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Report of the I.C.E.S. Working Group on Pollution of the North Sea

Following the Helgoland Symposium on Pollution of the North Sea and the I.C.E.S. meeting of 1967 the Council established a Working Group of the Fisheries Improvement Committee "for the purpose of assembling factual data regarding substances harmful or potentially harmful to fisheries being discharged or likely to be discharged into the North Sea and adjacent seas". The Working Group was to consist of "one expert in the field of pollution from each member country concerned, assisted by two experts nominated by the Hydrography Committee".

The Working Group, under the chairmanship of Dr. H. A. Cole (U.K.), held its first meeting in London on 6-8 February 1968, when the following representatives attended:

Dr. Ir. W. Deschacht	Belgium	
Dr. J. Boetius	Denmark	
Prof. Dr. H. Mann	Federal Republic of Germany	
Prof. Dr. P. Korringa	Netherlands	
Mr. G. Berge	Norway	
Mr. B. I. Dybern	Sweden	
Mr. A. C. Simpson	United Kingdom	Observers
Mr. R. E. Craig	United Kingdom (Scotland)	Observers
Dr. J. E. Portmann (Secretary)	United Kingdom	
Mr. L. Otto	Netherlands	Representatives of Hydrography Committee
Dr. G. Weichart	Federal Republic of Germany	Representatives of Hydrography Committee

Mr. Craig was replaced by Dr. R. Johnston for the meetings on 7 and 8 February.

The various representatives put forward factual information on the following aspects of pollution in their own countries.

(1) Legislation controlling pollution of the sea
(2) Sewage pollution
(3) Pollution by industrial wastes
(4) Pollution by pesticides
(5) Pollution by oil, including oil-removing chemicals
(6) Toxicity studies, methods and results
(7) Dispersion studies

Although radioactive wastes could be considered to fall within the terms of reference of the Working Group this type of pollution was not discussed since other more highly qualified groups, e.g. E.N.E.A., were already working on this topic.

class was added with the addition of a methylene blue test requirement. In practice the law is enforced by the Ministry of Public Health which concentrates on the bacterial aspects of pollution. There are no other inspecting organizations, and control over other aspects of pollution is rather loose.

Special laws govern the disposal of wastes from sugar factories (10 December 1954, Moniteur Belge 1955), paper mills (2 August 1956, Moniteur Belge 1956a), and the steel industry (12 September 1956, Moniteur Belge 1956b). Belgium has ratified the London Oil Pollution Convention 1954, and oil disposal is controlled. There is, however, no control of disposal of other pollutants outside territorial waters, although in the one known case of dumping outside territorial waters the Government was consulted and the dumping was in an agreed area of no fishing importance.

(ii) Denmark

Pollution of rivers, lakes and marine waters is governed by the Watercourse Act of 11 April 1949 (Denmark 1949) and subsequent amendments in 1963 (Denmark 1963) to this Act, and an ordinance of 1945 (Denmark 1945) which relates to measures for purifying watercourses. Under this Act no material such as earth, sand, stones, etc. may be deposited near a watercourse so as to create a risk of being washed into it. This also applies to solids or liquids, such as pesticides, which may pollute the water. Section 5 of the Act states that waste waters from towns and factories must not be discharged to a watercourse, including the sea, in such a way that "considerable pollution" arises. The decision as to what constitutes "considerable pollution" is left to the Water Courts.

The Water Courts are constituted on a local basis and there are about one hundred of them. Each case of pollution is considered separately by the Water Court concerned and the various interests involved are taken into consideration. Experts can be called if the court feels this to be necessary but the Water Court must in any event notify the Ministry of Fisheries of the case. After considering all the facts the court can impose limits if they feel this to be necessary. The decision of the Water Court is open to appeal but in practice this course is rarely taken.

In general all sewage and other waste waters should be treated prior to discharge to the sea. In the case of fjords and other such waters the Ministry of Agriculture, after consulting the Ministry of Fisheries and Ministry of the Interior, may prohibit discharge of untreated or insufficiently treated wastes. Responsibility for the supervision of the provisions concerning effluent quality rests with the Police and Fishery Control, whereas supervision of the watercourses is by the Ministry of Agriculture. Failure to comply with the provisions of the Watercourse Act, or rulings by the

(iv) France

France has four laws which give control of pollution of the sea and sea water. Two of these (France 1958, 1964a) were designed to limit, and prevent, respectively, the pollution of the sea by oil. The other two govern (a) the aquatic regime, methods of assessment of the waters and measures to be taken against their pollution (France 1964b) and (b) the limits of protection to be established near, or in some instances, some distance away from, places where surface waters are extracted (France 1967).

In addition to these laws there are a number of ministerial Circulars or Instructions which supplement or explain the laws and the way in which they are to be enforced. All the regulations apply to the marine environment.

The laws giving powers of control are all fairly new and because the scale of the pollution is very large and the organizations of enforcement are new the process of putting the laws into effect is rather slow; however, considerable progress has been and is being made. In the case of a factory or town wishing to discharge effluent to the sea permission must be obtained from the Prefecture of the area concerned. A public enquiry is held and then, according to the merits of the application, the Prefecture either authorizes the discharge or imposes conditions.

(v) Netherlands

A new law concerning pollution was passed in 1968. This law (Nederlandse Staatocourant 1968) will rigidly control pollution of inland waterways and coastal waters and no discharge will then be permitted without prior consent from the government. The Ministry concerned will be that for Public Works but will consult the Ministries for Agriculture and Fisheries, of Public Health, Economic Affairs and of Recreation, i.e. it will be a joint decision. In addition to controlling the pollution of coastal waters the new law will also control the disposal of waste outside territorial waters; this will include the disposal of wastes by other countries where the waste is transported through the Netherlands.

One of the difficulties arising in the new law is how to control discharges to inland waters prior to their passage through the Netherlands. The main river involved is the Rhine, and an International Rhine Commission has been set up to look into the general reduction of the Rhine pollution. This Commission is made up of representatives of all the interested countries i.e. Switzerland, Federal Republic of Germany, France, Luxemburg and Netherlands. Analyses of Rhine waters are regularly made and studied. Attempts are made to improve the pollution situation. Fisheries representatives can attend the meetings of the Commission as observers.

law most towns will have to treat their sewage although some small coastal communities may be exempt. The new law will only cover pollution from ships where the waste has been taken aboard specifically for disposal at sea. It will not include other, more general, pollution from ships but this will continue to be controlled by existing legislation, e.g. the Salt Water Fisheries Law.

Norway recognizes the London Oil Pollution Convention and oil pollution is controlled.

(vii) Sweden

There are several laws governing water pollution in Sweden and the main one of these is the Water Law (Stockholm 1918) which has been amended several times (Stockholm 1964). This states that anyone who discharges or intends to discharge sewage to rivers, lakes or other waters is responsible for any eventual damage and must, to a reasonable extent, take the necessary steps to prevent pollution of the receiving water. This in effect means that for all communities of 200 or more persons, primary treatment of sewage is compulsory; further treatment may be required where the use of the water, e.g. for drinking purposes, makes this necessary. In practice there have been many exceptions but pressure is now being exerted and a big improvement is in progress. All new discharges will have to be notified to the National Nature Conservancy Office which controls all important outlets of sewage and industrial waste waters.

