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Measures for preventing pollution in harbours and on coasts. Means of minimizing and remedying such pollution.

Mesures de prévention contre la pollution des ports et des côtes. Moyens de la réduire et d'y remédier.

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Section II - Ocean Navigation - Subject 6

Measures for preventing pollution in harbours and on coasts.
Means of minimizing and remedying such pollution.

GENERAL REPORT

by

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LIST OF PAPERS PRESENTED :

Australia : A.B. Hicks, B.C.E., M. Sc. (Eng.), D.I.C., D.H.E. (Delft), M.I.E. Aust., M.A.S.C.E., M.I. Struc. E. Commonwealth Department of Works, Australia; T.D. Meagher, B.Sc. (Hons.), Ph.D., Environmental Resources of Australia Pty. Ltd.; P. Waterman, B.A., Dip. I.T. (W.A.), Environmental Resources of Australia Pty. Ltd.

Belgium : Ir. M. De Wilde, Chief Engineer of Technical Service, Port of Antwerp and Ir. P. Lagrou, Chief Engineer-Director of Bridges and Roads, Ministry of Public Works, Ghent.

Canada : J.H. Birtwhistle, Deputy Chairman, Bd of Steamship Inspection, Marine Services, Department of Transport, Ottawa.

Denmark : B.O. Juhl, Chief Engineer, Port of Esbjerg Authority.

France : Michel Pechere, Ingénieur des Ponts et Chaussées, Directeur de l'Exploitation du Port Autonome de Marseille.

Germany (F.R.) : Dipl.-Ing. Carl Boe, Baudirektor, Strom- und Hafenbau, Hamburg; Dipl. Ing. Wilfried Bohlmann, Oberbaurat, Strom- und Hafenbau, Hamburg; Dipl.-Ing. Dieter Lerch, Baurat, Strom- und Hafenbau, Hamburg; Dr. rer. nat. Fritz Lucht, Wiss. Angestellter, Wasser- und Schiffahrtsdirektion, Hamburg; Dr. ref. nat. Manfred Nauke, Wiss. Angestellter, Deutsches Hydrographisches Institut, Hamburg; Dipl.-Ing. Horst Oebius, Wiss. Angestellter, Versuchsanstalt für Wasserbau und Schiffbau, Berlin; Dipl.-Ing. Fritz Reuter, Präsident der Wasser- und Schiffahrtsdirektion, Hamburg; Dr.-Ing. Heinz Wismer, Regierungsbaurat, Wasser- und Schiffahrtsdirektion, Hamburg.

India : M.V.K. Menon, Deputy Conservator, Cochin Port Trust.

Netherlands : ir. G.J.R. Nales, Chief Engineer in the Department of Cleansing, Disinfecting, Transport and Workshops, Rotterdam and Dr. Ir. P.K. Baaij, Chief Engineer of the Laboratory of the Government Institute of Sewage, Purification and Industrial Waste Treatment, Voorburg.

Portugal : Joao A.A. Bello, Managing Director, Gaslimpo-Sociedade de Desgasificaçào de Navios, S.A.R.L., Carlos M.S.B. Pimentel, Secretary of Portuguese Commission for Prevention of Pollution of the Sea, Ministério da Marinha.

Spain : Francisco Enriquez Agos, Dr. Ing. de C.C. y P., Subdirector General de Costas y Senales Maritimas del Ministério de Obras Publicas; Enrique Sanz Pareja, Dr. Ing. de C.C. y P., Jefe del Negociado de Saneamiento y Defensa de la Direccion General de Puertos; Leopoldo Pellon Diaz, Dr. Ing. de C.C. y P.

Sweden : A. Waldemarson, Port Director of Malmö.

United Kingdom : Capt. A.F. Dickson. Extra Master Mariner, FIN Director, Shell International Marine Limited and J.H. Potter, B.Sc. (Tech.), C.Eng., MICE Chief Engineer, River and Principal Pollution Control Officer, Port of London Authority.

U.S.A. : Donald A. Wahls, Director of Planning & Research, Port of Los Angeles.

INTRODUCTION

The thirteen papers submitted contain, among them, an extremely comprehensive review of present day knowledge in the field of pollution of coastal and ocean waters. They deal with all aspects of the problem, including causes, effects, methods of minimizing and combating pollution and the current status of anti-pollution laws. Most of the papers deal in general terms with the problem of pollution but several deal in very specific terms.

Discussion of the various papers follows :

Australia

This paper deals with the various studies which were carried out in connection with the construction of a 2 1/2 mile long causeway between the mainland of Western Australia and Garden Island. Garden Island, which runs parallel to the mainland coast and which helps form a body of water known as Cockburn Sound, was to be the site of a new Australian naval base and it was necessary that highway access be provided to this off-shore area. A causeway was selected over a shorter bridge because it would supply protection to the lower end of Cockburn Sound, which was to be subsequently developed by the nearby port of Fremantle.

The chief concern of the Authorities charged with the construction of the causeway was that the proposed structure might restrict the flow of water through the southern entrance to Cockburn Sound, to a point where there might be significant damage to the marine ecosystem. Their concern was heightened by the fact that a large portion of the mainland shore of the Sound was devoted to an oil refinery, a steel plant and other industries which handle potential pollutants and which generate polluting effluents. Some of the beaches along the Sound provided a recreational area for the people of Fremantle and Perth and the Authorities were anxious that these invaluable facilities not be disturbed.

To achieve the best possible design for the causeway, an extensive, multi-discipline environment investigation programme was initiated. This programme, which provided for continual environmental studies throughout all phases of the causeway project, showed, the authors state, that the commencement of such construction work need not be delayed until a final environmental assessment had been made.

The authors stress that investigations of this type must be carefully planned so that unnecessary data is not assembled and so that costs are kept within reasonable bounds. In the preliminary stages, the investigators should make full use of existing information and should obtain generalized data and opinions from qualified environmentalists. Once this has been done, it is possible to formulate a definite plan of attack and the necessary investigations can be commenced. At this point the authors stress that, although the investigations are to be made by a multi-disciplinary team, it is essential that they be led by an engineer, since only an engineer can possess an over-all view of the project.

The authors describe the philosophy of their investigations at some length and detail the seven steps which were followed in each of their various studies.

The group which directed the investigations included biologists, botanists, chemists, engineers, geologists and geographers. Among them were experts in the fields of marine ecology and biology, marine botany and algology, water chemistry and analysis of animal flesh for toxic contaminents, near-shore hydrology, coastal geomorphology and sedimentology and coastal engineering.

The paper describes Cockburn Sound as a « barred basin », inasmuch as it is totally enclosed by Garden Island on the west and mainland Australia on the east and is partially closed-off by shallow sandbanks at the northern and southern entrances. The chief concern of their studies was, therefore, to determine (1) the rate and nature of the natural replacement of water (if any) within the Sound (2), the effect of a causeway across the southern entrance and (3) the long-term effects of the causeway, combined with the continued disposal of industrial waste into the Sound.

To provide partial answers to the foregoing questions, a number of hydrological investigations were carried out. These included measuring of the salinity/temperature characteristics of the Sound, recording of water velocity and direction profiles with a direct-reading current meter, measurement of current velocity and direction with continuous-recording current meters, tracking of drogue floats and release of dyes, with associated aircraft observation.

The salinity and temperature surveys revealed that complete replacement of water in Cockburn Sound did take place and that the replacement period varied from 1 to 3 weeks. This study also showed that the water movement was generally northward in the summer and southward during the winter and that the movement of water in the Sound is largely independent of either tide or wave action.

The metering studies generally confirmed the conclusion reached from the salinity/temperature survey and the float studies overcame certain inconsistencies which were noted during the salinity profiling and the current metering.

During the course of all investigations, fluctuations of dissolved oxygen levels were recorded and these fluctuations could be directly related to the photosynthetic processes of the seagrass meadows. Also, light penetration measurements were taken. These measurements related industrial discharge-caused turbidity to the breakdown of the seagrass meadows.

The paper summarizes the hydrological investigations by stating that the water exchange in Cockburn Sound is dominated by oceanic currents and that the localized influence of wind and tide are unable to individually dominate the water exchange.

Other investigations included studies of coastal stability and these studies concluded that seagrass and its root material are the major stabilising element for off-shore sediments. The beach morphology studies included :

(1) Seasonal profiling of the beaches, to determine their fluctuations with regard to configuration and volume.

(2) The tracking of dyed sand.

(3) Physical and chemical analysis of sediments.

From the foregoing studies the authors conclude that the beaches of Cockburn Sound are in a state of dynamic equilibrium and that any changes in beach formation can be monitored and related to either man-induced or natural phenomena.

The principal purpose of the investigations initiated by the need for the causeway was to establish an ecological baseline for monitoring environmental change. Such monitoring would then permit the concerned Authorities to develop a programme for the Sound which could permit the use of its water for industrial, recreational and navigational purposes.

In establishing its baseline, the investigating team posed for themselves four ecological questions and then proceeded to discover answers to these questions. Their investigations covered various studies of the seagrass communities, a study of the distribution of algæ on seagrass fronds, a study of the biology of a group of filter-feeding sedentry animals (mussels, clams, etc.), a study of plankton distribution, chemical analysis of contaminated and non-contaminated water samples, contaminated and non-contaminated bottom sediments and algæ from polluted and non-polluted areas, micro-biological investigations to determine the dispersion of bacteria from Fremantle sewer outfalls into surrounding waters, an evaluation of spillage from ships operating in Cockburn Sound and a study of the thermal pollution effects of industrial cooling water discharged into the Sound.

The ecological investigations indicated clearly that it was essential that adequate water circulation be maintained in Cockburn Sound and, to accomplish this, two bridged openings, located at the sections of maximum flow, were incorporated into the causeway.

A further finding of the ecological investigation was that pollution-caused deterioration of the environment was the result of improper introduction of the pollutants into the Sound, rather than their chemical composition.

The authors indicate that further ecological assessment of the Sound will be made during the coming years.

The paper continues with a detailed description of matters relating more directly to the actual construction of the causeway than to the ecological effect of the completed causeway. Such matters as sounding surveys, testing of soils, quality of construction materials, wave conditions at the causeway site and hydraulic model testing are discussed at some length.

In conclusion, the authors indicate that they are pleased with the results of the multi-disciplinary approach to this problem and they state that cooperation, among the various disciplines, is not difficult to achieve « when each discipline is accorded its appropriate place ». They go on to state that all-encompassing approaches of this type can prove to be expensive. Finally, they admit that, while the « completion of the causeway has demonstrated the adequacy of the normal engineering investigations » it is still too early to state with certainty that the group's ecological conclusions have been fully verified.

Belgium

The paper states that water pollution in Belgian ports can be divided into two principal categories :

(1) The discharge of pollutants directly into the waters of the ports by vessels, industrial plants and municipal sewers, and

(2) by the adduction of polluted waters by the rivers on which the ports may be situated.

A special category of pollution is that caused by petroleum products and this matter is dealt with later in the paper. The authors state that, while all Belgian ports have polluted waters brought to their boundaries by the rivers on which they are situated, the port most acutely affected by this situation is Ghent, which is situated on the rivers Scheldt and Lys. These rivers rise in Northern France and flow through highly industrialized areas of France and Belgium. While both rivers are badly polluted by industries and communities lying along their upper reaches, the Lys has an additional problem which is caused by the discharge into it of waste waters from the flax-retting industry. This pollution is so severe that, for six months per year, the Lys' waters must be made to by-pass the city of Ghent. There are no water treatment plants along the Belgian section of the Lys.

The Lys and the Scheldt join at Ghent and their waters are further polluted by the fact that these streams must also act as the city's sewers.

To the pollution of Ghent's sewers and the pollution brought to the city from inland communities is added the industrial discharges of the port itself. The quality of the water in the port is equivalent to that which would be created by a community of one million inhabitants (Ghent has a population of 270,000) which discharged its untreated sewage into the waterway. In Ghent, all of the factories, except the very newest, discharge their cooling and waste waters, without treatment, into the waters of the port area. Ports such as Ghent are greatly handicapped by the fact that much of their polluted water originates outside their boundaries and they are unable to act effectively without cooperation from the national Government — and even foreign Governments.

The authors divide the prevention of water pollution into two categories : (a) the drafting of regulations controlling the discharge of polluted materials into waterways and (b) the actual treatment of industrial and domestic wastes before they are discharged.

Dealing with regulations, the authors state that Belgium has had simple anti-pollution regulations on its statute books since ancient times. However, it was not until 1950 that more comprehensive laws were drafted. These laws require that all dischargers into rivers, canals, etc., receive authorization and they laid down certain basic rules regarding waters which were to be used for various purposes. Despite the numerous decrees emanating from the 1950 pollution law, pollution still proved very difficult to control in actual practice.

This situation developed from divided authority, complicated administrative procedures and the fact that the cities were still permitted to discharge untreated domestic sewage into the rivers and streams.

The 1950 law was replaced by a new anti-pollution law in 1971. This new law centralized the administrative authority and gives the pollution control authorities greater powers to achieve wholesale purification.

A recent study of polluted waters of the Port of Ghent indicated that the left bank of the canal, where the older industries are located, was by far the greatest local contributor to the pollution situation. On the right bank, the big, modern industries have special water purifying plants and no special action is required in their cases. For the left bank, however, a central purifying plant, complete with collector sewers, is recommended. Once this system has been put in place, the pollution in the port of Ghent will be limited to pollutants brought in from upstream and to petroleum products which may accidently escape into the water. The authors are hopeful that new Belgian and French anti-pollution measures will soon improve the quality of the water being brought to the City by the Scheldt and the Lys.

Turning now to pollution by hydrocarbons, the authors state that this has developed into an acute problem during the past several decades. The petroleum products not only pollute the ports' waters but they also present a fire hazard.

The paper points out that the risk of petroleum spills is closely related to the number of vessels powered by petroleum products, the number and deadweight of tankers using the port facilities and the increasing number and size of the refineries located adjacent to the harbour. Illustrations accompanying the paper clearly indicate the manner in which the opportunities for oil spills have steadily increased during the past sixty years.

Petroleum pollution can result from two situations : (1) the discharge of process water from refineries and washing waters from tankers and (2) accidents which occur during bunkering, during loading and unloading of petroleum products and as a result of collision leakage and breakdowns. Pollution caused by the first situation can be controlled by adequate regulation and treatment. Pollution caused by the latter situations, being usually the result of human error, is not so much subject to regulation and, therefore, the main hope lies in the field of successful clean-up techniques.

With regard to improvement of process water from refineries, the paper states that petroleum losses from this source can be reduced to acceptable levels by means of air-cooling and re-cycling. In the case of washing water from tankers, the loss of petroleum products can be reduced to acceptable levels through the use of the « load-on-top » system and the introduction of more land-based cleaning and storage stations.

Equally as important as the development of methods of treating process water and washing water is the development of techniques for the cleaning-up of petroleum which has been spilled into the water. The containment and the removal of such spills is accomplished by absorption products, detergents, mechanized removal apparatuses, separation gates, air-bubble curtains and floating booms. Many of these methods have been tried and, later, rejected. For various practical reasons, the authors believe that, for closed areas such as the port of Ghent, the best solution lies in the use of floating oil skimmers, used in conjunction with « carefully selected detergents ».

After intensive studies, regarding the best type of floating oil skimmer, the authors further conclude that the vacuum-pumping type is superior. Such a unit was constructed and put into service, in Antwerp, in 1954 and a detailed description of its operation is included in the report. Refinements, to the operation of this unit, were effected over the years and the 1955 ratio of 1 litre of petroleum product to 28 litres of pumped emulsion, was reduced to 1:2.2 by 1971. In 1967, during a major oil spill, the unit was able to recover an average of 100 tons of oil per day, over a 12-day period.

The authors believe that the Antwerp floating oil skimmer has more than proved its worth and they feel that an up-to-date and larger variation of the existing unit is urgently needed for the port.

Canada

The paper states that pollution from ships arises from three principal sources :

(1) Spillages resulting from accidents.

(2) The need to clean the interior of the ships with water prior to loading different cargoes.

(3) The discharge of sewage, garbage and bilge water.

With regard to the discharge of petroleum products into the sea, the paper indicates that, in the past, up to ten million tons of oil have been discharged into the oceans in a single year. This figure has now been reduced to 1/10th of the record tonnage but even this amount is considered unacceptable and efforts should be made to achieve an additional 90% reduction.

The author discusses the various types of pollution individually and indicates the procedures currently being adopted to minimize and/or remedy each type.

Pollution by oil : It can be considered that, for practical purposes, all modern ships are fuelled by petroleum products and their bunker tanks have capacities ranging from 300-5,000 tons. These fuels range from light diesel oil to heavy bunker « C ». A portion of this fuel usually ends up in the sea, as the result of the discharge of bilge and ballast water. This situation can be remedied by means of better housekeeping aboard the ship and by not using fuel oil tanks for the carrying of ballast water.

More important than the foregoing, however, is the oil which reaches the sea as a result of tank-cleaning on oil tankers. This process takes place because of the need to use a portion of the oil tanks as ballast tanks when these vessels are travelling light. This type of pollution can be all but eliminated by the use of the « load-on-top » method. However, at the present time, a substantial portion of the world's tankers are unable or are unwilling to use this system. The author suggests that, if these vessels are to avoid discharging oil into the sea, the only solution for them is to have shore reception tanks available at all ports used by vessels of this type.

One solution to the tank-cleaning-water problem would be to completely separate the cargo-carrying tanks from the ballast tanks. While this solution would be a 100% effective from the pollution point of view, it would add greatly to the capital costs of the vessels. The author feels, however, that since the additional cost is proportionately less with the large new tankers presently being built, this method will eventually be universally used.

A serious cause of oil pollution at sea is spills resulting from ship-wrecks, collisions and groundings. While accidents at sea can never be totally eliminated and while it is not possible to construct ships in a manner which would guarantee total retention of their fuel/cargo in cases of such casualties, it is possible, if costly, to construct vessels in a manner which would greatly reduce the possibility of oil pollution in such circumstances. The author suggests that this end could be achieved by limiting the size of cargo tanks, by installing double bottoms, by locating fuel and cargo tanks in less vulnerable parts of the ship and, ultimately, by using complete double hulls.

Obviously, the best method of preventing accident-caused oil pollution at sea is to prevent the accidents themselves. The paper suggests that the number of accidents can be greatly reduced through the use of traffic routing schemes, by increased and improved navigational equipment, by traffic control and through the use of more highly qualified seamen.

The paper deals at some length with methods of treating oil spills at sea, when they do occur. The first step should be the containment of the spill and booms are suggested for this purpose. There are many manufactured booms on the market but, when such booms are not readily at hand, it is possible to jerry-rig booms from logs, barrels, etc. Once the oil has been contained, it can be removed from the water through the use of oil absorbents and/or floating equipment, such as « slick-lickers ».

It is often more difficult to cope with spills once the oil reaches the beaches. When this happens, it is often necessary to resort to steam-cleaning and even physical removal of the oil-soaked beach material.

Pollution by chemicals : In recent years, more and more chemicals, of types which could pollute the sea, have been carried by ships in bulk form. While, to-date, pollution from this source has not been extensive, the potential is there and international codes, covering the carrying of bulk chemicals, have been developed. These codes go as far as requiring double-skinned hulls for the more dangerous and polluting chemicals.

Bilge discharges : The author states that it is relatively simple to remove pollutants (mainly oil) from bilge discharges and that there is no reason for this type of pollution to continue.

Pollution from sewage : Not only is sewage introduced into the oceans by the ships which cross them but many nations make a practice of dumping their shore-generated sewage at sea, from specially designed ships. The author believes that this latter practice should be abandoned but states that, if this is not possible, then such discharge should be beyond the continental shelves.

The author suggests several ways of doing away with pollution caused by ship sewage. These methods include the retention of sewage in tanks, for later discharge to a shore treatment plant, and the treatment of sewage on board ship to a degree such that the discharged effluents will be non-polluting. A number of variations of the former system are being developed and it is expected that, when these methods are perfected, on-board purification treatment systems will no longer be used.

Pollution by garbage : This particular problem is relatively simple to resolve, in that garbage can either be incinerated on board ship or it can be ratained and discharged ashore. To serve ships electing to use the latter method, the various port authorities should be prepared to receive and dispose of garbage from vessels docking at their wharves.

Pollution from ship-loading and unloading operations : This type of pollution consists principally of dust from such products as grain and coal. The degree of pollution can be greatly reduced through the use of canvas screens around the ship's holds and, in the case of grain, by the installation of vacuum-type, dust removing equipment in the grain elevators.

The author concludes that, while progress has been made in the campaign against ship-caused ocean pollution, much work remains to be done. He believes that the major problems will be resolved to a point where such pollution will no longer be a cause for public concern.

Denmark

The fishing ports on the west coast of Jutland each year handle a million tons of fish which is destined for processing into fish meal and fish oil, rather than for human consumption. This fish, referred to as « trash fish », consists mainly of herring, pout and sand eel and it is caught by trawlers in the 50-250 G.R.T. range.

These Danish ports have been plagued with polluted waters as a result of the pumping of the fishing vessels' bilge water directly into the harbours. The surfaces of the harbours have been almost entirely covered with patches of organic oils and fatty substances and, below the surface, discharged blood, lymph, etc. has done great damage to the water.

The fishing vessels in question normally spend up to eight days at sea obtaining their cargoes and, during this period, there is a considerable build-up of liquid in the bottom of the cargo-holds. This liquid consists of salt water, oil, blood and lymph from the fish, melted ice and sea water resulting from leaks. When the fish are removed from the vessel, a considerable volume of the above-mentioned liquid remains in the hold. This volume amounts to approximately 5% of the gross weight of the fish and it is composed of approximately 8% flesh and protein, 42% oil and 50% water. The normal practice has been to pump this liquid directly into the harbour, with the resultant pollution described above.

Fortunately, the pumping of this bilge water into the harbours has now been prohibited and these Danish fishing ports are developing methods to take care of this undesirable liquid, without polluting their harbours. This paper describes the method used at Esbjerg, which is the most important of the Danish trash-fish ports.

Basically, the Esbjerg system consists of pumping the bilge water directly from the vessels' holds to the various fish factories, where this material is then used in the processing of the fish. This is accomplished by means of (*a*) a special vertical suction pipe in each fishing vessel-extending from just above the vessel's bottom to 20″ above the deck (*b*) a 3″ self-priming pump located at each point of discharge (*c*) special drains along the wharves which lead to a single sump for each factory (*d*) sewer pumps in each sump which force the bilge water into large retaining tanks from which (*e*) connecting lines lead directly to the factories.

When a vessel is ready to get rid of its bilge water, it is only necessary to connect the hose from the discharge pump to the suction line on the craft and commence pumping into the special drains.

When traffic is heavy and there are not sufficient discharge pump connections available for all vessels requiring them, bilge water is transferred temporarily to a small tank vessel, from which it is later pumped back into the system described above.

At Esbjerg, this system has been designed to handle approximately 25,000m³ of bilge water per year and none of this water will be returned to the sea or the atmosphere until it has been totally cleaned by the factories.

In conclusion, the author states that, although this pumping system had only been in effect for a month at the time of writing, it was already possible to measure the improvement in the water in the harbour.

France

The French paper deals with means for protecting Harbours and Coastlines against pollution.

Because of the immensity of the sea, man has always felt free to throw waste of any kind into it. The most important part of pollution finds its refuge along the Coast and man has to suffer the direct and indirect consequences. Changes near the Coastlines, being the result of the development of human activities, do not necessarily bring pollution but some effects with no consequence to-day can become dangerous in the long term. Inventory of existing pollution and study of its effects can only lead to positive action to keep the sea clean.

Type of Pollution

Pollution may be classified into two groups :

(*a*) Pelagic pollution, which is connected with marine transport, commercial and pleasure-boat activities, voluntary acts, like disposal of nuclear wastes, and ship collisions at sea.

(*b*) Telluric pollution, which is directly related to wastes coming from rivers, streams and outfalls and contains all types of pollution, such as bacteria and organic matters.

Pollution Effects

(a) **Hydrocarbons** : Sheets of hydrocarbons spread on water may disturb the gaseous exchange between the sea and the atmosphere. This situation becomes disastrous for the life of birds, fish, etc. If the results do not go as far as a complete destruction of life, they could affect the organisms to a point that they become unfit for food.

(b) **Organic matters** : The fermentation of organic matters in water contributes to the deterioration of the oxygen level with the result that species of low oxygen-demand are growing very rapidly while higher species are asphyxiated.

(c) **Bacterial pollution** : Almost all of the pathogenic micro-organisms are of human origin. Although the sea can kill most of the germs, some micro-organisms can live a certain period of time and keep their pathogenic power.

(d) **Miscellaneous toxics** : Detergents, phosphorous and chlorous products, metallic compounds and nuclear substances can have disastrous effects when present in excessive quantities in the sea.

(e) **Thermal pollution** : The future development of thermal stations near the sea must be vigilantly studied.

Action Taken to Fight Pollution

France is giving particular attention to the pollution problems created by hydrocarbons. Disposal at sea of polluted ballast or petroleum is severely controlled and many harbours are equipped with treatment plants to take care of pollutants at the time of unloading a ship. In the case of ship collisions, efforts are made to collect petroleum products at the site of the casualty, which is less costly than cleaning the Coastline later.

The treatment of wastes on shore before their disposal at sea must be submitted to scientific processes and be permitted only if good control is exercised.

Scientific studies are also carried out in connection with the location of sewer outfalls. This has led to positive results in connection with determining the amount of activity that can take place at sea without endangering the quality of the environment.

Regarding pleasure-boat activities, strong action has been taken to reduce pollution by imposing severe rules on the owners of marinas and boat-builders, who must respect certain criteria and provide adequate facilities.

France possesses a National Centre to co-ordinate the scientific research related to marine pollution. Administrative regulations are implemented to prevent pollution at sea. There are laws in effect which prohibit pollution in harbours. International action should be well co-ordinated and should deal with the pollution problem in general, and not just hydrocarbon pollution. In order to protect the environment, it is imperative that the objectives be well defined, so that pollution problems may be inventoried and understood, and positive action be taken.

Germany

This report deals with the steps already taken, as well as those being considered, to prevent and combat pollution in the harbours and coastal regions of the German Federal Republic. The report considers conditions on both the North Sea and the Baltic coasts of Germany and it states that, because of the country's relatively short coastline, in relation to its large population, very intensive use is made of that coast.

The North Sea and the Baltic differ greatly in their ability to handle pollutants. The relatively high tides of the North Sea, combined with storm surges, provide for rapid dispersal of incoming pollutants. In the Baltic, however, water movement is mainly controlled by the winds, which act chiefly on the surface waters, and, in certain basins of this sea, there are periods when oxygen is temporarily absent. Because there is very little interchange of Baltic waters with the ocean, the Baltic is particularly exposed to the threat of pollution.

As is the case in Belgium, the quality of the water in German harbours is often adversely affected by activities which occur on the upper reaches of the rivers on which they lie. The authors attribute the pollution of German harbours to three sources : Domestic sewage, industrial processing and cooling waters and shipping.

The authors deal at length with the various types of polluting agents and their effects.

Oil and Oil dispersing contrivances : Each year, German coastal waters are subjected to oil pollution amounting to as much as 100,000 tons. The authors suggest that unauthorized discharge from vessels may be a source of this oil. Among the serious results of the escape of this oil are the destruction of ocean plants, the annual killing of thousands of sea birds, the contamination of fishing tackle, with subsequent undesirable effects on fish being used for human consumption, and the rendering unuseable, at least temporarily, of seaside resorts.

The authors state that the use of oil dispersing contrivances can also be extremely damaging to organisms in the water.

Pesticides and Polychlorinated Biphenyls : Germany, like other countries throughout the world, uses large quantities of pesticides to overcome weeds and plant diseases. A high percentage of these pesticides finds its way into the country's rivers and is then carried to the sea. Pesticides appear to present a greater menace to the waters of the Baltic than those of the North Sea. Recent tests have shown that the DDT content in Baltic seals runs ten times as high as that in seals inhabiting the North Sea. Pesticides attack the enzyme systems in organisms, affect the production of hormones, reduce the calcium production of birds, thereby making their shells subject to breakage, and produce tumorous growths with cancerous affinities.

While the effects of polychlorinated biphenyls have not yet been fully investigated, it is known that numerous organisms in the Baltic and North Seas have concentrations of these dangerous substances which are greater than their DDT content.

Heavy Metals : Heavy metal salts normally enter the waterways through the discharges of industrial plants. The most dangerous of these metals are mercury, lead and cadmium and these are followed by zinc, copper and arsenic. Out of the total German annual consumption of 775 tons of mercury, 60 tons finds its way to the North Sea via the Rhine river alone. In certain oxygen-starved areas, this mercury is transformed into highly poisonous methylmercury. Methylmercury and tetra-ethyl lead are stored in the brain and nervous system and, among other things, can cause grave genetic troubles.

Cadmium, which is stored mainly in the kidneys, can cause damage to the kidneys, the nervous system and the bone structure.

Oxygen-Consuming Matter : Both domestic and industrial effluents contain large quantities of nitrates and phosphates. These, combined with the nutrient salts of nitrogenous and phosphoric fertilizers, contribute to the growth of certain undesirable aquatic plant life, thus reducing the available oxygen in the water.

Other pollutants in this class consist of industrial and domestic effluents which contain organic residues and need oxygen for their disintegration. Not only do these materials consume oxygen but they could also, as a result of the infectious bacteria which they carry, be a source of epidemics, in cases where these were carried back to man by edible sea-life.

It is interesting to note that, in addition to the large quantities of untreated domestic sewage carried to the Baltic and North Sea by rivers and sewer outfalls, Germany also each year sends some 270,000 tons of sewage to sea by ship.

Inorganic Matter : This class of pollutant is carried to the sea both by rivers and by specially-constructed vessels and the authors estimate that, in the latter category, over five million tons per year are dumped into the North Sea by the various nations bordering on it.

Inorganic wastes fall into three groups :

(1) Salts, acids and alkalines (slightly toxic).

(2) Toxic inorganic substances (fluorides and cyanides).

(3) Insoluble solids.

Solid Substances : This category includes such items as scrapped automobiles, drums of waste material, such as arsenic, cyanide, etc., and war materials, such as poison-gas shells. The authors content that all such substances present a hazard but they have not made a particularly strong case for a ban on the dumping of scrap metal and similar items, under controlled circumstances.

Radio-active substances : The escape of these substances from generating plants and other industrial installations is carefully controlled by the German Government.

Thermal Burdening by Cooling Water : The paper relates the raised temperatures of river and harbour waters to the creation of fog, which can adversely affect shipping. It also mentions the advantageous side of this temperature change, in that the formation of ice is retarded. No mention is made of the effects of the higher temperatures on plant or animal life.

In concluding this section of the paper, the authors appear to indicate that, while the potential for pollution exists, there is little cause for concern at this time.

The paper discusses, at some length, the current state of anti-pollution legislation in the Federal Republic of Germany and it points out that, under a Federal structure, close cooperation is required, among the various levels of Government, to establish effective anti-pollution measures. Mention is also made of the necessity of securing the cooperation of the Governments of adjacent countries. At the present time, there does not seem to be an over-all pollution-checking network in Germany. Special tests are made for radioactivity and oil pollution but other types of pollution appear to be handled on an ad hoc basis.

The paper proceeds with a discussion of different methods by which pollution can be controlled and it deals specifically with the control of oil-caused pollution by means of reducing shipping accidents. The methods suggested follow generally the recommendations outlined in the Canadian paper.

In Section 3.2.2, the authors list Germany's general phylosophy regarding the fighting of oil pollution and, in Section 4.1, they call for increased knowledge of all factors relating to pollution so that the authorities will be better equipped to combat the increase in pollution which will correspond with the increase in sea traffic and industrialization in the coming years.

The authors state that « At present, our knowledge of the physical, chemical and biological processes in water, in relation to the inflow of deleterious matter, remain obscured by a series of unknown factors ». They urge that both Governments and industries devote more energy to the study of pollution, the definition of threshold values and the development of new techniques whereby waste matter can be re-employed in production processes.

In Section 4.3, the authors make a number of recommendations which, if implemented, would go a long way towards solving ocean pollution problems.

While at the present time the fight against sea pollution is restricted principally to petroleum products, it is felt that the experience gained in this work can eventually be applied to the fight against other types of pollutants.

The authors appear to feel that the world is not yet sufficiently aware of the degree of pollution which has already occurred and of the ultimate results of continued attacks on the environment. This may be true in Germany but there are other areas where the public has become so aroused about pollution that it cannot act or think rationally in any situation involving alleged damage to water. Great care must be taken to prevent unnecessary economic hardships, brought about in the name of ecology.

India

This long, but interesting, paper commenced with a definition of « marine pollution » and the author then makes the point that this problem « has to be solved taking into due consideration the fundamental economical needs of a developing country ».

India has advanced technologically since independence but this advance has been accompanied by an increase in pollution. All types of pollution known to the west are present, in a greater or lesser degree, in India.

The author divides pollution of water into three categories : Oil pollution, general pollution and miscellaneous pollution. Under general pollution he includes solid, liquid and gaseous wastes, sewage and radioactive material. Included in the miscellaneous category is pollution caused by weeds.

Oil pollution is sub-divided into « persistent » and « non-persistent » oils but only the former is considered a serious problem. These oils enter the sea in the manners already described in previous papers and there are no hard and fast rules for dealing with such pollution — each case must be studied and handled individually.

To-date, India has had no cases of oil pollution in its surrounding seas but tanker traffic is increasing rapidly and planning must be carried out to handle serious spills, if and when they do occur. The author discusses the basis upon which this planning should be carried out.

While there have been no recorded cases of offshore oil pollution in India's neighbourhood, there have been a number of such cases in the various ports. The paper describes four such instances at the port of Cochin. The causes of these incidents and the corrective actions taken are described in detail.

Under the heading of « general pollution », the paper describes the source of the various types of pollution which fall in this category and describes methods for combating the different pollutants. The author discusses in detail several documented cases of water pollution by toxic chemicals.

The sea has enormous capacity to assimilate wastes and the paper contends that, with proper scientific research, efficient management of wastes and very precise controls over these wastes, certain types of pollutants can be used to provide fertilizers which will improve the marine environment.

At the present time, only a very small percentage of the sewage produced in India receives any treatment whatsoever. For instance, even in Bombay, while seventy-two million gallons of sewage per day receive primary treatment, before discharge to the sea, the remaining one hundred and twenty-eight million gallons are sent directly to the river or the ocean.

Under the heading of miscellaneous pollutants, the paper discusses the dumping of dredged spoil in the sea and it makes the point that a very high percentage of all ocean dumping consists of dredged material. The paper does not make it sufficiently clear that, while some of the dredged materials may be polluted, the great majority are not — nor does it make the point that the effects of dumping dredged spoils on fish-breeding grounds might be positive, rather than negative.

Also under the heading of miscellaneous pollution is an interesting discussion of pollution caused by weeds. The weed discussed is the water hyacinth, which has become an economic scourge in the backwaters of Kerala State. These weeds clog the canals and rivers and block navigation, smother fish, destroy fertile fields and encourage the breeding of disease-carrying mosquitos. In addition, it is stated that these weeds can endanger the operation of hydro-electric generating stations and can weaken bridge piers.

In the paper's « conclusion », the author expresses his concern about the rapidly increasing world population and the effects that this will have on pollution. He states that rapid industrial expansion has led to an unhygienic and unsanitary environment in his country and he states that this situation must be halted, by remodelling the communities, re-using waste water and planning settlements in a manner which will avoid pollution. The author states that « the worst pollution of undeveloped countries is the pollution of poverty which must be eradicated from source by an all-out effort ». The paper does not mention the birth-control efforts which are currently under way in India.

Netherlands

This paper is divided into two parts. The first part contains a general discussion of water pollution in the Netherlands and of the steps which have been taken to combat this pollution.

Although there had been many attempts, over the past 110 years, to legislate against water pollution, the Netherlands did not obtain statutory power to deal with this problem until the passing of the Surface water Pollution Act, in 1969.

In the Netherlands, they believe that an automatic prohibition of the discharge of wastes into waterways is unrealistic. They therefore have developed a licensing policy which gives the Governments control over all waste disposal operations, both as to quantity and quality. The national Government is responsible for the licensing of discharges into the principal rivers, the harbours and the North Sea, while the Provincial Governments are responsible for licensing with regard to minor waterways. Each application for a licence is treated individually and the issuance of the licence is subject to whatever conditions and restrictions may seem appropriate in the particular case.

An interesting aspect of the licensing system is the fees which accompany the permits. Thus, the polluting organization is not only bound to improve the quality of its discharge into the waterways but it is also required to help finance the construction and operation of anti-pollution systems.

The paper deals at some length with various methods of combating pollution of the water by oil and, as was the case in several previous papers, it favours the removal of oil by mechanical means.

The authors believe that, in the foreseeable future, the regulations regarding the discharge of waste material into the sea will be almost as stringent as those covering discharges into inland waters.

In the second part of the paper, the authors deal with the history of waste disposal in the City of Rotterdam and then describe a new installation for the handling of pollutants.

Since the Second World War, the docks of Rotterdam have been expanded considerably. This dock expansion was accompanied by extensive industrial growth, a great part of which was in the petro-chemical field. This industrial growth led to a large increase in the quantities of waste materials generated by the port. These wastes included packaging material, damaged goods, chemicals and polluted water. The volume of the wastes became so large that a number of businesses were established for the specific purpose of collecting and removing these materials.

The solid materials were deposited on dumps near the city but, for the most part, the liquids were discharged into the water. Neither of these methods of disposal offered acceptable long-term solutions and, in 1963, the City Authorities authorized an extensive study of the subject. The ultimate aim of the study was to determine the best method for processing the City's wastes and it was decided that the method selected should be capable of disposing of all of the wastes generated, regardless of quantity or composition. It was finally decided that a new incinerator offered the best solution to the City's problems. The incinerator was to be designed to process 700,000 tons of material per year and it was estimated that its cost would be approximately forty-eight million dollars. Since Rotterdam did not have this amount of money readily available, it was finally arranged that the plant would be constructed by a limited company, the shareholders of which were to be twenty-three municipalities from the Rhine delta area.

The incinerator was divided into two parts, one section to handle domestic and industrial wastes and the other to handle chemical wastes. The first section consisted of six combustion units, each with a capacity of sixteen tons of waste per hour. The heat produced by these combustion units is used for the production of steam. The boilers produce steam at the rate of 50 tons per hour and this steam is used for two purposes : the generation of electricity and the distillation of river water. The turbo-generators are designed to produce 200 million KWH of electricity per year and the evaporators are designed to produce approximately 16 million cubic meters of distilled water per year.

The second section of the plant, that for the disposal of chemical wastes, consists of two large rotary furnaces behind which are after-burning chambers for the disposal of liquid chemical wastes. Each of these furnaces has a capacity of 1 1/2 tons of solids and 2 tons of liquids per hour.

Before being fed to the rotary furnaces, the solid chemical wastes are stored in a sub-divided bunker having a capacity of four thousand cubic meters. They are fed to the furnaces, in 50 kilogram charges, via an airlock. The liquid wastes are temporarily stored in a tank farm, which contains nineteen tanks and has a total capacity of five hundred cubic meters, and are then delivered to the after-burning chambers by means of nitrogen pressure on the tanks.

Methods of removing chemical pollutants, such as HCL, SO_2 and HF, from the flue gas of the rotary furnaces have, as yet, not been perfected. Tests are being carried out with the hope that effective filtering methods can be developed.

The plant is designed to receive waste materials by truck and, by ship.

The final cost of the plant, which went into full operation in March of this year, was almost seventy-two million dollars and it is expected that the annual operating cost, including an allowance for interest and depreciation, will be eleven million dollars. It is planned that the revenues derived from the operation of this plant (sale of electricity, distilled water and scrap and fees for the destruction of wastes) will exactly meet the cost of operation. To accomplish this will involve the annual adjustment of charges and fees.

Portugal

This paper deals exclusively with the treatment of oil-bearing waters extracted from oil tankers.

In the introduction, the authors deal, in general terms, with the nature, causes and effects of water pollution caused by petroleum products. In particular, they deal with the types of polluted water which are associated with oil tankers.

There then follows a discussion of international efforts to prevent pollution of the seas by oil. Particular reference is made to five resolutions passed by an Inter-Governmental Conference which took place in London in 1954. These resolutions contained specific recommendations that major ports be equipped with stations capable of collecting oil and oily mixtures.

The authors point out that, inasmuch as sixty percent of the world's tanker fleet passes the coast of Portugal on its way to and from the Middle Eastern oil fields, it is particularly important that the country should be equipped with oil-collecting stations.

With the construction of the Lisnave ship repair yards, which are capable of receiving the largest tankers afloat today, it became more important than ever that Lisbon have facilities for washing and de-gassing tanks and disposing of oil residues. This requirement led to the formation of Gaslimpo in 1967. The sole purpose of this Company is to receive oil and contaminated water from vessels visiting the port of Lisbon.

Gaslimpo utilized for its cleaning stations tankers, in the 17/23,000 TDW range, which were nearing the end of their useful lives as operating ships. There are now three of these vessels in service. To convert these ships to cleaning stations, the owners removed all machinery and structures, such as main engine, shafting, propellers and mid-ship accommodation, which were not strictly necessary for the carrying-out of the new functions of the vessels. However, the boilers, pumping systems and auxiliary generators were retained and overhauled, since they play a vital role in the operation of the stations.

The oil received by the stations is separated by means of a continuous cascade system which utilizes the ships' cargo tanks. In preparing the ships for this service, the cargo tanks were interconnected and discharge lines were constructed. Because the stations handle a high percentage of paraffin wax, the heating coils in the tank bottoms play an especially important role and, in some cases, it was necessary to add additional coils, to achieve proper oil temperatures.

The stations are equipped with all facilities necessary to assist in the cleaning of average-size tankers. They can provide hot and cold wash water, steam, electricity, compressed air and, also, mobile ventilators for de-gassing work.

Cleaning operations are normally carried out at anchor in the harbour, rather than at one of the port's wharves. The station, which is equipped with special fenders, is towed to the tanker and moored alongside the latter vessel. Both ships are held in position by the tanker's anchor. Since the establishment of Gaslimpo, there has not been a single accident involving cleaning stations and the tankers being serviced.

The liquid which is recovered from the primary separators is piped to storage tanks. It does, however, still contain a high percentage of water and secondary separation is therefore carried out, by decanting the storage tanks, where the mixture is kept at a high temperature.

Intake and output of these cleaning stations varies widely with the type of mixture being processed. With liquids containing less than one percent oil, the stations have an intake rate of up to 2,500 tons per hour but this rate may fall as low as 200 tons per hour when highly emulsified oils are being handled. In its five years of operation, Gaslimpo has treated in excess of two million tons of contaminated water. The effluent discharged from the stations is constantly sampled and analyzed, to assure that its quality meets the required standard.

A feature of the cleaning stations which helps to hold down operating costs is the ability to use the recovered oil as fuel for the stations' boilers. Before this can be done, however, the flashpoint, which because of the high proportion of light products is very low, must be rectified. This is accomplished by means of releasing the light products through steam injections in the processing tanks.

Because the machinery in these vessels is old, it requires more than normal maintenance, to ensure that no stoppages occur while the station is in operation. For the same reason, the owners attempt to have duplicates of most vital pieces of machinery.

The crew of the station consists of seven men per shift during cleaning operations and this crew is augmented by a bridge officer and two seamen when the ship is manœuvring. Operations are carried on twenty-four hours per day and seven days per week.

The authors suggest that the cost of a complete cleaning station, such as those owned by Gaslimpo, would run between 1.4 and 2 million dollars. This figure could vary further, depending on the size of the vessel, the process used and the country in which the station is prepared.

Vessels of this type have two sources of income (1) the fees which they charge the ships using their service and (2) the receipts from the recovered oil which they sell.

Spain

Man has neglected, until recently, to treat oceans and seas with the respect due to them for all the fauna, flora and treasures of all kinds to be found therein. Strangely enough, it is only when man hopes that the sea will be helpful to him that he realizes his presence has changed the physical and biological characteristics of marine life. Faeces, chemical products, petroleum an nuclear wastes present serious danger to the environment. The good health of the oceans and seas is largely dependent upon activities on shore. The problem dealt with in this paper is the discharge of sewage and industrial refuse into the sea.

Types of Pollution

Pollution created by disposal of waste into the sea may be classified into two groups :

1. **Pollution affecting the appearance of an area :** Included in this group are wood debris, chemical residues, pulpwood and dirty water. These can prevent normal coastal development and they present an embarrassing aspect to leisure activities.
2. **Dangerous pollution :** Human waste is one of the chief offenders in this group. Due to the ever-increasing number of people who spend their vacation near the

sea, this situation is becoming more acute. Even though numerous studies made in different countries did not come to the conclusion that this type of pollution could be dangerous to human health, it can be observed that fauna and flora absorb toxics and bacteria, making them unfit for human consumption.

Auto-Purifying of the Sea

The sea possesses mechanisms to fight against foreign matter deposited in it. Physical processes, such as solar light, as well as biological processes help to purify the oceans. This auto-defence, in some instances, take place without changing the biological equilibrium of the sea but, in the case of dangerous pollution, ecological changes occur. The sea will then take its revenge on man by giving back contaminated products containing a high concentration of the foreign substances which man has deposited in it.

Human Action

Administrative measures should be adopted to control the disposal of sewage into the sea, thus preventing its pollution. In the case of the first class of pollution, as described above, the satisfactory quality of water seems to be assured, for swimming purposes, if the color is not spoiled and there is no bad odor. With regard to the second class of pollution, certain standards will have to be established in order to treat sewage refuse and reduce the degree of danger to a strict minimum.

Sewage Systems

The sewage disposal systems that are of concern in this study deal with the ones which would have an effect on coastal areas. Wastes coming from urban communities, farming areas and from industries should be adequately treated before they reach the sea via direct discharge of rivers or agricultural drainage ditches.

Other systems for disposal of sewage include treatment plants with no discharge into the sea and the use of sewage waste for agricultural purposes. Spanish standards do not permit the use of septic tanks close to beaches. They can only be permitted if located well away from the sea at locations where the soil offers good permeability.

Sub-Marine Outfalls

Many factors govern the choice of locations for sewage outfalls. The end of the discharge should be located in an area and at a depth where the most favourable conditions exist for antibiotic action and dispersion. In other words, in order to obtain the best purifying results, the outlet should be located at the point where physical and biological processes will perform at optimum levels. When we deal with the disposal of human waste, complete treatment must be accomplished before depositing it into the sea. Both æsthetic and biological standards have to be respected.

Design and Construction of Outfalls

In the design of submarine outfalls, special attention has to be given to the chemical and corrosive action on the construction materials to be used and to the dynamic forces acting on the sewer pipe. The design of these structures will depend on the nature of the bottom on which they are to be laid and different anchorage systems will be developed to suit the existing conditions. The characteristics and the location of the diffusers are of prime importance.

Large Treatment Plants

In order to solve problems created by the present development along Spain's Mediterranean coastline, studies are under way for large treatment plants. The most advanced one of these is for the complete treatment of all wastes for the Malaga area and the author gives data used in the design of this sanitary scheme.

Sweden

The author introduces his subject by saying, with regard to ocean pollution, that « one phenomenon creates the problem and another leads to demands for measures limiting the effects of the first ». As he sees it, the first phenomenon is rapid technical development and the second phenomenon is the recent rapidly growing consciousness that the limit of pollution which can be accepted has almost been reached.

This paper limits itself to those aspects of ocean pollution having to do with petroleum products. There are lengthy sections dealing with (*a*) the various ways in which oil pollution can occur (*b*) methods of improving the design of tankers, so as to reduce pollution (*c*) methods for improving ocean navigation, so as to reduce accidents (*d*) methods of improving cargo handling on tankers (*e*) the state of Sweden's current preparation for the handling of oil spills (*f*) the establishing of oily water receiving stations in the harbours (*g*) the routing of traffic (*h*) the combating of oil pollution. All of the aforementioned sections deal, for the most part, with matters covered by earlier papers and it would not be profitable to repeat the information outlined elsewhere in this report. For this reason, discussion will be limited to the unique features of the Swedish paper.

An interesting suggestion, contained in the discussion of water ballast, is the possibility of installing a flexible membrane in the oil tanks, to prevent the intermixing of oil residues and water ballast.

In his discussion of ship collisions, the author states that the question of stopping distance is of great importance and he points out that, currently, it takes a 250,000 tons tanker almost three miles to stop. The paper suggests that parachutes could be used to reduce this stopping distance by as much as 75%.

In this section dealing with safer navigation, the paper lists a number of new navigation aids which have come into common use in recent years. These include anti-collision radar, satellite navigation and Doppler logs. Satellite navigation works completely automatically and the precision of position determinations is normally accurate to within less than 100 m. The number of possible « fixes » varies with the location of the vessel but they average about one per forty minutes. Between « fixes », position determination is carried out by dead-reckoning. The Doppler log, which records velocity over the bottom, gives the navigator accurate speeds with which to determine the ship's position by dead-reckoning.

For continuous accurate position determination, the Decca and the Toran systems, which are activated by continous radio waves, can be used.

The report contains a most interesting description of the anti-collision radar system. In this system, ships on collision courses, or those which will pass very close to each other, are specially marked on the radar screen and the system sounds or flashes an alarm.

In the section dealing with safer cargo-handling, the paper describes automatic cargo handling devices which, during the course of loading, continuously monitor the shearing force, bending moments, deadweight, draft and trim. When any of these factors fall outside pre-determined limits, so that the safety of the ship is endangered, an alarm is immediately given.

With regard to methods of combating oil pollution, this paper is in agreement with the earlier papers, in stating that mechanical methods of oil removal are superior to chemical methods.

Dealing with dispersion agents, the paper states that there is now a « third generation » of these materials on the market and that they are characterised by low toxicity, greater dispersion action, lower cost and better decomposition properties.

Still in the section dealing with the combating of oil pollution, the author describes a series of microbes which have the capability of serving as « oil eaters ». The drawback here, however, is the possibility that, after they have devoured the oil and have died, they may become fish food and thus endanger the ocean fish population.

The paper presents a well-detailed description of most aspects of pollution of ocean water by petroleum products. As stated in the conclusion, space limitations prevented a discussion of oil discharges through sewer outfalls, from damaged shore-based oil tanks in close proximity to ocean waters and from off-shore oil drilling operations. Also not included in the report was a discussion of pollution resulting from the discharge into the ocean of chemicals and waste industrial and domestic materials.

United Kingdom

This paper deals with the subject of ocean pollution but confines itself principally to the problems associated with oil pollution. It is similar in many respects to earlier papers and the areas of similarity will not be touched on in this report.

In the introduction, the authors pose a number of interesting questions. They refer to the public hysteria which, of recent years, has been aroused by the mere mention of the word pollution and they point out how easily politicians respond to this hysteria. They also ask if the general public is prepared to pay the price for a better environment and they wonder from whence the money to fight pollution will come if the « conservationists » have their way and the rate of industrialization is reduced.

The paper contains an interesting discussion on the « resurrection » of the Thames, which receives the waste from eleven million people but has only an average freshwater flow of 2,500 cfs. The river's troubles began in the 1860's when water-borne sanitation was first introduced. By 1949, the Thames had become « stinking and lifeless ». At this point, a lengthy study was initiated, to identify sources of pollution, to establish mechanics of tidal mixing, to study the chemistry of purification and to determine the strategy to be used to revive the river. Nine years after the completion of the study and implementation of its recommendations, the Thames is well on its way to recovery.

The authors believe that the thinking of the 1860's, with regard to the disposal of wastes downstream from the City of London, is being repeated at the present time, with the sea being substituted for the river. They feel that such thinking is short-sighted and that immediate steps must be taken to prevent serious damage to the seas, especially those sections immediately adjacent to land masses.

The authors points out that, while the Inter-Governmental Maritime Consultative Organization (IMCO) has been severely criticized for its failure to attain its goals, it has achieved very worth-while results. They suggest that much of the oil pollution at sea results from ships which fly « flags of convenience » and which do not comply with the procedures recommended by IMCO.

The paper points out that the general public appears to be more concerned about aesthetic pollution than the more serious hidden types of pollution. It says, further, that this same public rarely recognizes its own very considerable contribution to the pollution problem.

In the section dealing with the prevention of oil pollution, the paper disagree with the belief that the introduction of any petroleum into the sea is harmful.

The paper discusses the port of Milford Haven, where forty-three million tons of crude oil are handled each year. The authorities there believe that, despite the high volume of oil passing through the port, oil pollution has been kept at a satisfactory level. Monitoring of the harbour waters indicates that there have been no harmful ecological effects.

The authors contest the belief that the risk of oil pollution increases as the tankers grow in size. They contend that there is no evidence to show that large ships are more prone to collision or stranding than are smaller ships. They therefore maintain that, if fewer ships are used, there should be fewer casualties. In reply to the argument that those fewer casualties might be of greater magnitude, they point out that hazards can be kept within acceptable limits by complying with the tanker construction regulations approved by IMCO.

The authors approve highly of offshore single buoy moorings for oil tankers. One of the great advantages of this system is the fact that small accidental spillages of oil are quickly dispersed in the ocean, whereas a similar spillage inside the harbour could present serious problems.

In discussing remedial action in cases of accidents involving tankers, the paper states that the best way of reducing the threat of serious oil pollution is to undertake successful salvage operations, whether or not such operations can be financially justified by the value of the salvaged ships and their cargoes.

The paper discusses means by which tanker owners may protect themselves from liabilities relating to the spillage of oil and it describes insurance coverages which can be achieved through TOVALOP and CRISTAL.

One favourable feature of oil spillages at sea, in temperate waters, is the fact that oil is degraded biologically quite rapidly.

The report points out that spillage of non-petroleum products, during their handling at a terminal, can pose considerable pollution problems. As an example, one pound of sugar requires as much oxygen, for its « bacteriological breakdown as does the total raw sewage emanating from one man in one week ».

The authors deal at some length with the effects of dredging activities on water pollution. They point out that, because of their quiet waters and generally greater depths, port areas act as traps and collect large quantities of sewage discharges and toxic materials. The act of dredging such areas can put into suspension materials which might otherwise lie dormant on the bottom. Dealing with the Port of London, the authors state that it was past practice to deposit dredged spoil in coastal waters, « in the hope that it would not come back quite as quickly as it was dredged ». This latter problem is now being overcome by selecting new spoil areas where adequate mixing and dispersal can be achieved.

The Port of London has recently provided pump-ashore facilities for the disposal of most of the material dredged within its jurisdiction. This method of disposal has resulted in a reduction in sediment movement, a reduction in dredging requirements and a reduction in the level of suspended solids in the water. The authors state that this system has progressively removed polluting materials from the waters of the Thames but, unfortunately, no details are given of the methods employed to prevent the carrying water, used in the pumping process, and its non-solid pollutants (dissolved chemicals and bacteria) from re-entering the Thames. It is possible that this water receives treatment, and is then returned to the river, but the paper does not say so.

When discussing means of preventing accident-caused pollution, the paper makes the telling point that heavy fines levied against Corporations have « little effect on their remote employees ».

The paper deals with several unwelcome side effects which can accompany an improvement in water quality. These include the return of marine borers, hydroids and barnacles and a need for cathodic protection for marine structures constructed of steel.

In its conclusion, the paper warns that marine pollution control must not become a political matter.

U.S.A.

In its treatment of pollution in harbours and in coastal waters, this paper describes many of the practices, studies, international organizations, pollution fighting devices, etc., which have been discussed earlier in this report. However, to achieve some degree of brevity, the discussion of this paper will be limited to those sections which contain additional information or which present ideas at variance with those expressed in other papers.

The author places the commencement of « the great anti-pollution crusade » on March 18th, 1967, the date of the stranding of the « Torrey Canyon ». The initial reaction to this accident was « a deluge of ill-advised and often times conflicting legislation by various governmental entities ». Much of the legislation was a duplication of effort by overlapping jurisdictions and there was no coordinated overall plan for the effective control of pollution. The author states, however, that this situation is now being reassessed in the United States and revisions, based on economic practicalities and ecological and environmental considerations, are being made.

The author foresees a great increase in oil pollution potential in United States waters as a result of the oil shortage which that country is now facing. He estimates that, by 1985, some fifteen million barrels of oil will be imported each day and he forecasts that a high percentage of that quantity will arrive by tanker.

The paper introduces a new source of ocean pollution when discussing the effects of the very large propellers on the super tankers now coming into service. These propellers may have an effect on turbidity and salinity and, thereby, a detrimental effect on some species of fish.

The paper discusses at some length the requirements of various anti-pollution laws in the United States and other countries. Details of the U.S. Water Quality Improvement Act of 1970 are provided and the interaction of Federal and State regulations are discussed.

In the United States, the Coast Guard currently has the responsibility of enforcing the above-mentioned Act. The Refuse Act of 1899, which prohibits discharges into navigable waters without a permit, is administered by the Army Corps of Engineers but attempts are being made to transfer their permit-granting authority to the Environmental Protection Agency.

The paper makes mention of the British Oil and Navigable Waters Bill, the Canada Shipping Act of 1971 and the Greek Pollution Control Act of 1971. It also advises that the State of Maine has passed a law which imposes a tax of 1/2c per barrel on all oil transfers. This money is to be used to pay for policing terminals and for the cleaning-up of tanker spills.

The paper deals at length with various international conferences and conventions which have taken place, or will take place, in the interest of fighting oil pollution. On the question of pollution insurance, the paper describes TOVALOP and CRISTAL.

This paper contains interesting descriptions of various pollution detection devices and methods. Among these are the « finger print » method for establishing the source of a given oil by the use of modern analytical techniques, a microwave radiometer, a device for spotting oil slicks from above (even during foggy or night-time conditions), a portable floating oil detector, which can record traces of oil not visible to the naked eye, and infra-red sensors which, when used aboard helicopters, can detect sources of pollution by means of measuring temperature differentials.

In its discussion of containment devices, the paper mentions a bottom tension type oil containment boom, which can be used in waves up to 20', currents up to 2 knots and winds up to 60 knots, a floating air barrier device, which can be used in rough waters, and underwater tents, which are used for containing oil seepage from below.

In the same section of the paper there is a description of the « Seadragon », which has been developed for the American Petroleum Institute by the Garrett Corporation of Los Angeles. This device is light enough to be transportable by air and it sweeps, skims, separates and stores the oil from ocean spills. It is designed to work in waves up to 8' high and to sweep an ocean area at the rate of 120 acres per hour. Furthermore, it is expected that this unit will process a minimum of 25,000 gallons of oily water per hour.

Under the heading of mechanical recovery devices, the paper discusses skimmers and vacuum barges and the author points out that, for the efficient operation of the former, the water must be almost flat calm.

The paper also deals with absorbents and mentions the use of such materials as straw, sawdust, styrofoam and peatmoss. An interesting addition to this list is cotton which, the author states, is more absorbent than straw and, in cases where it cannot be recovered after a spill, is less harmful than certain chemicals.

The author deals with the « sand sinking » method of treating oil spills but states that, although it is effective in removing spills, there is some doubt regarding its effect on the ocean bottom.

In the section headed « other means of limiting pollution » the author discusses vessel construction, accident prevention, shoreside reception facilities, the « load-on top » procedure, harbour flushing, aeration, ship-board waste-treatment and ship-board waste compactors.

In the section dealing with « port clean-up operations and contingency plans », the author points out that a great effort is being made to control pollution of the harbours and coastlines of the world and that the leaders in this effort are some of the smaller ports, rather than the super-ports. The paper then goes on to describe the programmes being carried out in Portland, San Francisco, Oakland, Fremantle, Baltimore, Boston, Mobile, Norfolk, Hong Kong, Toledo and Los Angeles.

The author then lists certain suggestions and objectives which he feels would be beneficial in the fight to clean up the environment. These include formation of pollution fighting co-operatives, identifying marks on vessels, to indicate the cargo being carried, the confinement of super tankers to a relatively small number of ports, further study into physical properties of various products being handled by ocean shipping, monitoring and data collection programmes in each major harbour, additional research, of a type that would be « directed to solutions of real problems and not merely satisfy academic curiosity », over-dredging of harbours and channels, to minimize propeller-caused turbidity, the establishment of realistic standards for water quality, the replacement of the existing multiplicity of single purpose agencies with a single multi-purpose regulatory agency and the closing of the communication gap between the academic world & lawmakers, on the one hand, and the practical decision-makers of the business world, on the other.

The author decries the fact that the professions most directly affected by world pollution problems have not, to-date, offered sufficient leadership in the anti-pollution war. He feels that people who have practical first-hand knowledge of engineering, economics, etc. must assume leadership roles before millions of dollars are wasted on « impractical and uneconomical academic ideas ». Despite all obstacles, the author feels that definite progress is being made and ventures to hope that, by 1975, the necessary legal machinery, equipment and knowledge will be available to control pollution not only along the world's coastlines but on all of the high seas. In closing, the author counsels his readers to make it known to the public that one hundred percent elimination of pollution is an impossible goal. They should be advised that there are certain safe levels of water quality which are technically feasible and economically practical and that those in authority are striving to meet those levels.

CONCLUSION

All of the papers considered were well written and informative. There is probably no aspect of ocean pollution which has not been touched-upon by at least one of the papers.

Unfortunately, a great number of papers covered almost identical ground and this has led to rather unbalanced reporting of those from this group which, in the alphabetical treatment used herein, appear towards the end of the report.

Because of the above-mentioned duplications, those papers which dealt with specific attacks on pollution were, generally speaking, the most interesting. This comment, of course, is not meant to reflect on the authors of the general papers but it would seem more than worth-while, in the future, to offer central guidance, as to subject matter, to the various authors. Such guidance would avoid duplication and would, by reason of directing the authors to specific, rather than general, subjects permit greater amounts of data to be submitted to the Congress.

XXIII^e CONGRES INTERNATIONAL DE NAVIGATION

S. II - 6

Section II - Navigation Maritime - Sujet 6

Mesures de prévention contre la pollution des ports et des côtes.
Moyens de la réduire et d'y remédier.

RAPPORT GÉNÉRAL

par

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LISTE DES RAPPORTS PRESENTES :

Allemagne (R.F.) : MM. Carl Boe, Wilfried Bohlmann, Dieter Lerch, Fritz Lucht, Manfred Nauke, Horst Oebius, Fritz Reuter et Heinz Wismer.

Australie : MM. A.B. Hicks, T.D. Meagher et P. Waterman.

Belgique : MM. M. De Wilde et P. Lagrou.

Canada : Mr. J.H. Birtwhistle.

Danemark : Mr. B.O. Juhl.

Espagne : MM. Francisco Enriquez Agos, Enrique Sanz Pareja et Leopoldo Pellon Diaz.

France : M. Michel Pechere.

Inde : M. V.K. Menon.

Pays-Bas : ir. G.J.R. Nales et Dr. ir. P.K. Baaij.

Portugal : MM. João A.A. Bello et Carlos M.S.B. Pimentel.

Royaume-Uni : Capt. A.F. Dickson et Mr. J.H. Potter.

Suède : M. Ake Waldemarson.

U.S.A. : M. Donald A. Walsh.

INTRODUCTION

Les treize rapports présentés contiennent une revue extrêmement complète des connaissances actuelles dans le domaine de la pollution des eaux de mer et des côtes. Ils traitent de tous les aspects du problème, y compris les causes, les effets, les méthodes de réduire et de combattre la pollution, et l'état actuel des lois anti-pollution. La plupart des rapports traitent en termes généraux du problème de la pollution, mais certains d'entre eux le font en des termes très spécifiques.

La discussion des différents rapports suit :

Allemagne (R.F.)

Ce rapport traite des mesures déjà prises, de même que de celles qui sont envisagées, pour prévenir et combattre la pollution dans les ports et les régions côtières de la République Fédérale Allemande. Le rapport examine les conditions tant de la Mer du Nord que de la Baltique, et il déclare que, vu la longueur relativement faible des côtes du pays, par rapport à sa grande population, cette côte est utilisée de manière très intensive.

La Mer du Nord et la Baltique diffèrent beaucoup dans leur capacité de traiter les polluants. Les marées relativement hautes de la Mer du Nord, combinées avec les ondes de tempête, permettent une dispersion rapide des polluants qui y parviennent. Dans la Baltique, cependant, les mouvements de l'eau sont principalement contrôlés par les vents, qui agissent principalement sur les eaux de surface, et, dans certains bassins de cette mer, il y a des périodes où l'oxygène est momentanément absent. Comme les eaux de la Baltique se mélangent peu avec celles de l'océan, la Baltique est spécialement exposée à la menace de pollution.

Comme c'est le cas en Belgique, la qualité de l'eau dans les ports allemands est souvent affectée de manière nocive par les activités qui sont exercées sur le cours supérieur des rivières à l'embouchure desquelles ils se trouvent. Les auteurs attribuent la pollution des ports allemands à trois sources : les égouts domestiques, le traitement industriel et les eaux de refroidissement et la navigation.

Les auteurs traitent longuement les différents types d'agents polluants et leurs effets.

Le pétrole et les appareils de dispersion de celui-ci : Chaque année, les eaux côtières allemandes sont sujettes à une pollution par le pétrole s'élevant jusqu'à 100.000 tonnes. Les auteurs suggèrent que le déversement non autorisé par les bateaux pourrait être une source de ce pétrole. Parmi les conséquences sérieuses de la fuite de ce pétrole, il y a la destruction des plantes marines, la mort annuelle de milliers d'oiseaux de mer, la contamination des engins de pêche, avec les effets secondaires peu désirables sur le poisson destiné à la consommation humaine, et la mise hors service, au moins temporaire, de stations balnéaires.

Les auteurs affirment que l'emploi d'appareils de dispersion du pétrole peut aussi être extrêmement dommageable aux organismes aquatiques.

Pesticides et Biphenyls polychlorurés : L'Allemagne, comme d'autres pays du monde, utilise de grandes quantités de pesticides pour combattre les mauvaises herbes et les maladies des plantes. Un pourcentage élevé de ces pesticides fait son chemin vers les rivières du pays et est ensuite charrié vers la mer. Les pesticides semblent présenter une plus grande menace pour les eaux de la Baltique que pour celles de la Mer du Nord. Des tests récents ont démontré que la teneur en DDT dans des phoques de la Baltique était dix fois plus élevée que dans les phoques qui habitent la Mer du Nord. Les pesticides attaquent les systèmes d'enzymes dans les organismes, affectent la production d'hormones, réduisent la production de calcium des oiseaux, rendant leurs coquilles fragiles, et produisent des tumeurs à affinités cancéreuses.

Bien que les effets des biphenyls polychlorurés n'aient pas encore été pleinement découverts, il est connu que de nombreux organismes de la Baltique et de la Mer du Nord possèdent des concentrations de ces substances dangereuses qui sont plus grandes que leur contenu de DDT.

Métaux lourds : Les sels de métaux lourds pénètrent normalement dans les voies d'eau grâce aux déversements des usines industrielles. Les plus dangereux de ces métaux sont le mercure, le plomb et le cadmium, et ceux-ci sont suivis par le zinc, le cuivre et l'arsenic. Sur la consommation totale annuelle allemande de 775 tonnes de mercure, 60 tonnes trouvent leur chemin vers la Mer du Nord, par le Rhin seulement. Dans certaines régions manquant d'oxygène, ce mercure est transformé en mercure méthylique hautement toxique. Le mercure méthylique et le plomb tétra-ethyl sont emmagasinés dans le cerveau et le système nerveux et, entre autres choses, ils peuvent provoquer de graves troubles génétiques.

Le cadmium, qui est emmagasiné principalement dans les reins, peut causer des lésions aux reins, au système nerveux et à la structure osseuse.

Matières consommatrices d'oxygène : Les effluents domestiques et industriels contiennent de grandes quantités de nitrates et de phosphates. Ceux-ci, combinés avec les sels nutritifs de fertilisants azotés et phosphoriques, contribuent à la croissance d'une certaine vie de plantes aquatiques indésirables, réduisant par-là l'oxygène disponible dans l'eau.

D'autres polluants dans cette classe consistent en effluents industriels et domestiques qui contiennent des résidus organiques et qui ont besoin d'oxygène pour leur désintégration. Ces matières, non seulement consument de l'oxygène, mais elles peuvent aussi, à cause des bactéries infectieuses qu'elles transportent, être une source d'épidémies, dans les cas où ces dernières retournent à l'homme par des produits marins comestibles.

Il est intéressant de noter que, outre les grandes quantités d'eaux domestiques non traitées charriées vers la Baltique et la Mer du Nord par les rivières et par les débouchés d'égouts, l'Allemagne envoie également chaque année quelque 270.000 tonnes d'eaux d'égout par bateaux.

Matières inorganiques : Cette catégorie de polluants est charriée à la mer chaque année tant par les rivières que par des bateaux spécialement construits à cet effet, et les auteurs estiment que, dans cette dernière catégorie, plus de cinq millions de tonnes par an sont déversées dans la Mer du Nord par les différents pays qui la bordent.

Les matières inorganiques se répartissent en trois groupes :

(1) Sels, acides et alcalins (légèrement toxiques).

(2) Substances inorganiques toxiques (fluorures et cyanures).

(3) Solides insolubles.

Substances solides : Cette catégorie comprend des objets tels que des automobiles au rebut, des fûts de déchets tels que l'arsenic, le cyanure, etc., et du matériel de guerre tel que les bombes de gaz empoisonné. Les auteurs prétendent que toutes ces substances présentent des risques, mais ils n'ont pas particulièrement insisté pour qu'on interdise le rejet de métal de rebut et d'autres objets, fait sous contrôle.

Substances radio-actives : La fuite de ces substances des usines génératrices et d'autres installations industrielles est soigneusement contrôlée par le Gouvernement allemand.

Charge thermique par eaux de refroidissement : Le rapport décrit l'augmentation des températures des eaux de rivière et des ports allant jusqu'à la création de brouillard, ce qui peut être nuisible à la navigation. Il mentionne aussi le côté avantageux de ce changement de température, en ce qu'il retarde la formation de glace. Il n'est pas fait mention des effets des températures plus élevées sur la vie des plantes et des animaux.

En concluant cette section de l'exposé, les auteurs semblent indiquer que, encore que les potentialités de pollution existent, il y a peu de motifs de se faire du souci actuellement.

Le rapport discute assez longuement l'état actuel de la législation anti-pollution de la République Fédérale d'Allemagne et il souligne que, dans une structure fédérale, une étroite collaboration est nécessaire, aux différents niveaux du Gouvernement, pour établir des mesures efficaces contre la pollution. Il mentionne également la nécessité de s'assurer de la collaboration des pays voisins. A l'heure actuelle, il ne semble pas exister en Allemagne un réseau global de contrôle de la pollution. Des tests spéciaux sont effectués en ce qui concerne la pollution par la radioactivité et par les hydrocarbures, mais les autres types de pollution semblent être traités au fur et à mesure qu'ils se présentent.

Le rapport poursuit en discutant différentes méthodes par lesquelles la pollution peut être contrôlée et il traite spécialement du contrôle de la pollution causée par le pétrole, contrôle effectué en réduisant le nombre d'accidents de navigation. Les méthodes suggérées suivent généralement les recommandations décrites dans le rapport canadien.

Dans la Section 3.2.2., les auteurs donnent la philosophie générale allemande en ce qui regarde la lutte contre la pollution par hydrocarbures et, dans la Section 4.1., ils plaident en faveur d'une meilleure connaissance de tous les facteurs ayant trait à la pollution en sorte que les autorités soient mieux équipées pour combattre l'accroissement de la pollution qui va correspondre à l'accroissement du trafic en mer et de l'industrialisation dans les prochaines années.

Les auteurs déclarent que « A l'heure actuelle, nos connaissances des réactions physiques, chimiques et biologiques dans l'eau sous l'afflux de matières délétères restent obscurcies par une série de facteurs inconnus ». Ils insistent pour que les Gouvernements et les industries consacrent plus d'énergie à l'étude de la pollution, à la définition de valeurs limites et au développement de nouvelles techniques grâce auxquelles les déchets puissent être réutilisés dans les processus de production.

Dans la Section 4.3, les auteurs font un nombre de recommandations qui, si elles sont mises en vigueur, aideraient beaucoup à résoudre les problèmes de la pollution des océans.

Tandis qu'actuellement la lutte contre la pollution en mer est confinée surtout aux produits pétroliers, on estime que l'expérience acquise en ce domaine peut éventuellement être appliquée à la lutte contre d'autres types de polluants.

Les auteurs semblent estimer que le monde n'est pas suffisamment conscient du degré de pollution qui prévaut déjà et des conséquences ultimes des attaques continuelles contre l'environnement. Cela peut être vrai en Allemagne, mais il y a d'autres régions où le public est tellement en éveil au sujet de la pollution qu'il ne peut pas agir ou penser rationnellement dans les situations qui comportent un dommage supposé causé à l'eau. On doit prendre grand soin d'éviter des contraintes économiques inutiles, édictées au nom de l'écologie.

Australie

Ce rapport traite des différentes études qui ont été poursuivies en vue de la construction d'une chaussée (causeway), longue de 2 milles et demi, entre le continent d'Australie occidentale et Garden Island. Garden Island, qui s'étend parallèlement à la terre ferme de la côte et qui enferme en partie un plan d'eau connu sous le nom de Détroit de Cockburn, devait servir de terrain pour une nouvelle base navale australienne; il fallait prévoir une chaussée d'accès vers cette base au large de la côte. On choisit de créer une chaussée, plutôt qu'un pont plus court, parce qu'elle formerait une protection pour l'extrémité inférieure du Détroit de Cockburn, qui devait par la suite être développé par le port voisin de Fremantle.

Le principal problème des autorités chargées de la construction de la chaussée était que l'ouvrage projeté pouvait diminuer le débit d'eau passant par l'entrée sud du Détroit de Cockburn, à tel point que cela pouvait provoquer des dégâts importants dans le domaine de l'écologique maritime. Leur problème se compliquait du fait qu'une grande partie de la côte continentale était occupée par une raffinerie de pétrole, une aciérie et d'autres industries qui manipulent des polluants possibles et qui donnent naissance à des effluents polluants. Certaines plages le long du Détroit formaient une zone de loisirs pour les habitants de Fremantle et de Perth, et les autorités ne voulaient pas porter atteinte à ces lieux favorisés.

Pour arriver à la meilleure conception possible de la chaussée, un vaste programme, multi-disciplinaire, de recherches de l'environnement fut entrepris. Ce programme, qui prévoyait des études continuelles de l'environnement pendant toutes les phases du projet de chaussée, démontrait, dit le rapport, que le début des travaux de construction ne devait pas être retardé jusqu'à ce que les conclusions finales sur l'environnement aient été atteintes.

Les auteurs du rapport insistent sur le fait que des recherches de ce genre doivent être soigneusement programmées, en sorte qu'on ne rassemble pas de données inutiles et qu'on puisse ainsi maintenir les dépenses dans des limites raisonnables. Au stade préliminaire, les chercheurs doivent utiliser au maximum les renseignements existants et doivent recueillir des données et des opinions généralisées auprès d'experts qualifiés de l'environnement. Lorsque cela a été fait, il est possible d'élaborer un plan définitif d'attaque et les recherches nécessaires peuvent commencer. A ce moment les auteurs soulignent que, encore que les recherches doivent être poursuivies par une équipe multi-disciplinaire, il est essentiel qu'elles soient dirigées par un ingénieur, car seul un ingénieur peut avoir une vue d'ensemble du projet.

Les auteurs définissent assez longuement la philosophie de leurs recherches et détaillent les sept étapes à suivre dans chacune des différentes études.

Le groupe qui dirigeait les recherches comprenait des biologistes, des botanistes, des chimistes, des ingénieurs, des géologues et des géographes. Parmi eux il y avait des experts dans les domaines de l'écologie et de la biologie marines, de la botanique et de l'aloguologie marines, de la chimie de l'eau et de l'analyse de la chair animale au point de vue des substances toxiques, de l'hydrologie des côtes, de géomorphologie et de sédimentation côtières et de la construction côtière.

L'exposé décrit le Détroit de Cockburn comme « un bassin barré », en ce sens qu'il est totalement entouré par Garden Island à l'ouest, par le continent australien à l'est, et qu'il est partiellement fermé par des bancs de sable peu profonds à ses entrées nord et sud. Le principal objet de leurs études était donc de déterminer (1) la vitesse et la nature du renouvellement de l'eau à l'intérieur du Détroit (s'il y en avait), (2) l'effet que produirait la chaussée en travers de l'entrée sud et (3) les effets à long terme de la chaussée, combinés avec la décharge continuelle de déchets industriels dans le détroit.

Afin de fournir des réponses partielles aux questions précédentes, des recherches hydrologiques furent effectuées. Elles comportaient la mesure des caractéristiques salinité/température du Détroit, l'enregistrement de la vitesse de l'eau et des profils de sa direction à l'aide d'un courantomètre à lecture directe, la mesure de la vitesse du courant avec des instruments de mesure à enregistrement continu, le pistage d'ancres flottantes et le jet de colorants, associés à l'observation par avion.

Les observations de salinité et de température ont révélé que le renouvellement total de l'eau dans le Détroit de Cockburn s'effectuait bien et que la période de renouvellement variait entre une et trois semaines. Cette étude a démontré également que le courant était généralement en direction du nord pendant l'été et en direction du sud pendant l'hiver, et que les mouvements de l'eau à l'intérieur du Détroit sont indépendants en grande partie de l'action des marées et des vagues.

Les études de mesurage ont en général confirmé les conclusions auxquelles on est parvenu par l'examen salinité/température et l'étude des flotteurs a résolu certaines anomalies qui avaient été relevées par les profils de salinité et les mesures de courant.

Au cours des investigations, on a noté des fluctuations des niveaux d'oxygène dissous et ces fluctuations ont pu être directement rattachées aux processus photosynthétiques des prairies de varechs, etc. En outre, on a mesuré la pénétration de la lumière. Ces mesures ont rattaché la turbidité provoquée par les décharges industrielles à la destruction des prairies de varechs, etc.

