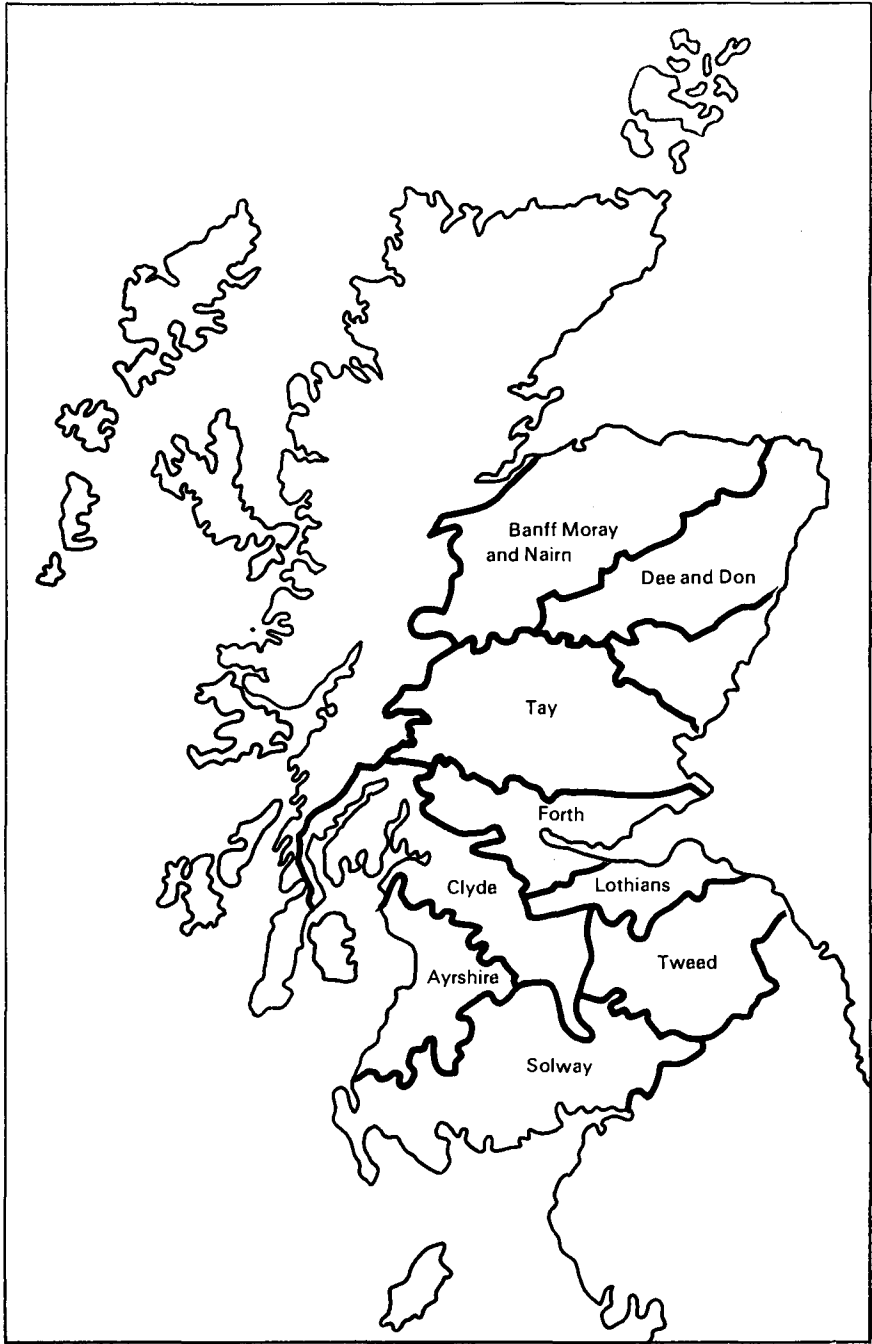
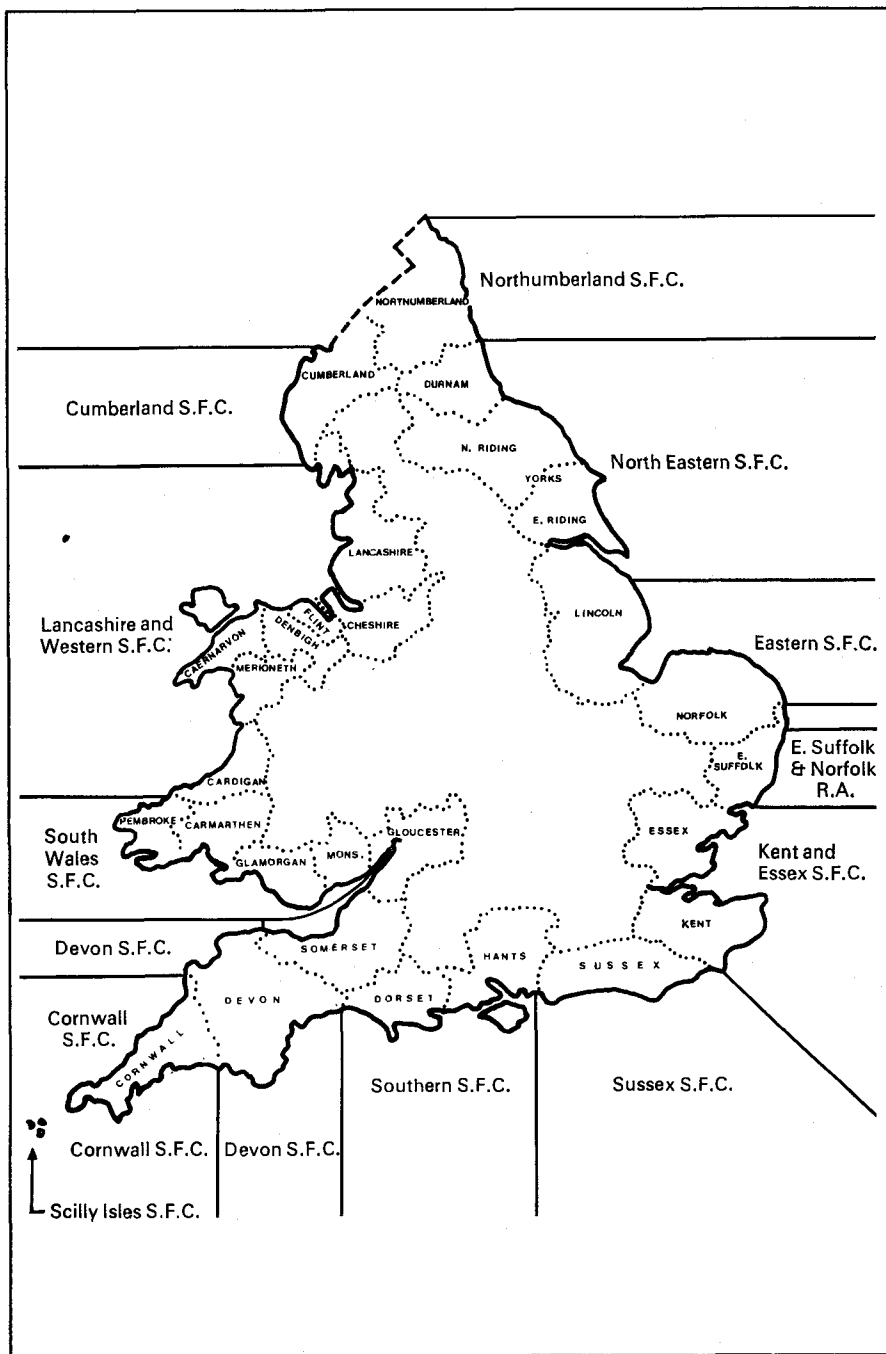


FIGURE 11

Sea fisheries committee districts



APPENDIX A

SOME POLLUTANTS DISCHARGED INTO ESTUARIES AND THE SEA

Introduction

1. The more important classes of pollutants discharged into estuaries and the sea are:

Sewage

Heavy metals

Organochlorine compounds

Industrial effluents

Cooling water

Oil

Radioactive discharges

Inert materials such as colliery waste, china clay waste, dredged material, etc.