Industrial wastes may not be discharged in such a way that considerable inconvenience is caused. For most industries this means at least a limited form of treatment. Certain types of industry, e.g. pulp and paper, butcheries, dairies, bone-meal, oil-refineries and some chemical industries must obtain a permit from a Water Court. The permit will detail the measures which must be taken to avoid pollution of the receiving waters. Under certain conditions, e.g. where the industry is essential to the national economy, the government may disregard the ruling of the Water Court. In almost every case new discharges are now thoroughly discussed before they take place and the body responsible for the pollution must always provide all the necessary material for the investigation. On occasions where a detrimental effect is produced by an effluent the industry concerned must pay a "fishery charge" of up to 10 000 SW Crowns/year. Much of this money is then allocated for various forms of water research.

At the regional level questions of water conservation are the province of the County and Municipal Councils in their capacity as Boards of Health, etc. They have at their disposal experts in various fields who exercise a advice of the Ministry of Agriculture, Fisheries and Food (Fisheries Department). Specified areas are set aside for dumping of various materials and according to the nature of the material dumping may be requested in one of these areas or in very deep water beyond the edge of the continental shelf. A suitable form of container is usually prescribed. A copy of an extract from the ship's log recording the deep-water disposal of the wastes is normally required by the authorities.

(b) In Scotland there are no Sea Fisheries Committees, and powers to control pollution, both of inland streams and of tidal waters, rest entirely with river purification authorities.

There are twenty-one river purification authorities in Scotland. These include nine River Purification Boards, established under the Rivers (Prevention of Pollution)(Scotland) Act 1951 (H.M.S.O. 1951), each with power to control pollution of a whole river or group of rivers from source to sea in the more highly industrialized areas in Scotland, and twelve local authorities who control the pollution of rivers in the more sparsely populated areas of Scotland.

Under the Rivers (Prevention of Pollution)(Scotland) Act 1951 (H.M.S.O. 1951), the river purification authorities have powers, similar to those of river authorities in England and Wales, to control all new discharges of effluent to non-tidal streams in their areas and to prohibit the use of such streams for the disposal of polluting matter. The Rivers (Prevention of Pollution)(Scotland) Act 1965 (H.M.S.O. 1965), extended these powers and gave the river purification authorities power to control, in addition, all discharges to non-tidal streams which pre-dated the coming into effect of the 1951 Act.

The 1965 Act also gave river purification authorities power to control new discharges of effluent into certain tidal waters, defined in Schedule 2 to that Act as "controlled" waters. These cover all the coastal areas where pollution is most likely to occur.

Where it is shown that stricter control of tidal waters in an area is required, the Secretary of State for Scotland may by order extend the full powers of both Acts to any of the tidal waters around the Scottish coastline.

Dumping outside territorial waters is administered in Scotland in a similar way to that for England and Wales.

Oil pollution around the United Kingdom is controlled under the London Oil Pollution Convention provisions. Possible pollution from oil or gas exploration and exploitation is controlled under the Petroleum (Production) (Continental Shelf and Territorial Seas) Regulations 1964 (H.M.S.O. 1964a).

(iii) Federal Republic of Germany

All sewage must be treated; very large quantities of treated wastes are carried by the main river systems. The total quantity of sewage discharged directly to sea is very small and is insignificant compared to that carried by the rivers. No figures are available for the polluting load carried by the rivers.

(iv) France

Treatment of waste water is now a matter undertaken by all communities wherever possible. At present approximately 85 000 m^3/day of sewage is discharged from France directly to North Sea or English Channel waters. About 48 per cent of this receives some form of treatment prior to discharge.

(v) Netherlands

There are not many discharges direct to sea but the tendency is for the number to increase. There is a trend towards long sea outfalls with little or no treatment of the wastes. The sewage discharged directly to sea comes from a population of about 3 million and imposes a pollution load of 10 tons/day phosphorus, 100 tons/day nitrogen and 1 500 tons/day BOD. The polluting load carried by the Rhine is much greater and the 2 x 10^8 m^3/day flow carries 60 tons/day phosphorus, 1 000 tons/day nitrogen and 2 x 10^3 tons/day BOD.

(vi) Norway

Under a new pollution control law expected in 1968 large towns will have to give at least primary treatment to their sewage. Many do not do so at present. The total quantity of sewage discharged directly to the sea is estimated at 3.8 x 10^5 m^3/day. No figures are available for the quantity of nitrogen or phosphorus pollution.

(vii) Sweden

There are many untreated wastes at present but a programme of construction of treatment plants is in progress and there is a rapid move towards treatment of wastes. There are no figures available for the total quantity of sewage discharged directly to sea or for the polluting load.

(viii) United Kingdom

(a) England and Wales. Much untreated sewage is discharged directly to the sea, and a tendency for long pipelines to be used is increasingly evident. Treatment is adopted at some holiday resorts and also for many estuarine discharges. In some shellfish-producing areas treatment of sewage is required by local legislation. Large seasonal variations occur in areas where tourism is important. The total quantity of sewage discharged directly to the sea is estimated at 25 x 10^5 m^3/day and this imposes a pollution load of about 23 tons/day phosphorus, 100 tons/day nitrogen and 550 tons/day BOD.

in the coastal waters. A study of the nutrient levels in Oslofjord has been in progress since 1936 and the evidence shows a gradually extending enriched zone moving out along the fjord. In the United Kingdom a study of nutrients and suspended solids in the inshore waters off the north-east coast of England is underway in connection with an investigation of the possible effects of pollutants on marine flora and fauna in that area.

Most of the delegates knew of blooms of phytoplankton which had either caused death of fish or shellfish indirectly by de-oxygenation of the water or had had direct toxic effects on fish or shellfish. In some instances these had also been observed in man and birds (Rae, Johnston and Adams 1965; Ingham and Wood, in press). The effects of these blooms are usually confined to individual fjords or estuaries but a few have been very widespread and two recent ones off Norway and the United Kingdom have extended over several hundred kilometres (Brongersma-Sanders 1957, 1966; Ingham and Wood, in press). It was generally agreed that nutrient upwelling was of prime importance as a causative agent in the blooming of phytoplankton. However, other factors such as sunlight, temperature, stability of the water column and addition of nutrients from sewage discharges or even large colonies of wild-life have also been suggested as possible causes of plankton blooms.

A typical case of a bloom due to nutrient enrichment occurs in Oslofjord where Gyrodinium aureolum now blooms regularly. Although in this area the prime cause of plankton blooms is thought to be nutrient upwelling this particular organism was not reported prior to the fjord becoming polluted by sewage. However, Gyrodinium aureolum is a fragile organism and is not easily preserved; it is therefore possible that it was missed in earlier investigations. Among other cases discussed was a recent bloom of Prorocentrum micans off the Netherlands coast which was stated to be unique in Netherlands' records.

Although there have been many of these plankton blooms reported, and in some instances nutrient enrichment as a result of man's activities has been suspected as the causative agent, in no case has there been any conclusive evidence to prove that this was so.