Le rapport résume les recherches hydrologiques en disant que l'échange des eaux dans le Détroit de Cockburn est régi par les courants océaniques et que l'influence locale du vent et des marées n'est pas capable de régir individuellement l'échange des eaux.

D'autres recherches comprenaient des études de la stabilité des côtes et ces études concluaient que les herbes marines et leurs racines sont les éléments les plus importants de stabilisation des dépôts côtiers. Les études de la morphologie de la plage comprenaient :

(1) Le profilage saisonnier des plages, afin de déterminer leurs fluctuations au point de vue configuration et volume.

(2) Le dépistage de sable coloré.

(3) L'analyse physique et chimique des dépôts sédiments.

Suite aux études précédentes, les auteurs concluent que les plages du Détroit de Cockburn sont dans un état d'équilibre dynamique et que toutes les modifications dans la formation des plages peuvent être surveillées en permanence et rattachées soit à des phénomènes naturels ou introduits par l'homme.

Le but principal des recherches entreprises pour le problème de la chaussée était d'établir une ligne de base écologique permettant de surveiller les changements de l'environnement. Cette surveillance permettrait ensuite aux autorités concernées d'établir un programme pour le Détroit qui permettrait l'utilisation de ses eaux à des fins industrielles, de divertissement et de navigation.

En établissant sa ligne de base, l'équipe de recherches s'est posé quatre questions écologiques et s'est ensuite attachée à découvrir les réponses à ces questions. Leurs recherches ont comporté différentes études sur les communautés d'herbes marines, une étude de la distribution des algues sur les frondes des herbes marines, une étude de la biologie d'un groupe d'animaux sédentaires se nourrissant par épuration (moules, palourdes, etc.), une étude de la distribution du plancton, une analyse chimique d'échantillons d'eau contaminés et non contaminés, de dépôts de fonds contaminés et non contaminés, et d'algues provenant de régions polluées et non polluées, des recherches micro-biologiques afin de déterminer la dispersion des bactéries provenant des déversements des égouts de Fremantle dans les eaux avoisinantes, une estimation des déchets provenant des bateaux évoluant dans le Détroit de Cockburn, et une étude des effets de la pollution thermique de l'eau de refroidissement industrielle déversée dans le détroit.

Les études écologiques ont clairement indiqué qu'il était essentiel qu'une circulation d'eau suffisante soit maintenue dans le Détroit de Cockburn. Pour y parvenir, deux ouvertures pontées, situées aux sections de débit maximum, ont été incorporées dans la chaussée.

Une autre découverte des études écologiques fut que la dégradation de l'environnement provoquée par la pollution était le résultat d'une introduction défectueuse des polluants dans le Détroit, plutôt que leur composition chimique.

Les auteurs indiquent qu'une évaluation écologique ultérieure du Détroit sera réalisée dans les prochaines années.

Le rapport poursuit en donnant une description détaillée de matières se rattachant plus directement à la construction elle-même de la chaussée plutôt qu'aux effets écologiques de celle-ci lorsqu'elle sera achevée. On y discute assez longuement des questions telles que les sondages, les essais de sol, la qualité des matériaux de construction, les caractéristiques des vagues à l'endroit de la chaussée, et des essais hydrauliques sur un modèle.

En conclusion, les auteurs indiquent qu'ils sont satisfaits des résultats d'une étude multi-disciplinaire de ce problème, et ils affirment que la coopération entre les diverses disciplines n'est pas difficile à réaliser « quand on accorde à chaque discipline sa place adéquate ». Ils poursuivent en affirmant que cette façon globale d'aborder le problème peut se révéler très coûteuse. Finalement, ils admettent que, alors que « l'achèvement de la chaussée a démontré la justesse des recherches normales de construction civile », il est encore trop tôt pour affirmer avec certitude que les conclusions écologiques du groupe se sont complètement vérifiées.

Belgique

Le rapport affirme que la pollution de l'eau dans les ports belges peut être rangée en deux catégories principales :

(1) Le déversement de polluants directement dans les eaux des ports par les bateaux, les usines et par les égouts des villes, et

(2) par les eaux polluées des rivières sur lesquelles les ports peuvent être situés.

Une catégorie spéciale de pollution est celle provoquée par les produits pétroliers, et ce sujet est traité plus loin dans l'exposé. Les auteurs affirment que, alors que tous les ports belges ont des eaux polluées qui sont amenées par les rivières sur lesquelles ils sont situés, le port qui est le plus affecté par cette situation est Gand, qui est situé sur les rivières Escaut et Lys. Ces rivières prennent leur source dans le Nord de la France et coulent à travers des régions fortement industrialisées de France et de Belgique. Tandis que ces deux rivières sont très polluées par les industries et les communautés qui bordent leur cours supérieur, la Lys a un problème supplémentaire que cause le déversement dans ses eaux des eaux usées en provenance de l'industrie du rouissage du lin. Cette pollution est si forte que, pendant six mois par an, les eaux de la Lys doivent être détournées pour éviter la ville de Gand. Il n'existe pas d'usine de traitement des eaux le long de la section belge de la Lys.

La Lys et l'Escaut confluent à Gand et leurs eaux sont encore polluées davantage par le fait que ces rivières doivent aussi servir d'égouts à la ville.

A la pollution des égouts de Gand et à la pollution amenée à la ville par les communautés de l'intérieur des terres, s'ajoutent les déversements industriels du port même. La pollution des eaux du port est équivalente à celle que provoquerait une population d'un million d'habitants (Gand a une population de 270.000 habitants) qui déverse ses eaux usées non traitées dans le bassin. A Gand, toutes les usines, sauf les plus récentes, déversent leurs eaux usées et de refroidissement, sans traitement, dans les eaux de la zone du port. Des ports comme Gand sont fortement handicapés par le fait qu'une grande partie de leurs eaux polluées ont leur origine en dehors de leurs frontières et qu'ils sont incapables d'agir avec efficacité sans la collaboration du Gouvernement national et même celle des Gouvernements étrangers.

Les auteurs divisent la lutte contre la pollution de l'eau en deux catégories : (a) l'élaboration de règlements contrôlant le déversement de matières polluées dans les voies d'eau et (b) le traitement effectif des déchets industriels et domestiques avant leur déversement.

Parlant des règlements, les auteurs exposent que la Belgique a été dotée de règlements simples contre la pollution figurant dans sa législation depuis les temps anciens. Cependant, ce n'est pas avant 1950 que des lois plus étendues ont été votées. Ces lois exigent que tous ceux qui déversent dans les rivières, canaux, etc., reçoivent une autorisation, et elles imposent certaines règles fondamentales concernant les eaux qui doivent être utilisées à différentes fins. En dépit des nombreux décrets pris en vertu de la loi de 1950 sur la pollution, il s'est révélé fort difficile de contrôler la pollution dans la pratique. Cette situation provient de la multiplicité des autorités, de la complication de la machine administrative et du fait que les villes sont encore autorisées à déverser des eaux usées domestiques non traitées dans les rivières et les ruisseaux.

La loi de 1950 a été remplacée par une nouvelle loi anti-pollution en 1971. Cette nouvelle loi a centralisé l'autorité administrative et elle donne aux autorités de contrôle de la pollution de plus grands pouvoirs pour réaliser une épuration totale.

Une étude récente des eaux polluées du port de Gand indiquait que la rive gauche du canal, où sont situées les plus anciennes industries, était de loin l'élément le plus responsable de la pollution. Sur la rive droite, les grandes industries modernes possèdent des installations d'épuration de l'eau, et il ne faut pas prendre de mesure spéciale dans leur cas. Pour la rive gauche, toutefois, on recommande de créer une usine centrale d'épuration avec égouts collecteurs. Une fois que ce système sera mis en place, la pollution du port de Gand sera limitée aux polluants venus de l'aval et aux produits pétroliers qui peuvent accidentellement se déverser dans l'eau. Les auteurs espèrent que de nouvelles mesures belges et françaises anti-pollution amélioreront bientôt la qualité des eaux amenées à la ville par l'Escaut et par la Lys.

Se tournant maintenant vers la pollution par les hydrocarbures, les auteurs mentionnent qu'elle est devenue un problème lancinant au cours des dernières décades. Les produits pétroliers ne se contentent pas de polluer les eaux des ports mais ils présentent également un danger d'incendie.

Le rapport souligne que le risque de déversements d'essence est en rapport direct avec le nombre de bateaux utilisant comme force motrice des produits pétroliers, le nombre et le port en lourd des bateaux-citernes se servant des installations du port et le nombre et la taille croissants des raffineries situées près du port. Des illustrations accompagnent le rapport qui indiquent la manière dont les occasions de déversements ont constamment augmenté pendant les soixante dernières années.

La pollution par le pétrole peut résulter de deux situations : (1) le déversement d'eau de traitement provenant des raffineries et d'eau de rinçage des bateaux-citernes et (2) les accidents qui se produisent pendant la mise en soute, pendant le chargement et le déchargement de produits pétroliers et aussi comme résultat de collisions, de fuites et de pannes. La pollution causée par la première situation peut être contrôlée par des règlements et par un traitement adéquats. La pollution causée par les secondes situations, étant habituellement le résultat d'erreurs humaines, n'est pas aussi soumise aux règlements et, par conséquent, il faut mettre son espoir dans les techniques de nettoyage..

En ce qui concerne l'amélioration de l'eau de traitement des raffineries, le rapport déclare que les pertes en pétrole provenant de cette source peuvent être ramenées à des niveaux acceptables grâce au refroidissement par air et au recyclage. Dans le cas d'eau de rinçage des bateaux-citernes, la perte de produits pétroliers peut être réduite à des niveaux acceptables grâce à l'utilisation du procédé de lavage en mer (load on top) et à l'introduction de plus nombreuses stations de rinçage et d'emmagasinage construites à terre.

Aussi important que le développement de méthodes de traitement des eaux d'usine et des eaux de rinçage, est le développement des techniques pour l'élimination du pétrole qui a été déversé dans l'eau. Circonscrire et enlever pareils déversements s'effectue grâce à des produits absorbants, à des détergents, à des appareils mécanisés d'évacuation, à des portes de séparation, à des barrages de bulles d'air et à des barrières flottantes. Beaucoup de ces méthodes ont été mises à l'essai, puis ensuite rejetées. Pour différentes raisons pratiques, les auteurs croient que, pour des bassins fermés tel que le port de Gand, la meilleure solution réside dans l'utilisation d'unités d'écumage flottantes, employées en même temps que « des détergents soigneusement choisis ».

A la suite d'études approfondies concernant le meilleur type d'écumoire flottante, les auteurs concluent que le type à pompe à vide est supérieur. Cet appareil fut construit et mis en service à Anvers en 1954, et une description détaillée de son fonctionnement est fournie dans le rapport. Des perfectionnements de cet appareil furent apportés au cours des années, et le rapport de 1955 de 1 litre de produit pétrolier pour 28 litres d'émulsion pompée a été ramené en 1971 à 1:2.2. En 1967, au cours d'un important déversement de pétrole, l'appareil a été en mesure de récupérer une moyenne de 100 tonnes de pétrole par jour, pendant une période de 12 jours.

Les auteurs sont persuadés que l'unité d'écumage flottante d'Anvers a plus que démontré son efficacité et ils estiment qu'une variante moderne et plus grande de l'appareil actuel répond à un urgent besoin pour le port.

Canada

Le rapport déclare que la pollution en provenance des bateaux découle de trois sources principales :

(1) Rejets résultant d'accidents.

(2) La nécessité de nettoyer l'intérieur des navires avant le chargement de cargos différents.

(3) Le déversement d'égouts, d'immondices et d'eau de cale.

En ce qui concerne le déversement de produits pétroliers dans la mer, le rapport indique que, dans le passé, c'est jusque dix millions de tonnes d'hydrocarbures qui ont été déversées dans les océans en une seule année. Ce chiffre a maintenant été réduit à 1/10^{e} du tonnage record, mais même ainsi ce montant est considéré intolérable et des efforts doivent être faits pour amener une réduction supplémentaire de 90 %.

L'auteur discute les différents types de pollution et indique les méthodes actuellement adoptées pour minimiser et/ou pour porter remède à chaque type.

Pollution par hydrocarbures : On peut considérer que, en pratique, tous les bateaux modernes sont alimentés par des produits pétroliers et que leurs réservoirs de soute ont des capacités allant de 300 à 5.000 tonnes. Ces combustibles vont de l'huile diesel légère jusqu'au lourd bunker « C ». Une partie de ce combustible se perd habituellement en mer, suit au déversement de l'eau de cale et de l'eau de déballastage. On peut remédier à cet état de choses par plus de propreté à bord du bateau et en n'utilisant pas les réservoirs à mazout pour transporter de l'eau de ballast.

Plus important que ce qui précède, cependant, est le pétrole qui se répand dans la mer suite au nettoyage des réservoirs des navires-citernes. Ceci a lieu à cause de la nécessité d'utiliser une partie des réservoirs à pétrole comme réservoirs de ballast quand ces bateaux voyagent légèrement chargés. Ce genre de pollution peut être presque complètement éliminé par l'emploi du procédé de lavage en mer (« load on top »). Cependant, à l'heure actuelle, une grande partie des navires-citernes du monde ne peuvent pas ou ne veulent pas utiliser cette méthode. L'auteur suggère que, si ces navires veulent éviter de déverser du pétrole dans la mer, la seule solution pour eux est de disposer, à terre, de réservoirs de réception, disponibles dans tous les ports où ces navires font escale.

Une solution au problème de l'eau de nettoyage des réservoirs serait de séparer complètement les réservoirs destinés au cargo et les réservoirs de lest. Cette solution serait efficace à 100 %, du point de vue de la pollution, mais elle augmenterait fortement les dépenses d'investissement des navires. L'auteur estime, cependant, que, comme ces dépenses supplémentaires sont proportionnellement moindres pour les nouveaux navires-citernes que l'on construit actuellement, cette méthode pourrait éventuellement être universellement adoptée.

Une cause grave de pollution par le pétrole en mer sont les rejets résultant de naufrages, de collisions et d'échouages. Comme les accidents en mer ne peuvent jamais être totalement éliminés, et comme il n'est pas possible de construire des navires qui donneraient la garantie de retenir complètement leur chargement de pétrole dans les cas d'accidents, il est cependant possible, encore que coûteux, de construire des navires en manière telle qu'ils réduiraient fortement les possibilités de pollution par pétrole dans de telles circonstances. L'auteur suggère que ce but pourrait être atteint en réduisant les dimensions des citernes, en installant des double-fonds, en situant les citernes à des endroits moins vulnérables du navire et, finalement, en utilisant des doubles coques complètes.

Evidemment, le meilleur moyen de lutter contre la pollution par les hydrocarbures en mer, provoquée par des accidents, est d'empêcher les accidents eux-mêmes. Le rapport suggère que le nombre d'accidents peut être fortement diminué grâce à l'emploi de plans de route, grâce à des équipements de navigation améliorés, grâce au contrôle du trafic et par l'emploi de marins plus pleinement qualifiés.

Le rapport discute assez longuement des méthodes de traitement des rejets de pétrole en mer, quand ils se présentent. La première mesure est de circonscrire la nappe, et l'on suggère à cette fin des barrages. Il existe sur le marché beaucoup de barrages tout faits mais, lorsqu'on n'en a pas sous la main, il est possible d'en improviser avec des tronçons de bois, des tonneaux, etc. Une fois que le pétrole a été contenu, il peut être enlevé de l'eau grâce à des absorbants d'huile et/ou un équipement flottant tel que « le lécheur de nappe d'huile » (slick-licker).

Il est souvent plus difficile de venir à bout des déversements, une fois que le pétrole a atteint les plages. Quand cela arrive, il est souvent nécessaire d'employer le nettoyage à vapeur, et même de faire enlever les objets de plage eux-mêmes encrassés de pétrole.

Pollution par produits chimiques : Dans les dernières années, de plus en plus de produits chimiques susceptibles de polluer la mer ont été transportés en vrac par bateau. Tandis que, à ce jour, la pollution de cette provenance ne s'est pas répandue beaucoup, la possibilité de pollution est là et des codes internationaux, réglementant le transport de produits chimiques en vrac ont été élaborés. Ces codes vont jusqu'à exiger des coques à double épaisseur pour les produits chimiques les plus dangereux et les plus polluants.

Décharges d'eau de cale : L'auteur expose qu'il est relativement simple d'enlever les polluants (surtout le pétrole) des décharges d'eau de cale, et qu'il n'y a pas de motif pour que ce genre de pollution continue.

Pollution par les égouts : Les eaux d'égout ne sont pas seulement introduites dans les océans par les navires qui les sillonnent, mais beaucoup de pays ont adopté la pratique de déverser en mer leurs eaux d'égout provenant des terres à partir de bateaux spécialement conçus pour cela. L'auteur estime que cette pratique doit être abandonnée mais dit que, si ce n'est pas possible, ce déversement doit se faire au-delà de la plate-forme continentale.

L'auteur suggère différents moyens de supprimer la pollution engendrée par les eaux d'égout des navires. Ces méthodes comportent de garder les eaux d'égout dans des réservoirs, pour les décharger plus tard à terre dans une usine de traitement, ainsi que le traitement des eaux d'égout sur le bateau lui-même d'une manière suffisante pour que les effluents déchargés ne soient pas polluants. Un certain nombre de variations du système précédent sont développées et on espère que, lorsque ces méthodes seront perfectionnées, les systèmes d'épuration à bord des bateaux ne seront plus utilisés.

Pollution par les ordures ménagères : Ce problème particulier est relativement simple à résoudre, parce que ces ordures peuvent ou bien être incinérées à bord du bateau ou bien être déchargées à terre. Pour servir les bateaux qui préfèrent la dernière méthode, les autorités des ports devraient être équipées pour recevoir et détruire les ordures ménagères en provenance des bateaux faisant escale à leurs quais.

Pollution pendant les opérations de chargement et de déchargement : Ce genre de pollution consiste principalement en poussières provenant de produits tels que les grains et le charbon. Le degré de pollution peut être considérablement réduit par l'emploi d'écrans de toile dressés autour des cales du navire et, dans le cas de grains, par l'installation d'un équipement de pompe à vide aspirant la poussière dans les silos à grains.

L'auteur conclut que, bien que des progrès aient été réalisés dans la campagne contre la pollution des océans causée par les navires, beaucoup reste à faire. Il est persuadé que les problèmes les plus importants seront résolus à un point tel que cette pollution ne sera plus une cause de souci public.

Danemark

Les ports de pêche de la côte occidentale du Jutland manipulent chaque année un million de tonnes de poisson destiné à être transformé en farine de poisson et en huile de poisson, plutôt que destiné à la consommation humaine. Ce poisson, dénommé « poisson de rebut » consiste surtout en harengs, lottes et anguilles de sable, et il est capturé par des chalutiers entre 50 et 250 G.R.T.

Ces ports danois ont été empoisonnés par des eaux polluées résultant de ce que l'eau de cale des bateaux de pêche était pompée directement dans les ports. Les eaux de surface des ports ont été presqu'entièrement couvertes de plaques d'huiles organiques et de substances grasses et, en dessous de la surface, du sang et de la lymphe déversés, etc., ont causé un dommage considérable à l'eau.

Les bateaux de pêche en question restent normalement huit jours en mer pour capturer leur cargo et, durant cette période, il s'amoncèle une quantité considérable de liquide dans le fond des cales. Ce liquide est composé d'eau salée, d'huile, de sang et de lymphe de poisson, de glace fondue et d'eau de mer provenant de fuites. Quand le poisson est enlevé du bateau, un volume considérable du liquide ci-dessus décrit reste dans les cales. Ce volume représente approximativement 5 % du poids brut du poisson et il est composé d'environ 8 % de chair et de protéine, de 42 % d'huile et de 50 % d'eau. La pratique courante était de pomper ce liquide directement dans le port, avec comme résultat la pollution décrite plus haut.

Heureusement, le pompage de ces eaux de cale dans les ports est maintenant défendu et ces ports de pêche danois sont en train d'élaborer des méthodes pour lutter contre ce liquide désagréable sans polluer les ports. Ce rapport décrit la méthode employée à Esbjerg, qui est le plus important des ports de pêche danois pour le poisson de rebut.

Essentiellement, le système d'Esbjerg consiste à pomper des cales des bateaux les eaux de cale directement jusqu'aux différentes usines à poisson. Cela s'effectue grâce à (*a*) un tuyau spécial vertical de succion dans chaque bateau de pêche s'étendant de tout près du fond jusqu'à 20" au-dessus du pont (*b*) une pompe à amorçage automatique située à chaque endroit de décharge (*c*) des égouts spéciaux le long des quais qui conduisent à un seul puisard pour chaque usine (*d*) des pompes d'égout dans chaque puisard qui forcent les eaux de cale dans de grands réservoirs de retenue, d'où (*e*) des tuyaux de raccordement conduisent directement dans les usines.

Quand un bateau est prêt à se débarrasser de ses eaux de cale, il est uniquement nécessaire de relier le flexible de la pompe de refoulement au tuyau de raccord sur le bateau et de commencer à pomper dans les égouts spéciaux.

Quand il y a beaucoup de trafic et qu'il n'y a pas suffisamment de raccords disponibles à la pompe de refoulement pour tous les bateaux qui en ont besoin, les eaux de cale sont transférées temporairement dans un petit bateau-citerne, d'où elle est pompée plus tard dans le système décrit plus haut.

A Esbjerg, ce système a été conçu pour traiter approximativement 25.000 m^3 d'eaux de cale par an, et aucune portion de ces eaux ne retournera à la mer ni dans l'atmosphère avant d'avoir été totalement purifiée par les usines.

En conclusion, l'auteur déclare que, bien que ce système de pompage n'ait fonctionné que pendant un mois au moment d'écrire ces lignes, il était déjà possible de mesurer l'amélioration des eaux du port.

Espagne

L'homme a négligé, jusque récemment, de traiter les océans et les mers avec le respect qui leur est dû pour toute la faune, la flore et les trésors de toute espèce qu'on y trouve. Il est assez étrange de constater que ce n'est que lorsque l'homme espère que la mer pourra lui être utile qu'il se rend compte que c'est lui-même qui a changé les caractéristiques physiques et biologiques du milieu marin. Les matières fécales, les produits chimiques, le pétrole et les déchets nucléaires présentent de sérieux dangers pour l'environnement. La salubrité des océans et des mers dépend largement des activités du rivage. Le problème traité dans ce rapport est celui du déversement en mer des égouts et des résidus industriels.

Types de pollution

La pollution créée par le déversement en mer de déchets peut être classée en deux groupes :

1. **La pollution affectant l'apparence d'une région :** Ce groupe comprend les débris de bois, les résidus chimiques, la pulpe de bois et les eaux usées. Ces objets peuvent empêcher un développement normal du littoral et ils donnent un aspect embarrassant aux activités de loisirs.
2. **Pollutions dangereuses :** Les déchets humains sont l'un des plus grands coupables dans ce groupe. Vu le nombre toujours croissant de personnes qui passent leurs vacances près de la mer, la situation devient plus critique. Quoique de nombreuses études faites dans différents pays n'arrivent pas à conclure que ce type de pollution pourrait être dangereux pour la santé humaine, on peut observer que la faune et la flore absorbent des matières toxiques et des bactéries, ce qui les rend impropres à la consommation humaine.

Auto-épuration de la mer

La mer possède des mécanismes de lutte contre les matières étrangères qu'on y dépose. Des procédés physiques, tels que la lumière solaire, de même que des procédés biologiques, aident à purifier les océans. Cette auto-défense, en certains cas, s'effectue sans changer l'équilibre biologique de la mer, mais, dans le cas de pollution dangereuse, des modifications écologiques surviennent. La mer prend alors sa revanche sur l'homme en lui renvoyant des produits contaminés contenant une forte concentration des substances étrangères que l'homme y a déposés.

Action humaine

Des mesures administratives devraient être adoptées pour contrôler le déversement en mer des eaux résiduaires, afin d'empêcher ainsi la pollution. Dans le cas de la première catégorie de pollution, décrite plus haut, une qualité satisfaisante de l'eau semble être assurée, pour les baignades, si ni la couleur ni l'odeur de l'eau n'est altérée. En ce qui regarde la deuxième catégorie de pollution, certaines normes devront être établies pour traiter les eaux résiduaires et réduire le danger à un strict minimum.

Systèmes d'égouts

Les systèmes d'élimination des eaux résiduaires qui concernent cette étude sont ceux qui auraient un effet sur les régions du littoral. Les déchets provenant des communautés urbaines, des régions agricoles et des industries devraient être traités convenablement avant qu'ils ne parviennent à la mer par le débouché direct des rivières ou des fossés d'irrigation agricoles.

D'autres systèmes pour se débarrasser des eaux d'égout comprennent des usines d'épuration sans déversement dans la mer et l'utilisation des eaux résiduaires pour l'agriculture. Les normes espagnoles n'autorisent pas l'usage de fosses septiques près des plages. Elles ne sont permises que si elles sont situées à une bonne distance de la mer à des endroits où le sol présente une bonne perméabilité.

Emissaires sous-marins

Beaucoup de facteurs régissent le choix des endroits vers où seront dirigés les effluents. L'extrémité de la décharge devrait être située dans une zone et à une profondeur où existent les conditions les plus favorables pour une action antibiotique et pour favoriser la dispersion. En d'autres mots, afin d'obtenir les meilleurs résultats d'épuration, l'émissaire devrait être situé à un point où les réactions physiques et biologiques se feront à des niveaux optima. Lorsqu'il s'agit du déversement d'eaux fécales, un traitement préalable complet doit être réalisé avant le rejet dans la mer. Les normes tant esthétiques que biologiques doivent être respectées.

Conception et construction des émissaires sous-marins

Dans la conception des émissaires sous-marins, on doit accorder une attention spéciale à l'action chimique et corrosive sur les matériaux de construction à employer et aux forces dynamiques agissant sur les conduites de l'égout. La conception de ces structures dépendra de la nature du fond sur lequel elles sont déposées, et différents systèmes d'ancrage seront étudiés pour s'adapter aux conditions existantes. Les caractéristiques et la localisation des diffuseurs sont de première importance.

Grandes usines de traitement

Afin de résoudre les problèmes suscités par l'actuel développement le long du littoral méditerranéen de l'Espagne, des études sont en cours pour de vastes usines d'épuration. La plus avancée de ces études est celle pour l'assainissement intégral de tous les déchets de la région de Malaga, et l'auteur fournit des données utilisées dans la conception de ce programme sanitaire.

France

Le rapport français traite des moyens de protéger les ports et le littoral contre la pollution.

A cause de l'immensité de la mer, l'homme s'est toujours cru permis d'y déverser des déchets de tous genres. La masse la plus importante de pollution trouve son refuge le long de la côte, et l'homme doit en subir les conséquences directes et indirectes. Les modifications à proximité du littoral, étant le résultat d'activités humaines, n'amènent pas nécessairement la pollution mais certains effets qui sont sans conséquence aujourd'hui mais qui peuvent devenir dangereux à long terme. L'inventaire de la pollution existante et de ses effets ne peut qu'entraîner une action positive pour garder la mer propre.

Type de pollution

La pollution peut être divisée en deux groupes :

(*a*) La pollution pélagique, qui est liée aux transports maritimes, aux activités commerciales et de plaisance, aux actes volontaires, tels que le fait de se débarrasser des déchets nucléaires, et aux collisions de bateaux en mer.

(*b*) La pollution tellurique qui est directement liée aux déchets provenant des rivières, des ruisseaux et des déversoirs, et qui comporte tous genres de polluants, tels que bactéries et matières organiques.

Effets de la pollution

a) **Hydrocarbures :** Des nappes d'hydrocarbures répandues sur l'eau peuvent déranger l'échange gazeux entre la mer et l'atmosphère. Cette situation devient désastreuse pour la vie des oiseaux, des poissons, etc. Si les résultats ne vont pas jusqu'à détruire complètement la vie, ils peuvent affecter les organismes à un point tel qu'ils deviennent impropres à la nourriture.

(b) **Matières organiques :** La fermentation des matières organiques dans l'eau contribue à la détérioration du niveau d'oxygène, avec comme conséquence que les espèces qui n'exigent que peu d'oxygène croissent très rapidement tandis que les espèces supérieures sont asphyxiées.

(c) **Pollution bactérienne :** Presque tous les micro-organismes pathogènes sont d'origine humaine. Quoique la mer puisse tuer la plupart des germes, certains micro-organismes peuvent vivre pendant un certain temps et garder leur pouvoir pathogène.

(d) **Matières toxiques diverses :** Détergents, produits phosphoreux et chloreux, composés métalliques et substances nucléaires peuvent avoir des effets désastreux quand ils se trouvent en quantités excessives dans la mer.

(e) **Pollution thermique :** Le développement futur des stations thermiques près de la mer doit être étudié soigneusement.

Action entreprise pour combattre la pollution

La France accorde une attention particulière aux problèmes de pollution créés par les hydrocarbures. Le rejet à la mer de lest pollué ou de pétrole est sévèrement contrôlé et beaucoup de ports sont équipés d'usines de traitement des polluants au moment du chargement ou du déchargement des navires. En cas de collision de navires, des efforts sont faits pour ramasser les produits pétroliers à l'endroit de l'accident, ce qui est moins coûteux que de nettoyer plus tard le littoral.

Le traitement des déchets à terre avant leur rejet à la mer doit être soumis à des procédés scientifiques et n'être permis que si un contrôle efficace est exercé.

Des études scientifiques sont également poursuivies concernant l'emplacement des débouchés d'égouts. Elles ont donné des résultats positifs pour déterminer le volume d'activités qui peuvent se produire en mer sans mettre en danger la qualité de l'environnement.

En ce qui regarde les activités des bateaux de plaisance, une action énergique a été entreprise pour réduire la pollution en imposant une réglementation sévère aux constructeurs et exploitants de ports et aux constructeurs de bateaux, qui doivent respecter certains critères et fournir des installations adéquates.

La France possède un Centre National pour coordonner la recherche scientifique concernant la pollution marine. Des règlements administratifs sont imposés pour empêcher la pollution en mer. Il y a des lois en vigueur qui interdisent la pollution dans les ports. L'action internationale devrait être bien coordonnée et devrait s'occuper du problème de la pollution en général, et pas seulement de la pollution par les hydrocarbures. Afin de protéger l'environnement, il est indispensable que les objectifs soient bien définis, en sorte que les problèmes de pollution puissent être inventoriés et compris, et qu'une action positive soit entreprise.

Inde

Ce long mais très intéressant rapport commence par une définition de la « pollution marine » et l'auteur fait valoir que ce problème « doit être résolu en tenant compte des nécessités économiques fondamentales d'un pays en voie de développement ».

L'Inde a progressé technologiquement depuis l'indépendance mais ce progrès a été accompagné par une augmentation de la pollution. Tous les genres de pollution connus en Occident sont présents en Inde à des degrés plus ou moins grands.

L'auteur divise la pollution de l'eau en trois catégories : la pollution par hydrocarbures, la pollution générale et la pollution par causes diverses. Sous le vocable de pollution générale, il comprend les résidus solides, liquides et gazeux, les eaux d'égouts et les matières radioactives. Comprise dans les pollutions « diverses » est celle causée par les plantes aquatiques.

La pollution par hydrocarbures est subdivisée en produits « persistants » et « non-persistants », mais les premiers seulement sont considérés créer un problème sérieux. Ces pétroles pénètrent dans la mer par les moyens déjà décrits dans les rapports précédents et il n'y a pas de règles fixes pour traiter cette pollution — chaque cas doit être étudié et traité individuellement.

Jusqu'à ce jour, l'Inde n'a pas connu de cas de pollution par le pétrole dans les mers qui l'entourent, mais le trafic des navires-citernes augmente rapidement et une planification doit être élaborée pour s'occuper des rejets sérieux, quand ils se produiront. L'auteur discute les principes selon lesquels cette planification doit être établie.

Bien qu'on n'ait pas enregistré de pollution par pétrole au large des côtes dans le voisinage de l'Inde, il s'est produit un nombre de cas de l'espèce dans les différents ports. Le rapport décrit quatre cas dans le port de Cochin. Les causes de ces accidents et les actions pour y remédier sont décrites en détail.

Sous le titre de « pollution générale », l'auteur décrit la source de différents types de pollution qui se classent dans cette catégorie et les méthodes employées pour combattre les différents polluants. L'auteur discute en détail plusieurs cas circonstanciés de pollution de l'eau par des produits chimiques toxiques.

La mer possède une capacité énorme d'assimiler les déchets et le rapport prétend que, grâce à une recherche scientifique adéquate, à une utilisation judicieuse des déchets et à des contrôles très précis de ceux-ci, certains types de polluants peuvent fournir des fertilisants qui amélioreront l'environnement marin.

A l'heure actuelle, un très faible pourcentage seulement des eaux d'égout de l'Inde passe par un traitement quelconque. Par exemple, même à Bombay, alors que septante-deux millions de gallons d'eaux d'égout reçoivent journellement un traitement sommaire, avant d'être déversées dans la mer, les cent vingt-huit millions de gallons restants sont envoyés directement à la rivière ou à la mer.

Sous le titre de polluants divers, le rapport discute le rejet à la mer de déblais dragués, et il souligne qu'un très fort pourcentage de tout ce qu'on déverse dans l'océan consiste en matériaux de déblai. Le rapport ne fait pas apparaître suffisamment clairement que, tandis qu'une partie des matériaux dragués peut être polluée, la grande majorité ne l'est pas — et il ne prouve pas non plus que les effets de déversement de déblais dragués à des endroits où se nourrissent les poissons peuvent être bénéfiques, plutôt que nuisibles.

Sous le titre également de polluants divers, se place une discussion intéressante de la pollution provoquée par certaines plantes aquatiques. La plante dont il discute est la jacinthe d'eau, qui est devenue un fléau économique dans les eaux stagnantes de l'Etat de Kerala. Ces plantes bloquent les canaux et les rivières et arrêtent la navigation, elles étouffent le poisson, détruisent les champs fertiles et encouragent la prolifération de moustiques porteurs de maladies. En outre, on déclare que ces plantes peuvent mettre en danger le fonctionnement de stations hydro-électriques et affaiblir les piliers des ponts.

Dans la « conclusion » du rapport, l'auteur exprime ses soucis au sujet de la croissance rapide de la population mondiale et de ses effets sur la pollution. Il déclare que la rapide expansion industrielle a conduit à un environnement anti-hygiénique et anti-sanitaire dans son pays, et il déclare qu'il faut mettre fin à cette situation, en réformant les communautés, en réutilisant les eaux usées et en planifiant des installations de manière à éviter la pollution. L'auteur déclare que « la pire des pollutions des pays sous-développés est la pollution de la pauvreté, qui doit être extirpée jusqu'à la racine par des efforts vigoureux ». Le rapport ne mentionne pas les efforts faits en matière de contrôle des naissances et qui sont en cours en Inde.

Pays-Bas

Ce rapport est divisé en deux parties. La première partie contient une discussion générale de la pollution de l'eau aux Pays-Bas et des mesures qui ont été prises pour combattre cette pollution.

Quoiqu'il y ait eu beaucoup d'essais tentés, pendant les 100 dernières années, de légiférer contre la pollution de l'eau, les Pays-Bas n'ont pas obtenu un pouvoir législatif pour traiter de ce problème avant le vote en 1969 de la Loi sur la Pollution des Eaux de Surface.

Aux Pays-Bas, on croit qu'une interdiction automatique de déverser des déchets dans les voies d'eau est chimérique. Ils ont donc élaboré une politique d'autorisations qui donne aux Gouvernements le contrôle sur toutes les opérations d'immondices, tant en ce qui regarde les quantités que la qualité. Le Gouvernement national est responsable pour la délivrance de permis de déversement dans les principales rivières, les ports et la Mer du Nord, tandis que les Gouvernements provinciaux sont responsables pour la délivrance de permis en ce qui concerne les voies d'eau plus petites. Chaque demande de permis est traitée individuellement et la délivrance du permis est soumise aux conditions et aux restrictions qui paraissent appropriées à chaque cas particulier.

Un aspect intéressant du système des permis, ce sont les redevances qui accompagnent les permis. De la sorte, l'organisme polluant n'est pas seulement tenu d'améliorer la qualité de ses déversements dans les voies d'eau mais il est aussi obligé d'aider à financer la construction et le fonctionnement d'installations anti-pollution.

Le rapport traite assez longuement des différentes méthodes de combattre la pollution de l'eau par les hydrocarbures et, comme ce fut le cas dans différents rapports antérieurs, il est partisan de l'enlèvement du pétrole par des moyens mécaniques.

Les auteurs croient que, dans un avenir prévisible, la réglementation concernant le déversement des déchets dans la mer sera aussi contraignante que celle qui s'occupe des déversements dans les eaux de l'intérieur du pays.

Dans la seconde partie du rapport, les auteurs résument l'histoire du traitement des immondices dans la ville de Rotterdam et décrivent ensuite une nouvelle installation pour la manipulation des polluants.

Depuis la Deuxième Guerre Mondiale, les bassins de Rotterdam ont été agrandis considérablement. Cette expansion des bassins s'est accompagnée d'une forte croissance industrielle, dont une grande partie dans le domaine de la pétrochimie. Cette croissance industrielle a provoqué une forte augmentation des quantités de matériaux de rebut provenant du port. Ces déchets comprenaient du matériel d'emballage, des marchandises avariées, des produits chimiques et des eaux polluées. Le volume des déchets est devenu si considérable que nombre d'industries se sont établies spécialement pour recueillir et enlever ces matières.

Les matières solides étaient jetées sur des dépotoirs à proximité de la ville mais, pour la plus grande part, les liquides étaient déversés dans l'eau. Aucune de ces méthodes n'offrait de solution acceptable à long terme et, en 1963, les autorités de la ville donnèrent l'autorisation d'effectuer une étude approfondie de ce sujet. Le but ultime de cette étude était de déterminer quelle était la meilleure méthode de traiter les ordures de la ville et il fut décidé que la méthode choisie devrait être capable de la débarrasser de tous les déchets, peu importe leurs quantités et leur composition. Il fut finalement décidé qu'un nouvel incinérateur offrait la meilleure solution pour les problèmes de la ville. L'incinérateur devait être conçu pour traiter 700.000 tonnes de matières par an et on estima son coût à environ quarante-huit millions de dollars. Comme Rotterdam n'avait pas cette somme d'argent à sa disposition, on arrangea finalement que l'usine serait construite par une société anonyme, dont les actionnaires seraient vingt-trois municipalités de la région du delta du Rhin.

L'incinérateur était divisé en deux parties, une section pour traiter les déchets domestiques et industriels, et l'autre pour les déchets chimiques. La première section consistait en six appareils de combustion, chacun d'une capacité de 16 tonnes de déchets par heure. La chaleur produite par ces appareils de combustion était utilisée pour la production de vapeur. Les chaudières produisent de la vapeur à raison de 50 tonnes par heure, et cette vapeur est utilisée à deux fins : la production d'électricité et la distillation de l'eau de rivière. Les turbo générateurs sont conçus pour produire 200 millions de KWH d'électricité par an et les évaporateurs sont conçus pour produire environ 16 millions de mètres cubes d'eau distillée par an.

La deuxième section de l'usine, celle pour le traitement des déchets chimiques, consiste en deux grands fourneaux rotatifs, derrière lesquels se trouvent deux chambres post-incinératoires pour le traitement des déchets chimiques liquides. Chacun de ces fourneaux a une capacité de 1 1/2 tonne de solides et de 2 tonnes de liquides par heure.

Avant d'être enfournés dans les fourneaux rotatifs, les déchets chimiques solides sont emmagasinés dans une soute sous-divisée ayant une capacité de quatre mille mètres cubes. Ils sont jetés dans les fourneaux, par paquets de 50 kg, par un sas à air. Les déchets liquides sont momentanément emmagasinés dans une ferme à réservoirs, qui contient dix-neuf réservoirs et a une capacité totale de cinq cents mètres cubes, et ils sont ensuite versés dans les chambres post-incinératoires grâce à une pression d'azote sur les réservoirs.

Les méthodes pour enlever les polluants chimiques, tels que HCl, SO_2 et HF, du gaz de carneau des fourneaux rotatifs, n'ont pas encore été mises au point. Des essais sont en cours, avec l'espoir qu'on pourra élaborer des méthodes efficaces de filtrage.

L'usine est conçue pour recevoir des matières de déchets par camion et, également, par bateau.

Le coût final de l'usine, qui a été mise en fonctionnement en mars de cette année, atteignait presque septante-deux millions de dollars et on compte que les dépenses annuelles de fonctionnement, y compris une marge pour les intérêts et l'amortissement, seront de onze millions de dollars. On prévoit que les revenus provenant du fonctionnement de cette usine (vente de l'électricité, de l'eau distillée et des rebuts, et les redevances pour la destruction des ordures) suffiront exactement à couvrir les dépenses de fonctionnement. Pour y arriver, il faudra chaque année réadapter les dépenses et les redevances.

Portugal

Ce rapport concerne exclusivement le traitement des eaux chargées d'hydrocarbures en provenance des pétroliers.

Dans l'introduction, les auteurs parlent en termes généraux de la nature, des causes et des effets de la pollution de l'eau causée par les produits pétroliers. En particulier, ils traitent des types d'eau polluée qui sont associés aux pétroliers.

Suit alors une discussion des efforts internationaux pour prévenir la pollution des mers par les hydrocarbures. On se réfère spécialement aux cinq résolutions adoptées par la Conférence Intergouvernementale qui s'est tenue à Londres en 1954. Ces résolutions contenaient des recommandations spécifiques visant à ce que les grands ports soient équipés de stations capables de recueillir le pétrole et les mélanges huileux.

Les auteurs soulignent que, du fait que 60 % de la flotte mondiale des pétroliers passent le long des côtes du Portugal venant ou allant aux gisements pétrolifères du Moyen-Orient, il est particulièrement important que le pays soit équipé de stations de réception des résidus d'hydrocarbures.

Avec la construction des chantiers navals de radoubage de Lisnave, qui sont capables d'accueillir les plus grands pétroliers naviguant aujourd'hui, il devint plus important que jamais que Lisbonne dispose d'installations de nettoyage et de dégazage des pétroliers et pour se débarrasser des résidus de pétrole. Ces exigences amenèrent la création de Gaslimpo en 1967. L'unique but de cette société est de recueillir le pétrole et les eaux contaminées des navires faisant escale au port de Lisbonne.

Gaslimpo a utilisé pour ses stations de nettoyage, des pétroliers, dans la gamme des 17/23.000 TDW, qui approchaient de la fin de leur existence utile comme bateaux opérationnels. Il y a maintenant trois de ces bateaux en service. Pour convertir ces bateaux en stations de nettoyage, les propriétaires en ont enlevé tout l'équipement et les superstructures, tels que le moteur principal, les arbres de transmission, les hélices et les cabines du milieu du navire, qui n'étaient pas strictement nécessaires aux nouvelles fonctions des navires. Cependant, les chaudières, les systèmes de pompage et les génératrices auxiliaires ont été gardés et révisés, car ils jouent un rôle vital dans le fonctionnement des stations.

Le pétrole reçu par les stations est séparé par un procédé continu de cascade qui utilise les citernes du navire. En conditionnant les bateaux pour ce service, les citernes ont été reliées entre elles et des lignes de décharge ont été construites. Comme les stations traitent un pourcentage élevé de paraffine, les rouleaux d'échauffement dans le fond des réservoirs jouent un rôle spécialement important et, en certains cas, il était nécessaire d'ajouter des rouleaux supplémentaires, pour obtenir les températures adéquates d'huile.

Les stations sont équipées de toutes les installations nécessaires pour aider à nettoyer les pétroliers de taille moyenne. Elles peuvent fournir de l'eau de nettoyage chaude et froide, de la vapeur, de l'électricité, de l'air comprimé et également des ventilateurs mobiles pour les travaux de dégazage.

Les opérations de nettoyage sont normalement effectuées à l'ancre dans le port, plutôt qu'à quai. La station, qui est munie de défenses spéciales, est remorquée jusqu'au pétrolier et amarrée le long de ce navire. Les deux bateaux sont maintenus en position par l'ancre du pétrolier. Depuis l'établissement de Gaslimpo, il n'y a pas eu un seul accident impliquant les stations de nettoyage et les pétroliers pris en charge.

Le liquide qui est récupéré des séparateurs primaires est conduit dans des réservoirs d'emmagasinage. Il contient cependant encore un pourcentage élevé d'eau, et une seconde séparation est par conséquent effectuée en décantant les réservoirs d'emmagasinage où le mélange est maintenu à une température élevée.

La capacité de prise et de débit de ces stations de nettoyage varie beaucoup suivant le type de mélange qui est traité. Avec des liquides contenant moins d'un pour-cent d'huile, les stations ont une capacité d'admission allant jusqu'à 2.500 tonnes par heure, mais ce taux peut tomber aussi bas que 200 tonnes par heure quand on traite des slops fortement émulsionnés. Pendant ses cinq années de fonctionnement, Gaslimpo a traité plus de deux millions de tonnes d'eau contaminée. L'effluent déversé par les stations est constamment échantillonné et analysé, pour s'assurer que sa qualité répond bien aux normes exigées.

Une caractéristique des stations de nettoyage qui aide à maintenir à un niveau bas leur coût de fonctionnement est leur possibilité d'utiliser le pétrole récupéré comme combustible pour les chaudières des stations. Pour que ce soit possible, cependant, le point d'inflammabilité, qui est très bas à cause de la forte proportion de produits légers, doit être rectifié. Ceci se fait en faisant passer les produits légers à travers des injections de vapeur dans les réservoirs de traitement.

Comme la machinerie de ces bateaux est vieille, elle demande plus qu'un entretien normal pour s'assurer qu'un arrêt ne se produira pas pendant que la station est en fonctionnement. Pour la même raison, les propriétaires essayent d'avoir des doubles des pièces les plus vitales de la machinerie.

L'équipage de la station compte sept hommes par équipe pendant les opérations de nettoyage, et cette équipe est renforcée par un officier de pont et deux marins quand le bateau manœuvre. Les opérations se poursuivent 24 heures sur 24 et sept jours par semaine.

Les auteurs suggèrent que le coût d'une station de nettoyage complète, comme celles que possède Gaslimpo, représente entre 1,4 et 2 millions de dollars. Ce montant peut varier, suivant la grandeur du bateau, le procédé utilisé et le pays dans lequel la station est préparée.

Des navires de ce type ont deux sources de revenus (1) les sommes qu'ils facturent aux bateaux qui utilisent leurs services et (2) les recettes provenant de l'huile récupérée qu'ils vendent.

Royaume-Uni

Ce rapport traite de la pollution de l'océan mais se borne principalement au problème concernant la pollution par les hydrocarbures. Il ressemble, en beaucoup d'aspects, aux autres rapports, et les points de similarité ne seront pas évoqués ici.

Dans l'introduction, les auteurs posent un certain nombre de questions intéressantes. Ils parlent de l'hystérie qui s'est emparée du public, ces dernières années, à la seule mention du mot pollution et ils soulignent combien facilement les politiciens répondent à cette hystérie. Ils demandent aussi si le grand public est disposé à payer le prix qu'il faut pour un meilleur environnement et ils se demandent d'où viendra l'argent pour combattre la pollution si les « conservateurs » font ce qu'ils veulent et que le taux d'industrialisation est réduit.

Le rapport contient une discussion intéressante au sujet de la « résurrection » de la Tamise, qui recueille les ordures de onze millions de personnes mais dont le débit d'eau douce n'est que de 2.500 pieds cubes par seconde. Les difficultés de la rivière ont commencé dans les années 1860, quand les installations sanitaires par eau ont été introduites pour la première fois. En 1949, la Tamise était devenue « malodorante et sans vie ». A ce moment a commencé une vaste étude pour identifier les sources de pollution, pour établir le mécanisme du mélange des marées, pour étudier la chimie de l'épuration et pour définir la stratégie à suivre pour faire revivre le fleuve. Neuf ans après l'achèvement de cette étude et la mise en œuvre de ses recommandations, la Tamise est sur le chemin de la récupération.

Les auteurs croient que la façon de penser des années 1860, en ce qui regarde le déversement des détritus dans le fleuve à partir de la Cité de Londres, se répète à l'heure actuelle, la mer étant substituée à la rivière. Ils estiment que cette façon de penser fait preuve d'imprévoyance et que des mesures immédiates doivent être prises pour empêcher de sérieux dommages à la mer, spécialement dans ses zones voisines des côtes.

Les auteurs soulignent que, malgré que l'Organisation Intergouvernementale Consultative de la Navigation Maritime (IMCO) ait été sévèrement critiquée pour n'avoir pas atteint ses buts, elle a néanmoins obtenu des résultats très valables. Ils suggèrent qu'une grande partie de la pollution des mers par le pétrole provient de bateaux qui naviguent sous un « pavillon de convenance » et qui ne se soumettent pas aux méthodes recommandées par l'IMCO.

Les auteurs préconisent l'amarrage au large à une bouée (single buoy mooring) pour les pétroliers. Un des grands avantages de ce système est que les petits rejets accidentels de pétrole sont rapidement dispersés dans l'océan, tandis qu'un rejet identique dans les eaux d'un port pourrait présenter de sérieux problèmes.

En discutant des remèdes en cas d'accidents impliquant des pétroliers, le rapport déclare que la meilleure manière de réduire la menace d'une grave pollution par les hydrocarbures est de mener à bien des opérations de sauvetage, que ces opérations soient ou non justifiées financièrement par la valeur des navires récupérés et de leur cargaison.

Le rapport discute les moyens par lesquels les propriétaires de pétroliers peuvent se couvrir contre les responsabilités qu'entraînent les rejets d'hydrocarbures, et il décrit les assurances qui peuvent être souscrites chez TOVALOP et CRISTAL.

Une des caractéristiques favorables des rejets d'hydrocarbures en mer, dans des eaux tempérées, est le fait que le pétrole est très rapidement dégradé biologiquement.

Ce rapport souligne que le rejet de produits non pétroliers, au cours de leur manipulation à un terminal, peut poser des problèmes considérables de pollution. Par exemple, une livre de sucre exige autant d'oxygène pour « sa décomposition bactériologique » qu'il en faut pour la totalité des déchets bruts provenant d'un seul homme en une semaine ».

Les auteurs traitent assez longuement des effets des activités de dragage sur la pollution de l'eau. Ils soulignent que, à cause de leurs eaux tranquilles et de leur profondeur généralement plus grande, les ports agissent comme des trappes et recueillent de grandes quantités de décharges d'égouts et de matières toxiques. Le fait de draguer ces zones peut mettre en suspension des matières qui autrement pourraient rester tranquilles sur le fond. Parlant du Port de Londres, les auteurs déclarent que c'était pratique courante dans le passé de déposer les déblais dragués dans les eaux côtières, « dans l'espoir qu'ils ne reviendraient pas aussi vite qu'ils étaient dragués ». Ce dernier problème est maintenant résolu en choisissant de nouvelles zones de déversement des déblais là où peut s'effectuer un mélange adéquat et une bonne dispersion.

Le Port de Londres s'est récemment équipé d'installations de pompage à terre pour l'enlèvement de la plus grande partie des matières draguées dans les limites de sa juridiction. Cette méthode a amené une réduction du mouvement des sédiments, une réduction des besoins de dragage et une réduction du niveau des matières en suspension dans l'eau. Les auteurs déclarent que ce procédé a progressivement retiré des eaux de la Tamise des matières polluantes, mais, malheureusement, ne donnent pas de détails sur les méthodes employées pour empêcher l'eau utilisée par le pompage et ses polluants non solides (produits chimiques dissous et bactéries) de retourner à la Tamise. Il est possible que cette eau reçoive un traitement et soit ensuite rendue à la rivière, mais le rapport ne le dit pas.

Lorsqu'il discute les moyens de prévenir la pollution causée par des accidents, le rapport argumente avec raison que les lourdes amendes infligées aux Sociétés n'ont « que peu d'effet sur leurs employés éloignés ».

Le rapport parle de différents effets secondaires néfastes qui peuvent accompagner une amélioration de la qualité de l'eau. Parmi ceux-ci il y a le retour des tarets marins, des hydroïdes et des bernaches, et la nécessité d'une protection cathodique pour les structures marines faites d'acier.

Dans sa conclusion, le rapport émet l'avertissement que la pollution marine ne doit pas devenir une affaire politique.

Suède

L'auteur introduit son sujet en disant, concernant la pollution des océans, que « un phénomène crée le problème et un autre phénomène nous amène à demander des mesures propres à limiter les effets du premier ». Comme il voit les choses, le premier phénomène est le rapide développement technique et le second phénomène est la récente prise de conscience, qui s'accroît rapidement, que la limite de pollution acceptable a presque été atteinte.

Ce rapport se limite aux aspects de la pollution de l'océan où les produits pétroliers entrent en ligne de compte. De longues sections du rapport traitent de (*a*) les différentes manières dont la pollution par l'huile peut se produire (*b*) les méthodes pour améliorer la conception des pétroliers, de manière à réduire la pollution (*c*) les méthodes pour améliorer la navigation en mer, pour réduire les accidents (*d*) les méthodes pour améliorer la manutention sur les pétroliers (*e*) l'état de préparation actuel de la Suède pour traiter les déversements d'hydrocarbures (*f*) l'établissement dans les ports de stations pour recevoir les eaux huileuses (*g*) la coordination du trafic (*h*) la lutte contre la pollution par le pétrole. Toutes ces sections ci-dessus mentionnées traitent, pour la plus grande partie, de matières déjà discutées dans les rapports précédents; il serait donc superflu de répéter des renseignements déjà donnés ailleurs. Pour ce motif la discussion sera limitée aux points particuliers au rapport suédois.

Une suggestion intéressante, contenue dans la discussion de l'eau de ballast, est la possibilité d'installer une membrane flexible dans les réservoirs à pétrole, pour empêcher le mélange de résidus d'huile et d'eau de ballast.

Dans sa discussion sur les collisions de navires, l'auteur déclare que la question de la distance qu'il faut pour s'arrêter a une grande importance et il souligne que, actuellement, il faut à un pétrolier de 250.000 tonnes presque trois milles pour s'arrêter. Le rapport suggère que des parachutes pourraient être utilisés pour réduire cette distance jusqu'à 75 %.

Dans la section traitant de la sécurité dans la navigation, le rapport énumère un certain nombre de nouvelles aides à la navigation qui sont devenues d'usage courant dans les dernières années. Ces aides comprennent le radar anti-collision, la navigation « satellite » et les lochs Doppler. La navigation satellite fonctionne tout à fait automatiquement et la précision des déterminations de la position sont normalement justes jusqu'à moins de 100 m. Le nombre de « fixes » possible varie avec la situation du navire mais ils sont en moyenne d'environ une position toutes les quarante minutes. Entre les « fixes », la détermination de la position s'effectue à l'estime. Le loch Doppler, qui enregistre la vitesse sur le fond, donne au navigateur des vitesses exactes grâce auxquelles il peut déterminer la position du navire à l'estime.

Pour une détermination exacte continue de la position, les méthodes Decca et Toran, qui sont mues par des ondes radio continues, peuvent être utilisées.

Le rapport contient une description très intéressante du système de radar anti-collision. Dans ce système, les bateaux se trouvant sur des trajectoires de collision, ou ceux qui vont passer très près l'un de l'autre, sont marqués spécialement sur l'écran radar, et le système émet un bruit ou une lumière d'alarme.

Dans la section qui traite d'une plus grande sécurité dans la manutention de la marchandise, le rapport décrit des dispositifs de manutention automatique qui, pendant le chargement, surveillent constamment les efforts de cisaillement, les moments de fléchissement, le port en lourd, le tirant d'eau et le déjaugeage. Quand l'un de ces facteurs tombe en dehors de limites pré-déterminées, mettant en danger la sécurité du bateau, l'alarme est immédiatement donnée.

En ce qui concerne les méthodes de lutte contre la pollution par les hydrocarbures, ce rapport est d'accord avec les précédents, en affirmant que les méthodes mécaniques d'enlèvement de pétrole sont préférables aux méthodes chimiques.

Traitant des agents de dispersion, le rapport déclare qu'il existe actuellement sur le marché une « troisième génération » de ces matières et qu'elles sont caractérisées par une faible toxicité, un plus grand pouvoir de dispersion, un coût moindre et des propriétés meilleures de décomposition.

Toujours dans la section traitant de la lutte contre la pollution par le pétrole, l'auteur décrit une série de microbes qui ont la propriété d'être des « mangeurs de pétrole ». Le revers, cependant, est la possibilité que, après avoir dévoré le pétrole et en être morts, ils peuvent devenir une nourriture pour les poissons et ainsi mettre en danger les poissons de l'océan.

Le rapport présente une description bien détaillée de la plupart des aspects de la pollution de l'eau de mer par les produits pétroliers. Comme il est dit dans la conclusion, le manque de place a empêché la discussion des déversements de pétrole par les débouchés d'égouts, ou provenant de réservoirs à huile situés sur le littoral à proximité de l'océan, ou résultant d'opérations de forage au large. Le rapport ne comprend pas non plus la discussion de la pollution provenant du déversement dans l'océan de produits chimiques, de résidus industriels et de déchets domestiques.

U.S.A.

En parlant de la pollution dans les ports et dans les eaux du littoral, ce rapport décrit beaucoup de pratiques, d'études, d'organisations internationales, de procédés pour combattre la pollution, etc., qui ont été discutés antérieurement dans ce rapport général. Aussi, la discussion de ce rapport sera limitée aux sections qui contiennent des renseignements supplémentaires ou qui présentent des idées différentes de celles exprimées dans les autres rapports.

L'auteur situe le début de « la grande croisade anti-pollution » le 18 mars 1967, date de l'échouage du « Torrey Canyon ». La première réaction à cet accident fut « un déluge de lois et règlements mal avisés et souvent contradictoires élaborés par les diverses entités gouvernementales ». Beaucoup de cette législation était une répétition d'efforts faits par des juridictions se chevauchant, et il n'y avait pas de plan global coordonné pour un contrôle efficace de la pollution. L'auteur déclare, cependant, que cette situation est en train d'être réexaminée aux Etats-Unis et que des révisions, basées sur des faits économiques et sur des considérations écologiques et de l'environnement, sont effectuées.

L'auteur prévoit une forte augmentation des possibilités de pollution par hydrocarbures dans les eaux des Etats-Unis comme conséquence de la pénurie d'essence à laquelle ce pays fait face actuellement. Il estime que, en 1985, on importera journellement quelque quinze millions de barils de pétrole, et il prévoit qu'un pourcentage élevé de cette quantité parviendra par pétroliers.

Le rapport introduit une nouvelle source de pollution des océans quand il discute les effets des très grandes hélices des super-pétroliers mis en service actuellement. Ces hélices peuvent avoir un effet sur la turbidité et sur la salinité et, par-là, un effet nuisible sur certaines espèces de poissons.

Le rapport discute assez longuement les exigences de différentes lois anti-pollution aux Etats-Unis et dans d'autres pays. Des détails sont fournis sur la loi de 1970 des Etats-Unis sur l'Amélioration de la Qualité de l'Eau, et l'interaction des réglementations fédérales et des Etats est discutée.

Aux Etats-Unis, la Garde des Côtes a actuellement la responsabilité de faire respecter la Loi susmentionnée. La Loi des Déchets de 1899, qui interdit le déversement dans les eaux navigables sans un permis est du ressort du Corps des Ingénieurs de l'Armée, mais on tente de transférer leur pouvoir d'accorder des permis à l'Agence de Protection de l'Environnement.

Le rapport mentionne la Loi britannique sur les hydrocarbures et les voies navigables, la Loi canadienne de 1971 sur la Navigation et la Loi grecque de 1971 sur le Contrôle de la Pollution. Il mentionne aussi que l'Etat du Maine a voté une loi qui impose une taxe de 1/2 cent par baril sur tous les transports de pétrole. Cet argent est destiné à payer pour l'entretien des points de destination et pour les nettoyages des rejets en provenance des pétroliers.

Le rapport traite longuement des différentes Conférences et Conventions internationales qui ont eu lieu ou qui vont avoir lieu dans le but de combattre la pollution par les hydrocarbures. Pour la question de l'assurance contre la pollution, le rapport explique ce que font TOVALOP et CRISTAL.

Ce rapport contient d'intéressantes descriptions de divers dispositifs et méthodes de détection de la pollution. Parmi elles, il y a la méthode d'« empreinte digitale » qui permet d'établir la source d'une huile donnée par l'emploi de techniques modernes analytiques, un radiomètre à micro-ondes, un appareil pour détecter des nappes d'huile en mer par avion (même par brouillard ou pendant la nuit), un détecteur portable de pétrole flottant, qui peut enregistrer des traces de pétrole qui ne sont pas visibles à l'œil nu, un enregistreur à l'infra-rouge qui, quand il est utilisé à bord d'hélicoptères, peut déceler des sources de pollution en mesurant des différences de température.

Dans sa discussion des dispositifs de retenue, le rapport mentionne un barrage (boom) de retenue de pétrole à tension dans le fond, qui peut être utilisé dans des vagues de 20', des courants de 2 nœuds et des vents de 60 nœuds, un barrage flottant à air, qui peut être utilisé dans des eaux agitées, et des tentes sous-marines qui sont employées pour contenir les fuites d'hydrocarbures sous l'eau.

Dans la même section du rapport, il y a une description du « Dragon de la Mer » (Seadragon), créé pour l'Institut Pétrolier Américain par la Société Garrett de Los Angeles. Cet appareil est assez léger pour être transportable par air, et il balaye, écume, sépare et emmagasine le pétrole provenant de déversements en mer. Il est conçu pour fonctionner parmi des vagues pouvant atteindre 8' de haut et pour balayer une zone au rythme de 120 acres par heure. En outre, on escompte que cet appareil traitera un minimum de 25.000 gallons d'eau huileuse par heure.

Sous le titre d'appareils mécaniques de récupération, le rapport discute les écumoires et les barges à vide, et l'auteur souligne que, pour obtenir un fonctionnement efficace des premières, l'eau doit être presque tout à fait calme.

Le rapport traite aussi des absorbants et mentionne l'emploi de matières telles que la paille, la sciure de bois, la mousse de styrol et les sphagnacées. Une addition intéressante à cette liste est le coton qui, déclare l'auteur, est plus absorbant que la paille et, dans les cas où il ne peut pas être récupéré après l'accident, est moins nocif que d'autres produits chimiques.

L'auteur parle du « sable coulé », méthode de traiter les rejets de pétrole, mais il déclare que, encore qu'elle soit efficace pour enlever les rejets, il subsiste des doutes concernant ses effets sur le fond de l'océan.

Dans la section intitulée « autres moyens de limiter la pollution », l'auteur traite de la construction des navires, de la prévention des accidents, des installations de réception à terre, du procédé « Lavage-en-mer », du curage des ports, de l'aération, du traitement des déchets à bord des navires et des compacteurs de déchets à bord.

Dans la section traitant de « opérations de nettoyage des ports et plans pour imprévus », l'auteur souligne qu'un gros effort a été fait pour contrôler la pollution des ports et du littoral du monde et que les pionniers dans cette lutte sont de petits ports, plutôt que les ports géants. Le rapport continue en décrivant les programmes qui sont en cours à Portland, San Francisco, Oakland, Fremantle, Baltimore, Boston, Mobile, Norfolk, Hong-Kong, Toledo et Los Angeles.

L'auteur donne alors une liste de certaines suggestions et objectifs qui, à son sens, seraient bénéfiques pour le nettoyage de l'environnement. Elle comprend : la formation de coopératives de lutte contre la pollution, un marquage des bateaux indiquant la cargaison qu'ils transportent, le fait de confiner les super-pétroliers dans un nombre relativement petit de ports, des études ultérieures des propriétés physiques de différents produits qui sont manipulés dans les navires océaniques, des programmes pour chaque grand port de surveillance constante et de récolte de données, des recherches supplémentaires d'un type qui serait « orienté vers des solutions de problèmes réels et qui ne se contenterait pas de satisfaire une curiosité académique », le dragage excessif des ports et des canaux, pour réduire la turbidité provoquée par les hélices, l'établissement de normes réalistes pour la qualité de l'eau, le remplacement de la multiplicité actuelle des agences à fonction unique par une seule agence régulatrice à fonctions multiples, la suppression du « fossé de communication » entre, d'une part, les législateurs et le monde académique et, d'autre part, ceux qui, dans le monde du commerce, doivent prendre des décisions pratiques.

L'auteur regrette de constater que les professions qui sont le plus directement affectées par les problèmes de la pollution mondiale n'ont pas, à ce jour, suffisamment pris la tête de la guerre anti-pollution. Il estime que les personnes qui ont une connaissance pratique de première main du Génie Civil, de l'économie, etc., doivent assumer le rôle de chefs avant que les millions de dollars ne soient gaspillés « dans des idées académiques peu pratiques et anti-économiques ». En dépit de tous les obstacles, l'auteur pense que des progrès réels sont réalisés et il se permet de croire que, en 1975, les rouages du mécanisme légal nécessaire, l'équipement et les connaissances seront disponibles pour contrôler la pollution non seulement le long des côtes du monde entier mais sur toutes les mers. En conclusion, l'auteur conseille à ses lecteurs de faire connaître au public que l'élimination de la pollution à 100 % est un objectif impossible, mais qu'il y a certains niveaux de sécurité pour la qualité de l'eau qui sont réalisables techniquement et praticables économiquement, et que les autorités s'efforcent d'atteindre ces niveaux.

CONCLUSION

Tous les rapports examinés sont bien élaborés et instructifs. Il n'y a probablement aucun aspect de la pollution des océans qui n'ait été relevé par l'un au moins de ces rapports.

Il est cependant regrettable qu'un grand nombre de rapports traitent à peu près des mêmes sujets, et ceci a mené à un compte rendu plutôt déséquilibré pour ceux de ce groupe qui, du fait de l'ordre alphabétique adopté ici, ne figurent qu'en fin du rapport général.

A cause des doubles emplois ci-dessus mentionnés, les rapports qui traitent de luttes spécifiques contre la pollution sont, de manière générale, les plus intéressants. Ce commentaire, bien sûr, ne doit pas être considéré comme critique envers les auteurs des études plus générales. Mais il semblerait souhaitable, à l'avenir, de donner des directives aux différents auteurs quant aux sujets à traiter. Ces directives éviteraient les doubles emplois et permettraient, en aiguillant les auteurs vers des sujets spécifiques, plutôt que vers des sujets généraux, qu'un plus grand nombre de données soient soumises au Congrès.

XXIIIrd International Navigation Congress

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OTTAWA
1973

Section II

OCEAN NAVIGATION — NAVIGATION MARITIME

Subject 6 — Sujet 6

Measures for preventing pollution in harbours and on coasts. Means of minimizing and remedying such pollution.

Mesures de prévention contre la pollution des ports et des côtes. Moyens de la réduire et d'y remédier.

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PAPER

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INVESTIGATIONS FOR THE GARDEN ISLAND CAUSEWAY, WESTERN AUSTRALIA

INTRODUCTION

In 1969 the Australian Government decided to develop a naval base on the Western coast of the continent on Garden Island in Cockburn Sound. Previously all significant naval facilities had been concentrated on the South Eastern Coastline. The general area of Cockburn Sound had been selected as a site for a naval base as early as 1911. Careening Cove, on Garden Island, forms a naturally protected harbour for the wharf facilities and other parts of the Island provide isolated areas for barracks and an armament depot which are normally most difficult to locate adjacent to centres of population. The base is only 25 miles (40 km) by road from Fremantle, the port of Perth, capital of Western Australia (Fig. 1).

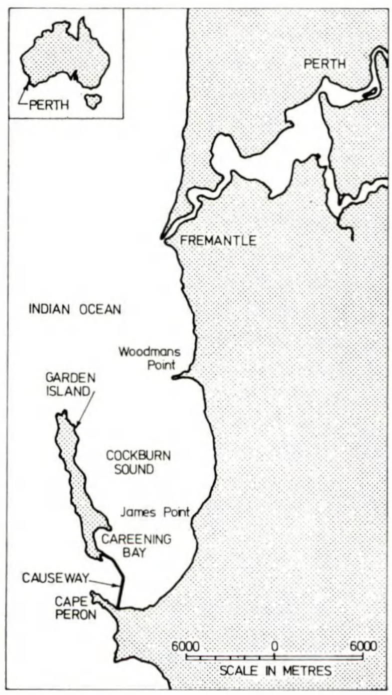

Fig. 1.
Location.

The efficient operation of the base and its economical construction required the construction of an access road between the Island and the mainland. The two alternatives were a bridge or a causeway. The latter was selected as it would provide protection to an area which the Port of Fremantle had planned to develop, was probably cheaper due to the exposed location of the shorter bridge route and represented a smaller security risk.

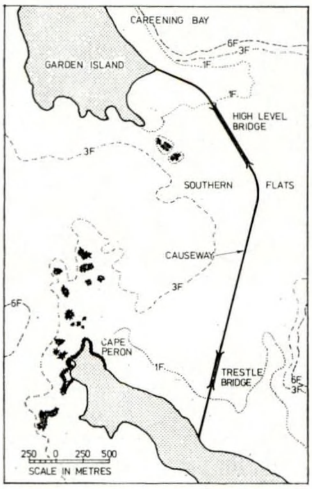

Fig. 2.

Causeway layout.

The causeway, which is approximately 2 1/2 miles long (3.3 km) was located in relatively shallow water over its full length, the greatest depth being 18 feet (5.5 m) below low water. It was kept back from the edge of the sand flats it was to be built upon so that the larger ocean waves would break before reaching the structure (Fig. 2). The causeway would have otherwise faced the full force of the waves from the almost limitless Southern Indian Ocean.

The chief concern with regard to the layout was that the causeway might so restrict the passage of water moving to and from across the Southern Flats that it might cause significant damage to the marine ecosystem within the Sound. This was strongly linked to the fact that one third of the mainland shore of Cockburn Sound had been industrialized with an oil refinery, a steel plant and other industries also requiring the handling of bulk, obnoxious and potentially polluting materials and effluents. At the same time, the waters of the Sound and some of its beaches represent an invaluable recreational resource for the city of Perth. The Sound has clear warm water which is protected from ocean waves and swell and is comparatively free of nuisance organism such as sharks, sea wasps and sea snakes.

Consequently an extensive marine environment investigation programme was set up to provide the best possible basis for an assessment of such possible damage and any necessary design variations, to advise upon problems in the construction phase and to monitor the actual effects of the construction. The investigation programme, conducted on a multi-discipline basis integrated information gathered by natural scientists, design and construction engineers and port planners. This allowed continual environmental assessment throughout all phases of the project from initial planning to construction. The programme showed that work could proceed without a protracted wait whilst environmental documentation and assessment were being undertaken.

The causeway has been completed at a cost of approximately $A10 million including the cost of investigations (approximately $A700,000). Figure 3 is a photograph of the causeway in a late stage of construction.

All costs are quoted in Australian dollars : $A1 = $US1.2.

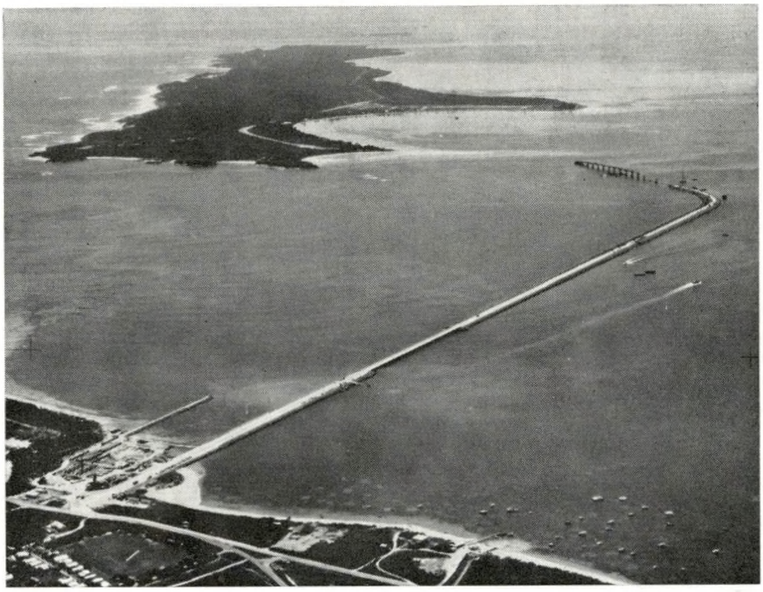

Fig. 3.

Garden Island causeway.

INVESTIGATIONS - GENERAL

Apart from the main marine environmental investigation programme, it was necessary to undertake hydraulic model testing for detailed design purposes, mathematical hydraulic modelling to check the preliminary assessment of flows through the restricted openings, wave measurements, materials surveys and subsurface investigations.

Many of these investigations posed problems which were not fully overcome although in all critical areas the results were adequate to enable a successful outcome to the project. The individual sections of this paper will emphasize these problems.

In a maritime project such as this, the investigations themselves are very expensive and need careful planning as a separate project.

The investigations need to be staged so that excessive amounts of money are not spent on unnecessary detail which is later not used. Various alternative solutions are firstly examined using all available information such as Admiralty Charts, wind and wave information from generalized sources, and the opinions of environmentalists who would draw on basic reference data sources. It is not possible to overemphasize the importance of taking the environmental factors into account at this very first stage, this is the stage where it is easiest to ensure a proper environmental solution.

Thus, before even commencing any investigations on site, an « order of cost » estimate is available combined with an « order of problem » statement of all aspects both engineering and environmental.

The first stage of site investigations is then planned; these should be extensive rather than intensive and are planned specifically to prove the relative merits of the alternatives. They would include environmental investigations; in many cases it will be necessary to commence the environmental investigations first as they frequently have seasonal aspects. Commonly it is necessary for the biologists to establish methods and techniques which are normally already established for engineering facets of investigations.

As the results of the site investigations become available, the alternative likely to be adopted crystallizes and effort is concentrated upon the investigations concerning it.

A stage is then reached when a « preliminary » statement of the engineering and environmental aspects can be made.

Following upon a decision to proceed with one definite scheme, a new stage of site investigations is planned to give detailed information for design and final assessment of the effect of the proposal upon the environment. Even at this stage variations will occur and the investigational programme must remain flexible so that it is possible to concentrate upon problem areas when they arise and to limit effort upon areas proven to be satisfactory.

It will be seen that this method of proceeding required a very closely knit multi-disciplinary team. The member of each discipline must be given the opportunity to impress his professional judgement on each relevant issue but, for a project of this type, the leader must be an engineer as only he is aware of the possible alternatives which are available to solve other discipline's problems.

MARINE ENVIRONMENTAL INVESTIGATIONS

Philosophy of Investigations.

The environmental investigations were conducted using problem solving scientific methodology. By adopting this philosophy data collection and collation became an assessment process rather than an encyclopaedia documentation of environmental phenomena such as winds, waves, direction and speed of currents and extensive species lists of the flora and fauna of the area. All investigations were conducted within the following conceptual framework.

(i) The phenomenon to be measured was *observed* and the « apparent » relationships between the parameters noted.

(ii) The problem was *defined* and a research *hypothesis* postulated.

(iii) The hypothesis was *tested* using low intensity field investigations.

(iv) Data gathered was *evaluated* in relation to the hypothesis which was either accepted or rejected.

(v) Programme *re-direction* followed either the acceptance or rejection of the hypothesis. The pragmatic approach facilitates a multivariable examination of the relationships between environmental phenomena. This is in contrast to the uni variable approach usually adopted by research scientists.

(vi) *Intensive* data collection followed re-direction, with an emphasis on the integration of field techniques to give as broad a range of simultaneous data as possible.

(vii) Data *synthesis* in the report preparation phase incorporated all environmental parameters relating to the problem.

Data collection was conducted by a team of scientists drawn from the disciplines of biology, botany, chemistry, engineering, geology and geography. These scientists were specialized in the subject areas of; marine ecology, and biology, marine botany and algology, water chemistry and analysis of animal flesh for toxic contaminents, nearshore hydrology, coastal geomorphology and sedimentology and coastal engineering.

Communication of ideas and the redirection of the investigation programme followed close liaison with all members of the multi-disciplinary project team. This facilitated an integration of hydrological, ecological, geomorphological and engineering concepts at all phases of the investigations.

Preliminary Analysis.

Figure 1 shows that Cockburn Sound is a euxinic (barred basin) structure enclosed by Garden Island to the west and shallow sand sills to the north and south-west. Although industrialization had been progressing along the mainland foreshore of the Sound, since the mid 1950's little hydrological information was available. Therefore, it was essential to determine what was :

(i) The natural replacement of water within Cockburn Sound.

(ii) What would be the effect of constructing a causeway across the Southern Flats.

(iii) What long term changes would be induced by the combined effect of the causeway structure and the continued disposal of industrial waste into the Sound.

Cockburn Sound has one of the smallest ranges of tide in the world with an average daily tidal range of 0 5 m, the tides are normally diurnal. Hodgkin and Dilollo (1958), Easton (1970). Tidal currents measured along the South West Australian coast were either very weak or non-existent. Therefore tidal rise and fall could be anticipated to cause an intruding and retreating wedge of water moving across the sills. This type of water exchange would not effect any significant rinsing of the bottom water of Cockburn Sound. Under these conditions any constructional impediment to the southern entrances of Cockburn Sound would further restrict what was already a very low level of circulation.

The Fremantle area records a high incidence of seasonal and local winds. Winter storms, which have persistent north west to west winds as the low pressure systems approach the coast, would produce flows to the south. Throughout the summer there are consistent afternoon sea breezes at 15-18 knots (7-9 m/sec.), from a south to south westerly direction. It was postulated that these southerly winds would produce a nett flow of water to the north. However, the sills at either end of the Sound were considered likely to impede the circulation of bottom water in the basin of Cockburn Sound.