Spoil from mining and drilling at sea.

Sewage

2. Sewage contains not only material of human origin, but also all the liquid waste products of domestic usage, and certain trade and agricultural wastes which are passed for disposal into the sewage system. Sewage discharged into freshwater rivers is almost invariably treated to remove the settleable solids (primary treatment). The remainder is usually given secondary treatment in which the sewage is converted into comparatively harmless substances by the action of micro-organisms. After this treatment the sewage takes the form of a clear effluent which is discharged into rivers. Fully treated effluent usually makes only small demands on the oxygen content of the river water, though it contains inorganic salts, such as phosphates and nitrates, some of which will eventually find their way into the sea.

3. At coastal sites and in estuaries any treatment of sewage is often confined to maceration to reduce the size of the solid particles before direct discharge into the sea or estuary, where it is degraded. In being degraded it may lower the oxygen content of the surrounding water to such a degree that fish cannot survive.

4. Sewage sludge is dumped in approved areas at sea by some of the larger towns. Approximately seven million tons a year (200,000 tons on a dry weight basis) is dumped in this way and this quantity is likely to increase in the future.

Sludge from inland towns is usually disposed of on land where it has some value as a fertiliser. A minor proportion is incinerated but this is often more costly than other methods.

5. Effects of pollution from sewage. The presence of sewage in estuaries and coastal waters may have a number of harmful effects:

- (a) on human health due to pathogenic bacteria present in the untreated sewage;
- (b) on fish because the oxygen content of the water is decreased;
- (c) on plant growth due to the presence of excessive amounts of nutrients (nitrogen and phosphorus);
- (d) on fish nursery areas and spawning grounds due to sludge dumping at sea; and
- (e) on bird life and sea mammals if the discharges contain certain industrial effluents.

6. The possible effect on human health. The effect on health due to discharge of untreated sewage has been the subject of much investigation^(7,11). Contrary perhaps to what one might expect there is no evidence of any hazard to health due to bathing in seawater polluted by sewage.

7. There is, however, an indirect danger to health by the contamination of edible shellfish living in waters which receive sewage and other discharges. The production of shellfish is therefore subject to control by the local public health authority (paragraph 139 of the main Report). They can be sterilised or cleansed but the consequent slowing-down of commercial operations is estimated to add at least ten per cent to the production costs of the industry. Bacterial contamination of other fish due to pollution of the sea has not been found to be associated with any significant human hazard.

8. Effect on fish. As explained in paragraph 3 above the oxidation of sewage may seriously lower the oxygen content of the water; this may occur to the extent that the water is no longer able to support fish. Many major river estuaries in this country are affected in this way, sometimes for only a few miles, which is nevertheless enough to stop migratory fish like sea trout and salmon from passing into or out of the river.

9. Effect on plant growth. The presence of nutrients, mainly in the form of nitrates and phosphates, in rivers, estuaries and the sea in excess of the quantities which are naturally present, is not entirely due to sewage. Leaching from agricultural land is also an important source and lesser amounts are derived from industrial processes and the oxidation of atmospheric nitrogen from the burning of fuel.

10. The total annual contribution to the nutrient content of rivers and coastal waters from agricultural land in Great Britain is estimated at 240,000 tons of nitrogen (as N) and 7,000 tons of phosphorus (as P) ⁽³⁰⁾. The annual contribution from sewage is 180,000 tons of nitrogen and 50,000 tons of phosphorus (45 per cent of the phosphorus is due to detergents).

11. The presence of nitrates and phosphates is essential to plant growth but over-abundance can lead to excessive growth (blooms) of microscopic plants which when they die cause deoxygenation of the water and anaerobic decay. This is more likely to be a serious problem in slow-running rivers and lakes. In the marine environment many plankton blooms have been reported and in some instances nutrient enrichment (eutrophication) as a result of man's activities has been suspected as the cause, although in no case has there been any conclusive proof⁽³¹⁾. Eutrophication is only a minor problem in Great Britain.

12. **Effect on fish nursery areas and spawning grounds at sea.** Direct discharge of untreated sewage from pipelines into coastal waters may result in deposition on to fish nursery areas or spawning grounds of large volumes of waste high in BOD or particulate matter and containing appreciable quantities of heavy metals. Juvenile stages are more sensitive to pollution than adult fish so that considerable harm may be done by badly sited outfalls⁽³²⁾.

13. An additional problem arises from the discharge of sludge (paragraph 4 above) which has been going on around the coasts of Britain for nearly a century. The main areas of deposition and the quantities disposed of are given in paragraph 56 below. The sludge consists of 96 per cent of water and is discharged by special vessels, although feasibility studies are being made of discharges from submarine pipelines⁽³³⁾.

14. The deposition of suspended solids reduces the amount of light and can smother animals living on the bottom. However, there are a number of animals adapted to living in silty conditions, so that the total biomass and quantity of fish food available may not be much affected. Whether or not the reduction of light affects photosynthesis depends on the level of other factors which affect growth, for example, nutrients and carbon dioxide. Studies made on two of the major dumping areas used by Great Britain suggest that neither the oxygen content of the overlying water nor the characteristics of the bottom-living communities have been materially affected^(34,35). This is in marked contrast to dumping of sludge off New York where deleterious effects have been noted⁽³⁴⁾.

Heavy metals

15. A number of potentially toxic heavy metals are produced and used on a large scale (Table 18). It is therefore inevitable that significant quantities of these will escape into the environment and will eventually find their way into river estuaries and thence into the sea. Traces of these elements occur naturally in river estuaries as a result of the weathering of rocks which contain them. However, their widespread use has led, locally, to far greater concentration in the marine environment than would occur naturally.

16. The presence of heavy metals in estuaries in concentrations above the natural levels is usually due to direct discharges of trade wastes which contain the metals in solution⁽³⁶⁾, or to discharges of sewage contaminated with trade wastes (Table 19). Also, aerial transfer from land to sea is responsible for the presence of significant amounts of some metals, notably lead and mercury.

Much of the lead in the atmosphere results from the use in motor fuel of lead anti-knock compounds which are released in the exhaust fumes. On a global scale about 200,000 tons of lead have been estimated to be introduced into the marine environment each year from this source alone ⁽³⁷⁾.

17. Similarly, the amount of mercury discharged each year to the atmosphere by burning fossil fuels containing traces of mercury is estimated at 5,000 tons. This eventually finds its way into the sea and a similar amount enters the sea by losses from industrial processes⁽³⁷⁾. The yearly amount of mercury naturally transferred to the sea by rivers is estimated at 5,000 tons⁽³⁸⁾.

18. A number of other metals besides lead and mercury are considered as potentially hazardous; some of these are listed in Table 18. The order of toxicity depends both on the chemical compound or form in which the metal occurs and on the relative susceptibility of the particular plants or animals affected⁽³⁹⁾. This can vary enormously from species to species and within a species at different stages in its life cycle. The order of toxicity given in Table 18 is therefore a rough indication only.

TABLE 18
Heavy metals to be considered as pollutants of the marine environment
(Data from References (40) and (41))

<i>Metal</i>	<i>Natural concentration in sea-water¹</i> (parts per thousand million)	<i>World production in 1969</i> (tons)	<i>Routes of entry into the sea²</i>	<i>Pollution category³</i>
Mercury	0.1	9,500	A,R	1b
Lead	0.02	3,200,000	A,R	1a
Cadmium	0.02	17,000	A,R	2c
Arsenic	2	29,000	D	2c
Zinc	2	5,100,000	D,R	3c
Chromium	0.04	1,800,000	R	4c
Copper	1	5,800,000	D,R	4c
Vanadium	2	9,500	A	4a

¹ These values are approximate but are representative for low levels in unpolluted sea-water.