(ii) Bacteria

The risks of bacterial contamination from sewage pollution have long been recognized in connection with illnesses arising as a result of consumption of infected shellfish, particularly oysters and mussels (Bulstrode 1896, 1911; Dodgson 1928). It was pointed out that escallops (Pecten maximus) which had previously been considered safe might well become infected as a result of the growing move towards the adoption of long sea outfalls discharging in deep water.

fauna, e.g. Pearson (1960). The general conclusions of this work are that locally the effect is to increase the quantities of lower forms of life, often with a reduction in the number of species. A study in the Firth of Forth, Scotland, of the fauna of a polluted shore had shown that *Polydora ciliata* was abundant almost to the extent of excluding other organisms (Smythe 1968). Similar work was carried out by Swedmark (1966), in the harbour and outside it, at Goteborg. He found that *Capitella capitata* was very common in polluted, but not heavily polluted, waters. In exceptional circumstances, however, even local effects could be important, e.g. if a nursery area was affected. A joint Swedish-Danish study had been carried out in the Oresund (Bonde 1967) to study the effects of sewage pollution on fisheries and the conclusion was that there were no detectable effects except perhaps with herring, the fishery for which has declined.

Complete de-oxygenation of marine waters over extensive areas was not a problem except in certain special cases such as fjords, e.g. Oslofjord (Anon. 1968) where the rate of exchange was very slow. However, a Swedish study (Fonselius, in press) demonstrates that there is no cause for complacency. The oxygen concentration at a number of stations in the Baltic Sea has been studied for the past sixty years. At one of these stations, F75, 100 Km east of Gottland, the oxygen level in the water at 100 m had decreased from over 3 ml/l in 1904 to less than 0.4 ml/l in 1967. Some scientists believe that this is at least partly due to the breakdown of organic matter carried out from the coasts. This breakdown would cause the consumption of oxygen in the deep water which, due to the salinity conditions and pronounced halocline, is rather stagnant.

Summary

Sewage pollution may have detrimental effects as a result of its oxygen demand, its nutrient content (either actual or potential) and its bacterial content. The effect of oxygen demand is usually local only and is not considered to be significant in terms of the North Sea as a whole, although it may be important in restricted areas, e.g. fjords. There is some evidence that increased nutrient levels as a result of sewage pollution may be associated with blooms of algae and that these may be important in coastal waters, particularly in shellfish-producing areas in the case of a bloom of a toxic alga. There was no evidence brought forward that bacteria caused more than local problems.

The overall conclusion was that the situation as regards sewage must be watched but at present the effects are believed to be local.

In common with other Scandinavian countries Denmark is concerned about mercury pollution and although this does not at present seem to be as serious as in Sweden (see part (vii) of this section) the situation is being examined to see what may need to be done.

(iii) Federal Republic of Germany

The Federal Republic has very little industry near the coast and there are no important industrial discharges directly to the sea. The main industries of the Federal Republic at present discharge their effluents to inland waterways but under the new laws for pollution control much of the present pollution will have to stop. As a result many industries are turning to sea disposal as an alternative. Since coastal water pollution is now also controlled this sometimes means dumping beyond coastal waters.

A number of applications for permission to carry out disposal of waste at sea have been received by the authorities. The materials to be disposed of cover a wide range, but they include regular dumpings of gypsum (300 tons/day), sulphuric acid (375 tons/day), iron sulphate (750 tons/day), gypsum (200 000 tons/year), chlorohydrocarbons (40 tons/month), and polyethylene (40-50 tons/month). Single dumpings are also common and proposals for such things as creosote, pyrites cinders (600 m^3), calcium arsenate (350 tons), arsenic residues (10 tons) and spoilt lecithin (300 tons), have been received and dealt with.

These proposals for sea disposal are dealt with as described by Weichart (1968) (see section 1, part (iii)) and according to the danger class they are assigned, permission to dump may or may not be granted. Most proposals are granted and very often the area designated for disposal is the North Atlantic beyond the continental shelf; examples of wastes disposed of in that way would be arsenic, the chlorohydrocarbons and gypsum (since it contains some U^{235}). The proposal to dump polyethylene was turned down since it does not decay and will float. If a waste is to be disposed of in drums then the drums must be completely filled and weighted so as to sink. The disposal of some solids in very strong paper sacks is proposed.

(iv) France

Industrial pollution of the North Sea proper, i.e. from the French coast east of Pas de Calais, comes primarily from an oil refinery at Dunkirk; a factory treating titanium minerals, a paper mill and a small distillery at Calais. There are a number of smaller factories and cooling water effluents but these do not have any marked effect on the environment. West of Pas de Calais the main industrial centre is Le Havre which has bunkering facilities, oil refineries, a petrochemical plant and a factory treating titanium minerals.

of gypsum wastes, 60 000 tons/year iron sulphate, 700 tons/year pickling wastes containing cyanide and 10 per cent metals, 4 000 tons/day sewage sludge, an unspecified quantity of 6-chlorocresol, etc. Many of these new proposals came from other countries, e.g. Federal Republic of Germany, as a result of new pollution control measures in these countries.

There has been no evidence of large-scale and lasting harm to fish or shellfish as a result of industrial pollution but there have been a number of incidents at pesticide manufacturing plants (see section 4, part (iv)) which have resulted in fairly extensive fish mortalities. A case of pollution by copper sulphate in coastal waters caused locally extensive fish mortalities (Roskam 1965, 1966).

(vi) Norway

Industrial pollution in Norway has not yet reached levels of very great importance but the growth rate of industry is very rapid and pollution is on the increase. Two of the principal industries involved at present are timber products and fishing. Pollution caused by the timber and paper pulp industries has caused a reduction in home fisheries, particularly in the fjords. Among the first species to be affected are sea trout and salmon. Mussels may be affected up to 100 metres from the pulp mills by the blanketing of fibres. The fish processing side of the fishing industry gives rise to effluents which cause local complaints but these are frequently on aesthetic grounds. Preservation of fish in formalin prior to curing results in the discharge of wastes containing 18 000 tons of 40 per cent formalin solution per year, about half of which is discharged to the sea, often in the upper reaches of fjords. Over half of the formalin is used during the summer months; it does not appear to affect fisheries. In addition to the formalin waste the fish curing industry gives rise to wastes containing fish oils and soluble material; these can give rise to pollution problems up to several kilometres from the release site. Improved methods for the regeneration of oil and organic solubles are however under development and an improvement is expected.

Mining activities, chiefly in southern Norway, for iron, copper, sulphur and niobium cause some local problems. These are most serious in the sulphur mining areas but as most of the mines are situated inland their effects on the marine environment are negligible and no complaints are received from marine fisheries interests.

Of the newer industries aluminium is one of the most important. Most of the factories are situated on the west coast and many of them use bauxite ores. The wastes from these factories include some aluminium oxide, hydrofluoric and sulphuric acids and large quantities of "red mud". The effects toxic waste liquor. However other types of paper are required and it is impossible to change over entirely to one manufacturing process.

Many factories are now attempting to remove fibres and other substances prior to discharge of the wastes. Under the new law which will take air pollution into account it may not be possible to dispose of the wastes by burning and the pulp industry may be faced with another problem.