The general plant and animal communities of the shallow sand flat fringing Cockburn Sound are typical of embayment environments along the West Australian Coast. It was considered that reduction of surface circulation by the causeway construction and a consequent increase in salinity and temperature might acrue from a reduction in the size of the southern entrance to Cockburn Sound. A large ecological imbalance might then occur and this would effect sea grass meadows maintaining the foreshore stability along the unconsolidated sand beaches. The programme therefore required and integrated study of hydrology marine ecology and foreshore stability.

The marine investigation time table from 1969 until December 1972 is shown in Fig. 4.

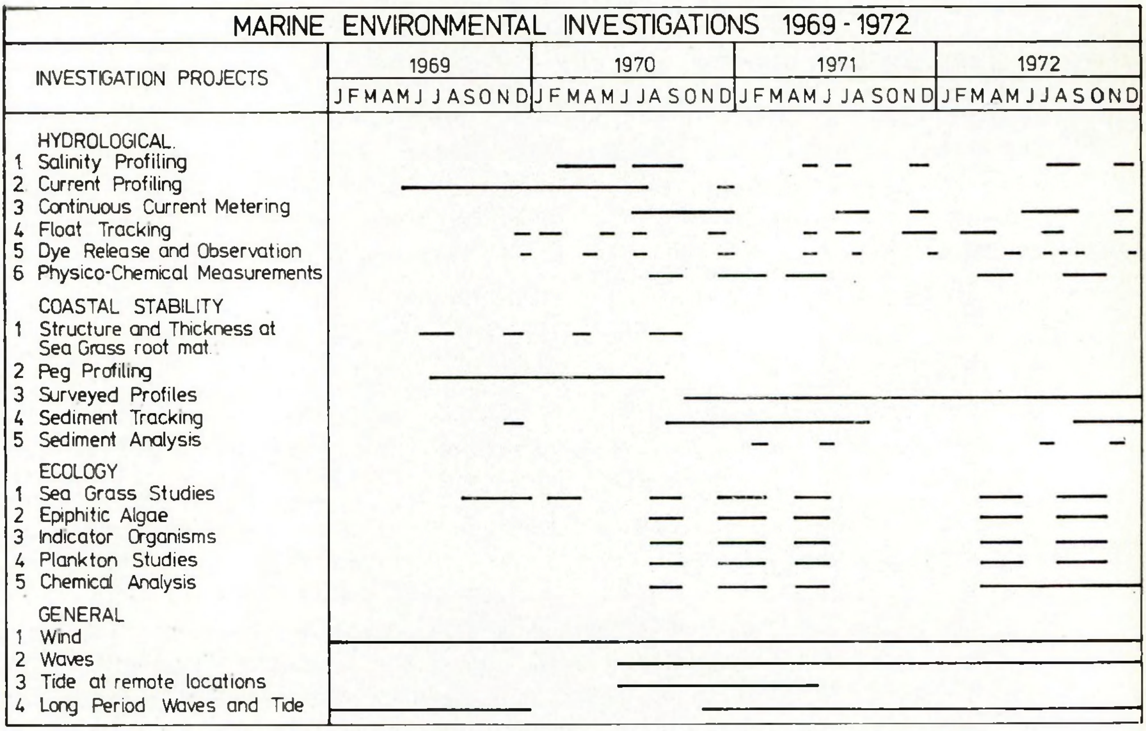

Fig. 4.

HYDROLOGICAL INVESTIGATIONS

The hydrological investigations were to determine the existing exchange rate of water and the mechanism by which exchange in Cockburn Sound occurred.

To do this within the period of time that would enable the results to be taken into account in the design of the Causeway a number of techniques were used simultaneously. This recognises the limitations of individual techniques and broadens the base for data collection. The techniques used were as follows :

1. Measuring the salinity/temperature characteristics of the Sound.
2. Recording of water velocity and direction profiles across the Southern alignment with a direct reading current meter.
3. Measurement of current velocity and direction using continuous-recording current meters mounted on towers at selected stations in the bottom of Cockburn Sound.
4. Tracking of drogue floats at different locations in the Sound in relation to environmental parameters of wind and tide.
5. Release of dyes with associated aircraft observation at significant locations within and outside the Sound.

Salinity Profiling.

The first essential feature of the hydrology of Cockburn Sound to be determined was the general time scale in which water was rinsed through the Sound, i.e. whether it was a period of hours, days, months or years.

Reconnaissance of Cockburn Sound showed that discrete water bodies could be visually identified. In many cases the interfaces were only inches thick and the difference in salinity and temperature, between the two bodies, could be established using portable temperature and salinity bridges. Where the water mass contained blooms of uni cellular algae the interface could be identified within the width of a divers face mask.

The work of Rochford (1969) showed that the salt content of ocean water off Fremantle changed seasonally, with high salinity in summer and low salinity in winter. He showed that these alterations in salinity were related to the origin of the water mass in that the low salinity water was « tropical » in its origin and moved southward down the coast during winter. This was subsequently replaced by a northward flow of water from temperate latitudes in the summer period. The overall annual change in water salinity off the West Australian Coast was approximately one and a half parts per thousand (35.0-36.5 ppt) which is well within the range of portable salinometers which have an accuracy of $\pm$ .03 parts per thousand.

From field observation of water bodies and the general information on the salinity characteristics of the waters of the South West Australian coast an investigation programme was designed. It was hypothesised that it was possible to determine the replacement period for both top and bottom water in in Cockburn Sound by measuring the salinity of the water mass, at a number of stations, over a short period of time in relation to the general onshore oceanic salinity. The lapse rate of oceanic water through Cockburn Sound could thus be plotted and the rate of rinsing calculated.

Some 36 sampling sections were selected both adjacent to and within the Cockburn Sound. These were plotted at 6 ft (1.8 m) intervals from the surface to the bottom at each station for both salinity and temperature. The profiling was completed at all stations within a 12 hour period.

Recordings were made either once or twice per day depending upon the manner in which the patterns of salinity were changing. If the pattern plotted after each survey showed marked changes, the survey was repeated immediately.

Repeated surveys of salinity and temperature showed that the replacement of water in Cockburn Sound was complete. Water from top to bottom is replaced within a period of time ranging from one to three weeks. The study confirmed that there is a general northward directional movement of water in the summer and a southward flow of water during the winter. There are accasional short-term reversals of these seasonal flows. The direction of exchange of water through the Sound was largely independent of either tide or wind stress.

Fig. 5 summarizes the winter pattern of flow documented by the salinity plotting technique. The winter pattern shows how bodies of diluted river water either enter the Sound or pass along the western shore of Garden Island. Rising tide retards the flow of riverine water into the ocean. Ebb tides release water with a high unicellular algal bloom which proliferattes when mixed with oceanic water and is readily identifiable. The movement is assisted by a persistent longshore oceanic current, which is retarded by the southern sill in Cockburn.

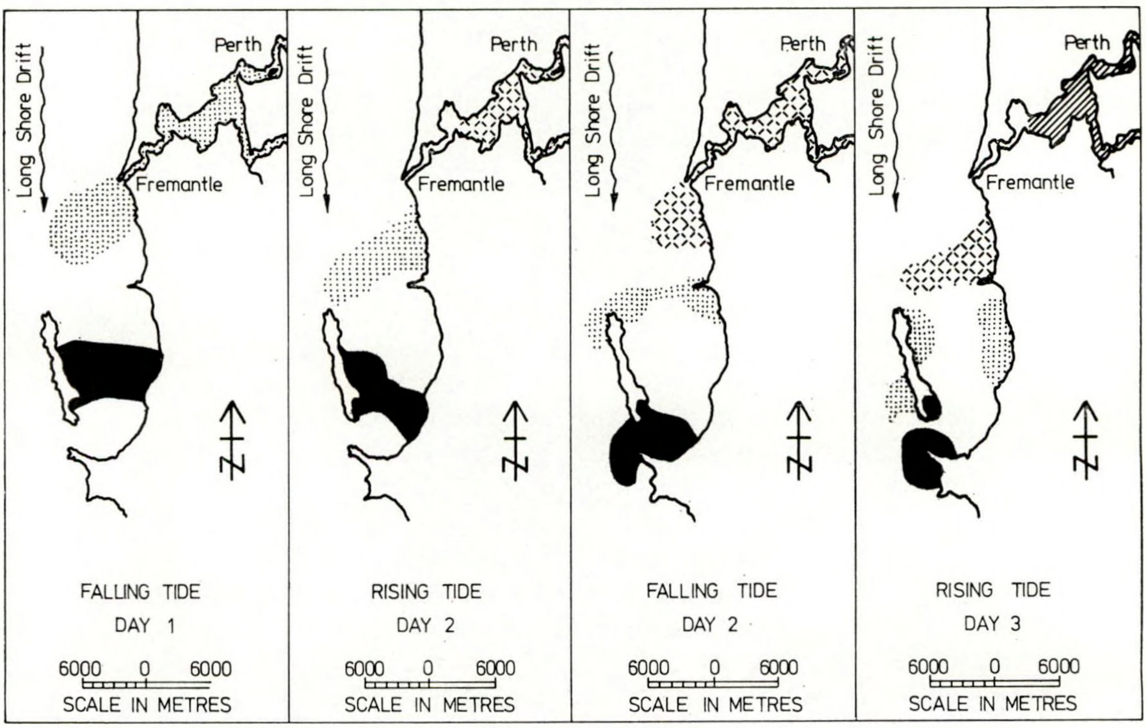

Fig. 5.
Winter pattern of exchange.

This produces an acceleration through the gap to the open sea (Fig. 7). The intrinsic circulation pattern set up within the Sound causes some deflection of water north of Garden Island.

Current Meter Profiling.

The direction and velocity of water movement at 11 individual stations across the southern opening to Cockburn Sound was measured at approximately 3 week intervals, twice per day for fourteen months. A Kelvin Hughes direct recording current meter was used with a diver controlled bottom release technique. Calculations were made from the profile measurement to determine the nett volume exchange for each sampling period. It was considered that this sampling would be random for wind and tide over the extended period and that variation due to tide and wind stress would be absorbed within the sampling period. The sites surveyed were in a reasonable sheltered location and the tides were daily.

The results of this survey are given in Figure 6 and confirmed the hypothesis on the seasonal directional movement of water through Cockburn Sound. Flow is northward in summer and southward in winter. However, a number of significant short term deviations from this general trend occurred.

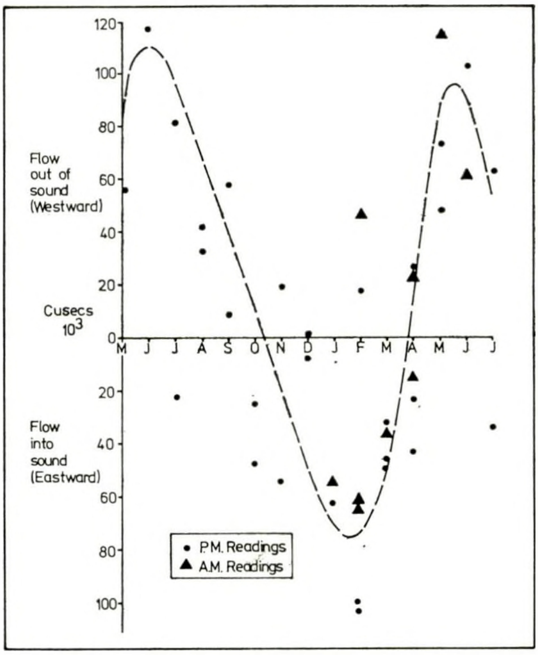

Fig. 6.

Nett flow of water through the southern opening of Cockburn Sound during the period 27 May 1969 to 16 July 1970.

Continuous Recording Current Meters.

Alekseev 2B current meters (usually three) were run synchronously at different locations within Cockburn Sound. This programme was subsequently amended to include a current meter located in the ocean west of Garden Island. These meters were suspended from tripod towers at selected stations. Recordings were taken 5 ft (1.6 m) above the bottom at 10 minute intervals with the data recovered weekly. The Alekseev meter averaged the current velocity for the 3 minutes prior to recording and gave an instantaneous reading for direction at the time of recording. The basal velocity of these meters was 3 centimeters per second.

This study showed that the bottom water moved continuously in relation to the seasonal pattern of exchange, gyres were detected at certain locations and they demonstrated the localized influence of bottom and sill configuration upon the pattern of water movement within the Sound. Long period waves (in excess of 10 minutes) were detected and were found to be important in accelerating the movement of water in the bottom layers. Short term changes in current direction were noted and often showed a strong correlation with barometic changes following the passage of low pressure fronts across the coast.

Tracking of Drogue Floats.

A number of types of drogue floats were tested in the field until a type with a suitable response to water movement was obtained. (This was ascertained by cross calibration with current meters and observation of performance into surface, wind-induced, currents). Following this detailed experimentation a set of floats were constructed for the field investigation programme.

Floats were chosen as a primary mode for recording water movement because they can record the spatial dispersion of the currents as well as the current speed at different depths beneath the supporting buoy.

Each float was individually marked and identified by a numbered flag. The set of floats was dropped in a pattern best suited to sampling the environmental conditions of wind and tide. Radio controlled shore based theodolites were used to fix the location of the floats as marked by the tracking vessel.

The float studies overcame some of the inconsistencies noted with the current metering and salinity profiling. These included documentation of changing patterns of dispersion with time and detecting currents below the threshold value of the current meters.

During the float tracking programme continuous current metering was conducted from a central station. Current data obtained from the floats could be cross correlated with continuous metering data and salinity profile information. Tide, long period wave and wind data was gathered synchronously with the hydrological data.

Figures 7*a* and *b* shows the typical patterns of flows into and out of the Sound as detected by the drogue floats. The natural channeling of flow has been utilized in the siting of the bridge openings. A reduction in current speed is seen in Fig. 7*a* as the floats enter the deeper waters of the Sound.

Dye Release and Aircraft Observation.

Dyes were used to obtain a qualitative picture of the gross pattern of water movement within and outside Cockburn Sound. Rhodamine B and fluorescein dyes were dissolved with chemicals and mixed with ten gallons (approximately 45 litres) of sea water. The dye was released from the 10 gallon containers one meter and six meters below the surface. The movement of the dyes were observed and photographed (hand held obliques) in relation to either topographical features or patterns of marker floats and navigational aids.

During the observation period the distinctive water bodies were also recorded by colour photography. Industrial effluent was also used to detect water movement in foreshore areas.

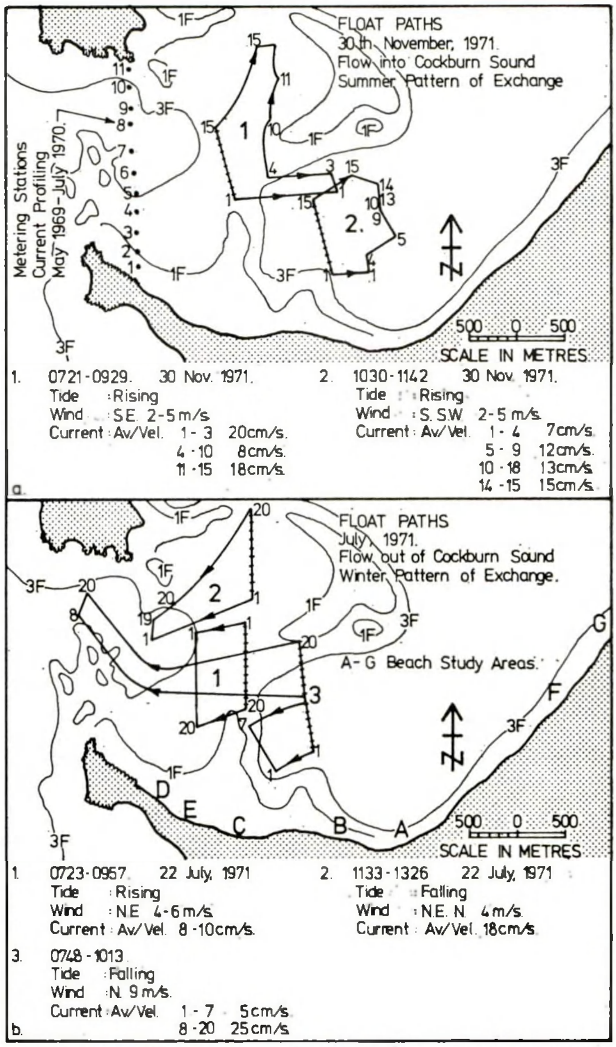

Fig. 7.

Tide and Long Period Waves.

Intensive tide and long wave recording was conducted to document the following phenomena :

(i) The differences in wind set between mainland and Garden Island locations.

(ii) Variations in tide height at shoreline and deepwater locations.

(iii) The occurrence of seiche waves within the basin.

Data obtained was integrated with the general hydrological data and evaluated in relation to the meteorological conditions prevailing during the study.

These studies showed that wind set occurred under varying conditions of wind and tide. Micro barometric changes associated with localized low pressure systems could cause rapid variations in water level and induce seiche waves.

Physico-Chemical Measurements.

The diurnal fluctuation in dissolved oxygen levels was recorded during the course of both hydrological and ecological investigations. These fluctuations could be directly related to the photosynthetic process of the sea grass meadows.

Light penetration was measured as it related directly to the respiration of macroscopic benthic plants. This investigation related turbidity due to industrial discharge to the breakdown of sea grass meadows. The spread of turbid waters was recorded during all phases of the hydrological investigations.

Summary of Results of Hydrological Investigations.

The results of all studies showed that the localized influences of wind and tide were insufficient to individually dominate water exchange in Cockburn Sound. Current recordings made in the open sea showed that the tide had insufficient power to produce ebb and flood currents. Wind was, however, the dominant factor moving water in the nearshore areas.

Water exchange between Cockburn Sound and the open sea is dominated by the oceanic current which has a distinct seasonal direction of flow. Short term (3-4 days) reversals in the direction of flow were detected. This oceanic current is due to the combined effects of a number of forces. However, the persistent seasonal pattern, with its associated short term reversals in flow, indicated that major variations in the atmospheric pressure gradient, along the West Australian coast, are most probably the primary cause. Further interpretation of data will be necessary to determine the exact cause of the seasonal oceanic current.

Wind and tide within the Cockburn Sound area act to inhibit or assist the dominant direction of flow. Submarine topography serves to inhibit flow and produce local gyrations.

The investigations showed that the water mass of Cockburn Sound is exchanged with the open sea. Bottom circulation is inhibited by topographical influences but is maintained by the inertia of the dominant pattern of surface water movement.

STUDIES OF COASTAL STABILITY

WINTERBOTTOM (1917) documented the virtually indestructable nature of the root fibre of sea grass. As part of the causeway structure was to be founded on this substrata, investigations of the depth and durability of the material were conducted.

These investigations showed that the root mat was from 0.5-2.0 m in thickness along the causeway alignment. The sea grass and its root mat are the major element stabilizing offshore sediments. This study confirmed the stable nature of much of the surface of Southern Flats. The source of sediments and rate of sedimentation of the submarine deltaic feature, is still being investigated.

Beach Morphology.

The beaches of Cockburn Sound have been monitored over a period of time for their variation in volumetric configuration (Fig. 4). These studies have been made in relation to water level oscillation together with prevailing winds and wave attack. The studies of beach morphology are as follows :

1. Profiling of the beach on a seasonal basis for its configurational and volume fluctuation.
2. The tracking of dyed sand used as a tracer released onto the beach then collected on a statistical grid for spatial dispersion over a 12 month period.
3. Physical and chemical analysis of sediments collected from the off shore, swash and backwash and æolian energy zones at selected beaches.

Profiling.

Eighteen individual beaches, on the mainland and on Garden Island, were surveyed at monthly intervals over a 27 month period. The average number of transects per beach was 15. From the results of these surveys the beach shape and volume was ascertained and evaluated in relation to the environmental conditions of wind, tide and waves which maintain the particular beach configuration. The methods and techniques used included the calculation of the amount of material moved monthly together with a quantitative statement on the stability of each beach studied on an annual basis.

This detailed study developed from a simple reference peg monitoring programme which commenced in 1969. A line of five pegs 5 m apart, across the beach face, were measured for the rate of erosion or accumulation of material.

The results of the beach profiling showed that the beaches were in a state of dynamic equilibrium when the annual sediment budget was considered. Profiles showed that there was oscillation in the beach structure. The variations in the sweep profiles at different beaches was due to the relative exposure and shelter from prevailing wind and wave attack. Garden Island and mainland beaches showed discrete seasonal variations in form. This is due to the direct influence of land and sea breezes across the length and width of the Sound.

Sediment Tracking.

Sand material from the individual beaches was collected, dried and painted with a fluorescent marker-paint. The material was then released in the nearshore zone of individual test beaches. It was subsequently collected at different time intervals using greased cards on a gridded statistical basis. The dilution and dispersion of the marker sand were then traced. This enabled a determination of the natural movement of sand along beaches in Cockburn Sound. Different coloured sand was used for individual beaches.

This study showed that while there is an equilibrium in the beach configuration there is a movement of sediments between certain of the beaches of Cockburn Sound and retention of sediments in other areas.

	a		b		c	
	F	J	F	J	F	J
G	—	—	—	—	—	—
F	+	+	—	—	—	+
A	✱	+	—	—	+	+
B	×	×	+	—	—	—
C	+	×	+	+	+	+
E	✱	✱	✱	✱	×	×
D	×	×	✱	✱	+	✱

KEY

Ratios of SiO_2 to CaO
- — 1 : 0·50 to 1 : 2·49
- + 1 : 2·50 to 1 : 4·49
- × 1 : 4·50 to 1 : 6·49
- ✱ 1 : 6·50 +

F - February.
J - June.
a - Aeolian zone.
b - Breaker zone.
c - Offshore zone.

Distribution of Seasonal Patterns of SiO_2 and CaO ratio of Study Beach Sediments Samples, February and June, 1971.

Fig. 8.

Sediment Analysis.

Sediments from selected mainland beaches were representatively sampled in summer and winter and analysed for their physical sorting characteristics and chemical composition. The results of these studies showed that selected beaches could be categorized by both their energy regime and the chemical composition of the beach material.

Figure 8 shows the calcium silica ratio for selected beaches, over two seasons. Each beach was sampled within three discrete energy zones. The locations of the beaches investigated are shown in Figure 7.

The results show that there are discrete mainland beaches. These are related to the input of silica from the breakdown of the æolian calcarenite headland at Cape Peron and the calcium carbonate produced by organic material from the sea grass meadows.

Summary.

The studies of coastal stability showed that the beaches were in a state of dynamic equilibrium.

Sweep profiles have established a mean from which possible changes, induced by the causeway structure, can be assessed.

The stable nature of the coastline of Cockburn Sound was assessed by :

(i) The depth and distribution of sea grass root systems.

(ii) The rate of beach volume changes.

(iii) The pattern of the seasonal beach profile changes.

(iv) The response of beach sediments to sorting under various energy conditions.

(v) Documenting the discrete nature of selected beaches by chemical composition.

Therefore any changes in beach form can be monitored and related to either man induced or natural phenomena.

ECOLOGICAL INVESTIGATIONS

Prior to the ecological investigations conducted by the Fremantle Port Authority and the Commonwealth Department of Works, only limited biological and ecological information had been obtained to document the natural environment of Cockburn Sound. The information available was restricted to unpublished academic theses and a few scientific journal articles.

The geological history of the Sound was briefly described by FAIRBRIDGE (1950) and CHURCHILL (1959).

Rationalle for Ecological Investigations.

The investigations initiated in connection with the causeway design and the further planning of the port complex at Cockburn Sound were to establish an ecological baseline for monitoring environmental change. These studies provide the basis for a management programme to maintain the waters of Cockburn Sound for a multitude of uses. The area may be used by industry for cooling water and to receive industrial waste. The causeway offers protection for the development of bulk cargo and other port facilities. Recreational use and æsthetic enjoyment of the area must also be maintained as far as is compatible with port and industrial activities.

A programme was developed to assess what effects industrial waste was having on the Sound prior to the commencement of causeway construction. The techniques used were refined to provide the basis for a monitoring programme that could discriminate between the effects induced by either industrial pollutants or the imparement to water flow caused by causeway construction. This programme integrates data obtained during hydrological investigations to fully assess the dispersion and mixing characteristics of industrial wastes and shipping spillages.

Investigation Objectives.

In developing an investigation programme the following factors were assessed and a research plan implimented.

1. What were the critical elements within the marine environment contributing to ecological stability.
2. What plant and animal communities would best reflect the subtle changes produced by :
   a) Naturally changing seasonal energy regimes of;
      (i) Wave and swell.
      (ii) Tide and mean sea level oscillation.
      (iii) Storm paths and water spout activity.
      (iv) Natural water turbidity.
   b) The discharge of industrial effluents either in solution or as suspended solids.
3. What natural elements could be used to assess the results of physically changing the geographical configuration of the boundaries of the Sound.
4. What functional role did Cockburn Sound have as an ecosystem. There was a need to determine what was its importance as an economic fishery, nursery or as a unique biological habitat for rare floral and faunal species.

Projects.

The following projects were conducted as part of the ecological investigations.

1. The distribution, density and diversity of the sea grass communities were documented in relation to the submarine morphology of the basin.
2. The biology and life history of the seagrass community *Posidania Australia* was studied in detail to ascertain the plants growth habits and the susceptibility of the sea grass meadows to changes induced by both engineering construction and industrial contaminants.
3. The distribution of epiphitic algæ on sea grass fronds was related to natural regimes of; wave and current energy, light penetration with water depth and turbidity. The distribution of epiphitic material was then related to the dispersion of industrial pollutants.
4. The biology of a group of filter feeding sedentry animals was studied and their flesh and stomach contents chemically analysed. During the programme detailed studies were made of the common mussel *Mytilus edulis* the « razor clam » *Pinna dolabrata* (a bi-valve molusc), and various species of ascidians « sea squirts ».
5. Plankton distribution in relation to the general hydrology of the Sound was documented. The data obtained was statistically analysed using standard biometrical statistical techniques. This study provides base line data for assessing water quality in relation to industrial discharge and natural rates and patterns of water circulation.
6. Chemical analysis of :

   a) Water collected from industrial outfalls.

   b) Sea water collected on a grid basis within and outside Cockburn Sound covering contaminated and oceanic conditions.

   c) Bottom sediments collected from a range of sites covering both industrialized and non-industrialized locations.

   d) The alga *Ulva lactuca* collected from both polluted and non-polluted areas.

   Sampling was repeated at random intervals to overcome problems arising from the release of « slugs » of effluent. All sampling was related to the prevailing hydrological and meteorological conditions.
7. Microbiological investigations were conducted to determine the dispersion of coliform and salmonella bacteria from sewerage outfalls into all marine locations around Fremantle. One major sewerage outfall is located at the Northern end of Cockburn Sound.
8. An evaluation was made of spillage from shipping operating in the industrial areas of Cockburn Sound. The industrial area contains; an oil refinery, blast furnace and steel rolling mill, alumina refinery and a chemical and fertilizer plant. Bulk cargo spillage had been recorded from all these industries.
9. The thermal pollution effects of cooling water discharge were examined during the water sampling programme.

Results.

A base line programme for monitoring the ecology of Cockburn Sound had been established by May 1971. This was five months after causeway construction had commenced and before there was any significant reduction in water flow through the southern opening into and out of the Sound. The base-line study provided a thorough documentation of the deleterious effects of industrial waste on the floral and faunal communities along the eastern shoreline of the Sound.

SEA GRASS STUDIES

The data obtained related the dispersion of industrial effluent to the intrinsic nearshore circulation patterns adjoining the industrialized area. Investigations showed that by May 1971 the physical stability of over one third of the eastern shoreline had been impared by the break down in the physical structure of the sea grass meadows. For a distance of 5.5 km the sea grass meadows had been almost completely destroyed leaving only fossil rhizomes (root material) to stabilize the loose nearshore sediments.

Figure 9 shows the difference between the length and width characteristics of sea grass leaves from a non-polluted (Woodmans Pt) and a polluted (James Point) location. The studies showed that turbid and toxic conditions, produced by industrial waste, reduces the size and width of the sea grass fronds. This enables areas which are « stressed » by natural conditions of turbidity to be differentiated from those affected by industrial contaminents. The sea grass in areas affected by natural conditions responds by having either a second « morph » (a plant with a distinctive leaf width characteristic) or a bi-modal distribution of leaf widths.

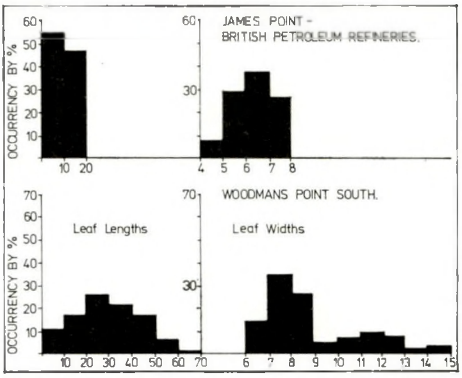

Fig. 9.

Effect of industrialisation on the sea grass Posidonia Australis.

Epiphytic Algæ.

The studies found that there were 84 varieties or species of epiphytic algæ using the fronds of the sea grass *Posidonia australis* as a substrate. Distinctive suites of epiphytes were found and these suites could be related to polluted, transitional and non-polluted environments by using algæ epiphytes as a method of pollution detection. It is possible to observe the effects of industrial waste 1 km ahead of zones where it is stressing the sea grass communities.

Indicator Organisms.

Biological studies and chemical analysis, of ascidians and razor clams showed that they effectively filter particulate matter from the water. Therefore, they can be used to accumulate material which is released into the water mass at levels below normal chemical detection. The animals can monitor the areal dispension of industrial contaminents in relation to the hydrological regime of the Sound.

Plankton were found to differ generally in abundance between the Sound and the open sea. They confirmed that these was a lag in the natural rate of flow through Cockburn Sound. This lag gave the organisms time to proliferate. Plankton were found to be distributed in relation to the hydrology of the Sound and confirmed that the water quality of the body of the Sound differed from the nearshore locations where industrial wastes were released.

General.

The results of the ecological investigation showed that it was essential to maintain adequate water circulation if the Sound was to be retained as a viable ecosystem. This factor was taken into account in the causeway design that was finally adopted. The two bridged openings allow for optimum exchange between the Sound and the open sea.

An integration of hydrological shoreline stability and ecological data indicated that deterioration of the environment was due to pollutants being incorrectly introduced into the Sound rather than the chemical composition of the waste. Pollutants are discharged into the narrow littoral fringe and directly affect the stability of all floral and faunal nearshore communities.

The ecological stability of the areas adjoining the causeway alignment were documented prior to construction commencing. This will allow a thorough assessment to be made of any deterioration in the sea grass meadows or change in the structure of animal communities in relation to the engineering works.

SURVEYS

Theoretically, surveys of the sea bed level can now be undertaken quickly and effectively by echo sounder. Two contracts were let, the first ran 320 miles of line at a cost of $A88 per mile or 515Km at $A55/Km (which includes plotting but not the initial baseline survey on shore or tide guages), the second ran 160 miles of line at a cost of $A26 per mile (257 Km at $A16/Km) with the same exclusions.

The surveys took much longer to complete than anticipated (4 months from letting contract to completion of final drawings) and the first one was so dubious that a hand leadline survey had to be carried out on the whole area directly beneath the causeway location for contract purposes. It is still not known what went wrong; careful control of tide guages, calibration of equipment and location was exercized. There were no problems with the second survey.

Materials.

Critical to the design of a causeway or breakwater are the materials available for its construction. Careful investigation of these before design will be repaid manyfold. This area of Western Australia is most fortunate in having extensive areas of a medium quality limestone within 8 miles (13 Km) and of good quality granite approximately 14 miles (22 Km) away.

The limestone was suitable for core material for which purpose it was placed at a cost of $A3.50 per cubic yard $A4.6/m³ and the granite was suitable for armouring ($A9 per cubic yard or $A12/m³ placed). As the armouring sizes were not large (7 tons maximum) no problem was encountered in obtaining such material although larger sizes would have required a change in quarrying methods and hence increased cost.

Soils.

Investigations of the engineering properties of the materials supporting a causeway are nearly always required. However, obtaining this information from beneath the sea can be surprisingly difficult. The investigations nearly always take considerably longer than anticipated, are more expensive than expected and results which are by no means complete, have to be accepted. Apart from the direct effect of bad weather e.g. a 15 to 20 knot (7.5-10m/sec) wind will often prevent drilling and sampling proceeding and cause standby rates to be paid, there is the problem of logistics with the floating rig; the loss of only one critical item may stop work for many hours whilst a replacement is obtained.

These problems put a premium on forward planning to ensure the rig and all its ancillaries are in good working order and that spares for critical items are carried. It also emphasizes the need for a higher level of supervisory control than for land based drilling as it is often necessary to make onsite decisions as to which items (depth, S.P.Ts, samples) to abort when the wind and waves start to rise. In this case a junior engineer from the design team is a good solution as he can make a decision against his background of the information the preliminary design requires.

The drilling contractor designed a light frame which was to enable the drilling to proceed without interference from the weather. However, the frame and its moorings were too light and whilst the results were better than from floating plant it emphasized the need for such equipment to be substantial.

The boreholes showed that the subsurface consisted of loose sand overlying a mixture of sandstone and sand layers starting at about 60 feet (18 m) below datum down to a dense sand layer at 100 feet (30 m) below datum. The types of materials and their depths were unusually uniform, for example, the dense sand layer depth varied by less than ten feet (3 m) over a distance of four miles (6 Km).

Waves.

The initial assessment of the wave climate at the causeway location was based on deep water wave information from « Ocean Wave Statistics » (Hogan and Lumb 1967) and was undertaken by a refraction/diffraction analysis using wave directions from West North West to South South West and periods of 8 to 16 seconds. These have to be carried out by hand as though programmes are available for refraction analyses the combined refraction/diffraction analysis is highly subjective and not amenable to being programmed for a computer. The analyses showed a surprising selectivity with regard to direction and it was necessary to undertake them, in some cases, with differences of approach angle as little as seven degrees as large changes to the wave height were derived. As the most uniform of wave trains has an angular spread of more than that amount it could be seen how the waves would probe for the least line of resistance.

The entrance between Garden Island and Point Peron has scattered reefs and sharphy varying seabed levels; these make a refraction/diffraction analysis in that area very difficult and the results susceptible to considerable error even after using smoothing techniques. Consequently, a series of aerial photographs were taken at appropriate times, the wave crests plotted and the wave orthogonals used to calibrate the earlier theoretical assessments. Wave period and tide level were measured at the time of taking the photographs. It was not easy to obtain useful photographs as it was necessary to wait for the required conditions of reasonable large waves, clear sky and sun in the right position to outline the crests.

Simple fetch/wind velocity/duration calculations were combined with refraction diagrams done for local wind blowing down the Sound to provide design wave heights for the landward side of the causeway.

As the causeway had been located approximately 1000 feet (300 m) from the seaward edge of the Southern Flats, the design wave height was in many cases governed by the limiting water depth criterion.

The length of the causeway was split into sections over which the design wave height was constant.

At an early stage it was decided to measure the wave heights offshore, to the North of the Island, in Careening Bay where the Naval Support Facility is to be built and in the Southern entrance to improve the quality of the preliminary assessment of the design wave heights for the causeway and at the proposed facility.

The Datawell Waverider system was adopted and became the second such installation to be put into operation in Australia, the first being placed off the Gold Coast by the Beach Protection Authority of Queensland.

The waverider system consists of a series of buoys (in this case four including one standby) which directly measure the vertical acceleration of the water surface, doubly integrate this and then radio the vertical displacement to shore where it is picked up by a receiving unit which then punches the information onto paper tape which can be fed directly into a computer either for analysis or for storage on magnetic tape.

The only two problems which have of significance have been breakages in the mooring system and many little things going wrong with the Preflok punch unit. The former has been a worldwide problem and has been solved by substituting a chain and polypropylene rope for the stainless steel wire and by placing the rubber length next to the anchor. The buoy are remarkably robust and have been found undamaged on beaches several times.

The system can be operated in various ways; in our case the system records the data transmitted from each buoy for twenty minutes every six hours. The limitation is the batteries which power the buoy; these transmit information for approximately 9 months before replacement.

Despite the problems previously described, the system can definitely be regarded as satisfactory as we have obtained data for approximately 70% of the time. This is a high figure for this type of work particularly as the outages have not been concentrated at times of high waves as has been the case with other systems.

The cost of the whole installation was \$A25,000 of which the main part was the receiving station at \$A16,000. Each buoy costs \$A2,100. A maintenance contract for the electronic and mechanical maintenance has cost \$A6,000 per year whilst work done by the Department in replacing the buoys and other work is estimated to have cost \$A2,000 per year. Cost of analysis is not included.

Hydraulic Model Testing.

After preliminary designs had been established using criteria from « Shore Protection, Planning and Design » (Corps of Engineers, 1966) they were tested in the Water Research Laboratory of the University of New South Wales. The length of the causeway trunk was divided into six sections representing various wave exposures, each section was tested in a flume with waves at 90° and 45° to the face. Wave heights varied from three feet to twelve feet (1-3 m) and periods from four seconds to twelve seconds. The four bridge abutments representing breakwater heads were tested in a three dimensional tank with a total of six combinations of wave directions and periods. Special series of tests for a non-armoured trunk (three foot waves), toe blankets, a straight sheet piled bridge abutment and a cellular sheet piled bridge abutment were also undertaken. Details of the tests are contained in a report of the Water Research Laboratory (Foster and Nelson, 1971).

The tests on the preliminary designs of the causeway trunk sections and abutments demonstrated that amendments were necessary. Figures 10 and 11 show typical changes. The main changes were due to the runup coefficients being higher than anticipated; they varied from 1.3 to 1.4. These refinements indicate the type of changes required when proceeding from the general design rules to a particular case.

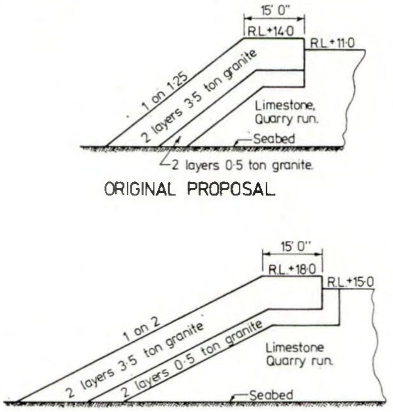

Fig. 10.

Nine foot design wave. — Original proposal (top) and Recommended design (bottom).

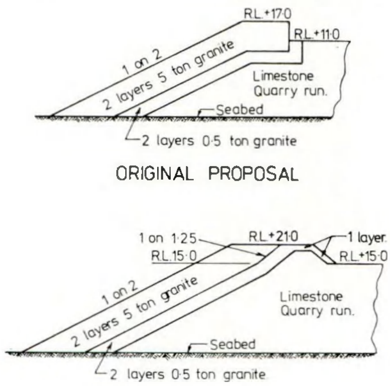

Fig. 11.

Twelve foot design wave. — Original proposal (top) and Recommended design (bottom).

It was originally proposed that an unarmoured quarry run material should be used for the lengths in which the design waves were three feet (0.9 m). The tests showed that, whilst this may have been suitable for the Sound side of the causeway where maximum wave periods were about five seconds it was quite unsuitable for the Ocean side where twelve second waves could attack the causeway at an angle of 45° (due to the movement of material along the causeway). These lengths therefore had to be armoured although with only one layer of limestone.

The limestone which was used in the causeway is a porous rock with a dry bulk specific gravity of between 1.2 and 1.4. When saturated the specific gravity is increased to between 1.8 and 2.0; tests on stones seven pounds (3.5 kg) in weight showed that they became saturated in about five seconds. Although fairly soft, the material has been used successfully in a number of maritime works in Western Australia. The unusual properties of the material required all relevant model tests to be undertaken using the prototype material.

For contractural reasons it was desired to use a straight wall of sheet piling as the abutments for the Southern bridge. Tests of this showed that whilst the size of armour units which would be required for the alternative rounded head structure would be stable in the sheet piled case, a Mach stem wave was produced along the wall which would have endangered the beams under the bridge deck, also severe turbulence and erosion was created, extending ninety feet (27.4 m) at the leeward end of the wall. This only occurred on the Southern abutment, so a normal rounded head structure was used there whilst the sheet piled wall was used for the Northern abutment.

A single sheet piled cell (diameter 70 feet, 21.3 m) was used for each abutment of the Northern bridge to enable the bridge contract to proceed independently of the rubble mound. Rock armouring was later placed around the cell to join it to the rubble mound. Tests were undertaken to see if the armour would be moved by back pressure but they showed that at design wave conditions no more than three stones would be removed and the rest were stable.

The toe blanket tests showed that there would be undermining of the armour rock if no blanket was used whilst a blanket 20 feet (6 m) wide was too conservative. A blanket width of 10 feet (3 m) was adopted except that this was increased to 15 feet (4.6 m) at the bridge abutments.

Mathematical Modeling.

Considerable thought was given to the construction of a physical hydraulic model of the Sound and the surrounding waters to check the preliminary estimate of the effect of the causeway upon the flow of water across the Southern Flats. In a more normal case where one causative factor such as tide has a dominant effect upon such flows a physical model is theoretically easy to construct, operate and assess although for such a large area problems of size and/or distortion would have arisen.

But in the case of Cockburn Sound the tide is very small and ill defined. The causative factors which are normally secondary, such as effect of oceanic current, wind and macro and micro meteorological disturbances, can then be as important as the tide. At the time when the decision whether to build an hydraulic model had to be taken it was not known which of these factors were important and which could be neglected or be taken into account by small corrections. It was therefore pointless to further consider building such a model as it could not even be designed.

At a much later date, mathematical modelling techniques had advanced to a stage where they could be considered. Professor Radok of the Horace Lamb Institute, South Australia, undertook a preliminary analysis using a coarse grid (points 460 m apart and time steps of 40 sec.) treating separately the cases of a twenty knot (10 m/sec.) wind from the North and a 0.4 knot (0.2 m/sec.) oceanic current flowing Southwards. These were each undertaken for a model without the causeway and for one with the causeway in position. These tended to support the earlier preliminary assessment of flows through the bridged openings.

Figure 12 shows the computer print out for the part of the model at the Southern Flats for a case without the causeway; obviously the grid is too coarse for detailed considerations. Figure 13 shows the readings which would be obtained if a velocity meter were placed at position A in figure 12 and then a North wind commenced to blow. As the wind is applied, Cockburn Sound begins to seiche with a period of approximately 20 minutes as was confirmed on site. Twelve hours after the onset of the wind the Sound has almost reached a steady state.

It is intended to select a case of known tide, wind and oceanic current when currents have been measured and calibrate the model with these; the mesh of points would also be made finer.

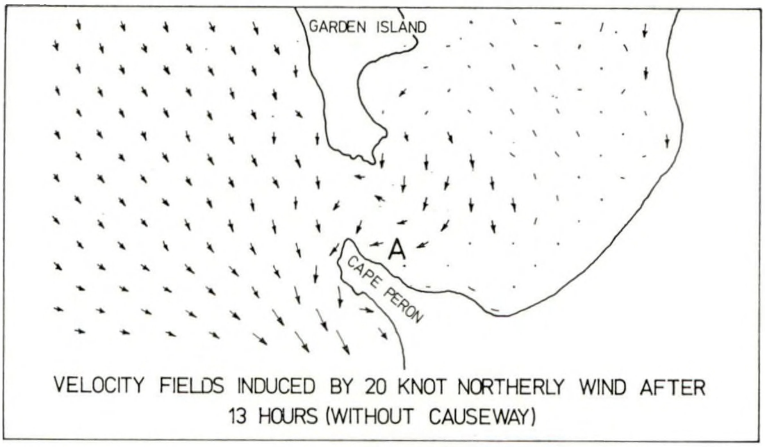

Fig. 12.

As Mr. F.L. WILKINSON of the Department was studying Coastal Engineering at Delft University at the time, it was decided to try a programme which had been developed in Denmark for the mathematical modelling of such hydraulic problems. Preliminary results were obtained for the cases of 20 knot (10 m/sec.) wind from the North plus rising 0.6 m tide, 20 knot wind from the North plus steady flow, 20 knot wind from the North plus falling 0.6 m tide each case being repeated with and without causeway.

It was then decided to proceed with a more detailed analysis to calibrate the model against data obtained in the hydrological studies but despite efforts

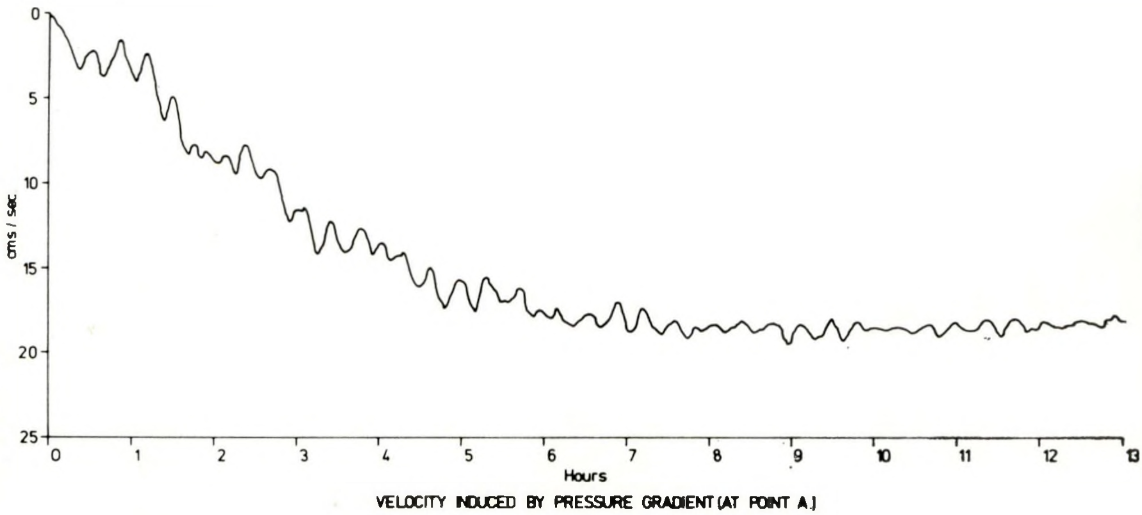

Fig. 13.

by the originators of the system instability problems arose and the attempt had to be abandoned. A worrying feature of this is that, at the present time, there appear to be no known analytical methods which can predict with certainty whether instability problems will arise. There is no doubt that these problems will be overcome and engineers will then have two possible methods of modelling such a hydraulic system; one physical and one mathematical.

CONCLUSIONS

An engineering project of this type must be planned in close co-operation with the local conservancy authority and with an awareness of the possible multiple use of the area. These concepts must be integrated with those of function and cost so that a properly planned result is obtained.

This approach requires a multi-disciplinary group to solve the problems; the natural scientists and planners must be brought in prior to the commencement of initial site investigations and remain in the team throughout the project. Experience on this project has shown that such cooperation is not difficult to achieve provided that each discipline is accorded its appropriate place.

Investigations of such projects are expensive, approximately \$A700,000 has been expended in this case including \$A300,000 for the marine environmental investigations. Investigations should be staged and integrated with the continuous refinement of the designs.

Whilst the successful completion of the causeway has demonstrated the adequacy of the normal engineering investigations, it is too early to state that the ecological investigations have been validated. Nevertheless, there is no indication that any ecological problems are arising and coupled with the more stringent attitude of the conservancy authority towards industrial pollution, it appears likely that the objective of no significant damage to the marine ecosystem has been accomplished.

ACKNOWLEDGEMENTS

It is desired to express appreciation to Mr. A.S. Reiher, Director General of the Commonwealth Department of Works and Capt. B.L. Noble, General Manager of the Fremantle Port Authority for permission to publish this paper. Nevertheless, the opinions expressed herein are those of the authors.

Whilst the people who assisted in the work are too numerous to detail, special mention must be made of Professor A.L. Main, Professor of Zoology, and Dr. J. Genlilli, Reader in Geography, University of Western Australia, for their guidance throughout the investigations

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RÉSUMÉ

Le rapport décrit les études de génie civil et les recherches faites sur l'environnement lors de l'élaboration du plan final d'une chaussée (causeway) d'une longueur de 4 km, dans le détroit de Cockburn. Cette digue doit relier une base navale située sur l'Ile Garden à la côte de l'Etat de Western Australia au sud de Perth. On souligne l'importance d'une bonne conception de tels plans et de les réaliser en étapes; de plus, on insiste sur l'utilité de consulter des experts de diverses disciplines professionnelles.

Les plus importantes recherches, concernant l'environnement, discutées dans le rapport sont dans le domaine de l'écologie maritime; ces études sont étroitement liées aux recherches d'ordre hydrologique du détroit et à celles sur la stabilité des plages de la côte voisine. Le rapport passe également en revue les levés hydrographiques, les types de sols et de matériaux, ainsi que la mesure des lames et l'application des modèles physiques hydrauliques et mathématiques au projet.

Pour bien concevoir des projets de ce genre, il faut prendre en considération les divers besoins locaux et insister, dès le commencement, sur l'intégration précise et la coopération de toutes les disciplines d'importance. Enfin, le rapport évoque les problèmes généraux des diverses investigations entreprises.

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PAPER

by

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MEASURES FOR PREVENTING WATER POLLUTION IN THE PORTS OF ANTWERP AND GHENT

The prevention of the pollution of the waters of the harbour docks etc. of the Belgian ports is, like in most of the industrial countries of the world, a very topical problem.

This water pollution can be classified in 2 main categories : pollution caused by the discharge of all sorts of waste products (and liquids) directly in the docks of the ports and pollution by the adduction of polluted waters by the rivers and streams on which the ports are situated or from the sea (although this latter is rather hypothetical). The pollution caused by the discharge of petroleum products forms a special chapter of the first sort of pollution and the action of the Port of Antwerp to prevent it will be treated extensively in the latter part of this paper.

A. **Pollution caused by the feeding waterways.**

This sort of pollution exists only in ports which are connected with their hinterland by a system of waterways and are therefore situated on a river or canal with an upper discharge.

All the Belgian ports are of this type and the quality of the river- or canal water is of a more or less great importance.

The question is however the most acute for the Port of Ghent since the waters of the upper rivers the Schelde and the Lys are very polluted near the town.

Both rivers have their origin in the North of France and flow through the very industrialised French Departments of the « Pas de Calais » and the « Nord » and in Belgium respectively through the industrial zones of Tournai and Oudenaarde and through the South West Flanders for the river Lys.

The used waters of the French Metropole of North Lille are released on both rivers.

Both rivers are already polluted by the industries in their upper section. For the river Lys, the so called « Golden River », an additional problem is caused by the waste waters of the flax retting industry through which the pollution takes such dimensions that in the period from 15 April till 15 October the river water cannot be used any more to feed the port of Ghent and has to be evacuated directly to the sea. The waste water of the flax industry which contains a rather high percentage of $H2S$ still represents about 1 million of ieq. The only treatment plants which are in service are a few in France on the river Lys.

The river Lys flows into the Schelde in the town of Ghent itself. Ghent is a city of about 270,000 inhabitants where the rivers also function as town sewers so that immediately upstream of the port an important pollution of domestic type takes place which prevents the auto-purification of the river.

The flow off of the two rivers just upstream from Ghent has a mean level of only about 16 m^3/sec. for each river whilst the characteristic minimum discharge is about 6 m^3/sec. so that it is quite conceivable that the feeding waters are not of the quality that could be expected.

B. **Industrial pollution.**

The second cause of pollution is the pollution by industrial and domestic discharges in the port zone itself. For the port of Ghent this pollution is of the same degree as the pollution of the feeding waters and can be estimated of the order of 1,000,000 ieq.

In nearly all ports, the factories discharge their waste waters (purified or not) in the nearest waterway or dock of sufficient section to evacuate them. Most of the industries in the Belgian ports thus discharge their cooling- and waste waters in the dock of the ports; only those of the newest factories are previously purified.

Although the nature of the direct pollution of the ports resembles the pollution of the feeding waters, the greatest difference consists in the fact that in this case the polluting materials are discharged directly into the port zone itself so that the port authorities have to take the initiatives themselves not only to remedy the pollution but also to prevent it. The prevention of pollution of the upper waters on the other hand is not a local problem but one which demands national or even supranational interventions such as for the Schelde and the Lys where the pollution is partially caused outside the country's boundaries.

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ieq = inhabitants equivalents.

C. **The prevention of the water pollution.**

As nearly all over the world, public opinion in Belgium has been made aware of the question of water and air pollution and action is taken in this respect by many very different bodies.

The prevention of water pollution can be subdivided into two different categories :

a) rules to be observed and the drafting of norms as to the tolerated discharges without repressive measures;

b) the purification of the industrial and domestic waste waters before they are discharged into the docks or waterways (this can be an individual or a collective purification).

a) 1) *Rules to be observed.*

From old times there exist in many countries some regulations which forbid the pollution of the waterways. Often it was only a simple sentence in a regulation book or a law by which all discharge of waste waters or materials was forbidden without any further specification.

In Belgium there exists since about 20 years a lawful regularisation : « the law of 11 March 1950 on the protection of the waters against pollution ».

This law forbids all discharges in the canals, rivers, docks etc. without a preliminary authorisation. The practical regulations were not defined by the law itself but had to be settled by different decrees and specially by the Royal decree of 29-12-53 that fixes the general stipulations which the discharges that do not come from borough sewers have to meet.

The royal decree divides the Belgian waters into three classes :

Class. No. I : Waters for the supply of drinking-water;
II : Waters for fishing and for watering cattle;
III : Waters used for industrial needs.

The rigour of the discharge stipulations diminishes naturally with the number of the class.

For class No. III in which the Schelde, the Lys and the Sea canal to Ghent (the Port of Ghent) are classified, these stipulations are :

1. The temperature of the receiving water may not exceed 30 °C through the discharged waters.
2. The pH of the receiving water may not, through the discharged waters, exceed 8.7 and not be less than 6.5. It may however locally attain 9.2 and 5.
3. The percentage of oxygen dissolved in the receiving water may not, through the discharged waters, fall below 3 mg/l; locally it may fall lower than 3 mg/l but not lower than 1 mg/l is allowed during a maximum period of one month per year.

4. The percentage of materials which precipitate in a static sedimentation may not exceed 0.5 mg/l in the discharged water; the determination of this percentage must be made on the water that has not been previously diluted.
5. The percentage of materials in suspension in the receiving water may not, because of all the discharged waters, increase by more than 100 mg/l.
6. The concentration of any chemical material in the receiving water may not, because of the discharged waters, increase in such measure that the water becomes unsuitable for the purposes for which it is used by the industry or for the irrigation of the land.

   The limit concentration is fixed for every case by the Minister of the Public Health and Family. Advice is supplied by the Service for the Purification of Waste Water of the Ministry of Health concerning the special stipulations which have to be included in every authorisation, reckoning with the type of industry, the quantity and the composition of the discharged water, the volume of the receiving water and its degree of load. These stipulations also prescribe the sort of purification which is accepted.

Although different execution decrees were published in the meantime, for example these concerning the steel industry, the sugar industry, the paper industry etc., the above mentioned law appeared very difficult to be brought into practice and the control and the checking of the trespassings were very inefficient. One of the principal factors of this was the very complicated administrative procedure which had to be followed and also the great number of authorities which had to intervene.

Another reason of inefficiency was the fact that the above mentioned royal decrees only concerned the individual discharges whilst for those in the borough sewers there were no further specifications and the abuses of the discharges in these sewers could not be checked.

To remedy this inefficiency, the law which in principle was very good, was replaced by a new law voted on 26-1-71 which divides the country into 3 water purification companies according to the catchment areas.

This new law instructs these companies not only to build and run the necessary sewers and purifying plants for the sewage and other waste waters in their area but they are also empowered to deliver the authorisations for the discharge of waste water and to supervise these discharges. By this new law which comes in action at last on the 30-4-74, all the powers which were dispersed over several bodies for the previous law are now centralised (naturally under government control) in one hand; the water purification company is a public body with legal status of which are members, the concerned provinces, the bodies which gain superficial water supplies for distribution purposes in the area, and also those undertakings which bring on a big pollution.

This centralisation will remedy the unwieldiness of the administrative apparatus of the previous law which was partially cause of its inefficiency.

Both the ports of Antwerp and Ghent are situated in the jurisdiction of the Water Purification Company of the Basin of the Schelde.

a) 2) *Special administrative actions against pollution in the Belgian ports.*

Since the enforcement of the legal stipulations and the checking of the trespassings were very inefficient, several instances, supported in this by public opinion which had become aware about the problem, have created committees and action groups to try to prevent, in the measure of their power, the continuously growing air and water pollution.

The town Council of Antwerp took the initiative in this respect to establish a « Centre against Air and Water pollution». This centre is a municipal service whose object is to study and to solve problems which arise in an efficient fight against air and water pollution.

The area of action was later extended to the whole province in compliance with an agreement with the provincial government of Antwerp. The authority of the Centre is both to give advice and to control. The advising task includes delivering of advice concerning the building and exploitation requests of the industries.

The controlling function includes permanent measuring of different polluting materials and also to control if the imposed stipulations of the building and exploitation licences are being observed. A permanent guard service was installed in the « Centre » to deal with the complaints of the population.

The Governor of East-Flanders, following this example, established at the end of 1969 « The technical commission for the Environment » which advises the Permanent Deputation of East-Flanders on each exploitation request and also on the extension of existing industries.

The authority of this Commission covers the whole province of East-Flanders but its principal action confines itself to two areas : the surroundings of Ghent and its port and the left bank of the Schelde, on the territory of the province of East Flanders on which the extension of the port of Antwerp is in full construction. The commission in close collaboration with the Centre of Antwerp tries at present to keep this last zone « unpolluted ».

The Technical Commission of the Environment, consisting of experts and technicians of the different disciplines concerned, after investigation proposes very strict standards against air and water pollution. It officiates further as a « complaint bench » to which all the complaints concerning the environment pollution are submitted. The commission, after examining the complaints and in case it finds it opportune, proposes new exploitation conditions to the Permanent Deputation. It can even propose to withdraw the exploitation licence which results in the closing of the industry.

Although so far no spectacular improvements have been obtained concerning water pollution, some points have been scored and different anti-pollution installations are under examination or under construction in some factories. The noticeable result concerning the air pollution is already greater.

D. The purifying of the waste waters in the « Canal Zone » of Ghent.

As already mentioned above, the Canal zone of Ghent (or the port of Ghent) constitutes one of the most important problems in Belgium as concerns the environment pollution (and especially air and water pollution).

The extent of pollution of this zone by industrial waste waters took such proportions in the last years, that it was impossible to wait for the effective coming into operation of the new law and that special measures had to be taken.

On the initiative of the Minister of Regional Economy, the engineering consulting bureau « Haecon » from Ghent was instructed to make a study of the purification of the waste waters of the Canal Zone after a preliminary study by the Technical Commission of the environment had proved the proportions of the problem which reaches to about 1,000,000 ieq.

The result of the study which was laid down in the summer of 1972 has pointed out that the problem was the greatest on the left enbankment of the canal where the older industries are settled. Only a few big modern industries with individual water purifying plants which deliver water that conforms to the standards, are situated on the right bank so that here no special measures have to be taken. For the left bank with its many and very polluting industries, individual purification is not considered to be economical and the study leads to the conclusion that a central purifying plant for about 1 million ieq. with the necessary collectors to which the borough of Zelzate (13,000) would be connected, is the adequate solution.

The investment expenses are estimated at 1.5 thousand million BF and a special aid has been asked from the Minister of Regional Economy.

Once this collector and the purifying plant is in service, the port of Ghent will no longer be polluted by its industries but only by the feed water of the rivers and by petroleum products which now and then accidentally flow into the docks.

For the feed waters there are hopeful expectations as to the effect of the new law on the discharges in Belgium and to the measures which will be taken in France.

DOCK WATER POLLUTION BY HYDROCARBONS

During the last decades, port pollution by floating hydrocarbons has developed into an acute problem. The increased quantities of hydrocarbons, spilled into the docks, constitute a serious risk, as well in the field of cleanliness, as in that of fire hazard in port installations.

The port authorities concerned are confronted with the task of developing an ever more effective and extend apparatus in order to cope with the spills of hydrocarbons and to evacuate the quantities spilled in the most efficient way. Such, after exhaustive study and research on the matter and in close cooperation with all parties interested in safe port exploitation.

The problem of hydrocarbon pollution is not confined to ports; on a larger scale it amounts to an international problem of pollution of the sea, coasts and rivers.

The importance of the situation was clearly stressed by the convocation of an international conference, held in London, 1954, exclusively devoted to this problem. In 1957 as well, during the XIXth International Navigation Congress of PIANC, in London, a major conclusion was that a study was to be made of the means of fighting pollution of coasts and ports by crude oil and ballast waters of petroleum tankers.

Risks and volume of hydrocarbon spills in docks are in close relation to :

— the number of vessels using hydrocarbon fuels (either for the heating of boilers or for internal combustion engines);

— the number and deadweight of tankers berthing in docks for unloading (cargo + fuel);

— the increasing implantation and exploitation (number and capacity) of crude oil refineries alongside docks, these refineries being the primary « energy suppliers » of modern industrial communities, with an ever growing consumption of energy of which, in Western Europe, more than 50% originates from the processing of mineral oil.

Figures 1, 2 and 3 give an idea of the change in coal/oil burning vessels, expressed in percentages of the world fleet, as from 1914 (data given in the annual reports of Lloyd's Register of Shipping) and of number and deadweight of tankers,

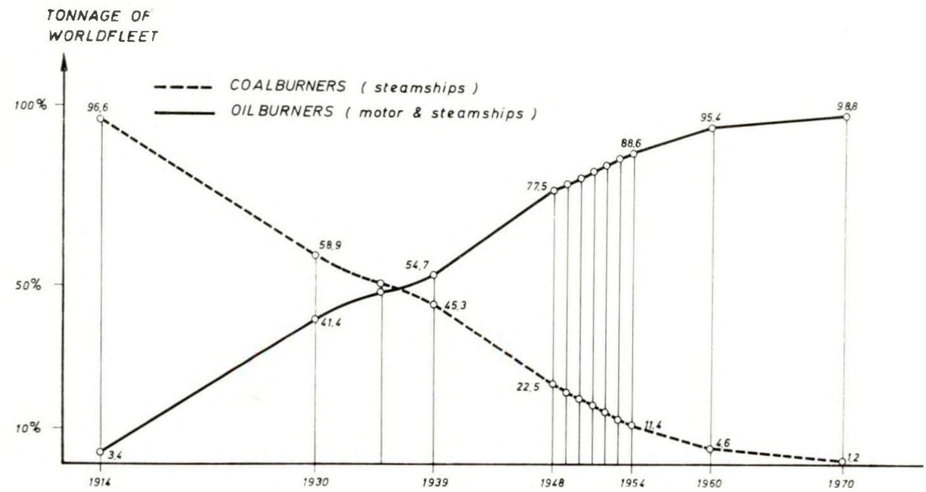

Fig. 1.

Number of coal and oil burning vessels — Evolution as from 1914 (data from Lloyd's Register of Shipping — annual report 1970).

moored at the petroleum berths in the north part of the port of Antwerp as from 1951.

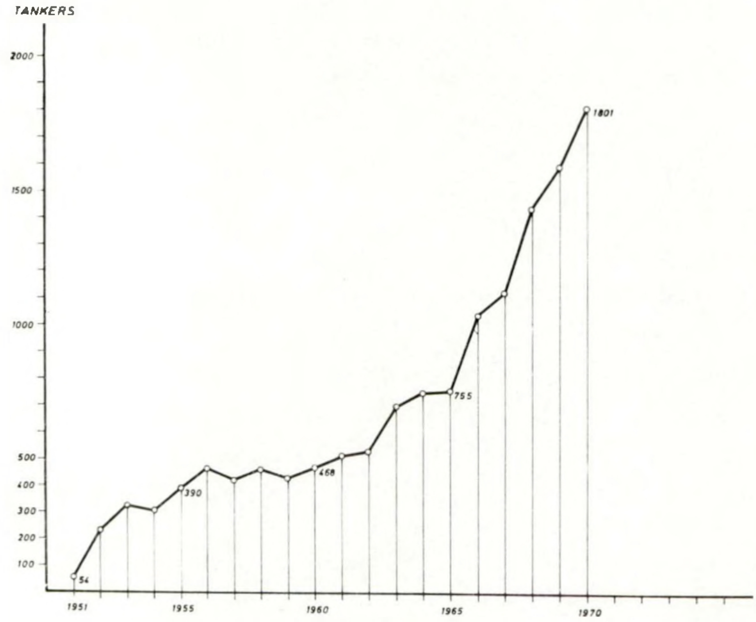

Fig. 2.

Number of petroleum tankers berthed in the north part of the port of Antwerp.

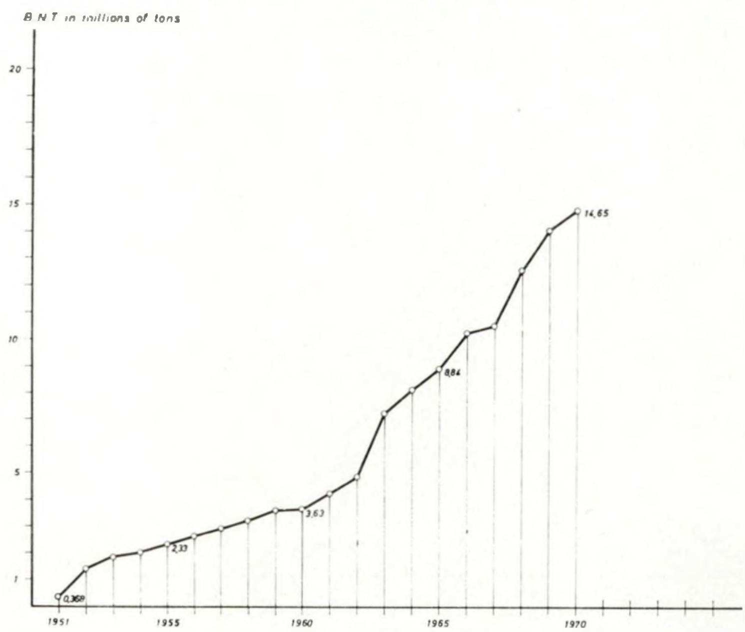

Fig. 3.

Belgian net tonnage of the tankers shown in figure 2.

Basically, causes of hydrocarbon pollution are grouped in two categories :

— pollution resulting from normal treatment or processing of crude oil, i.e. caused by the process water from refineries and cleaning water from petroleum tankers; both subject to control and regulation;

— pollution caused by accidental circumstances during bunkering, loading/unloading of crude oil and finished products, as a result of collision, leakage, breakdowns, foul pumping. These generally are of accidental nature and therefore not subject to routine control, resulting as they are from unforeseeable mechanical and human failures; they are to be mastered by protection measures and techniques for evacuation.

Responsibilities for these accidents cannot always be established; moreover clandestine spills cannot be fully eliminated, which accounts for considerable quantities of hydrocarbons finding their way to the dock waters.

An inquiry held in the port of Antwerp in 1955 pointed out that less than 40% (in volume) of oil spills were identified. Which are the means to be used in fighting hydrocarbon pollution?

It seems appropriate to deal first with the pollution from causes subject to control and regulation, i.e. the « process water » from refineries and the cleaning water from tankers.

Process water from refineries.

The waste water- and processing installations must be designed in such a way that the waters discharged do not contain more than the admissible quantity of oil expressed in parts of oil in a million parts of water (ppm). For inland refineries this regulation must be very strict.

Development of air cooling and of recycling of the cooling waters, especially in regions having water shortages, is very interesting from this point of view.

In traditional cooling systems, including one passage of water through the system, the quantity of cooling water required for refining one volume of crude oil may amount to 30/1. Via recycling, this ratio can be reduced to 0.5/1 and if cooling is effected mainly by air, a ratio of 0.2/1 can be obtained. The presence of oil charges in the water is then considerably reduced.

Cleaning water from petroleum tankers.

The water ballast, to be carried in the holds by light tankers, in view of stability, is evacuated either outside or inside ports. Moreover, the tanks need cleaning in order to prevent oil deposits; the cleaning waters with the oil slicks are generally dumped into sea.

In order to attenuate the effect of this kind of pollution, a convention came into force, as from 1958, indicating the zones wherein dumping of oils or water emulsions containing more than 100 ppm of oil became forbidden. (Final act of the International Conference on Prevention of Pollution of the Sea by Oil, and the Conference of Contracting Governments to the Convention signed at London on 12 May, 1954). In addition, the «Load-on-top» system with sloptank was designed about 1962 with a similar goal, and adopted by more than 75% of the world petroleum tanker fleet.

This system avoids — roughly estimated — the spillage of more than 1.6 million tons of oil a year (data from « The impact of the Oil Industry on the Environment » — W.C. Hopper and B. Rayzachter of « The Oil Companies International Study Group for the Conservation of Clean Air and Water in Western Europe — CONCAWE ».

If, however, the goal set by the prementioned Convention is to be reached, it is essential to eliminate the dumping of polluted ballast water and cleaning water into the sea by installing « cleaning stations » in the ports where oil tankers make their calls for loading/unloading and for repairs.

A cleaning and storage station of this nature was built in the port of Antwerp in 1971. It has a storage capacity of 5,500 m³ for cleaning waters, slops and residues at a maximal pumping capacity of 500 m³/hour, and features the equipment for evacuation, to unlimited quantities, via separators, of ballast waters, at a rate of 500 m³/hour, and the media necessary for making tanks gasfree. Steam (at a pressure of 7 kg/cm²), hot water, compressed air and fresh water can be furnished to ships.

On the other hand attention must be given to the techniques to be employed for removal of hydrocarbons by means of adapted equipment and products.

To this effect primary media of elimination (absorption products, detergents and apparatus for mechanical removal) are available and, parallel to these, secondary means such as separation gates, air bubble curtains and floating booms. The secondary means can yield good results in the separation or sectioning of docks or parts thereof and in containment and isolation of oil spills, pending the treatment of those spills by the primary media (integration of means). Needless to say that environment, local circumstances, nature and importance of spills are co-decisive in the choice and way of use of these media.

In impounded docks, as found in Antwerp, the use of products occasioning absorption and sinking of floating oils is to be disregarded. Indeed, the sedimentation process in these circumstances does not meet with essential requirements such as :

— the oils remain on the dock bottom, albeit in a less harmful condition;
— repeated use of this system causes unwanted rises of the dock bottom, resulting in additional dredging works;
— the materials dredged are polluted and cannot be used for reclamation of port sites;
— the system may be relatively expensive, when considering price and quantity needed of the absorption product.

Use of detergents — not a cheap solution either — is also subjected to strict limitations in impounded docks. The hydrocarbons treated are indeed not completely eliminated; in the most favourable supposition they are caught in a stable emulsion. Moreover, considerations relating to emulsifying effect, toxicity and biological destructibility dictate severe restrictions in choice.

Together with the use of carefully selected detergents, availability of effective and well-dimensioned equipment for mechanical removal, i.e. floating oil skimmers, forms the most favourable solution in impounded docks.

This calls for a survey of the measures to that effect prevailing in the port of Antwerp.

Up to 1953-54, floating oils were exclusively skimmed off « by hand », collected in drums, transported and destroyed. Increasing pollution soon made it evident that this procedure was indequate. Skimming off by hand could only be effected from the coping stone of quay walls, when the floating oils, under the influence of wind from a constant direction, had accumulated in dock corners.

Possibilities and efficiency of this method, depending on a host of factors such as thickness of the oil film, wind, wave height, ship traffic, viscosity of the oil, temperature, presence of driftwood, etc. were insufficient for elimination of major spills within an acceptable delay.

So option was made for mechanical removal of hydrocarbons by means of a floating oil skimmer. Basically, the choice to be effected was : direct or vacuum pumping.

Tests had been carried out in the port of Le Havre on both systems.

Direct pumping involves collection of a thin layer of oil in an outboard drum, lowered below the water surface. The emulsion of water and oil is sucked in by a rotating water pump and forced to an open decantation tank, having siphons or a perforated bottom for elimination of surplus water.

The major disadvantage of this system consists in the danger of small drifting objects (fibres, paper, straw, cork, wood, etc.) blocking the grid of the collecting drum or entering the pump body and thus blocking or damaging the impeller. In the vacuum pumping system the emulsion is not brought into the pump body, but sucked into a tank wherein a certain vacuum is maintained by an air pump. This way, damage to the delicate pump impeller by small drifting objects is avoided. The remaining part of the operation is similar to that of the direct pumping method. Difficulties encountered here result from high viscosity of the oils to be skimmed.

As satisfactory results kept lacking, tests were abandoned in Le Havre. Useful output was insufficient : in favourable conditions the efficiency factor obtained (i.e. volume of oil to volume of emulsion pumped) did not exceed 1 : 31 which means that, in order to skim off 1,000 litres of oil, at least 31,000 litres of emulsion were to be pumped and decanted. After thorough study of both systems, Antwerp gave its preference to a floating oil skimmer of the vacuum pumping

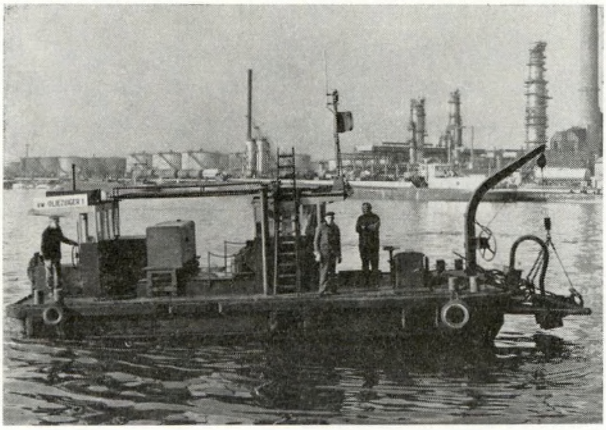

Fig. 4.

Oil skimming vessels of the port of Antwerp.

type (see Fig. 4). Contract was passed in 1953 and 1954 saw the first trial runs and pumpings. The oil skimming vessel consists mainly of a steel pontoon (10 m × 4 m × 2.20 m), propelled by an outboard motor (see Fig. 5), a combined vacuum-compressor group, two tanks for simultaneous operation, of 3,500 litres each, an open decantation tank (20,000 litres contents) fitted with siphons, a 2 1/2″ suction pipe, connected to the collecting drum, and two 1 1/4″ suction pipes.

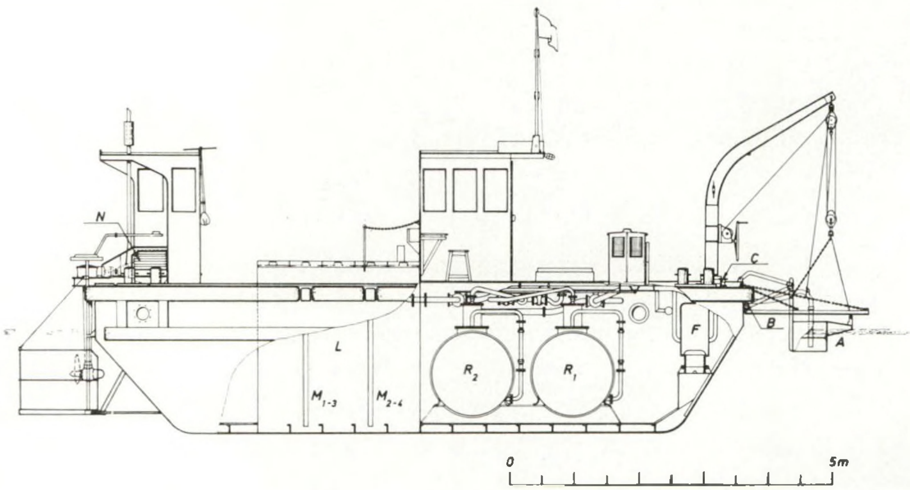

Fig. 5.

Oil skimming vessel (port of Antwerp) — Longitudinal section.

A. Articulated collector
B. Suction pipe ⌀ 2 1/2"
C1-C2. Suction pipes ⌀ 1 1/4"
D. Vacuum pump
E. Compressor
F. Motor
G. Power generating set
K1-K2. Valves on suction- and discharging pipes
K3-K4. Valves on air pipes
R1-R2. Tanks for simultaneous action
L. Decantation tank
M1-M2-M3-M4. Overflow siphons
N. Outboard motor

The personnel accommodation includes a mess and a shelter room, a wheelhouse on the aft deck and a dressing- and storage room. Lighting and signal equipment are fed by a power generator and batteries.

The system operates on the vacuum principle and is designed for synchronised double action (simultaneous suction and discharge) — see Figure 6.

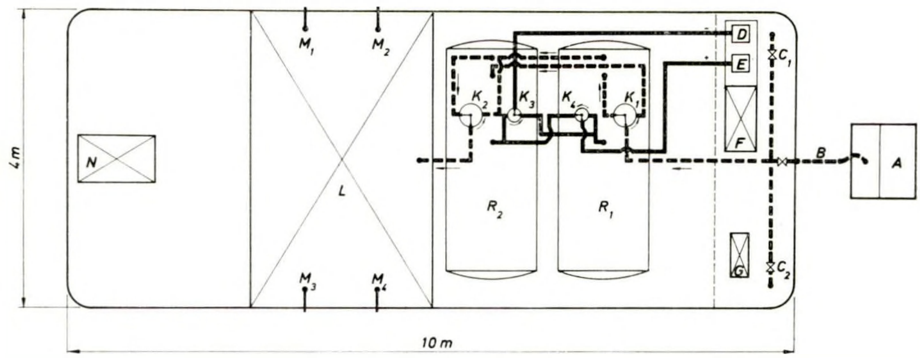

Fig. 6.

Oil skimmer vessel (port of Antwerp) — Principle of operation.