² A through atmosphere pollution, R through rivers (run-off) or pipelines, D through dumping.

³ 1-4 order of decreasing menace; a—worldwide, b—regional, c—local (coastal bays, estuaries and single dumpings).

TABLE 19

Heavy metal content of sewage sludge from London⁽³⁴⁾ and Glasgow⁽³⁵⁾
(All figures expressed in parts per million of the dry solids)

<i>Metal</i>	<i>London</i>	<i>Glasgow</i>
Copper	505-2,500	300-700
Cadmium	30-70	5-15
Zinc	2,390-5,860	1,200-1,900
Lead	Not given	500-600
Chromium	200-1,065	100-2,400
Nickel	150-350	60-100
Mercury ⁽¹⁾	Crossness 2-7 Beckton 35-150 ⁽²⁾	1-10

¹ Data on mercury supplied by the Greater London Council and Glasgow Corporation.

² The higher mercury content of the Beckton sludges as compared with those from Crossness has been investigated and the source of the major mercury contribution determined. As a result the level of mercury is expected to be considerably reduced by the second half of 1972.

19. Effects of heavy metals. Heavy metals in trace amounts are normal constituents of marine organisms. Some of them, such as zinc, copper and cobalt, are essential for normal growth and development. However, some heavy metals are toxic at remarkably low concentrations—a few parts per million—and the situation is complicated by the fact that some organisms can accumulate them. Concentration factors for different metals vary from species to species but factors of hundreds of thousands are commonly found⁽³⁹⁾. This concentration effect by some species is the principal cause of concern: the metals may build up within an organism to the level where a species assimilating them receives a lethal dose. An example of this occurred in Japan where the inhabitants around Minimata Bay suffered an epidemic of neurological disorders, which was eventually traced to mercury poisoning from eating fish and shellfish.

20. One part per million (ppm) of mercury is considered by many national governments to be an unacceptably high content for food fish⁽⁴²⁾. However, in assessing damage to human health it is the total amount of mercury ingested that is important. Because different countries have different eating habits, a limit imposed by one country may not be applicable to another (for example, Japanese fish consumption per head is three times that of Great Britain). In Great Britain the average daily intake of mercury per person is well within safe limits and is about eight micrograms of which about 25 per cent comes from eating fish⁽⁴²⁾. Nevertheless, as the figures in Tables 20 and 21 show, fish caught in British coastal waters have mercury contents substantially above those of fish from "Distant and Middle Distance Waters". In some parts of the world the mercury levels have reached dangerous concentrations in limited areas and the consumption of fish from such areas has been banned. The areas which have been banned for fishing purposes are exposed to much higher concentrations of mercury than have been found in British coastal waters and have been in land-locked areas of water.

TABLE 20

Mercury in and catches of fish landed in England and Wales
from distant and middle distance waters⁽⁴²⁾

Mercury contents expressed in ppm (by weight)

<i>Sampling area</i>	<i>Number of samples analysed (single fish)</i>	<i>Mean</i>	<i>Range</i>	<i>Area catch¹ estimated as per cent by weight of (A) total distant waters catch and (B) total middle waters catch</i>
(A) Distant waters				
Greenland	17	0.10	0.01-0.30	1
Iceland	49	0.05	0.02-0.12	40
Norway coast	43	0.08	0.03-0.25	16
Barents Sea	39	0.05	0.03-0.11	36
Other	0			7
(B) Middle distance waters				
Mid North Sea	61	0.11	0.03-0.34	78
Southern North Sea	95	0.11	0.05-0.38	3
Other	0			19

¹ Landed in England and Wales by British vessels, provisional figures for 1970.

TABLE 21

Mercury in and catches of fish from coastal waters¹ of England and Wales⁽⁴²⁾

Mercury contents expressed in ppm (by weight)

<i>Sampling area</i>	<i>Number of fish analysed</i>	<i>Mean</i>	<i>Range</i>	<i>Area catch² estimated as per cent by weight of (A) total catch in coastal waters (B) total catch in Irish Sea only</i>
Berwick to Sunderland	99	0.11	0.04-0.35	(A) 18
Sunderland to Whitby	10	0.21	0.05-0.43	19
Whitby to Mablethorpe	78	0.13	0.01-0.48	13
Mablethorpe to Hunstanton	0	—	—	3
Hunstanton to Harwich	48	0.14	0.03-0.35	5
Thames Estuary	394	0.45	0.06-2.5	3
Margate to Beachy Head	148	0.32	0.02-1.4	2
Beachy Head to Portland Bill	13	0.27	0.15-0.52	2
Portland Bill to St. Austell Bay	214	0.16	0.01-0.66	8
St. Austell Bay to Hartland Point	246	0.19	0.01-1.2	7
Hartland Point to St. David's Head	163	0.23	0.03-1.2	2
Irish Sea	575	0.33 ³	0.01-2.4	18 (B)
St. David's Head to Anglesey	64	0.26	0.05-0.66	4
Anglesey to Formby Point	28	0.55	0.26-1.5	3
Formby Point to St. Bees Head	239	0.51	0.05-2.4	17
Solway	36	0.24	0.06-0.58	2
Central area (IOM)	71	0.34	0.05-0.91	39
Off Belfast	54	0.10	<0.01-0.31	8
South of Belfast	29	0.10	0.01-0.40	6
South East Ireland	54	0.23	0.08-0.67	8

¹ "Coastal" is to be interpreted as within 25 miles from the coast of England and Wales except in the case of the Irish Sea all of which is included.

² Landed in England and Wales by British vessels; provisional figures for 1970.

³ This figure is a mean weighted according to the catch in the different areas of the Irish Sea shown.

21. So far, contamination from mercury has received the most attention, but instances are known where contamination from copper has resulted in the tainting of shellfish and green discolouration⁽⁴³⁾, for example, in oysters off the the Cornish coast where copper from old mine workings is present in the water.

Organochlorine compounds

22. Organochlorine compounds are extremely rare in nature: their presence in the environment is almost entirely due to man's activities. Many organic compounds containing chlorine are produced by the chemical industry but the

two classes of particular concern are organochlorine compounds, such as DDT and dieldrin, which are used as pesticides, and PCBs, which have several industrial uses.

23. Organochlorine compounds are very stable: their biochemical stability is possibly related to their scarcity in nature. They undergo slow biochemical breakdown but the rates are such that their half-life (the time required for 50 per cent of the original material to decompose) may be several years.

24. The very purpose of the use of organochlorine pesticides means that they are released into the open environment; and PCBs, though not deliberately released into the environment, escape into it from some of the products into which they are incorporated. Organochlorine compounds which have been used on an increasing scale for the last 30 years are therefore of widespread occurrence. Table 22 gives the amounts of two common pesticides which have been determined in a number of situations.

TABLE 22

Mean concentrations (in ppm) of some organochlorine compounds in various materials⁽⁴⁴⁾

<i>Type of Sample</i>	<i>DDT & related compounds</i>	<i>Dieldrin</i>
River water (US)	8×10^{-6}	7×10^{-6}
Air (UK)	13×10^{-6}	21×10^{-6}
Rainwater (UK)	79×10^{-6}	8×10^{-6}
Sewage effluent (UK)	131×10^{-6}	145×10^{-6}
Human blood (UK)	1.5×10^{-2}	9×10^{-4}
Milk (UK)	3.5×10^{-3}	2×10^{-3}
Human fat (US)	10.30	0.22

25. Organochlorine compounds are used almost exclusively on land but they eventually find their way to the sea. It is estimated that as much as 25 per cent of the total amount of DDT compounds that have been produced to date may already have found their way to the sea. In view of their persistence it has been suggested that much of the remaining 75 per cent will in time also be transferred there⁽⁴⁵⁾.