Pollution by mercury compounds is very serious in Sweden. Although usage of mercury has been curtailed it will remain in the environment for a long time to come. The main usage of mercury compounds was in the forestry industry where they were used as fungicides but they were also used in agriculture and in some other industries. The problem has now reached the stage where commercial fishing has had to be prohibited in certain lakes and some coastal areas, although exceptions may be made for some migratory fish. In some of the restricted areas the level of mercury found in fish tissue reaches 3-4 mg/Kg wet weight which is far above the recommended safe consumption level set by F.A.O., i.e. 0.02-0.05 mg/Kg. The safe level at present in Sweden is set at 1.0 mg/Kg but there is an official recommendation that such fish should only be eaten once a week. Mercury is a cumulative poison and the uptake and transformation into dangerous compounds by the organism is now being thoroughly studied by several scientists (see, e.g. Noren and Westöö 1967; Hannerz 1968a and Jernelöv 1968). Boetius (1960) has reported on the levels of mercury, both inorganic and organic, which are known to be harmful to fish.

Although usage of mercury and its compounds has now been restricted within Sweden, air-borne mercury from industrial sources in Europe will still be rained out over Swedish territory and thus mercury pollution may continue to be a problem. A further air-borne source of pollution is sulphur dioxide from European and Swedish industry, e.g. nylon and titanium dioxide production. This is also rained out and although it has not yet caused trouble in the sea some fish kills have been experienced in lakes as a result of lowered pH.

Other industries such as metallurgy, engineering, food and chemicals are primarily in southern Sweden and some of the biggest factories are in coastal areas. Generally their wastes are controlled and only local trouble may be caused. A number of accidents do occur and in some areas these have caused mortality of marine flora and fauna. One such example is a copper refinery where some of the marine animals are affected from time to time. Until recently arsenic was dumped in the sea as a waste but this is now being reclaimed.

This situation is slowly being rectified by sewage purification and treatment of trade wastes but at present fishing is still seriously affected. South of the Thames the Medway and Swale are affected by wastes from the paper industry which is concentrated in that area. Fishing has been adversely affected, particularly the oyster industry which has been almost completely wiped out in the estuaries. The nearby Whitstable native oyster fishery has also declined, probably as a result of the loss of parent stock in the Swale.

Southampton Water on the English Channel coast receives about 1×10^6 m^3/day of trade wastes, part of which is power station cooling waters. However, between one-third and one-half of the total is effluent from chemical factories and oil refineries. Fishing is affected locally, chiefly by tainting by oil of both fish and shellfish. On the south-west coast china-clay wastes are the major problem. These are at present carried by the river waters and a total of about 1.4 million tons/year are discharged into Mevagissey and St. Austell Bays and the Fal Estuary. Approximately 0.3 million tons/year are also discharged into the Plym Estuary. Fishing is affected but it is not known to what extent; a survey this year will attempt to assess the situation.

In addition to the discharge of trade wastes direct from the shore some wastes are disposed of in deeper water offshore by barges. The materials are dumped in recognized areas around the coast and range from harbour dredgings and sewage sludge to gas-works liquors. Apart from harbour dredgings the amounts involved are generally not very great except off the north-east coast where 1 million tons of power station ash and 2 million tons of colliery wastes are dumped in the sea each year. The effect on fisheries of these materials, which are not toxic but increase the suspended matter in the water, appears to be slight. Further investigations are to be made.

(b) Scotland. The industries in Scotland which give rise to the majority of the industrial wastes are iron and steel, coal-mining, pulp and paper or board production, and whisky. The iron and steel and coal industries do not appear to affect fishing interests and no problems arise from that source.

Paper and board production in Scotland give rise to about 2.4×10^3 m^3/day of effluent but most of the mills treat their wastes and discharge them to inland waters and so do not affect marine fisheries. The only pulp mill in Scotland has been in operation for only two years. The effluent carries up to 30 tons of suspended material and has a BOD load of up to

Summary

(i) Belgium

There is very little industrial waste known to be discharged directly to the sea but the one known case takes place in an agreed area outside territorial waters.

(ii) Denmark

There is not a great deal of industry to give rise to wastes. There have been one or two local problems in the past but these are now controlled.

(iii) Federal Republic of Germany

Since most industry is inland there is very little direct industrial pollution of the sea. However, as a result of new anti-pollution laws concerning inland waters the trend is towards disposal of wastes at sea, often in the deep water of the Atlantic by special vessels.

(iv) France

There is not a great deal of industrial pollution from the French coast and there are only three towns which cause any real degree of pollution. All industrial wastes discharged to the sea must satisfy certain conditions. The effects of industrial wastes are thought to be extremely local in nature.

(v) Netherlands

The major source of pollution is the Rhine, which also carries pollution from outside the Netherlands. Rapid expansion of industry is resulting in increased pollution in the Netherlands but apart from a few isolated cases the effects are local. There is a marked move towards the disposal of wastes beyond territorial waters as a result of anti-pollution measures in force in Netherlands and other countries along the Rhine.

(vi) Norway

There is not much industrial pollution at present although it is increasing. The main sources are pulp and timber, electrochemicals and fish processing. Mainly it is the fjords which are affected, particularly Oslofjord; these, as well as the coastal waters are becoming increasingly affected by drifting plastic articles and discarded fishing gear. The latter problem has been shown to be seriously affecting shipping traffic and has definitely hampered local fishing activity.

(vii) Sweden

Large areas of the coastal waters are polluted and fishing is affected. The main sources of pollution are the forest products industries but minor problems arise as new industries, such as chemicals, expand. Mercury pollution of Swedish waters is also a major problem and many inland and some these materials in special circumstances.) As new pesticides are developed they are tested for efficiency in their intended role and for toxicity to fish and a working agreement is then drawn up between the manufacturer and the land and fisheries ministries on the uses to which the new product can be put. It is compulsory to label containers, where appropriate, with warnings as to danger to fish.

Some fish kills have been experienced in inland waterways and one case of tainting of carp in a fish-farm by "gammexane" a distance of 50 Km down-stream of its source has been reported. There is at present little or no work being done on pesticides in the marine field but work will shortly start on this topic at the Institute of Inland and Coastal Fisheries, at the Helgoland Biological Station and at other establishments. Most of the German work to date is summarized by Bauer (1961) but much of the information given refers to the freshwater environment.

(iv) France

Research is carried out at a number of laboratories in France on the subject of pollution by pesticides. Some measurements have been made with marine animals but no results have been published, however the pesticide contents were described as being "extremely low".

Some fish kills have occurred as a result of accidental spillages of herbicides in estuarine waters. A fish kill was observed some years ago in Mediterranean salt ponds after spraying as an anti-mosquito measure. As a result subsequent treatments have been confined to biological measures.

Usage of pesticides is governed by the following legislation: the Law of 2 November 1943 (France 1943) which was ratified by the Ordinance of 13 April 1945 (France 1945) and later modified by the Law of 30 July 1963 (France 1963b). All pesticide formulations must be approved before they can be sold. No maximum permissible pesticide content has been fixed for foods but the matter is being considered. The European Economic Community is at present preparing regulations to this effect.