The hydrocarbons, floating as a thin film on the dock water, converge into the outboard collector when it is lowered slightly below the water surface. A circular collector, originally used, was replaced by an articulated one in 1956, which allowed doubling the efficiency during 1957. Through a grid, needed in order to keep floating debris out, oil and inevitably a certain quantity of water reach the collector, connected via a suction pipe (⌀ 2 1/2") and two three-way valves to the two tanks for simultaneous action. One of these offers a certain vacuum, maintained by a rotating air pump. The oil and water sucked in form an emulsion which, after the filling level has been reached, and the tank is subjected to the pressure of a compressor, is forced to the decantation tank.

Manipulation of one single lever effects alternative operation of both tanks on the suction or pressure regime, resulting in uninterrupted operation without painstaking handling of several valves.

Initially, the decantation tank is filled with water, in view of balance and stability of the vessel. The emulsion, received for decantation, reaches a certain degree of tranquillity which permits net separation of oil and water. The specific gravity of oil being inferior to that of water, the oil floats up and the excess water, via the siphons, is returned to the dock. As pumping goes on, the thickness of the oil layer in the decantation tank increases. Practical experience has shown that, even with an 1.5 m thick oil top decantation remains virtually perfect : the water returning to the dock via the siphons carried negligible oil charges.

This induces the conclusion that the decantation tank — measuring 4 m × 2.5 m — offers a collecting capacity of at least 15,000 litres of oil between two successive evacuations. In the initial stage this evacuation was done by hand; later on, on account of the soiling and time consuming nature of the operation, it was performed by means of a vacuum-tank vehicle of 6,000 litres contents. The vacuum in the vehicle tank is originated by connection to one of the smaller suction pipes of the skimmer vessel. A suction hose between decantation and vehicle tanks permits a 15,000 litres/hour evacuation. As from 1971, when the cleaning and storage station became operative, all collected oil is pumped and delivered there directly from the vessel decantation tank.

After a break-in period, during which the equipment of the skimming vessel was run in and adjusted, and the personnel familiarised with operation and possibilities of the craft, satisfactory results were obtained.

The results of the pumpings as from 1955 are gathered in the Table given below. These show that the efficiency, originally 1 : 28, has increased to 1 : 2,2 which signifies amelioration by more than 1,000%.

A remarkable achievement was performed in October 1967 : the vessel skimmed 1,219,000 litres of oil in less than 12 days, after an exceptional spill upon refinery tank rupture.

Year	Quantity of emulsion pumped (litres)	Quantity of hydrocarbons removed (litres)	Average factor of efficiency	Average capacity of evacuation per hour
1955	8,260,000	295,000	1:28	700
1956	5,185,000	305,000	1:17	1,160
1957	6,384,000	480,000	1:13.3	1,650
1958	5,541,000	386,005	1:14.3	1,528
1959	2,904,000	226,400	1:12.8	1,427
1960	2,829,000	264,000	1:10.7	1,719
1961	3,018,000	324,000	1:9.3	2,009
1962	3,123,000	438,000	1:7.1	2,595
1963	4,689,000	779,500	1:6	2,928
1964	4,011,000	500,000	1:8	2,171
1965	7,374,000	985,500	1:7.5	2,225
1966	5,106,000	752,500	1:6.8	2,577
1967	6,027,000	2,113,500*	1:2.8	5,500
1968	4,278,000	1,351,000	1:3.2	3,758
1969	3,135,000	1,098,500	1:2.9	3,797
1970	3,105,000	1,359,000	1:2.3	3,220
1971	2,832,000	1,271,000	1:2.2	3,839
TOTAL .	77,801,000	12,929,400		

Note : As from 1956 an articulated collector is used in replacement of the suspended collecting drum used initially.

* Esso spill : 1.219.000 litres removed from 5 to 16 October.

The experience, gathered during the 1955-1971 period, pointed out that in the specific Antwerp port conditions the principle of vacuum pumping adopted yielded the best results.

During the same period the dock water area grew from 460 ha to 1,300 ha, as a result of port extension. Moreover, the number of petroleum tankers, berthed in the impounded docks, rose from 468 units in 1956 to 1,892 in 1971, while the tonnage increased from 2,330,000 B.N.T. in 1956 to 12,273,122 B.N.T. in 1971.

While in 1956 the oil skimmer evacuated 305,000 l of floating hydrocarbons, in 1971 it had to deal with a volume of 1,271,000 l.

This shows the urgent need for an additional oil skimmer.

The studies have been carried out, implying the same principle of vacuum pumping and featuring some secondary improvements such as :

— an increase of the decantation tank capacity from 20 tons to 50 tons;

— an increase of the max. propulsion speed to 15 km/hour;

— fitting of a deck-mounted pump for the spraying of detergents;

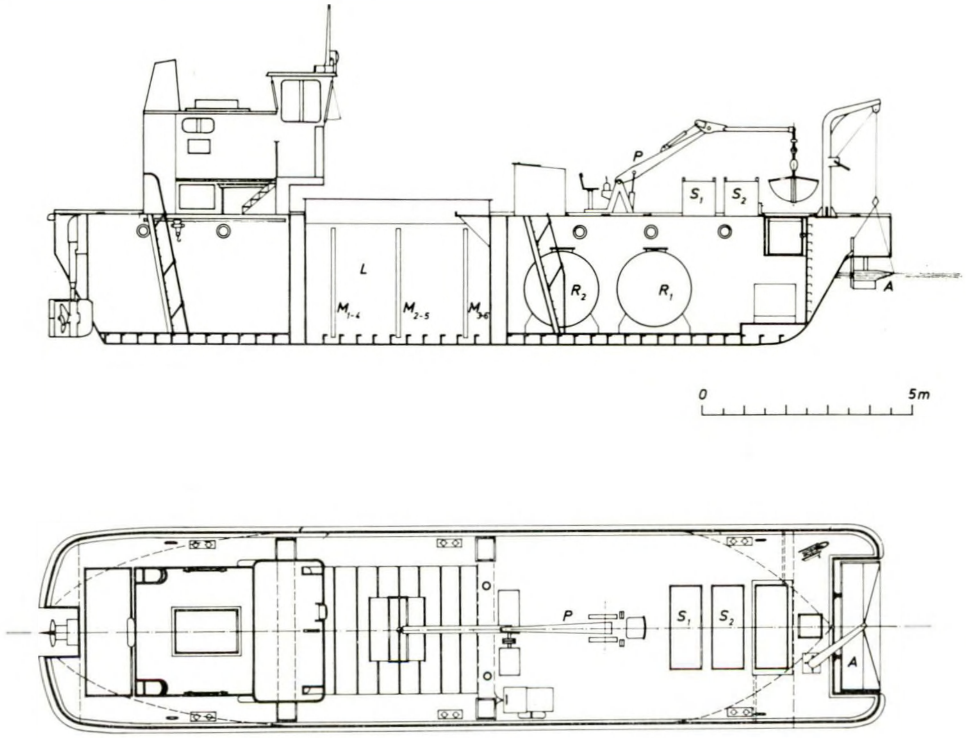

Fig. 7.

Oil skimmer II (port of Antwerp) — Longitudinal cut and vertical view.

A. Articulated collector
R1-R2. Tanks for simultaneous operation
L. Decantation tank
M1 to M6. Overflow siphons
P. Grab crane
S1-S2. Containers for floating debris and driftwood

— installation of a grab-crane and containers on deck, for evacuation and storage of driftwood and other floating debris;

— radio-telephonic equipment.

Availability of a second oil skimmer of the type shown in Figure 7, will result in an important improvement of the means for efficient fighting of the pollution of the docks complex by hydrocarbons.

RÉSUMÉ

Mesures de prévention contre la pollution des eaux des ports d'Anvers et de Gand

Les causes de pollution des ports peuvent être divisées en 2 grandes catégories : la pollution par les débits d'alimentation des rivières et canaux sur lesquels les ports sont situés, et la pollution provoquée par la décharge d'égouts et d'eaux résiduaires industrielles directement dans les darses des ports. La pollution par produits pétroliers forme un chapitre spécial de la dernière catégorie.

Les ports belges étant reliés avec leur hinterland par un réseau de voies navigables sont tous confrontés avec les deux sortes de pollution, mais le problème des eaux d'alimentation est le plus grand pour le port de Gand, l'Escaut et la Lys étant très pollués par les décharges sur leurs cours supérieurs qui traversent les zones industrielles du Nord de la France et du Sud Ouest de la Belgique. Une source supplémentaire de pollution pour la Lys est le rouissage du lin qui donne une pollution de l'ordre de 1.000.000 e q h contenant beaucoup de H2S. Le confluent des 2 rivières est dans la ville de Gand (270.000 hab.) qui y déverse ses eaux d'égouts non épurées. Le débit caractéristique minimum total des 2 rivières étant d'environ 12 m^3/sec., la capacité d'auto-épuration est nulle à l'entrée du port.

La pollution industrielle des eaux du port de Gand est également d'environ 1.000.000 e q h.

Les mesures de prévention contre la pollution des eaux peuvent être divisées en 2 catégories : la réglementation des décharges autorisées avec ou sans mesures répressives et l'épuration proprement dite des eaux résiduaires industrielles ou domestiques (soit épuration individuelle ou collective).

Comme réglementation il existe en Belgique la loi du 11 mars 1950 sur la protection des eaux contre la pollution. Cette loi-cadre défend toute décharge dans un cours d'eau officiel sans autorisation préalable. Les clauses générales auxquelles les décharges qui ne proviennent pas d'égouts communaux doivent satisfaire sont réglées par des Arrêtés Royaux d'exécution et entre autres celui du 29 décembre 1953.

Cet arrêté divise les eaux belges en 3 catégories :

Classe I : les eaux servant d'alimentation en eau potable.
Classe II : les eaux piscicoles et pour l'abreuvage du bétail.
Classe III : les eaux employées pour des buts industriels.

Pour la classe II dans laquelle sont classés l'Escaut, la Lys et le Canal Maritime vers Gand (le Port) les clauses sont les suivantes :

1. la température de l'eau recevante ne peut dépasser 30°;
2. le pH de l'eau recevante doit être compris entre 8,7 et 6,5, et localement entre 9,2 et 5;
3. le pourcentage d'oxygène dissous dans l'eau recevante ne peut descendre en dessous de 3 mg/l (avec un minimum d'au moins 1 mg/l pendant maximum 1 mois par an);
4. les eaux déchargées ne peuvent contenir plus de 0,5 mg/l de matières qui se déposent dans une sédimentation statique;

5. le pourcentage des matières en suspension dans l'eau recevante ne peut augmenter de plus de 100 mg/l;
6. la concentration de n'importe quelle matière toxique ne peut être telle que l'eau devient impropre pour l'usage industriel ou l'irrigation des terres.

L'Office d'épuration des eaux usées fixe, pour chaque autorisation, les conditions spéciales tenant compte des circonstances particulières à la décharge.

La procédure pour le contrôle et la répression des abus était très longue de sorte que cette loi qui était en soi excellente devenait inefficiente. En plus, les décharges dans les égouts communaux n'étaient pas réglées par les arrêtés précités, de sorte qu'il était impossible de réprimer les abus des déversements dans les égouts.

C'est pour cela que la loi a été remplacée par celle du 26 janvier 1971 qui divise la Belgique en 3 sociétés d'épuration des eaux suivant les bassins hydrologiques. Les sociétés, qui sont des associations de droit public ayant la personnalité civile, sont compétentes non seulement pour l'établissement et la gestion des stations d'épuration des eaux résiduaires industrielles et domestiques mais elles délivrent et contrôlent en outre les autorisations pour déverser des eaux résiduaires dans les cours d'eau, etc.

La pollution de l'air et de l'eau a pris de telles dimensions qu'une multitude de comités et de groupes d'action ont été créés en Belgique.

Ainsi, un Centre contre la pollution de l'air et de l'eau fonctionne à Anvers. Ce service communal a non seulement un rôle de conseil quant aux autorisations de bâtir et d'exploitation pour toute la province, mais il contrôle aussi leur observance et il mesure continuellement différentes matières polluantes. En plus un service de garde est à la disposition du public.

En Flandre Orientale « La commission technique pour l'hygiène du milieu » conseille la députation permanente au sujet des autorisations d'exploitation et au sujet des plaintes du public. Son terrain d'action couvrant toute la province se concentre surtout sur la zone portuaire de Gand et sur l'extension du port d'Anvers sur la rive gauche de l'Escaut.

En ce qui concerne l'épuration des eaux de la zone portuaire de Gand, l'étude du bureau HAECON conclut que pour la rive gauche du canal maritime vers Gand la solution consisterait dans la construction d'une station d'épuration centrale pour une charge d'environ 1.000.000 e q h qui traiterait également les eaux de la commune de Zelzate (13.000 hab.).

La rive gauche est en effet occupée par un grand nombre d'usines très polluantes datant de plusieurs années de sorte qu'une épuration individuelle est à déconseiller.

Sur la rive droite on trouve un nombre restreint de grandes industries récentes outillées d'installations d'épuration; des mesures spéciales ne s'imposent donc pas pour cette rive.

Les coûts d'investissements pour la rive gauche sont estimés à 1,5 milliard de FB.

La pollution des eaux portuaires par hydrocarbures

Le problème de la pollution des eaux par hydrocarbures pose un problème aux autorités portuaires du monde entier.

Elles se voient confrontées avec la tâche d'adapter et de moderniser constamment les moyens et l'appareillage destinés à combattre ce fléau dont les risques ne cessent d'accroître.

La fréquence de la pollution, ainsi que le volume des matières polluantes à évacuer sont en relation directe avec :

— le nombre de navires utilisant les hydrocarbures comme carburant (fig. 1);
— le nombre et le tonnage des navires transporteurs d'hydrocarbures faisant escale aux ports (fig. 2 et 3 pour Anvers);
— la présence dans les ports de raffineries, qui représentent en Europe occidentale 50 % des producteurs d'énergie primaire.

Fondamentalement, on peut distinguer deux sources majeures de pollution :

— celle qui résulte du processus normal de transport et de traitement d'huiles minérales (eaux de rinçage des navires pétroliers et eaux de refroidissement des appareillages de raffinage), qui est bien connue et constante et de ce fait soumise à contrôle et réglementation;
— celle provenant de circonstances accidentelles au cours du chargement/déchargement des porteurs en vrac, de collisions, d'avaries, d'erreurs de manipulation au cours du pompage, etc. qui elle, au contraire, n'est pas contrôlable d'avance et pour laquelle on n'a recours qu'à des mesures de protection et d'évacuation. Un grand nombre de ces pollutions accidentelles est clandestin et de ce fait sans recours contre les responsables, ce qui ne diminue en rien la nécessité d'y remédier dans le plus bref délai possible.

Le volume des eaux polluées provenant du raffinage connaît une diminution spectaculaire, due à la modernisation des procédés. Cette diminution peut atteindre, dans le cas optimum, le rapport 150 : 1 vis-à-vis des volumes d'eau requis dans le passé.

D'autre part, des installations destinées à la réception des eaux de rinçage des navires, fonctionnant depuis 1971 à Anvers, éliminent cette source antérieurement importante de pollution.

Reste alors le problème d'évacuation des hydrocarbures introduits quand même dans les bassins, par quelque cause que ce soit.

Dans le passé, la cueillette se faisait à la main. Vu l'accroissement constant des volumes à traiter, cette méthode s'est avérée inadéquate depuis bien des années.

L'arsenal moderne met à la disposition des intéressés des moyens primaires d'élimination (produits absorbants, détergents et appareils pour l'évacuation mécanique) et des moyens secondaires, comme les portes de sécurité, barrages à bulles d'air et barrières flottantes. Les moyens secondaires s'utilisent utilement pour le barrage et le sectionnement de bassins, et pour la circonscription et l'isolement de déversements d'huile, en attendant le traitement par les moyens primaires (intégration des moyens).

Le traitement aux détergents et celui aux matières absorbantes, provoquant la précipitation, présente, outre ses avantages, des inconvénients qui dictent la plus grande circonspection lors de leur usage en bassins éclusés, comme ceux du port d'Anvers.

La nécessité d'appareillage mécanique d'évacuation est de ce fait indéniable.

Depuis 1954, le port d'Anvers dispose d'une unité flottante d'écumage, munie d'un collecteur articulé positionné hors bord juste en dessous de la nappe d'huile (fig. 4). Par l'intermédiaire d'un groupe aspirateur/compresseur, l'émulsion (eau/huile) est aspirée dans une des deux citernes de réception jumelées, prévues pour fonctionnement continu (une étant remplie pendant que l'autre est vidée), d'où elle est refoulée dans un bac de décantation.

Pour le pompage, il fut fait appel à une pompe à vide, ce qui a le grand avantage de ne pas mener le liquide dans la pompe même et de ce fait de pallier aux inconvénients inhérents au pompage direct, qui sont : usure rapide des parties mobiles de la pompe et blocage fréquentss par corps étrangers aspirés avec le liquide.

Cet engin, dont le texte décrit en détail le fonctionnement, et dont des coupes schématiques (fig. 5 et 6) montrent la réalisation pratique, donne entière satisfaction et permet un rendement utile (huiles évacuées/émulsion pompée) très élevé. L'article donne des chiffres exacts sur les quantités assez impressionnantes évacuées de cette façon.

La conclusion de l'article met en évidence la nécessité, en raison de l'augmentation toujours croissante des volumes d'huile à évacuer, de la mise en œuvre d'un deuxième navire écumeur, pour lequel les études sont terminées et qui sera construit à bref délai suivant les mêmes principes de fonctionnement (fig. 7).

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PAPER

by

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POLLUTION FROM SHIPS

TYPES OF POLLUTION EMANATING FROM SHIPS

Nearly all of the world's goods and resources must at some time in their passage from producer to consumer be carried by ship. Inevitably a percentage of the material carried is deposited in the sea itself because of accidents to the ships and because of the need to clean the interior of the ships with water before loading different cargoes. The principal material carried at sea and which forms 60% of the tonnage so carried is oil and most of this is in the crude form. In addition, practically all ships at sea today burn oil as fuel for propulsion of the ships and for providing power for ship services. The ships also, in their normal operations, generate sewage and garbage, most of which is discharged into the seas.

Hence ships become a serious source of pollution of all types and while the most serious at this time is oil, it must not be forgotten that ships also discharge polluting chemicals, sewage, garbage, grain dust, coal dust and cargo packing materials in the course of their normal operations. When ships are damaged as a result of collision or grounding the release of oil and polluting chemicals can be catastrophic.

The loss of chemical cargoes has caused considerable destruction of marine resources in various parts of the world, but to nowhere near the same extent as the damage caused by oil. Ships have in the past discharged from shipwreck and normal operations up to 10 million tons of oil per year into the oceans. This has been lowered now to about one million tons per year, but this reduced figure is still unacceptable and it is hoped that further efforts will eventually reduce it to less than 100,000 tons.

These various sources of pollution will now be discussed in greater detail, item by item, commencing with that of oil. I will try to show what is being done at this time to prevent, to minimize and to remedy each.

POLLUTION BY OIL

Practically all modern ships burn oil as fuel and for this purpose carry in their bunker tanks amounts varying from 300 to 5000 tons. Such oil can be light or heavy diesel fuel in diesel powered vessels and Bunker C oil in steam-powered vessels. While diesel fuel is not so messy as Bunker C, it is nevertheless a source of pollution to be avoided because of the poisonous additives contained therein.

Some of the fuel eventually ends up in the sea, principally by way of the bilges and the discharge of ballast. Much of this pollution can be prevented by means of good housekeeping on board the ship and by not using oil fuel tanks for carrying water ballast.

It has to be noted that all ships must carry ballast in varying quantities depending on the voyage and sea conditions. In ships other than tankers the oil fuel itself is often used as ballast but when it is consumed the tanks used for the fuel must be refilled with water in order to preserve ship stability. This water usually has to be discharged in port because discharge in the open sea before arriving at a safe harbour could endanger the ship by changing the stability and seaworthiness characteristics. It is difficult to clean the tanks thoroughly and some oil is inevitably discharged with the ballast water.

This situation could readily be avoided in the case ships other than tankers, by providing them with fuel tanks that are always entirely separate from ballast tanks. Studies have shown that such redesign would result in only a very slight increase in the cost of the vessel. It is well worth the result, however, and will be put forward at the 1973 Marine Pollution Prevention Conference as a means for preventing pollution from this source.

The far greater proportion of oil carried at sea, however, is carried by tankers as cargo, and it is much more difficult and expensive to use separate tanks to segregate cargo oil from ballast. The majority of oil cargo carried at sea is crude oil in the state in which it was first extracted from the ground, and it is highly polluting because of the large quantities of tars and greases it contains. It gets into the water principally from the operation of cleaning tanks on oil tankers in order that those tanks can be used for carrying ballast water.

Oil tankers must carry water ballast on voyages where they are empty of cargo and this ballast varies from 30% to 60% of the deadweight capacity of the tankers. Final discharge of this ballast must take place at the loading port and, in order to avoid pollution of the water in the port, it is necessary to clean the ballast tanks during the ballast passage. This used to be done by discharging the dirty ballast into the open ocean from each tank successively and then refilling with clean sea water. This method of cleaning the tanks has until recently been the major source of pollution of the sea from shipping.

The majority of tankers no longer use this method for cleaning tanks but instead separate the oil from the water on board ship by using the «load-on-top» method. In this method, the ballast water from uncleaned tanks is allowed to drain into the sea until a level is reached at which minute traces of oil become evident. Discharge to the sea is then stopped and the remaining ballast water with its oil content is discharged into a separate receiving tank. After the cargo tank has been emptied in this fashion it is washed by means of high pressure hot water jets projected from rotating nozzles which force the hot water at high pressure into all parts of the tank. The washing water, with its oil content, is then passed into the same receiving tank as the ballast water and the process continued until the tank is cleaned. The cargo tank is then filled with clean sea water and remains until eventually discharged as clean ballast in port. This process is continued with all the tanks that have to be cleaned, and results eventually in the receiving tank being filled up. In the receiving tank further separation of the oil from the water takes place with a continual discharge of clean water from this tank to the sea, such discharge being stopped the moment traces of oil become evident in the water. The separation is aided by means of division bulkheads, heating coils, oil sensors and cascade arrangements. When the ship arrives at the loading port there will be in the receiving tank a large amount of residues consisting of oil mixed with water and no further discharge will take place from this tank until the ship returns to an unloading port. Meantime, if there is any space available in the receiving tank, cargo oil is loaded on top of the oily residues and this process gives the name of « load-on-top » to the method. When the tank is finally discharged at an unloading port the sea water will be separated by the refining process at the refinery. The process has proved to be economically viable as the waste oil is reclaimed. The method is continuously being improved with the introduction of efficient oil detectors, better separation processes and other means.

A bigger problem at the moment concerns the 20% or so of tankers which, for various reasons such as a length of voyage not giving enough time for separation, will not or cannot use the load on top method. The only solution in such cases, if discharge of oil into the water is to be avoided, is to discharge the oil ballast into shore reception tanks. These tanks can then be used to achieve a very high degree of separation of the oil from the water, although it should be noted that it is almost impossible to achieve a greater degree of purity than about 15 parts per million of oil in the water eventually discharged. This problem is also under consideration by IMCO and countries will be asked to supply lists of shore receiving facilities for oily water ballast from those ships that depart on voyages too short for on-board separation of oil.

Considerable thought is now being given to the possibility of segregating of the cargo tanks from the ballast tanks of oil tankers as an alternative to the load-on-top method for avoiding the discharge of oily ballast water and tank washings. Such segregation of oil from ballast carries with it a considerable economic penalty but one that becomes less as the size of the tanker is increased. The segregation of cargo tanks from ballast tanks requires that the tanker be constructed with a number of tanks for carrying cargo only and with separate tanks for ballast water only. As the amount of ballast required can be up to 60% of the dead weight capacity of the tanker, depending on voyage and sea conditions, it is necessary for complete segregation for 60% of the tanker capacity to be devoted at all times to carrying ballast only, This could result in a reduction in tanker carrying capacity by 60% of the present tonnages and such a reduction in the flow of oil to the world's industries would have a very pronounced economic effect. At least for the next few years it is probable that the method of segregation of oil tanks from ballast tanks will be on a partial basis so that, for example, up to 40% of a tanker's capacity will be designed for ballast only. Where weather conditions demand 60% ballast, the cargo tanks would be used for the additional 20% and these tanks would be cleaned eventually by the load on top process.

This method of ballast segregation becomes more feasible in the case of very large tankers which even now have to be built with many tanks used for flotation and ballast only and that never carry oil. It is probable that by increases in the size of tankers this method will eventually be universally used to solve the problem of oil ballast discharge unless greatly improved on-board separation procedures can achieve the same objectives. This can only be decided by future technical progress.

There is still the question of pollution caused by shipwreck, collision and grounding. It has to be accepted that no ship can be designed to contain its cargo in the face of a maximum disaster. All that can be done is to design the ship with the object of minimizing the loss in the case of those groundings and collisions which do not cause more than relatively minor damage. The type of construction to achieve this consists of limiting the size of cargo tanks, installing of double bottoms and locating oil cargo tanks in the less vulnerable parts of the ship. An eventual solution might be the use of complete double hulls but this at present would appear to be economically feasible only in the case of very large tankers of deadweights approaching one million tons.

Some tankers have already been built with double bottoms as this has an economic advantage in that the tanks are more easily cleaned. It is likely that this design will be seen in increasing numbers in order to prevent pollution and to optimize the efficiency of operation of the vessel.

However, the best way to avoid pollution from shipwreck is to avoid the shipwreck in the first place and this can be achieved by the use of traffic routing schemes, increased and improved navigational equipment, traffic control and the application of higher standards in crew qualification. All of these are now being given consideration by IMCO and various countries, including Canada. As most shipwreck is caused by human error it is possible that pollution from this source may never be completely eliminated, paralleling in this regard a similar problem relating to automobile accidents.

Another problem in relation to oil pollution of the sea arises with the question of what to do when the damage has been done and oil has been spilled. The first step should be to contain and limit the spill by means of booms. These should preferably be one of the many excellent types now on the market, but if necessary they can be manufactured at the scene of the spill from logs, barrels, brush-wood, etc. After containment the oil can be removed from the water by means of oil absorbants such as peat moss and straw or by means of machines, known as « slick lickers » which, by use of a rotating oil absorbant belt, remove the oil from the water and deposit it into tanks. If the oil has reached the shore or beaches a severe problem arises as the oil then becomes very difficult to remove, requiring steam cleaning of stone-work and the physical removal of oil soaked sand. It is when oil is approaching a beach or the shore that consideration should be given to the use of chemicals to disperse the oil. There are many such chemicals on the market but they all have a disadvantage in that they are toxic in varying degrees to marine life or else they render the water and oil mixture toxic by means of their action. They should only be used after consultation with fisheries and health authorities and only when valuable shore amenities, such as beaches, are to be protected.

Oil is still, and likely will be for some considerable time, the source of most of the pollution caused to the sea by ships, the other categories, which I am now going on to describe, having a far smaller impact on the environment. Much of the work to date, and this work commenced in 1922, has been aimed at the prevention of pollution caused by oil. The task has been growing harder every year because if the ever-increasing volume of oil carried across the ocean, but this work now seems to be yielding dividends and should result eventually in discharging to the sea of only minimal quantities of oil.

POLLUTION BY CHEMICALS

Chemicals of all types have been carried by ships since the days of gunpowder. It was indeed the carriage of gunpowder that led to the application of the first safety rules to ships. Many of these chemicals are dangerous and their shipment by sea has resulted in a demand for international action. This has resulted, after international consultation, in the promulgation by many countries of a code of rules covering the packaging and storage on board ship of dangerous chemicals, the list of which has been steadily lengthened over the years. Until about 10 years ago these chemicals were carried in packaged form in drums, carboys, glass bottles and plastic containers. The world demand for chemicals has resulted, however, in a need to move larger and larger quantities and this has led, as happened similarly in the oil trade, to the carriage in bulk form of the chemicals in tanks which are part of the ships themselves. For this purpose many small oil tankers have been concerted to bulk chemical tankers and such ships often carry many different grades and types of chemicals for which a separate pumping system is required for each.

The safety provisions which already applied to the carriage of dangerous chemicals in packaged form were usually sufficient also to safeguard the environment from pollution, such dangerous chemicals being frequently recovered from shipwrecks intact in their original containers.

This is not the case, however, when chemicals are carried in bulk because, in the case of shipwreck, it is practically impossible to prevent leakage of the chemical. The need also arises, in the normal operations of chemical tankers, to clean the tanks when changing cargo or sometimes before refilling with the same cargo. This cleaning results in a discharge of chemicals to the environment. The discharge is usually in a highly diluted form, but this is for many chemicals still too much.

As a result of the growing practice of shipping chemicals in bulk, two international codes have been developed, one of which sets out rules for the carriage of dangerous chemicals in bulk on existing ships, while the second sets conditions and standards for the construction and operation of new chemical tankers. These codes were written in the first place from the point of view of safety, but are now being reviewed to see if they are equally applicable from the point of view of preserving the environment from pollution. To date it would appear that many of the provisions for safety might also be sufficient to prevent pollution, but the work is still proceeding and the revised codes will probably form part of the discussions at the 1973 IMCO Conference on Marine Pollution.

The code for new chemical tankers introduces a new conception of ship construction in that for the more dangerous and polluting chemicals a double skinned hull is required together with very high standards for ship stability and construction. These measures can never prevent a release of cargo in the event of a severe accident, but will reduce the losses caused by less severe shipwreck such as grounding, and should certainly reduce to zero loss resulting from minor damage to the ship.

The problem of chemical pollution has, I feel, been tackled capably and efficiently, and investigations have shown that the amount of pollution of the oceans from this source has not been excessive although of serious consequence to the local waters concerned. It has, however, not caused to date problems of the magnitude of those created by oil pollution.

Of interest to note at this time is that the number of chemicals carried by ship is continually increasing as a result of the demand for, and production of, many new chemical compounds each year. Most of these are fairly innocuous but some are dangerous and others are potential pollutants.

The problems relating to the action necessary after a release of dangerous chemical into the sea are still largely unsolved due to the great variety of such chemicals carried. It is for this reason that so much effort has been put into the prevention of such release. One thing that must be done, however, and which is now under international consideration, is to require all ships to maintain a readily available cargo list which would show the quantity and position on board of all dangerous and polluting chemicals and provide the information necessary to assist in clean up or retrieval in the event of release to the sea.

BILGE DISCHARGES

Water accumulates in the bilges of all ships from sources such as minor leaks, hoses, rain, gland leakage etc. and this has to be pumped overboard from time to time. Its polluting effect occurs principally because of the presence with this water of oil which has leaked from various parts of the machinery and boilers and is, of course, most prevalent in the machinery spaces.

Machinery space bilge water is therefore usually a pollutant because of this oil content and should not be discharged overboard, although a considerable quantity is discharged annually by shipping into the oceans from this source. Much of it could be eliminated by good housekeeping and by eliminating the minor leaks or by the collecting and piping of such leaks to special containers.

Another means of preventing or minimizing this pollution is by passing all the bilge water through an oily water separator before pumping overboard. This process will reduce the oil content to about 20 or 30 parts per million. It is hoped to improve this figure in the near future as a result of research now being carried out on various types of filters, such as polyurethane, which are capable of removing a much higher proportion of the oil.

Pollution of the seas from oil contained in bilge water has not to date received the same attention or concern as that given to oil tankers. It is considered, however, to be fairly easy of solution and there is no reason for pollution from this source to continue.

POLLUTION BY SEWAGE

Sewage is discharged from ships either by the routine operation of the ship or by the dumping at sea of shore generated sewage. Many countries have been in the practice of loading shore generated sewage into specially designed ships, taking it out to sea and dumping it in the open water. This has resulted in the various areas of water used for this purpose becoming so polluted as to drive away all marine life. It is desirable that such dumping of sewage should cease but, if this is not possible, then such discharge should only be made well clear of land and continental shelves. It must be admitted, however, that pollution from this source is only a very small fraction of the pollution caused by the discharge all over the world of shore generated sewage into coastal waters from the world's rivers and waterways and which never gets far away from land and continental shelves.

In so far as inland and coastal waters are concerned, the discharge of sewage caused by the routine operation of ships is small when compared to that discharged from shore, but must be viewed as a serious source of pollution because ships pass by and through water used for drinking, swimming, and other social amenities.

There are three basic ways of handling ship generated sewage, it can be retained in tanks for eventual discharge to a shore treatment facility, it can be reduced in volume by evaporation of the water content with eventual discharge ashore of the resulting small quantities of residual solids, and it can be treated on board ship to reduce the pollutant effects and then discharged overboard. All these systems have a greater chance of success if the toilets and other waste receptacles are designed to avoid the present wasteful use of water for transporting the sewage. It is the large volume of transportation water, slightly diluted but highly polluted by sewage, that makes the problem difficult of solution. For this reason radical new systems have already been developed to transport sewage by other means such as vacuum created air flow which have proved to be useful and practical.

The containment of the sewage in holding tanks appears at first sight to be simple and efficient and the system works very well when ships are not obliged to contain sewage for any length of time and when it is possible to discharge the contents of the tanks without undue delay or impediment in the operation of the ship. Containment could be an acceptable solution to the problem for ships that spend no more than one or two days in port, if it is also acceptable that such tanks may then be emptied in the open sea or if shore discharge facilities are available. It should be noted that if the sewage has to be contained for any length of time it becomes objectionable, dangerous gases are created and the liquid itself becomes highly poisonous.

Reduction in volume on board ship may be achieved by evaporating the water out of the sewage either by means of special evaporators or by injecting the sewage into boiler furnaces. One pound weight of fuel will evaporate ten pounds weight of sewage and the method is simple and reliable. Redesign of sewage systems to use less water will render the use of evaporation systems more practicable and the two in conjunction would appear to provide a satisfactory answer to the problem.

Recirculating systems, which recirculate the sewage transport medium, have been used for many years and have proved to be a highly efficient way of handling sewage. The transporting fluid has to be changed at periodic intervals but these are far apart and, as small quantities are involved, no difficulty is found in finding a suitable time and place for discharge. This system has proved to be practicable and efficient and will probably be accepted as one of the better solutions to the problem.

Treatment of sewage on board ship to reduce the polluting effects before discharge has not generally been found to be satisfactory. This type of treatment requires that methods normally used for purifying sewage ashore have to be adapted and compressed into a small space and be capable of functioning under conditions never met ashore. Many systems have been designed on this principle and used for many years, but without too much success as a high degree of skill and expertise is required if they are to operate within acceptable discharge standards. It is probable that as other systems are developed, on-board purification treatment systems will fall into disuse.

POLLUTION BY CARBAGE

Under this heading I am referring only to kitchen refuse, cardboard containers, empty cans and other refuse resulting from human habitation on board a ship. Materials such as these would, if discharged into the sea, cause pollution by depriving the water of oxygen and by littering the sea bottom and beaches. Garbage need not be discharged into the seas at all, it can be either retained on board for eventual discharge ashore, or incinerated on board ship. Where large quantities have to be retained on board it is desirable that as much as possible should be incinerated and that what cannot be burnt should be compressed for easy storage.

The principal problem in garbage disposal is that the garbage must eventually be discharged ashore, and not all ports and harbours are in a position to accept and dispose of the refuse. Municipalities must be prepared to receive the garbage, and ports should ensure that truckers are available who will be in a position to transport the material.

POLLUTION FROM SHIP LOADING AND UNLOADING OPERATIONS

Many cargoes, such as grain, ore and coal, when loaded and unloaded, create a great deal of dust which settles on the water and causes both air pollution and aesthetic pollution of the water. Grain dust will also accumulate in patches on the water which then decompose and create objectionable odours.

Much of this pollution can be prevented by the provision of canvas screens around the holds during the loading operations, and this practice is gradually being adopted at inland loading ports. The problem may also be overcome in the case of grain loading apparatus by fitting vacuum type dust removing equipment into the grain elevators and many elevators have already installed such equipment.

CONCLUSIONS

I feel that the problems of pollution of the sea caused by ships must continue to be tackled both internationally and nationally with the full co-operation of the industry itself. Much work, however, must still be done before such pollution can be completely eliminated, or reduced to an acceptable minimum if complete elimination should be found technically impossible.

It is confidently expected, however, that all the problems will be resolved and that pollution from shipping will eventually cease to be a matter for public concern.

RÉSUMÉ

Pollution provenant des navires

A un moment ou un autre de leur passage du producteur au consommateur presque tous les produits du monde sont transportés par bateau et, par voie de conséquence, l'eau reçoit inévitablement un certain pourcentage de ces produits, non seulement à la suite d'un naufrage mais aussi du fait de l'exploitation normale des navires. Au fil des années il s'est ainsi déposé dans les océans quelque dix millions de tonnes d'hydrocarbures sans compter les dépôts importants de produits chimiques dangereux et polluants. De grands progrès ont été accomplis dans le domaine de la lutte contre la pollution par les hydrocarbures mais il s'en déverse encore 1 million de tonnes par an dans les eaux. Une telle quantité est inadmissible et on espère pouvoir la ramener à l'avenir à moins de 100.000 tonnes. Celle-ci est le résultat des meilleures méthodes de vidange des réservoirs des pétroliers. Jusqu'à récemment, l'eau des réservoirs des navires-citernes était déversée à la mer avec les hydrocarbures qu'elle contenait. Cette pratique a été largement abandonnée et l'eau est maintenant séparée des hydrocarbures avant d'être jetée à la mer.

Les navires-citernes servant au transport de produits chimiques polluent également les mers, bien qu'à un degré moindre que les pétroliers. Leurs nouvelles caractéristiques de construction et de stabilité ont pour but de réduire les pertes de cargaison lors d'un échouement ou d'un abordage.

Une autre cause de préoccupation est le déversement à la mer des eaux usées des navires et le seul moyen de remédier à cette pratique est d'améliorer les systèmes d'épuration des eaux usées. Les déchets de cuisine accumulés à bord des navires et jetés à la mer est une autre source de pollution et la seule solution à ce problème est de les décharger à terre ou de les brûler à bord.

On commence à observer les effets polluant des poussières nuisibles produits par les céréales et le charbon chargés à bord des navires. On dispose cependant de moyens pour prévenir cette forme de pollution et on commence à les appliquer dans les divers ports du monde.

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PAPER

by

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SYSTEMS TO COLLECT BILGE WATER FROM FISHING VESSELS IN BASINS, WHERE TRASH FISH IS LANDED

INTRODUCTION

In the Danish fishing ports on the West Coast of Jutland (see Fig. 1) 1,000,000 tons of fish is landed every year which is not for consumption but only made into fishmeal and fishoil (so called trash fish).

It has been an essential problem in these ports to keep the water in the basins clean. The surface has been polluted by big almost connecting flakes of organic oils and fatty substances and the water in general is polluted by blood, lymph etc.

With the pickle of fatty substances sticking to the ladders and similar things it has become a danger to the men who are working there, just as it has polluted the air with evil-smelling vapours. Besides this fact the pollution of the water has given conditions of growth for sulphate reducing germs and, therefore, the water in the basins has been aggressive against metals with a very strong corrosion of the fishing vessels and their sea-connection as a result.

The pollution is mainly deriving from the polluted bilge water which is pumped out into the basins from the holds of the fishing vessels.

To remedy this pollution, systems have been made during recent years in order to gather the bilge water from the vessels to prevent the water from being pumped out into the basins.

THE NATURE OF THE FISHING

The fish which are caught for industrial purposes (trash fish) are mainly herring, Norway Pout, and sand eel. These are in general caught by fishing vessels of 50-250 g.r.t. by means of trawl.

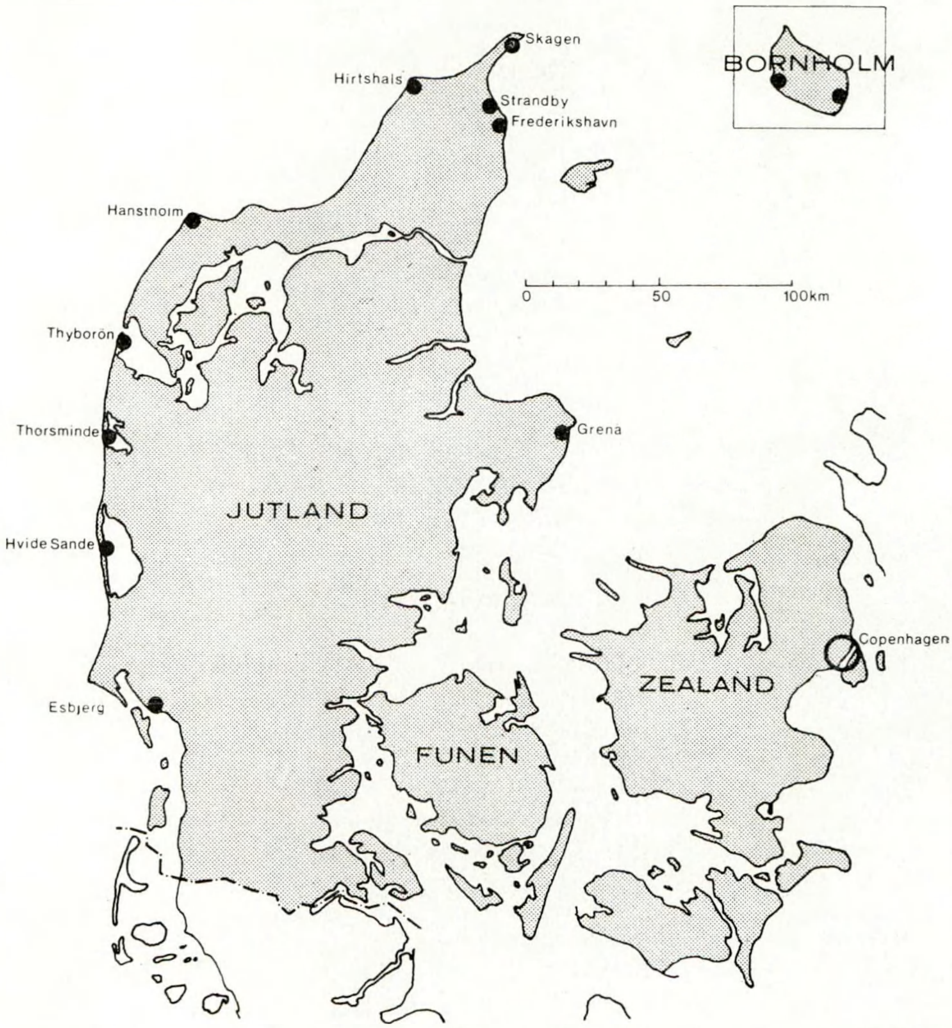

Fig. 1.

The most important Fishing Ports in Denmark.

The fish are caught in the North Sea in distances of up to 300 nautical miles from the port.

The crews of the vessels are amounting two to six men and the vessels are normally owned by the fishermen. The cargoes of fish are fluctuating between 30 and 150 tons and are landed in bulks. In the summer time the fish is mixed with appr. 15% of ice and with 10% of ice in the winter time.

The discharging of the cargoes in the ports is done by means of special « herring cranes » (see Fig. 2). These are fitted with vertical buckets which can be lowered down into the holds of the vessels through the discharge hole. From the upper end of the vertical bucket elevator the fish is led along a horizontal belt into the wharf where it falls into leak tight tipping wagons. The filled up tipping wagons are towed to the factories by tractors.

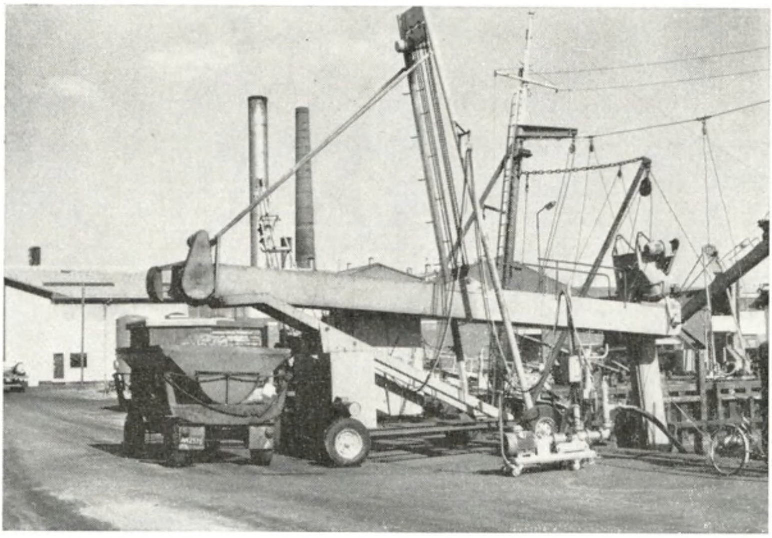

Fig. 2.

« Herring crane » at work. In front one can see the pump for the bilge water.

THE BILGE WATER

The fishing vessels are on the sea in up to 8 days and the cargo is producing some liquid in this period. The liquid consists of the salt water from the fish when caught, meltet ice and oil, blood, lymph etc. from the fish. Besides this some sea water, which may ooze in from possible leakages in the vessel. This liquid (bilge water) is gathered in the bottom of the hold.

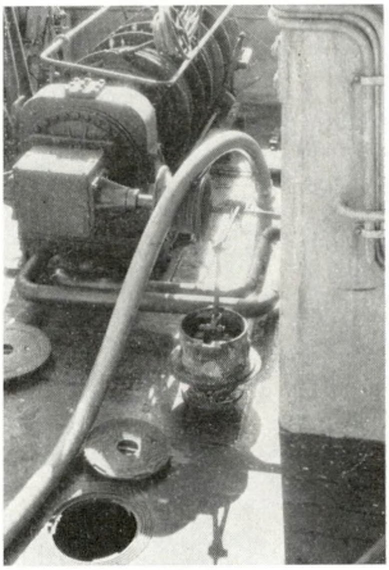

Fig. 3.
Diaphragm pump and connection.

When the fishing vessel is at sea this bilge water is pumped up from the hold by the normal bilge pump which is a diaphragm pump which is often connected to the winch of the fishing vessel (see Fig. 3), this pump can also be operated manually. The bilge water which is pumped out at sea is disappearing rather quickly as it is taken by fish and sea birds and transformed by micro organism.

Previously the bilge water was also

pumped outboard when the vessel was in the port but this is now prohibited and this prohibition is kept strictly, and penalties of 3 D.Kr. per g.r.t. are given.

The amount of bilge water, which is to be pumped out while the fishing vessel is in port amounts to appr. 5% of the gross weight of the capture and the bilge water is often consisting of :

appr. 8% flesh and protein
appr. 42% oil
appr. 50% water.

In this way it is substantial amounts of dry matter which has been led out into the basins along with the bilge water and consequently a vast reduction of the pollution of the basins which has been achieved by no longer pumping out the bilge water.

DESCRIPTION OF THE SYSTEM AT ESBJERG

In the following it is described how the problem has been solved at Esbjerg which is the port where most trash fish is landed in the whole of Denmark (appr. 500,000 tons per year).

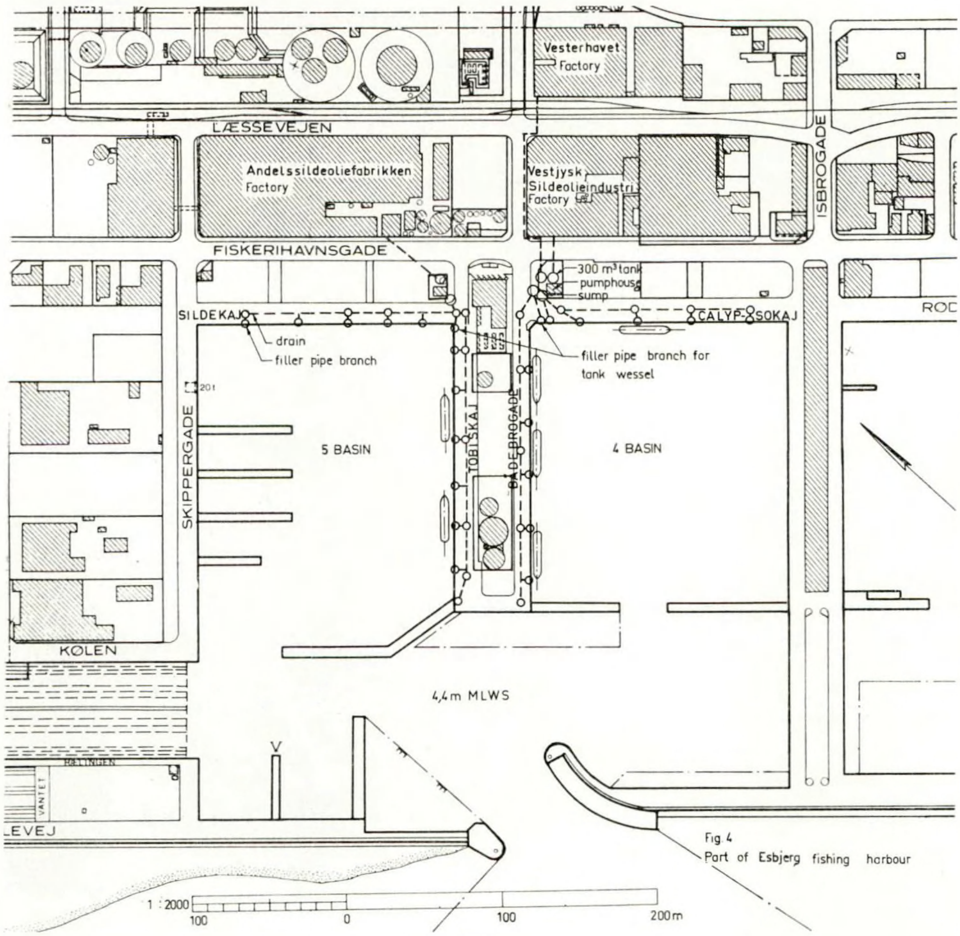

Fig. 4.
Port of Esbjerg Fishing harbour.

The main principle in the system is that the bilge water which was previously led out into the basins now is taken to the factories where it is used in the production.

There are three individual factories at Esbjerg and each of the factories have firm suppliers among the fishing vessels. To the three factories respectively 220, 50 and 50 vessels are landing.

Each factory has been assigned certain wharfes so that the wharfes « Sildekaj » and « Tobiskaj » are reserved for the « Andelssildeoliefabriken » (see Fig. 4), « Calypsokaj » has been reserved for « Vestjysk Sildeolieindustri », and « Bådebrogade » for the factory of « Vesterhavet ». The three factories have established respectively 11, 5 and 5 places of discharging.

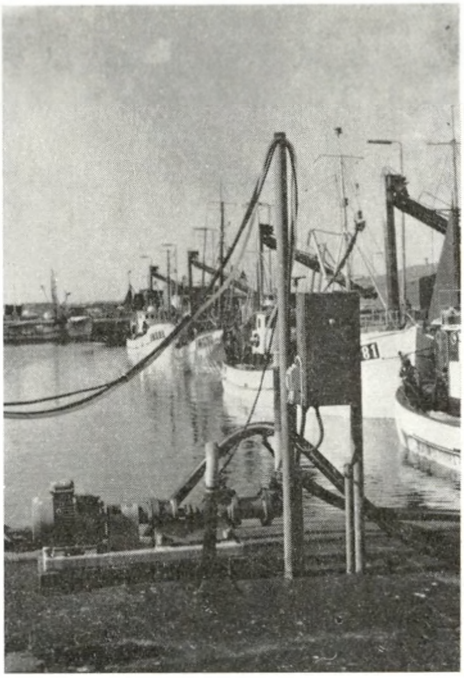

Fig. 5.
Pump for bilge water.

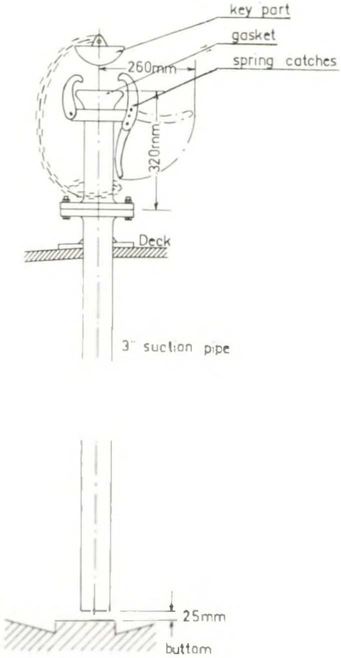

Fig. 6.
Suction pipe for the fishing vessel.

By each place of discharge a pump has been mounted (3" self priming pump) (see Fig. 2 and 5).

In all the vessels a special suction pipe has been fitted to suck from the bottom. The suction pipe ends appr. 0.5 m over the deck in a special connection with spring catches (see Fig. 3 and 6).

When the fishing vessels are to be discharged the suction hose from the pump is connected with the pipe branch on the vessel and all the bilge water is taken ashore instead of out into the basin.

From the pump the bilge water is led to a special drain which has been layed down in the street on the wharf.

This drain is layed down as a graviation drain and is made from 20 c.m. plastic tubes with 5‰ drop. There is a branch connection out to a filler pipe branch by each discharging crane. The filler pipe branch is closed by an ordinary 20 × 20 c.m. tight cover fitted with hinges which is easy to open and close.

The drain takes the bilge water to one sump for each factory. The sumps are made of 2 m concrete well-rings and are about 4 m deep. In the sumps 2 pcs. 3" sewer pumps are installed by which the bilge water is pumped up into a 300 cbm tank (see Fig. 7) from where the bilge water can be pumped into the factories and be used in the production.

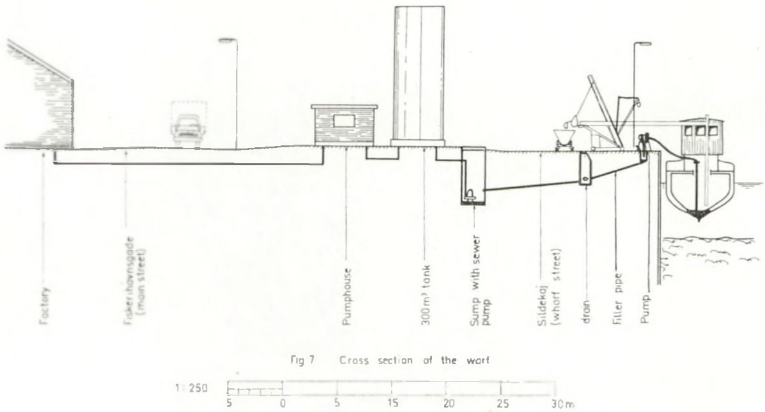

Fig. 7.

Cross section of the wharf.

In days with substantial landings not all the fishing vessels can be discharged at once and avail the bilge water pumps.

Fig. 8.

Tank vessel to accept the bilge water from the fishing vessels.

As it is often necessary to empty the bilge water from the fishing vessels while these are waiting to be discharged a smaller tank vessel has been obtained « Alright » (see Fig. 8) which has a capacity of 14 cbm. bilge water and which is equipped with pumps which can suck the bilge water up from the fishing vessels which are waiting and subsequently lead the bilge water ashore by a special branch connection on the drain.

CAPACITY

The system is constructed to take up the bilge water from appr. 500,000 tons of trash fish a year, which is landed in appr. 8,000 landings, or as each vessel has averagely appr. 3 cbm. bilge water, this amounts to appr. 25,000 cbm bilge water per year.

As the landings, however, are not regularly spread in time, but concentrated at the beginning of the week and besides in a large extend limited by weather conditions the system will probably take care of still larger amounts of bilge water.

The limit is set by the working up in the factories as all the water has to be evaporated or cleaned totally as polluted water must not be led out from the factories.

ECONOMY

The receiving system for bilge water has been established as a co-operation between Port Authorities and the three factories which are using the landed fish in production.

The installation of suction pipes and connections in the fishing vessels are payed by the owners of the vessels and amount to appr. D.Kr. 700,00 per vessel. The pipes in the wharf and sumps etc. are installed by the Port Authorities to a total amount of D.Kr. 220,000 or appr. D.Kr. 10,000 per place of discharge.

The expenses for pumps, tanks, tank vessel etc. are payed by the three factories and amount to appr. D.Kr. 650,000 or D.Kr. 30,000 per place of discharge.

CONCLUSION

The system at Esbjerg was started August 1st, 1972 and already by September 1st, 1972 perceptible results have been measured as the amounts of oil and fatty substances which can be seen floating on the surface in the basins have been reduced substantially.

At Hirtshals a corresponding system has been running for appr. 3 years with good results and similar systems have been installed in all Danish ports during recent years where trash fish is landed with a consequently reduction in the pollution of trash fishing ports.

RÉSUMÉ

Ces dernières années les ports de pêche danois ont de plus en plus à lutter contre le problème de la pollution de l'eau de leurs bassins. Pollution provenant de l'huile de poisson, du sang, etc., déchargés des bateaux de pêche.

Au courant des 4 dernières années, des installations ont été construites pour décanter l'eau des cales des bateaux de pêche dans des réservoirs au moyen de tuyaux de décharge. De l'eau impure peut être conduite à l'usine pour y être traitée.

Depuis la construction de telles installations le problème de la pollution de l'eau a considérablement diminué dans les bassins de ports où l'on décharge le poisson pour l'industrie.

Le rapport décrit les installations du port de pêche d'Esbjerg, construites en 1972 dont le prix approximatif s'élève à D.Kr. 40.000 par débarcadère.

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RAPPORT

par

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1. LA MER N'ÉPURE PAS TOUTES LES POLLUTIONS

La mer, par son immensité, a de tout temps incité l'homme à y déverser les détritus et déchets de toutes sortes résultant de ses activités.

Une masse d'eau mouvante de plus d'un milliard de km^3 pourrait effectivement constituer un lieu de décharges public idéal. La dispersion dans un tel volume, les processus secondaires d'épuration par décantation sur des fonds hors d'atteinte de l'homme semblent pouvoir fournir des conditions optimales pour le rejet des résidus. Mais en vérité, un examen plus attentif incite à des conclusions moins hâtives et le problème de l'élimination d'effluents dans le milieu marin doit être abordé avec circonspection.

En effet, une partie importante de la pollution trouve refuge près des côtes, et l'homme en subit donc les conséquences directement ou indirectement, par exemple par l'intermédiaire de la faune qui, elle-même, trouve refuge dans les zones de petits fonds.

Il faut d'abord souligner l'importance de ce problème pour un pays comme la France. En effet, baignée par deux mers dans un climat tempéré, la France doit, bien souvent, procéder à des arbitrages délicats entre les vocations concurrentes de ses côtes : urbanisation, industrialisation, tourisme, conchyliculture, pêche.

La définition de la notion même de pollution nécessiterait de longs développements. Certaines évolutions du milieu marin à proximité des côtes, ayant pour cause le développement d'activités humaines, ne doivent pas nécessairement être qualifiées de pollution.

Ainsi, l'Etang marin de Berre, près de Marseille, en communication avec la mer par un étroit canal, reçoit depuis peu 3 à 4 fois son volume d'eau douce, chaque année du fait de la mise en service de l'aménagement hydroélectrique de Saint-Chamas.

L'écologie du milieu s'en trouve profondément perturbée, sans qu'on puisse qualifier ces déversements de pollution.

Par contre, certains effets sans conséquence à court terme peuvent se révéler dangereux à plus long terme. C'est par exemple le cas bien connu de certains toxiques qui, distillés en quantités très faibles pendant de longues années, peuvent se concentrer dans les chairs de certains coquillages ou poissons et, par-là, devenir dangereux.

Faute d'une approche tout à fait rationnelle, nous proposons, dans la suite de ce rapport, de procéder par touches successives des différents aspects de la question.

Le plan adopté se résume en trois mots : observer, comprendre, agir.

Observer, c'est faire l'inventaire de la situation actuelle de la pollution, c'est se tenir à jour des évolutions et c'est surveiller les risques d'apparition de dangers nouveaux, pour devancer l'événement. Cette partie sera la moins développée, car son intérêt est plus spécifiquement national.

Comprendre, c'est mettre en évidence les mécanismes et les conséquences de la pollution, par l'étude du comportement physique, chimique et dynamique des polluants, et de leurs multiples effets.

Agir, c'est nettoyer la mer et la conserver propre.

2.1. LES POLLUTIONS PÉLAGIQUES

Nous désignons ainsi les pollutions liées à des rejets effectués en haute mer.

De tels rejets peuvent être inhérents aux transports maritimes (déballastage en mer de navires-citernes, pollution bactérienne liée à la navigation de commerce classique ou à la navigation de plaisance), ou à des actions volontaires (immersion en haute mer de toxiques ou de déchets nucléaires) ou enfin à des accidents (collisions ou naufrages de cargos chargés d'hydrocarbures ou toxiques, éruptions de forages sous-marins).

La France est concernée par ces trois types de rejets.

Sur le premier point notamment, la France a procédé à une série d'études sur la pollution de la Méditerranée par les rejets opérationnels des navires pétroliers. Il y sera fait allusion plus loin.

2.2. LES POLLUTIONS TELLURIQUES DES CÔTES FRANÇAISES

Ce sont celles liées aux rejets effectués à partir de la terre. Il s'agit de rejets directs par les fleuves, par les eaux de ruissellement, par les émissaires en mer. Ces pollutions comprennent tous les types de polluants, notamment les bactéries et des matières organiques liées aux rejets d'eaux usées urbaines et à des toxiques liés à certains effluents industriels.

Un inventaire assez complet des pollutions telluriques sur les côtes françaises existe.

En vérité, un tel inventaire a été difficile à réaliser.

Il a été jugé préférable de limiter l'inventaire aux communes ou groupements de communes ayant une partie de leur territoire adjacent au littoral, avec extension aux communes importantes proches d'estuaires, telles que Rouen, Caen, Nantes, Bayonne, Perpignan.

Les apports de fleuves ont été approchés par les données actuellement disponibles dans le cadre de l'inventaire national de la pollution des eaux continentales, actuellement en cours. Ce sont les flux de DBO_5 qui ont été retenus.

Une fois définies ces limites, il faut constater que les renseignements recueillis ne permettent qu'une approche partielle de l'appréciation de la charge polluante des rejets effectués en mer.

Ces renseignements sont en effet directement liés aux paramètres permettant le calcul de l'assiette des redevances pollution existant actuellement en France, c'est-à-dire les matières en suspension et les matières oxydables.

Des mises à jour de l'inventaire ainsi qu'un perfectionnement des méthodes d'appréciation des charges polluantes réelles, permettront de mieux mesurer, à l'avenir, l'évolution de la situation de la pollution des côtes françaises.

A l'examen de l'inventaire, on peut remarquer que la pollution apportée par les fleuves côtiers joue un rôle important. Pollution des eaux de l'intérieur et pollution des côtes sont donc liées : c'est fondamental de s'en rappeler au niveau de l'action.

3.1. EFFETS D'UNE POLLUTION PAR LES HYDROCARBURES

Les hydrocarbures ont des effets mécaniques liés à leur propriété physique, destruction d'oiseaux, de poissons, de coquillages par engluage et colmatage des branchies, etc...

— Ils s'étalent en nappe et peuvent perturber les échanges gazeux à l'interface mer-atmosphère.

— Ils ont des effets chimiques directs ou insidieux.
En particulier, les hydrocarbures aromatiques sont connus pour leur grande toxicité.

On a signalé la possibilité de concentration des hydrocarbures au long des chaînes trophiques (communication d'un goût de pétrole à des produits consommables, concentration de substances cancérigènes).

Le destin des hydrocarbures en mer reste peu connu. Les processus de dégradation par les bactéries interviennent ainsi que l'évaporation des fractions légères et la sédimentation à plus ou moins longue échéance des reliquats. Lorsqu'ils sont répandus en faible quantité, les pétroles attentent moins que d'autres polluants à la vie marine, car étendus en fil mince à la surface de l'eau ou émulsionnés, ils sont dégradés relativement vite par l'action combinée des bactéries et de l'oxydation.

Un grand nombre de souches existant dans la mer ou dans le sol sont capables de dégrader les pétroles avec une certaine spécificité selon la nature de ceux-ci.

Une partie des hydrocarbures est ainsi transformée en acides gras qui rentrent dans le cycle biologique. Certains estiment entre 30 et 40 % le taux de conversion en matières vivantes, le reste passant à l'état d'anhydride carbonique, méthane et eau.

Cependant, dans les zones polluées à l'état chronique, les organismes se chargent en produits pétroliers non métabolisés qui les rendent impropres à la consommation. Des exemples peuvent être trouvés dans l'estuaire de la Seine et sur l'Etang de Berre. Ainsi, des thons rouges pêchés en octobre 1969 dans le Golfe de Fos présentaient un fort goût de pétrole qui justifiait leur refus par les transformateurs. Après enquête, il est apparu que les produits polluants venaient de l'Etang de Berre où ils avaient été entraînés plus loin que d'ordinaire par le renforcement considérable du courant de surface consécutif à l'ouverture du barrage de Saint-Chamas. La forte densité de la mer à la fin d'un été chaud et un vent favorable avaient contribué à l'étalement de ces eaux et à une migration massive de leurs hôtes habituels, muges et loups en quête d'eau fraîche. Or, muges et loups sont une nourriture recherchée par les thons. Le pétrole qu'ils acquièrent dans leur habitat normal leur a donc été transmis.

Le pétrole à faible dose paraît plus toxique pour les plantes que pour les animaux. Un contact de quelques heures avec des produits à haut point d'ébullition à la dose de 0,1 % suffit à perturber fortement la photosynthèse d'algues, sans doute en raison d'une infiltration jusqu'au cytoplasme à travers les membranes cellulaires ou par suite de formations d'une couche isolante à la surface. L'action devient irréversible après 6 à 12 heures.

Les poissons fuient les eaux pétrolières qu'ils supportent d'autant moins que les hydrocarbures en cause ont des points d'ébullition bas. Divers bivalves supportent normalement 1 % de pétrole.

Cependant, dans le cas où le pétrole est stocké dans les graisses de réserve de ces animaux, il les rend immangeables dès que la dose dans l'eau dépasse 100 mg par m^3.

Lors des déversements massifs, consécutifs à un naufrage par exemple, la vie animale disparaît à peu près complètement à l'exception de quelques espèces qui parviennent à s'isoler du milieu. De rares végétaux subsistent. Les oiseaux marins sont décimés. Le rétablissement de la situation antérieure demande parfois des années. Il est relativement plus facile quand les pétroles en cause sont légers, donc se dégradent plus facilement.

3.2. EFFETS D'UNE POLLUTION PAR LES MATIÈRES ORGANIQUES

La destruction naturelle des matières organiques par des processus bactériens peut entraîner un enrichissement du milieu marin en éléments nutritifs (phénomènes d'eutrophisation).

On assiste, dans un premier temps, à des poussées anormales de phytoplanctons avec dans certains cas la prolifération exclusive d'une espèce (cas des eaux rouges). Il s'en suit une poussée du zoo-plancton dont la respiration conjugue ses effets avec les processus bactériens initiaux pour abaisser dangereusement le taux d'oxygène dissous. Un stade ultime peut être la transformation de certains milieux fermés en bassins anoxiques hostiles à la vie marine.

De nombreux exemples le montrent :

— Les eaux ménagères, les eaux vannes, les eaux résiduaires des industries alimentaires (abattoirs, laiteries, conserveries, distilleries, etc.) charrient des milliers de tonnes de matières fermentescibles qui se décomposent en absorbant l'oxygène dissous du milieu.

— Les matières organiques dont la décomposition produit de l'amoniaque, des nitrites, des nitrates, des phosphates et des sulfates (normalement accompagnées de phosphates produits d'excrétion ou ajoutés aux lessives pour empêcher leur redéposition des crasses). Cet apport de sel nutritif entraîne le développement d'espèces planctoniques nitrophyles habituellement peu nombreuses au détriment du peuplement varié d'origine correspondant à une eau pure.

— L'efflorescence du phytoplancton est suivie d'une multiplication elle aussi sélective du zoo-plancton.

— La croissance pléthorique du zoo-plancton augmente la consommation d'oxygène alors que la photosynthèse diminue. Un peuplement d'espèces peu exigeantes en oxygène s'installe tandis que les organismes supérieurs sont asphyxiés.

Les phénomènes de ce type se rencontrent fréquemment dans les étangs méditerranéens, plus rarement dans les estuaires des petites rivières bretonnes. Une tendance à l'eutrophysation existe aussi dans la rade de Marseille et celle d'Hyères.

3.3. EFFETS D'UNE POLLUTION BACTÉRIENNE

Précisons tout d'abord que sous ce titre, nous traiterons des pollutions causées par les divers micro-organismes unicellulaires, tels que bactéries, levures, champignons, virus, etc...

La quasi totalité des micro-organismes pathogènes parvenant à la mer, milieu récepteur final, est d'origine humaine. Il s'agit d'une pollution chronique constante. Rappelons, pour mémoire, qu'un adulte élimine environ 300 g d'excrétats par jour, contenant des germes en quantité énorme jusqu'à plusieurs milliards par g de matières fécales.

Cette pollution intéresse tout particulièrement le littoral marin et les zones qui s'y rattachent. Les problèmes d'hygiène et épidémiologiques qu'elle pose sont donc nombreux. Ils sont d'une brûlante actualité du fait, en particulier, du développement des loisirs et de l'accroissement démographique des villes en zone littorale.

Il est classique d'apprécier l'importance des pollutions bactériennes des milieux naturels par le dénombrement des germes tests des contaminations fécales, eschérichia coli, colliforme, streptocoque du groupe D; en particulier, eschérichia coli reste ainsi un des meilleurs indices de souillure fécale. Mais à côté de ces germes, on peut rencontrer d'autres espèces hautement pathogènes comme les salmonelles, responsables d'affections thyphoïdiques, éliminés par les malades en nombre quelquefois considérable. Les salmonelles sont une cause fréquente de contamination des coquillages et de certains autres fruits de mer collectés le plus souvent dans des zones insalubres.

On peut aussi rencontrer des germes du choléra, de la tuberculose, du tétanos, du botulisme.

Les baignades en eau de mer polluée sont enfin en relation, selon plusieurs auteurs, avec certaines affections oculaires, rhinopharyngées ou cutanées, dont les agents peuvent être des bactéries, des levures ou des champignons.

Enfin, des virus éliminés par des malades peuvent également parvenir en milieu marin. Certains résistant au chlore sont susceptibles de se maintenir même dans les effluents traités.

Les conditions de survie de ces micro-organismes dans les milieux naturels marins ont fait l'objet de nombreuses études assez contradictoires selon les auteurs.

Tous les auteurs sont d'accord sur le fait que le milieu marin peut être considéré comme hostile vis-à-vis des pathogènes. Mais la durée de survie et de conservation du pouvoir pathogène dépend de nombreux facteurs.

Parmi ceux-ci, il est intéressant de se pencher sur les processus d'auto-épuration du milieu marin.

On constate d'abord qu'une réduction apparente du nombre des micro-organismes est due en fait à une absorption sur des particules en suspension. On les retrouvent au niveau du sédiment à partir duquel ils peuvent être remis en suspension par le jeu des vagues et des courants.

Dilution et dispersion sont également des facteurs réductionnels et non des agents bactéricides.

Les études consacrées à l'action bactéricide des radiations scolaires en milieu marin sont difficiles à interpréter. Il semble toutefois bien établi que cette action ne peut s'exercer qu'au niveau des couches les plus superficielles (quelques dizaines de centimètres).

Il semble établi de manière certaine que les basses températures favorisent la survie des bactéries mais ralentissent par contre une éventuelle croissance. On ne sait pratiquement rien sur l'influence de la température sur la survie des virus dans la mer.

Les variations du taux d'oxygène dissous dans les eaux de mer ne semblent pas avoir de rapport direct avec la survie des micro-organismes pathogènes.

Des avis contradictoires sont donnés quant à l'influence des sels minéraux sur la survie des germes entériques; il semble cependant que les hautes teneurs en sels minéraux de l'eau de mer ne doivent pas être considérées comme des facteurs déterminants du pouvoir auto-épurateur. Cependant, il faut souligner que seules les espèces euryhalines subsistent dans l'eau de mer de sorte qu'une sélection intervient très rapidement parmi les germes.

Le milieu marin est en règle générale très pauvre, et convient mal au développement des micro-organismes.

Lorsque les germes pathogènes arrivent en milieu marin, ils subissent une série d'agressions aboutissant à une diminution brutale de la charge polluante, mais aussi à la sélection d'individus résistants, susceptibles de survivre et quelquefois même de proliférer dans certaines zones riches en matières organiques facilement utilisables (débouchés d'émissaires, plages, etc.). Ces germes survivants sont rencontrés préférentiellement au niveau des sédiments à granulométrie fine. Sous l'influence de certains mouvements océaniques, ils peuvent être remis en suspension, véhiculés sur des distances parfois importantes et contaminer ainsi secondairement des zones marines éloignées.

Le problème du danger des baignades en eaux polluées a suscité lui aussi de nombreuses polémiques. Ainsi, les avis sont très partagés pour ce qui est de la dose infectante de salmonelles. Pour certains auteurs, il faudrait absorber plusieurs litres d'eaux polluées pour contracter une salmonellose; pour d'autres, des quantités beaucoup plus faibles suffiraient. Là encore interviennent des notions de virulence des germes, de terrains plus ou moins réceptifs à l'infection, qui compliquent singulièrement le problème.

En ce qui concerne les virus, les longues périodes d'incubation de ces maladies rendent difficiles de manière précise de montrer les relations de cause à effet entre des baignades en eau polluée et la maladie. Il est évidemment plus aisé de montrer cette relation dans le cas des affections cutanéo-muqueuses.

Ainsi, le milieu marin reçoit de manière constante d'importantes charges de micro-organismes dont certains sont hautement pathogènes.

Une grande partie des germes arrivant en milieu marin est rapidement détruite par l'action de divers facteurs non encore définis de manière précise mais certains micro-organismes s'adaptent au milieu et sont capables de s'y maintenir un certain temps en conservant leur pouvoir pathogène.

La survie est favorisée par la présence de matériels organiques dégradables.

Les données épidémiologiques actuelles ne permettent pas de rendre compte de manière précise les dangers présentés par les baignades en eau de mer polluée, exception faite pour certaines affections. La règle est cependant d'être vigilants eu égard à l'état de réceptivité accrue des citadins arrivant au bord de mer. Ceux-ci sont en général nettement plus sensibles aux actions des micro-organismes que les populations vivant sur place qui se sont progressivement immunisées dans des conditions d'hygiène moins bonnes. Cette règle très générale en pathologie infectieuse revêt ici une singulière importance.

Certains produits de la mer comme les bivalves, les oursins, consommés crus servent fréquemment d'intermédiaire dans la propagation des maladies hydriques. Ces animaux respirent et se nourrissent en effet en filtrant des quantités considérables d'eau de mer. Se faisant, ils retiennent les particules en suspension dans l'eau et, en particulier, les bactéries et les virus qui se concentrent ainsi dans l'animal.

Il a donc été nécessaire très progressivement en France de surveiller de très près les zones où sont exploités les coquillages vivants avant leur commercialisation. Il est possible dans certains cas de rendre sains des coquillages ayant vécu dans un milieu pollué par des méthodes d'épuration. Ce procédé, cependant, devient aléatoire quand la contamination est trop forte. En dépit de la surveillance exercée, surviennent chaque année des cas de maladies contractées par ingestion de coquillages pêchés clandestinement ou récoltés par des touristes dans des zones insalubres.

En conclusion, nous disons qu'on rencontre en mer des micro-organismes traditionnellement associés aux matières fécales. Parmi celles-ci, il en est qui sont pathogènes. Ils peuvent entraîner des épidémies, soit à la suite de baignades (affections oculaires, rhinopharyngées, cutanées, muqueuses), soit à la suite d'ingestions de coquillages crus qui les ont concentrés (typhoïde, choléra, hépatite infectieuse).

Il reste à déterminer avec exactitude la survie de ces organismes en mer, les chiffres donnés par les auteurs étant très différents. Il semble acquis que, si de nombreuses bactéries disparaissent, certaines peuvent prendre certaines formes de résistance et réacquérir leur pouvoir pathogène même après un assez long séjour dans l'eau de mer. Le facteur de disparition des bactéries en mer par absorption et sédimentation sur des matières en suspension, par dilution ou dispersion, du fait de la lumière solaire, de la température (la résistance étant renforcée à basse température), par la richesse en substances nutritives et par un possible pouvoir bactéricide de l'eau de mer reste à approfondir.

De même, il est certainement opportun d'affiner nos connaissances sur les données épidémiologiques concernant des affections très fréquemment rencontrées chez les baigneurs, les plongeurs et, en règle générale, chez les estivants des bords de mer.

3.4. EFFETS D'UNE POLLUTION PAR LES TOXIQUES DIVERS

Les phénomènes de toxicité pris en compte peuvent être directs mais momentanés, le toxique considéré étant dispersé ou détruit dans le milieu marin ou bien indirects lorsqu'un toxique rémanant s'accumule dans le milieu ou se concentre le long des chaînes trophiques. Parmi les produits étudiés en France, on peut citer :

— les détergents, dont la réglementation impose à l'heure actuelle en France la biodégrabilité à 80 %. Toutefois, la toxicité directe de tels produits peut rester appréciable dans certains cas. De plus, les composés phosphatés servant d'adjuvents principaux aux détergents, peuvent participer à l'eutrophisation d'un milieu fermé;

— les biocides dont les plus toxiques sont les organo-phosphorés.

Les organo-chlorés sont moins toxiques mais par contre plus stables (D.D.T.) Les polychlorodiphényles de formule voisine de celle du D.D.T. trouvent une grande variété d'utilisation dans l'industrie (solvants, plastifiants). Extrêmement toxiques, ils présentent une stabilité supérieure ou égale à celle du D.D.T.;

— les composés métalliques : certains sont toxiques de façon directe tels le cuivre ou le chrome hexavalent. D'autres sont encore plus dangereux, tels le mercure spécialement dans sa forme méthylée qui peut se concentrer au long des chaînes trophiques.

Citons enfin le cadmium, le plomb, le zinc, le nickel, le cobalt;

— les produits nucléaires.