26. The routes by which PCBs enter the marine environment are not well-known. They have several industrial uses but they are relatively expensive so that large-scale discharges are unlikely, and they are not applied deliberately to the environment in the same way as pesticides. One possible route is the discharge of sewage and, in particular, sewage sludges which are dumped at sea (paragraphs 12-14 above). Analyses of London and Manchester sludges show that they contain PCBs in concentrations on a wet weight basis ranging from 0.1 to 5 ppm⁽⁴⁶⁾. Sludges from the Glasgow area have concentrations ranging from 0.1 to 6 ppm. The use and disposal of PCBs in this country is now closely controlled, due to voluntary action by the sole UK manufacturer.

27. Organochlorine pesticides can also enter the sea during manufacture, in sewage effluent (Table 22) and in sewage sludge⁽⁴⁷⁾. Their presence in sewage

is mainly due to trade effluents being passed into public sewers from industries which use them for the mothproofing of wools and woollen materials. When sprayed on land organochlorine pesticides are immobilised by soil particles and release by leaching is very slow. During spraying some of the material remains air-borne (particularly if low-volume aerial spraying techniques are used) and, although such compounds are comparatively non-volatile, they may also be lost from the soil by evaporation and by co-distillation with water. It has been shown that up to 60 per cent of DDT applied to crops may be lost by evaporation⁽⁴⁸⁾.

28. **Effects of organochlorine compounds.** The growing realisation that organochlorine compounds are building up in the marine environment has led to restrictions in their use by many countries bordering the North Sea and although pesticide residues in North Sea fish are relatively higher than they are in fish from elsewhere, they are not increasing⁽⁴⁹⁾.

29. Pesticides accumulate in the bodies of marine animals and can build up to quite high levels in certain species, such as sea birds, seals and large fish. The adverse effects have been most apparent in birds: eggshell thinning and consequent reduction in breeding success of some species is well substantiated. Analyses of the livers of birds killed in the sea bird "wreck" in the Irish Sea in the autumn of 1969 showed high concentrations of organochlorine compounds but evidence that these were responsible for the death of the birds was not conclusive⁽⁵⁰⁾.

30. Organochlorine compounds are very toxic to crustacea: concentrations of DDT in water as low as 0.003 ppm have been shown to be lethal to brown shrimps. It is possible that sub-lethal doses may upset behaviour patterns in fish and the survival of the young stages of molluscs and crustacea⁽⁵¹⁾. There is no evidence, however, that the concentration of these substances in fish which are of commercial importance in British coastal waters is affecting the yields from stocks.

31. DDT has been shown in the laboratory to be able to reduce the rate of photosynthesis of phytoplankton⁽²⁸⁾. But the concentration that inhibits photosynthesis is ten times the concentration expected in the open sea and also ten times the solubility of DDT in water (one part per 1,000 million)⁽⁵²⁾. If natural photosynthesis were affected it would have far-reaching implications, but the interpretation of variations in abundance of plankton in the open sea is complicated by the fluctuations of natural factors in the environment and pollution effects are difficult to establish⁽⁵³⁾.

Industrial discharges

32. The discharges from industry other than those already considered are varied but for convenience they may be divided into chemicals and treated natural products.

33. **Chemicals.** Many industries discharge directly into river estuaries, notwithstanding treatment of the type described in Chapter III, a wide range of

chemicals which are far too numerous to list individually. Many of these are relatively inert and do not present a serious pollution problem. Others can have an adverse effect, either because they are toxic, or because they lower the oxygen content of the water; some substances, for example, cyanides and phenols, fall into both categories.

34. In some estuaries the presence of discharges from industry outweighs the effects of discharges of untreated domestic sewage. For example, in the Tees the BOD released daily in sewage is only 32 tons compared with 218 tons released in industrial discharges. Similarly, the daily contribution to the suspended solids in the river is 23 tons from sewage compared with 525 tons from industry. Concentrations such as these mean that an estuary becomes totally devoid of fish. While the anaerobic conditions are partly responsible, oxygenated water from the Tees was found to be toxic even in 1935⁽⁶⁴⁾; subsequently the pollution load has enormously increased.

35. Commercial fisheries in many river estuaries in this country have been badly affected by industrial and sewage pollution; but such conditions are generally localised, and fishing conditions may be unaffected in the open sea off the estuaries.

36. **Treated natural products.** Distilleries, intensive stock rearing, food processing plants and paper mills produce considerable quantities of non-toxic effluent, which present acute problems because of their very high BOD and the presence of suspended solids. The problem is localised, but where such discharges occur they can be equivalent in terms of BOD to discharges of untreated sewage from a medium-sized town (seven per cent of the total pollution load from Scotland in terms of BOD comes from distillery wastes discharged into the Moray Firth⁽³¹⁾). These effluents can be treated, but if they are not, severe oxygen depletion may occur in the area of the discharge.

Cooling water

37. Nearly all discharges into an estuary or the open sea are at a higher temperature than the surrounding water. The largest thermal effects are generally produced by electricity generating stations which use large quantities of cooling water and discharge them at temperatures raised by as much as 12°C (Table 7). Such heated effluents tend to spread out in a thin surface layer, and to have much greater effects in an estuary than on the open coast because the diluting factor is very much less. For example, the average temperature of the Thames 12 miles (19km) below London Bridge has increased by 3°C during this century⁽²⁾.

38. **Effect of cooling water.** The temperature of the water has an important effect on some of the factors previously mentioned. For example, with increase in temperature the oxygen content decreases and the rate of decomposition of sewage and other organic material is increased. Problems connected with oxygen depletion of the water are thus aggravated by temperature increases.

39. An increase in the temperature of the water can consequently have considerable effects on the animals living in it; how damaging these are depends

on the local circumstances. In the tropics and elsewhere where summer water temperatures are high and the oxygen content as a result is low, even a small temperature rise can sometimes suffocate the fish. But round the shores of the United Kingdom where the waters are naturally cool, larger increases can generally be tolerated.

40. There can also be other effects on the flora and fauna. In our strongly seasonal climate, warm water effluents discharged into shallow coastal waters may "force" some kinds of bottom-dwelling species into spawning very early in spring. One small mollusc studied in shallow water off the power station outfall at Hunterston, Ayrshire, was found to be spawning three months early, in January, but to produce fewer eggs and larvae than normal, probably because of a shortage of suitable food at that time⁽⁵⁵⁾. In Southampton Water, on the other hand, the outflow of cooling water from a power station has enabled the American hard-shell clam, a large bivalve with some fish-farming potential, not only to grow faster but to reproduce for the first time in British waters and to form a viable colony⁽⁵⁶⁾.

Oil

41. The presence of crude oil or oil fractions in the water of estuaries is due to:

- (a) occasional serious leaks which may then give rise to severe contamination;
- (b) small accidental spillages;
- (c) the presence of oil in the cooling water of oil refineries; and
- (d) leakages from motor vessels.

42. Oil refining is concentrated on estuarine sites, mainly on the Thames, Milford Haven, Southampton Water, the Humber and the Mersey (Table 5). The increasingly large amount of oil refined in these areas gives rise to pollution risks from accidental leakages and spillages. The consequences are likely to be greater in estuaries than on the open coast because they recur in the same confined area.

43. Pollution of the open coast, mainly by crude oil or fuel oil from ships at sea, occurs all round the British coasts. Table 23 indicates where incidents of oil pollution of beaches have occurred. This Table gives the number of incidents reported to the DOE, the Welsh Office and SDD in connection with claims for grants from public funds for financial assistance in dealing with oil clearance. It is not a complete record of all incidents; for example, oil may come ashore and be subsequently removed by tidal action. Nor is it a record of the total costs of oil pollution on beaches, because it does not take into account the money spent by the local authorities themselves without grant, or the loss of amenity while the beach is covered by oil.

44. **Effect of oil.** Unlike most other pollutants, crude oil and oil fractions are virtually insoluble in water and float on the surface. Some of the more volatile components are toxic to many marine organisms. In the open sea this toxicity is not of great significance because the oil is rapidly dispersed and diluted and the

volatile components are quickly lost by evaporation. In the confined space of an estuary, however, the toxic components can have more serious effects in the event of a large spill.