(v) Netherlands

The Netherlands operates a system of pesticide residue tolerances as published in a Pesticide Residues Order of 1965 (Nederlandse Staatscourant 1965). This Order defines the maximum quantities of a large number of pesticides which can be permitted in foodstuffs. On the general subject of pesticides there is a moderate amount of work in progress and some of this is directly related to the marine environment. All new compounds must be thoroughly tested for their toxicity before they can be used but marine fish are not included in this scheme. Only approved pesticides can be used in applied to the freshwater environment than to the marine environment. It has now been established that very little organo-chlorine pesticide material is washed out of the soil into the river systems. The main supply routes to the marine environment are via rain water and rivers which carry pesticides which have been discharged as a result of industrial usage or accidents, or from the cleaning of agricultural spraying equipment and the disposal of sheep dips.

At present (August 1968) voluntary agricultural chemicals approval and pesticide safety precaution schemes are operated in the U.K. Under the first of these schemes recommendations for the correct usage of the various chemicals are made and the use of unsatisfactory chemicals is discouraged. Under the provisions of the second scheme, new chemicals, or formulations, are not released for general use until recommendations for their safe usage have been agreed by the various government departments concerned. Only pesticides which have been approved should be used and all containers should carry warnings of toxicity to fish or other animals where such warnings are needed.

It has recently been announced that this voluntary system is to be replaced by legislation. The proposed new Law will be called the "Pesticides Bill" and under it a Licensing Authority will be set up. The Authority will consist of the Minister of Agriculture, Fisheries and Food, the Secretary of State for Scotland, the Minister of Health and the appropriate Ministers for Northern Ireland or the Home Secretary on their behalf. A licence, which could be revoked, would be issued by the Authority for a "pesticide product" and this term would include fertilizers with pesticide additives. Conditions attached to the licence will, for example, stipulate the proportion of active ingredient permitted, the uses to which the product may be put and the directions regarding safe usage etc. which must be included on the label.

Under the new law it will be an offence to buy, sell, or import any pesticide product, for use in agriculture in its broadest possible sense, in the home or garden or in food storage, which has not been licensed or which does not fulfil the conditions of that licence. It will also be an offence to use a pesticide product in a way that contravenes the instructions of its licence, e.g. by deliberately overdosing a crop or foodstuff in store, or by continuing to use a pesticide for a purpose publicly announced as no longer allowed.

There are no tolerance limits for residues of pesticides in food in operation in the United Kingdom but a general limit of 0.1 ppm for aldrin and dieldrin in all foods with special exceptions, e.g. 1 ppm in mutton fat and 0.003 ppm in milk, has been proposed (Egan 1967). A clause in the new so far recorded was 19 ppm, generally, however, the level is about 1 ppm. Muscle tissue concentrations are generally lower by a factor of 10 or more and the flesh of oily fish, e.g. herrings, contains the highest concentrations (Portmann 1967).

In addition to the coastal water samples fish are also sent from deep water fishing areas off Norway, Iceland and Newfoundland. These fish usually contain less pesticide material than the specimens caught around England and Wales and the relative proportions of pesticide are usually different. Some analyses are also made of shellfish and the main emphasis to date has been on the analysis of oysters, which are examined at fortnightly intervals. Some analyses have, however, been carried out on shrimps and cockles (Portmann 1967) and others are planned for mussels and lobsters.

Only a very few analyses of sea water have been carried out so far and the concentrations found have been very low, ranging between 9 and 24 parts per million.

Toxicity tests based on the standard 48 hour LC_{50} test described by Portmann (1968) are being conducted and some of the pesticides tested have proved extremely toxic, e.g. an LC_{50} of 0.0003 ppm for azinphos-morhyl to brown shrimps. Experiments are also in progress to study the effects of the time scale factor but these are not yet complete. No information is available at present on the concentrations of pesticide in the animals killed in toxicity experiments but it is hoped to include this kind of work in the programme.

Since 1963, the Nature Conservancy have been analysing the eggs and flesh of coastal species of marine birds. The levels found in the eggs of a number of different species of seabirds varied but were generally within the range 0.2-8.9 ppm (Moore 1965). Analysis of the breast muscle, liver and egg contents combined have been carried out on two groups of seabirds, those feeding on plankton and those feeding on fish etc. The levels found in the plankton-eating birds were generally lower than those found in the fish-eating birds, with only one out of twelve specimens containing a total pesticide residue within the range 2-10 ppm, compared to twenty-three out of seventy-nine specimens in the fish-eating group (Moore 1966).

Summary

(i) Belgium

No work is in progress on pesticides in the marine environment and there is none planned at the present time.

moth-proofing woollen garments and carpets etc., is an important outlet for the pesticide manufacturers. In the United Kingdom this usage of pesticides in industry probably accounts for one-third to one-half of the pesticides discharged to the sea via rivers.

Manufacture of pesticide materials and/or formulation takes place in most of the member countries but the Federal Republic of Germany, the Netherlands and the United Kingdom are probably the main producers. Of the United Kingdom production of pesticides a high proportion is exported. The manufacture of pesticides inevitably leads to the need for disposal both of contaminated wastes and of surplus or superseded stock. The most commonly used method of disposal is sea dumping in deep water in sealed drums.

Considerable quantities of pesticides are transported by sea every year and must be considered to be among the most hazardous of cargoes from a fishing point of view. If a vessel carrying pesticides in its cargo were to be wrecked in the North Sea the effects on marine life could be disastrous. A government committee is at present working in the United Kingdom on methods of reducing the risk of such a catastrophe taking place, e.g. pesticides would be carried in strong corrosion-resistant, clearly labelled containers stowed in a readily accessible position to facilitate ease of salvage, etc.

Treatment of pesticide materials is not an easy problem. Some of the compounds involved, e.g. phenol-based herbicides, may be treatable with hypochlorite which causes splitting of the ring structure and inactivation. Many others are more or less intractable and incineration is often the only satisfactory method of treatment. This method of disposal/destruction can pose problems if not carefully supervised, e.g. through explosion and corrosion. A method of treating waste waters which could possibly be useful is filtration through activated carbon.

Monitoring

Only one country, the United Kingdom, is at present operating a monitoring programme although the Netherlands and the Federal Republic of Germany both have plans along these lines. At present the U.K. programme involves the analysis of fish and some shellfish at fairly regular intervals from a number of coastal and deep-water fishing grounds; seabird eggs are also being examined. Various animals were suggested as being suitable for inclusion in a monitoring programme and it was felt that non-migratory animals were most suitable for this purpose. It has been shown by Butler (1966) in the United States that oysters are good indicator organisms for organo-chlorine pollution since not only can they readily concentrate these materials but they can also excrete them once the polluted waters have passed. It is generally agreed

(iii) Federal Republic of Germany

Oil pollution affects the Federal Republic, particularly in the navigable rivers, and one major oil-spill has occurred in the German Bight. Oil-spill removers are generally toxic to fish whereas the oil is in many cases not thought to be so toxic. Wherever possible oil sinking agents are used and absorbent floating materials such as "Ekopell" (Mann 1966) and peat have been used successfully in harbours and rivers without harming fish. Attempts are being made to find a material which is equally effective at sea.