Les détergents se divisent en trois grandes catégories suivant la polarité de la partie active de la molécule, détergents anioniques, cationiques, ou non-ioniques.

La nocivité des détergents est extrêmement variable et elle tient plus à leur formule qu'à leurs propriétés tensioactives.

Il peut arriver que les détergents biodégradables soient plus toxiques que les non biodégradables. En tout cas, leur durée dans le milieu aquatique est suffisant pour qu'ils aient une action s'ils sont employés en quantité notable. Il semble même que la nocivité des détergents soit relativement plus forte en eau de mer qu'en eau douce.

La toxicité des détergents a été étudiée principalement dans la classe des anioniques produits par synthèse à partir du pétrole.

Les effets nocifs des détergents sur le milieu marin ont pu être démontrés en milieu naturel du fait des déversements massifs qui avaient été faits lors de la catastrophe du « Torrey Canion ». Dans les zones littorales intéressées par ce naufrage, divers animaux benthiques ont été très affectés, les espèces subsistantes étaient rares. Du fait de l'absence de ces animaux, l'été suivant fut marqué par une croissance prodigieuse d'algues. Au large des côtes traitées, la faune profonde était touchée plus irrégulièrement. Les mollusques, les crustacés furent plus sensibles que les moules ou les huîtres. Cependant, les poissons adultes, d'une façon générale, échappèrent.

Les biocides sont, par définition, destructeurs de la vie. Les produits minéraux ou naturels anciennement utilisés sont aujourd'hui largement supplantés par des produits organiques de synthèse, notamment organo-chloré, ou organo-phosphoré.

Plus de 10.000 préparations biocides sont actuellement vendues en France.

Les services rendus par ces produits en agriculture sont considérables. Cependant, leur emploi extensif n'est pas sans danger; beaucoup sont en effet très stables chimiquement et sont entraînés par les eaux jusqu'à la mer. La question est de savoir si leur persistance dans le milieu est suffisante pour avoir un effet, soit directement par destruction des espèces marines, homologues de celles auxquels ils étaient destinés, soit indirectement par accumulation en passant d'un organisme à son prédateur jusqu'au consommateur humain.

Les composés métalliques. La toxicité générale de certains éléments comme le plomb est connue de longue date, mais on n'imaginait pas qu'elle pût jouer à l'échelle des océans. Il a fallu des accidents spectaculaires, notamment au Japon avec des composés organo-mercuriels pour qu'on prenne conscience du problème. Des recherches sur ce sujet, qui étaient très délicates, se développent maintenant rapidement par un appareillage de laboratoires convenable.

Si le milieu se trouve chargé en sels minéraux, les organismes végétaux et animaux en absorbent plus qu'ils n'en ont besoin, et cet excès peut devenir néfaste.

Il faut donc s'inquiéter de la pollution par les métaux ou par des éléments comme l'arsenic connus pour leurs effets toxiques, surtout de ceux qui forment des combinaisons organiques liposolubles qui pénètrent facilement dans l'organisme, s'y accumulent et par le transfert d'espèces à espèces facilitent l'extension de la zone d'effets très loin des sources de pollution.

Les substances nucléaires. L'étude de l'implantation à La Hague, dans la presqu'île du Cotentin d'une usine de traitement chimique de barreaux d'uranium irradié a posé à la France, pour la première fois, le problème du rejet d'effluents radioactifs en milieu marin. Une étude écologique de la zone des rejets a été entreprise. Les résultats de ces investigations ont permis d'évaluer dans une estimation provisoire l'ordre de grandeur des activités qu'il est possible d'évacuer en mer sans entraîner un risque quelconque pour les populations.

Les bases du contrôle à mettre en œuvre lors des premiers rejets ont été définies. Les résultats de ce contrôle permettent de vérifier les résultats des études dans les conditions réelles des rejets.

3.5. EFFETS DES POLLUTIONS THERMIQUES

Elles ne font qu'apparaître à l'heure actuelle et ne posent pas encore de problèmes en France. Rappelons qu'un rejet d'eau chaude peut appauvrir un milieu en oxygène et perturber certains échanges par formation d'une thermocline. Le développement prévisible de centrales thermiques de grande puissance en bordure de mer doit cependant inciter à la vigilance. L'écart moyen de température entre l'entrée et la sortie des condenseurs est souvent voisin de 7°. Les débits peuvent atteindre plusieurs dizaines de mètres cubes seconde, les rejets étant susceptibles d'élever sensiblement la température à l'extrémité de l'exutoire.

4.1. ACTIONS CONTRE LES REJETS D'HYDROCARBURES

De nombreux chiffres sont avancés actuellement sur l'importance des rejets d'hydrocarbures en haute mer. Ils ne concordent pas toujours du fait de la difficulté qu'il y a à contrôler et à estimer des rejets dont la plupart sont clandestins. Une fourchette de 1 à 10 millions de tonnes par an peut être retenue au niveau mondial.

La France s'est penchée plus particulièrement sur le problème de la *pollution de la Méditerranée par les hydrocarbures.*

Il est en effet possible, à partir d'études sur les possibilités de nettoyage au port de déchargement des citernes des navires, sur la conservation à bord des eaux de lest polluées en vue de leur déchargement à terre, sur les installations de réception du ballast sale à terre et sur le trafic maritime de pétrole brut, d'en déduire un certain nombre de conclusions intéressantes.

L'analyse des flux de transport, de la capacité des pipelines européens, des productions des pays méditerranéens, ainsi que l'analyse des capacités des pétroliers effectuant ces transports, qu'ils soient internes à la Méditerranée, ou qu'ils concernent un port de chargement ou de déchargement en Méditerranée, et un port extérieur, permet de connaître le nombre de voyages et son évolution dans le futur.

Il semble que ce nombre de voyages aura tendance à décroître, compte tenu du fait que le port en lourd moyen des navires augmentera plus vite que les quantités à transporter.

L'une des conclusions est qu'une application satisfaisante du procédé de lavage en mer (LOAD ON TOP) est impossible sur des navires d'autant moins grands qu'ils effectuent des trajets plus courts (de 600 à 1.400 milles marins selon les navires). Pour les navires effectuant des trajets courts, la seule autre possibilité réaliste à court terme est de confier leurs effluents à une station de réception située soit au port de déchargement, soit au port de chargement.

L'implantation des stations dans les ports de déchargement présente les inconvénients et avantages suivants :

— le navire perd un temps précieux après déchargement à se laver au port;
— le coût des terrains est plus élevé dans les zones portuaires des pays européens;
— par contre, au plan des avantages, il faut noter que le dimensionnement de la station est déterminé par le volume des eaux de lavage, donc relativement faible. La création de stations et leur exploitation sont en principe plus faciles en Europe.

L'implantation des stations dans les ports de chargement présente, évidemment, des caractéristiques inversées.

Le bilan économique global semble plus favorable aux stations dans les ports de chargement.

Compte tenu d'une pondération des trafics, on constate qu'actuellement, un tiers seulement des terminaux de chargement sont équipés. Au plan économique le rapport coût/efficacité d'une mesure consistant à équiper les ports de chargement de Méditerranée de stations d'épuration est particulièrement intéressant.

Il appartient aux Etats concernés, pays producteurs de pétrole et pays riverains de la Méditerranée, plus particulièrement intéressés à la défense de l'environnement, en particulier l'Espagne, la France, l'Italie et la Grèce, de donner éventuellement suite à ce projet.

Pour ce qui concerne la France, il faut noter que Marseille, port pétrolier considérable, dispose de moyens modernes et efficaces de déballastage, au voisinage de ses installations de déchargement du pétrole brut, et de dégazage au voisinage de ses outils de réparation.

Problème des accidents survenant à des navires transportant du pétrole en haute mer.

Dans le cas des déversements accidentels, il est nécessaire de faire des choix, car les quantités d'hydrocarbure en jeu nécessitent la mise en œuvre d'un matériel extrêmement important Partant du fait que l'intervention en mer coûte 5 à 10 fois moins cher que le nettoyage du rivage souillé et que la récupération d'une nappe, plus économique que sa dispersion, entraîne moins d'aléas sur le plan biologique, les efforts ont surtout porté en France sur la mise au point de systèmes de ramassage des produits pétroliers.

Le procédé consistant à créer une dépression à la surface de l'eau par une petite turbine à axe vertical, dépression au fond de laquelle l'épaisseur de la couche d'hydrocarbures est suffisamment importante pour permettre le pompage, dans de bonnes conditions, paraît le plus prometteur (BERTIN-CNEXO). Bien entendu, la mise en œuvre d'un tel procédé suppose la maintenance d'un matériel flottant convenable capable d'être transporté sur les lieux du sinistre dans les délais les plus brefs.

Cette approche suppose aussi la mise au point de barrage permettant de contenir une nappe, même dans des conditions d'agitation difficiles. Ce problème n'est pas encore parfaitement résolu.

A titre accessoire, on a constitué des stocks de produits dispersants, dont la toxicité et l'efficacité ont été soigneusement testées, en les répartissant judicieusement sur les côtes.

De même, de nombreux ports français disposent de stocks de barrages flottants destinés à protéger les points les plus sensibles du littoral en cas d'arrivée sur celui-ci d'une marée noire.

4.2. ACTION PAR LES TECHNIQUES DE L'ÉPURATION A TERRE

Les premières études et expériences menées ces dernières années conduisent à considérer que l'épuration en zone littorale doit présenter les caractéristiques particulières suivantes :

— un fort pouvoir d'arrêt vis-à-vis des bactéries et des parasites;

— un bon rendement en matière en suspension, celle-ci jouant un rôle important dans le transport des bactéries et parasites et pouvant compromettre certains équilibres écologiques;

— une bonne adaptabilité aux variations en charge, qu'elles soient saisonnières ou bien liées aux fins de semaines.

Le cas des effluents industriels mérite des études particulières menées cas par cas et les méthodes de traitement peuvent être différentes selon que ceux-ci sont rejetés en mer ou en rivière.

Les conseils suivants peuvent être suivis à titre provisoire :

— la simple dilacération est en tous les cas à proscrire;

— la chloration à dose suffisante reste le meilleur moyen d'avoir des effluents corrects sur le plan bactérien, sans que l'on puisse toutefois affirmer que les virus soient ainsi détruits. La chloration est d'autant plus aisée qu'il reste moins de matières organiques dans le milieu et elle devient aléatoire après un simple tamisage. Des doses prohibitives sont nécessaires pour une action efficace après une simple décantation.

Il est utile que les stations littorales disposent dans tous les cas de dispositifs de mesure et de moyens de contrôle plus élaborés que les stations continentales.

Le rejet à la mer des boues produites par les stations d'épuration ne devra s'effectuer qu'à titre exceptionnel et après un traitement approprié du type pasteurisation ou stérilisation.

L'efficacité d'une station peut être traduite par un rendement en « Matière en Suspension » et en « Demande Biologique en Oxygène ». Le rendement correspondant à la « Demande Chimique en Oxygène » est moins important que le premier ratio, car il suit ses variations tout en restant légèrement inférieur, tout au moins dans les stations traitant les effluents urbains.

4.3. ACTION PAR LES ÉMISSAIRES EN MER

L'endroit où sont envoyés les effluents mérite des études de détail sur les conditions de leur dispersion en mer. Plusieurs études ont ainsi été menées en différents points du littoral français (Bassin d'Arcachon, Bassin de Marennes-Oléron, Marseille).

Il s'agit d'acquérir une bonne connaissance des transports des masses d'eau dans différents cas de vents, houles et marées.

Ces études sont effectuées en France avec tout l'arsenal classique : études par traçage radioactif ou par colorants (Rhodamine B), mesures au point fixe au courantographe, suivi de flotteurs lestés, bilans entrée et sortie de masses d'eau, études sur modèle réduit physiques ou mathématiques, études de houles, études de marée.

C'est ainsi que l'implantation à LA HAGUE dans la presqu'île du Cotentin d'une usine de traitement chimique de barreaux d'uranium irradié, à laquelle il a déjà été fait allusion, a donné l'occasion d'entreprendre des recherches portant sur la dispersion du rejet et abordées par plusieurs techniques convergentes :

— analyse des données générales d'hydrographie marine et de courantographie;

— essais sur maquette, notamment sur modèle tournant recréant la force de Coriolis;

— essais *in situ* par lâchers de cartes et de flotteurs lestés. Ces études ont conduit au choix du lieu d'implantation de l'émissaire et à la définition des conditions horaires optimum des rejets. L'étude des facteurs hydrographiques a été complétée par une étude sédimentologique de la région envisagée du double point de vue descriptif et dynamique. On a pu, ainsi, déterminer l'ordre de grandeur des activités qu'il serait possible d'évacuer en mer sans entraîner un risque quelconque pour les populations.

4.4. ACTIONS PARTICULIÈRES CONCERNANT LES PORTS DE PLAISANCE

L'accroissement rapide de la flotte de plaisance au cours des dernières années a mis en lumière les problèmes de la pollution des ports de plaisance en France qui, jusqu'à ces derniers temps, ne semblaient pas présenter une acuité particulière. Ces pollutions peuvent être d'origine organique et bactérienne, ou par hydrocarbures ou même chimiques (action des détergents utilisés pour le lavage des bateaux).

La lutte contre la pollution a été entreprise à divers stades :

— le constructeur et l'exploitant du Port doivent mettre à la disposition de l'usager tous les moyens, notamment sanitaires, pour minimiser les risques de rejets directs;

— les constructeurs de bateaux se verront sans doute imposer à bord des installations adéquates.

4.5. ACTION PAR LA RECHERCHE SCIENTIFIQUE

La France dispose d'un ensemble de moyens en laboratoires de recherches scientifiques ou appliquées qui se penchent depuis plusieurs années sur les problèmes liés à la pollution marine.

Les moyens comme les préoccupations de ces laboratoires sont au départ assez hétérogènes.

Une certaine coordination a donc paru utile dans ce domaine. Elle est maintenant assurée par le CNEXO (1), Etablissement Public dépendant de l'Etat.

Le programme de recherche actuellement envisagé par cet Organisme permet de mieux orienter les différentes recherches fondamentales ou appliquées en cours

(1) Centre national pour l'exploitation des Océans — Paris 16e.

et de compléter certaines lacunes existantes, notamment sur les problèmes technologiques.

Les Organismes français qui font de la recherche en matière de pollution marine sont les suivants :

— I.S.T.P.M. (Institut scientifique et technique des Pêches Maritimes Nantes);
— Centre de recherches et d'études océanographiques;
— Laboratoire de microbiologie de l'Ecole Nationale de Médecine et de Pharmacie de Poitiers;
— La Direction des Ports Maritimes et des Voies Navigables;
— Le CERBOM (Centre d'Etudes et de Recherches de Biologie et d'océanographie médicale — Nice);
— Le Centre d'études et de recherches scientifiques de Biarritz;
— Le Centre de recherches du service de santé des Armées;
— Les Universités de Bordeaux, Lille, Lyon, Paris et Caen;
— La Station Marine d'Endoume;
— Le Muséum National d'Histoires Naturelles;
— Le Laboratoire National d'Hydraulique;
— Le Laboratoire Central d'Hydraulique de France.

Parmi les Organismes proches de la France qui font également de telles recherches, il convient de citer l'Institut Océanographique de Monaco.

Les recherches entreprises portent notamment sur les points suivants :

— aspect biologique et écologique des rejets;
— action des détergents;
— recherche en mer des biocides;
— influence de certains polluants sur des micro-écosystèmes isolés en milieu naturel;
— influence des pollutions radioactives sur des micro-écosystèmes en laboratoire;
— déplacement des nappes d'hydrocarbures;
— bactériologie, virologie, parasitologie, bactériologie, pollution chimique.

L'ensemble constitue une dizaine d'équipes d'importance variable groupant environ 40 chercheurs à temps plein.

On voit que ce qui caractérise la recherche entreprise dans le cadre de la lutte contre la pollution marine, est extrêmement varié et qu'il est impossible de lui tracer les frontières précises.

Il est vraisemblable que les moyens mis en œuvre se développeront comme les préoccupations des diverses parties intéressées par la pollution marine : Etat et collectivités locales; industriels, touristes, pêcheurs et usagers de la mer.

4.6. ACTION AU PLAN RÉGLEMENTAIRE

Dans ce domaine, il apparaît que la réglementation française visant la pollution de la mer est très complexe. Elle donne théoriquement à l'Administration le moyen d'intervenir contre la pollution de la mer, sous réserve d'y apporter certains compléments, notamment dans le domaine des immersions de déchets par bateaux et de la pollution due à la navigation commerciale ou de plaisance, ainsi que dans le domaine des rejets telluriques.

En vérité, des difficultés d'application apparaissent et il est frappant de constater que la réglementation visant la pollution de la mer reste hétérogène et ponctuelle. Notamment, s'il est apparu opportun de fixer des objectifs de qualité à la mer, il n'est pas apparu souhaitable dans l'immédiat de les formuler par voie réglementaire.

Contrairement aux mesures réglementaires visant la pollution des eaux douces, celles visant spécifiquement le milieu marin sont en général récentes : les plus anciennes sont celles qui précisément ne tiennent pas compte de la spécificité du milieu marin.

Dans la plupart des cas, les mesures réglementaires visant la pollution de la mer restent essentiellement répressives. Bien souvent, elles représentent la traduction sur le plan interne d'engagements internationaux.

Les mesures les plus importantes au plan réglementaire touchent les points suivants :

En ce qui concerne les pollutions pélagiques, seule prise en compte de manière spécifique la pollution par hydrocarbures qui a fait l'objet de la convention internationale de Londres de 1954 amendée en 1962 et 1969. La tenue d'un registre des hydrocarbures pour les bâtiments dont la jauge brute est inférieure à 500 tonneaux mais dont les éléments de propulsion sont supérieurs à 200 CV a été rendue obligatoire.

Une loi répressive a été prise fin 1964 pour lutter contre les pollutions volontaires par hydrocarbures. Elle s'applique aux bâtiments français comme aux bâtiments étrangers dans la mesure, bien sûr, où l'infraction a lieu dans les eaux territoriales françaises.

Une procédure spéciale de coordination et d'intervention administrative a été prévue dans le cas de pollution accidentelle provoquée par les hydrocarbures. Cette procédure est connue sous le nom de « PLAN POLMAR » (Plan « Pollution Maritime »).

Il reste à mettre en place une réglementation spécifique tendant à rendre obligatoire les dispositifs ainsi que le contrôle de leur usage soit à bord, soit à terre, capables de traiter les eaux de ballastage et de lavage des navires pétroliers.

En matière de pollution tellurique, les mesures prises par la France sont, sur le plan réglementaire, très nombreuses et on peut les classer selon trois principes. Tous rejets dans les milieux naturels doivent être soumis à une autorisation de l'Administration. Cette autorisation fixe les conditions dans lesquelles doit se réaliser le rejet. Si le rejet effectué dans les conditions fixées par l'autorisation cause un préjudice à des tiers, son auteur est susceptible d'être poursuivi par les Tribunaux et condamné à indemniser les préjudices subis. Enfin, certaines catégories de produits voient leur déversement interdit. Il s'agit notamment des hydrocarbures et plus récemment de produits détergents non biodégradables à 80 %. D'une manière générale, on doit considérer que le milieu marin récepteur est astreint au minimum aux mêmes règles que celles applicables aux eaux douces.

Dans les ports, des mesures réglementaires ont été prises depuis longtemps. Il s'agit de mesures traitant des précautions à prendre lors du nettoyage des cales des navires dans les ports, des textes interdisant le rejet dans les eaux des ports de toutes matières. Enfin, il faut souligner l'importance en France des Agences Financières de Bassin de création récente, qui ont pour mission de prélever une taxe sur les pollueurs, notamment en mer, et de financer ainsi des dispositifs d'épuration.

4.7. ACTION INTERNATIONALE

Il faut souligner dans ce domaine l'extrême disparité des initiatives prises par les Organismes internationaux. Leur nombre même rend toute coordination difficile ou inexistante.

Les accords internationaux existants sont axés pour la plupart sur la lutte contre la pollution par les hydrocarbures.

Une convention sur les rejets par navires de substances toxiques ou dangereuses applicable à l'Atlantique du Nord-Est est actuellement en cours d'adoption par les Etats concernés (Accord d'Oslo 1971).

Le caractère préventif de cette convention est encore insuffisamment développé et le contrôle de l'application des règlements existants est fort difficile.

Des accords régionaux ont été envisagés de façon à traiter tel ou tel aspect de la lutte contre la pollution marine dans un cadre plus étendu que celui d'un seul pays (Projet RAMOGE, projets de construction à plusieurs pays voisins d'un navire dépollueur destiné à agir efficacement lors d'accidents par hydrocarbures).

5. LA POLLUTION DES COTES EXIGE UNE ATTENTION ET UNE ACTION SUR TOUS LES PLANS

Les problèmes de pollution marine doivent être inspirés d'un triple objectif ; voir, comprendre, agir.

La difficulté du problème tient à un certain nombre d'éléments dont nous soulignons quelques-uns ci-après.

Il est d'abord difficile de savoir ce qui, dans une évolution du milieu, peut être considéré comme l'effet d'une pollution ou, au contraire, comme une évolution normale. Le suivi de cette évolution pose le problème du choix des indicateurs physico-chimiques ou biologiques, caractéristiques d'un état du milieu. A plus long terme, les phénomènes d'accumulation dans les chaînes biologiques de certains produits risquent de mettre en évidence des phénomènes masqués à court terme.

On est gêné par l'insuffisance de nos connaissances sur les corrélations existant entre les rejets et l'état du milieu. En fait, ces corrélations ne peuvent pas encore être établies de façon rationnelle et seules des approches partielles ont pu être tentées. C'est ainsi que la question du pouvoir antibiotique de la mer reste posée, beaucoup d'auteurs estimant qu'un tel pouvoir n'existe pas.

Il est également intéressant du point de vue médical de faire une approche épidémiologique des phénomènes de pollution.

En vérité, si une certaine sensibilisation aux phénomènes de pollution se produit, on peut penser que, peu à peu, les moyens de lutte deviendront plus efficaces et qu'ainsi le capital naturel considérable mais fragile que constitue la mer près des côtes pourra être préservé des agressions de l'homme.

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SUMMARY

On account of the length of its coastline, France is particularly attentive to the phenomena of marine pollution. Inventory of existing pollution, observation and control of this pollution, as well as scientific approach to the effect on environment caused by main polluting elements have led to concrete and national action, concerning hydrocarbons, through the technology of filtering plants, thanks to a policy of outlying marine outlets, through scientific research and finally at the administrative and regulation level.

Many other problems ought to be investigated further : a scientific study is necessary on correlation between refuse and environment, and between environment and its human consequences.

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PAPER

by

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CONTENTS :

1. INTRODUCTION

Water pollution should be construed as the sum total of causes of human origin whose resultant effects exercise direct or indirect influences in the various ways set out below :

— alteration in the ecology of the waters in such manner as to cause damage to flora and fauna, as well as to people,

— in the down-grading of the water's quality,

— on account of works carried out on and in the waters exercising an injurious effect and

— restricting opportunities of human recuperation.

This paper deals with measures, executed and planned, aimed at preventing and fighting pollution in harbours and coastal regions of the German Federal Republic.

Conditions obtaining in the North Sea differ from those in the Baltic. In the North Sea area the tide (tidal range 2.5 m to 3.8 m) and the relatively greater river discharges, the water's movement and turbulence are of considerable importance; as regards the Baltic the tidal influence is quite small with wind currents predominating. The main harbours in the North Sea area lie relatively deep inland, and for this reason consideration should be given to the pollution of the important tidal reaches of the rivers affording access to the harbours.

The very short mileage of the coast of the German Federal Republic having regard to the size of the population results in the intensive use made of the sea resorts as areas for recuperation. The estuaries, moreover, and the shallow coastal waters are actively fished.

The density of traffic in German coastal waters is extremely high.

The Report deals with pollution in harbours, approach channels and seas suffering from a variety of pollutants.

2. GROUPS OF POLLUTANTS AND THEIR EFFECTS ON INDIVIDUAL REGIONS

2.1. The origin of waste matter.

Waste matter reaches the waters in different ways. The waters are mainly polluted by :

Atmosphere			Biocides Radio-active substances Carbo-hydrates Products of combustion
Sea	Utilisation of the Sea-bed		Mineral Oil, Natural Gas, Minerals
Sea	Ships	Accidents	Oil and Oil dispersal contrivances Chemicals Containers and solid substances
Sea	Ships	Ships' movements	Oil and Oil and water mixtures Fecal matter Solid waste
Sea	Ships	Dumping	Industrial wastes Putrified Mud Munitions
Land		Indirectly due to Rain-Flush	Biocides Fertilisers
Land		Direct entry	Industrial used water Used domestic waters Detergents Radio-active substances Cooling waters

(according to GESAMP II/11 Paris 1970)

2.2. Effects and damage to the environment occurring in particular regions by the most important pollutants.

Many waste materials are the cause of damage which remains unnoticed for a considerable period of time. The effects of pollution are many and complex; their impact being delayed, it is quite a difficult matter to determine the particular causes of contamination with accuracy. Damage can arise owing to high concentrations of long duration of pollutants in organisms (delayed effects), but also, in part, by assimilation, following the release of smaller quantities of a second substance (trigger effects).

In the North Sea the currents mix the waters in such thorough fashion that the salt and oxygen contents are generally relatively in balance down to sea-bed level. The tides and especially the residual currents provide for the rapid dispersal of incoming dirty wastes. In view of the fact that storm surges can stir up the sea-bed down to depths of 60 m, the southern portion of the North Sea discloses layerings of wastes of small calibre mixed with and distributed among natural sediments.

In the Baltic the movement of the waters is mainly conditioned by winds, whose impact is mostly at surface level, hardly making any impression on the many deep hollows. Pronounced discontinuous strata occur, and in individual basins oxygen may be temporarily absent. Owing to the low degree of interchange of the waters with the ocean, the Baltic Sea is, therefore, particularly exposed to the threat of pollution.

In German harbours the standard of the quality of the waters is not solely conditioned by the inlets into the harbour areas, but also by the standards of quality of the rivers on which the harbours are sited, and the extent to which they are subject to the tide. The tidal rivers having their outlet into the North Sea are already heavily polluted in their middle courses, with the result that notwith standing a lengthy reach allowing for recovery, waste matter is often to be found, which is difficult to eliminate and whose presence obtrudes itself most unpleasantly in the lower reaches where the harbours are located — in so far as the latter are not closed off by lock-gates. In many areas, tidal action produces but a relatively slow exchange of the water masses. As a result, the same water mass is, on the one hand, subjected a number of times to inlets affording ingress of spoilt water. On the other hand, the turbulence of tidal action results in a better integration of the water's mix.

The polluted water masses in tidal harbours are usually attributable to three fundamentally different origins. They consist of the harbour town's own domestic spoilt water and the highly polluted (i.e. oil and salt laden) rain-water, collected by the road gutters, the industrial plants and factories with their used processing and cooling waters and to which there should be added shipping itself; the latter discharge spoilt domestic and cooling waters, but, in point of fact, the unauthorized discharge of oil and refuse is by far the most important factor.

The conditions in harbours with lock-gates are distinguishable by the limited boundaries of the water masses and the low degree of water exchanges. The resultant reduced level of polluted waters corresponds to a far-reaching restriction of all land inlets. Intensive supervisory measures should avert the danger which may principally arise as a result of the unauthorised inflow of pollutants — not least attributable to shipping.

Generally speaking, the available documentation does not provide a comprehensive picture respecting the degree of pollution. Not all the pollutants are included; in specific regions only is an evaluation forthcoming from the qualitative and quantitative aspects. An adequate well-organised and central supervisory control bearing on all manner of water-polluting substances is apparently absent.

Oil and Oil Dispersing Contrivances.

It is estimated that German coastal waters are exposed to an annual oil discharge of between 50,000 and 100,000 tons. The discharge emanates chiefly from small, hardly noticeable oil ducts of domestic and industrial origin. Taking the annual average, much less oil can be attributed to the occurrence of tanker accidents in coastal waters. In such cases, however, local effects with serious consequences are apt to arise.

In the access channels, oil pollution is very frequently encountered, though it may be comparatively restricted in scope, being generally of local importance only. The most frequent cases of oil pollution are due to unauthorised discharge from vessels.

Polluted waters emanating from industrial plants and factories — local circumstances excepted — consist mostly of oil-bearing waters, very largely mixed with harbour waters, and consequently diluted, so that the oil content emanating from this source lies within the permissible margins of present-day methods of investigation. Nevertheless, the actual pollution due to oil is considerable seeing that in a few 100,000 m^3 of spoilt waters per day there is an accrual of a few milligrammes of oil per m^3, which cannot be removed by rational methods and which, in fact, adds up to a considerable quantity.

Thereto should be added an important volume of oil, difficult to compute, which enters harbour waters, due to the disturbance of cleansing installations or in an unauthorised manner, but mainly from vessels. Harbour installations are, as a consequence, not only highly polluted, but, on account of the high concentration, the quality of the waters is subjected to a pronounced negative influence locally over a protracted period.

Escaped unrefined oil covers the water's surface with a film corresponding to $1.5 - 10 \times 10^{-4}$ mm. About a third of the unrefined oil consists of light components, which evaporate relatively promptly. The heavy components sink gradually. The sunken oil destroys the flora on the sea-bed and it is only gradually disintegrated by bacteria. The larvae of numerous animals are poisoned by carbohydrates, such as benzol, toluol, pentane, hexane and heptane.

Many thousands of sea-birds die every year on the German coast owing to oil pollution. Fishing tackle belonging to trawlers is often polluted, and the flavour of the fish can be unfavourably influenced by oil products, such as phenol and cresol. Pasture lands and the sea resorts on the coastline suffer from pollution. Numerous beaches of the German North Sea resorts are subject to oil pollution for many days of the year.

Carcinogenic sediments and organic substances have been traced, which may be due to the inflow of oil.

It has been further established that the use of oil dispersing contrivances is liable to be extremely damaging in its effects on the organisms.

Pesticides and Polychlorinated Biphenils (P.C.B.).

The use of chemicals for plant protection, aimed at the destruction of weeds and plant diseases, as well as against animal interference, has increased throughout the world : total annual consumption in the Federal Republic exceeds 50,000 tons.

The compounds used for countering the threat of damage to crops reach the waters or are carried by wind drift to the lakes and sea. An instance may be quoted where measurements have revealed that, comparatively speaking, considerable quantities reach the river Elbe originating from the large neighbouring orchards.

The menace of pesticides is quite pronounced on the Baltic. This is shown as the result of measurements of DDT contents found in seals captured there, and which are ten times greater than found in seals in the North Sea and the Atlantic. Most pesticides disintegrate very slowly only (DDT endures up to 30 years, Dieldrin up to 25 years).

In the food range of plankton — fish — birds and mammals respectively, pesticides are found to incorporate themselves. Investigation of North Sea organisms revealed that plankton contained an average 0.04 mg/kg, fish in coastal waters about 0.7 mg/kg, sea-birds virtually 3.5 mg/kg and seals 10 — 40 mg/kg of DDT (live weight). The fatty tissues of seals caught in the Baltic showed a DDT content of 300 mg/kg.

The enzyme system in the organisms, involving at the same time the production of sexual hormones, suffers disturbances. Moreover, the calcium metabolism in birds is so potently influenced by DDT, that, due to deficient chalk production, egg-shells are liable to break.

Laboratory tests have shown that in numerous animal groups tumorous growths with cancerous affinities occur which may be ascribed to DDT.

Along the coastal areas of the North and Baltic Seas, the reduction in many types of bird species, especially of sea-swallows and eider ducks, is attributed to poisoning by pesticides.

The International Health Authority states that a human being can absorb 0.010 mg of DDT for each kg of the body's weight without any deleterious effects. It would appear, therefore, that a high fish consumption by human beings living in our regions ought not to be the cause of danger.

It is known since 1966, that polychlorinated biphenils (PCB) have been used over the last 25 years on a large scale in the artsilk, electrical and dye industries and that, likewise, they become included in the food cycle. These polychlorinated biphenils enjoy a greater stability even than DDT, abiding not only in the fatty tissues, but lodging also in the nervous system and in the gonads. Numerous organisms in the Baltic and North Seas have a PCB content, which is frequently higher than DDT concentrations. The effects on the organisms are still far from having been thoroughly investigated.

It is assumed that the effects correspond to those of pesticides.

Heavy Metals.

The admission of even small quantities of heavy metal salts can increase concentration in the waters to a dangerous extent. The effluence of waters from certain industrial plants results in heavy metals entering approach channels, harbour waters and the German sections of the Baltic and North Seas. The contents in the harbours and approach reaches are very high in comparison with those in the high seas; the direct effects, however, ecologically speaking, in these waters have, so far, been noticed in isolated instances only. Numerous investigations have demonstrated that mercury, lead and cadmium and their alloys are especially deleterious.

In the German Federal Republic 775 tons of mercury are consumed annually. Of this quantity 60 tons reach the North Sea via the Rhine alone. As the result of the activity of micro-organisms the oxygen-starved areas (the mud of rivers, lakes and seas) are exposed to the transformation of the less dangerous mercury into the highly poisonous methylmercury.

The world's annual lead precipitation amounts to at least 500,000 tons. Since the introduction of tetra-ethyl lead as a petrol anti-knock additive for motor cars (1923), the lead content of the water surface of the seas has risen twenty times (0.4 $\mu g/l$).

Methylmercury and tetra-ethyl lead are stored in the brain and nervous system. Apart from effects on the nervous system, they are apt to cause grave genetic troubles.

Cadmium is already deleterious in a dilution of 0.6 $\mu g/l$.

It is stored in the body over a great length of time (mainly in the kidneys) before causing damage to the central nervous system, to the kidneys and to bone structure.

Following on in the danger sequence, zinc, copper and arsenic are encontered. These substances too are liable to enter the food cycle and result in heavy poisoning. Copper was found in oysters showing an increase of 7,500 times, zinc being present in organisms attaining a factor of 100,000.

The heavy metal contents in German waters were ascertained in isolated cases only. After the perils of methylmercury became known, fish in Federal

German waters were investigated for mercury content. It is generally less than 0.2 mg/kg (live weight) and therefore beneath the tolerated limit, regarded as harmful to human beings.

On the Baltic's Scandinavian coasts some areas had to be closed to fishing owing to high mercury concentrations in the organisms (up to 3 mg/kg).

Oxygen Consuming Matter.

Domestic, industrial and manufacturing effluents carry large quantities of nitrates and phosphates into the waters. And together with nutrient salts of nitrogenous and phosphoric fertilisers, which are washed out of the soil, they contribute to the growth of phyto-plankton and the higher aquatic plant-life. The disintegration of plant-life moreover reduces the available oxygen.

Insufficiently cleansed domestic effluents and those of particular sections of industry (e.g. paper-mills) containing organic residues need oxygen for their biological disintegration.

Uncleansed effluents can, moreover, owing to their contents be the cause of infectious diseases. Furthermore, the outbreak of epidemics may become possible via a chain-infection leading from animals (mussels, crabs) to human beings.

Large quantities of domestic sewage pour into the Baltic and North Seas. Some coastal areas and bights are polluted already.

Mud originating from communal sewage basins is carried aboard vessels as far as the lightship Elbe 1 and to the outer Flensburg bight, where it is dumped at the rate of 216,000 and 54,000 tons per annum respectively.

The river mouth funnels still meet the general requirements, on the assumption, that the oxygen content does not fall below 50 per cent of saturation point. Further upstream and in affluents, the incidence of pollution may occur temporarily. Domestic sewage, largely unpurified, is also discharged in harbour waters.

Inorganic Matter.

Large quantities of inorganic matter reach rivers, coastal waters and the open seas. Further quantities are carried by special vessels to be dumped at sea.

Special vessels of the undermentioned countries unloaded the following tonnages :

Belgium . . . . approx.	272,000
Great Britain	3,350,000
Netherlands	716,000
German Fed. Republic	653,000
Norway	184,000

Figures giving the discharge of waste matter direct into the sea are incomplete.

It is estimated that daily loads aggregating 20,000 tons are dumped into the North Sea by neighbouring countries, and which consist of industrial and domestic waste matter.

In addition, large quantities of industrial wastes are brought by rivers (Thames, Rhine, Elbe) to the North Sea. At the present time, several German institutes are engaged in computing the quantities reaching the North Sea from the Elbe, Weser and Ems rivers.

Lesser quantities of industrial waste find their way into the Baltic.

The inorganic wastes (heavy metals excepted) can be divided into three groups :

Salts, acids and alkalines, only slightly toxic, are neutralised by sea action and converted into harmless salt components, which are anyhow to be found in the sea. Owing to the sea-water's large cushioning capacity — according to present-day knowledge — it is able to absorb relatively large volumes of low toxic salts, acids and alkalines. On the other hand, the capacities of rivers to absorb acids and alkalines is very small. It is, in fact, feared that threats to health arise in the vicinity of such points of entry. This problem emerges, most insistently, within the present purview, owing to the erection of large new chemical works.

Toxic inorganic substances (e.g. fluorides and cyanides) must be very thoroughly diluted, so that their concentrations, having regard to tidal movements, attain but negligible proportions.

Insoluble solids, according to size and density, reach bottom more or less rapidly. In certain circumstances, e.g. during storms in shallow depths and in the case of strong currents they may be whirled up and displaced. As they occupy a certain area of the sea-bed, many organisms are thereby suffocated due to lack of oxygen. We were faced with this problem when investigating the disposal of red muddy aluminium residues resulting from the production of aluminium.

Solid Substances, including Packed Wastes.

Solid wastes, which are virtually insoluble, sink rapidly, as, for instance, scrap and motor car wrecks; such operations take place in areas which are not used for fishing, and even though a certain depth is attained for the safety of shipping, the operation is still looked upon askance. Synthetic materials should in no event be tolerated, seeing that they cannot be broken down, as for instance, when in the shape of flotsam foil, they obstruct the cooling systems of vessels and become entangled in the ship's propeller.

Numerous drums with waste material are illegally dumped in the Baltic and North Seas. Account should be taken of the fact that a container's life is limited, and even dangerous products, such as arsenic, chlorinated carbo-hydrates and cyanides are released into the open sea. Similarly, a great danger threatens in the Baltic owing to the dumping of poison-gas shells at the end of the war (tabun and mustard gas).

The pollution of access channels in certain areas by solid wastes is considerable; passenger vessels are regarded as being the main culprits.

Radio-Active Substances.

We are confronted with the incidence of fissile materials in many technical processes making their appearance in air and water. Legal provisions governing the normal running of a reactor in Germany allow for a small escape of radio-active particles only.

As a result of biological concentrations, released radio-active particles, though of greatly reduced strength, are prone to re-concentrate again. It is for this reason that in Germany the contamination of the waters and of the living organisms therein form the subject of continual observation.

Thermal Burdening by Cooling Water.

In the winning of energy, as well as in the production of the most varied necessities, heat is developed and is reduced by means of water. The effects on marine organisms in the North Sea have not yet been observed.

In German access channels, the shedding of thermal loads is of hardly any significance on account of the need for obtaining prior approval. In the case of inflows into the tidal area, attention should however be drawn to the fact that they become subject to a rise in level and that seaward evacuation of the warmed waters will be retarded. This drawback is further enhanced where the upland water flows are small.

Usually, cooling waters constitute the greater proportion of the entire waste water flow; in Hamburg, for instance, it is in the ratio of 1.5 million m^3 to 2.5 million m^3 daily. The thermal disturbance can be the cause of fog and can, as a consequence, exercise harmful effects on harbour shipping.

The ensuing reduction in ice formation must, however, be regarded as an advantage. The danger occasioned owing to cross-currents constitutes a navigational hindrance occurring at important points of ingress and egress of the waters. It can, however, be circumvented by an appropriate shaping of the structures.

2.3. **Summarised review of prevailing pollution.**

The conclusion has been reached, that conditions now prevailing, especially in certain spheres, give rise to situations harmful in essence, though causing, by and large, little preoccupation.

At times, however, intolerable pollutions of limited scope have been noticed.

Attention should, nevertheless, be promptly drawn (vide also 4.1), to the fact that the unpredictable trend pointing towards pollution of wider scope in these waters calls for the adoption of additional measures.

3. EXISTING REGULATIONS

3 1. For the prevention and reduction of pollution of harbours and coasts.

3.1.1. *Statutory Regulations.*

In the German Federal Republic measures for the prevention of and reduction in the pollution of harbours, approach channels and coasts, are based on laws edicted by the Federal and Land Governments respectively. Far-reaching regulations for the maintenance of the waters in a clean state are foreseen, not only in the basic provisions of the Federal legislation, but also in the local legislation, promulgated by the coastal Land Governments, i.e. Bremen, Hamburg, Lower Saxony and Schleswig-Holstein.

Legal intervention in the case of shipping, aimed at the avoidance of dangers, are foreseen in a number of laws and police regulations. It remains to be defined, in each instance, under which statute proceedings should be instituted against the pollutant.

Attention is drawn to the following shortcomings :

a) difficulties often arise in practice for securing conviction of the guilty party,

b) penalties and fines have, so far, been mostly so slight, that their deterrent effect has been of little avail,

c) instructions issued by the water boards are inadequate for the prevention of dangerous occurrences. Instructions contained in Hamburg's water laws are the only ones where the requirements are more far-reaching.

d) The view held, that only the country whose flag the vessel is flying could prosecute in cases of pollution on the high seas amounts to an antiquated interpretation of the freedom of the seas. This attitude should not be supported by the German Federal Republic which is threatened, in large measure, by such pollution.

The federal structure of the German Federal Republic requires a specially close joint effort between the Federal government, the Land governments and communal and harbour authorities. In this connection a number of procedures have been evolved whose effects partly remain to be proved.

To sum up, attention should be drawn to the various international agreements, which have since been accorded force of law in the German Federal Courts.

Special mention should be made also of the agreement governing joint action for combating oil pollution in the North Sea.

3.1.2. *Supervision of Pollution (Control, Notification, Warning).*

Routine control of pollution has, so far, taken place in certain areas only. All waters are, however, tested for radioactivity. The check on sea-water for other deleterious impurities engages the full-time attention of the Deutsches Hydrographisches Institut in Hamburg. Severe pollutions are generally reported by observers (shipping, private individuals, supervisory authorities) direct to the police, who warn the public and any other users, as necessary.

A special regulation has been introduced in the case of oil pollution, in accordance with the agreement quoted under 3.1.1 of this paper, between the countries whose coasts are washed by the North Sea.

Oil pollutions, generally observed by shipping and aircraft, are reported to a central post, the permanently manned radar control centre of the WSA Cuxhaven. In case of need, this post takes steps to carry out a cross-check, outlines the observations made and works out the rate of drift.

In the case of the more extensive pollutions of the waters and of the coast, the areas threatened are warned and a specially appointed group of experts, provided by the Federal Government and by the coastal Lands, then decide on any remedial measures warranted by the circumstances.

3.1.3. *Technical Measures.*

Technical measures for preventing and reducing industrial pollution, domestic sewage, as well as in the course of a vessel's discharge, call, where necessary, for the imposition of the prescribed methods of procedure on these polluters.

Dangers arising from the movement of shipping are the subject of measures edicted at international and national levels for improving traffic safety and that of the vessels themselves.

These measures consist in :

- separate traffic lanes, above all in congested areas (e.g. the German Bight and the Kiel access channel).
- a continuation in the improvements in signalling along the traffic lanes,
- the seaward extension of existing land radar services on the Elbe and Weser, as well as the establishment of such facilities in the Jade basin and on the river Ems,
- facilities for traffic direction, especially for vessels carrying dangerous cargoes and those apt to endanger the waters,
- provision of the best possible equipment for all trading vessels in the matter of navigational aids and means of communication,

— improved education of captains and pilots concerned with sailing large tankers,
— the introduction of constructional improvements, especially in the case of tankers, e.g. the limitation in size of the individual tanks.

Having regard to tanker accidents, the paramount factor, where vessels run aground, is to prevent their breaking up and, in any event, promptly to pump as much oil as possible from the damaged vessel into barges. Police regulations foresee that the ship's master shall ensure that adequate tug facilities are summoned without delay. Yet another measure is concerned with the introduction of a system whereby the unloading of cargo oil into barges on the high seas can take place safely and easily even in the frequent bad weather.

3.2.1. *Statutory Regulations Governing Occurrences of Pollution.*

Within German territorial waters the following legislation and by-laws have been enacted, reference to which has been made in this paper under 3.1.1.

Oil afloat on the water's surface is ownerless and free from interference by any governmental authority. The fight against oil flows in international waters is, however, often not the concern of one state only; neighbouring countries too may fall victims of the pollution. The active co-operation of several governments then becomes necessary. It is for this reason, and due to German initiative, that the conclusion of an « Agreement for Joint Endeavour in Fighting Oil Pollution in the North Sea » came into being between all the countries with a North Sea coastline. It contains the obligation of mutual notification regarding reported oil slicks involving the national oil-fighting organisations, and the adoption of new fighting measures obliging the partners, moreover, to reciprocal aid.

3.2.2. *Technical Measures in Occurrences of Pollution.*

Until recently measures for combating oil pollution consisted of suggestions and elementary equipment only. In isolated cases, recourse was had to salvage so as to render harmless other dangerous poisonous substances discharged into the sea (such as war material, packed fluorised carbo-hydrates).

In the fight against oil pollution the Federal Authorities and those of the Länder along the coast of the German Federal Republic have created oil accident commissions Sea/Coast which have worked out technical and organisational proposals.

The attitude adopted towards existing means and methods for combating oil pollution is as follows :

a) The emulsifying and dispersal, as well as the burning of the oil on the water is possible only under conditions specifically laid down.

b) The insertion of floating oil-binding elements cannot be envisaged on the high seas on economic and practical technological grounds; it is recommendable in quiet and restricted waters.

c) The submerging of oil in conditions obtaining with us (shallow waters throughout) cannot be entertained.

d) All measures consisting in the oil's mechanical removal from the water's surface are specially recommended. Similar suggestions have been put forward by the commission for the procurement and development of such systems.

4. PROPOSALS RESPECTING FUTURE MEASURES

4.1. Future evolution of pollution.

Assuming the further development of sea traffic and industrialisation, experience and statistics all point to a corresponding increase of pollution in harbour areas. This eventuality calls pressingly for an accurate knowledge of all polluting factors, not only qualitatively but quantitatively, which the foreseeable future has in store and thus demands a higher priority for environmental conservation than has been vouchsafed to date.

German economic growth over the next years is estimated at 40-45 per cent. The chemical industry will be expanding at a much higher rate than other industrial sectors. The volume of spoilt domestic waters will increase in similar proportions. On the basis of these estimates the quantity of waste matter will rise from 5 to 10 per cent annually, measured by the present output of waste matter.

Present-day industrial Germany is developing a trend towards the erection of industrial plants in the vicinity of the coast, in order to benefit from better communications and to facilitate the disposal of waste materials, extracted from duly purified used water (salts), at sea rather than in overloaded rivers.

The works, in respect of which plans are being drawn, consist mostly of metal plants (steel, aluminium, zinc), oil refineries and chemicals. The aluminium works, in course of erection, anticipate having to dispose of some 7 million tons of residues consisting of red muddy aluminium residues (mainly iron oxide). A zinc works at the mouth of the river Weser proposes to dump annually 100,000 tons of mud residues containing 2 per cent of zinc and 0.12 per cent of lead.

The Netherlands proposed to dispose of industrial waste waters of high organic content into the mouth of the river Ems. It was only as a result of a strong protest lodged by the German Federal Government that purification of the waters to the extent of 85 per cent was secured. This will still leave a spoilt water delivery equivalent to a domestic sewage outflow of 3.5 million inhabitants.

In order to meet the growing demand for power, plans for nuclear power stations are presently being drawn up. It is now anticipated that deliveries of riverborne fissional and corrosive wastes, aggregating some 30 Ci per annum are likely to reach the North Sea. Every power station will probably shed much increased quantities of tritium which is most difficult to control. For the time being, the quantity cannot be estimated (outflows via the river Ems amounted to 32 Ci in 1970).

The rapid increase in power requirements involves a corresponding need of water for cooling purposes. In view of the fact that narrow margins are foreseen where river-water is concerned, increasing recourse is had to sea-water for such purposes. It is anticipated that oil consumption will double every ten years. As a result of the rise in consumption, means of transportation will be increased and thus the share to be borne by the large tanker and the pipe-lines will grow in like manner.

4.2. Aims for the respective conservation and improvement of the environment.

The entry of waste materials in the waters cannot, as a general rule, be avoided. It should be the aim, however, to contrive for the concentration and technical entry of the waste materials to be so governed that care of health and the aesthetic aspects are not neglected in favour of the interests of the economy and the short-sighted ends of social progress. It should be held as a principle that works « producing » waste material should in all decisions affecting development, extension, choice of location and manufacturing program consult with the appropriate experts on the environment.

A number of problems await a solution on the way to these objectives. It involves a thorough analysis of the situation, and a computation of the incidence of pollution of the waters by the inflow of harmful wastes and, in connection therewith, the definition of threshold values beyond which acceptance of such wastes cannot be tolerated. As regards the analysis of the situation and of the definition of the load potential of pollutants to be borne by the waters, the following investigatory programs have been elaborated :

— ascertainment of the spread in the concentration of deleterious matter in the waters and on the water-beds, as well as clarification of the biological and physico-chemical processes of concentration,

— computation of the quantities of deleterious wastes reaching the waters annually,

— determination of the horizontal and vertical transportation of such matter under various conditions of the current,

— analysis of the lethal and sub-lethal concentrations on the organisms in the waters and investigation of the effects of incoming harmful matter on the ecology,

— analysis of the dissolution and possibilities of disintegration of deleterious matter.

For the purpose of completing an inventory of the actual concentrations of harmful matter, as well as tracing the alteration and computation of the annual rates of growth, a measuring system is advocated which will keep a running record of the presence of the principal deleterious substances. The development, standardisation and automation of the analytical and measuring methods constitute important postulates in the installation of such a supervisory system of control.

Where the entry of deleterious matter is proposed, it follows that the chemical and mineralogical composition of the waste material should be predetermined, as also its concentration and the rates of inflow per unit of time. The physical characteristics (solubility, density), the bio-chemical properties (oxygen consumption and production of nutrients), besides the viruses and bacteria content must be cross-checked. The reactions and changes in the biological sphere (toxicity, concentration, disintegration) and the chemical reciprocal actions with other soluble organic and inorganic substances should be known.

In the choice of the location of entry, apart from overall economic aspects and the distance from the coast, the location of the fish and their breeding-grounds, as well as the hydrological parameter and the climatic effects should be regarded as decisive.

Furthermore, attention should be drawn to the fact that the introduction of waste should not result in damage being caused to other water users. Factors, such as the lowering of the water's quality, needed for industrial purposes, the prejudice caused to shipping and fishing, besides corrosion of the structures should be taken into account. For this reason, public enterprise and industrial undertakings are compelled, in increasing measure, to resort to action in the purification of spoilt waters of industrial and domestic origins. Industry should be concerned with the developments of new techniques, thanks to which, waste matter would be re-employed in a production process.

When all these factors and processes have been settled, the conditions governing the inflow can be formulated and a generally approved threshold of values can be laid down in respect of the allowable concentrations of deleterious matter. The determination of the volume potential of deleterious matter in water remains, above all, a matter for investigation. At present, our knowledge of the physical, chemical and biological processes in water, in relation to the inflow of deleterious matter remains obscured by a series of unknown factors.

In order to establish a complete inventory of the existing concentrations of deleterious matter, as well as the investigation of the variation and estimation in the annual rates of increase, the creation of a supervisory and warning system is a necessity and the proportions of the main deleterious substances should be subject to uninterrupted recording. An important and general function in this sphere consists in the development, standardisation and automation of the methods of measurement and analysis.

4.3. Statutory regulations.

As stated already, the preparations for the prevention and for the fighting of oil pollution in the German seas and coastal areas have made relatively good progress, although the legal background covering the joint working of the Federal and Land Authorities is still lacking. It is now a question of extending these measures, so as to include the other harmful pollutions. This is of particular importance, seeing that the danger exists and that pronounced tendencies are emerging in the economic and industrial sectors to dump waste materials on the high seas, while the inner and coastal waters are legally protected.

It is recommended :

— to establish a register for the purpose of recording all the names of the creators of the spoilt waters with the latter's characteristics,

— to prohibit the direct inflow of certain heavy metals, pesticides and fluorised carbo-hydrate substances into the sea,

— to tighten the requirements of communal and industrial cleansing centres, aimed at a reduction in deliveries of heavy metals, pesticides, fluorised carbohydrates and toxic inorganic matter, and for zones to be established in which dumping of ship's waste is forbidden.

It is further recommended to work towards a general prohibition of the decanting of mineral oil and other carbo-hydrates.

International or regional conventions are also urgently needed in connection with the feasibility or prohibition of dumping of industrial wastes at sea; their disposal in large quantities has hitherto been described as only « slightly harmful » (red muddy aluminium residues, ash, salts, acids and alkalines).

Furthermore, in so far as appropriate regulations do not exist, a legal basis should be found to ensure control of vessels, even on the high seas, and for agreements to be reached, whose scope is both regional and international, to provide for the creation and working of supervisory and warning systems.

4.4. Technical measures.

For preference, technical measures should be divided into prevention, early warning and the elimination of water pollution.

The measures for the prevention of pollution are generally directed at the creator, necessitating enactments for their entry into effect. There are, of course, administrative difficulties of a technical nature in the application of such legal prescriptions, i.e. the defining of the spheres of effective validity, besides policing to ensure compliance. In this connection, it may be assumed that, where pollutions are currently concerned (e.g. in the case of spoilt water inflows), in the event of periodic pollutions (e.g. in the case of dumping and of spraying of industrial wastes), or again in fortuitous cases (e.g. the overflow of tanks and vents), legislation would be needed to make compulsory the enforcement of technical preventive measures. In this connection, special measures were enacted in Germany, or are in course of preparation, or are being worked out; Chapters 3 and 4 of this paper have dealt with the subject.

Vessels carrying dangerous cargoes, as well as those whose cargo is of a perilous nature where water pollution is concerned, may, owing to such regulations and directions, be affected in a twofold manner.

The technical traffic aspect points to an increase in the safety measures consisting in a better marking of the traffic channels, in the removal of dangerous wrecks, in the development of the land radar system and other navigational aids, in the separation of the traffic lanes near to the coast, as also, where necessary, by introduction of traffic directional regulations.

From the technical shipbuilding angle, protection from pollution can be increased, so that, on the one hand, tougher constructional elements may be foreseen, e.g. by the introduction of double walls and floors, improved sectional isolating partitions, based on the IMCO proposal, special rapid closing gear for all cargo hatches and other points of egress, and, on the other hand, by fitting the vessels with improved equipment for increasing manœuvrability.

Despite all safety measures, pollution of the hydrosphere is still likely to occur, particularly in the case of accidents. In such events — and obviously also in cases of pollution of another kind — an important prerequisite for effective intervention depends on an early awareness and appraisal of the danger, especially when the original structure of the harmful substance is still retained and the dispersion stage can be delayed. This aim is, however, difficult of achievement. In the case of pollutions, currently controlled, the degree of technical progress, thanks to the intervention of the human element and that of an automated manœuvrable system, the nature and degree of pollution can be ascertained. In this sphere a routine program of supervision is already in being. The area of operation remains to be extended and increasingly concentrated.

In the event of unpredictable pollution, possibilities of detection are reduced, owing to a lack of means in identifying all types of pollution one from another in an expeditious and simple manner; apart from visual detection, procedures mostly involve time-consuming costly testing and analyses. In addition, the controlled area is too extensive to be able to spread an observation net which is sufficiently closely knit on terms regarded as financially bearable.

This means that, for the time being, pollution can be ascertained solely by successful regular visual control, as is the case already where oil pollution and that of solid substances are concerned. The human element alone remains paramount for detection for a long time to come, seeing that, in existing circumstances, no other control can be exercised satisfactorily. The human element has vessels and aircraft as means of transport, besides additional detection equipment.

In association with the « Integrated Global Ocean System » (IGOSS) plans have been drawn up for the static and movable stations near the coast and on the high seas to be equipped with sensors and monitors, so that they may thus form an integral part of the observation net.

Technical methods for combating sea pollution, with few exceptions, remain restricted to mineral oils and solid substances, for the time being and in as much as they remain afloat retaining a cohesive structure. Other harmful matters, such as pesticides, heavy and semi-heavy metals, organic and inorganic matter and radio-active substances hardly lend themselves to elimination, once dissolved.

For this reason, the Federal Government has so far limited its endeavours to planning and working in the fight where oil pollution is concerned. In the fight against oil pollution reliance should, for the present, be placed on mechanical equipment, seeing that physical and chemical interventions no more than provoke a modification of the carbo-hydrates, which, to some extent, will therefore create polluting elements of their own.

As regards the foreseeable future, the groups of harmful substances require to be fought with new means and methods; the experience acquired in combating oil pollution can, however, be applied throughout towards the elimination of various kinds of harmful substances, particularly the following :

— means of detecting, identifying and fighting harmful substances, especially pesticides, carbo-hydrates, toxides, heavy and semi-heavy metals, radio-active substances etc.,
— development and procurement of equipment for the identification of oil pollution from the air in periods of low visibility,
— development and procurement of equipment for determining and identifying pollution of other kinds, even at greater sea depths,
— development, standardisation and preparedness in the fighting methods, appliances and means, especially the development and procurement of floating filtering-plants, scooping and dispersal contrivances, barriers, agglutinating agents, emulsifiers, etc.

These developments are valid for all harmful substances. Pending their realisation, and subsequently too, the most effective cure certainly consists in prevention.

5. CRITICAL VIEW

Despite warnings by scientists and technicians, engaged in the problem of environmental pollution and conversant with the threatening dangers, they have, as yet, not succeeded in bringing home an awareness of the situation to the world at large. The public should be made to appreciate that, due to the rise in living standards, pollution of the environment is on the increase, and that expenditure for cleansing operations is no less likely to increase proportionately.

The unbridled effects of unimpeded pollution, according to the latest survey, are first likely to arise in 50 or 70 years' time. It will then certainly be too late to overcome the damage which will have occurred.

The federal structure of the German Federal Republic and politico-economical interests will find themselves in conflict by reason of the irksome need for recognition and implementation of defined threshold limits, called for by plans governing load possibilities. Regulations at national level should also take account of international interests, seeing that harbours may be in national and international competition with one another. One should, therefore, not assume that laws or regulations, likely to favour one or other of the competitors, unwittingly or otherwise, would be accepted without demur.

RÉSUMÉ

L'augmentation de la population et l'amélioration du niveau de vie — qui vont de pair avec une industrialisation croissante et une densité de trafic en progression — ont pour effet d'apporter au milieu naturel où vit l'homme des modifications d'un caractère nuisible. Ces modifications affectent particulièrement les rivières, les canaux, les ports, les voies d'accès et la zone côtière avoisinante.

Tout comme dans d'autres pays, il existe, en République fédérale d'Allemagne, des lois et des règlements ayant pour objet de parer à une augmentation de la pollution. D'importantes études effectuées par les pouvoirs publics, par des instituts universitaires, etc... portent sur la nature, les effets des divers toxiques et sur la lutte pouvant éventuellement être menée contre eux.

Dans le présent travail, il sera tout d'abord pris position, en partant d'une définition de la pollution, sur l'origine et sur les effets des produits toxiques, cette prise de position revêtant un caractère général. Ensuite, une description sera faite des inconvénients causés actuellement par les principaux produits toxiques dans les ports, les voies d'accès et les zones côtières. Nous constatons que, dans certaines régions, la situation actuelle révèle l'existence d'inconvénients particulièrement préjudiciables; néanmoins, si on l'analyse globalement, elle n'est pas encore préoccupante. On observe toutefois, par endroits, des pollutions intolérables.

L'unique possibilité d'améliorer, avec succès, la situation actuelle ou de maintenir cette dernière, est de procéder, dans les diverses circonscriptions, à des analyses de situation, tout en dressant des plans fixant les limites de pollution. Le réseau d'observation à mettre sur pied à cet effet existe à l'échelon régional; il faut l'étendre et le rendre plus dense.

Le rapport portera ensuite sur la discussion des règlements existants ayant pour objet d'empêcher et de réduire les pollutions. Le contrôle du respect des dispositions légales suscite des difficultés.

En se basant sur l'évolution future présumée de la pollution et sur l'ampleur qu'elle prendra, le rapport propose des mesures de contrôle de la pollution des eaux, des dispositions juridiques plus vastes et des moyens de lutte d'ordre technique. Ces derniers sont propres à empêcher une aggravation des dommages causés. Ils se basent principalement sur le fait que, dans un proche avenir, une lutte efficace contre la pollution ne pourra être engagée que par des mesures préventives car, à l'heure actuelle, à quelques exceptions près, on ne dispose pas de moyens de lutte et de méthodes pleinement efficaces, à effet direct. Le devoir du législateur est d'encourager lesdites mesures.

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PAPER

by

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INTRODUCTION

The term « marine pollution » is defined as « introduction by man of substances into the marine environment resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water and reduction of amenities ».

Pollution knows no boundaries and is a pressing problem of the world to-day caused by indiscriminate release of wastes in air, water and land. Release of untreated waste into seas, rivers, lakes, estuaries, harbour waters and coastal areas (the traditional recipients) is an important aspect of the pollution problem. Coastal and ocean pollution occurs when deliberately or accidentally a significant quantity of an undesirable alien substance or pollutant is released into these waters.

The pollution problem has to be solved taking into due consideration the fundamental economical needs of a developing country. On the one hand there is every need for the Society to exploit the available resources and facilities offered by nature in order to produce the necessities for its development and prosperity. On the other hand there is also necessity to ensure that man does not pollute the environment as to make impossible the vital activities such as transportation, food produce, recreation and industry which depend on the enviromnent. Apart from the Mariners, the Fishermen, the Harbour Authorities, the Ecologists, Statesmen and the Governments through out the world are concerned about the problem of pollution.

Man is dependant on air, water and food from his environment (an average human being can live without food and water for five days but only five minutes without air and it is estimated that he requires 2.8 pounds of food, 4.5 pounds of water but 30 pounds of air daily). He is the worst culprit in polluting these resources to the point of no return. In India, since independence, we have advanced technologically in many respects. Our industrial production in every sphere has considerably increased. Green revolutions are causing water pollution due to overflow of excess fertilizers and pesticides. Huge public and private enterprises, while promising unprecedented economic possibilities to the Nation are causing air and water pollution with all kinds of latest synthetic chemicals and also radio-active materials. Coal, diesel oil and other fossil fuels are polluting the environment with sulphurdioxide. Synthetic chemicals like plastic are adding to the problems of solid wastes disposal while new detergents that cannot be decomposed by micro organism are polluting our rivers, streams, harbour areas and coastal waters. Though pollution has not posed a serious problem to India, the bitter lessons learned by the affluent developed nations must be grasped in all their implications so that control measures can be taken well in advance instead of remedial measures when pollution actually materialises.

Pollution was not a problem in the early stages of civilization since the space to man ratio was high. The exodus of working class population to urban areas has resulted in uncontrolled and unplanned development of human settlements creating complicated problems leading to unhygienic condition and insanitation leading to pollution.

The problems created by pollution in harbours and coastal waters are many sided. Its solution involves a close knit local organisation accommodating many conflicting interests capable of applying various approaches to the localised problems to be solved in accordance with the geographical, ecological, economic and health factors. The complexity of the pollution problems demands organised and individual, public and private, national and international collaboration. In devising and instituting legislative measures, the philosophy of « the scientifically possible, the technically feasible and the commercially tolerable » must be given utmost consideration respecting the national and international interests.

The problem of pollution at harbour areas and coastal waters can be widely divided into the following three categories.

I. *Oil Pollution.*

(*a*) At sea.
(*b*) Coastal areas and Harbours.

II. *General Pollution.*

(*a*) Pollution by solid wastes.
(*b*) Pollution by liquid wastes.
(*c*) Pollution by sewage.
(*d*) Pollution by gaseous wastes.
(*e*) Pollution by weightless wastes (Radio-active material, etc.).

III. *Miscellaneous.*

(*a*) Dumping of dredged materials.
(*b*) Interaction of salt and fresh water.
(*c*) Pollution by soil erosion, river diversion and water withdrawal.
(*d*) Pollution caused by weeds.

I. OIL POLLUTION

a) Oil pollution at sea

All over the world, more and more people are taking to sea for pleasure and business. All of them are bound to meet traces of oil pollution which is universal. But when a whole area of the beach is covered with an evil looking sticky black ribbon of oil and dead birds land up on the beach, local authorities, fishermen, holiday makers and luxury hotel owners are put to severe hardships. The situation is worse in and around major harbour areas, oil terminals and main tanker routes.

In modern times, with the phenomenal growth of the oil industry, tanker traffic at sea has increased and the problem of oil pollution has become serious. The philosophy is « to keep the oil in places where it is intended to be ». Once the oil gets in the wrong place it is liable to catch fire and if the fire reaches the source it may result in disastrous conflagration.

There are two categories of oil, viz. « Persistent » and « Non-persistent » oils. Persistent oils discharged into the sea usually spread on the surface of thin films so that a small quantity can quickly cover a very wide area in relation to its volume (it has been calculated that within ten minutes one cubic metre of Middle East crude oil can spread to form a circle 48 m in diameter). Volatile elements quickly evaporate after discharge. Evaporation takes place 25 to 30% in two to three days and the remaining oil becomes more and more viscous due to the decrease in volatile components and the rate of spreading also reduces considerably. Due to the sea and wave conditions some emulsification takes place in oil and in the sea water. As the slick spreads out, the chemical and biological action results in the increase of the water content to 70 to 80% and finally a gel-like mass, the unwelcome « Chocolate Mousse » is formed. On reaching the shore, the « Chocolate Mousse » will pick up sand and debris and the water evaporates resulting in waxy lumps, very difficult to disperse, and which are a familiar feature of the polluted beaches.

Non-persistent oil such as petrol are highly volatile and evaporate quickly leaving practically no residue behind. The main problem of oil pollution at sea is caused by persistent oils which include crude oil transported in bulk by tankers for refining and heavy fuel, diesel and other lubricating oils used in the engines of modern ships.

There are no hard and fast rule of dealing with major oil spills at sea. Though there are certain accepted formulæ like limiting the amount of oil spill and containing them and cleaning up, the most appropriate action to take in any particular case will largely depend on the specific circumstances of the accidents, its location and resources of the country involved.

There are two main categories of pollution of oil at sea.

(*a*) Pollution resulting from accidents like collision and grounding.

(*b*) Pollution arising from the deliberate discharging of oil into the sea in contravention of the international conventions.

Major Oil Pollutions Accidents

Sl No.	Date	Name of vessel	Nationality	Location	Cause	Approximate oil spills in tons
1.	March 1967	Torrey Canyon	British	Scilly Island	Collision	20,000 Tons
2.	March 1968	General Colocotrones	Greek	Eleuthen Island Atlantic	Grounding	3,000 Tons
3.	June 1968	Ocean Eagle	Liberian	San Juan Harbour Port Area Puerto Rico	Grounding	
4.	January 1969	Oil Rig	American	Santa Barbara South California	Oil rig fire	500-1,000 barrels a day for 129 days
5.	April 1969	Hamilton Trader	British	Liverpool Bay	Collision	900 Tons

The lessons of the major oil pollution incidents of the world is worthy of introspection so that future remedial action can be evolved from the mistakes of the past. The public consciousness of oil pollution was roused by the «Torrey Canyon» disaster in March 1967, an unfortunate incident resulting in the largest known oil spills in world history. Later, significant oil spills due to ship and off shore drilling casualties helped to highlight the oil pollution problem on a global scale attracting the immediate attention of the Nations of the World.

Oil pollution at sea is closely interrelated with the pollution of Harbour waterways and coastal areas and it is of utmost concern to the Government, Local Authorities and Harbour Officials.

The general conclusions from the above are as follows :

(*a*) Speed of action is the most essential factor as it will be much easier to tackle a compact slick. If the oil is left untreated, the harder becomes the slick due to evaporation leaving a viscous gummy slick which is difficult to deal with.

(*b*) Aerial reconnaissance to be supplemented by reports from all vessels in the vicinity of the slick regarding the thickness, type and state of oil and also estimated drift of the slick.

(*c*) In view of the speed of the slick it is necessary that early warning and communications are essential to deal with oil pollution under a unified central authority who will make a swift appraisal of the best techniques to be adopted for a given crisis.

(*d*) An alert is essential to the Harbour and local authorities of coastal areas to stand by for necessary action in the event of the oil slick spreading to the coastal areas.

(*e*) The available chemicals (Penetrating agents, emulsifiers and dispersants) must be used the right way and in time under an unquestioned overall authority.

(At the time of the « Torrey Canyon » and Liberian tanker « Ocean Eagle » grounding it is reported too many types of chemicals were used by too many inexperienced firms. It is even reported some excited people even dumped unopen drums in the oil slick).

A variety of mechanical devices have been developed to contain and dispose off oil, like log booms or fabricated inflated booms to ring the oil spills. Once contained, the floating oil is retrieved by many contraptions of recent development applying the principle of skimming, wiping and sucking of the oil. Whatever the system used — be it burning, absorption, sinking or even leaving it to natural forces, it is important to note that the removal of oil must be accomplished before it pollutes the beaches and harms the marine life.

(Burning a tankers' cargo « in situ » must be a last desperate resort after all attempts to salvage the ship and cargo have failed. In 1966 in Persian Gulf, the tanker « British Crown » which had loaded about 25,000 tons of crude was on fire. She was towed two miles off the berth and allowed to burn out. After a period of two months it was noted that 12,000 tons of oil was unburnt and was transferred into another vessel).

The « International Conventions for the prevention of oil pollution of the sea by oil » in 1954 as amended in 1962 with certain exceptions prohibits the discharge of « Oil and oily mixtures into the sea ». The International Conventions present a great force and Nations which are partners to the conventions must discharge their obligations seriously and enforce regulations at national and international levels. In spite of all conventions there are some tanker operators who do not abide by the rules and cause oil pollution breaking the law. It should be the duty of ships plying in the oceans as well as air craft to report all unlawful actions of ships and tankers who discharge oil into the seas and cause oil pollution which has become a veritable global menace.

Fortunately India has had no oil pollution cases at sea or on the coastal areas. As the tanker traffic has increased considerably and the major ports are handling crude oil and product tankers, a plan of action has to be envisaged so that remedial measures can be taken in the event of any emergency. This has to be given due consideration in the light of the fact that on 4th August 1970 Panamanian Tanker M.T. Ampuria with 15,000 tons of furnace oil grounded on the South Sourashtra coast near Porbunder Port and there was every chance of a major oil pollution. Fortunately the superb efforts of the Indian Navy saved the situation for the country and the oil was transferred safely.

A suggested plan of action for India is as follows :

A Central Pollution Control Organisation to be based at Bombay and in addition each major Port in India to have its own local Pollution Control Units and the local Unit is to work in close liaison with the Industry, State Government, Central Government and Navy. The history of all routine spillages and action taken by the local units to be recorded and a proforma to be submitted to the Central Organisation. Appropriate and adequate stock of chemicals and equipment are to be stored and trained personnel available for an emergency in any Port of India. The Central Organisation to keep in close touch with world organisations and give the benefit of the advanced techniques to the local units.

Assuming that there is a major oil pollution about 50-60 miles off Port of Cochin, the following is the expected procedure to be followed on receipt of the wireless message from the ship indicating the extent and nature of the oil pollution.

(*a*) The Pollution Control Unit at Cochin to establish immediate contact with the vessel and Central Pollution Control Unit.

(*b*) Arrange reconnaissance with the help of the Naval aircraft at Cochin and also arrange reports from all ships in the vicinity.

(*c*) If there was a collision between a tanker and another vessel, arrangements of salvage of the vessel in consultation with the masters of the vessel.

(*d*) Containing the oil slick by available chemicals with the aid of tugs, fishing crafts and other available suitable crafts.

(*e*) It may also be advisable to divert hopper dredgers fully loaded with sand so that the oil can be sunk before it reaches the coast. As large seaworthy hopper dredgers with good speed are generally available in the Harbour areas they can be diverted with full load of sand to the oil polluted area. (More recently Royal Dutch-Shell have carried out experiments on sinking oil at sea using a mixture of treated sand in water, to produce an approximately 10% sand in water slurry, it is proposed that the treatment to be carried out on board a hopper dredger which would thus be available both to procure its own dredged sand to treat it and then by a relatively simple modification to spread it over the sea.)

(*f*) Warning to be issued to all coastal areas to mobilise manual and mechanical arrangements to fight the pollution if it reaches the beach. (Saw dust, sand, bales of straw and less toxic chemicals to be ready).

b) **Oil pollution on the coastal areas and Harbours**

Oil is almost bound to arrive at the beach sometime after a spill at sea. The action of repeated tides, the sun and the ultra violet rays and the oxygen from the air combine fairly rapidly to remove oil from the ordinary beach surface. A single heavy application of crude oil has little permanent effect on either the flora or fauna of the intertidal zone, but chronic pollution rapidly produces deterioration resulting in the extinction of many marine species.

The problem of dealing with oil pollution close or near to the coast is to reduce the effects of pollution at minimum cost. On an unfrequented coast the cheapest thing is to do nothing and leave it for the tidal action to clear the mess. If oil threatens a pleasure beach, the removal of the oil as expeditiously as possible must receive the highest priority. Consideration must be given on each occasion to the position of the oil slick in relation to the use made of the threatened coast by holiday makers, proximity to fishing grounds and harbours.

Oil is a definite pollutant in Harbour areas and coastal waters because of the historic relationship between ships and oily discharges. Every precaution must be taken to ensure that oil and oily products do not escape so as to give rise to pollution and fire hazards. The pipelines connecting the ship to the Refinery storage tanks and storage tanks to distribution centres must be defined, built, operated and maintained so that escape of oil is avoided at all times. The age old definition of a successful pipeline as one which does not leak, still holds good. The pipeline technology has progressed immensely and the probability of leakages has been reduced to the barest minimum.

An accident is an unexpected event and cannot be totally eliminated, but if an accident occurs, necessary remedial measures of arresting pollution to be taken with the maximum speed and with the available resources at hand. Indigenous resources like straw, saw dust, sand and the use of fishing nets and booms to contain the oil should be resorted to in the initial stages. Manual removal, mechanical removal, ignition, emulsification, absorption and sinking of oil to be employed according to the gravity and necessity of the situation.

The oil pollution problem in developing countries like India may not appear to have such great significance as those in advanced industrial countries although industrial advancement is bound to increase, sooner or later the potential risk which must be borne in mind. The law which governs oil pollution Acts of Port waters and riverine areas must be strictly enforced. The oil pollution cases in Major Ports of India are dealt with under the regulations of the Indian Port's Act Section 21, Sub-Section (1), (2) and (3).

« 21. *Improperly discharging ballast.*

(1) No ballast or rubbish, and no other thing likely to form a blank or shoal or to be detrimental to navigation, shall, without lawful excuse, be cast or thrown into any such Port or into or upon any place on shore from which the same is liable to be washed into any such Port, either by ordinary or high tides, or by storms or land-floods (and no oil or water mixed with oil shall be discharged in or into any such Port, to which any rules made under clause (ee) of sub-section (1) of Section 6 apply, otherwise than in accordance with such rules.

(2) Any person who by himself or another so casts or throws any ballast or rubbish or any such other thing (or so discharges any oil or water mixed with oil), and the Master of any vessel from which the same is so cast (thrown or discharged), shall be punishable with fine which may extend to five hundred

rupees, and shall pay any reasonable expenses which may be incurred in removing the same.

(3) If, after receiving notice from the Conservator of the Port to desist from so casting or throwing any ballast or rubbish or such other thing (or from so discharging any oil or water mixed with oil), any Master continues so to cast (throw or discharge the same), he shall also be liable to simple imprisonment for a term which may extend to two months. »

Vigilant patrol and immediate detection of pollution cases will assist to minimise minor pollution cases. Apart from legislative and administrative measures, both the oil and water industries as well as water resource authorities and other interested parties must jointly strive to ensure that oil pollution is eliminated. The need to keep oil and water apart is mandatary to water resource development and utilisation. The problem is one of education which can be achieved by a rational approach and understanding of the relevant problems, by the application of precautionary measures, by the maintenance of high standards, by programmes or research and by education of all concerned, especially the user.

OIL POLLUTION CASES AT COCHIN

1. Fire at South Jetty Exchange Pit on 23-2-1967 due to Naphtha spill.
2. Pollution of crude oil by Tanker « Covenas » on 30-1-1971 at North Tanker Berth, Cochin Port Trust.
3. Oil Pollution at Tourist Resort Kovalam (Trivandrum) — January 1971.
4. Pollution of Kerosene oil by Tanker « Atys » — 28-2-1971 South Tanker Berth.

1. *Fire at South Jetty Exchange Pit on 23-2-1967 due to Naphtha Spill*

At about 19.30 hours on February 23, 1967, a fire was observed to have originated about 100 ft. towards the south of the Tanker berth South jetty exchange pit in the Ernakulan channel. In a matter of seconds the fire proceeded towards the south jetty exchange pit all the time burning on the water. The fire continued to burn along the retaining wall and also at the outlet opening of the sump of the exchange pit. Some portion of exposed insulation of some of the pipelines inside the pit also started smouldering. Before any damage could be caused, the fire was efficiently extinguished by the City Fire Brigade and the Port Trust Fire Brigade with available chemical and mechanical foam. The fire on the water rose to a height of 15 to 20 ft. while it lasted. On seeing the magnitude of the fire the tanker « Confidence » loading furnace oil at South Tanker berth and the crude oil discharging tanker « Master Michael » at North Tanker Berth stopped all operations. Luckily the property damaged was practically negligible.