TABLE 23

Numbers of oil pollution incidents* on beaches, and cleaning grants from central government funds 1 April 1968–31 March 1972

County	1968/69		1969/70		1970/71		1971/72		Total	
	No.	(£)	No.	(£)	No.	(£)	No.	(£)	No.	(£)
England and Wales										
Durham	—	—	3	1,980	—	—	—	—	3	1,980
Yorkshire	2	530	1	40	—	—	1	140	4	710
Lincolnshire	1	280	2	330	—	—	1	40	4	650
Norfolk	—	—	—	—	—	—	1	50	1	50
Suffolk	5	2,200	4	650	1	110	2	420	12	3,380
Essex	—	—	3	2,340	1	9,830	3	550	7	12,720
Kent	3	5,320	7	4,340	13	6,180	14	18,880	37	34,720
East Sussex	—	—	3	1,520	5	2,820	1	1,270	9	5,610
West Sussex	3	1,970	6	3,960	3	150	1	300	13	6,380
Isle of Wight	—	—	5	5,010	2	400	2	2,280	9	7,690
Hampshire	1	6,690	10	50,540	7	17,610	8	4,700	26	79,540
Dorset	—	—	—	—	1	110	—	—	1	110
Devon	—	—	4	970	4	390	2	380	10	1,740
Cornwall	—	—	55	3,520	16	1,770	6	1,430	77	6,720
Somerset	—	—	—	—	2	520	—	—	2	520
Glamorgan	—	—	1	10	9	15,940	1	—	11	15,950
Carmarthenshire	—	—	—	—	1	75	—	—	1	75
Pembrokeshire	—	—	—	—	2	185	1	—	3	185
Cardiganshire	—	—	1	200	—	—	—	—	1	200
Merioneth	—	—	5	925	—	—	—	—	5	925
Caernarvonshire	1	300	2	625	1	300	—	—	4	1,225
Anglesey	—	—	1	60	—	—	1	—	2	60
Flintshire	—	—	1	140	1	30	—	—	2	170
Cheshire	—	—	1	200	—	—	—	—	1	200
Lancashire	—	—	9	6,080	9	2,910	2	1,200	20	10,190
Cumberland	—	—	1	2,380	—	—	—	—	1	2,380
Scotland										
Angus	—	—	1	180	3	1,315	—	—	4	1,495
Fife	—	—	—	—	3	345	—	—	3	345
West Lothian	1	295	1	40	—	—	—	—	2	335
East Lothian	—	—	—	—	3	205	1	50	4	255
Wigtown	—	—	1	80	1	40	—	—	2	120
Argyll	1	485	—	—	—	—	—	—	1	485
Dunbarton	—	—	—	—	1	1,130	1	50	2	1,180
Total	18	18,070	128	86,120	89	62,365	49	31,740	284	198,295

* This relates to incidents along the coasts of the county reporting them. Several counties may be affected by a single oil spill.

45. After the volatile components have evaporated the residue is much less toxic, but it causes a great deal of mechanical damage by coating organisms

with a film of oil. The effect of this can be disastrous to sea birds; the oil readily impregnates their plumage causing them to lose both their insulation and buoyancy. There have been numerous occurrences of large-scale deaths of sea birds due to oil pollution incidents. Some 150,000–450,000 birds are estimated to be killed each year by oil pollution in the North Sea and North Atlantic. Shellfish do not appear to be directly affected by oil but they can develop an oily taste, which may persist for a considerable time, making them unfit for human consumption⁽⁵⁷⁾. Fish coming into direct contact with oil may be similarly tainted.

46. Oil deposits on beaches create clearance problems and in areas of high amenity value the need to clear the beaches as rapidly as possible is the major consideration. This is usually done with dispersants which help to form an oil-in-water emulsion so that the oil is carried away by the tide. Unfortunately, many of the dispersants used in the past were highly toxic to marine organisms, and in many instances the dispersants damaged organisms which had not been seriously affected by the initial oiling. However, less toxic dispersants are now coming into use. The damage caused by dispersants is most severe when they are used to clear beaches but there is no evidence of any long-term damage. When used on the open sea to break up oil slicks their effect on the environment is slight.

Radioactive waste

47. The arrangements for the safe disposal of radioactive waste are described in paragraphs 156–157 of the main Report. Table 24 sets out the establishments which discharge liquid radioactive waste into estuaries and coastal waters, the maximum quantities which they are permitted to discharge and the amounts actually discharged. Most of the major sites are nuclear power stations, the wastes from which are principally beta or beta/gamma radionuclides; alpha activity is negligible. Tritium is often distinguished from other beta and beta/gamma activity (these terms are defined in the notes below Table 24) because it is of very much lower radiotoxicity.

48. Discharges are never authorised in rates in excess of the accepted limits, which are arrived at after considering the dilution available at the site, the possible concentration of radioactive isotopes by marine organisms, and other sources of possible risk to man. For many disposals the authorised quantity is only a small proportion of the permissible maximum.

49. Regular monitoring of radioactive discharges is carried out by the Fisheries Radiobiological Laboratory (MAFF) which publishes Annual Reports of the results of its surveys⁽⁵⁸⁾.

TABLE 24

Major discharges of liquid radioactive waste to estuarine and coastal waters
(Data from Reference⁽⁵⁸⁾ and from the Fisheries Radiobiological Laboratory)

<i>Site</i>	<i>Location of discharge point</i>	<i>Type of radioactivity</i>	<i>Authorised discharge (curies/year)</i>	<i>Mean discharge rate 1968-1970 (curies/year)</i>
Nuclear Power Stations				
Berkeley	Severn Estuary	Tritium	1,500	61.2
		Other	200	62.1
Bradwell	Blackwater Estuary	Tritium	1,500	213.2
		Other	200	101.2
Oldbury	Severn Estuary	Tritium	2,000	22.9
		Other	100	3.6
Hunterston	Firth of Clyde	Tritium	1,200	224.8
		Other	200	63.9
Dungeness	English Channel	Tritium	2,000	102.3
		Other	200	100.8
Hinkley Point	Bristol Channel	Tritium	2,000	37.9
		Other	200	116.7
Sizewell	North Sea	Tritium	3,000	20.7
		Other	200	15.8
Wylfa	Irish Sea	Tritium	4,000	0.2
		Other	65	3.7
Fuel fabrication Springfields	Ribble	Alpha	360	13.1
		Beta	12,000	960
Capenhurst	Mersey (via a short tributary)	Total activity		Negligible
Fuel re-processing Windscale and Calder	Irish Sea	Alpha	6,000*	1,471
		Beta	300,000	101,600
		Strontium 90	30,000	3,371
		Ruthenium 106	60,000	24,900
Dounreay	Pentland Firth	Alpha	240	50.6
		Beta	24,000	20,142
		Strontium 90	2,400	915
Reactor R and D Winfrith	English Channel	Total Activity	30,000	1,623

* From October 1970.

TABLE 24—continued

Major discharges of liquid radioactive wastes to estuarine and coastal waters

Site	Location of discharge point	Type of radioactivity	Authorised discharge (curies/year)	Mean discharge rate 1969–1970 (curies/year)
Naval Establishments				
Chatham	Medway	Tritium (1969–1970)	20	5.9
		Other Activity (1969–1970)	20	0.14
Rosyth	Firth of Forth	Total Activity	30	0.42
Faslane	Gareloch/Firth of Clyde	Total Activity	1	0.1

Notes: α -particles—positively charged particles emitted from a nucleus and composed of two protons and two electrons, in effect the nucleus of a helium atom.

β -particles—electrons emitted from a nucleus.

γ -rays—electromagnetic radiations of short wavelength and high penetrating powers.

Tritium—A radioactive isotope of hydrogen with a half-life of 12.26 years.

Curie—A unit of radioactivity defined as the quantity of any radioactive nuclide in which the number of disintegrations per second is 3.7×10^{10} .