Some work has been carried out on the toxicity of oil and oil-emulsifier mixtures with the larvae of Clupea harengus and Agonus cataphractus (Rosenthal and Gunkel 1967). This showed that although oil alone did not damage the larvae over a four day period concentrations as low as 0.5 mg/l of solvent-emulsifier, mixed with 2 mg/l of oil, did. Fourteen different solvent-emulsifiers were examined by Kühl and Mann (1967) for their toxicity to sea and freshwater animals. Lethal limits of between 0.001 and 0.1 ml/l were found. Although very little attention has been paid to the toxicity of oil alone to marine animals a report on the toxicity of oil to freshwater fish showed that oil could be harmful at 200 ppm and that motor fuels were toxic at between 40 and 200 ppm depending on the boiling point (Zahner 1962).

At a meeting held in Helgoland in September 1967 a Working Group discussed various aspects of oil pollution and its removal. The main proceedings of that Working Group have been published in the Helgolander Journal (Anon. 1967a) and some of the papers are referred to individually below. For example Wallhauser (1967) reported on investigations into the role of naturally occurring bacteria in the normal breakdown of oil on the sea or on the shore and suggested that cultures of these bacteria might be used to deal with oil-spills in some cases. Wallhauser (1967) has also developed a method of isolating these bacteria which can break down oil, and Gunkel and Trekel (1967) have worked out a quantitative determination technique.

Work by Hellmann, Klein and Knöpp (1966) at Koblenz has suggested that although solvent-emulsifiers are effective in emulsifying oil the emulsion breaks down again in a few hours. However, since dispersion will probably have occurred by then this need not necessarily be important. Work by Gunkel (1967) in Helgoland has shown that the degradation of oil by bacteria is inhibited by the use of solvent-emulsifiers.

(iv) France

Oil pollution of the North Sea coast is caused by passing ships and to some extent by the Dunkirk refinery. Pollution due to oil refineries has caused some damage to marine life and certain inshore areas are no longer out oil, have shown promise for use in sheltered waters.

(vi) Norway

Three oil refineries are either in production (2) or being built (1) but so far no spills have occurred and stringent measures are taken to prevent them. Some experience has been gained however in dealing with accidental oil-spills and an official "Oil Pollution Commission" advises on means and techniques for the treatment of oil-spills. Mechanical recapture followed by cleaning of beaches using emulsifiers has been used; for example, after the stranding of a tanker on the west coast of Norway in spring 1968 which caused an oil-spill of several hundred tons. Only a minor part of this was recovered and the cleaning of beaches using solvent-emulsifiers is still in progress (August 1968) in a few places. To date approximately 30 000 litres of detergent have been used.

(vii) Sweden

As in other countries, oil pollution as a result of accidental oil-spillages does occur. No definite procedures have been devised for treating oil-spills but where oil is on the sea it is usually dispersed or collected by various methods, e.g. peat, because of dangers to bird life and recreation areas.

(viii) United Kingdom

Oil pollution is quite an important problem in the United Kingdom although Scottish waters are less seriously affected. Release of oil accidentally at oil terminals or for one reason or another from ships at sea results in about 50 000 tons of oil contaminating the coast and coastal waters of the United Kingdom each year. This figure was exceeded in 1967 when the wreck of the TORREY CANYON alone resulted in approximately 100 000 tons of oil polluting the waters off the south-west coast, and of this about 20 000 tons actually reached the coast of Cornwall causing serious pollution of beaches, cliffs and harbours.

The general practice in the United Kingdom is to treat oil on beaches with oil-spill removers provided these beaches are not in estuaries or near other important shellfish areas. The toxic nature of solvent-emulsifiers is recognized but it is accepted that, in many instances, in the interests of beach amenities and of seabirds, steps must be taken to clear the oil. Each large oil-spill is considered on its merits before permission is given to use solvent-emulsifiers: in minor incidents the local authority - or at an oil terminal the company concerned - usually deals with the problem. A report by the Warren Spring Laboratory of the Ministry of Technology (1968) advises on the various methods of dealing with oil pollution and at the same time claimed by Cooper (1968) that the rate of bacterial decomposition of oil is enhanced when materials such as chalk are used. On the matter of bacterial decomposition, observations after the TORREY CANYON incident indicated that although bacteria were initially killed off by the solvent-emulsifiers they rapidly recovered and attacked the oil.

Summary

(i) Belgium

Has had only limited experience with oil pollution which has been dealt with chiefly by bulldozing it on beaches or by solvent-emulsifiers.

(ii) Denmark

Until recently oil sinking agents have been used to deal with pollution by oil but these are now suspected of causing tainting of fish and contamination of fishing gear and are no longer used.

(iii) Federal Republic of Germany

The main problems arise in estuaries and rivers and since solvent-emulsifiers are recognized as being toxic, sinking and floating absorbent agents are preferred although owing to the difficulties involved in using these materials solvent-emulsifiers are frequently used. Research work is in progress on various methods for dealing with oil and of oil degrading bacteria. In 1967 a committee was set up, within the Ministry of Traffic, to deal with oil accidents on the sea.

(iv) France

Oil pollution is a recurrent problem on the French coast. Considerable experience was gained in both the effects of oil pollution on marine life and the ways of combating it, at the time of the TORREY CANYON disaster. Standard procedures are now being worked out which will lay down the organizing body and methods to be used in the event of oil pollution occurring again.

(v) Netherlands

Oil pollution presents a recurrent problem on beaches and bulldozing has been the method used for dealing with serious oil pollution. Solvent-emulsifiers are being considered but there is a reluctance to use them because of their toxicity. A committee receives regular reports from coastal towns on the state of the beaches and also from lightvessels etc. on floating oil patches.

(vi) Norway

Complaints of oil-spills have occasionally been received. Oil in Oslofjord and from accidental losses on the coast are the main causes of complaints. There is no generally accepted method for dealing with oil

North Sea has been defined as being that area south of latitude 61°N, including the Skagerrak, as far as a line in the English Channel, the exact position of which remains to be fixed.

Domestic detergents

Household detergents were briefly discussed under this heading and it was concluded that there is very little chance of these materials being damaging to marine life, particularly now that many countries are using biologically "soft" detergents. In Germany, where the river system carries large volumes of sewage effluent, the sale of "hard" detergents is forbidden by law. In the United Kingdom "hard" detergents have almost completely been replaced by "soft" materials on a voluntary basis.

(6) Toxicity studies, methods and results

Information on the topic of toxicity experimentation was rather scattered and has been collected together under sub-topic headings rather than by national contributions as in other sections. Brief notes are, however, included concerning the work being done in the various countries which were members of the Working Group.