During the enquiry it was revealed that the source of ignition started about 100 ft. south of the exchange pit in the open channel. At the time the fire commenced there was a boat near the point where the fire originated. It can therefore be presumed that the boatman trying to light a cigarette has caused the ignition. Judging from the way the fire started and propagated it can be reasonably assumed that the product floating on the sea was of low flash like gasoline or naphtha. A little while before the fire occurred the spectacle blind S8 at valve PV16 was removed and it was understood that the outlet from the sump into the sea was only partially covered. Stringent measures for preventing such recurrence of spillage and consequential fires were taken and up-to-date there was no further incident.

2. *Pollution of Crude oil by Tanker « Covenas » at North Tanker Berth, Cochin Port Trust, on 30-1-1971*

The Motor Tanker « Covenas », flying Colombia Flag, of 5,996 Net tons loaded approximately 16,094 M/Tonnes Iranian Light Crude oil at Kharg Island and arrived at Cochin on 29-1-1971. She was berthed at North Tanker berth, Cochin Port. While discharging crude oil in bulk to Cochin Refineries sprung a leak in forward tanks polluting backwaters of Cochin between 13.00 hours and 15.30 hours on 30th January. Immediate action was taken to transfer oil from forward tanks and to expedite pumping to Refineries and also pumped salt water to help oil float on surface arresting pollution. All possible precautions were taken and fire float and Port launches were directed to churn oily water as best as possible. The exact quantity of crude oil discharged in backwaters could not be estimated but it was believed to be about 50 Tons. Action was initiated against Master of Tanker under Section 21 (2) of Indian Ports Act 1908.

A spot enquiry was conducted on the ship as well as later in the Office of the Deputy Conservator and the cost of about Rs.15,000,— was debited to the ship on account of the oil pollution cost. As the Captain admitted the fault and since it was an act of God and all possible steps were taken as quickly as possible, no prosecution was conducted.

3. *Oil Pollution at Tourist Resort, Kovalam*

The National Tourist Resort at Kovalam, Trivandrum was reported to be affected by oil pollution and on 24-1-1971 as soon as the Cochin Port was apprised on the pollution the following measures were taken.

(i) A wireless warning from Cochin Port Authority was issued to all ships. « National Tourist Resort at Kovalam, Trivandrum, being spoiled due to oil pollution. All ships passing West Coast are requested to conform strictly with the International Convention for the prevention of the pollution of the sea by oil. »

(ii) The Indian Navy was requested to promulgate the above signal in their W.I.G. broadcast and also Notices to Mariners were issued in the above context.

(iii) Letters were addressed to the Director of Fisheries, Trivandrum with copy to the State Port Officer, Trivandrum and Asst. Director of Fisheries, Quilon, with a view to alert all fishing crafts regarding the spillage of oil and also to report of sighting of oil slick.

As Kovalam is situated in the close proximity of the direct international tanker route, it is quite likely that some tanker has infringed the international convention of the prevention of pollution of sea by oil by cleaning the tanks and pumping out the same into the sea on her way to the loading terminal. In spite of international conventions and agreements some irresponsible tankers do break the law and the reported oil pollution on the beaches of Kovalam is a typical example.

On 5th February 1971, the Chairman, Cochin Port Trust and the Chairman of Tourist Corporation along with the Deputy Conservator, Cochin Port Trust, visited Kovalam beach and inspected the oil polluted areas. A careful examination was made of the immediate vicinity of the beach which was of a concave shape, ideal for receiving the oil dumped in the proximity and deposited on the beach by the sea and the swell. The Chairman of the Tourist Corporation mentioned that pollution happens once in a way which confirms the fact that the reported oil pollution is due to the stray case of a passing tanker cleaning tanks off Trivandrum. The authorities were advised to resort to the manual cleaning of the area and the samples of sand mixed with solidified oil were collected from the Kovalam beach and send for analysis to the Cochin Refineries, Cochin. The Cochin Refinery Authorities analysed the sample and intimated that the pollution was likely due to crude oil.

4. *Pollution of Kerosene oil by Tanker « Atys » on 28-2-1971*

At 22.00 hours on 28th February, Fire Officer, Cochin Port Trust reported of a slight leakage of superior kerosene oil from tanker « Atys » berthed at Tanker berth. The leakage was reported to be under control and the Fire Float was ordered for patrolling in the Ernakulam channel in the vicinity of the tanker berth and also to work her propellers to disperse the oil as fast as possible.

At 09.30 hours on 1st March a report was received from the Navy that there was fire on the foreshore near the Naval area and two fire engines were despatched from the Cochin Port and since it was reported to be a major fire, Mattancherry, Ernakulam and Fort Cochin Fire Units were also alerted. At 10.00 hours the Deputy Conservator visited the spot and the Chief Staff Officer, Indian Navy was also present. It was noticed that the entire area fringing on the naval foreshores was covered with a thin film of kerosene oil and the fire was ranging to a height of 60-100 feet.

The following action was taken.

(1) The fire was allowed to extinguish on its own so as to burn away as much oil as possible without endangering the surrounding area.

(2) Navy was requested to cover their areas with their fire brigades and security guards.

(3) The Fire Brigade of Cochin Port was instructed to cover Ernakulam Wharf Berths and Embarkation jetty of Willingdon Island.

(4) Fire Float was to stand by at rail road bridge ready to use foam in case of fire.

(5) All possible launches were to be diverted for patrolling in the back waters on the Ernakulam side with sand, saw dust, etc. to be used, if necessary.

(6) The Commissioner of Police was contacted to guard railroad bridge and stop all vehicles passing that way and to instruct them not to smoke and throw cigarettes in the backwaters.

(7) Navy was requested to send the helicopter to find out the extent of the leakage of oil and intimate any sighting of smoke/fire.

(8) The Port Signal Station, Willingdon Island was alerted to keep a very keen look out until further orders.

(9) The Traffic Manager was contacted to instruct all ships on both wharves to be careful about smoking and throwing away cigarette butts in the backwaters.

(10) Ernakulam and Mattancherry Police and Fire Brigade to standby for any emergencies of fire anywhere in the backwater area.

(11) The District Collector was contacted and a message of the emergency was conveyed to him.

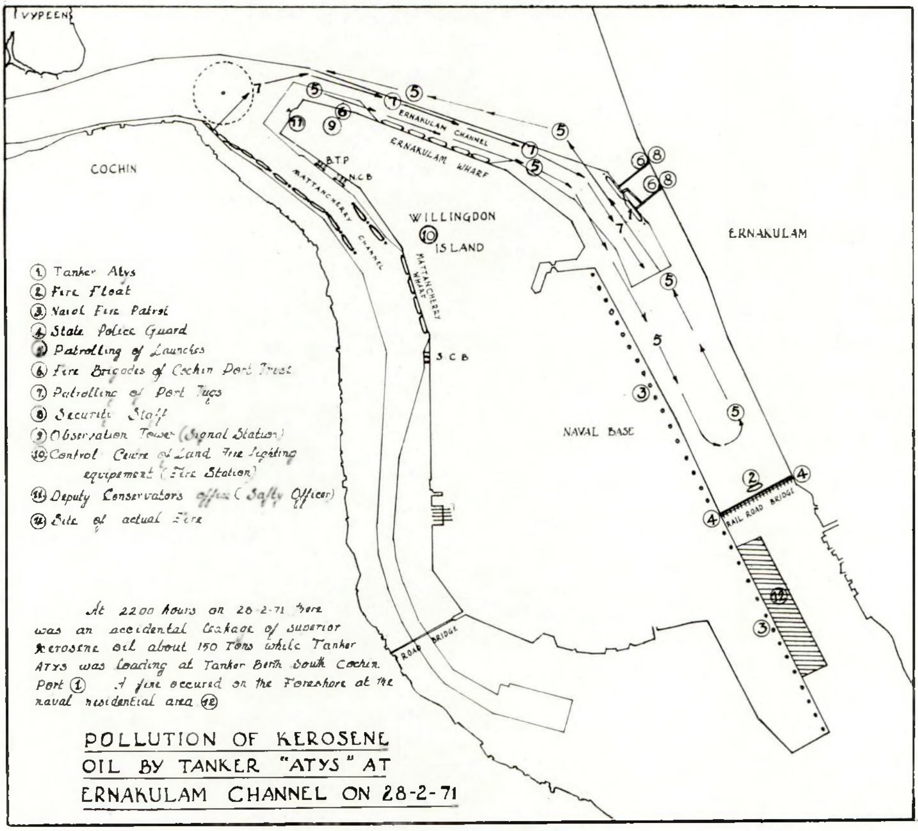
(12) Tug « Shaktan » was instructed to patrol Ernakulam backwaters by using loud hailers for warning and alerting ferry boats and other crafts.

(13) Security Officer specially instructed to order security staff in tanker berths to exercise utmost vigilance regarding passing crafts in and around the tanker berths.

(14) One fire engine and personnel at Ernakulam ferry jetty to warn all ferry-boats and passengers and to cope up with any fire in the Port premises of the backwaters.

On 1st P.M. an enquiry into the incident of oil pollution was conducted by the Deputy Conservator and the statement of the Master was recorded. The Master admitted that the incident occurred due to error in not closing the sea valves properly and apologised for the act of omission. He was however issued a notice that action will be taken under Section 21 (2) of the Indian Ports Act and all reasonable expenses incurred by the users of the backwaters be charged to his Agents. The Indian Oil Corporation personnel and also the Agents of the vessel were heard and their statements on the incident were recorded. They were instructed to exercise stringent precautions in future. The Port Fire Brigade and the Security personnel on the Wharf were also likewise instructed. It was estimated that about 150 to 200 tons of kerosene oil had been spilt in the backwaters.

The emergency was called off at 6 P.M. on 3-3-1971 after a personal inspection was made of the backwaters and satisfied that the oil spilt was not likely to be of any hazard. All concerned were alerted to safeguard against future pollution cases and there is no recurrence of the above nature.



POLLUTION OF KEROSENE OIL BY TANKER "ATYS" AT ERNAKULAM CHANNEL ON 28-2-71

II. GENERAL POLLUTION

The general pollution in coast and harbour areas can be divided into :

(1) Pollution by solid wastes.

(2) Pollution by liquid wastes.

(3) Pollution by sewage.

(4) Pollution by gaseous wastes.

(5) Pollution by « weightless wastes » like radio active pollution.

The rivers and the coastal waters of a Harbour area have traditionally been the final receptacle of many of man's numerous waste materials. Sewage, chemicals, garbage and other pollutants are carried to the sea through the connecting water ways from Municipal, industrial and agricultural sources or dumped directly by barges and pipelines. The sea also has been used to dispose of radio active wastes and toxic acids and other chemical substances. Industrial liquid waste is a prominent source of pollution in the coastal regions. Agricultural pollutants from land run, all animal waste, pesticides and fertilisers add to the volume of waste which pollutes the harbour mouth areas and coastal waters.

(1) **Solid Waste.**

Solid waste constitutes a number of materials which are both domestic and industrial. Domestic waste may be garbage from the kitchen, rubbish of all sorts of materials like broken glasses, plates and plastic materials, etc. and also leaves, grass and plant cuttings from the gardens. The domestic waste which contains garbage, litter or rubbish is commonly dumped into the river. It is estimated that an average city dweller in advanced countries produces more than half ton of garbage per year. It is reported that the Bombay Municipal Corporation removes more than 2,000 tons of garbage every day. The combustible materials like leaves, paper and other matters can be burnt at high temperature in incinerators. In this process though the solid waste is being converted into gaseous waste causing air pollution, it can be properly controlled and managed. Another method is composting the organic materials thus converting them from waste to fertilisers that can be used to advantage. Non-combustible materials like ash, rubbish, tins, glass pieces and broken plates, etc. can be disposed of by land fill method in low lying areas and solid waste material from industries can also be similarly treated.

(2) **Liquid Waste.**

Man obtains fresh water from the well known hydrological cycle naturally operated from the surface water or from ground. Surface run off gathers impurities, both mineral and organic as it flows through the rivers down to the sea. Under normal conditions the river takes care of many polluting substances that enter its regime of flow.

Pollutants act on marine plants and accumulates in a number of ways. A high concentration of certain toxic materials discharged in any water body can result in a massive initial mortality. Traces of toxic wastes in which may be found raw chemicals, insecticides and heavy metals like mercury might be assimilated by microscopic aquatic plants. These plants are basic source of food for all animals in the sea especially clams, prawns, oysters and shrimps. Tainted fish consumed by human beings eventually affect life in a number of cases.

At an International Conference in London on the biological effects of pollution in the sea a novel method of pressing a hollow needle into the breast of a sea bird — which does not harm the living animal — provided a valuable clue to scientists to assess the quantity of Pollutants absorbed by the bird concentrated in the fat of the breast.

Minimata village in Japan had a fertiliser plant for many years. In 1949 it started manufacture of vinyl chloride (a base material for production of plastics) using mercury catalyst. The production of vinyl chloride which was only 60 tons in 1949 went up to 18,000 tons in 1959. From 1953 onwards many Japanese villagers living near Minimata Bay showed neurological disorders. It was suspected that the villagers suffered because of eating fish and oysters from the Bay which had accumulated mercury from the plant effluences. The disease took an epidemic form in Japan. Some died while many others suffered for life.

Few pollution stories have received so much publicity as the « red » herring fish kills in Long Harbour, Placentia Bay, Newfoundland. In May 1966 large numbers of herring were dying on the beaches with their heads and fins tinted a brilliant red, and cod were said to be skittering blindly across the surface of the water before sinking to the bottom to die. Scientists from the Fisheries Research Board of Canada under the direction of Dr. D.R. Idler played a significant role in the investigations which proved that elemental phosphorus emanating from the plant of the firm of the Electric Reduction Company of Canada Ltd. was responsible for the fish kills. After implementing the recommendations of the Research Board the plants started functioning and the waters of Long Harbour are still being monitored and Phosphorus analysis carried out on fish from Long Harbour and Placentia Bay, to ensure that there is no trace of phosphorus in the tissues of the fish.

The major worry in India is about water pollution. It is reported that in Benares on the banks of river Gunga about 3,000 gallons of sewage are discharged into the sacred Gunga river every day in addition to industrial wastes and water of unknown sources. Scores of people died in the northwest part of India in 1968 by drinking polluted water of the sacred river Gunga where indiscriminate refinery waste was discharged which was realised only when a long stretch of river caught fire. This catapulted national attention and resulted in the appointment of a commission. Since then water pollution prevention Boards prescribing safety standards was adopted by several states.

The rivers of India have become virtual sinks for depositing sewage and waste. In Hooghly river there are about 100 Industries discharging waste into the river.

Another serious problem is the tendency of some pollutants to deplete the dissolved oxygen in coastal and oceanic areas. Oxygen supports marine and aquatic life and is also necessary to the biological degradation of organic materials. Much of the World's oxygen perhaps 50 to 90% is produced by marine plants and threat to their health from any pollutant would gradually threaten the earth's oxygen supply.

Many harmful compounds have often been used in the preparation of pesticides, herbicides, seed preservatives, etc. Pesticides used in India namely, D.D.T., Aldrin and Dieldrins, etc. eventually find way in our public streams and rivers along with fertiliser salts.

If the problems of waste release are taken good care of at the design and planning stage by the right choice of site, process and outfall, the wastes can be released safely and useful byproducts can be recovered from them. Thus one could also make pollution work the other way round. The sea also has a great capacity to assimilate wastes due to its large volume and rapid mixing. By diluting the wastes, so that its micro-organisms can break down the organic constituents, it provides an efficient means of waste disposal. But optimum use of the sea for waste disposal for municipalities, power and chemical plants, requires careful management of local environment and understanding of its transport, diffusion and biological degradation. Domestic sewage, with deliberate additions of certain elements or organic compounds, can be used to produce naturally balanced fertilisers for the marine environment; and pollution can be used to actually increase productivity. Obviously, this would require scientific research, efficient management and precise controls.

(3) **Sewage Pollution.**

Pollution by domestic sewage may cause serious oxygen depletion in estuaries, land-locked bays and coastal waters. It can render shell fish unsafe to eat without prior purification and also limit the use of bathing beaches and thus reduce amenities. Methods of treating sewage are well known but the impediment is the high cost of the modernising and expanding the existing plant, installing new outfalls and providing treatment where it is either non-existent or inadequate. The high cost of treatment and the scarcity of land in the right place has compelled to the adoption of long sea outfalls sited so as to enable to carry the polluting materials away from the shore.

In a thickly populated country like ours with overcrowed cities and harbours, having inadequate facilities for sewage treatment, sewage contamination of the water resources becomes a great problem. It is reported that there are 600 towns which have open drains and 80 towns and Cities with complete or partial sewage system. Estimated total volume is about 30,000 million litres per day. In Bombay the World Bank Team recently conducted a study by their consultants, Messrs. Binnie and Partners. Bombay received about 220 million gallons of water daily confronting her with the problem of disposal of about 200 million gallons of sewage per day. Out of the 170 million gallons of sewage received daily at different treatment works, about 72 million gallons were discharged into the sea after giving it a primary treatment. The remaining 98 million gallons of untreated sewage is being discharged into the sea either directly or through the creek. About 30 million gallons of sewage mainly from the unsewered areas of the suburbs and extended suburbs is also released into the sea with or without septic tank treatment.

The disposal systems in the country are mainly by discharges of treated sewage effluent and use of dry sludge as fertiliser and discharge of raw sewage into the nearest coastal waters, river or stream. The estuarine disposals present a slightly different problem in as much as the indirect utilisation of sea water was involved. Most domestic sewage is mixed with wastes from local industries and direct sea discharge may lead to the inclusion of highly toxic and persistent wastes at concentrations which could not be accepted in sewage treatment works. The continued discharge of nutrients in sewage and the phosphate added by detergents may lead to oxygen depletion in the enclosed bays and coastal waters.

Sewage, industrial wastes, as well as organic pollutants when dumped into an enclosed body of water, will put an immediate demand on the oxygen content of water. If sewage were introduced oxygen supply might well be reduced to a point at which many organisms could not live. In 1972 January thousands of dead sardines lay rotting round the parts of Bombay City's coastline. The stench was more terrible than the sight. The sardines had come a long way from the waters off Kerala carried by ocean currents. These fish breed only in pollution-free waters and need a lot of dissolved oxygen in the water to survive. They died when they entered the bay waters around the city which happen to be the repository of the city's sewage. When the bay water was analysed, it was found it contained practically zero parts per million of oxygen.

The importance of operating the plants must be appreciated and plants must receive the attention they deserve. For meeting the challenges in the operation of such plants, trained, qualified and willing personnel must be selected.

As the installation and operation of sewage treatment plants involve large funds, it is necessary to assess the extent of treatment before disposal. This needs a thorough study of the outfall which amounts to oceanographic study of the sea in and about the outfall. In India at Bombay the study is being carried out through a joint collaboration of Central Public Health Engineering Research Institute and National Institute of Oceanography. Madras, Calcutta and other Cities and other Ports along the sea will also be undertaking such studies.

There is a general tendency to drop anything and everything in sewers. It is absolutely necessary to guard against uncontrolled discharges in sewers as it will cause many problems not only at sewage works but also to the staff engaged in sewer maintenance works. Top priority of allotment of land required for sewage treatment must be given.

Specific rules must be laid down for sewage treatment disposal. Indiscriminate discharge of sewage in water resources should be prohibited. A sample treatment that of oxidation ponds will be very suitable because it is cheap and greatly reduces the potential hazards. The sewage water can be used for increasing agricultural production provided necessary steps are taken to control its effects on pollution of the human employment.

(4) **Pollution by Gaseous Wastes.**

« In A.D. 1309 an Aztec Indian inhabitant of what is now Mexico City was found guilty of burning charcoal in the city and polluting the air. He was ordered to be hanged for this offence. To-day Mexico City has a carbon monoxide level greater than metropolitan New York, a sulphur-dioxide level greater than that of London, and ten times the industrial contaminants of the industrialized Rhine River Valley. » The above fact holds good the world over in all the metropolitan areas. Noxious fumes from factory chimneys have already begun to pose a health hazard. The people of Bombay have noted on many days a blackish smog/smoke from factories and power houses moving like a dense cloud towards sea. The same sight can be seen in Calcutta, Madras, Cochin and other major Ports of India.

The World Health Organisation has defined air pollutants as « substances put into the air by the activity of mankind in concentration sufficient to cause harmful effect to his health, property or to interfere with the enjoyment of his property ». With the increasing industrialisation of India and concentration of the same in coastal and Harbour areas, the problem of air pollution is severely felt. It is reported that diseases such as bronchitis, asthma, lung cancer as well as many other types of lung, skin and eye troubles are linked with air pollution. The oxides of sulphur and nitrogen which are contained in the gases emitted by Power Houses, Oil Refineries, Petro Chemical and Fertiliser Industries irritate the eye, nose and throat and damage the lungs. Other pollutants of the air are carbon monoxide, oxides of nitrogen and hydro-carbons which are emitted by internal combustion engines.

A study by the Health Physics Division of the Bhabha Atomic Research Centre in the Chembur-Trombay region has shown that noxious fumes have reached such levels of concentration that are likely to have harmful effects on the population. It is said that Bombay burns about 9,500 tons of fuel every day, coal, gas, petroleum, kerosene, diesel, refuse and garbage, etc. All precautions are being thought of by industries especially chemical, rubber and plastic units which are likely to pollute the air. The World Bank recently laid a condition on a promoter of a fertiliser project that assistance will be given only if built-in emission control devices were introduced.

The air pollution in developing countries has reached such a dangerous level that in U.S.A. the invisible pollutants are estimated to be around 85 to 90% of the total pollutants in U.S.A. In certain areas in U.S.A. the children are warned not to have heavy physical experiences to prevent deep breathing of the polluted air and in Japan children and adults have to wear masks on smoggy days. India has to take serious note of the evil effects of air pollution as experienced in the developed countries and devise ways and means to counteract the malady in time.

(5) **Pollution caused by weightless wastes.**

The effluent releases from nuclear industry have received serious public attention throughout the world. Describing the practices in the nuclear industry in India, where discharge criteria are extremely stringent, Shri H.N. Sethna, Director Bhabha Atomic Research Centre stated at a Seminar on Pollution and Human Environment in Bombay in 1970 :

« The approach to environmental control of pollution in the nuclear industry is based on the principle of containment and controlled release to the environment when inescapable. We set limits on releases based on the safe receiving capacity of the environment and the control is achieved by effective methods of treatment, decontamination and containment of the pollutant. This is perhaps the only industry which looks into the environmental pollution control and demontration of conformance to set norms as a part of operational responsibilities. »

Controlled releases have been made after due consideration of all the parameters. The Scientific planning of pollution control at a nuclear site consists of :

(*a*) Pre-operational study of dilution, transport and dispersion mechanisms in the bay waters.

(*b*) Radiation background.

(*c*) Ecological uptakes and

(*d*) A systematic monitoring of the receiving environment.

The basic philosophy for radio active disposal adopted by the Bhabha Atomic Research Commission is « Maximum containment » and « Minimum Release ».

All possible sources of exposure to the local population from bay water as a result of discharge of radio active effluents into it is examined in detail, such as the consumption of fish and salt manufactured in the bay waters. Monitoring of the aquatic environment is continuously carried out including the analysis of the bottom sediment samples collected from different localities. The levels of radio activities in the adjacent coastal waters and foreshores, the area of the receiving sea water, silt and marine organisms in the area are assessed and permissible content limits are compared.

The effect of radioactive elements is difficult to judge unless they are in such concentrations to give acute effect. Cancer, malformation of body at birth, abnormalities in organ development are some of the effects observed in the laboratory experiments conducted on animals. Radio-activity is not the only waste that nuclear plants produce. There is another « unseen waste » which is Thermal Pollution.

For cooling purposes nuclear reactors use large quantities of water. This water, even if it does not pick up radioactivity, is meant to pick up the heat energy and the waters are returned to the stream or river from which it may have been drawn. Large number of industries require water for cooling. It is found easier to take water from the source of lower temperature and let off the hot waters into rivers causing thermal pollution. In this process ecological balance of the stream or river is affected as many organisms are killed. This form of pollution is fairly easy to eliminate if industries use cooling towers or spray ponds and thus reuse the water.

III. MISCELLANEOUS

Natural pollution is not new. There are many natural pollutants like the solid decaying organic matter from plants and animals; surface run-off carrying organic materials to rivers and other water bodies. Volcanoes, floods, thunder storms and earthquakes disturb the balance in environment causing at times pollution of rivers, estuarine waters and coastal areas.

a) Interaction of salt and fresh water.

The interaction of the tides resulting in the ebb and flood, the seasonal currents, wind and weather and other hydrodynamic factors have considerable effect both positive and negative in respect of pollution. At times pollutants especially oil dry out on the coastal areas and inland water areas during two successive periods of neap tides and become more and more viscous while on the other hand the interaction of the low and high tides automatically cleans the beach.

In the Port of Cochin every year during a particular season, i.e. between August and September (just after the South-west monsoon), a phenomenon of heavy mortality of fish occurs due to the interaction of the salt and fresh water caused by the intrusion « Salt tongue ». « It is found out that after the monsoon is over, an under current of the sea would cause the water of the demersed strata to come up and the fish in that level of water, mostly demersed fish, would also naturally come up due to the force of the current. This water would be retaining a low temperature, but when it comes up it gets heated then the oxygen contents in the water would be reduced and thereby the fish therein would get suffocated due to lack of a sufficient oxygen required for their existence and the heavy mortality occurs. »

b) Dumping of dredged materials.

Dredged spoil, waste material from the dredging of harbours and channels, is also dumped at sea. In some harbours the spoil itself is polluted and when dumped offshore further pollutes the area where it is dumped. Hence care must be taken to ensure the dredging spoils do not affect the breeding ground of fish. Dredge spoils account for 80% by weight of all ocean dumping by the United States.

c) Pollution by soil erosion and river diversion.

Pollution is also caused due to soil erosion in the catchment area, river water diversion and withdrawal of water on water regime. This silt load in the stream can be described as water pollution caused by erosion in the river catchment. The silt load in the stream depends on the watershed management practices in the catchment area which ought to be governed by planned and scientific irrigation and restricting deforestation. River water diversion has been on increase for consumption uses, particularly for irrigation. While increased utilisation of surface water resources would bring in prosperity and development, there is a danger of increased pollution in rivers which has to be assessed, appreciated and controlled. With the rising rates of the river diversion, the balance flow left into the water is considerably low. If untreated industrial waters are led into such channels having inadequate flow the harmful ingredients will not disperse and pollution takes place.

The withdrawal of water on river regime also increases pollution. With the construction of storage dams the very geometry of the river lower down is likely to undergo changes. (A typical example is the Thanneermukkam barrage in the back waters of Cochin. This has increased the flow of water in the Ernakulam channel of Cochin Port and reduces the flow of water in the Mattancherry channel of Cochin Port). Reduction in the channel capacity lower down which may be caused by diversion of stream flows is likely to cause pollution owing to drainage congestions that may follow. All estuarine harbours are at the sea end of the back water complex and while planning the operational schedule for reservoirs the flow in the regime of the river must be maintained by special large scale release from reservoirs during the monsoon months.

The problem of pollution of rivers and streams have already assumed and is attracted the legislative attention of the Indian Government. The Prevention of Water Pollution Bill, 1969 aims at comprehensive programme for prevention and control of pollution of stream by constituting a Central Water Pollution Prevention Board. Under this bill no person can cause entry of polluting water into streams. The bill is a right step and many states of India have already enacted legislation to enforce the water pollution regulation.

d) **Pollution caused by weeds.**

Call them what you like, the Devil's Lilac, Million Dollar Weed, Terror of Bengal, African Payal or water hyacinth, the weeds in the Kerala Backwaters do constitute an economic scourge. They clog canals and rivers, block navigation, smother fish and pollute the water. They lay waste fertile fields spilling on to them and encourage the growth of disease-carrying mosquitoes. In Kerala, where fisheries and farming are the means of livelihood and the basis of the region's economy, weeds now threaten both. Dr. F.J. Simmonds, Director of the Commonwealth Institute of Biological Control, Trinidad, who studied the problem reports that « in the inland water the weed covers and blocks canals, interfering with navigation, irrigation, fishing and even domestic washing. It covers paddy fields and reduces the crop by competing for available nutrition etc. It alters the aquatic environment to produce optimum breeding conditions for some species of mosquitoes, and also deoxygenates the water to the detriment of fish, particularly small ones, populations ». In the Port of Cochin itself, during some months fishing and boating are impossible. A boat got stuck in weeds recently and the passengers were stranded for a few days. Weeds even damage engines in small motor boats and block water intake apertures of ships.

About 200 km from Cochin, the weeds have formed a thick mat over the 0.2 sq. km Kakki water reservoir (of a 300 mW power station). The threat here is so serious that the water level in the lake has fallen by more than a metre following loss of water caused by transportation of the weeds. In the long run, decomposition products, particularly organic acids and hydrogen sulphide, can damage the turbines. Besides, they can weaken bridge spans (two bridges near Cochin face this threat) by the extra strain the stagnated water puts on them. Weeds clogging drainage and irrigation ditches have been worrying farmers in West Bengal and Assam. On the Congo river in Africa, weeds have reduced river traffic by 10%; the annual loss has been put at Rs.350 million.

According to two experts from Switzerland, Dr. C.D.K. Cook and Dr. K. Gut, who visited Kerala recently, the weeds cannot be wiped out permanently and the people will have to learn to live with them. Not necessarily so, say Dr. Simmonds and Dr. V.P. Rao, entomologist at the C.I.B.C. Station at Bangalore. They plan to employ biological control, that is to introduce insects which are natural enemies of the weeds. But these insects should attack only the weeds against which they are used and not other useful plants. The C.I.B.C. has studied and tested such host-specific natural enemies of African Payal.

Realising the threat to the hydroelectric project at Kakki from weeds spreading on the reservoir, the Kerala State Electricity Board will soon try out the insects in a pilot project scheme which will be eagerly watched by all in Kerala for the results.

CONCLUSION

To-day the world is faced with an unprecedented menace of growing pollution which is the prize mankind is paying for achieving affluence.

To fight pollution which is threatening with alarming speed, the world has to unite and any further delay will be too late and result in the earth being unfit for human habitation. It is this impending danger to humanity that brought together a 114 Nation-Conference at Stockholm in July 1972 under United Nations to plan the strategy for survival.

Our country has a vast coastline of more than 5,000 km. with numerous rivers and estuaries periodically enriching the coastal waters with essential nutrients and minerals. Our coastal waters are very important nursing grounds of our fishes and prawns and pollution is causing considerable decline of fishery to our country.

All environmental problems are local at the outset, but they can quickly become international. Pollution can swiftly move across national borders by the prevailing winds and by the interlinking oceans. Prime Minister of India, Sry. Indira Gandhi stated at the Stockholm Conference that « there is a branch of experimentation and discovery in which scientists of all nations should take an interest. They should ensure that their findings are available to all nations unrestricted by patents... We do want new directions in the wiser use of knowledge and tools with which science has equipped us. And this cannot be just one upsurge but a continuous search for cause and effect and an unending effort to match technology with higher levels of thinking. We must concern ourselves not only with the kind of the world we want but also with the kind of man should inhabit it ».

The population of the world is now 3,600 millions and doubling every 30 years or so. In the year 2000 we can expect our population will increase to 7,200 millions and by 2090 to 57,600 millions which means there will be no breathing place and in fact no salvation for anyone in the entire universe, unless we migrate to the moon or other planets!

In our country not only the population has increased but industrial expansion has drawn the working class population to urban areas compelling the people to have a sub standard life devoid of hygienic conditions and proper and adequate sanitation resulting in pollution and disease. Thus the rapid industrial expansion without adequate attention to raise the standard of human settlements has led to uncontrolled, unhygienic and insanitary environment in our country resulting in pollution and the indiscriminate growth of population in areas unplanned to receive them has led to the growth of slums. This state of affairs must be halted by developing ideally located self-contained units, reusing waste water and planning colonies and settlements to avoid pollution of the general environment and coastal water areas. The worst pollution of undeveloped countries is the pollution of poverty which must be eradicated from the source by an all-out effort.

India, which is on the threshold of industrialisation cannot take a complacent attitude but must make a serious note of the disastrous consequences of pollution and take lessons from developed countries which are fighting hard the evil effects of man-made pollution. In Genesis 1 : 28 God said « *Be fruitful and multiply and replenish the earth and subdue it* ». But the nations of the world, especially the advanced nations, do not seem to abide by the replenishing part of the Biblical saying.

It may be true that pollution of our Harbour areas and coastal waters are not as alarming as those of the advanced countries but we must initiate action not only to minimise but eradicate the disastrous effects of pollution. Polluted air, contaminated water, despoiled land, crowded slums are the direct and unwelcome results of haphazard urban and industrial growth and population explosion. The indiscriminate dumping of the raw effluents from municipalities and factories into our natural water courses have poisoned our water supplies and killed many useful forms of plant and animal life in our lakes, streams and coastal waters. The insanitary disposal of human wastes in streams and rivers are mainly responsible of filth borne diseases, like cholera, typhoid, dysentry, gastro-enteritis and jaundice among the poor and other vulnerable sections of the population. A pollution-free environment must be regarded as part of the wise usage of all other resources.

In the above context it is important to educate the common man about the hazards of aquatic pollution so that public consciousness is suitably aroused. Strict enforcement of legislative measures for the control of pollution is also necessary and the formation of a high power body like the Pollution Control Board is very essential if the rivers, Harbours and estuaries and coastal waters are to be kept free from pollution.

The statement of Mrs. Indira Gandhi, Prime Minister of India at Stockholm Conference in 1972 is a fitting eye-opener to advanced as well as developing countries. She stated that « Man must reestablish an unbroken link with nature and life and learn to invoke the energy of growing things and to recognise, as did the ancients in India centuries ago. *One can take from the earth and atmosphere only so much as one puts back into them* ».

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RÉSUMÉ

L'expression « pollution marine » se définit comme « l'introduction par l'homme dans le milieu marin de substances ayant des effets nuisibles sur les ressources naturelles, la santé de l'homme, et gênant les activités liées à la mer, telles que la pêche, et une diminution de la qualité de l'eau de mer et de ses propriétés ».

La pollution ne connaît pas de frontières et est devenue un problème urgent pour le monde d'aujourd'hui, à cause de la décharge incontrôlée de produits résiduels dans l'air, l'eau et la terre. L'échappement de résidus non traités dans les océans, les rivières, les lacs, les estuaires, les zones portuaires et côtières (égouts traditionnels) est un aspect important du problème de la pollution. Il y a pollution portuaire ou côtière lorsqu'il y a échappement volontaire ou accidentel d'une quantité significative d'une substance étrangère ou polluante.

Le problème de la pollution doit être traité en tenant compte des besoins économiques fondamentaux des pays en voie de développement. D'une part, il y a le besoin essentiel pour la Société d'exploiter toutes les ressources offertes par la nature et qui permettent le développement

et la prospérité d'un pays. D'autre part, il y a aussi la nécessité de veiller à ce que l'homme n'altère pas le milieu naturel jusqu'à un point qui rendrait impossible les activités essentielles, tels que le transport, la production de nourriture, l'industrie et les loisirs, qui reposent sur le milieu naturel. En dehors des marins, des pêcheurs, des autorités portuaires, des écologistes, des hommes d'état et des gouvernements, c'est le monde entier qui est concerné par ce problème.

L'homme a besoin d'air, d'eau et d'aliments pour vivre (un homme moyen peut vivre sans eau ni nourriture pendant cinq jours mais seulement cinq minutes sans air). On estime qu'il lui faut quotidiennement 2,8 livres de nourriture, 4,5 livres d'eau et 30 livres d'air. C'est l'homme le plus grand coupable de la pollution. En Inde, depuis notre indépendance, nous avons progressé dans de nombreux domaines techniques. Dans tous les domaines notre production industrielle a considérablement augmenté. La révolution agricole a pour conséquence une pollution de l'eau par excès d'engrais et de pesticides. De grandes entreprises privées et publiques, bien qu'ouvrant au pays des horizons économiques sans précédent, polluent l'air et l'eau avec toutes sortes de résidus chimiques synthétiques et radioactifs. Le charbon, l'huile diesel et les autres hydrocarbures polluent avec des émanations d'oxyde de carbone. Les matériaux synthétiques, comme les matières plastiques, augmentent les problèmes d'évacuation de déchets solides tandis que les détergents polluent nos ruisseaux, nos rivières et nos ports car ils ne sont pas décomposés par les micro-organismes. Bien que la pollution ne pose pas encore de graves problèmes en Inde, l'expérience amère des nations riches devrait servir d'exemple et nous aider à prévenir, et non pas à guérir ces maux.

Dans les premiers temps de l'humanité, il n'y avait pas de problème de pollution car le rapport homme/espace était important. L'exode des masses ouvrières vers des zones de concentration urbaine a eu pour conséquence un développement incontrôlé et irrationnel de l'habitat humain avec pour résultat la pollution créée par des conditions de vie sans hygiène.

Les problèmes créés par la pollution des eaux portuaires et côtières ont plusieurs aspects. Leur solution impose une organisation locale structurée regroupant des intérêts variés et parfois contradictoires capables de solutionner les difficultés locales en fonction des facteurs géographiques, écologiques, économiques et sanitaires. La complexité de ces problèmes exige une collaboration collective et individuelle, publique et privée, nationale et internationale. En préparant et en fixant des mesures législatives, il faut considérer ce qui est « scientifiquement possible, techniquement faisable et commercialement acceptable », tout en respectant les intérêts nationaux et internationaux.

On peut diviser les problèmes de pollution des eaux portuaires et côtières en trois catégories principales :

— Pollution par hydrocarbures :
  a) en haute mer;
  b) en zones portuaires et côtières.

— Pollution générale :
  a) par résidus solides;
  b) par résidus liquides;
  c) par égouts;
  d) par produits gazeux;
  e) par éléments sans consistance (produits radio-actifs, etc...).

— Divers :
  a) déversement de résidus de dragage;
  b) interaction d'eau douce et d'eau salée;
  c) pollution par érosion des sols, détournement de rivières et assèchement;
  d) pollution causée par des végétaux (algues).

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PAPER

by

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CHAPTER I

An important development in the control of surface water pollution in the Netherlands is the entry into force of the Surface Water Pollution Act.

Despite many attempts since 1873, the Netherlands had no Act against water pollution until 1969. On 11 June, 1968, the Second Chamber of Parliament adopted the Bill, followed on 11 November, 1969, by the First Chamber. This Act, officially entitled : « Act containing rules concerning the pollution of surface waters », will doubtless have an encouraging effect on the control of water pollution. As, within certain limits, this Act covers both the important ports and harbours and the sea, it seems useful further to explain its main outlines.

The first section of the Act begins with the words : « It is forbidden ». The prohibition is obvious. Society has gradually become highly dependent on good surface water. Although pollution is becoming more and more unacceptable, it is steadily increasing, for instance through population growth, through a change in hygienic habits and through industrialization. In fact the time has come when this process of increasing pollution must be reversed. The prohibition must present the formal point of view for all this.

However, an absolutely universal prohibition is inconceivable. In the first instance the prohibition relates only to pollution by works or installations whose purpose is quite simply to dispose of waste. These are sewage works, waste pipes from industrial concerns but also quite simple domestic drains. Subsection 2 of Section 1 makes it possible also to lay down further-reaching prohibitions by general administrative order, so that not much will remain that is not forbidden.

Small diffuse discharges are difficult to counter. Moreover, in general they will not do much harm; should this nevertheless be the case, it is possible to prosecute the polluter under Sections 173a and 173b of the Code of Criminal Procedure.

An automatic prohibition would be unrealistic. The prohibition will have to serve as a basis for a policy for controlling pollution. That means a licensing policy under which regulations can be made.

By making these regulations the licensing authority will be able to take into account firstly the interests of the applicant for a licence and secondly the interests of the others who in some way or another also wish to utilize that water. Basically the licensing authorities are the Minister of Transport, Hydraulics and Public Works for the waters under State management (the big rivers, the North Sea and harbours in open communication with State waters) and the provincial executive councils for the other surface waters. The great variety which occurs in the discharge of waste water, both in respect of the nature and quantity of effluent and in respect of the self-cleansing capacity of the receiving water, does not make it possible to lay down in the Act what regulations must be complied with when discharging waste water. For each individual case it will have to be considered whether any treatment of the waste water is necessary and, if so, whether the obligations to be imposed must more or less completely define the provisions to be made, or whether it must only be required that the effluent satisfies certain standards. The conflicting interests which often occur among those concerned with water management will have to be considered in this respect. Insofar as this is not regulated by the licensing authority, the Act can render it possible through its appeal arrangements. For instance, such a licence for a firm may include the following :

1. An exact definition of the quantity of waste water to be discharged, with the obligation to report any changes;
2. A prohibition on the discharge of any rising or colouring substances, or any substances rendering water turbid;
3. Regulations for a suitable oil catcher or other treating plant used judiciously;
4. Prohibition on the discharge of water with a temperature higher than 30°C;
5. Regulations regarding the acidity or alkalinity of the water to be discharged;
6. Prohibition on noisome substances;
7. Prohibition on the discharge of taste-spoiling substances;
8. Prohibition on the discharge of toxic substances;
9. Officials charged with supervision of compliance with the conditions should at all times have access to the installations to which the licence relates.

Another important aspect of the Water Pollution Act is the levies. The principle behind this is that every polluter should himself counter the pollution and also pay the costs of this. Secondly, the levies must render possible financing of the construction, maintenance and operation of the means for countering pollution.

The levies are therefore clearly intended for a specific purpose. They will be imposed on each licence-holder. Thus for instance it will be possible to oblige a firm to pay for the waste which it discharges into a surface water. A municipality can be charged for its sewage system emptying into a surface water. In its turn that municipality derives from the Act the right to recover that levy via contributions from those connected to the sewage system.

It has already been stated that a general administrative order is being prepared for regulating the disposal of waste otherwise than via an installation for that purpose. Within that framework measures will therefore be available for restricting pollutants from entering water in the conduct of business or as deliberate dumping. This means that for instance inland shipping — which for the exercise of its business is bound to the water — must be given an opportunity of disposing of its waste in some other way. As regards waste oil, those measures will be included in general regulations for the collection of waste oil from firms. As for the domestic refuse of inland craft, consultation has been started to arrive at rounded regulations. Since September 1971 a provisional scheme has been in force under which plastic refuse bags have been made available free of charge at a large number of points new locks and harbours, while an opportunity is given to hand in filled bags free of charge. This provisional scheme has been welcomed in shipping circles.

It will be clear that under the Act measures can be taken which can make an essential contribution to the control of pollution in the surface water of rivers and thus also of the harbours in open communication with these rivers. Both the licensing policy which makes it possible to impose clear restrictions on the quantity and nature of effluent and the levies on the permitted discharge, which often involve large sums of money, will result in the near future in a reduction of waste water discharges.

Quite soon after the Act entered into force various firms found that it was feasible to restrict the flow of waste water and likewise to take internal measures by which particularly harmful substances could be withheld more than previously. Pollution of the coast is of course closely connected with discharges into the sea. As already mentioned, the operation of the Surface Water Pollution Act extends in the open sea to an area laid down by general administrative order.

The pollution of the sea is mainly determined by the pollution entrained by rivers. This problem will for the time being have to be solved by the riparian countries, each taking its own part of the catchment area via its national legislation. For the international rivers and the coastal waters the consultation going on within the Council of Europe to arrive at regulations and agreements is of great importance.

For oil discharges an international convention for the prevention of marine pollution by oil was concluded on 12 May, 1954, in London as part of the regular consultation within the Inter-Governmental Maritime Consultative Organization (I.M.C.O.). The Netherlands has implemented this convention.

In this connection it is interesting to mention the measures which have been taken in the Netherlands to deal with serious marine pollution by oil.

Reports of oil slicks observed by ships or aircraft are received by the Harbour Mouths Division of the Government Public Works and Hydraulics Department. In special cases the Bonn Convention concluded in 1969 provides for collaboration between the coastal States of the North Sea.

The Netherlands has the availability of a Government control vessel, the « Smal Agt », and a private vessel. The construction of a second Government vessel is in preparation.

Oil floating on sea or washed ashore will in the course of time be naturally decomposed. The « Smal Agt » is equipped with booms for spraying detergents. Great care has to be taken with the use of these chemical agents in certain areas of importance to commercial fishing, as most of these agents are injurious to marine organisms, although it must be said that the « second generation » of these agents is much less toxic than the first. In certain cases it is also possible to burn the oil, although the serious oil pollution which is the result imposes restrictions regarding the scope of application. Tests have been made with sinking the oil. For this purpose use was made of sand treated with certain chemicals. Although the tests gave good results, this method is not universally applicable either. Here again allowance should be made for fishing interests. Consequently, it has been endeavoured to make maximum use of mechanical aids, for instance extracting the oil by suction. Tests are being made on this at present. However, it does give some difficulties in the open sea and when a wind is blowing. The same applies to the use of booms, which hardly proves successful if weather conditions are somewhat unfavourable.

Another form of pollution is the dumping of waste in the sea from ships. Considerable progress has been made in the control of this by the Oslo Convention. This Convention was signed on 15 February by 12 countries, including the Netherlands. In the granting of a licence the recommandation of the Government Institute for the Treatment of Waste Water and of the Government Institute for Fishery Research will determine the conditions to be included in the licence, under which substances stated in the « grey list » of the Oslo Convention may be discharged. For substances that are on the « black list » no licence will be granted, except under a few special conditions permitted by the Convention.

For the time being it is not the intention to impose levies for these substances. There are two arguments in favour of this. In the first place these discharges may be stopped immediately if they present a danger to the receiving water, i.e. the sea. In the second place it must be borne in mind that these discharges relate to substances which may be regarded as innocuous and which can be disposed of in some other way less effectively or at much greater expense. Placing these discharges under the levy system will encourage evasion of the licensing obligation, which will give rise to unsupervised discharges.

An important factor in pollution of the sea and coastal waters is formed by the effluent pipes. In the past the discharge of effluent into the sea or the estuaries was regarded as one of the means which under certain conditions could form a solution for the control of surface water pollution in the Netherlands. This particularly related to the discharge of kinds of effluent which could only be treated with difficulty, if at all, or to discharge from areas with a considerable effluent production where, even after treating, the discharge of the effluent into the surface waters of this area would still give rise to impermissible pollution. It was recognized that the necessary caution would have to be observed in discharge into the sea. The problems of the discharge of toxic matter, an adequate length of the pipes and a good dilution with seawater at the mouth of the pipes, together with the prevention of pollution of the coastal waters, received attention.

In recent times the view has been gaining ground at a fairly quick rate that it will be necessary to take steps with regard to the discharge of waste matter into the sea. It may be expected that the requirements that will be made for discharges into the sea will approximate those made of discharges into fresh water. It is important here? to consider the discharges of domestic effluent into the sea via a pressure pipe, which are the subject of increasing interest. The possible resultant pollution of the coastal waters by fæcal bacteria is becoming increasingly unacceptable, especially if these coasts are of great recreational importance through the presence of bathing beaches, as is the case in the Netherlands. It is therefore not surprising that the length of the pipelines, the dilution and even the possible use of treatment for the discharge and/or disinfection of the effluent are being subjected to a reappraisal.

It is obvious that, just as has been done for the rehabilitation of fresh water, the State will also introduce regulations for financing the measures for abatement of pollution of the sea and estuaries, as a result of which the costs will in principle be borne jointly by those discharging the effluent. This means that the discharges into the sea and estuaries will also be subject to a levy. In the light of these developments with regard to prohibitions, licences and levies for discharge into the sea it is of course of importance that considerable attention be paid to the collection and disposal of chemical wastes by other means than discharge. Burning them is one of these means.

CHAPTER II

After 1945 the Rotterdam docks were greatly expanded. New harbours were built to the west of the city, initially in the Botlek area, joining on to the existing docks, later extended by Europoort and now by the Maasvlakte. This was accompanied by an intensive growth of the industry established in these areas. The leader in this was the petrochemical industry.

The harbours themselves naturally required a large number of facilities, notably transhipment firms and storage yards. All these activities of course yielded a large quantity of wastes.

For the transhipment firms and storage yards this was packaging material, spilt or damaged goods and sweepings, while for the petrochemical industry a great diversity in chemical wastes and polluted water could be added to the list. In the Rotterdam docks and industrial area, too, the initial idea was that the firms themselves had to solve their waste problems and that the authorities had at most a supervisory task.

A large number of firms engaged in the collection and removal of wastes.

The great majority of these substances was deposited on tips in the vicinity of Rotterdam. Other wastes, mainly liquid and soluble chemical wastes, were discharged into the water.

Although in theory a selection was applied to wastes and tips, it soon proved in practice that a number of these waste removal firms took considerably greater risks than was acceptable.

In particular the discharges of wastes via ships that had to dump these in the Atlantic gave rise to serious problems. Many substances were discharged into the North Sea, just out from the coast, or even into the river. Packaging material as well was too easily dropped into the river or the harbours.

Ever since the beginning of the century the floating waste in the harbours had been fished out and disposed of by special vessels of the Rotterdam Cleansing Department. What was dumped in the river either floated into the harbours and was fished out there, or was carried by the tide out to sea.

There were various reasons for the municipal authorities of Rotterdam to devote an extensive study to waste disposal around 1963.

The tips close to Rotterdam were becoming full or had to make way for urban extensions. The high population density in this part of the Netherlands in any case made the creation of tips an unpleasant business.

The waste disposal firms sought their refuge in municipalities further away from Rotterdam. This led to conflicts with these municipalities, which found out the hard way that the regulations on tips were difficult to check and that compliance with them left much to be desired.

The longer transport routes also made costs higher, and this again led to clandestine tipping on waste land or dumping in the water.

And yet it was above all the increase in the petrochemical industry and the marked expansion of the production package, often by toxic, inflammable or badly decomposable substances, that was the reason for examining the possibilities of placing the destruction of refuse in official hands.

After all, even small quantities of these substances, the tipping of which in the large quantity of other wastes can hardly be verified, may have catastrophic effects on soil, ground water and open water, to say nothing of the risk of air pollution from tip fires.

The survey made by the Municipality of Rotterdam, performed by the city's Cleansing Department, was in the first instance directed towards determining the existing supply of wastes. For this purpose a survey was held among over

900 firms and more than 50 employers into the quantities and nature of the wastes from those firms. At the same time a statistical study was made of the annual increase in wastes. The latter was dependent on the one hand on an increase in wastes per firm, and on the other on the increase in the number and size of the firms, to be coupled with the granting of land in the areas concerned.

The investigation also related to the supply of domestic refuse in the area. Since 1912 Rotterdam's domestic refuse has been burnt. In 1964 a highly modern incinerator with an annual capacity of 360,000 tons was commissioned to replace the installation built in 1912. However, the other municipalities mostly deposited their wastes on tips which, like those for industrial wastes, became full and could practically not be replaced.

Extrapolation of the research data to 1972 supplied an annual expected supply of refuse of :

— 190,000 tons of domestic refuse;

— 440,000 tons of industrial waste;

— 40,000 tons of liquid chemical wastes;

— 30,000 tons of solid chemical wastes.

The domestic refuse also includes 80,000 tons of domestic refuse from Rotterdam, in connection with the expected undercapacity of the city's own incinerator around 1972.

The investigation was further directed towards the possible processing methods. The starting point here was that all the wastes supplied would be processed irrespective of quantity and composition. This requirement made recovery impossible as a system, since this form of refuse processing assumes a reasonably constant supply of a limited number of substances.

The fact that recovery was not chosen as the system does not, of course, mean that it will not be used for certain products, given a suitable supply. The choice had to be made between tipping, composting and burning. It has proved in practice that industrial wastes are not interesting for composting. Tipping would not be universally applicable in connection with poisonous, inflammable and explosive substances and would therefore require considerable supervision in selection and treatment.

Tips would also have to be found far away from Rotterdam, which would make the costs of transport an extra burden. Moreover, tipping must always be regarded as a system in which the unpleasant residue of today's prosperity is carefully put on one side for posterity, insofar as substances are concerned that do not decompose naturally and without danger to the environment. Burning yields a number of exactly known products. Here too there are a number that must be regarded as pollutants. We may think here of substances in flue gases like SO_2 (from oil and rubber), HCl (from PVC and chlorinated hydrocarbons), HF (from Teflon), in slag and fly ash like asbestos, mercuric oxide, arsenic oxide etc. The spreading of dust in a chemically innocuous form must also be considered. However, since the dusts are released in relatively small quantities and at a known place in the process, it is quite possible to separate them. Suitable means are the electrostatic dust precipitators much used in incinerators, flue gas scrubbers for chlorine, sulphur or fluorine-containing flue gases etc.

In view of these considerations the choice therefore fell on an incinerator. The capacity was kept at the expected refuse supply for 1972. True, consideration was given to making the plant even larger, but transport problems would become disproportionately large through the overloading of the road system. Consequently, it was also laid down in the plan that within the foreseeable future a third plant will have to be built on the north bank of the Maas.

The plant for a total processing capacity of 700,000 tons was estimated at ƒ140,000,000. The Municipality of Rotterdam could not make this amount available precisely at a time when Government expenditure was subject to rigorous retrenchment. Nor did it prove possible to have the plant built and operated by a private firm. On the one hand this calls for very strict standards and very intensive supervision, since protection of the environment when incinerating refuse is a very costly business, and these costs will of course be limited as much as possible so as to get the maximum profit out of running the plant. On the other hand such an operation is not very attractive to business as long as it is not absolutely certain that all firms will have their waste processed in this way, with its high charges compared to the cost of tipping.

A solution was found in the creation of a limited liability company. The shareholders in this limited company are the 23 municipalities from the Rhine Delta area and the Rhine Delta Public Authority. The latter is an administrative body that has to coordinate the activities and interests of the 23 municipalities.

This made it possible to borrow on the money market, something which municipalities are not permitted to do without the approval of the central government.

Meanwhile, the basic design for the plant, known as the Botlek Incinerator, had been completed. The incinerator was divided into two parts, one department for domestic and industrial wastes and another for chemical wastes.

In the first group come all wastes that can be burnt without any problems on the special grates developed for this purpose. The second group covers all substances that cause problems if they are burnt on grates.

The latter substances are :

— liquid wastes;
— wastes that melt when heated and would run away between the grate bars;
— wastes that are poisonous or that generate toxic gases when burnt;
— wastes that present the danger of explosive combustion;
— wastes that yield products unacceptable to the environment in the flue gases, fly ash or slag.

In principle the incineration of normal industrial wastes does not differ from the well-known method of domestic refuse incineration.

The differences are a great degree of inhomogeneity in respect of composition and heating value, the presence of many large particles and an on average considerably higher heating value than domestic refuse. These are factors that must be taken into account in the design. In the Botlek Incinerator 6 combustion units for normal refuse are being built. These units each have a nominal capacity of 16 tons of waste an hour, based on a heating value of 3,000 kcal/kg. A combustion unit of an incinerator is very liable to break down, owing to the inhomogeneity of the fuel. For that reason a large number of small units are being built, so that if one drops out only a small reduction in total capacity occurs. In the case of the Botlek Incinerator it is assumed that one unit is normally down for inspection or repair. The incinerator consists in all of 6 boiler units.

The processing capacity is therefore nominally 5 × 16 = 80 tons/h. The maximum continuous combustion capacity per furnace is 20 tons/h, so that even with 4 units in service the nominal processing capacity of 4 × 20 tons/h = 80 tons/h can continue to be maintained. The heat produced in combustion of the wastes is used for the generation of steam. For this purpose the furnace is surrounded by a steam boiler. As a result of this the flue gases are also cooled from approx. 1,000°C to 300°C. This cooling of the flue gases to at least 300°C is also necessary for arriving at a good and effective dust removal from the flue gases. The flue gases from the combustion of wastes contain a fairly large number of dust particles, so that they may not freely disappear into the atmosphere via the stack without further treatment. The most effective method of removing dust from flue gases is the use of electrostatic filters installed in the flue gas duct for the stack.

However, these filters operate only at a flue gas temperature lower than 300°C. Each of the 6 boilers is fitted with its own electrostatic filter installation.

To limit corrosion of the boiler tubes as much as possible, the boiler heating surface is so sized that a relatively low steam pressure and steam temperature occurs, viz. steam pressure nominally 36 atm. ga. and steam temperature after the superheater 360°C.

The nominal steam production of 50 tons/h per boiler is further utilized for two purposes.

In the first place it is employed for the generation of electricity in a power plant with two back-pressure turbogenerators, each of 14 MW, and a vacuum turbo-generator set of 27 MW. The total electricity production of this plant will be approx. 200,000 MWh per year.

The low-pressure steam of 2.5 atm. abs. obtained is further conducted to a water distillation plant, consisting of three evaporating units. Here the low-pressure steam is used to produce very pure distillate from river water, which can be sold to the surrounding firms as process water.

The capacity per evaporator is 450 tons/h at a steam consumption of 50 tons/h. The estimated total annual production is approx. 16,000,000 m³. This water distillation plant has been coupled with the incinerator at the request of the Rotterdam Municipal Water Works.

The management of the incinerator attends to the production of the process water while the sale and distribution to firms is the task of the Water Works.

Special attention has been devoted to the processing of solid and liquid chemical wastes as regards supervision, storage and transport and combustion furnaces.

Chemical waste may be brought to the incinerator only after prior notice has been given, and it must be packed in accordance with legally prescribed requirements (Dangerous Substances (Transport) Act). The supervision is exercised by the incinerator's own chemical service, which has a well-equipped laboratory available.

For the storage of solid chemical wastes, chiefly plastics, a bunker of some 4,000 m³ has been built. This is divided into three sections to confine as much as possible any fire that may break out.

For the storage of liquid wastes, chiefly oils, a tank farm has been created, consisting of 9 large tanks each of 50 m³, and 10 small tanks, each of 5 m³, so that a wide variety of liquid wastes can be stored separately. The liquids are not pumped to the combustion furnace; they are delivered through the lines by nitrogen pressure on the tank.

The solid chemical waste is if necessary first reduced in size by Lindemann shears and can then be deposited in the combustion furnace in maximum charges of 50 kg via a special air lock.

Two rotary furnaces have been installed with a length of 10 m and a diameter of 4 m. Immediately behind the furnace is an after-burning chamber in which the 4 burners for liquid wastes are installed. The capacity per furnace is 1.5 tons/h of solid waste and 2 tons/h of liquid waste.

Beside the two furnaces the foundations have already been laid for a third one, since it is expected that in the near future the maximum processing capacity will be reached.

The flue gas discharged from the combustion furnaces calls for special atten-. tion in connection with the burden on the environment. No dust particles are expected in these flue gases, so that here no electrostatic dust filters have been fitted. In this case only chemical pollution, chiefly by HCl, SO_2 and HF, plays an important role.

In the initial period, therefore, a large number of analytical measurements will be made and tests performed with limestone filters so as to arrive in the near future at the most effective chemical flue gas cleansing possible.

It is expected that the largest quantity of wastes to be destroyed will arrive by truck. But the plant has been so designed that arrivals by ship are also entirely possible, both of industrial wastes and of domestic, solid chemical and liquid chemical wastes.

Financial survey.

The total investment costs of the complete plant are approx. *f* 211,000,000. This figure is made up as follows :

structural works	*f* 40,000,000
6 grate furnaces	58,000,000
2 rotary furnaces	12,000,000
power plant	29,000,000
water plant	37,000,000
general costs	35,000,000

The annual operating costs are composed approximately as follows :

Expenditure :

interest and depreciation	*f* 20,500,000
maintenance	5,000,000
wage costs	6,000,000
materials + raw materials	1,500,000
miscellaneous	500,000
TOTAL	*f* 33,500,000

Income :

proceeds from electricity	*f* 4,500,000
proceeds from water plant	10,500,000
fees for destruction of chemical waste	3,500,000
fees for industrial wastes	14,500,000
sale of slag and scrap	500,000
TOTAL	*f* 33,500,000

The whole plant must break even. This means that every year the prices that firms have to pay for having a ton of waste destroyed will be adjusted to the costs incurred. For the initial period the following prices have been calculated.

For the destruction of 1 ton of domestic refuse : approx.	*f* 25
For the destruction of 1 ton of industrial waste	28
For the destruction of 1 ton of chemical waste	65

Construction of the plant started in August 1969.

The first furnace unit becomes operational on 1 September, 1972.

Every month from then on a following unit is to become operational, so that by mid March 1973 the whole plant will be in service.

In this plant all the small and large floating refuse from the Rotterdam harbours can also be destroyed, since a reduction installation (Hazemag crusher) has been incorporated.

Floating oil slicks that have formed after a collision between ships or incorrect tanker loading and unloading manœuvres can also be transported to this plant after being sucked up by special vessels.

An oil separator can attend to the separation of oil and water, after which the oil can be burnt as chemical waste. The above is being done in collaboration with the Municipality of Rotterdam.

RÉSUMÉ

Mesures en vue de prévenir la pollution dans les ports et sur les côtes.

Deux conditions sont essentielles pour prévenir et combattre la pollution de l'eau dans les zones portuaires et en mer. D'une part, la législation doit donner les moyens d'interdire ou du moins de limiter dans une large mesure la pollution de l'eau, et prévoir l'imputation des coûts d'épuration des eaux résiduaires aux pollueurs. D'autre part, il faut trouver les moyens techniques permettant d'évacuer les déchets sans avoir à les déverser dans les eaux de surface.

Le Chapitre I traite des mesures légales prises à cet effet aux Pays-Bas.

Le Chapitre II étudie une des solutions techniques mises au point à Rotterdam.

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PAPER

by

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CLEANING AND SLOPS RECEIVING FACILITIES AT THE PORT OF LISBON

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I. INTRODUCTION

Effluents from Tankers.

For some time the oceans, which cover 3/4 of the earth's surface, have been acting as a vast free dumping-ground for waste from human activities. Nevertheless, bearing in mind that the water available to us, i.e. what is regarded as essential for ensuring life on this planet, is represented to the extent of some 98 % by the oceans, there is no doubt that the most serious threat to our survival comes from changes caused in the biological balance of the seas. The question arises as to whether the seas can continue to be subjected to this uncontrolled discharging of the effluents, namely of petroleum and its derivates.

If we want to prevent self-destruction, the answer must obviously be in the negative, since one of the most serious aspects to be taken into account is that much of the damage caused by such dumping is fatal and permanent, without any possibility of recovery or inversion. A flagrant example is the extinction of certain species of marine fauna and flora.

We can also affirm that the transportation of petroleum and its derivates is in itself a potential source of pollution that becomes more serious as tankers become bigger.

We shall divide the major causes of such pollution into two categories :
— accidental causes (explosion, collision, running aground, etc.);
— causes resulting from the actual exploitation of tankers.

The first, originating in accidents, lie outside the scope of this paper. We shall only analyse those under the second heading.

Effluents from tankers, contaminated with oil, may be arranged into four groups :
— contaminated ballast water;
— water from washing, and slops;
— residue from cargo tanks that remains in the tanks before tankers enter dock for repairs;
— discharging of bilge water.

Contamination of ballast water is practically impossible to eliminate under present systems, for after unloading at a terminal, owing to reasons of navigability, some of the load tanks that have not yet been washed, have to be used for ballast. This cause would only disappear if vessels could have a sufficient number of tanks so that it would never be necessary to use cargo tanks for ballast. This might be a long-term aim, but on a short or medium term basis it is rather unlikely, since it would require an overhauling of the whole oil-carrying economy. This means that those tanks must be washed, which are to be used for ballast, in order to avoid contaminating the sea when the ship gets rid of her ballast.

Together with this reason for cleaning are others connected with the exploitation of tankers, such as : preventing contamination of the cargo by residue from previous cargo; degassing of tanks and removal from them of all residue that might cause accidents through explosion, and also preventing the accumulation on tank bottoms of sediment, which on docking is extraordinarily inconvenient and difficult to remove.

Bilge water has to be discharged, and comes from residual water accumulating in the engine room, can be separated and processed beforehand in small separators : these can easily be fitted on to ships as accessory equipment.

The residue accumulating at the bottom of the tanks, and that resulting from washing, are characterised by a high percentage of paraffin wax, which is difficult to cope with, and forms a water/oil mixture that is highly emulsified by the action of the washing jets and pumping operations.

II. INTERNATIONAL CONVENTIONS FOR THE PREVENTION OF POLLUTION OF THE SEA BY OIL

The growth of industrial activity and, in particular, transportation by sea of petroleum in enormous quantities, have become a great preoccupation for the nations and made them aware that the struggle for survival can only be effective if there is a joint effort. In the light of such facts, there was in 1948 signed the Convention that defined the responsibilities of the future IMCO (Inter-Governmental Maritime Consultative Organization).

In 1954 there took place in London an Inter-Governmental Conference which resulted in the International Convention for the Prevention of Pollution of the Seas by Oil. This Convention, together with modifications introduced on 13th April 1962, accepted and ratified by 42 countries including Portugal, even today constitutes the basis for anti-pollution laws in the majority of the signatory countries. It specifically forbids the discharge of oily mixtures containing more than 100 parts per million, in zones within 50 miles of the coast, but defines zones in which the limit is 100 miles. The Convention applies in general to all commercial ships over 500 gross tons, with the exception of tankers, in which case the limit is reduced to 150 tons (Fig. 1).

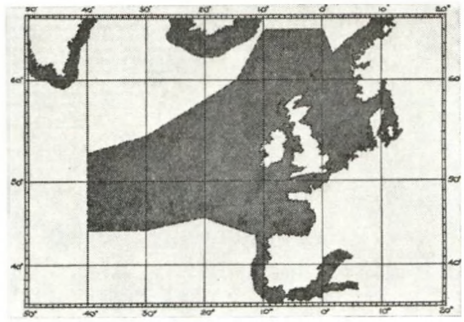

Fig. 1.

Map showing N.E. Atlantic, Norwegian, North Sea, Baltic, Icelandic, Portuguese and Spanish prohibited zones as laid down by The International Convention of 1962, with 100 miles zones off other coasts.

Among the resolutions passed at the 1962 Conference, which was held under the ægis of IMCO, we quote below some extracts that we consider more closely related to the aims of this work. Such resolutions are presented as fundamental conditions for controlling the discharge of oil and contaminated water.

RESOLUTION 1.

The complete avoidance as soon as practicable of discharge of persistent oils into the sea.

« While the Conference have come to the conclusion that a date cannot be fixed at present time by which there should be complete avoidance of the discharge of persistent oils into the sea they consider that complete avoidance of the discharge of these persistent oils should, with certain necessary exceptions, be observed from the earliest practicable date and strongly urge all Governments and other bodies concerned to use their best endeavours to create the conditions upon which the observance of such a prohibition necessarily depends by securing the provision of adequate facilities in their ports and the necessary arrangements in ships. »

RESOLUTION 3.

Interim measures pending the coming into force of the Convention.

« (*b*) the increased provision of facilities in their ports for the reception of oil residues, where such facilities are at present inadequate; »

RESOLUTION 4.

The discharge of oily mixtures from tankers.

« (1) that in addition to observing the requirements of the present Convention all tankers should, wherever it is reasonably practicable to do so, avoid altogether the discharge into the sea of oily mixtures and should retain them on board for discharge into shore reception facilities; »

« (2) that the terms of this Resolution should be specially brought by contracting Governments to the attention of owners and masters of tankers, oil companies, port authorities and ship repairers. »

RESOLUTION 6.

The provision of facilities for the reception of oil residues at oil loading and other bulk loading terminals.

« (1) that for the avoidance of oil pollution of the sea the provision of facilities for the reception of oil residues from tankers at oil and other bulk loading terminals is most important; »

« (2) that such facilities, where they still do not exist, should now be provided as a matter of urgency by those organizations which have it within their means to provide them or to secure or to promote their provision; »

RESOLUTION 7.

Discharge of oil or oily mixtures from ships other than tankers.

« *Strongly urge* Governments which accede to the Convention in the future to take steps to prevent ships other than tankers from discharging oil or oily mixture within the prohibited zones when proceeding to a port where facilities for the reception of oily residues exist. »

We thus have in 5 resolutions — of the 15 in the Convention — specific recommendations for ports to be equipped with stations for collecting oil and oily mixtures, and this shows the importance of this type of installation for the purpose of completely suppressing the discharge of persistent oils into the sea.

III. THE GEOGRAPHICAL SITUATION OF PORTUGAL

Owing to Portugal's geographical situation, nearly all the oil carried to the north of Europe passes along the Portuguese coastline. This tanker traffic corresponds to about 60% of the world fleet and represents for Portugal, on the voyage under load, a potential risk of pollution from accidents, and on the return journey a potential pollution risk owing to washing operations and the need which may arise to change contaminated ballast (Fig. 2).

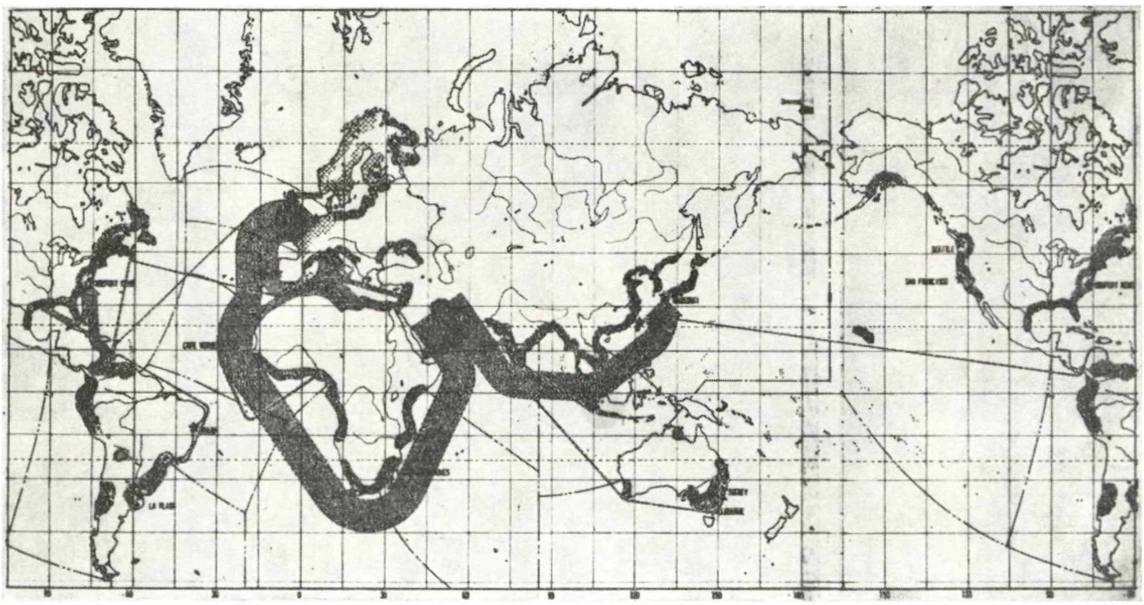

Fig. 2.

The World Maritime Oil Traffic.

The defense of the Portuguese coast has always been a major preoccupation of the Portuguese Government, which thus became a signatory to the Convention previously mentioned and introduced into it national law. The penalties envisaged for breaches of the law involving the discharge of oil or contaminated water, are heavy, with fines that may go as high as 40,000 dollars plus indemnity for damage caused, and for expenditure incurred in dealing with such illegal discharge. Existing inspection and control measures will continue to be intensified, thus defending the patrimony of a country that depends on tourism for one of its main sources of foreign exchange.

IV. THE DEVELOPMENT OF THE BIG LISBON SHIPREPAIR YARDS

With the building of the Lisnave shiprepair yards, equipped to receive the largest tankers existing in the world, the potential risk of pollution increased for the Portuguese coastline. It therefore became necessary to carry out the unloading of slops, washing residues and ballast water from tankers which were to be repaired in Lisbon. Such vessels, for safety reasons, would have to be washed and degassed before entering drydock. This fact made it all the more urgent for studies to be made as to how to eliminate the discharging of such residues into the sea, and the Government took advantage of the occasion to press for solutions and to impose conditions which would enable exploitation of shiprepair activities, which were regarded with the greatest optimism from the economic point of view, and would at the same time ensure defence of the coast (Fig. 3).

Fig. 3.

LISNAVE Shipyard in the Port of Lisbon.

After the rectification of the 1956 Convention, and in order to comply with the resolutions adopted in 1962, Portugal had to provide shipowners and masters with the means that would offer them an alternative to the discharge into the sea, by constructing stations for receiving contaminated water, and ensuring that terminals for unloading crude had installations for collecting slops and ballast water.

This led to the formation in Portugal of Gaslimpo, a company whose aim is to give service to ships docking in our ports, by receiving from them oil and contaminated water, separating them and eliminating them. Gaslimpo started operating in 1967, thus enabling the Government to carry out a substantial part of the IMCO recommendations, and to alter Portuguese legislation as regards fines applied to vessels guilty of discharging oil in Portuguese waters, since they now had the possibility of getting rid of their waste without polluting the sea.

In fact, the setting up of cleaning and degassing stations at the Lisnave Shipyards in Lisbon has led to a considerable reduction in the volume of polluting discharges by tankers on their way to those yards. It is hoped to obtain even better results when those stations are able to carry out a more accurate monitoring of polluting discharges made on route, if these, as is hoped, are completely forbidden at any point on the seas.

It may logically be concluded that an increase in the number of operational receiving units, together with a close collaboration between those existing or to be constructed at strategic points of the globe, and their technical improvement, will mean the elimination of a large part of the potential causes of sea pollution, and thus dispense with the present local inspection work, which is very costly and not always efficient.

Portugal's situation in relation to the main shipping routes makes pollution from shipwreck a permanent danger. As regards this, a strategic distribution along the coast is also being studied, of mechanical and chemical means for immediately dealing with pollution in an efficient manner, so as to reduce the effects of any accident endangering our resources.

V. THE SOLUTION ADOPTED IN PORTUGAL BY GASLIMPO

The solution adopted by Gaslimpo for cleaning stations is based on making use of tankers that are nearing the end of their useful life, and turning them into stations for collecting and separating water contaminated by oil. The Port of Lisbon's first floating tank cleaning station, called « Praia Branca », started its activity in May 1967. It was the result of converting a former T2 tanker of 17,000 TDW. The second cleaning station, « Praia Limpa », started operating in April 1970, and was a converted 17,000 TDW motor tanker belonging to a Portuguese oil tanker company. A third cleaning station, « Praia Clara », has been completed and will come into service shortly. It is the result of converting a 23,000 TDW turbine tanker (Fig. 4).

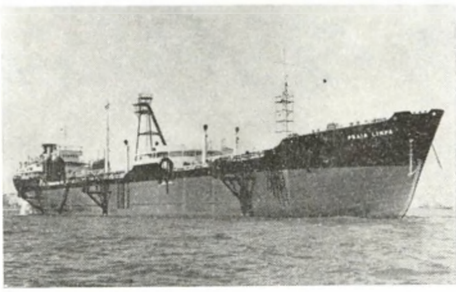

Fig. 4.

The second Cleaning Station « PRAIA LIMPA ».

The marine engines, shafting line and propellers were taken out of these three cleaning stations. For safety reasons, the midship accommodation was cut out in order to avoid spaces that might be filled by gases. All the boiler installations, pumping systems, auxiliary generators and systems forming part of the working of the engine room were kept in working condition. The pumprooms were not altered, with the exception of connections required for new circuits that had to be put in. Equipment such as winches and windlasses were kept on board for the purpose of manœuvring the vessel, with the sole exception of those which, since the ship was no longer self-propelled, could be dispensed with. In brief, all equipment got rid of all that was not strictly necessary and continuance of which would only mean extra maintenance cost.

The separation system is based on a continuous cascade system, for which the ship's tanks are used. Communication was opened up between tanks and discharge lines were constructed.

Owing to the difficulties of handling and pumping products with high percentages of paraffin wax, the coils on the bottom of the tanks have in this case a more important role than in operational tankers. In some cases, therefore, it was necessary to strengthen the heating circuits, in order to allow temperatures to be reached which must be higher than those required for the normal transportation of petroleum.

On these stations was fitted all the cleaning equipment thought necessary for helping the cleaning of average size tankers. All of them can provide hot or cold water for washing, and also steam, electricity and compressed air. They also have mobile ventilators with which the degassing work is carried out.

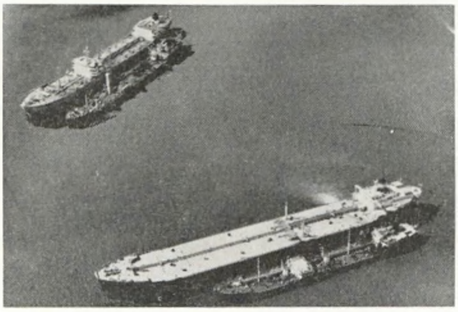

Fig. 5.
« PRAIA BRANCA » and « PRAIA LIMPA » in simultaneous operation.

Since they are floating, these cleaning stations are towed to the ships they have to service, and do not need to make use of piers for the operations of receiving slops, washing and degassing. This solution enables as many vessels to be serviced simultaneously as there are stations, the only thing required being one anchorage per ship serviced (Fig. 5).

This aspect of exploitation is very important, since the occupation of specific piers is avoided, and manœuvring of large vessels, which is always troublesome, is avoided (Lisnave can receive ships of up to a milion TDW). This simplification of manœuvres has considerably enhanced the safety of cleaning and degassing operations, and at the same time reduced their cost by reducing the time element and the number of tugs needed.

It is important to stress that during some 500 manœuvres carried out to date, there has not been a single accident between the vessels serviced and the cleaning stations, which underlines the safety of this type of tying up. For coming alongside, the stations are equipped with fenders fixed on their sides. At the beginning it was thought of carrying out simultaneous mooring to two ships, and fenders were put on both sides. This solution had to be discarded for safety reasons, which make it inadvisable to keep three ships anchored using only the anchors of the station. Mooring is done with the bows of the two vessels facing in the same direction.

The first cleaning station was equipped with special booms for supporting the hoses connecting it with the ship being serviced. This solution was abandoned in the subsequent stations built, since the difference in height between the tankers and the cleaning stations increased as the former became bigger, so that the connection by means of the boom became impossible. The last two stations constructed are fitted with metal towers, and the connection is made, at the ends, through flexible hoses. The residues are received through the hoses and then enter the tubes which constitute the actual supports of the towers. These towers can provide connections at different heights, so as to make it possible to service ships of different sizes.