Inert solid wastes

50. Various solid non-toxic waste materials are disposed of into coastal waters around Britain. The quantities dumped each year include:

- Colliery waste: $2\frac{1}{2}$ million tons are tipped into the sea from cliff tops between Hartlepool and Sunderland. A further $1\frac{1}{2}$ million tons are deposited on the foreshore north of Blyth and used for land reclamation purposes. In addition about $1\frac{1}{2}$ million tons of waste from coastal collieries are dumped at sea beyond the three-mile limit.
- Pulverised fuel ash: 500,000 tons of this material (a fine powder resulting from the combustion of finely-ground coal) is currently dumped at sea from power stations on the North East coast. The amount is declining as uses are found for the ash: over 60 per cent of total production in England and Wales is used commercially, mainly by the road and building industries, and most of the remainder is used inland to reclaim worked-out gravel pits, quarries, etc. In the period 1960–66 870,000 tons were dumped each year; the projected 1980 figure is 450,000 tons.
- China clay waste: about 0.8 million tons is deposited into river estuaries in Cornwall and carried out into Mevagissey and St Austell Bays.
- Waste from potash workings: about $3\frac{1}{2}$ million tons will be deposited in suspension off the Yorkshire coast when operations begin.

51. **Effects of inert solids.** All the mineral wastes mentioned above are siliceous in nature. Their main effect is to smother the sea bed and increase the turbidity of the water which makes it unsuitable for organisms such as lobsters and crabs.

Wastes of this kind may also damage spawning and nursery grounds in the same way as sewage sludge (paragraphs 12-14 above) if the dumping sites are badly chosen.

52. Dumping at sea off the North East coast of mineral wastes of the kind described is estimated to have made at least 15 square miles (39 km²) of the sea bed unsatisfactory for fishing for crabs and lobsters. In addition, dumping of colliery waste on the coast in the same area has resulted in some local loss of crab and lobster grounds⁽³¹⁾.

53. In Cornwall deposition of china clay wastes has had a marked effect on the flora and fauna of bays which receive the discharges. Fishing for crabs and lobsters has also been somewhat affected. About one square mile (2.6 km²) of the sea bed is estimated to have been badly affected for fishing as a result of deposits of china clay waste. However, further offshore there is evidence that the deposits have made the bottom life richer than it would otherwise have been and have thus provided more food for fish⁽⁵⁹⁾. A re-appraisal by the china clay industry of its methods of disposal will lead to the gradual reduction of the present method of disposal of wastes and it is planned to end all discharges of micaceous residues into river estuaries and coastal waters after 1974.

54. The effects of the discharges from the potash workings in Yorkshire are not yet known and the owners have been given permission in the first instance to discharge for a period of only five years. During this time investigations of the effects will be made as a basis for reviewing the method of disposal.

55. Inert mineral waste in addition to affecting the flora and fauna may also affect amenity. Ill-judged choice of sites can lead to the materials being washed up later on beaches and the filling of navigational channels.

Other dumping in coastal waters

56. All materials dumped from ships in British coastal waters outside the three-mile limit are subject to voluntary controls exercised by the appropriate Departments (paragraph 135 of the main Report). The quantities of material for disposal on the continental shelf, as approved by MAFF, are set out in Table 25.

57. The effects of sewage sludge and the inert non-toxic materials have been already considered. The industrial wastes consist mainly of sludges which may well contain toxic materials of a similar nature to those mentioned in paragraphs 33-34 above. However, before agreement is given to disposal at sea each application under the voluntary arrangements is evaluated by the scientific and technical staff of MAFF (or DAFS) as described in paragraph 135 of the main Report.

58. The annual quantities of material disposed of in this way are very small compared with industrial discharges entering the sea from direct discharges into estuaries and coastal waters. In the North Sea a comparison of the solids content (excluding inert mineral wastes) shows that about three million tons are derived from coastal discharges along the East coast of England compared

Appendix A

with 264,000 tons from vessels. Of the 264,000 tons dumped from vessels only 15,000 tons are of direct industrial origin, the remainder being derived from sewage sludge. Industrial discharges in the North Sea by dumping from British vessels is thus only 0.5 per cent of that from direct discharges.

TABLE 25
Quantities of material from England and Wales approved by MAFF
for disposal on the continental shelf
(Consents in operation at end of August 1971)¹

<i>Dumping area</i>	<i>Material</i>	<i>Thousand tons per annum</i>
Irish Sea	Mixed industrial and domestic wastes	124
	Sewage sludge ²	550
Bristol Channel	Mixed industrial wastes	29
	Sewage sludge ²	365
English Channel	Mixed industrial wastes	86
	Pulverised fuel ash	3
North Sea	Mixed industrial wastes	288
	Mixed mineral wastes	23
	Pulverised fuel ash	600
	Colliery wastes ³	1,500
	Sewage sludge ²	5,052
		<hr/> 8,620 <hr/>

¹ Each consent is valid for a twelve-month period commencing from its date of issue; quantities dumped do not normally reach the approved totals.

² The figures for sewage sludge are wet weight and include disposals by local authorities.

³ Excludes shore tipping.

Mining and drilling at sea

59. In 1970 over 12 million tons of sand and gravel were dredged from the sea mainly for use in Great Britain. Marine dredging accounted for over ten per cent of the total annual production of sand and gravel for that year. This figure fluctuates from year to year but there is a pronounced upward trend (Table 26). The areas where dredging can be carried out are restricted because of navigational hazards, fishing interests, and considerations of coastal erosion; the main producing areas and the quantities dredged are given in Table 26.

60. Dredging operations give rise to effects similar to those of the deposition of inert mineral wastes (paragraph 51 above), but the effects are more acute because a great amount of turbidity results from the dredging. Similar conditions

arise near drilling rigs, which are used for prospecting for oil and natural gas in the North Sea, but the effects are more localised. With oil drilling there is also the danger of oil leaks from the sea floor.

TABLE 26
Production of sea-dredged aggregates
 (Data supplied by Crown Estate Commissioners)

<i>Area</i>	<i>Quantities dredged ('000 tons)</i>			
	1967	1968	1969	1970
East Coast	198	384	1,896	1,940
Southern North Sea	2,414	5,211	4,284	4,445
South Coast	121	505	263	297
Solent	2,235	2,064	2,483	2,161
Bristol Channel	2,141	2,156	2,163	2,310
Liverpool Bay	305	482	734	826
Mersey	920	786	764	788
Rivers	100	113	44	74
Total England & Wales	8,434	11,701	12,631	12,841
Clyde	49	51	55	82
Tay	53	55	145	137
Total UK	8,536	11,807	12,831	13,060

APPENDIX B

INTERNATIONAL AGREEMENTS AND ACTIVITIES CONCERNED WITH MARINE POLLUTION

A. INTERNATIONAL AGREEMENTS

Oil

1. Within the Intergovernmental Maritime Consultative Organisation (IMCO) a number of international conventions have been negotiated which are bringing under increasingly stringent control the operation of tankers and other ships at sea and liability of their owners to pay for the damage caused by oil spills.

2. The 1954 International Convention for the Prevention of Pollution of the Sea by Oil lays down conditions under which oil may be discharged into the sea; in particular, limitations are placed on discharges within the prohibited areas (which include the whole North Sea and English Channel, and much of the North Atlantic). In 1969, amendments to the 1954 Convention were negotiated which make the whole sea a prohibited area and limit discharges to a minimum amount which has been experimentally shown not to give rise to lasting oil slicks. When these amendments are in force, most oily residues will have to be kept on board or discharged to shore installations; and the Convention provides for a system of records and inspection to assist enforcement. 44 countries, including the major maritime nations, are contracting parties.

3. The 1969 amendments have been enacted for the UK by the Oil in Navigable Waters Act 1971 (the Prevention of Oil Pollution Act 1971 will consolidate this and previous relevant Acts). This Act also improves the law in other respects and increases the maximum summary penalty for illegal discharges of oil to £50,000. Regulations are being prepared under the Act which will apply these amendments to British ships without waiting for them to come into force internationally.