Type of test

Only one country, the United Kingdom, had toxicity testing apparatus actually in continuous operation, with two laboratories - one run by Imperial Chemical Industries (I.C.I.) in Devon and the other by M.A.F.F. - carrying out tests on a routine basis. Both of these laboratories conduct short-term (5 days or less) toxicity experiments as routine with the object of determining lethal doses to 50 per cent of the test organism. The apparatus used by M.A.F.F. has been fully described by Portmann (1968) and that used by I.C.I. is similar (Carter 1963), the main different being one of scale. I.C.I. uses a larger arrangement. The drawback to any static water system, such as these, is that toxin may be lost from the water by one means or another during the course of the experiment. This loss naturally becomes more serious the longer the experimental period. To overcome this difficulty continuous flow methods must be devised and although a number of these have been used in the freshwater field, such methods do not yet appear to have been widely used in the field of marine toxicity testing.

There are many advantages in studying lethal doses over a relatively short period, among them that feeding is unnecessary and that complications arising as a result of a "normal" death rate are negligible. However, such experiments give no information about sub-lethal effects and frequently do not even give information on the threshold lethal concentrations. The classical methods for obtaining threshold concentrations have been described shrimp and crab larvae (Portmann and Connor 1968), barnacle larvae (Corner, Southward and Southward 1968), but most experiments have been carried out on the adult or partly-grown adult stages of the species. It was generally agreed that larvae are more sensitive than adults to a particular toxin (see e.g. Portmann and Connor 1968). Similar results have been experienced with young shrimps (Portmann 1968) and with fish where the size measured by body weight was related to metabolic rate by a fixed power of between 2/3 and 1 and this in turn was related to death rate (Boetius 1960).

Although no definite conclusions were drawn, there was a general feeling that any meaningful toxicity testing should be carried out with representatives of the different groups of marine life, e.g. fish, crustacea, mollusca, flagellates, etc., and that care should be taken to avoid using the more resistant members of each group. It was also felt to be undesirable to base all conclusions on tests with very sensitive species. Tests with various stages in the life cycle of the test organism were generally felt to be important, with different member countries emphasizing different stages.

Factors affecting susceptibility

A number of factors were mentioned as affecting susceptibility of the test animal and work by Boetius (1960) and Portmann (1968) has already been mentioned in the section above. In the same paper Portmann gives details of the effect of starvation and found that it increased susceptibility. Details are also given of experiments carried out at various temperatures and although different responses were noted with different organisms, there was a general pattern of increased susceptibility with rise in temperature. The influence of feeding conditions on the uptake of radionuclides by cod has been noted by Berge (1964). Sundnes (1957) discussed the acclimation time of cod and noticed that small changes in the environment might affect the oxygen uptake. Thus, for example, a change in observer caused an immediate rise in the oxygen uptake by cod (Sundnes, unpublished work).

The period of exposure to a toxin is clearly important, particularly where lethal concentrations are in question, and this subject was briefly discussed above under the heading of "Type of test" when work by Wuhrmann and Woker (1948, see also 1953) was mentioned as having shown that many chemicals do have threshold concentrations.

Important environmental effects are not confined solely to the higher marine life. Measurements of photosynthesis in phytoplankton have demonstrated that such organisms are sensitive to the quality of the bottles as well as to the techniques applied in washing them.

1967a and b). Routine toxicity tests are carried out. Some tests with caged fish to study their susceptibility to certain pollutants, especially those from the pulp and paper industry, have been conducted (Hasselrot 1964).

(viii) United Kingdom

Two main laboratories are carrying out routine toxicity testing. Most experiments at present are based on lethal concentrations. Some experiments, however, are intended to measure sub-lethal effects and work is in progress on the development of methods of studying such factors as oxygen uptake, growth rates and possible avoidance behaviour. A variety of marine organisms are used which include representatives of several biological groups, e.g. fish, molluscs, crustacea and algae.

(7) Review of transport and diffusion mechanisms with respect to the pollution of the North Sea

The polluting substances can be divided into three groups:

(1) dissolved substances and substances forming a stable suspension;

(2) substances floating at the surface (for instance, oil);

(3) substances temporarily in suspension which are slowly sinking to the bottom.

Under certain conditions substances from one group may pass into another, for instance, if dissolved substances are adsorbed on sediment particles, they change from group (1) into group (3). The processes of transport and dilution of the polluting substances may be different for the different groups. This report will deal mainly with substances of group (1).

We may consider the following processes:

(1) initial dilution (determined by the method by which the polluting substance is discharged into the sea);

(2) turbulent diffusion: (a) vertical diffusion;
(b) horizontal diffusion;

(3) advective transport.

It is important to point out that in many cases people are not so much concerned about average processes of diffusion and transport, but rather more about the chance that certain extreme conditions may occur that are thought to be critical. The probability of such an occurrence in similar situations is usually estimated directly from a statistical analysis of a long time series of values of the relevant variable. However, no long series of observations of rates of diffusion has been made and the limited number of long series of current observations is insufficient for most transport problems. In this case we can only make an indirect assessment by considering the influence on diffusion and transport of such better documented factors as wind field and river outflow.

Joseph (1954) has estimated the vertical diffusion coefficient K_z due to the tidal current at a station off Texel. A review of values of K_z and of the coefficient of eddy viscosity N_z, which is of the same order of magnitude as K_z, has been given by Bowden (1964).

From the practical point of view we may divide the North Sea, apart from the near-coastal waters where salinity stratification occurs, into three main regions: the region with vertical homogeneous water during the whole year, the region with a summer thermocline, and the region with a permanent salinity stratification along the Swedish and Norwegian coasts (Dietrich 1950; Laevastu 1963). The conditions for which a thermocline develops have been described by Dietrich (1954). An atlas, giving the monthly average depth and intensity of the thermocline from July till September is given by Tomczak and Goedecke (1964). A review of these investigations may be found in the publication of Sager (1965).

In the shallow areas of the southern North Sea where no stratification occurs the values of the vertical diffusion coefficient are determined by turbulence generated by the tidal currents. Some variation of the diffusion coefficient is therefore to be expected from one area to another, according to the strength of the tidal flow. In the bottom layer of the region with a temporal or permanent stratification tidal or other currents (together with the bottom roughness) determine the value of K_z, while in the upper layer above a thermocline the wind will usually be the determining factor. In the latter case the diffusion coefficient may show irregular variations with time. Diffusion through the thermocline will be slow and is often negligible.

Horizontal transport by diffusive and advective processes

No sharp distinction is possible between processes to be classified under the headings "turbulent diffusion" and those that are considered as transport. A small-scale view may regard as transport those processes which, on a larger-scale view, would more reasonably be regarded as diffusion. Usually the nature of the problem under consideration will determine where the boundary between the two methods of description has to be drawn.

Thus, for a few days following a point source release the tidal currents may be regarded as producing mainly advective transport. However, at later times, or when considering a continuous discharge, they may be considered as a system of large-scale turbulent eddies. Therefore, in most cases it will be necessary to investigate the hydrographic conditions in the area under consideration, and especially the circulation patterns of different scales. The publications that are relevant to such a study can be found for the years prior to 1961 in the bibliography prepared by Model (1966).

approach being considered. Experimental results have provided some confirmation of the above equation although verious values of n have been indicated within the range stated.

The area of significant pollution, that is the area in which the concentration exceeds some critical value, changes with time in the following manner. At first this area will increase rapidly then, after reaching a maximum value, it will decrease again until it finally reaches zero. The time taken to reach the maximum area of significant pollution will depend upon the rates of diffusion, the quantity of substance released and the critical concentration. Formula and diagrams for this process are given in the publication of Joseph and Sendner (1958).