VI. SEPARATION SYSTEM

The separation system in use by Gaslimpo has, since the beginning, been a continuous separation system, based on a volumetric separator, of the cascade type, which has been improved. The first cascade built occupied a volume of 4,500 m³, and made use of five central tanks of the vessel. These tanks were partly filled with water at decreasing levels (cascade), connection between two consecutive tanks being made by means of conduits. At the higher levels of the liquid to be separated, heating coils were fitted, and these enable the temperature of the mixture to be raised to 85ºC in order to facilitate and speed up the water/oil separation. Unfortunately this process permitted the formation of gaseous masses in the spaces of the tank that were not filled with water, with the risk of losing the operations safety.

In the second ship that was converted, the volume of the separator was stepped up to 7,500 m³, occupying four lateral and two central tanks amidships. The most important alteration introduced in this separator is that the tanks are completely filled, the whole volume being used for separation.

For the communication between consecutive tanks, the conduits were abandoned, and this is now carried out through simple openings that are alternately higher and lower. The fluid that enters a tank in the lower part is forced out through the upper part, and thus a current is ensured involving the whole mass of water being processed. Discharge into the sea is provided through a pipe, two metres above the deck, so that a system of communicating compartiments maintains a permanent flow after reception has begun.

Whereas in the original cascade, collection of the separated oil was made at the upper level of the water in the various tanks, through openings that comunicated with the lateral tanks, in this second station collection is done through the hatch covers, where the necessary connections have been made leading to the storage tanks.

In the third cleaning station, the principle described above was retained, but in this case two separators were arranged, each with a volume of 7,000 m³ and capable of working independently of each other or together, thus increasing the volume to 14,000 m³. Here too, the total volume of the tanks was used for separation, but conduits are once again utilized for connection between tanks, as in the first station.

Entry of residues to be processed is, in all these separators, made through a damper placed just after the entrance of the first separating tank. The purpose of this is to cause the formation of small particles, by slowing down the incoming flow, and thus allowing separation of the water/oil mixture to be carried out more easily.

All these separators are equipped with heating coils placed in the upper part of the tanks, independently of the bottom coils which are kept in all tanks used for separation. The working of the upper coils is considered very important for the return obtained in separation, as the clean state of the separator is fundamental, since the quality of the effluent from the cleaning station deteriorates quickly if there is any accumulation of solid residue on the separator tank walls.

In order to collect the oil that is recovered, one has fitted conduits at the separation levels : these remove the oil to the storage tanks. This oil is, however, still mixed with a high percentage of water, and a second separation has to take place, by decanting in the storage tanks, which have bottom coils for maintaining a high temperature. At the end of a period from 48 to 96 hours, the water has been almost completely separated, and is pumped once more into a separator, where it is thoroughly cleaned of any residual oil that it still contains.

Separation output, as well as the rate of intake, depend on the quality of the mixture that one wishes to process. Should we have to separate or process ballast water in which oil contaminated is around 0.5 to 2%, the output of the separator is quite different from when we have to process slops, which contain as much as 50% oil and 50% water. Another factor to be taken into consideration, and which considerably affects the separation output, is the degree of emulsibility of water/oil, often aggravated by the addition of chemical products used for cleaning the tanks. In these cleaning stations intake rates are attained, which vary between 2,500 Tons/hour, in cases of low contamination ballast, and 200 or 300 Tons/hour, in the case of highly emulsified oil which is hard to separate.

A knowledge of the kind of residue that has to be processed is thus a fundamental need, and it is the characteristics of that residue which will determine the pumping rate. Also the cleanliness of the cascade must be considered in each case, its working conditions and rest period between consecutive operations.

Gaslimpo has five years' operating experience with these units, and during that time more than 2,000,000 tons of contaminated water have been treated.

Analysis of the effluent discharge into the river from the cleaning station has received great attention. During the servicing of each vessel, samples are taken for analysis, and these are periodically monitored.

VII. PARTICULAR ASPECTS OF THE CLEANING STATIONS AND THEIR EXPLOITATION

The use of recovered oil as fuel.

An important factor in exploiting these cleaning stations is that the fuel burnt by the boilers comes from making use of the oil recovered by the separators. In order to make this possible, the vessels had to be fitted with a processing system capable of rectifying the flash point of the crude recovered. This flash point is about 20 °C and has to be corrected to about 70 °C so that the crude can be safely used in the burners. Processing tanks were constructed for this purpose, and inside them the light products are released by means of steam injections. The fuel thus obtained is used in the normal burner installations of the station, precautions being taken to heat the feed circuit, since the pour-point of this fuel is high owing to its high content of paraffin wax. The use of processed oil as fuel for the station is regarded as one of the factors having the greatest influence on the exploitation economy of these installations.

Maintenance of the Stations.

The problems of maintenance presented by installations of this kind are delicate, since they are the result of converting vessels which were nearing the end of their profitable exploitation as oil carriers. First of all, therefore, an investment has to be made in a careful overhaul and repair of those sectors that will be most important for the working of the station : boilers, auxiliary generators, the whole pumping installation of the engine room, pump installation in pump-room, electrical installations, tanks, namely ruptures and cracks in the bulkheads, careful repairs to the bottom coils and repair of all the manœuvring equipment needed for moving the cleaning station. After such initial repairs, all thsee organs that are essential for the proper operation of the station must be kept in good working order, and it is a wise practice to keep in duplicate any that may involve a risk of stoppage for the whole station.

Maintenance costs for this type of installations are usually high when compared with fixed new installations, for it must be borne in mind that the ageing of the various organs will mean a high maintenance cost. A favourable factor in these costs is the use that can be made of the crew during periods when the station is not operating and is idle at its anchorage. The engine room personnel can then be employed on maintenance which would otherwise have to be done by men contracted outside specially for the purpose.

Crew.

The crew of a cleaning station consists of seven men, and is increased during manœuvring by a bridge officer and normally two seamen to help in passing cables between the two ships.

Since cleaning stations have to operate 24 hours a day, the total number of persons involved in the exploitation is multiplied by three, but we must consider

28 men for keeping an installation of this type working throughout the year, allowing for absence, weekends and holiday periods.

Safety precautions on board.

Safety measures on board are one of the most important points in operating a cleaning station, since it is a non-degasified installation, and the risk of accidental explosion is high. All personnel engaged in this work are put through strict damage control courses, with the aim of reducing to the minimum any accident due to ignorance. Safety precautions on board are widespread and are strictly enforced, any breach of regulations being severely punished.

VIII. ECONOMIC VIABILITY

Investment.

Investment in a station of this kind reaches a figure that may vary between \$1,500,000 and \$2,000,000, which is considered to include :

— initial cost of the vessel;
— towage expenses;
— initial repair of the vessel;
— conversion of the vessel into a cleaning station;
— final trials.

This figure is variable, depending on the tonnage of the vessel to be bought and the processing capacities that are aimed at.

Operational costs.

These may be divided into :

— labour;
— maintenance;
— fuel and other materials.

Labour.

It is hard to give numbers for the personnel involved in operating one of these stations, since this basically depends on the daily number of hours of activity, as well as on the local cost of labour.

The following crew must be regarded as necessary :

— 1 engine room officer;
— 1 boilerman;
— 1 greaser;
— 1 pumpman;
— 2 seamen;
— 1 electricien,

for each shift.

To this personnel must be added one bridge officer and the seamen required during tying-up manœuvres, but they may be contracted for only these periods.

Maintenance.

For a cleaning station of about 20,000 TDW, obtained from converting a 20 years old ship, it is necessary to rate an annual maintenance cost of about $120,000.

Fuel and other materials.

Having in mind that the fuel has to be recovered from oil processed by the station itself, $50,000/year to operate the three ships is considered sufficient for this item.

Rates and Profits.

There are two ways of working out charges for this kind of service :

— hourly rate for keeping the station occupied, regardless of the type of residue received;
— rate per ton of residue received, the charge rate varying according to the type of residue.

Gaslimpo charges the hourly rate for use of the station, although in other European countries and in Japan, the rates per ton of residue received from the tanker are more common.

Working out rates will aways depend on a forecast of the work produced, since this type of operation offers few possibilities of conversion into other activities.

As regards earnings, it is important to take into account for the exploitation, the value of the oil recovered that can be sold as fuel or to refineries.

A cleaning and slops-receiving station is usually presented as a low-return investment. We know that some shipowners are not prepared to use slops-receiving stations, involving extra expense, unless they are obliged to do so. However the evolution of national and international laws, which are becoming tighter and more exacting, will tend to change the situation, fundamentally under the pressure of heavier fines. An investment that at the present moment may seem of little economic interest, may thus later on deserve the attention of some of entrepreneurs.

IX. CONCLUSION

It has been our intention to present a solution as carried out in Portugal, — one which enables IMCO's fundamental recommendations to be met, in their aim of wholly eliminating the discharge of oil into the sea. Its generalised use will depend on studies and analysis of the local conditions of each port.

In Lisbon, the high occupation density of the zones round the port, the land values in those same zones, the difficulty of reclaiming land from the sea, and the considerable manœuvring area available in the Tagus estuary, have made floating residue-collecting stations a solution that is both economical and efficient. Their efficiency is proved by the five years of operation, during which over two million tons of oil-contaminated water has been tested, this means more than 100,000 tons of oil which not only have not been dumped into the sea, but also have been economically recovered.

RÉSUMÉ

La pollution des eaux des mers par le pétrole résultant du transport maritime, constitue un des problèmes difficiles à résoudre dans l'objectif de la lutte contre la pollution des mers. Les navires-citernes représentent une source potentielle de pollution soit accidentelle soit opérationnelle que le trafic maritime en progrès met de plus en plus en évidence. Il est pratiquement impossible d'éviter à bord la contamination d'eau par le pétrole et son élimination traditionnelle est faite par rejet à la mer.

Les résolutions de l'IMCO, contenues dans la Convention Internationale sur la prévention de la pollution des eaux de la mer en sont les conséquences. Parmi ces résolutions on peut retenir celles souhaitant la création d'installations de réception des résidus d'hydrocarbures et eaux polluées dans les ports de chargement et déchargement de produits pétroliers, ainsi que dans les ports où existent des chantiers de réparation. On attend la mise en place d'un réseau stratégique de ces installations pour promulguer une législation interdisant tout rejet d'huiles à la mer.

La situation géographique du Portugal (60 % de la flotte mondiale de navires-citernes longent sa côte), alliée à l'existence à Lisbonne des grands chantiers navals de réparation de Lisnave, a alerté le Gouvernement portugais sur la nécessité de promouvoir une politique de défense de la côte contre les risques éventuels de pollution. C'est ainsi, qu'ont été construites des installations de nettoyage et de réception pour les résidus d'hydrocarbures et d'eaux polluées, qui constituent, elles-mêmes, un élément décisif dans la réduction de la pollution de la côte portugaise provenant des effluents résultant de l'exploitation normale des navires-citernes.

A Lisbonne, il y a trois stations exploitées par Gaslimpo, entreprise qui a été créée spécialement dans ce but.

Ces stations résultent de la conversion de trois anciens navires-citernes dont on a démonté tous les organes superflus et laissé en service tous ceux qui sont indispensables pour le fonctionnement d'une installation de ce genre. Ces stations permettent : la réception des résidus d'hydrocarbures et des mélanges hydrocarburés, le stockage des huiles récupérées et également le nettoyage et le dégazage des tanks.

Dans le cas particulier du Port de Lisbonne, on est arrivé à la conclusion que les installations flottantes présentaient des avantages techniques et économiques par rapport aux installations à terre. Parmi les avantages qui ont constitué des facteurs essentiels dans la prise de décision, on peut citer la grande mobilité, l'absence d'occupation de quais, de meilleures conditions de sécurité, le tout réalisé avec un investissement moindre.

Le procédé de séparation utilisé par Gaslimpo est un système continu, type cascade, réalisé dans les tanks du navire qui ont été spécialement modifiés pour satisfaire à leur nouvelle fonction. Les rendements de la séparation et le débit de réception dépendent de la qualité du mélange à traiter, variant entre 2,500 Tonnes/heure et 200 Tonnes/heure selon qu'il s'agit d'eaux de lest ou de slops trop émulsionnés.

Comme aspect particulier de ces stations et de leur exploitation on peut faire remarquer que le pétrole récupéré peut être utilisé comme combustible dans les chaudières. Les dépenses d'entretien des installations de ce type sont nécessairement plus élevése que celles d'installations sur terre du fait qu'elles sont réalisées à partir de vieux navires-citernes. L'équipage comprend sept hommes par journées de travail successives. La sécurité à bord est un des points les plus importants dans le fonctionnement d'une station de ce genre.

La viabilité économique d'un projet de ce type est parfaitement assurée et démontrée dans le cas du Port de Lisbonne et on s'attend à ce que cette croissante intensification dans la lutte contre la pollution des mers rende dans l'avenir cet investissement plus attrayant pour les entrepreneurs.

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RAPPORT

par

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DÉVERSEMENTS D'EAUX RÉSIDUAIRES EN MER

I — NATURE DU PROBLÈME

1. Depuis peu d'années seulement, l'homme a commencé à se préoccuper de la pureté des océans et des mers et a cessé de les considérer comme des puits sans fond capables d'absorber toutes les matières étrangères déversées dans ceux-ci, soit systématiquement, soit par des accidents technologiques.

La pureté des eaux de mer est de plus en plus précieuse pour l'homme car celui-ci, qui n'a jamais perdu sa nostalgie ancestrale de la mer d'où surgit la vie, fait un usage de plus en plus grand du moyen marin, s'approprie sa surface en la sillonnant avec des navires géants, exploite au départ de plateformes les trésors enfermés sur son fond, et vu l'accroissement des loisirs qui est le propre de notre civilisation, envahit la bande littorale, inonde les plages et descend dans les profondeurs marines à la recherche de nouvelles sensations agréables ou de futurs moyens de subsistance, par l'exploitation rationnelle de la flore et de la faune marines.

2. C'est à ce moment que l'homme commence à se rendre compte que les caractéristiques physiques et biologiques du milieu marin peuvent subir des changements, sans doute irréversibles, dûs à son intervention, et que ces changements peuvent prendre des formes très dangereuses pour sa santé, en aggravant ainsi les conditions dans lesquelles l'homme doit lutter dans un milieu hostile où, cependant, il désire pénétrer à tout prix.

Ces dangers prennent parfois des formes scandaleuses, telles les grandes taches de pétrole provenant d'un accident quelconque ou de délestements inconsidérés, de résidus de matières fécales ou chimiques provenant de déversements terrestres qui nuisent à la vue ou à l'odorat. Mais ils peuvent prendre aussi des formes sournoises, encore plus dangereuses, telle la pollution bactérienne due à des déversements d'eaux fécales, d'eaux agressives ou porteuses d'éléments nocifs provenant de l'industrie chimique, qui en passant par un processus que l'on connaît plus tard, peuvent arriver à engendrer des maladies chez l'homme, et, finalement, celle qui serait la plus létale, celle qui provient d'éléments radioactifs produits par les déversements de centrales atomiques, par des accidents ou des explosions nucléaires ou par l'immersion consciente de résidus de cette espèce dans les profondeurs marines.

3. Cependant, c'est dans le voisinage du littoral, là ou la vie marine s'agite et où se produisent de constants réajustements isostatiques entre la terre et la mer, que la conscience de l'homme moderne est plus sensibilisée en ce qui concerne la pollution, probablement parce que le phénomène migratoire si actuel qu'est le tourisme, attire vers ces fenêtres sur la mer que constituent les côtes, une marée croissante d'êtres humains qui recherchent des loisirs, demandent des eaux libres et propres et, paradoxalement, en raison de leur propre affluence, les salissent et les polluent.

La mer, qui est de plus en plus considérée comme le sang de notre planète et dont la productivité biologique est très supérieure à celle de la terre, dépend, quant à sa pureté des échanges, avec la bande côtière. Naturellement, c'est celle-ci qui à travers les cours d'eau ou artificiellement par des conduites faites de la main de l'homme, déverse à la mer ses déchets, ses résidus humains et industriels en posant ainsi le problème qui nous occupe : celui du déversement des eaux résiduaires dans la mer.

II — FORMES DE POLLUTION

1. Les formes de pollution par déversement d'eaux résiduaires en mer en provenance de la terre peuvent se diviser en deux grands groupes :

a) Pollution gênante ou antiesthétique, comme celle qui se produit par la présence d'ordures dans l'eau de mer, d'écumes persistantes, de boues stériles et similaires, qui détournent les baigneurs, peuvent causer des préjudices à la navigation de plaisance ou sportive et, d'une façon générale, nuisent à la vue et à l'odorat;

b) Pollution dangereuse, aussi bien pour les personnes, car il s'agit d'eaux fécales ou chimiques agressives marines ou vénéneuses, que pour la flore ou la faune, en rompant leur équilibre écologique par des modifications physico-chimiques ou biologiques du milieu marin ou en les utilisant comme réceptacle de concentrations bactériennes, substances chimiques ou radioactives et servant de véhicule aux maladies de l'homme une fois ingérées par celui-ci.

2. Le premier genre de pollution est plus accentué sur les plages fréquentées se trouvant près des embouchures d'un cours d'eau, lequel, en amont, emporte

les déchets qui y sont jetés (papiers, plastiques, bois), les déversant dans la mer où, selon le régime de courants dominants, ils sont répandus sur toute la côte. Les bois flottants constituent spécialement un danger pour le motonautisme. Si ces cours d'eau sont, en outre, utilisés comme voies d'élimination de produits stériles provenant de lavages de minéraux ou d'usines chimiques, ils peuvent engendrer une pollution très gênante car ils altèrent la couleur de l'eau de mer ou la remplissent d'écume persistante, accumulée sur les plages par le vent et les courants. Un cas particulier est constitué par les eaux terrestres qui, servant de drainage aux zones agricoles d'irrigation ou étant porteuses de résidus provenant de fabriques chimiques, contiennent une grande concentration de nourrires, normalement des phosphates qui, dans des zones abritées de la côte (cales, estuaires), produisent une prolifération de la flore marine à double effet : celui de la décomposition des matières organiques produisant de mauvaises odeurs et des eaux troubles, ainsi qu'une consommation excessive d'oxygène arrivant même à éliminer la faune marine de ces lieux.

Cette pollution, gênante mais non dangereuse pour la santé de l'homme, peut être très nuisible au développement économique de zones littorales qui disposent de ressources côtières pour les emplacements destinés à l'habitat et aux loisirs (bains, sports terre-mer).

3. Le second genre de pollution, celui qui est dû aux eaux fécales, s'accentue fortement dans les grands centres urbains permanents qui connaissent l'affluence en période d'été. Même si apparemment le fait de se baigner dans l'eau de mer ainsi polluée établit, à première vue, une association avec un risque de maladie, la réalité est que les nombreuses études faites dans différents pays n'ont pas abouti à l'établissement d'une corrélation définie qui pourrait conduire à un rapport cause-effet. Ce qui est plus dangereux et où réellement on observe cette corrélation c'est dans les mécanismes par lesquels la flore et la faune sont capables de fixer et de concentrer des matières toxiques ou des bactéries; c'est pourquoi la présence de parcs de mollusques dans les eaux polluées est aussi dangereuse pour la santé de l'homme que l'irrigation de terres de cultures maraîchères avec des eaux résiduaires qui n'auraient pas été préalablement épurées.

III — AUTOÉPURATION MARIN

1. Une fois dépassée l'idée de considérer la mer comme un puits sans fond, il convient de signaler, d'autre part, le fait qu'elle possède les mécanismes adéquats pour lutter contre l'accumulation de substances étrangères que l'homme y déverse. Ces mécanismes agiront parfois sans diminuer les propriétés de ses eaux, ni son équilibre biologique; dans d'autres cas, ils produiront des altérations plus ou moins profondes, certaines d'entre elles irréversibles en ce sens qu'elles peuvent faire disparaître localement des espèces incapables de résister aux changements écologiques dans une zone déterminée.

2. Quant à la pollution gênante, engendrée par des objets flottants, une fois que ceux-ci ont atteint la surface, l'action conjointe du vent et de la houle peut provoquer leur dispersion, mais normalement ils sont entraînés vers les côtes et

contaminent le littoral. Il faut absolument tenir compte de ce fait au moment d'effectuer les déversements d'ordures dans la mer, même si l'on prétend avoir choisi judicieusement l'endroit pour les réaliser. Nous devons signaler que, si le déversement se fait à une profondeur suffisante, nous parlerons plus loin de son importance, la plupart de ces solides restent déposés dans le fond et ne flottent pas, comme on l'a observé dans des émissaires espagnols, la décantation s'enregistrant même pour les emballages en plastique.

3. Au chapitre de la contamination dangereuse, on a parlé de différents mécanismes par lesquels la faune et la flore épurent les eaux contenant certaines matières et bactéries mais c'est pour les concentrer en substances que l'homme emploie dans son alimentation, ce qui ne suppose qu'un processus inverse par lequel la mer se venge de l'homme et, d'une façon dangereuse, lui rend les objets étrangers que celui-ci y déverse. Cependant, on doit faire ressortir l'existence de deux genres de processus, qui assure un certain degré d'épuration bactérienne des eaux de mer :

a) les processus physiques, basés sur la dilution et la décantation de la matière organique porteuse de bactéries qui, en réduisant leur concentration, diminuent le danger de pollution en ce qui concerne l'eau de mer. Il peut cependant arriver que le phénomène de la décantation ait pour résultat de hautes concentrations de matières organiques et de bactéries à l'état léthargique dans le fond de la mer d'un tirant d'eau insuffisant, de sorte que les grandes tempêtes — qui, d'autre part, se produisent généralement en dehors de la saison normale de bains — la renouvellent et provoquent rapidement des concentrations élevées de matières contaminantes; ou bien cette matière organique déposée dans le fond sert d'aliment aux êtres marins et, dans ce cas, le mécanisme dévolutif mentionné plus haut entre en jeu. Parmi les processus physiques il faut signaler aussi l'influence que pourraient avoir la lumière, les rayons ultraviolets et les températures sur la flore microbienne, mais les recherches entreprises dans ce domaine ne sont pas fort optimistes au sujet de la possibilité d'une sensible réduction des bactéries par ces effets;

b) les processus biologiques où la mer, de préférence en été et coïncidant avec l'existence d'une plus grande concentration de la flore marine, exerce, au moyen de mécanismes qui ne sont pas encore bien expliqués, une action antibiotique évidente, indépendamment des processus physiques mentionnés précédemment.

Si cette action est due, à ce qu'il paraît, à l'existence du phytoplancton, il serait très intéressant d'établir le profil marin qui lui sert d'habitacle écologique, aussi bien en distance (D) à la côte qu'en profondeur (P) de façon qu'en combinant, comme il est indiqué à la fig. 1, le triangle défini par D et P avec la zone H où se fait sentir l'action de la houle sur le fond, on obtient la détermination d'une zone Z où sont combinées les propriétés favorables des niveaux antibiotiques, avec sédimentation

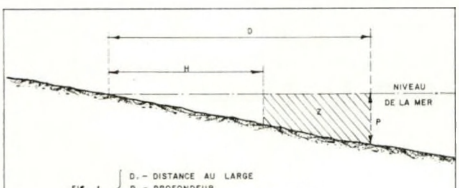

FIG. 1 D. – DISTANCE AU LARGE
P. – PROFONDEUR
H. – ACTION DE LA HOULE SUR LE FOND

stable de matière organique, c'est-à-dire qu'il y aura une coïncidence entre les processus physiques et biologiques en ce qui concerne l'épuration.

IV — ACTION HUMAINE

1. Etant donné la portée et l'importance du problème que posent les déversements d'eaux résiduaires en mer, la prévention et le contrôle doivent s'effectuer au plus haut niveau national, en adoptant des mesures qui relèvent précisément du domaine du droit administratif, avec le concours duquel les Gouvernements peuvent établir la norme, régler son application et sanctionner les infractions, sans préjudice de la responsabilité civile incombant au contaminant pour les dommages qu'il pourrait causer à un tiers.

Une des actions préalables à toute élaboration de normes consisterait à fixer les conditions que doivent remplir les eaux résiduaires déversées, en fonction des standards de qualité que doivent conserver les eaux de mer afin déviter, selon les cas, d'inadmissibles contaminations gênantes ou dangereuses.

2. En ce qui concerne la contamination gênante, touchant spécifiquement les lieux destinés aux bains, la qualité voulue semble être atteinte si la contamination ou ses résultats ne sont sensibles ni à l'odorat ni à la vue, dans ce dernier cas, ni du fait de la présence de corps solides ou d'écumes flottantes ni par des altérations appréciables dans la couleur normale de l'eau. Ce critère idéal serait difficile à maintenir, et la difficulté provient du fait de pouvoir établir quelle est la quantité de solides ou d'écumes flottantes ou à partir de quelle modification de la couleur de l'eau apparaissent les gênes aux personnes, c'est-à-dire qu'il faut essayer d'établir un standard esthétique. Dans les normes provisoires concernant le déversement d'eaux résiduaires en mer, le long des côtes espagnoles, on part d'une DBO moyenne de 360 gr/m^3, ce qui conduit à une dilution initiale minima de 40, et, compte tenu du fait que, sur les plages et zones destinées aux bains, on prend un cœfficient de sécurité de 2, la dilution monte à 80 ou la DBO admissible descend à 180. Cependant ces chiffres, à eux seuls, ont démontré parfois qu'ils ne peuvent pas résoudre le problème de la turbidité. Il faut tenir compte, en outre, qu'on exige, au moins, un traitement de dilacération qui réduise les solides à une grandeur moyenne de particules inférieure à 1 m/m.

3. La contamination qui pourrait s'avérer dangereuse pour la flore ou la faune marines, comme celle qui provient du déversement de nourrires, normalement des phosphates, se produit, soit par des résidus d'usines chimiques déversés directement ou par des égouts urbains non séparatifs, soit par des écoulements directs de cours d'eau qui traversent et drainent des zones agricoles. Il est difficile d'établir le niveau de nourrires qui peut causer des déséquilibres écologiques dangereux et, en tout cas, l'action doit être dirigée non pas tellement vers l'établissement de normes, mais plutôt vers l'imposition de traitements qui éliminent une proportion plus réduite de matière organique et une plus grande quantité de nourrires; en tout cas, il faudrait arriver à interdire les déversements dans les zones de

flottaison fermées, comme les cales et les estuaires d'une abondante biologie marine. On doit faire remarquer que nombre de ces zones sont utilisées pour les bains et les loisirs, et la prolifération d'algues avec leur décomposition correspondante de matières organiques entraîne une importante contamination gênante et dangereuse pour l'économie de la zone.

4. Il nous reste à parler du problème de la détermination de standards de qualité des eaux par rapport à la contamination dangereuse pour les personnes. L'élément composant des eaux résiduaires, facile à déterminer par des procédés de routine est le E. coli. Les bactériologues espagnols procèdent très différemment les uns des autres pour déterminer le standard de danger : certains le signalent à partir de 2.000 coli par 100 ml, d'autres seulement à partir de 1000, et d'autres ont défini strictement comme plages peu recommandables, celles qui, à moins de 250 m du rivage, contiennent 500 coli par 100 ml, comme douteuses celles qui présentent entre 200 et 500 et comme recommandables celles qui ne dépassent pas le chiffre de 200. D'autre part, il y a des standards fixés à 2.400 coli par 100 ml. et des plafonds allant jusqu'à 10.000. Ce problème qui, en principe, semblerait contradictoire, pourrait être résolu si, en tenant compte des procédés de comptage et du fait qu'il s'agit de déterminer des critères statistiques, on arrivait à définir une distribution par sa valeur moyenne la plus probable et en spécifiant à quel pourcentage doit se trouver la valeur de comptage considérée comme plafond maximum, en établissant un rapport entre ces chiffres et certaines fractions de la distance entre le point de déversement et la côte.

5. De toute façon et, en supposant que l'on puisse arriver à l'établissement de standards réalistes et satisfaisants pour chaque cas, le problème de leur application simultanée, surtout dans les zones fréquentées par les baigneurs, subsisterait encore, car, psychologiquement, la contamination gênante produit sur les personnes un impact plus fort que la dangereuse; celle-ci, n'étant pas aperçue immédiatement par les sens, ne sensibilise pas le danger qu'elle représente.

V — SYSTÈMES DE DÉVERSEMENTS

L'élimination des eaux résiduaires peut se produire de différentes manières. Dans celle que nous mentionnons ci-après, on se réfère aux méthodes qui, directement ou indirectement, ont une incidence sur le littoral.

1. Une des formes les plus courantes d'arrivée d'eaux résiduaires en mer, est celle qui se produit par des écoulements (drainage du terrain, écoulements d'irrigations littorales) et à l'embouchure des cours d'eau. Ces deux formes de déversements sont très nuisibles car ces eaux contaminent, immédiatement et directement, les eaux de mer en contact avec la côte, et leur incidence est encore plus grande dans les mers non soumises à marée. Dans le cas des écoulements, le problème est difficile à résoudre, bien qu'alors la contamination provienne principalement de nourrires mais aussi de pesticides. La seule solution possible serait celle de la canalisation des écoulements artificiels des irrigations, avec

traitement postérieur à l'aménagement de l'eau, mais cela entraînerait certainement des dépenses considérables.

Quand il s'agit de cours d'eau, le problème doit être étudié en amont de ceux-ci, en agissant préventivement sur les centres urbains ou sur les industries qui y déversent leurs eaux. Si les standards de qualité, fixés pour ces eaux terrestres, sont bien en rapport avec la distance de leurs points de déversement en mer et si le pouvoir épurateur des cours d'eau est supérieur à celui de la mer, on peut arriver à obtenir une qualité acceptable à l'embouchure. Cependant, le problème se complique dans des pays qui, comme l'Espagne, ont des cours d'eau de régime très irrégulier, avec de grands étiages malgré le vaste réseau de réservoirs de retenue construits ou en construction. De toute façon, on peut arriver à renforcer les mesures de prévention en fonction des débits apportés par le cours d'eau, bien que cela constitue, en principe, plus une considération technique qu'une mesure établie facilement.

2. Le deuxième système de déversement d'eaux résiduaires pourrait s'appeler de « non déversement », cette dénomination comprenant deux classes : *a*) installations d'épuration sans sortie à la mer et *b*) utilisation des eaux résiduaires à l'intérieur du pays.

3. Dans les normes espagnoles mentionnées ci-dessus, on interdit formellement l'utilisation de puits septiques filtrants à proximité des plages; ils ne sont autorisés que s'ils se trouvent suffisamment éloignés et situés dans des terrains dont la perméabilité ne puisse pas supposer une communication directe avec la mer, à travers le sous-sol, les distances entre les puits et le nombre d'habitants qu'ils desservent étant limitées. Les fosses septiques étanches ne posent pas ce problème mais bien celui de leur nettoyage; ils sont seulement utiles pour des logements unifamiliaux ou de petits ménages car ils admettent même un traitement chimique de l'effluent à un prix peu élevé. On a même parlé d'injections d'eaux résiduaires dans le sous-sol comme méthode d'élimination, mais en prenant comme point de départ que la garantie d'un bon résultat résiderait dans une parfaite connaissance du sous-sol et de ses courants et afin de ne pas provoquer des risques de contamination supérieurs à ceux que l'on désire éviter; nous rappelons ici un événement qui s'est produit en un endroit situé sur la côte de l'île de Majorque. L'accumulation dans le sous-sol de cet endroit, pendant des mois, d'eaux résiduaires provenant d'un grand hôtel à travers une fosse septique non étanche, produisit soudainement, un jour, un effet siphonique et la décharge consécutive de tout l'effluent accumulé dans une cale voisine, ce qui la contamina totalement et compromit, durant une saison, la pureté de ses eaux, d'où un désastre sur le plan économique pour les établissements hôteliers.

Un phénomène analogue se produisit, il y a quelques années, en un autre lieu de la côte, où les eaux résiduaires provenant d'une fosse septique d'un grand hôtel commencèrent à jaillir en forme de puits artésiens au milieu d'une plage contiguë.

4. La récupération des eaux résiduaires présente, en principe, le double avantage d'éviter la contamination de la mer et de contribuer à résoudre le manque

croissant de ressources hydrauliques, qui commence à se manifester dans certains pays.

Cependant, la récupération n'est pas exempte de difficultés, non seulement d'ordre économique. Le caractère unitaire de la plupart des collecteurs des grands centres habités fait que les eaux résiduaires fécales sont mélangées aux eaux résiduaires industrielles, en compliquant et en élevant ainsi le coût des traitements et en réduisant les possibilités d'une utilisation postérieure. Dans les centres urbains nouveaux, situés sur la côte et à vocation touristique, le problème ne se pose pas, mais il existe dans l'emploi des eaux résiduaires, traitées, s'il n'y a pas de zone agricole à proximité. De cette façon, si les coûts d'élévation aux zones de traitement — normalement situées loin des côtes et isolées — et les coûts du traitement se situent à des taux abordables, le déséquilibre économique que suppose un long transport aux zones agricoles, où pourrait être utilisée l'eau, peut avoir une influence négative. Dans d'autres cas où cet aménagement est possible, il n'existe pas toujours un équilibre entre la demande et l'offre et si celle-ci est supérieure, le problème de l'élimination des excédents se pose de nouveau.

De toute façon et, malgré ces difficultés, les plans espagnols d'infrastructure sanitaire dans les zones côtières ne négligent pas la possibilité de récupération lorsque les circonstances sont favorables. Dans les nouveaux centres d'expansion, les réseaux d'égouts séparatifs d'eaux fécales et industrielles s'imposent, à moins que ceux-ci n'effectuent une épuration spécifique dans chaque cas.

5. Si, des considérations ci-dessus, on déduit qu'il est important de situer l'effluent dans une masse d'eau de mer suffisante pour favoriser une grande dilution et une sédimentation stable, si le point de déversement doit être suffisamment éloigné de la côte pour que, soit la distance, soit les courants marins évitent l'arrivée d'eaux contaminées à un haut degré au littoral et si, finalement, on doit éviter les déversements dans des zones où existent des bancs de mollusques ou faune et flore marines susceptibles d'être affectés par la contamination, on arrive à la conclusion finale que cette action, conditionnée par tant de facteurs, ne peut être menée avec succès que grâce à la construction d'émissaires sous-marins.

VI — ÉMISSAIRES SOUS-MARINS

1. Les facteurs, dont on doit tenir compte dans le projet d'un émissaire sous-marin, sont très complexes. Il faut, tout d'abord, signaler la zone de la mer où doit être située l'extrémité — en principe, le critère signalé à la figure 1 pourrait être appliqué — et indiquer les moyens économiques d'y parvenir ainsi que les possibilités techniques de l'ouvrage. Un autre point important est celui de la répercussion que pourrait avoir le déversement sur la flore et la faune existant dans cette zone; et, enfin, l'efficacité de l'émissaire projeté doit être étudié du point de vue des deux formes de contamination : la dangereuse et la gênante, car les considérations de caractère esthétique et psychologique sont de plus en plus importantes et conditionnent de plus en plus les solutions à adopter, impliquant

parfois que les standards de qualité esthétique soient plus impératifs, et obligeant de réaliser des ouvrages excessifs par rapport aux autres standards.

Photo 1.

Importance de la profondeur.
Longueur = 500 m.; profondeur = 8 m.
On voit parfaitement la tache.

2. Lorsqu'il s'agit du projet d'un émissaire sous-marin destiné au déversement d'eaux fécales, l'alternative suivante est inévitable : traitement préalable complet de l'effluent et déversement court ou déversement long avec un traitement sommaire. Diverses questions sont mises en évidence dans l'exposé du problème :

— possibilité d'accomplissement simultané suivant les normes esthétiques et bactériologiques;
— degré de traitement et possibilités en terre;
— complexité des ouvrages en fonction de la longueur et de la profondeur;
— étude économique des deux systèmes.

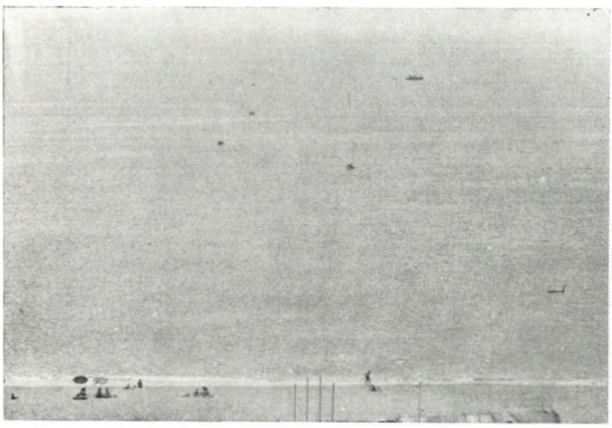

Photo 2.

Importance de la profondeur — Emissaire, prolongé jusqu'au bateau au fond, sans tache, même avec emploi de fluorescéine. (Longueur = 1.000 m.; profondeur = 36 m.).

Du point de vue bactériologique, la solution de traitement complet semble être la plus raisonnable car, même à des températures très élevées, il continue à exister entre 15 et 20 % de bactéries, tandis qu'avec un traitement de simple décantation on n'arrive pas à un chiffre inférieur à 70 %. Mais, précisément parce que l'on déverse des eaux traitées, la démarche logique suivante est de projeter un émissaire court car, à ce moment, la dilution exigée sera plus petite. Par exemple, dans les normes espagnoles, un traitement par décantation réduit la dilution initiale exigée de 40 à 30 tandis qu'un traitement à épuration complète, biologique et chimique la réduit à 10.

L'émissaire court — on comprend par là un émissaire d'une longueur inférieure à 300 mètres pour un débit de plus de 100 l/sec. — présente deux inconvénients :

a) à moins qu'il ne s'agisse de profils du fond marin à grande pente — comme c'est le cas des îles Canaries — un émissaire de ce genre se situe entre 6-8 mètres de tirant d'eau; l'expérience espagnole signale que, à moins d'effectuer un traitement préalable complet, il est difficile, à cette profondeur, d'arriver à un standard esthétique acceptable. Inévitablement la classique tache couleur chocolat apparaîtra et une couche de graisse s'étendra sur la surface de l'eau, et si le traitement est parvenu à éliminer ces effets, il reste encore la sensation gênante de se trouver dans un milieu différent de celui de l'eau de mer, en raison de la faible salinité;

b) tout défaut ou fonctionnement défectueux de la station épuratrice engendrera de grandes contaminations, ce qui implique la nécessité d'ajouter au traitement, déjà coûteux, une stricte surveillance, qui ne fait qu'augmenter les frais d'entretien.

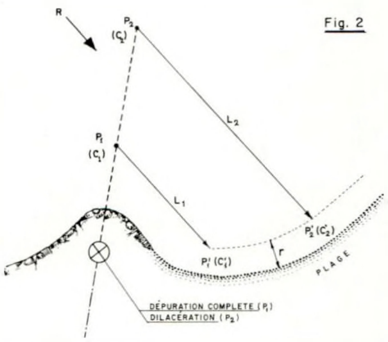

Fig. 2

P_1 – rejet court
P_2 – rejet long
R – orientation dominante des vents et courants
r – rayon d'action des baigneurs
C_1, C_2 – concentration de E. coli

Il faut considérer que, si, en principe, l'idée de traitement préalable intense est acceptable, elle ne l'est pas si on l'associe avec un émissaire court; il s'agirait alors d'examiner le problème sous le point de vue que résume la figure 2. Considérant les points de déversement P_1 (court et à traitement complet) et P_2 (long et à traitement sommaire) avec leurs concentrations de coli respectives de C_1 et C_2, et R étant la direction dominante d'entraînement, la mortalité bactérienne due aux multiples causes étudiées au paragraphe III agirait tout au long des distances L_1 et L_2, en arrivant ainsi à la limite de la zone de bains (P_1 et P_2) avec des concentrations C_1 et C_2. L'étude de l'alternative P_1 — P_2 devrait partir de l'hypothèse $c_1 \leqslant c_2$ si l'on donne la préférence au traitement complet ou de la $c_2 \leqslant c_1$, si l'on donne la préférence au déversement éloigné et traitement sommaire. Naturellement la distance P_1P_2 dépendra du degré de traitement et atteindra son maximum lorsque celui-ci sera complet.

De ce schéma ressort l'énorme importance qu'il y a de parvenir à établir un index moyen de vie des bactéries en mer (actuellement les temps oscillent d'heures à jours, selon les auteurs) et des études détaillées des courants (et en définitive de R) qui doivent être effectuées pour déterminer le point le plus adéquat du déversement.

3. Compte tenu du coût élevé qu'implique une épuration complète, si l'on compare le coût d'une installation de traitement de ce genre avec déversement court (comprenant les frais de premier établissement, capital et entretien annuel) à celui d'un déversement éloigné avec traitement sommaire, la seconde hypothèse serait très favorable, compte tenu du fait que le coût au mètre de l'émissaire n'augmente pas proportionnellement à la longueur de ce dernier, que le coût du traitement augmente à mesure que celui-ci est plus complet, l'hypothèse étant émise que, pour des raisons d'ordre esthétique, il n'y aurait pas lieu de prolonger l'émissaire au-delà du point de déversement répondant aux normes bactériologiques exigées.

Il existe, cependant, des arguments plaidant pour la solution du traitement complet, tels que la possibilité de récupération des eaux et même des boues pour engrais, ce qui, en certains cas, ferait pencher la balance vers cette solution. Cependant, l'utilisation comme engrais n'a pas donné de résultats pratiques; leur pressage, leur enfouissement ou leur incinération occasionnent des frais et posent des problèmes de contamination gênante, tandis que leur déversement en mer au moyen de barcasses présente les mêmes riques que celui des ordures. Comme on le signale plus loin, la solution doit résider incontestablement dans le renvoi à la mer par le même émissaire ou mieux encore par un autre projeté spécifiquement à cette fin.

4. On a parlé antérieurement de l'émissaire long à traitement léger, en comprenant comme tel celui qui exige — et les normes espagnoles l'imposent — une élimination préalable des corps solides de l'effluent. Lorsque cette élimination s'effectue par un simple dispositif broyeur, les résultats ne sont pas satisfaisants. Les dimensions des résidus humains, papiers et fibres en plastique se réduisent un peu mais n'arrivent pas aux dimensions fixées par les normes esthétiques minima. Ce qui arrive en fait c'est que les broyeurs, avec leur orifice d'entrée limité, ne fonctionnent pas sans criblage des solides, lequel peut s'effectuer au moyen d'une double grille ou, comme dans l'installation de Palma de Majorque, par des tambours de mailles. Les solides ainsi séparés peuvent être retirés, soit pour être enterrés, soit pour être broyés, à la grosseur demandée, dans une installation spéciale et être conduits de nouveau au point de déversement.

Pour que les installations de criblage puissent fonctionner d'une façon satisfaisante, il est nécessaire que les chambres de ramassage des eaux criblées, préalables au pompage, soient d'une grandeur réduite, de manière à ce que la stagnation des eaux soit minime, évitant ainsi la formation de nouveaux solides si la stagnation des eaux est un peu prolongée. Il en serait autrement si ces chambres étaient conçues comme des réservoirs de sédimentation pour une impulsion postérieure au moyen de pompes spéciales et ramassage de matières pour leur élimination dans la terre.

Etant donné la difficulté d'éliminer ou d'utiliser les boues résultant d'un traitement de digestion, une bonne solution consisterait à les incorporer à l'émissaire, à la sortie de la station de dilacération, en réduisant ainsi la contamination, si toutefois les standards esthétiques ont été respectés. De toute façon, la difficulté de trouver, près de la mer, des terrains disponibles pour les installations de digestion, rend parfois difficile cette solution, à moins que l'on ne pompe les eaux noires loin des côtes, en les traitant sur des terrains isolés, ce qui implique des solutions coûteuses mais techniquement bonnes et viables, si l'importance de la zone demande un traitement intégral de l'effluent.

5. On a vu antérieurement l'importance qu'a la longueur de l'émissaire pour son bon fonctionnement. Ceci est intimement lié à la profondeur atteinte par son extrémité.

Il existe de nombreuses études traitant de la manière dont le jet de l'effluent se mélange à l'eau de mer et de la difficulté d'obtenir une dilution rapide, car les effets accumulés d'une densité minima, la vitesse de sortie et la plus grande température de l'effluent lui donnent de la flottabilité et atteignent la surface dans une zone de transition superficielle où la dilution obtenue est très petite. Ces mêmes expériences démontrent que si l'on porte la profondeur à des valeurs $H/d = 150$, c'est-à-dire 15 m pour un diffuseur d'un diamètre de 10 cm, les lignes ayant la même concentration prennent la forme de bulbe autour de l'axe du jet et celui-ci peut arriver à se renfermer sur soi sans atteindre pratiquement la surface. A ce moment, la transition d'une dilution verticale à une dilution horizontale se produit au-dessous de l'eau et l'on arrive quasi à l'absence de signes d'effluents à la surface.

L'expérience espagnole opérée sur des fonds à pentes moyennes de 2 ‰, de façon qu'avec des émissaires de 1.000 à 1.500 m on atteigne des profondeurs de 20 à 30 m démontre que, même sans broyage, on obtient des résultats satisfaisants; avec criblage et broyage les résultats sont sûrs et l'effluent n'apparaît pas à la surface, ceci pour des débits jusqu'à 200 l/sec. Par contre, les émissaires de 500 m, même à débits réduits, donnent des résultats incertains et dans certaines conditions de vents, de courants ou lors de règlements des régimes de pompage, les normes esthétiques exigées ne sont pas respectées. En outre, à des profondeurs entre 8/10 m, l'effet nuisible de la houle peut se produire sous un double aspect : celui de creuser l'extrémité de l'émissaire, de l'enterrer avec des courants de sable ou de remuer la matière organique déposée sur le fond.

6. Il est donné, ci-dessous, des exemples de comportement d'émissaires pour des objectifs bien différents, où l'influence de la profondeur est mise en relief :

a) Emissaire de Salou (Tarragone) composé de deux conduites de PVC de 250 mm de diamètre, d'une longueur de 1.300 m, 23 m de profondeur et un débit de 200 l/sec. avec broyage préalable et des eaux exclusivement fécales. La norme esthétique est tout à fait respectée car, à première vue, il n'existe pas de coloration trouble ni de taches de graisse; pour pouvoir apprécier la zone de déchargement, il faut recourir à la photographie aérienne. Il n'y a pas eu de variation appréciable de la flore existante à l'extrémité de l'émissaire, mais une augmentation de la faune marine.

Quant au standard bactériologique, les analyses effectuées en été, à l'époque d'un plus grand débit, donnent les résultats moyens suivants :

— Sortie de diffuseurs : plus de 200.000 coli/100 ml.

— A 100 m des diffuseurs en direction de la plage :

— prise surperficielle, plus de 200.000/100 ml;

— prise à 5 m de profondeur, plus de 200.000/100 ml.

— A 200 m des diffuseurs en direction à la plage, plus de 100.000/100 ml.

— A 500 m en direction de la plage, de l'eau non contaminée.

— A 700 m en direction de la plage, de l'eau non contaminée.

Comme on peut le constater, on n'a pas tenu compte, dans les prises d'échantillons successives à différentes profondeurs, des concentrations pratiquement similaires ayant été arrêtées (comme on a pu l'observer dans des analyses systématiques à la côte de Grenade avec des prises à 0,25, 2 et 5 m de profondeur), ce qui vient renforcer les observations qui signalent l'influence minime que les actions de la surface (lumière, soleil) ont sur la mortalité bactérienne.

b) Il s'agit d'un déversement en mer de boues stériles provenant d'un complexe de concentration de mines de spath fluor aux Asturies. Les boues, d'une concentration de 0,83 kg/m³, se composent fondamentalement d'anhydride silicique (50 %) et d'oxyde de fer et baryte (40 %), et leur rétention au tamis de 325 mailles/cm² n'atteint pas 10 %, ce qui fait qu'elles rentrent en suspension dans l'eau, en la colorant vivement, mais ne se déposent pas sur les plages. C'est un cas typique de contamination gênante. Après avoir effectué plusieurs essais de laboratoire, on est arrivé aux conclusions suivantes :

1) Si le déversement s'effectue tout près de la surface, les boues se maintiennent longtemps à la surface et les mouvements de celle-ci contrarient la vitesse de sédimentation.

2) Si le déversement s'effectue en profondeur et si on fixe convenablement la profondeur et la vitesse de sortie, les solides en suspension sont rapidement déposés et n'atteignent pas la surface. La vitesse de sédimentation augmente notablement si l'effluent se refroidit préalablement et surtout s'il est mélangé à l'eau de mer, résultat logique car les deux processus produisent un accroissement de la densité de l'effluent et diminuent sa flottabilité. De cette façon, il se comporte comme une dissolution de densité égale ou supérieure à celle de la mer et se dépose rapidement sans donner une coloration aux eaux de mer. En partant de ces résultats, on construisit l'émissaire d'une longueur de 1.000 m, d'un débit de 250 m³/h et de 20 m de profondeur, qui se comporte correctement, car même le cône de sédiments, qui se formait les premiers jours au fond, à la sortie des diffuseurs, était distribué dans une ample zone par les mouvements de l'eau.

c) Il s'agissait de déverser directement dans la mer l'effluent d'une usine de cellulose reliée actuellement au réseau d'égouts de la ville (fig. 3), avec débouché dans la mer en un point très proche de la côte. Ces eaux résiduaires ont un haut contenu de DBO, mais surtout de lessives qui, étant agitées à la surface et propulsées contre la côte, produisent des écumes persistantes, constituant donc un cas évident de contamination gênante au point (A), tandis que la plage de la ville en est libérée par la présence du cap et la direction de la composante dominante de traînage (R). L'usine qui, à la demande de la Municipalité, déversait par le point A les eaux fécales, uniquement, demanda l'autorisation de déverser à (B) avec un émissaire court à une profondeur de 8 m. L'autorisation fut accordée mais subordonnée à l'épuration de l'effluent des lessives déjà mentionnées; le déversement n'a pas été autorisé pour le moment tant que l'épuration ne sera pas effectuée, car le phénomène qui se produirait est évident : petite dilution à (B), haute concentration superficielle près de la digue et battement des eaux, avec formation correspondante d'écumes qui, entraînées par R contamineraient la meilleure plage de la ville à l'aménagement de laquelle on vient de consacrer près de 100 millions de pesetas.

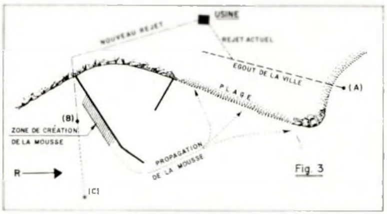

Fig. 3

En ce moment, l'usine est placée devant l'alternative d'épurer ou de prolonger son émissaire jusqu'à (C) avec un tirant d'eau de 25 m. Avec cette profondeur on obtient une grande dilution, l'effluent étant entraîné hors de la zone de battement contre la digue.

VII — GÉNIE DES ÉMISSAIRES

1.1. Dans le projet et la construction d'émissaires sous-marins, on doit tenir compte de deux sortes d'actions auxquelles ils sont soumis :

a) les actions chimiques, dérivées de la nature de l'effluent même et les effets corrosifs du milieu où il se trouve, et

b) les actions dynamiques, soit par les sollicitations directes de la dynamique marine, soit par celles qui proviennent des mouvements du fond marin.

1.2. Du point de vue de la corrosion, l'emploi du béton peut poser certains problèmes en présence d'eaux agressives, comme par exemple l'acier, qui doit être protégé contre la corrosion du milieu marin, tandis que les plastiques et la fonte ne posent pas ces problèmes.

1.3. Une conduite déposée au fond est soumise à une série de forces horizontales (F) en raison de la houle et des courants, ainsi qu'à une force ascensionnelle, et sa stabilité dans le fond sera assurée, lorsque :

$$V < P \quad ; \quad f \times (P\text{-}V) > F$$

(P) étant le poids et (f) le coefficient de frottement. De toute façon et étant donné la grande longueur des émissaires, on déduit des déformations excessives qui nécessitent parfois l'enfouissement et l'ancrage des conduites. A ce sujet, il faut tenir compte que les mouvements du fond de la mer peuvent déterrer les conduites et c'est pourquoi, en cas de non ancrage, leur poids doit être en rapport inverse à la stabilité des matériaux qui constituent le fond.

1.4. En ce qui concerne les procédés de construction, il en existe généralement deux, avec leurs avantages et leurs inconvénients. Celui du tuyau continu soudé, possible en acier et en thermoplastique qui, bien qu'il contribue à éliminer les points faibles constitués par les joints, présente des difficultés de placement car il nécessite un grand espace de lancement, soumet la tuyauterie à de grandes sollicitations au cours de ce lancement et rend plus difficile la réparation des avaries. D'autre part, on trouve la fonte ou autres plastiques disposant de joints qui ne seront ni à bride ni à raccord avec cordon, trop rigides.

2.1. Les conduites en chlorure de polyvinyle (PVC) furent, au début, très employées en raison de leur grande résistance à la corrosion, de leur maniabilité et de la sécurité de leurs joints, qui les rendent très appropriées pour des fonds de boues ou de sable, car, d'un autre côté, leur poids léger et leur résistance mécanique les rendent très vulnérables, surtout pour des diamètres supérieurs à 300 mm.

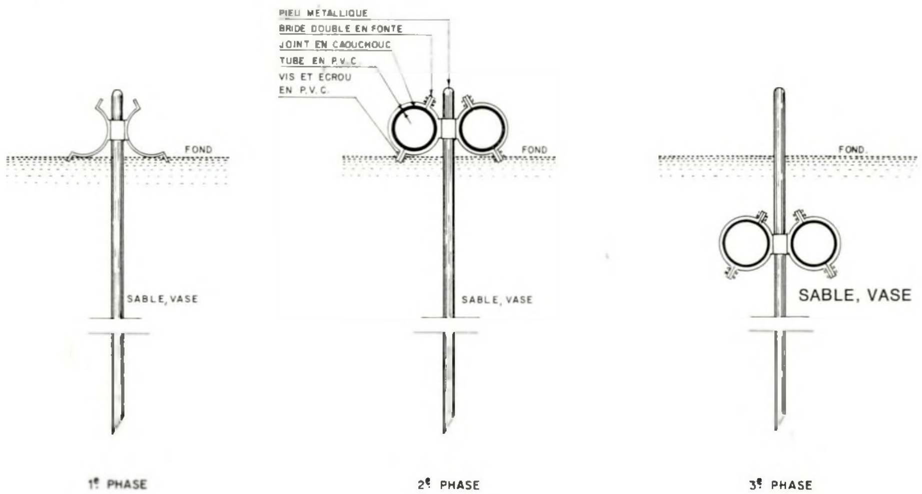

Fig. 4.

La pose la plus adéquate de ces conduites consiste à les enfouir et à les fixer avec des brides à pieux. Les jonctions ne doivent pas être rigides mais réalisées au moyen d'un joint néoprène. La figure 4 présente un dispositif approprié pour des fonds de boue et de sable, avec des épaisseurs de 3 à 5 m, où le pieu peut être enfoncé par une injection d'eau sous pression. Le comportement est bon, même avec une régression de 1 à 2 m des matériaux du fond. Il est cependant très sensible aux sollicitations verticales, aggravées par la présence de l'air dans la conduite, et on doit établir des dispositifs d'élimination de celui-ci sur de longs tronçons.

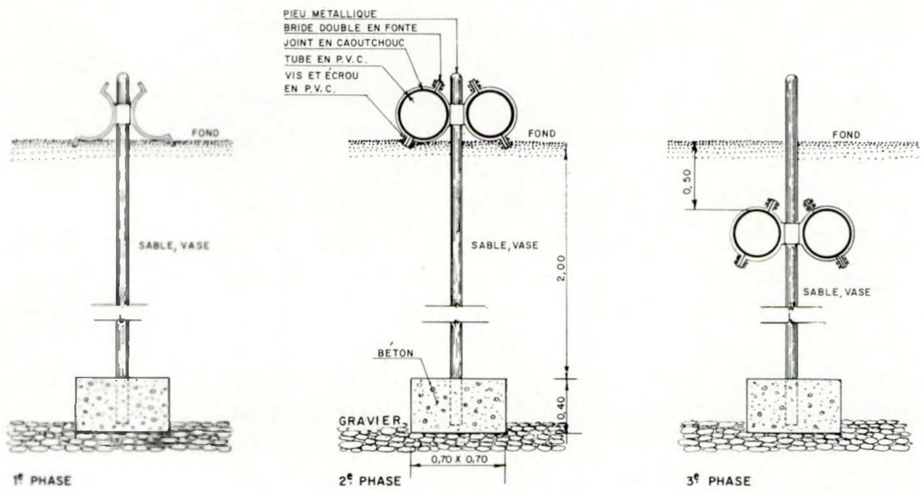

Fig. 5.

Le dispositif de la figure 5 a été employé avec des épaisseurs réduites de boue ou de sable ou aux endroits où l'existence de matériaux gros ou de roches ne permettait pas la mise en place de pieux par injection. La fixation au moyen d'ancrages est sujette à de fréquentes avaries car l'action de la mer est la cause de petits mouvements qui provoquent la rupture des conduites. L'emploi du PVC sur roche n'est pas recommandable à moins de creuser un fossé et de le recouvrir postérieurement avec du béton, la conduite agissant alors comme un coffrage perdu à propriétés anticorrosives. Ces propriétés font que l'on utilise comme protection d'autres matériaux, en ajoutant un tube de PVC dans un autre en acier, lequel agit en qualité de support résistant.

2.2. Le polyéthylène a été employé dans des cas d'effluents hautement corrosifs (acides, chlorés), comme protection intérieure des conduites métalliques (fig. 6). Le plus grand inconvénient de celui-ci est sa flottabilité, qui réclame

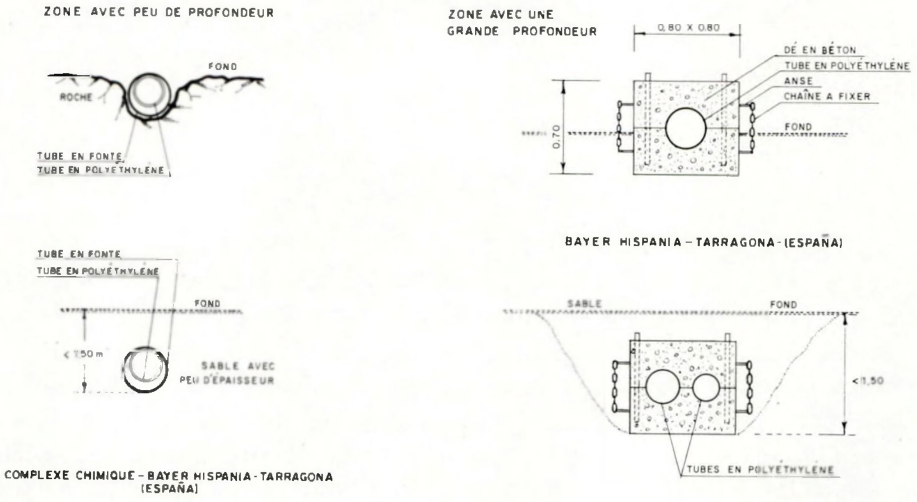

Fig. 6 et Fig. 7.

l'emploi d'ancrages très proches afin d'obtenir une pente uniforme et d'éviter les ondulations. Mais en même temps sa flexibilité permet des dispositifs d'ancrage avec du béton (fig. 7) sans que les mouvements éventuels puissent causer la rupture de la conduite.

2.3. Le polyestre réunit les propriétés anticorrosives des précédents, mais seulement celles de flexibilité dans de grands diamètres et ne doit pas être employé dans de petits diamètres en raison de sa grande rigidité.

2.4. Parmi les matériaux métalliques, on dispose de l'acier et de la fonte. Celle-ci, plus économique, peut être grise (pour des petits diamètres) ou souple (pour des grands) et le genre de joint adéquat est l'express, d'exécution simple, qui permet des mouvements à la conduite et ne nécessite pas une fondation soignée. La souple se comporte très bien sur des gros matériaux et sur la roche et a une grande résistance mécanique; son résultat est analogue à celui de l'acier sans présenter le peu de résistance de celui-ci à la corrosion.

3.1. Les recherches, effectuées dans des conditions optimales d'immersion, ont fait connaître l'énorme importance des caractéristiques et de la disposition des diffuseurs pour éviter des perturbations dans les déversements. Leur premier objectif est celui de distribuer, d'une façon uniforme, les débits dans les différents orifices de sortie, ce que l'on obtient avec des diminutions graduelles des sections et en variant les diamètres de sortie. On emploie ainsi des pièces de PVC d'un aspect tronconique avec des coupes en biais des becs, en obtenant des jets qui, bien que possédant un haut contenu de matière organique, ne provoquent pas une intense désoxygénation, nuisible à la flore et à la faune marines.

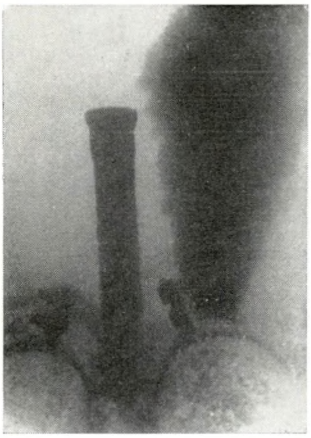

Photo 3.

Diffuseurs et ancrages
D = 100 m/m — Pieu d'ancrage.

Leur distance optimale se trouve près de la profondeur du déversement et dans le calcul de leur débit, on doit adopter au moins un coefficient de sécurité de 1,25, afin d'assurer un fonctionnement correct et d'éviter des vitesses excessives à la sortie.

Photo 4.

Diffuseurs et ancrages
D = 100 m/m — Dé en béton.

La position la plus favorable à la sortie est l'horizontale ou l'oblique peu inclinée par rapport au fond et son orientation dépendra de la zone de déversement. D'une façon générale ils doivent être orientés normalement vers le courant dominant d'entraînement. Dans la Méditerranée espagnole, pour des émissaires de 1.000/2.000 m et des profondeurs supérieures à 20 m, avec des orifices de sortie de 10/20 cm, les meilleurs résultats sont obtenus avec des diffuseurs sensiblement parallèles à la côte, bien que, dans chaque cas, on doive étudier les courants dominants, surtout lorsque le tracé de la côte n'est pas sensiblement Nord-Sud.

Ils doivent être développés sur une grande longueur, surtout pour des grands débits. C'est pour cela que les diffuseurs de l'émissaire de Palma de Majorque, d'un débit de 1.000 l/sec. ont été projetés sur la base de 400 m.

VIII — GRANDES INFRASTRUCTURES D'ASSAINISSEMENT

1. Actuellement, divers projets de grandes infrastructures d'assainissement concernant tout le long de la côte méditerranéenne et les Iles Baléares sont à l'étude, afin de résoudre les problèmes posés par le développement et l'expansion de ces zones, tant d'une façon permanente que conjoncturelle en raison de l'affluence touristique.

2. Parmi les plus avancés se trouve l'assainissement intégral de la Côte du Soleil (Malaga), dans l'élaboration duquel on a tenu compte de la population, tant stationnaire qu'additionnelle, des superficies à assainir et des débits à évacuer. On a procédé à l'évaluation suivante concernant les années 1985 et 2000 :

Prévisions	1985	2000
Population permanente	173.013	244.863
Capacité additionnelle hôtelière	55.463	91.733
Capacité additionnelle extra-hôtelière . .	373.433	617.258
Population de pointe	601.909	953.854
Population moyenne	459.281	717.806
Population moyenne en chiffres ronds. . .	459.300	717.800

La superficie assainie comprend des centres urbains et la zone touristique intermédiaire, avec près de 15.000 ha et plus de 100 km de côte.

Le Plan est fondé sur les prévisions suivantes :

1. Intervention urgente dans les zones ayant des problèmes de contamination.
2. Promotion des zones desservies par le système d'approvisionnement en eau de la rivière Verde et non assainies.
3. Souplesse et indépendance aux divers stades de l'exécution.
4. Normalisation et modulation des différents éléments utilisés afin de rendre plus économique la solution, et programmation de son développement en fonction de la demande.

5. Conception du projet des éléments linéaires de telle manière qu'ils affectent le moins possible les complexes urbains existants.
6. Dualité des collecteurs généraux au nord et au sud de la Route Nationale 340 (parallèle à la côte), afin d'éviter la prolifération des travaux de croisement sur celle-ci, qui pourraient troubler la fluidité de sa circulation.
7. Eloignement de la zone côtière des Stations d'Epuration de boues activées, afin d'éviter les inconvénients psychologiques, économiques et coûteux de l'expropriation de la superficie occupée et des abords.
8. Emplacement, sur les zones côtières seulement, de Stations Epuratrices d'oxydation totale qui, étant plus compactes, permettent leur recouvrement et affectent une superficie plus réduite, en palliant ainsi les inconvénients exposés ci-dessus.
9. Evacuation de l'effluent résultant, de manière à assurer la non contamination de l'environnement, en utilisant des émissaires terrestres et sous-marins convenables et, pour le moment, sans réutilisation des eaux résiduaires.

Pour les collecteurs on a employé des sections variables qui vont de la circulaire à 0,30 m de diamètre à l'ovoïde de 120-180. La longueur totale de ces conduites est de 126,8 km et la matériel employé pour celles-ci est le béton centrifugé.

Pour les stations élévatrices, au nombre de 25, on a adopté une structure unique en modifiant seulement les groupes moteurs pour chaque installation. Les stations épuratrices à boues activées ont été mesurées au moyen d'un module de 125 l/sec. en débit pointe pour un total de 76 modules, distribués en 20 stations disposant chacune de 2 à 8 modules. Il en existe seulement une qui est plus grande, d'un module de 250 l/sec. en débit de pointe, aux environs de la marge droite du Guadalhorce. Les stations à oxydation totale ont été mesurées au moyen de modules de 35 et 125 l/sec. en débit de pointe, distribués en 4 stations de 1 à 4 modules chacune.

Les émissaires sous-marins ont été mesurés conformément aux normes en vigueur et, par leur intermédiaire, les effluents, dûment traités, seront déversés dans la mer. Les sections varient entre 250 et 400 mm et la longueur totale de ces émissaires atteint 19 km. Les matériaux à employer seront le PVC et la fonte ductile à joint élastique, protection de béton submergé et ancrages adéquats dans le fond marin.

En règle générale, le système adopté pour la zone touristique intermédiaire a été celui de la division en tronçons partiels, qui sont traités indépendamment.

Ce traitement comprend le tracé et la mesure de collecteurs généraux qui figurent — pour leur épuration — dans des points adéquats, selon la topographie de la zone et en disposant, si nécessaire, les installations d'impulsion correspondantes.

Dans la mesure du possible, l'épuration s'effectue par des stations à boues activées. D'une façon générale, on prévoit leur emplacement vers l'intérieur afin d'éviter l'occupation de plages par ces usines, aussi bien pour faciliter les expropriations que pour éviter le mauvais effet psychologique provoqué par ces installations près des zones destinées aux bains.

Lorsque ce système n'est pas viable, on projette des stations d'oxydation totale qui, étant plus compactes, occupent moins d'espace et permettent leur établissement près de la côte; elles peuvent aussi être couvertes, ce qui évite les inconvénients mentionnés plus haut.

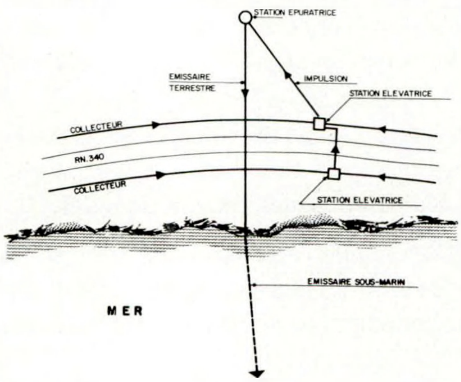

Fig. 8.

Dans la plupart des cas, le déversement de l'effluent déjà traité s'effectue au moyen d'émissaires terrestres tracés généralement tout au long des cours d'eau — ce qui diminue les problèmes d'expropriation — et postérieurement par des émissaires sous-marins qui complètent le traitement en déversant à une distance et à une profondeur adéquates.

En ce qui concerne les ensembles urbains ils ont été traités avec leurs particularités propres. On indique à la figure 8 un schéma type de traitement et de déversement.

SUMMARY

1. The paper begins by drawing attention to the increasing influence of human activities on the physical and biological characteristics of the marine medium. The salubrity of the shore waters depends on the maintenance of the ecologic balance between inshore and offshore and this question is in relation with the discharge of sewage and industrial waste into the sea.

2. The different ways of pollution are divided in two classes :
   — Nuisance or anti-aesthetics pollution produced by all kinds of solid wastes, dirty waters and industrial wastes.
   — Dangerous pollution for the human health or for the marine flora and fauna; the first, due to the contaminated sewages and the second, due to the aggresive or nutrient industrial wastes which destroy the ecologic equilibrium of the sea.

3. The sea has several ways of defense against these forms of pollution : keeping in its depth the solid wastes or spreading them along its immense surface. With respect to the bacteria, they have a permanent character insofar as they are concentrated into substances absorbed by man in some form or other. The influence of light, ultra-violet rays and temperatures on

the microbic flora can be listed as physical purifying mechanisms, not yet sufficiently known, but efficient enough, above all in certain zones as figure 1 shows.

4. Man, who is now aware of the problem, should take measures both at national and international level, to prevent and correct the pollution and its effects. One of the first things that can be done is to lay down certain conditions for discharging wastes, in order to prevent inconvenient and dangerous contaminations.

5. The disposal of sewage and waste water can be effected in different ways, causing several effects :
   - by means of direct discharge from rivers or agricultural drainages : bacteria and foods are carried along, causing contamination very difficult to overcome except by direct action on the waterways which produce it.
   - by means of what might be called « the non discharge method », a sort of closed circuit for the residual water, using it inland or discharging it into the subsoil — a method which can be dangerous for certain types of soils. The system of sewage recovery, attractive as it may seem in principle, presents some problems of supply and demand and others due to the elimination of sludges.
     For that it is necessary to arrange an effective technique such as the construction of submarine outlets.

6. Several factors must be taken into account when planning these outlets such as the aesthetic and biological standards, the most advantageous ratio between length and depth to be reached by the outlets, considering the standard of sewage-treatment (see fig. 2). In this connection, the paper mentions the advantages or disadvantages of two methods : a short outlet with complete treatment of sewage or a long outlet with superficial treatment only.

7. Three different cases of outlets are described :

   one of them for sewage waters and two for industrial wastes (fig. 3), bringing out in all of them the importance of the depth of the discharge point. Photographs illustrate this question.

8. The different materials to be used in the design and construction of the outlets are described, as well as their advantages or disadvantages and the most adequate means of fixing them to the sea bed (see figures 4, 5, 6 and 7 and also photographs of diffusers and anchorages).

9. Finally, the main characteristics of the whole sanitation scheme of the Sun-Coast of Spain are analyzed, including a model installation of sewerage treatment and discharge.

S. II - 6

PAPER

by

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Director, Port of Malmö.

1. INTRODUCTION

The pollution of watersheds and, as a consequence thereof, the pollution of harbours and coasts has been in process for several decades and has, during this time, grown to be one of the big problems in the world. Greatly simplified, it can be said that one phenomenon creates the problem and another leads to demands for measures limiting the effects of the first one. The first phenomenon, namely rapid technical development, results in the need of exploitation and transportation of very large quantities of raw materials (often dangerous for nature and living things). Intermediate and finished products to and within the areas of production and consumption spread over the face of the earth cause the same problem. The result of this is pollution and the problem of what to do with certain by-products becomes increasingly harder to solve. The other phenomenon is the rapidly growing conciousness during recent years, that irregardless of how « durable » and adaptable nature and life are, the limit for pollution which can (and must) be accepted has very nearly been reached. Public interest in Sweden, as elsewhere, has during later years been directed towards these problems and resulted in a series of conferences, opinions, research, technical solutions, and so on. Against such a background, the author of this paper has been faced with the certain « balancing problems » in order to present the state of this subject's present position in Sweden within the space allowed for a PIANC paper. The author gladly offers his assistance to those colleagues desiring complementary information beyond that which is presented here. Among those problems not taken up in this paper are those which arise from the injurious products of the land areas adjacent to harbours and coasts being carried out into the sea where they produce secondary pollution without first being satisfactorily rendered harmless.

II. THE TANKER

A. Shipboard treatment of water ballast and oil (chemicals).

The background to the permissible oil dumping allowed by the international oil convention is based on the need for tankers to carry water ballast on the return trip to the loading port. The ballast quantity needed for a large tanker is up to about 40% of its deadweight.

It has been hitherto economically impossible to construct a ship which contains separate ballast tanks corresponding to more than about 10-15% of its deadweight. Therefore it has been necessary to also carry ballast water in the cargo oil tanks. This is normally done during the last phase of the unloading when water is taken into the clean ballast tanks as well as some of the ship's oil tanks. During the trip, some of the empty tanks are cleaned of any remaining oil and sediment. These clean tanks are then filled with clean ballast water at the same time as the now dirty water in the ship's other tanks is pumped over board after suitable treatment. Thus the shipboard treatment of ballast demands great care and skill of the crew. This is wel illustrated by noting that a 250.000 ton tanker on its ballast journey may, according to the regulations, discharge a maximum of 16 tons of oil whereas the quantity of sediment and oil remaining after unloading can be up to about 800 tons.

One known method for reducing the quantity of left over oil and to facilitate the treatment of this left over oil in the harbours is the « load on top system ». This system is used for crude oil traffic and for traffic between the refineries and coastal and inland ports. Another method employs the use of tankers with special ballast tanks and/or equipment for the separation of oil polluted ballast water. Increased use and technical improvement of these methods is an area which, at the present, is the object of great interest. Among other measures, there is a need for the development of oil separators with large capacities and oil measuring devices which register the quantity of oil to be pumped out. Such devices can be coupled with automatic blocking of the outlet when the quantity of oil in the ballast water is too high, should a further safety margin be needed.

Still other methods which can be named are the following :

— Chemical methods to hasten and improve the settling of oil and water in the tanks.

— Installation of some form of flexible membrane in the oil tanks through the use of which the water ballast never comes in contact with the oil.

— Cleaning the tanks with some other substance than water, such as solvents, so that only small quantities need be used.

— (Stipulate that all cleaning of ballast water must be done in port at special receiving stations).

The problem of contaminated bilge water on board the ship appears to be easily solved. The ship could be equipped with special tanks for bilge water. After oil separation, the oil can be stored in special waste oil tanks or barrels for direct delivery to decomposition stations on land.

Two other possibilities for reducing damage are to reduce the risk of accidental dumping and prevent leakage into the sea. A warning system, or more properly a level control, could be used to produce a signal of some type if the liquid level (oil or chemicals) reaches a predetermined level. Such technical solutions exist for filling tanks on land (stationary tanks, truck and railroad tanks) but these methods have hitherto had hardly any marine application. It can also be feasible to use, as a first phase, a system of portable level controls until tankers are successively equipped with permanent level controls. When dependable permanent level controls are available for tankers, it would seem natural that these protective devices should be coupled to an automatic closure of the valves of bunkering and loading pipes.

As concerns the problem of preventing leakage into the sea, attention can be drawn to a collection device developed by some companies from the area of Gothenburg harbour for use during bunkering. In principle the method works by fastening a very temporary hose or sack of textile material onto the bunker tanker's gooseneck and letting it lie on the deck. It would not cause any obstruction in the vicinity of the gooseneck. If the tank overflows during bunkering, the oil which runs out will first be collected in the « oil sack ». A further development of this method would be to connect all the bunker tanker's vents and goosenecks from its tanks via a common ventilation conduit to a collection tank. In its turn, this tank could be connected to free air by a ventilation pipe. The collection tank should of course be equipped with a warning system and a valve closing system.

B. **Oil dumping caused by damage.**

Even though oil discharges caused by collisions or grounding amount to only a small portion of the total oil discharge into the sea, such discharges cause great damage to our environment due to the fact that such accidents usually occur near to land. It may be safely ventured that such damage is always caused by the so-called human factor.

Development in the size of tankers is governed by freight economy and it is probable that in the future larger and larger ships will be built.

It can be safely asserted that the probability that a ship's steel construction is faulty and could cause oil discharge is quite small. Today's knowledge of the forces met at sea is excellent. Coupled to this are the calculation methods reliably tested through full scale test measurements on ships up to 250,000 tons deadweight. All large ships are equipped with a load distributing instrument, Loadmaster 5, which enables the ship's officers to check the level of stress during loading and unloading. The problem remains however to educate the personnel on board, since any ship can be over-stressed in its steel structure through improper load distribution.

Another technical problem of interest is the manoeuvrability of large tankers. Even though technicians have limited theoretical knowlege of a ship's manoeuvring properties, especially as affected by external factors such as wind, tides and currents, these questions can be approached in a satisfactory manner. Special « manoeuvre pools » are available for testing the properties of models. There are also simulators coupled to computers which can simulate the properties of a full scale ship during different manoeuvres. It must however be stated that even if these large ships possess top technical equipment from the view point of manoeuvring, they need a well-trained crew. The simulators named above are excellent aids for this purpose.

Manoeuvrability for even the largest ships (over 300,000 tons) can be classified as good.

Manoeuvrability is of course important when the risk of collision arises, but as concerns conditions which prevent manoeuvring away from collisions, such as crowded channels, the stopping distance is of utmost importance.

Without a doubt, large ships in this respect are more poorly equipped than smaller vessels and much research is needed in order to reduce the stopping distance. A 250,000 ton tanker applying full use of accessible back-effect requires about 4,500 metres to come to a full stop. The corresponding distance for a 40,000 ton tanker is about 2,500 metres.

Among those proposals for measures to solve this problem is one for use of parachutes which can reduce the braking distans by 75%. It appears as though adjustable propellers should be of help as well as shrouding the propeller.