4. In 1971 IMCO adopted certain further amendments to the 1954 Convention, the effect of which is to limit the size of individual cargo oil tanks in large tankers so as to limit the amount of oil outflow in the event of a collision or grounding. Member governments have been urged to put these measures into effect in relation to their own ships without waiting for them to come into force internationally and the UK Government are considering this recommendation.

5. Another IMCO Convention, on Intervention on the High Seas in cases of Oil Pollution Casualties, agreed in 1969, which has already been ratified by the United Kingdom, makes it easier for governments to intervene to protect their coasts when an accident like that to the Torrey Canyon takes place. Powers comparable to those in the Convention have been conferred upon the Secretary

of State for Trade and Industry by Section 8 of the Oil in Navigable Waters Act 1971.

6. The Convention on Civil Liability for Oil Pollution Damage, also agreed in 1969, makes tanker owners strictly liable for damage caused by an oil spill, including claims for government expenditure on preventive measures. This liability must be covered by insurance. The Merchant Shipping (Oil Pollution) Act 1971 provides for the UK to ratify this Convention. The tanker owners themselves have already set up a special voluntary compensation scheme which provides, in certain circumstances, compensation for damage up to £4.2m per incident. There is also a scheme operated by the oil owners.

7. The liabilities defined by the Convention are probably the most that the present insurance market can cover, and a Convention has recently been concluded establishing a fund to meet costs of cleaning up after an accidental discharge of oil which are not covered under the liability imposed by the 1969 Convention. The oil industry are willing to bear their fair share of the cost of oil pollution damage and have set up a representative body which has offered assistance to IMCO in connection with the establishment of the compensation fund. One country only (Senegal) has acceded to the Liability Convention and none so far to the Compensation Fund Convention.

8. In 1969 an agreement for Co-operation in Dealing with Pollution of the North Sea by Oil was signed within the IMCO framework by this country and the other States bordering the North Sea. It divides the North Sea into areas, in each of which the relevant signatory State is responsible for reporting and tracing oil slicks, and provides for mutual assistance in dealing with oil which is polluting coasts. The English Channel and the Straits of Dover will be subject to special arrangements, to be concluded under the Agreement, between the UK, French and Belgian Governments.

Dumping

9. In February 1972 Her Majesty's Government became party to a Convention on the Control of Marine Pollution by Dumping from Ships and Aircraft, which will control the dumping of waste at sea by participating countries in the North East Atlantic area. Approval by the national authorities will be required for all dumpings in the sea and there will be a prohibition on the disposal of certain highly toxic and persistent substances and tight control over others requiring special care. The Convention relates specifically to dumping, but contains a general pledge to take all possible steps to prevent pollution of the sea.

10. The Convention will establish a Commission to co-ordinate its working and will provide for international co-operation in research into the monitoring of the marine environment.

11. Legislation will be introduced in this country to provide for the statutory control of dumping at sea in conformity with the Convention. The voluntary scheme at present operated by the UK to regulate dumping at sea accords with

the spirit of the Convention. A world-wide Convention on similar lines is under discussion at present (paragraph 15 below).

Radioactivity

12. Limits imposed on discharges of radioactive wastes within the UK, including the piping of slightly radioactive liquid wastes into rivers or the sea, are well below those recommended by the International Commission on Radiological Protection. Continuous monitoring and research have shown that no significant effect of these disposals can be detected on man or his environment.

13. Solid materials are also dumped in long-life canisters in the deep oceans. This is strictly controlled in the UK in accordance with the recommendations of the International Atomic Energy Agency. About one such dumping is made each year from Britain by the UKAEA, and in recent years these disposals have been made in conjunction with other European nations under the auspices of the European Nuclear Energy Agency, set up under OECD (paragraph 29 below).

B. INTERNATIONAL ORGANISATIONS AND THEIR ACTIVITIES

United Nations and associated organisations

14. The United Nations Conference on the Human Environment, held in Stockholm in June 1972, reviewed, among other matters, the question of marine pollution, and recommended priorities and guide lines for future work and as a basis for co-operation between the UN agencies.

15. An Intergovernmental Working Group on Marine Pollution was established to prepare for the Conference. This included work on the drafting of a Convention to control dumping at sea by regional Conventions, such as that covering the North East Atlantic, which will be the subject of a Conference to be held in the UK in November 1972.

16. The Intergovernmental Working Group on Monitoring and Surveillance has built on existing activities in other organisations to attempt to reach agreement on methodological practices and marine pollution forms an important element in its coverage.

17. In 1970, the UN General Assembly expanded the terms of reference on the UN Sea-Bed Committee to include a wide range of topics concerning the law of the sea including the question of the preservation of the marine environment, and charged it to undertake the preparatory work for an International Conference on the Law of the Sea to be held in 1973; the date and venue are to be decided.

18. The role of IMCO in producing the international Conventions already agreed is indicated above. The prevention of disastrous oil pollution resulting

from casualties to ships has been actively studied by governments within IMCO as well as by tanker companies, and has proceeded along four broad fronts: routing schemes to separate opposing streams of traffic; ensuring that ships carry modern navigational equipment; revision of the collision Regulations; and the improvement of training standards.

19. IMCO is also responsible for making proposals for the prevention of pollution of land, sea and air by ships and other equipment operating in the marine environment and, for example, is studying the safety of the construction, equipment and operation of drilling rigs. It has decided to convene an International Conference on Marine Pollution in 1973, which will have as its primary objective the achievement, by 1975 if possible, but by the end of the decade at the latest, the complete elimination of the wilful and intentional pollution of the sea by oil and other noxious or hazardous substances carried in ships and the minimisation of accidental pollution. The Conference is expected to prepare one or more international agreements on these matters.

20. IMCO is working on precautions in the carriage of dangerous substances, for example on the design of bulk chemical carriers to limit the damage to the environment in the event of a casualty and on the identification of the hazardous cargoes which may be considered as potentially serious pollutants. The UK is also proposing urgently to IMCO a system of reporting incidents to ships involving the loss or possible loss into the sea of hazardous cargoes immediately after such losses are known, and IMCO has urged member governments to put this proposal, similar to that which already applies to oil, into effect immediately.

21. The interest of other UN agencies in marine pollution is reflected in the joint establishment of a Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) under IMCO, FAO, UNESCO, WHO, IAEA and the UN itself. Topics which have been studied include: harmful chemical substances, marine pollution resulting from exploration and exploitation of the sea bed in international waters, the identification of noxious and hazardous cargoes, the natural dispersion and movement of pollutants in the sea, and the pollution of the sea through the atmosphere.

22. The Food and Agriculture Organisation of the UN (FAO) has a general interest in the effects of marine pollution on living resources and their exploitation, particularly in relation to the fishing industries of developing countries. This organisation held a Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing in Rome in December 1970 which resulted in a series of recommendations to governments.

23. The World Meteorological Organisation sponsors studies on topics including the transfer and dispersion through the atmosphere and the deposition (on land and sea) of airborne pollutants, including radioactive particles.

24. The UN's Economic Commission for Europe provides opportunities for East-West contacts, and for the exchange of information on pollution legislation and regulations. Studies envisaged also include the pollution of coastal and estuarial waters from inland sources.

25. The International Atomic Energy Agency (IAEA) is recognised as the UN Agency particularly concerned with radioactive waste disposal, and convenes panels of experts and publishes reports.

26. Scientific research in general is one of the concerns of the United Nations Educational, Scientific and Cultural Organisation (UNESCO). After a conference in 1968 on the Rational Use and Conservation of the Resources of the Biosphere, it established, on a long term basis, the "Man and the Biosphere" programme, directed in part at determining methods of identifying, evaluating, monitoring and controlling pollution nuisances. UNESCO has recently adopted a programme of Global Investigations of Pollution in the Marine Environment (GIPME) as a major project within the International Decade of Ocean Exploration which runs throughout the 1970s. It has also undertaken to carry out monitoring of marine pollution on a worldwide basis once the necessary background research has been carried out.