(2) The waste is released into the open North Sea in a relatively short time in the form of a straight line.

Although there are clearly practical differences between a release along a line and a point release, most of the comments above will be found to apply in both cases. However, the value of n in the formula quoted for the decrease of the maximum concentration with time is unlikely to exceed 2.

The concentrations of a pollutant in the case of a continuous release are dependent on the transport as well as on the diffusion. In this case the general practical rule cannot be given, as the prevailing conditions and the local situation are decisive.

Transport

Transport of pollutants by tidal currents can be evaluated using tidal current atlases as published by different authorities.

For a study of the transport by residual currents the variability of the current pattern for different conditions of stratification, river run-off and windfield has to be taken into account. Apart from the fact that charts of residual currents are often based upon rather scanty field data, these charts do not in any case give predictions for extreme critical situations. An impression of the influence of these factors may be obtained from the investigations of long series of current observations. Up till now this means the observations made from lightvessels. In this connection may be mentioned the work of Carruthers, Lawford and Veley (1950a and b); Lawford and Veley (1955); Mandelbaum (1956) and Veley (1959), in which the relation between the residual current and the local wind is studied. A study of the effect of the local wind on the current near the Netherlands lightvessels is in preparation by the Royal Netherlands Meteorological Institute, while publication of similar results for a number of German lightvessels is envisaged by Mandelbaum (personal communication). It can be expected that more information on this subject will become available in future since the

the wind speed (Smith 1968) in the same direction as the wind. This transport is superimposed on the general movement of the water.

If, on the other hand, the pollutant is in a particulate form or becomes adsorbed on particles, sedimentation must be considered. In that case the variation of the current with depth has to be taken into account, and in the presence of tidal currents the settling lag, as well as the effect of high seas, stirring up bottom material. This problem is very complex and an adequate review falls beyond the scope of this report.

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APPENDIX 2

Test material	48-hour LC_{50} expressed in ppm				
	Pandalus montagui	Crangon crangon	Carcinus maenas	Cardium edule	Ostrea edulis (5 days)
Copper as $CuSO_4$	0.14	29.5	109	1.0	> 100
Zinc as $ZnSO_4$	9.5	110	14.5	257.5	116.5 (7 days)
Lead as $PbNO_3$	c. 375 mechanical			> 500	
Mercury as $HgCl_2$	0.075	5.7	1.2	9.0	(Crassostrea) 4.2 (7 days)
Nickel as $NiSO_4$	139	125	255	> 500	100-150
Iron as $FeCl_3$ $6H_2O$	39	56	90-100	190	
Cyanide as KCN	c. 0.25		> 5.0	> 25.0	
Thiocyanate as NaCNS	> 6.2	> 500	> 500	> 500	
Phenol C_6H_5OH	17.5	23.5	56	> 500	
Octyl Phenol 11 Ethylene oxide	10.8	> 100	> 100	19.6	
Nonyl Phenol 12 Ethylene oxide	19.3	89.5	> 100	92.5	> 100
Dobs JN	> 100	> 100	> 100	> 100	
Dobs 055	> 100	> 100	> 100	34.3	
Lauryl Ether Sulphate 3 Ethylene oxide	> 100	> 100	> 100	24.0	> 100
Coco Monoethanolamide		> 100		> 100	
Coco Monoethanolamide 4½ Ethylene oxide 4/5 Ethoxy Monoethanolamide		> 100	> 100	> 100	
'Toxion'	0.98	6.6	163	27.4	
'Compass'		> 100	> 100	> 100	
'Doxcide'	> 500	> 500	> 500	> 500	
'Gamlen O.S.R.'	12.5	8.8	20.4	15.8	15-50
'Polyclens'	8.5	15.7	23.2	70.0	
'Slix'	12.1	114.5	> 300	12.7	c. 100
B.P. 1002	5.8	5.8	10-25	81.0	50-100
Cleanosol	32.0	44.0	100-105	19.2	
Essolvene	8.6	9.6	15-20	63.0	50-100
Gamlen 'D'	11.5	9.6		38.8	
Gamlen 'CW'	14.6			69.5	

APPENDIX 2 (continued)

Test material	48-hour LC_{50} expressed in ppm				
	Crangon crangon	*Agonus cataphractos*	*Cardium edule*	*Asterias rubens*	*Sabella pavalina*
Red Mud	> 100 000	> 100 000	> 100 000	> 100 000	
Hydrochloric Acid	100-330	100-330	330-1 000	100-330	
Nitric Acid	100-330	100-330	330-1 000	100-330	
Sodium Hydroxide	33-100	33-100	330-1 000	33-100	33-100
Sodium Chloride	10-20 x dilution*	10-20 x dilution*	< 5 x dilution*	20-30 x dilution*	20-30 x dilution*
Pea Waste	> 100 000	> 100 000	> 100 000	> 100 000	

* These figures indicate dilutions of a concentration of sodium chloride of 300 parts per thousand with sea water.

(a) their national organization for dealing with oil pollution;

(b) the competent authority responsible for receiving reports of oil pollution and for dealing with questions concerning measures of assistance for all Contracting Parties;

(c) new ways in which oil pollution may be avoided and about new effective measures to deal with oil pollution.

Article 5

(1) Whenever a Contracting Party is aware of a casualty of a presence of oil slicks in the North Sea area likely to constitute a serious threat to the coast or related interests of another Contracting Party, it shall inform without delay that other State through its competent authority.

(2) The Contracting Parties undertake to request the masters of all ships flying their flags and pilots of aircraft registered in their countries to report without delay through the channels which may be most practicable and adequate in the circumstances:

(a) all casualties causing or likely to cause oil pollution of the sea;

(b) the presence, nature and extent of oil slicks on the sea likely to constitute a serious threat to the coast or related interests of a Contracting Party.

Article 6

(1) For the purposes of this Agreement the North Sea area /with the exception of the English Channel westwards of a line from .... to ..../ is divided into the zones shown in the Annex to this Agreement.

(2) The Contracting Party within whose zone a situation of the kind described in Article 1 occurs, shall make the necessary assessments of the nature and extent of any casualty to a ship or, as the case may be, of the type and approximate quantity of oil floating on the sea, and the direction and speed of movement of the oil.

/(3) The responsibility for making the assessments referred to in paragraph (2) of this Article in respect of the English Channel area as defined in paragraph (1) of this Article shall be the subject of special arrangements made between the Governments of the United Kingdom and of France after consultation with the other Contracting Parties concerned./

(4) The Contracting Party concerned shall immediately inform all the other Contracting Parties of its assessments and of any action which it has taken to deal with the floating oil and shall keep the oil under observation as long as it is drifting in its zone.

Notes for a Protocol of Signature:

The Contracting Parties agreed that the provisions of this Agreement should also be applied to hazards as described in Article 1 arising from noxious or hazardous substances other than oil.

The southern limit of the Skagerrak is determined by a line joining Skagen-Pater Noster Scerry according to the International Hydrographic Bureau's "Special Publication", No. 23, 1950.