27. The Intergovernmental Oceanographic Commission, set up by UNESCO, promotes scientific investigation of the nature and resources of the oceans.

Other organisations

28. The Organisation for Economic Co-operation and Development (OECD) brings together the economically advanced countries of Western Europe and North America and Japan. It has a group which co-ordinates regional studies of the occurrence and distribution of pesticide residues in marine animals. OECD's interests and capabilities lie particularly in the economic and trade fields, and it therefore has a distinctive and valuable role in the consideration of the economic implications for industrialised countries of environmental problems.

29. Under OECD, the European Nuclear Energy Authority (ENEA), already mentioned in paragraph 13 above, considers such problems as the management of radioactive waste.

30. Under the North Atlantic Treaty Organisation (NATO) the Committee on the Challenges of Modern Society sponsors a number of national studies including one on coastal waters pollution led by Belgium. The NATO Science Committee's Oceanographic Sub-Committee also sponsors studies on oceanographic aspects of marine pollution. In 1970 a colloquium was held in Brussels on oil spills, and the NATO Council approved resolutions that within the next 5-10 years intentional discharges of oil and oily wastes into the sea should be eliminated and the risk and consequences of accidental spills minimised, and that IMCO should be given the task of bringing this about (see paragraph 18 above). In 1971, the Science Committee promoted a Conference on North Sea Science, including pollution.

31. The International Council for the Exploration of the Sea (ICES) encourages and co-ordinates national research programmes, including pollution problems, and is principally active in the North Atlantic, North Sea and Baltic region. It is currently carrying out an International Study of the Pollution of

the North Sea and its effect on Living Resources and their Exploitation. It is also about to start a similar study of the Baltic Sea in collaboration with SCOR (Scientific Committee on Oceanic Research of the International Council of Scientific Unions).

32. The Commission of the EEC has proposed to the Council of Ministers an "action programme" on the environment which includes the following items: measures concerning marine pollution by waste from the shore; action on the discharge or dumping at sea of industrial waste in the waters around the Community; organisation of the control of water pollution in frontier areas (this might be construed to include coastal as well as inland waters). The Commission's proposals are now under consideration by the governments of member states of the Community and acceding countries.

33. The Council of Europe has set up an *ad hoc* Committee of Experts to prepare a European Convention on the Protection of International Fresh Waters against Pollution. This Committee now proposes also to consider coastal waters where they are crossed by frontiers and possibly even all coastal waters.

APPENDIX C

ORGANISATIONS AND INDIVIDUALS WHO WERE CONSULTED BY THE COMMISSION

- * Includes attendance at meetings with the Commission
- ** Includes discussions during visits by the Commission

Government departments and research establishments

- * Ministry of Agriculture, Fisheries and Food
 - Marine Radiobiological Laboratory
 - Salmon and Freshwater Fisheries Laboratory
 - Sea Fisheries Laboratory
 - Shellfish Laboratories
- * Crown Estate Commissioners
- Ministry of Defence
- * Department of the Environment
 - Water Pollution Research Laboratory
- Department of Health and Social Security
- * Natural Environment Research Council
 - Institute of Marine Environmental Research
 - Unit of Coastal Sedimentation
- * Department of Trade and Industry
- * Department of Agriculture and Fisheries for Scotland
 - Marine Laboratory
- * Scottish Development Department
- * Scottish Home and Health Department
- * Welsh Office

Public corporations

- British Steel Corporation
- ** British Transport Docks Board (Hull)
- ** British Transport Docks Board (Southampton)
- Central Electricity Generating Board
 - Marine Biological Laboratory
- ** Fawley Power Station, Central Electricity Generating Board

- National Coal Board
- National Ports Council
- North of Scotland Hydro-Electric Board
- South of Scotland Electricity Board
- ** Teesside and Workington Group, General Steel Division, British Steel Corporation
- United Kingdom Atomic Energy Authority

Local authorities and local authority associations

- Association of County Councils in Scotland
- Association of Municipal Corporations
- Rural District Councils Association
- Urban District Councils Association
- ** Birkenhead CBC
- ** Cardiff CBC
- ** Edinburgh Corporation
- ** Glasgow Corporation
- ** Burgh of Grangemouth
- Greater London Council
- ** Hampshire County Council
- ** Hull CBC
- ** Isle of Wight County Council
- ** Lincoln (Lindsey) County Council
- ** Liverpool CBC
- ** Portsmouth CBC
- ** Southampton CBC
- Southport CBC
- ** Swansea CBC
- ** Teesside CBC
- ** Wallasey CBC

River authorities, river purification boards and salmon fishery boards

- * Association of River Authorities
- ** Hampshire River Authority
- ** Isle of Wight River and Water Authority

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- ** Lincolnshire River Authority
- ** Mersey and Weaver River Authority
- ** Northumbrian River Authority
- ** South West Wales River Authority
- ** Trent River Authority
- ** Usk River Authority
- ** Yorkshire River Authority
- ** Severn Estuary Joint Consultative Committee
- ** Clyde River Purification Board
- ** Forth River Purification Board
- ** Lothians River Purification Board
- ** Forth District Salmon Fishery Board

Sea fisheries committees

- * Association of Sea Fisheries Committees of England and Wales
- ** Lancashire and Western Sea Fisheries Committee
- ** North Eastern Sea Fisheries Committee
- ** Southern Sea Fisheries Committee

Firms and industrial organisations

- Albright and Wilson Ltd (Marchon Division)
- ** BP Chemicals Ltd
- ** BP Refinery (Grangemouth) Ltd
- Chemical Industries Association Ltd
- Confederation of British Industry
- ** Confederation of British Industry (Scottish Office)
- ** Courtaulds Ltd (Synthetic Fibres Division)
- ** Distillers Company Ltd
- English China Clays Ltd
- ** Esso Chemicals Ltd
- ** Esso Petroleum Ltd
- ** Imperial Chemical Industries Ltd (Agricultural Division)
- ** (Dyestuffs Division)
- ** (Petrochemicals Division)
- Imperial Chemical Industries Ltd (Brixham Laboratory)

International Tanker Owners Pollution Federation Ltd
Mersey Docks and Harbour Company

**** Monsanto Chemicals Ltd**

*** National Association of Waste Disposal Contractors**

Shell Chemicals (UK) Ltd

Shell International Petroleum Co Ltd

Shell Research Ltd

UK Petroleum Industry Advisory Committee

**** Unilever Ltd (Merseyside Committee)**

Other organisations and individuals

Professor R B Clark, Department of Zoology, University of Newcastle-upon-Tyne

**** Clyde Study Group**

*** Council of Engineering Institutions**

*** Council of Science and Technology Institutes**

Environment Protection Society

Dr J J D Greenwood, Department of Biological Sciences, University of Dundee

Mr Norman Humphris

Institute of Petroleum

*** Institute of Water Pollution Control**

Intergovernmental Maritime Consultative Organisation

*** Dr A Key, Chairman, Technical Committee on the Disposal of Solid Toxic Wastes**

**** Liverpool Bay Study Group**

Marine Biological Association of the United Kingdom

National Anglers Council

National Federation of Sea Anglers (Wessex Division)

Dr A Nelson-Smith, Department of Zoology, University College of Swansea

Dr E J Perkins, Department of Biology, University of Strathclyde

Professor S J Pirt, Professor of Microbiology, Queen Elizabeth College, University of London

Royal Society for the Protection of Birds

**** Sabrina Project Steering Committee, University of Bristol**

Scottish Marine Biological Association

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- ** Severnside Advisory Committee on Environmental Pollution**
Ship and Boat Builders' National Federation
Society of Chemical Industry
- ** Solent Protection Society**
- ** Department of Oceanography, University of Southampton**
Taff and Ely Rod Fishing Association
University Marine Biological Station, Millport
- ** Wellcome Marine Laboratory, Robin Hood's Bay, University of Leeds**

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