C. **Tanker Design.**

According to the 1971 admendments to the oil convention, newly built tankers are to be constructed so that they are partitioned. Damage of a defines scale does not then result in oil leakage of more than 30,000 m^3. For ships of over 420,000 tons deadweight, the allowable leakage is somewhat higher, but never more than 40,000 m^3. A 350,000 TDW tanker must be equipped with 28 tanks instead of 22. The increased weight of the extra steel added is 12,000 tons and the increased cost is approximately Skr 4 million. A tanker in the 600,000 ton class must have 40 tanks and probably a partial double keel in the forebody.

A more definite solution would be to provide the ship with a double keel and double sides to such a degree that the ship's tanks could not be penetrated if it was grounded or involved in a collision. A ship constructed in such a fashion could also solve its pollution problems involving ballast as the double bottom and sides could be used as clean ballast tanks. In order to satisfy the requirement just described, the penetration of structural damage occurring from a shipwreck must be investigated. If the penetration depth of the above mentioned 1971 IMCO-rule be followed, the main dimensions of ships must be markedly increased. Besides an increase in the price of such ships of perhaps 40%, such increase in dimensions will result in a velocity reduction in the neighbourhood of 0.10 knots or require an increase in motor effect of approx. 1870 HP (4.6%).

Another solution would be to use closer double hulls and to undertake an analysis of the ability of the steel construction to absorb impacts. This is the approach used for protective construction around the reactor tank of nuclear powered ships. This method also involves a considerable increase in cost (at least 30%).

III. NAVIGATION

A. Determination of position.

Investments in safer navigation and cargo handling procedures are well motivated. An incorrectly determined position or an instable cargo placement can result in the risk of pollution in harbours and on coasts. During recent years, a large number of auxiliary devices have been taken into use in order to increase safety at sea. Anti-collision radar, satellite navigation and Doppler logs have become standard equipment for those shipping companies wishing to keep their ships up to date.

Many of the modern safety promoting devices are based on electronics. The analogue technique has among others played an important part in automatic control applications. Radar is well established. Digital techniques and computers have been introduced on board ships.

A new method is satellite navigation. The only system available is the Navy Navigating Satellite System, NNSS, from the USA. By measuring the frequency change (Doppler effect) in radio signals when the sender and receiver approach each other or move away from each other, data is obtained for determining the position. The NNSS at the present uses five satellites. These orbit the earth at a height of about 1,100 km in a nearly circular polar orbit. The satellites are updated from stations on earth with data for their astronomical paths and individual velocities. This data is stored in a memory device on board the satellite. In a integrated navigation system, satellite navigation works totally automatically and has no manual phases. The precision is usually within half of the ship's length (<100 meters). The number of possible position determinations by satellite depends on where the ship is, but averages out to be about one position/40 minutes.

Between satellite fixes, position determination is done by dead reckoning. The ship's new position is calculated from information of the course and velocity. Accurate velocity determination is obtained by use of a Doppler log. This gives land velocity as opposed to conventional logs which give water velocity.

It can be advantageous, in crowded passages, to have continuous good position determination. Two systems for this purpose are the Decca and Toran Systems. These use continuous radio waves to produce position lines in the form of hyperboles through the use of measurements of phase differences. The position is determined by finding the intersection point between the hyperbole branches.

The precision can be as good as 5-10 meters or, with a considerable increase in cost, 2-3 meters.

All position determinations, whether from satellite navigation, Decca or Toran systems or dead reckoning, contain measurement errors. If these are in addition disturbed by random errors, the result can be that an individual position determination has a totally incorrect value. A natural solution for avoiding such difficulties is to filter the measurement values. This can be done for example in a so-called Kalman filter. Through use of the filter, the best possible position determination is continuously obtained. Programs are available for these complicated calculations.

B. **Manœuvring systems.**

Most collisions involving ships arise from incorrect manoeuvres by the ships. It is often the human factor which causes these. Anti-collision radar, channel navigation and automatic pilots provide a means to more safely manoeuvre the ship.

In a critical situation, an incorrect interpretation of radar information can mean catastrophe. Erroneous radar plots have in certain cases been a contributing factor to causing collisions. Because of this, investments in automatic radar plots have become quite large during later years.

Several systems have come into use which can with varying degrees of information, process radar data. One system which has been developed with Swedish help is called the Anti-collision (A/C) System. It has been produced through the combined effort of Raytheon/Selenia, Salén Shipping and Kockums. The system includes the following data :

— Automatic tracking of up to 40 traces;

— Automatic detection of new traces;

— Manual tracking;

— Determination of nearest passing distance and time until this is reached;

— Prediction of the trace's position;

— Simulation of manœuvres.

The anti-collision picture is superimposed on the information appearing on the radar screen. It is therefore also possible to follow the course with respect to land contours, etc. Ships on a collision course or those which will pass very close to each other are especially marked on the radar screen and an alarm is given. It is also possible to simulate how the anti-collision picture is changed by different manœuvres of the ships.

In crowded shipping lanes, a system such as the A/C system can be used. Information on a permissable lane in which the ship may manœuver is fed into the computer via a typewriter or paper tape reader. The outer contours of the lane are marked on the radar screen by the computer. These contours are then locked on to the picture by a radar fix.

Connection of the position determination, navigation and the A/C system can be carried out by computer integrated automatic control. Through such a system, the ship is given the chance to automatically manœuver within the shipping lanes.

C. **Safer cargo handling.**

Those damages which can arise during cargo handling are in principle of two types, namely damage to the hull resulting from excessive stress and damage from the tanks overflowing.

It is considered to be impossible to predict all possible combinations before loading/unloading. Load distribution instruments have therefore come to be an excellent aid. Stress in the hull is dependent on the distribution of the cargo in the different holds. Information on the cargo is fed into the instrument by a counting mechanism. During the time that the cargo is being loaded, the loadmaster performs immediate and continuous calculations of the draught, deadweight, trim, bending moment and transverse forces for preselected sections. The values calculated are presented on the control panel of the instrument.

Cargo handling for tankers can be made safer through the use of more automatic procedures. A well tested computer based cargo handling system greatly raises the safety level as concerns both tank stresses and overflows.

One cargo handling system in use controls 52 hydraulically operated valves as well as one hundred manually operated valves. The tank levels are read by the computer which also transforms this information into volume and weight. During the loading of the cargo, the shearing force, bending moment, deadweight, draught and trim are continuously monitored. If any of these variables fall outside given limits so that the safety of the ship is endangered, an alarm is immediately given. The operator can also obtain a print out of the tank contents, shearing force, bending moment and so on whenever he so chooses.

IV. PREPAREDNESS AND SUPERVISION

Organization of Swedish « oil guard preparedness at sea » is now in its third year. As concerns Nordic cooperation in combating large scale oil dumping, an agreement was made between Sweden, Norway, Finland and Denmark on Sept. 16, 1971. According to this agreement, cooperative measures for preventing the oil pollution of the seas have been discussed by respective representatives having national responsibility for these matters.

Sweden's store of supplies for oil pollution work as of 30/6/1973 as well as its acquisitions two years after this date are listed hereafter.

Type of Equipment.

Equipment for mechanical removal.

Heavy-duty oil booms — Light-duty oil booms — Oil collectors, vortex type — Oil collectors, catamaran type — Oil collectors, excavator type — Oil containers, 10 m² — Oil containers, 50 m² — Oil containers, deck type — Buoyant hoze.

Equipment for semi-mechanical removal.

Absorbent booms — Absorbent substances — Spreading equipment — Oil trawl.

Oil dispersion equipment.

Oil dispersion substances — Fixed spreading equipment — Portable spreading equipment — Drum pumps.

Anchoring and handling equipment.

Anchoring equipment of various types — Trucks, cranes, etc...

Vessels and boats.

Command and oil-control vessels (200 ton class) — Oil-control vessels (50 ton class) — Supply vessels — Smaller work-boats.

The cost for acquisitions for the two years following 30/6/1973 are approx. 7 million SKr. This cost is not however to be borne solely by the national government. Industries incurring the risk of causing damage will also have to purchase their share.

As an example of the « preparedness organization » for such activities can be taken a refinery located in a fjord with a yearly intake of approximately 7 million tons of crude oil. The protection devices needed for such a refinery would include :

— permanent booms around the piers;
— special leakproof devices on land to which the booms can be tightly connected;
— sea booms for closing off the fjord;
— 6,000 m of « ordinary » booms;
— a vessel for laying out booms and for dispersion;
— concrete pontoons for collecting oil;
— a vessel with 1,000 m of sea booms, 2,000 m of « quick » booms, dispersion liquid, and a 250 m³ tank for storing collected oil.

One definite handicap for supervising authorities is that they have not been able to any degree of certainity to trace ships guilty of illegal oil dumping. What is needed for this is some method for marking the oil in ships. A group of experts from Sjöfartsverket (the National Swedish Administration of Shipping and Navigation), Naturvårdsverket (the National Swedisch Environment Protection Board), AB Atomenergi (the Swedish Atomic Energy Company) and Tullverket (the Swedish Customs Office) have now developed a method for marking oil remnants in tankers with non-radioactive substances. If this left over oil is pumped out, the ship leaves its « calling card ».

Supervision of the seas by ship is gradually being complemented by air supervision. More qualified observations, e.g. discovery and tracking during darkness of an oil belt's position and movements and so on, need specially adapted remotesensing techniques. Development of such a Swedish RS-technique has recently been given a boost by a cooperative effort begun by a group of state authorities and private industries. This effort includes a series of tests at sea which are being carried out at the time of writing this paper.

V. PRESENT MEASURES IN HARBOURS

A. Receiving stations.

As concerns the technical possibilities in harbours to receive and render harmless oil remnants, the discussion must differentiate between oil polluted ballast water and oleaginous (oil-containing) mixtures. Different technical solutions for receiving and separating ballast water have been tested during a number of years and shown themselves to work well. The oil remnants from tankers actually do not differ from those oil remnants produced from corresponding technical operations on land. In both cases, the oil remnants are produced from engine rooms and from tank cleaning. Ships have hitherto been able to dump such refuse in the sea. What to do with these oil remnants is however a difficult technical problem to solve. In principle it is a question of having receiving stations in the harbours with sufficient capacity for the oil. Either small lighters can be drawn out to the ships and receive the oil remnants, or mobile slurry exhausters can be driven up to the ship while it is tied up to the dock. Another solution is to have on-shore tanks to which the ship directly pumps the oil refuse. A technical point to be observed here is that the oil and water mixture produced from cleaning tanks often contains emulsifiers. Such mixtures cannot be treated in today's stations for cleaning ballast water as the emulsifiers put the stations out of function. Thus there must be two separate receiving systems for taking care of such oil and water mixtures.

Special problems appear when tankers must be cleaned before they are to be repaired in the docks. The mixture of oil remnants and the water used to wash the tanks is either treated in a tank cleaning station or else it is collected and delivered to a receiving station for different oil remnants.

As concerns these different oil remnants, the real problem is not receiving the mixtures and separating them in different ways, but what to do with the final products. These must namely in their turn in some way be treated so that they are destroyed. The Swedish expression « kvittblivning » (get rid of) expresses the real problem. It is up to the receiver — usually the harbour — to do away with such remnants. Destruction of them is both technically difficult and economically costly. The processes must be carried out in such a way that the environment is not damaged. It is therefore natural that interest in this area is ever more being directed to converting. This involves converting the remnants so that they can be utilized in some way and thereby be of value. The processes involved are however so complicated that they are probably worth a separate « subject » at a PIANC congress. Such a conference could take up receiving, destruction, and converting stations for oil and chemical remnants from ships and loading/unloading in the harbours.

B. **Traffic routing.**

Traffic routing in crowded passages and near to land can be solved rather quickly. In addition, as opposed to remedying measures for new ships, this supervision can include those vessels already in traffic. One such traffic routing system — in a first phase perhaps as simple traffic supervision — can be accomplished by harbour radar or, for example, through the use of « Follow-the-wire marine aid » equipment.

VI. COMBATING OIL POLLUTION

Knowledge is needed concerning the damages pollution creates over short and long periods of time. This is also true of the secondary effects caused by the means used in combating the pollution. Such knowledge is of the utmost importance for use in designing the technical apparatus needed to limit the occurrences of acts of pollution and to combat « accidents ». As long as the total effect which different pollutions (type and size) that cause a given environment are not measurable by a given « yardstick », it will be a question of personal opinion and « moral judgement » which dictates the appearance of different solutions and remedying measures.

The two types of methods used in combating oil in water are mechanical methods for surrounding, gathering together and taking up the oil from the water and chemical methods for emulsifying or sinking the oil to the bottom. In order that the oil is eventually broken down, the chemical methods presuppose that nature's own processes can continue to decompose the oil. There are many uncertain factors concerning nature's ability to break down oil and the damaging effects oil emulsifiers have on sea water. The same is true for the effect which oil that has sunk to the bottom has on the sea bed. With respect to such unknown factors, the mechanical methods must be considered superior to the chemical ones.

Combating oil pollution by mechanical means as a rule demands access to a combined system of booms and equipment for taking up the oil and storing it (containers). Such requirements vary greatly, depending on whether the work is being done in, for example, an archipelago, or in the open sea, whether it is a small or large quantity of oil, if it is pumpable or not, and so on.

Although the access of booms for use in the open sea has been improved during the last year, the types possessing the most desirable characteristics are still being developed. However, it is planned that tests of a qualified boom for use on the open sea will be carried out by the Swedish coast guard this autumn. The two most currently used types of equipment for taking up oil at sea is a type of « endless band » (slick lickers) and a « whirl raiser » (vortex system). There is a « band type » equipment for taking up oil which has a capacity of 5-15 m^3 of oil per hour. This is either in the form of portable equipment for placement on board ships or else it is permanently built into machine powered catamarans.

For taking up large or huge quantities of oil, vortex type equipment is being acquired which has a capacity of approx. 200 m^3 per hour. Such equipment weighs more than three tons and has an outer dimension of approximately 6 m.

Other equipment for taking up oil, as foı other heavier types of oil combating equipment, needs access to a ship of suitable size and type. In order to properly use such equipment and retain it to a sufficiently high degree of preparedness, access is needed to a number of special large vessels (in the 200 ton class) with specially designed handling equipment, storage spaces, electric power, hydraulics, and so on. Just as important, there is needed a crew well trained in the function of such equipment.

Mechanical removal of oil involves the use of suction equipment of different types. There are units which float on the water and skim off the oil, or different types of nozzles which are put into the layer of oil. The disadvantage with these methods is that they cannot be used in waves over 15 cm high. In addition, large quantities of water are also taken up which must then be separated from the oil. It has been proposed to build a vessel with a V-shaped collector opening which would skim off and collect the oil layer for separation and storage on board as it advances through the water. Such vessels would be however too uneconomical. An apparatus at the side of a ship which generates a strong whirlpool could be used to suck the oil down and into a pipe leading into the ship's tank. Such a method presupposes a rather thick layer of oil in order to reach a sufficiently large capacity. Because of this, the oil must often be surrounded and collected. There exist differently constructed booms which have shown themselves rather useful. But it must be taken into consideration that the heavier booms are difficult to use for most purposes other than for use as permanent booms. On the other hand, the lighter constructions, even though they function well in harbours, cannot hold oil if the wind velocity exceeds 5 m/sec or if the current exceeds ½ knot. Booms have recently been produced in Sweden which can be used in wind up to 15 m/sec and a current of 1 knot but which still are not too clumsy to handle. A problem which has still not been satisfactorily solved is the anchoring of the boom. As usual, it is a question of finding a suitable combination of durability and « flexibility » without making it too heavy or awkwardly constructed. Another type of sea boom reported to be under construction in England is a floating one which is braked only by floating anchors.

Discharges of fuel oil 4 or heavier oil and oil remnants from tank cleaning do not float in any definite forms. It occurs mostly as clumps on and under the surface of the water. For this reason, booms are not especially applicable. Some more suitable means must therefore be developed such as a net, a trawl or some similar construction.

By using an absorber (or adsorber) agent, the oil can be given such a consistency that it is easier to be treated by mechanical means. This however produces a greater volume. Both « natural materials » and specially produced agents have been tested. It has unfortunately been difficult to find an agent which, after a length of time (week), does not sink to the bottom and simply release the oil. The ideal solution would be an agent which did not sink and at the same time created a comparatively greaseless consistence. This would help contribute to prohibiting the oil to be released in bays, beaches, wharfs, etc. Combating dumped oil with absorber agents in general requires equipment to effectively spread the agent over the surface of the oil as well as something to collect and take up the absorbed oil from the water. Ejector spreading and a surface oil trawl can be used for these purposes. The trawl, after it is filled with oil clumps, is hauled or lifted on board a suitable vessel. One method under discussion involves the adding of some harmless chemical to the oil thereby giving it a gelatinous consistence. This method could be used to treat the outer edges of floating oil thereby coagulating it and forming a « dike » to retain the rest of the oil. It could also be used to prohibit oil from floating out into the water from damaged tankers.

Mechanical methods, with or without the use of absorber agents, do however have their limitations. Wind and current conditions, even in areas near the coast, can be so difficult that it is hard or directly impossible to treat all the oil by mechanical methods. It is then necessary to apply another method, usually dispersion.

In using this method, the dispersion liquid is spread on the oil which is then agitated in some mechanical fashion. This breaks the oil down into small drops. The agitation is done by, for example, a special device towed along for this purpose, water sprayed under high pressure, or the ship's propellers. Use of a dispersion agent results in the introduction of yet another more or less harmful material into the water. It also results in that the oil, by itself not too harmful, is spread in a larger volume of water than if dispersion was not used. This later effect means that more organisms are exposed to the risk of injury, and not from only one but two components. On the other hand, it can be assumed that the oil is more quickly broken down due to the larger surface area offered to micro-organisms. The question is thus if the total effect is positive or negative. i,e., should dispersion methods be used or not. This is a question which cannot quickly or correctly be answered. Other conditions, as well as conditions from the locality, must be taken into consideration. In taking a technical look at dispersion agents, it is found that they as a rule consist of a portion which functions as a solvent and another portion which functions as an emulsifier. It is usually the solvent portion which is the most poisonously active substance. Therefore the problem is to find less poisonous solvents. A « third generation » of agents for the dispersion of oil has now begun to make its debut. The characteristics of these new agents is their low toxicity combined with higher effect, a lower price, and that they are more easily decomposed.

Other methods for combating oil are available, but these are hardly useable in the area considered in « subject 6 ». Burning in, e.g., coastal zones can result in that both beach fauna and flora are destroyed for a long time. The spawning grounds for fish can also be affected, and so on. In addition, burning can cause the formation of clumps and the pollution of oil thereby partially submerging it. Large oil discharges can be split into smaller parts and then spread out over a larger area. It can also be hard to set fire to oil floating on water since the parts most easily set fire to quickly evaporate and because oil flows out in thin layers. In general, a layer of oil at least 1 cm thick is needed. Oil that is emulsified with water cannot be burnt. And finally, a special igniting agent must be used to even start it burning.

Another method which can hardly be used in harbours or coastal zones from the biological view point, is sinking the oil. While the oil is sinking (from, e.g., sand or chalk), oil clumps can be spread by the currents and damage nets, etc. Sunken oil clumps can also come loose from the bottom and float up again. Bottom organisms are suffocated under the sunken oil. Therefore it is only under certain conditions that this method may used. Finally, one method can be named which is based on the property that oil in sea water is decomposed by bacteria and certain yeast cells. The speed of the decomposition process depends on, among other factors, the temperature, and it can occur very slowly. The same is true if certain substances are present in the oil which prohibit bacteria decomposition or if the oil is more or less mixed with bottom sediment. During the time a biological decomposition is taking place, sea birds are in danger. There is also the risk that nets will be damaged. There is today available a series of different cultivated microbes which can serve as « Oil eaters ». But even if they can serve as food for fish once « their food » has been depleted and they themselves die, the method can hardly yet be used in harbours and coastal areas.

VII. CONCLUSION

The discussion above has taken up preventative and remedying problems concerning oil discharges occurring on coasts and in harbours. Such discharges can be from tankers, bunkering stations, or refineries. Due to space limitations, the report has not taken up oil discharges via sewage pipes or from damaged cisterns on land. The numerous risks which can occur from oil drilling companies near coastal waters have also not been taken up.

An important preventative measure is all the information which is currently being given concerning these conditions and the extra-mural studies which are being conducted. The material presented in this report has mainly been taken from different reports given at such courses. These include courses given by ship builders, oil corporations, supervising authorities, harbours, and other companies concerned with this subject.

The problems connected with oil dumping occur as well from pollution as from other chemicals, biocides and certain refuse products from industries. In principle it can be said that the same methods can be used for reducing the dangers from these pollutants as for oil dumping. These include better ship construction, better navigation and maneouverability of the ship, safer shipping channels and harbour entrances as well as better traffic routing through the use of harbour radar and position determination, preparedness measures, and development of methods for remedying damages.

RÉSUMÉ

Ce rapport traite des questions touchant les méthodes de prévention et correction lorsqu'il s'agit de protéger les côtes et les ports des rejets de pétrole. Le rapport analyse premièrement les mesures en ce qui concerne les navires et là-dessus un relevé des nouvelles méthodes de navigation et de manœuvre plus sûres, des pétroliers. Dans les deux parties suivantes, on se préoccupe d'une part de l'organisation d'urgence et de surveillance et d'autre part des mesures préventives qui peuvent être prises dans les régions côtières et les ports. Dans une cinquième partie on fait part des dispositions à prendre pour la prise en main du pétrole qui s'est libéré. Dans la première partie, sur les navires, on expose les mesures à prendre pour effectuer plus sûrement le maniement à bord, des ballasts d'eau et pétrole. A ce sujet, parmi les méthodes exposées, on rend compte de la sauvegarde des trop-pleins, des méthodes chimiques pour activer et améliorer la décantation entre le pétrole et l'eau dans les réservoirs. D'autres théories selon lesquelles il s'agit d'installer une certaine forme de membrane flexible dans les réservoirs de pétrole, par laquelle le pétrole ne peut entrer en contact avec l'eau des ballasts ou d'employer d'autres produits que l'eau pour le lavage des réservoirs comme par exemple un dissolvant, utilisé en petites quantités.

Dans cette partie, on soulève aussi la question du rayon de manœuvre et de la distance de freinage et l'aspect de la construction des grands pétroliers.

Dans le passage suivant, on signale le problème au point de vue navigation. A ce sujet, on présente la navigation « satellite » et la possibilité, au moyen du filtre Kalman, d'obtenir les meilleurs relevés de position possibles en éliminant les fautes accidentelles et en employant à la fois les méthodes « satellite », « Decca », « Toran » et « à l'estime ».

Le chapitre suivant du rapport est consacré aux méthodes de manœuvre et présente un système, qui ressort d'une collaboration entre Raytheon, Selenta et une société suédoise, un « système anti-collision ». Cette partie s'achève par un bref compte-rendu démontrant comment l'on peut, grâce à une judicieuse répartition de la cargaison et le maniement de celle-ci opéré par un système basé sur ordinateur, obtenir un maniement plus sûr de la cargaison.

Dans la quatrième partie, on fait part de la composition du système d'urgence et de surveillance suédois et on donne une liste du matériel qui est maintenant en cours d'acquisition.

Dans la partie suivante, on expose les mesures préventives qui peuvent être prises dans les régions côtières et les ports en ce qui concerne les installations de réception et le contrôle de la navigation. En rapport avec celle-ci on note l'usage du radar de port et du « câble de navigation en rade ».

Dans un sixième chapitre le rapport aborde les mesures pour la lutte contre les rejets de pétrole. A ce propos, on présente des méthodes mécaniques, résorption et dispersion, combustion et diminution; des points de vue sur l'emploi de ces méthodes dans les régions côtières et les ports sont également donnés.

Dans la conclusion, on donne des avis généraux sur le problème de la lutte contre le pétrole et on y fait remarquer ensuite l'importance de la recherche et de l'information en vue de réduire les risques de rejets de pétrole.

S. II - 6

PAPER

by

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THE SHIP OPERATOR AND THE PORT IN POLLUTION CONTROL

INTRODUCTION

Pollution is a dirty word and those who generate pollution, howsoever indirectly, are besmirched in the eyes of a public opinion which is not particularly well informed.

The socio-economic implications of pollution and its control are not to be ignored. In Britain and indeed in Europe there is apparent conflict between the aims of economists, sociologists, ecologists and so-called conservationists. Consequently politicians are required to resolve the difficulties in the light of national and local interests, often in the face of a vociferous lobby to reduce the rate of development and « return to nature ».

Fundamental to the development of civilisation and standards of living are communications and transport, yet motorways and the motor vehicle, airport and aircraft, and ports and shipping have become the targets of abuse and described as anti-social. How has this hysteria about pollution developed and can it be justified? Have those responsible for the development of roads, airports and ports fully realised the impact of their activities upon the live of the individual? Is the only prospect of generation of trade also one of doom for life as we would like to enjoy it? Would the under-developed countries be able to advance without an equivalent advance in the more prosperous countries? Is the general public prepared to pay for a better environment and if so, how much? How is the money to be gained for such an improvement if not by an increase of development and trade?

There are no simple answers to any of these questions but certain facts become apparent. There has in the past been a connection between development and pollution and there has been a lack of vision on the part of our predecessors as to the effect of their activities on the ecological and social climate. Even if existing standards of living are merely to be maintained there must be further development to sustain a growing population increasingly aware and critical of its environment and newly conscious of its power to influence those who manage it for them. The resurrection of life in the tidal river Thames and the success of legislation in limiting atmospheric pollution in London have shown that development need not be accompanied by the misery of pollution. Enlightened and influential bodies can do much to restore acceptable conditions if they possess appropriate powers and have the determination and desire to use them wisely in the interests of the economic, social amenity and health aspects of the environment as a whole, not just one or another of them, for they are mutually dependent.

Great Britain has in recent years been regarded as being in the forefront of progress in pollution control. This is not because their people are better inspired, rather is it that the British Isles is a very densely populated area with a rivers system inappropriately small to cope with the water supply and waste disposal demands placed upon it. The tidal Thames receives the waste from some eleven million people but has an average freshwater flow of the order of only 25 cubic metres per second in the summer and 70 cubic metres per second over the full year. The population of Greater London was 2 1/2 million in 1842, 4 3/4 million in 1881 and now approaches 8 million. It is apparent that problems of pollution would be likely to arise earlier here than in many less intensively used areas and indeed the first portents of trouble were met in the 1860's after the introduction of water-borne sanitation had disposed waste to the river instead of, as previously, to fields as « night soil ».

The solution at that time was to collect the effluents and discharge them 20 Kms further towards the sea, outside the limits of the metropolitan growth area and where tidal mixing was slightly more effective. This remedy was essentially short-termed and it soon became necessary to introduce progressively better standards of sewage treatment. Nevertheless by 1949 the river had become stinking and lifeless, and something more effective had to be done. The outward growth of London had overtaken the sewage outfalls and a 15 year long investigation was initiated to identify the sources of pollution, evaluate their importance, establish the mechanics of tidal mixing and the chemistry of purification and determine a strategy of recovery. That nine years later a great measure of success has been achieved is a credit to those concerned but the desire and impetus was born of necessity, not of high moral judgement and foresight. The effectiveness of the campaign is based on sound technical knowledge, backed by co-operation and sharpened in the last resort by the presence of effective legal remedies and powers.

The same historical situation has been repeated in other parts of the British Isles and indeed in Europe and America and the important lesson to be learned is that we must not always be catching up with the past, we must make provision for the future as well, with the full co-operation, consultation and co-ordination of all the interests concerned in the social, economic and health triangle. More than that, it is the function of each of us to demonstrate to the public at large that we are conscious of our responsibilities to them but wherever possible to educate them to a broader vision of what the control of the environment means and entails and to guide their attitudes to a realistic perspective.

The fouling of our doorsteps has inevitably led to a trend, as with London in the 1860's, to move the centre of the discharge of our waste away from the public presence; consequently the sea has become a target for disposal, and more particularly the sea around our coasts where full mixing with the vast oceans of the world is rarely met. Once again we are dealing in short-term measures and our foresight is very much in doubt. Pollution knows no frontiers and the interaction of our considerations must become more comprehensive and more co-ordinated internationally. A world forum of connected interests such as PIANC is vital in such a context, but it is not enough to protest our innocence, we must be ready to accept our guilt whether it is of thoughtlessness, ignorance, omission or more rarely of deliberate action, and we must take steps to safeguard the environment from which we reap large economic and social benefits. In so doing it is necessary to appreciate the significance of our actions in relation to the incidence of pollution as a whole, not just in terms of direct effect but also in terms of what activity is generated as a consequence of our actions.

Ports and Ship Operators are coming under increasing criticism for their acceptance that some pollution from the carriage and handling of cargoes is inevitable. Similarly the evolvement of primary and secondary industry from the creation of a port is being looked at as the responsibility of the port and its' users, who in the public mind must bear some responsibility for the pollution arising from their operations, howsoever indirectly. Can the port transport industry face these charges with a clear social conscience? What more requires to be done and in what areas can the most significant contribution be made? Can the industry step outside the generally accepted standards and agree to make a deliberate effort to improve the image of the port and the ships that use them, overcoming a preoccupation with commercial competitiveness that blinds them to their surroundings?

Some important advances have already been made as a result of agreements made within trade or government organisations. The Intergovernmental Maritime Consultative Organisation has been much maligned for its failure to achieve 100 per cent following for its recommendations and for the delay in implementing them but has nevertheless achieved very tangible results. The Oil Industry has effectively introduced the « Load on Top » system and yet it is criticised because charter ships and flags of convenience rarely comply. This sort of criticism by exception ignores the very valid improvements which have been made and for which due credit should be given. More generally the United Nations is criticised in relation to its Resolutions and Conferences for verbal indigestion and statements of good intention unachievable in practice. Above all the general public is more concerned about aesthetic pollution than the often more serious hidden sources and it rarely recognises its own very considerable and individual contribution towards the problem. Nevertheless Ports and Harbours are rarely places of beauty and cleanliness and much can be done to improve them and the waters surrounding them.

Pollution in harbours and coastal waters can have origins on shore, from ship or aircraft, from pipeline or from deposit grounds. It is the purpose of this paper to review the types of pollution which can arise from some of these sources and to attempt to indicate their importance, with special reference to the contribution arising from the port transport industry. It is inevitable that a port area is also a centre of social, industrial and commercial activity, and the degree of responsibility and control which can be accepted and exercised by the port transport industry for the area at large must necessarily be limited, but it is nevertheless a highly influential body and its contribution to an improvement of the environment can and should be very significant.

One of the essentials of any scientific advance is that of identification and concentration of effort in a particular direction. By concentrating on oil pollution the IMCO Sub-Committee have achieved notable success. It is for debate whether they are wise to diversify their effort into marine pollution as a whole for a big advance over a limited front is easier and certainly more recognisable than a small advance over a very wide front. It is appropriate for the port transport industry and PIANC to ensure that the concentration and direction are appropriate for effective improvements in their own environment.

PREVENTION OF OIL POLLUTION IN HARBOURS AND COASTS

It is thought to be convenient to examine the risks of oil pollution and remedial measures under two separate headings :—

Operational Oil Pollution, that is pollution caused by oil discharged from tankers in accordance with the operational procedures followed by the particular ship.

Accidental Pollution, being pollution which occurs when tankers are involved in an accident resulting in emission of persistent oil from the hull of the tanker.

A case has been advanced that the emission of any petroleum into the sea is harmful. However, this case does not seem to have been substantiated and presently efforts of governments, other authorities and the Oil Industry toward limitation of risk of oil pollution are directed towards limitation of visible pollution of the environment by what are known as persistent oils. This part of the paper will therefore deal only with pollution problems relating to persistent oil as defined by the 1954 Oil Pollution Convention.

It is quite impracticable to eliminate the risk of accidental oil pollution but all the nations of the world have indicated that they wish to reduce these risks to an acceptable level. The Oil Industry is entirely in accord with this intent, the difficulty being to determine the level of safety which is economically justifiable, and the measures which must be set out and enforced to ensure that the required level of safety can be maintained.

The possibility of elimination of operational oil pollution would appear to be feasible but must be expensive. The whole subject is at present under study to determine the feasibility and cost effectiveness of a number of different approaches to the problem.

The world's trade in oil derives considerable benefit from use of shipping on a completely international basis and it would seem to be sensible to attempt to ensure that measures taken to reduce risks of oil pollution should be internationally accepted and applied, so that the appropriate acceptable level of protection against oil pollution risk can be enjoyed by all countries of the world and the Shipping Industry would have one standard with which ships would have to comply, thus ensuring fair competition. It is important to bear in mind that in addition to risks to the environment in ports and close proximity thereto of all countries where oil is laden and discharged, tankers on passage will in many circumstances be sailing in waters where oil discharged to the sea might pose a threat to the coastline of countries quite disinterested in the trade involving the movement of oil.

The present position with regard to international control of the oil pollution problem is that the Intergovernmental Maritime Consultative Organisation (IMCO) has accepted responsibility for formulating conventions dealing with the way in which tankers are designed and operated to deal with the problem of operational pollution, and IMCO has also accepted responsibility for measures by international agreement to reduce the risk of accidental pollution.

Operational Oil Pollution.

The main cause of operational oil pollution is that as presently operated, tankers on completion of discharge of cargoes of persistent oil load water as ballast into the dirty oil tanks and means have to be found of deballasting these tanks after suitable tanks have been cleaned and clean ballast loaded for discharge prior to loading the next cargo. Presently by far the greater proportion of tankers follow a system known in the Oil Industry as Load-on-top, which involves their cleaning tanks during the voyage using a cleaning process whereby virtually all the oil cleaned out of the tanks is retained on board and, together with a small quantity of water from the cleaning process, is mixed with the next cargo.

IMCO, accepting that this procedure could eliminate a substantial cause of operational oil pollution, introduced in 1969 some amendments to the Oil Pollution Convention of 1954 and it is considered to be of prime importance that these amendments should be ratified and that legislation should be introduced requiring tankers to conform to the provisions of the 1969 amendments.

The efficacy of the 1969 amendments depends very largely on efficient surveillance to ensure that the condition of tankers on arrival at loading ports, and equally important on arrival at repair ports for repairs, have on board virtually all the oil remaining from the previous cargo. The Oil Industry can do a certain amount in this regard and in the author's own Group of Companies measures have been introduced to examine all tankers presenting to load at terminals controlled by Companies of the Royal Dutch Shell Group to ensure that the tankers have carried out their Load-on-top procedures correctly. Other companies take similar measures and these could be extended to cover the Industry, but authority in this matter must surely rest with governments. Therefore, whilst the Oil Industry can provide a service to assist governments to determine where ships may not have complied with oil pollution legislation, action in the matter must rest with the government of the flag state of the ship concerned, and this action would be dependent on a report from the government where a possible contravention of oil pollution legislation had been discovered on arrival either at a loading port or at a repair port.

The author is entirely in accord with an opinion widely held in the Oil Industry that by far the most important contribution to the reduction of operational oil pollution would result from more efficient operation of the Load-on-top system. Whilst IMCO has under examination a number of measures to reduce oil pollution below the level obtainable using Load-on-top, whatever is the outcome of these investigations implementation of any solution must lie several years ahead, and in the meantime the level of operational pollution can and should be reduced.

Many alternative solutions to reduce the level of operational pollution have been considered in IMCO but only two seem to be practicable and both would be expensive. There is no possibility whatsoever of means for improvement being financed out of existing profits and the costs will have to be passed on to the consumers.

The two solutions which have received intensive study in the Industry and at IMCO involve either the provision of reception facilities at all loading terminals to take all the ballast water from ships' tanks, or the provision of separate compartments in tankers to enable them to carry an adequate quantity of ballast water which would be kept quite separate from their cargo systems.

The first solution would in some circumstances provide the more economical alternative but where loading berths are far offshore or where oil is being produced from oilfields in the sea the necessary facilities would be very expensive and in some cases technical difficulties could arise which might not be soluble. Another difficulty is that where large quantities of contaminated water must be received at loading terminals the water has eventually to be treated and returned in the vicinity of the loading terminal still with some degree of oil pollution There may be difficulties in persuading governments of countries concerned with the export of oil that they should legislate to require interests concerned with oil production in their countries to spend large sums of money to cure a problem which is not theirs in a way which will result in some contamination of their immediate environment.

The alternative solution would only really be applicable to new tonnage and would not seem to be attainable for practical reasons before about 1976. It has the advantage of being applicable to all trades and posing a common level of additional cost. It is certainly technically feasible to design tankers where the ballast system would be completely disconnected from the oil system of the ship; it would however be necessary to provide means whereby the two systems could be inter-connected in casualty circumstances or under force majeure.

Accidental Pollution.

This can be conveniently sub-divided under three heading :—

1. Pollution arising from discharges and emissions from engine room spaces.
2. Pollution caused by cargo handling accidents.
3. Pollution caused by accidents under way, usually collision or stranding.

Steps have been tanken to reduce the risks of pollution under the first category notably by legislative action and by the fitting of separators to deal with bilge water. Nonetheless, pollutions can occur from such causes as deliberate or accidental pumping of oil contaminated bilge water over the side, overflow of engine room tanks, mal-operation of separators and leakage from oil sealed stern glands. Although some of these are relatively minor, they can cause nuisance and they may originate from virtually any type of mechanically propelled ship. Their cure lies almost entirely in the provision of suitable equipment, its proper upkeep and the formulation and strict observance of appropriate operating practices.

Harbour pollution is usually related to small quantities of oil but because in many circumstances the oil is put into the water in an enclosed area the nuisance value may be high, and where large quantities of oil are being continuously handled the problem is regrettably ever present. However at Milford Haven where around 43 m t of crude oil are handled annually and the harbour must function not only as a large oil port but provide high amenity as well, the authorities are satisfied that they have been able to contain oil pollution to a level where the nuisance is minimal and acceptable. Scientific monitoring indicates that there has been no harmful ecological effect.

The causes of accidents related to the handling of cargo are many and varied. The possibility of mooring failure must be guarded against and tanker interests and harbour authorities should take note of work done on moorings, particularly in regard to moorings of large tankers by shipowning and oil company interests. Equipment failure, hoses, pipelines, valves etc., can obviously be reduced by suitable regular inspection and maintenance, and authorities should accept a responsibility to see that these are carried out.

Regrettably the most common source of oil pollution during cargo handling is attributable to human fallibility, overflowing of cargo or bunker tanks and emission of oil through inadequately closed tanker sea valves being the most common. Risk of this type of accident can in the author's opinion most effectively be reduced by good shipboard management, and employment of suitable quality of staff and training.

In nearly all countries of the world national and local authorities impose penalties on tankers where pollution occurs. These penalties have become much more stringent over the last few years and certainly those concerned in the operation of tankers must accept the philosophy that transgressors must expect to suffer penalties. However, it does not seem that ever more stringent penalties will cure the problem and there is a fear that if penalties are too severe defensive mechanisms will be set up which may make it difficult to find the cause of particular pollution and take sensible remedial action.

Recent history shows that oil pollution caused by accidents to ships underway can be very dramatic. There have been 25 major incidents of collisions and groundings over the last 5 year period amounting to a total emission to the sea of oil of 222,000 tons.

Navigational accidents over recent years have been analysed in the Oil Industry to see what can be learned to identify causes so that suitable remedial measures can be taken. From the analytical work done it can be shown that by far the most important consideration is human fallibility.

With regard to collisions, the navigation of high density traffic areas at too great speed and insufficient attention to establishment of the threat of danger, together with misinterpretation of the situation, prove to be the reasons underlying collision.

Groundings similarly are almost invariably due to human error and not to lack of manœuvrability of ships, or paucity or inefficiency of navigational equipment. Having identified the principal cause of accidents as human error, preventative measures must relate to reduction as far as possible of the area of potential error and changes in navigational procedures which will reduce the likelihood of such error. The following appear to be relevant :—

1. Discipline on the navigation bridge should be such that there is a clear understanding of responsibilities between Master, Ship's Officers and Pilot. It is of vital importance that the decision of any one navigator must be checked and that constant checks must be kept to ensure that the ship is in fact making good the required course, position finding methods being double checked wherever possible.

2. The international rules for prevention of collision at sea are to be amended by the IMCO Convention of 1972. In the author's opinion the revision of the rules is long overdue and whilst some of the short-comings of the previous

rules have been ameliorated, experience may show need for further revision in the not too distant future.

3. Traffic routeing is now generally accepted as being of considerable value in enabling ships to navigate areas of high traffic density and IMCO's role in setting internationally agreed means of traffic routeing and prescribing routes for specific areas must be of help.

4. The control of traffic in ports by harbour authorities is in the author's opinion highly desirable and experience may well be extended to other areas. But it would seem to be unwise to tackle control of routeing in coastal areas until the control of traffic in ports and port approaches can be made efficient.

Role of Large Tankers.

In the author's opinion quite inadvisedly, the risk of oil pollution is thought to increase with increase in size of ship employed on any given trade. Much has been written about problems related to manœuvrability, stopping distances etc. of large tankers. There is no evidence to show that large ships carry any more risk of collision or stranding than the smaller ships which they replace. In fact over recent years some of the most serious cases of large scale oil pollution have been attributable to accidents which have happened to relatively modest sized tankers.

So, given a requirement to transport a quantity of oil, it seems logical to argue that the risk of serious accident which must be related to the number of ships deployed is reduced by employing larger and therefore fewer ships. It is, of course, necessary to ensure that the magnitude of the hazard involved with very large ships can be kept within acceptable limits. However, this can be done and has been done by an IMCO Convention which requires tankers to be constructed in a way that does not allow the emission of oil to the sea after an accident to rise in proportion to increase in size of ship.

Use of Offshore Berthing Facilities, Single Buoy Moorings etc.

An argument is advanced in the previous heading that the pollution risk does not rise and may in fact be reduced by the use of very large tankers, and it is demonstrable that the use of these ships results in quite dramatic reduction in the freight cost of moving oil by sea, and therefore the delivered price. There is no reason to believe that any plateau has yet been reached in the development of ship size and we must expect that in the foreseeable future ships much larger than those presently in use will be used for the carriage of crude oil.

The existing large crude tankers are in many cases too large for ports and harbours which could be served efficiently by a smaller volume of oil carried in smaller size tankers. There is therefore in many parts of the world a case for the provision of entirely new facilities outside the confines of existing ports. The single buoy mooring is one of the most common ways of providing safe berth accommodation for very large tankers in sea areas unprotected by harbour works. Projects to provide moorings of this type have been developed in a number of parts of the world and companies associated with the author's employing company are presently operating 16 berths of this type, handling in excess of 75 million tons of oil per annum, and this level of operation has resulted to date in only two instances of very minor pollution of the surrounding coastline by oil. There have been several instances of spillage of oil into the sea, usually small spillages of the type which regrettably is associated with tanker loading and discharge operations, regardless of the type of berth used. A point to emphasize however is that in single buoy mooring operations these small spillages occur in most cases offshore, where the oil is usually naturally and quickly dispersed and does not cause any nuisance.

The use of single buoy moorings in offshore localities by removing tanker traffic from existing ports very often with considerable congestion of other shipping, and affording berths to which ships can approach with minimum navigational hazard of either stranding or collision, substantially reduces the risk of accidental pollution of the catastrophic type. Whilst there is evidence to indicate that the total quantity of oil spilt into the sea with single buoy moorings is somewhat larger than with conventional berths in quiet water, the degree of increase in spillage is relatively small and its effect is substantially reduced by the fact that the oil is not enclosed as would be the case in a conventional harbour.

Remedial Action for Oil Pollution.

Since the traumatic accident to the « Torrey Canyon » the Shipping Industry and the Oil Industry have spent considerable time and effort toward a higher degree of efficiency in salvage operation. Improvements have been made both in the field of equipment and equally importantly in regard to contractual problems which always arise when ships and cargo are in peril on the high seas.

It is the author's considered opinion that in the large majority of cases where tankers are badly damaged and pose a substantial pollution threat the best way of reducing the threat will be to mount a successful salvage operation. This may have to be done notwithstanding a residual nil value of ship and cargo. Bearing in mind that salvage operations may have to be mounted in any part of the world and may involve any number of different degrees of damage to ship and cargo, and also taking into account that crude oil as a cargo has hazards depending on its particular nature, the Shipping Industry together with the Salvage Industry and the Oil Industry is now well prepared to tackle the problems.

Cost of Clean-up and Liability to Third Parties.

At the time of the accident to the « Torrey Canyon » shipowners carried insurance which provided cover against damage for which the shipowner had direct legal responsibility. There was no certain way of ensuring that costs undertaken by authorities in limiting the effects of oil pollution or clearing polluted beaches would be recoverable from the shipowner. It was seen to be necessary to formulate arrangements whereby shipowners would have a responsibility for oil pollution damage attribuable to accidents to their ships up to whatever limits they could reasonably be expected to be able to insure, except in circumstances where the accident might be attributable to act of War, force majeure or entirely the default of some third party, and the nations assembled at IMCO formulated a Convention to give effect to this requirement known as the Civil Liability Convention of 1969. This Convention has not yet been ratified but the Shipping Industry has set up an organisation known as TOVALOP (Tanker Owners Voluntary Agreement Concerning Liability for Oil Pollution) which ensures that funds will be available to compensate for clean up done either by authority or voluntarily by the owner himself up to a maximum of $10 million or $100 per gross registered ton.

It was appreciated that it would be necessary to set up an international fund to provide full compensation for victims of oil pollution where these were not already covered by the 1969 Convention and to higher limits than the TOVALOP maxima, and a further IMCO Conference produced a Convention known as the International Compensation Fund for Oil Pollution Damage in 1971. In the meantime the Oil Industry produced a voluntary arrangement known as CRISTAL (Contract Regarding an Interim Supplement to Tanker Liability for Oil Pollution) which ensures that cargoes carried by TOVALOP entered tankers have cover on a mutual indemnity basis, which together with tanker owners liability from any other source will give an aggregate amount of $30 million per incident.

Equipment and Techniques for Cleaning Oil Pollution.

It is suggested that organisationally governments either at national or local level should provide and maintain whatever equipment is necessary for treatment of oil either on the sea or on beaches. The costs involved in use of this equipment, together with charges to reflect the cost of providing whatever is necessary, should logically come from the Shipping and Oil interests involved in the pollution.

Similarly harbour authorities should provide whatever is reasonably necessary to deal with oil spillage which might occur in a particular port.

It is fortunate that oil on the surface of the sea, at least in temperate water temperatures will be fairly rapidly degraded biologically and all the indications are that where large scale pollutions have occurred in close proximity to coastal areas, this biological degradation has been of great importance in dealing with a large proportion of the oil.

Oil on the sea surface can be treated with dispersants which can now be of very low toxicity and in many parts of the world chemical dispersant to be sprayed on to the surface of the sea and suitably agitated to mix it with the oil slick, is the main weapon which may be used to reduce risk of pollution of adjacent coastlines.

In areas where quantities of sand and suitable dredgers are available it is possible to equip the dredgers in order that they can spray suitably treated sand over the oil so that the sand and oil will sink, the oil being then degraded bacteriologically on the sea bed. This method obviously cannot be used where the sea bed in the area is used for fishing of any kind. The deployment of a suitable boom to contain the oil or to prevent its reaching a particular area is immediately attractive. Unfortunately to date booms have not proved efficient except in virtually quiet water not subject to current.

British Petroleum have recently spent considerable effort on development of a boom which can be used in rough water conditions, and whilst it may not be usable as protective equipment in areas subject to current, it may well prove efficient in providing a means of containment of oil of the surface of the water so that the oil may be more easily removed or treated. This boom is in the author's opinion the most efficient yet developed and its laying from a suitable craft which can be carried by air to the required location seem useful features.

Shell Oil Company in the United States have developed a chemical known as an Oil Herder which would appear to be usable in certain circumstances to avoid oil spreading in a dangerous manner and also to facilitate its collection.

Once oil arrives on beaches the only satisfactory way of cleaning seems to be physical removal, usually with the help of suitable absorbents when the oil, together with absorbents are subsequently destroyed by burning. A final polishing clean-up using the new low toxicity dispersants may be desirable in cases of beaches of high amenity value.

HARBOUR AND COASTAL POLLUTION (General)

The largest single source of coastal pollution is likely to arise from the disposal of sewage effluent and sludge into river and estuarial systems. 79% of the polluting load carried by the tidal Thames in the 1950's had this origin and its volume is three times as high as the upland flow entering the estuary in summer. With a resident hinterland population of eleven million people contributing to this problem, the significance of efficient ships' sewage systems in ports may appear to fade, especially if that port's passenger traffic is relatively low. Nevertheless in impounded docks, where the water movement is restricted, the problem can be very important and it is the author's view that a port or terminal must provide facilities for the reception or transfer of ships sewage and garbage ashore. Similarly where significant ship populations are assembled however transient and whether in docks, harbours or at river moorings, it is essential that facilities be provided such that waste generated is capable of transfer, reception and adequate treatment ashore and reliance should not be placed upon the possession by ships of adequate holding tanks or on-board sewage treatment systems, the latter of which cannot at this stage be considered to be in an adequate state of development.

Ship-board sewage treatment systems generally suffer from one or two major defects; sterilization techniques create acceptable conditions on board but lose their effectiveness as soon as the sewage is discharged to waters in which bacteria abound; biological treatment systems depend on tanks of a very large capacity allowing an appreciable period of retention, on the establishment by use on voyage of appropriate colonies of bacteria and on enlightened operation and maintenance, rarely achieved. It is important however to recognise that certain ships do not present problems in this respect; the provision of adequate holding tanks for sewage in VLCC's by virtue of their nature, size and population is a relatively simple matter. Container and Ro-Ro ships, dedicated as they are to an almost immediate turn-round, may require smaller holding tanks than more conventional cargo ships, but in none of these cases should untreated and direct discharge to dock, harbour or coastal waters be permitted. It is equally important that there is some standardisation between countries and ports in their requirements of ships for this purpose; it is unrealistic to demand the provision of a ship-board sewage system in, for example, Canadian Ports and to deny their use in European Ports but require instead large holding tanks or equipment capable of pumping ships sewage ashore. The rapid evolution of yacht marinas, houseboat colonies and floating restaurants has produced a sudden upsurge in waste disposal problems and ports and harbours should not allow their responsibilities to escape them in the desire to obtain the maximum financial advantage from this type of development.

The handling of cargoes in a port or at a terminal has a special significance in pollution terms and the losses due to spillages can be considerable. Grab-handling of loose cargoes, is relatively inefficient as a method, but is in general use. Sugar spilt as a result of being handled in this way has a very high polluting value and one pound weight of this substance requires as much oxygen for its eventual bacteriological breakdown as does the total raw sewage emanating from one man in one week. In investigating industrial pollution in its many forms it has often become apparent that processes have been developed which allow a considerable loss of raw materials and that appreciation of this together with remedial action and recovery can lead to a significant economic improvement with an equivalent benefit in a reduction in polluting load. This is equally evident in the port industry and much more attention should be paid to the provision of handling equipment which is capable of reducing spillages to a minimum. It is interesting to note that Ro-Ro ships and containerisation are very effective in this respect.

Driftwood and debris arising from port operations or decaying port structures is a common sight and can result in a considerable hazard and nuisance value and in vociferous public concern which could be greatly reduced if ports and the ships using them were to recognise that the effort in preventing the entry into the water of such materials is far less than that required for recovering them from the water at a later stage. In particular the habit of ship's crews of throwing dunnage overside as they leave port is to be deplored and the attention of the individual must be drawn to his responsibility for keeping ports and coastal waters clear of such a display of bad housekeeping.

The impact of dredging activities on water pollution is rarely appreciated. In a heavily used waterway, considerable accumulation of polluting matter can develop on the bed, whether by virtue of the mechanism of sediment transport or from deliberate or accidental dumping or spillage. In an area where the waterway receives industrial effluents and sewage discharges, certain toxic materials including mercury, arsenic and phenols which by pass the treatment systems, may over the years settle out and progressively contribute to an intensive pollution problem. The quiet waters often required for port operation, the salinity gradients inherent in basins adjacent to sea access channels, the maximising of depths for the reception of ships of successively increasing draught, all lead to a tendency for polluting matter to congregate around port areas which act as sediment sinks. The act of dredging these areas can liberate into suspension matter which otherwise might lie dormant beneath the mud. For many years it was and in some cases it still is the practice to deposit dredged spoil back into the estuarial or coastal water system in the hope that it would not come back quite so quickly as it was dredged. The choice of deposit grounds is now becoming more scientifically based but in the Port of London the economics of the provision of pump-ashore facilities for the disposal of virtually all dredgings has been proved and has resulted in a reduction in sediment movement, in dredging requirements and in the level of suspended solids in the estuarial system. The pollution side benefits of this method of disposal are believed to have been significant. In the first place accumulated polluting matter is being progressively removed from the waters of the Thames; secondly the less turbid waters of the estuarial river are more receptive to the re-introduction of life into the system; and thirdly the capacity of the water to receive oxygen from the atmosphere is being enhanced so that bacteriological purification is being accelerated. If the annual removal of some two million tons of sediment from the system can produce such beneficial results, how much better would it be if the dumping of over 5 million tons of digested sewage sludge each year into the relatively confined waters of the estuary were to cease or a new dumping area were chosen such that adequate mixing and dispersion within a larger water mass were achieved. This problem is not one for London alone and concern about the use of the North Sea as a « sink » for the waste of Europe is well founded; some 8½ million tons of sewage sludge, two million tons of industrial sludge and eleven million tons of dredging spoil are deposited in the coastal waters of Great Britain each year. The fault lies not with the method of disposal but with the areas chosen and the lack of dispersion and dilution. The total water mass in the vast oceans of the earth is quite capable of receiving our waste without detriment, but rarely the sea around our shores.

Ports, as the hubs around which industries develop, bring to themselves accusations of inviting pollution by association. Further, by the introduction of the concept of « industrial ports » such as Europort, the charge is brought that ports are instrumental, by virtue of their planning, in introducing pollution to an area. The responsibility to ensure that unacceptable conditions do not develop is inescapable. Technology is capable, at a price, of ensuring that industrial activities can be relatively inoffensive and planners and developers must be prepared to anticipate and accept that price. It is likely that they cannot do this unless either their competitors accept similar responsibilities or if they are by force of law compelled to do so. Since competition is international, the importance of international law or aligned national law becomes self-evident.

Land use in Ports has been the subject of a previous International Navigation Congress, with special reference to the area required per unit of throughput and certain ports have discovered that their ability to develop further is limited not by trade prospects but by land availability. In these circumstances land which should have been allocated to amenity or residential use has been eaten up by industry to the detriment of the quality of life of those who work there. In consequence public reaction to otherwise lesser forms of pollution becomes quite intense. It is in the Ports' own interests to ensure that these situations do not develop and their responsibility to provide adequate land is quite clear but rarely appreciated. In recent years it has not been unknown for developers or industrialists to counter the offensive presence of an industry by the free provision of an amenity area to appease the local population and this has made commercial sense. In some areas the creation of artificial islands for waste processing and disposal and for the more noxious industrial activities has been advocated to escape public objection, but here again « out of sight » should not mean « out of mind ».

Effluent from land based industry is usually a front runner with sewage treatment works discharges in the pollution stakes, but it often contains substances of a more persistent and toxic nature about which much concern is being expressed. The removal of these substances before discharge of the effluent to coastal waters is perhaps the most important problem in this field and an incentive to recover these often valuable materials is vital unless legislation is to provide the solution.

Oil refineries are capable of being designed in a manner such that their effluent is not objectionable and the use of air cooling and separation systems has become standard practice. Public concern at these installations is more often linked to atmospheric pollution and the hazardous nature of the operations coupled with the association of this industry with oil spill incidents, often exaggerated. In the tidal Thames during 1970 and 1971 there were 257 reported oil spill incidents involving a total quantity of oil estimated at less than 3,000 tons or less than 0.01 % of the total crude oil imports and transhipments. The origins of these spills and their significance is illustrated in the following table :

Source	Number of Incidents	Estimated total tonnage (maximum)
Untraceable	43	50
Dry Cargo Vessels	107	160
Shore Installations other than refineries . .	28	between 1,000 and 1,500
Refinery, Bulk Storage and Associated Tanker activities	79	1,400

It will be seen that about half of the incidents originated from refinery and associated tanker activities and a significant proportion was released to the estuary by users rather than suppliers. Recent forecasts of annual world oil pollution by ships of 66,000 tons in 1975 (IMCO), would appear to be too low in the light of these figures, but more important is the indication that a 50% increase in traffic by 1980 is likely, under present conditions, to produce a commensurate increase in oil pollution, both from ship and shore.

The significance of hazardous cargoes in ship transport and port handling is demonstrated by the categorisation in the International Chamber of Shipping « blue book », coupled with the GESAMP list of some 250 hazardous substances carried by ships which is to be prepared for the 1973 Conference on behalf of the Intergovernmental Maritime Consultative Organisation. This list is to indicate hazard ratings under four main headings :

a) Bio-accumulation;

b) Damage to living resources;

c) Hazards to human health;

d) Reduction of amenities

and indications are to be given of the relationship between the quantity of discharge, the nature of the receiving waters and the hazard resulting from the discharge. What is important here is not the evaluation of effect but the determination to reduce the risk of accidental spillage, stranding or sinking and of adequate notification to authorities whose waters may subsequently be affected, together with plans for appropriate remedial or recovery measures. IMCO is to sponsor recommendations on an appropriate reporting procedure.

Adequate facilities for the reception of residues and washings of noxious cargoes is vitally important for a port and it is the author's contention that it is the port's responsibility to ensure that such facilities are available, though not necessarily to provide them. IMCO is gaining information on the availability of such facilities within participating countries, with specific reference to the size of the reception facility and the type of waste which can be received. Countries should not quibble as to whether they should be required to provide facilities for the reception of residues resulting from the discharge of cargoes in the previous country of call. The port transport industry is international and interdependent.

The Port Transport Industry is most vulnerable to public censure in the occurrence of « incidents », « strandings », sinkings, collisions and fires at sea and at berth. That the port and ship industry has a remarkably safe record is forgotten in the heat of the moment and the advent of larger ships and more intense traffic year by year can only increase public concern, however unwarranted. The design and surveillance of sea port approaches must of necessity be at very high levels and the recommendations of the International Oil Tanker Commission should prove valuable to Ports and Ship Operators in this respect, especially in relation to channel design and the provision of hydro-meteorological information and navigational aids. Safety of the ship at sea and onto the berth requires the utmost co-operation between Mariner and Engineer, but it is becoming increasingly evident that regulation of traffic needs to be mandatory or more specific within heavily worked shipping channels, extending to international waters such as the English Channel, where too often ships have ignored advisory beacons, wreck buoys and even recommended routes. There would appear to be evidence that ships' crews are not always at the optimum state of readiness or training and this requires careful consideration. The wisdom of carrying two pilots on VLCC's in congested waters has been suggested so that one pilot can concentrate on handling the ship whilst the other monitors position direction and speed parameters in relation to the essentially narrow channels through which these ships have to pass.

It should be an accepted duty of port authorities periodically to inspect unloading and handling facilities within their ports to ensure that minimum safeguards and standards are adhered to and they should have and use the power to close any berth where the facilities do not reach an acceptable standard of safety which shall include the provision of anti spillage devices and emergency procedures. Check valves for oil pipe lines to limit spillages in the event of the pipe being severed by a collision with a jetty could be a case in point. In certain ports there are risks that tankers may be stranded in the approaches to the port. In such circumstances it may well be that the risk of oil pollution can best be avoided by providing adequate lightening capacity to take a sufficient quantity of oil off the stranded tanker to allow her to be refloated and removed to a position of safety. Salvage operations recently undertaken indicate that suitable lightening ships can usually be provided without too much difficulty, and the Oil Industry is actively engaged in a review of how to ensure the provision of adequate fendering and oil transfer equipment which may be necessary in operations of this kind.

The use of unit loads, containers and large bulk carriers has demonstrably reduced the incidence of losses per unit of throughput due to handling at berths and has often assisted the recovery of cargoes which have been lost in the water. There is still room for improvement in the packaging and identification of cargoes which could present problems of water pollution and too often cargoes are left in the water if they do not present a navigable hazard and their salvage has no financial merit or entails some handling danger.

The willingness of nations to engage in conventions for the protection of the environment is demonstrated by the Convention for the prevention of dumping in the North-east Atlantic which also draws attention to the instant, delayed or cumulative polluting effect of substances in a physical, chemical or biological manner. The effects will vary according to the geographical nature of the area and the extent and manner of water movement, dilution and dispersion, both horizontal and vertical. It will be difficult to monitor the effects of pollution in these areas and to identify those parameters or indicators which will give advance warning of undesirable effects, but the principle of prevention being better than cure is established, whilst recognising that complete prohibition is impracticable and that selective dumping can be accepted.

The minimising of pollution of port and coastal waters is dependent on the identification of the principal sources and the isolation of the more critical problems so that effort can be intensified in the optimum direction. Limiting levels need to be established for different substances in different areas with legal enforcement powers which can only operate satisfactorily if inspection facilities are adequate. The provision of facilities for the reception and treatment of waste ashore is essential as is the establishment of appropriate safety precautions, with appropriate equipment and procedures.

Even with such control of scheduled discharges or deposits, pollution regularly occurs as the result of human error, mechanical failure or from an unplanned event. It is in this field that ports and ship and berth operators can make the most useful contribution to the reduction of pollution at very little cost — constant vigilance, checking of equipment and most important of all the involvement, training and co-operation of the individuals at the end of the line is all that is required. Heavy fines on prosperous companies have little effect on their remote employees and an intensive public relations exercise can pay enormous dividends and bring to light problems which management often don't know exist.

The occurrence of deliberate discharges of polluting matter from ship or shore is fortunately relatively infrequent, but it happens and generally when it is felt that no-one is looking or can see. In fog or rain, at night-time or at week-ends and out of sight of shore are the general occasions when these things happen and monitoring systems must be random and not regular if offenders are to be detected and subsequently deterred from attempting such acts. The co-operation of the public and of fishing vessel crews is valuable if they are made aware of a reporting centre for events of this nature and which is open 24 hours a day.

Remedies for pollution, once it has happened, are of only limited effectiveness, though the IMCO manual of oil spill procedures is a direct attempt to improve this situation. Following the « Torrey Canyon » incident, the ingenuity of manufacturers has been stimulated by the concern of governments and the public, but must this sort of realism always require a catastrophe to activate it? If the sinking of the m. v. « Germania » with its cargo of 150 drums of tetra ethyl lead is to be used as a similar lesson, the recovery of hazardous cargoes after sinking should become common practice where they endanger life, health or amenity.

Pollution of a harbour or coastal water can affect the operations of a port in several ways. The release of obnoxious gases such as hydrogen sulphide from anaerobic waters was a distinct disincentive to work on the riverside of the Thames in the 1950's. Since the improvement in the quality of the tidal Thames there has been an upsurge of pride and satisfaction in their working surroundings by port and allied workers. This has been demonstrated by the formation of several angling clubs and by fishing competitions attended by two or three hundred people at a time. The counting of the number of species of fish and birds which are present in the area has become a regional pastime; surfing on pallett boards towed by tugs on the river has been observed; the area and the workers have become alive again. Conversely the presence of oil on ladders and equipment and the possibility of deterioration of port structures and indeed of the paint on ships hulls as a result of pollution has been observed to produce increased maintenance costs and an unhappy state of mind in port workers. The use of river and coastal waters for industrial cooling processes can be affected if the quality of the water deteriorates and concern about condensers ensues. On the other hand it is apparent that an improvement in water quality may bring about a return of unwelcome life in the form of marine borers, hydroids and barnacles, such that the use of preventive measures such as biological inhibitors, chlorination and ultra-sonic cleaning may become necessary. The increase of oxygen in river waters may result in an increase in the need for cathodic protection of metal structures.

The very direct influence which water pollution has upon port operations and their public image justifies, in the author's view, the appointment by port authorities of specialists to protect their interests in this field and act as advisers on preventive and remedial measures and on the need to educate public opinion and reduce the present emotive state which exists about port development and operations. This is true whether or not the port authority has a statutory responsibility for pollution control and these appointments should be regarded as vital in the same way as the more normally accepted « safety officers » with a seniority reflecting the port authority's sincerity in pollution control and the social responsibility of ports. Industry in general and the oil industry in particular, already have these officers, is it a lack of interest that has prevented ports from following suit?

CONCLUSIONS

The responsibility for minimising pollution, for the surveillance of approved discharges and monitoring of the quality of the marine environment, for the detection of offences and for the setting up of remedial activities cannot be allocated on a voluntary basis. It requires co-operation between nations with common standards applied in each, it needs research allied to need but most of all it needs the force of law, which should be used only when all else fails. In this framework national and regional governments, ports, ship owners and operators, engineers and naval architects and man as an individual, each have a significant role to play. In this activity consultation, co-operation, co-ordination and control need to be exercised at all levels but in particular require the determination and encouragement of managements.

Marine pollution control must never be allowed to become synonymous with politics, national or international; it must transcend social and ideological barriers. Who better to set an example in this regard than those whose very existence depends upon their relationship and understanding with other nations — the shipping and port transport industry!

There is much that can be done and the incentive to do it must not be reduced by distracting prophesies of doom and an inevitable extinction of mankind within the next 50 to 500 years.

The International Convention for the prevention of pollution from ships 1973, at present being prepared by IMCO is formed from the desire to achieve the complete elimination of intentional pollution by oil and other harmful substances and the minimisation of accidental release of such substances by the adoption of uniform rules in the exercise of maritime trade. This convention has the aim of protecting the human environment in general and the marine environment in particular from deliberate, negligent or accidental release of harmful substances from ships and provides for legal penalties for contraventions. Arising from the proposed convention are codes and conditions to be applied in the carriage of defined noxious substances, mandatory reporting of significant spillages of oil or noxious substances, and Government inspection of ships entering ports where reports of a discharge have been received. Part of IMCO's desire to minimise marine pollution is expressed in the attention given to safety factors in navigation, routeing, ship design and the provision of adequate and effective secondary systems of power generation and steering gear.

Whilst these general considerations, if adopted and exercised, will do much to reduce marine pollution, there are still many more specific areas in port operation where pollution gaps will exist and it is up to the ports in concert, perhaps through a PIANC or IAPH ad-hoc working party, to consider how they can actively contribute to the work started in the wider sense by IMCO. It is also for consideration whether PIANC and IAPH should henceforth involve themselves more directly in IMCO affairs as indeed the International Chamber of Shipping have done and end the period during which they have acted merely as « Observers » in an off-stage capacity. The success of such a venture will be assured only if port operators show themselves individually desirous of improving their own environment and this applies as much to smoke and noise control as to water and quayside housekeeping.

RÉSUMÉ

Le Commandant de navire, le port et le contrôle de la pollution.

Sommaire.

Le rapport aborde la question de la pollution de l'eau dans les ports et de leurs abords et examine l'importance des opérations portuaires et maritimes sous l'angle de la pollution en général.

On a émis l'opinion que développement ne signifie pas nécessairement accroissement de la pollution mais qu'il existe des zones où les autorités portuaires et navales peuvent contribuer individuellement et solidairement à l'amélioration de leur environnement dans le cadre d'accords commerciaux internationaux à l'échelle gouvernementale renforcés par des pouvoirs législatifs effectifs et moyens de droit.

Pollution due aux hydrocarbures.

Il a été suggéré qu'il était impossible d'éliminer le risque de pollution accidentelle par pétrole qui est dû plus à la faillibilité humaine qu'à toute autre cause. Cependant une organisation efficace à bord et un équipage bien entraîné peuvent contribuer dans une large mesure à améliorer la situation.

Il devrait être possible d'éliminer la pollution due au pétrole causée par des manœuvres mais l'efficacité d'une élimination totale est discutable.

Le moyen le plus efficace de réduire la pollution due au pétrole causée par des manœuvres serait d'accroître l'efficacité du système de chargement par le haut. Bien qu'IMCO a à l'étude plusieurs projets de réduction de la pollution par pétrole en deçà du niveau atteint par chargement par le haut, quelque soit le résultat de ces investigations, il faudra attendre plusieurs années avant qu'une solution quelconque ne soit appliquée et entretemps le niveau de pollution due aux manœuvres peut et doit être réduit.

Les deux solutions ayant fait l'objet d'études intensives de la part de l'Industrie et de IMCO prévoient d'une part des dispositions nécessaires pour assurer des facilités de réception dans tous les ports de chargement permettant de vider les ballasts, d'autre part des compartiments séparés dans les pétroliers de façon à ce que ceux-ci puissent transporter une quantité de lest liquide qui ne serait pas en contact avec leurs systèmes de cargaison.

Le rapport préconise un contrôle plus efficace du trafic portuaire qui devrait être étendu à d'autres zones. Le rôle des pétroliers géants est étudié et il semble logique que leur emploi réduise le risque d'accidents en mer spécialement en cas de mouillage au large et qu'il soit possible d'empêcher tout risque dû à un accident de prendre une importance proportionnelle à la dimension du bateau si la Convention de l'IMCO concernant la conception et la construction des pétroliers était appliquée.

Les remèdes, la responsabilité et les assurances en cas de pollution due au pétrole sont discutés tout particulièrement en ce qui concerne les mesures provisoires de l'Industrie Maritime actuellement appliquées et ce jusqu'à ce que les Conventions de l'IMCO aient été ratifiées.

Pollution portuaire et côtière.

Le rapport discute l'importance des systèmes d'évacuation des égoûts et ordures des navires, des méthodes de manutention des chargements, des bois flottants et débris, du dragage et méthodes d'évacuation, du développement industriel portuaire, des activités des raffineries de pétrole, des cargaisons dangereuses, des facilités de réception des résidus et du nettoyage des cargaisons nocives et de l'importance d'inspections régulières par les autorités portuaires et par les commandants de navire. La nécessité de chenaux d'accès aux ports bien conçus et renforcés par des appareils de navigation adéquats est soulignée et il est remarqué que le risque de pollution est réduit grâce à l'emploi de réservoirs et de systèmes « roll-on — roll-off ».

Il est admis que l'erreur humaine est la cause principale de la pollution accidentelle et il est préconisé d'intensifier tout effort en vue de rendre les dirigeants, le personnel et les ouvriers conscients du problème que pose le contrôle de la pollution. Les autorités portuaires sont invitées à employer des spécialistes de première force pour les conseiller pour toute question d'environnement, et pour créer dans chaque employé un regain de fierté dans l'économie domestique et de conscience de leur environnement.

Il est important que les organisations maritimes réalisent l'influence directe ou indirecte qu'elles ont sur la vie de l'individu. Le rapport souligne également la nécessité d'éduquer l'opinion publique. Il est un fait que les aspects économiques, sociaux, esthétiques et sanitaires de l'environnement dépendent l'un de l'autre et qu'aucun aspect ne doit être développé au détriment d'un autre.

Finalement il est reconnu que les autorités portuaires et les capitaines de navire ont une très grande influence et que par l'intermédiaire de l'IAPH et de l'AIPCN, ils peuvent et doivent encourager les organisations gouvernementales internationales telles qu'IMCO à élaborer des conventions et traités. En tant qu'individus, ces autorités ont un rôle important à jouer dans l'amélioration de leur propre environnement et de leur réputation et ce grâce à leur conduite éclairée.

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PAPER

by

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The sinking of the tanker TORREY CANYON in the English Channel on March 18, 1967, was probably the incident which contributed, more than any other, to touching off the great anti-pollution crusade in which port authorities and others throughout the world are now so deeply involved. This tanker accident which was followed in January of 1969 by the Santa Barbara Channel oil platform leaks, brought about an awareness on the part of the general public to the need for taking immediate and drastic measures to preserve the environment.

As might have been anticipated, the initial reaction to this situation was a deluge of ill-advised and oftentimes conflicting legislation by various governmental entities. Much of this legislation would appear to have been based more on emotionalism than on logical reasoned approaches to (1) the problem (2). Many times such legislation represented a duplication of effort and overlapping of jurisdictions among the various governmental agencies involved with no well coordinated plan as to how an effective and acceptable pollution control program could be implemented. Fortunately a period of re-assessment is now beginning to take place. Much of this over reaction in terms of regulations and legislation is now being contested. Revisions are being made in the light of economic practicalities and realistic ecological and environmental considerations. Most knowledgeable persons now seem to realize that there are no instant solutions to the many complex pollution problems which we face and regulation in this field will undoubtedly outpace technology over the next few years.

The seriousness of pollution problems, however, should not be underestimated. Many responsible persons have warned that the world's oceans are being polluted at an alarming rate and the continued disposal of wastes at sea both from onboard vessels and from shore side facilities cannot long continue at present rates (3).

The Mediterranean, for example, is now being described by some as a dying sea due to the enormous amounts of pollutants being dumped annually into that body of water. One source has determined that approximately 300,000 tons of oil per year are now being discharged into the Mediterranean from vessel ballast tanks, tank cleaning, industrial waste and oil terminal spills (4).

It has also been reported that approximately 500,000 tons of chemical wastes are shipped annually from the Rhine River area for dumping in the North Sea. In addition, about 4,500,000 tons of colliery waste are being dumped directly into the North Sea from English mines.

Other estimates indicate that the world fleet of some 48,000 ships over 100 gross tons pollute the seas at the rate of from 1 to 5 million metric tons of oily waste annually. About half of this is accounted for by the 44,000 passenger, cargo, military and pleasure ships flushing oily waste from their bilges. The other half comes from the 4,000 tankers which ply the world's sealanes (5).

Other statistics equally startling can be obtained from almost any agency having responsibility for monitoring and controlling pollution.

Since this subject covers such a broad area, the author will attempt to merely cover the highlights of harbor and coastal pollution problems as they now exist; what means are available for pollution control; what some of the world's ports are doing in pollution control; and finally some recommendations and conclusions as to what the future may hold. No attempt has been made in this paper to investigate in any great detail problems related to smoke, dust noise or aesthetic pollution and only to a limited extent is thermal pollution considered.

A. SOURCES OF COASTAL AND HARBOR POLLUTION

There are any number of pollution sources that contribute to the water quality of harbors and coastal areas. Some of the most troublesome and most easily identifiable are the following : 1) vessel waste, 2) oil spills, 3) floating trash and debris, 4) industrial waste discharge, 5) power plant and refinery coolant discharges, 6) dredging activity, 7) deep draft vessels turning up bottom sediment, 8) storm drainage runoff with agricultural chemicals, fertilizers and pesticides, 9) polluted stream discharges, 10) sewage plant outfalls, 11) tidal movements, 12) stack gases and smoke, 13) grain elevator and bulk handling dust, etc. Every port obviously has its own particular list of pollution sources.

Studies recently made by the Dillingham Corporation under the sponsorship of the American Petroleum Institute showed that 75% of the oil spills which occurred offshore between 1956 and 1969 was associated with tanker and vessel activity (6). The remaining 25% was due to offshore drilling, pipeline breaks and other causes.

Since it is estimated that world crude oil production will reach four billion tons per year by 1980 and at least one-third of this will probably come from offshore sources, the hardware and procedures to effect prompt and thorough clean-up are of urgent necessity.

In addition to pollution problems associated with offshore production, the United States, for example, faces an oil shortage of some 15 million barrels per day by 1985 or 58% of total needs at that time which will undoubtedly be supplied by imports with the resultant opportunity for spills and pollution by tankers. The alternative would be intensive development of oil shale, tar sand, coal and nuclear sources which can produce environmental problems much more serious than marine transport.

Oil is not the only pollutant to consider, however, and every port should analyze discharges being made within the harbor confines related to food processing, meat packing, brewerys, fish canneries, wineries, plating shops, chemical manufacturing, oil well brine, leather and textile dyeing plants, laundry wastes, petroleum waste, oil refinery waste, cooperage of barrel washing facilities, tank car washing, run-off from farmlands where pesticides and insecticides are used, and the oily waste from shipyards and ship repair facilities. The discharge from these processes as well as others of a related nature generally require some type of pre-treatment before discharge into harbor waters since they often contain both toxic substances and suspended solids.

Some pollution problems may arise from the sheer size of ships now coming into service. Very large propellers may have an effect not only on turbidity but also on salinity by increasing turbulent mixing in and through the halocline. If this occurs, it could seriously alter the relationship between salinity changes, depth and bottom type which are important to the spawning grounds for some fish and invertibrates (7). This problem would obviously be compounded if there is a greater trend toward the use of bow and stern thrusters on large vessels whether they be of the propeller or water jet type.

B. UNITED STATES AND INTERNATIONAL POLLUTION LAWS, CONVENTIONS AND POLLUTION INSURANCE

To anyone in the shipping business it is a cliche that apart from the expense of additional insurance and the operating costs and purchase price of special anti-pollution devices, every ship in the future may well have to carry as a member of its crew a properly qualified sea lawyer to guide his vessel through the maze of anti-pollution laws now being enacted throughout the world.

Just how uniform the multiplicity of laws and regulations will ultimately become is a matter of grave concern to the shipping industry. It appears obvious, however, that the costs which compliance will impose will be considerable and cannot be absorbed entirely by the industry.

Federal regulations in the United States are becoming more strict and ultimately will undoubtedly preempt many state, regional and local regulations. A case is to be heard in mid-1972 by the U. S. Supreme Court involving the State of Florida and whether or not it can impose pollution controls which are more strict than those of the federal government (8). New York, Connecticut, Virginia, North Carolina and Georgia are reportedly considering similar legislation. The

U. S. Supreme Court is also expected to rule in mid-1972 on a case involving a Michigan anti-pollution law forbidding barges with flush toilets to enter its inland waters while at the same time U. S. law permits such barges on inland waterways (9).

It is obvious to nearly everyone that completely independent action or « home rule » is a luxury which cannot be afforded in the field of pollution control and environmental management. A simple ship to shore connection for waste discharge, for example, if left to the discretion of each state or nation could lead to hundreds of different standards resulting in costly duplication of equipment and endless conflicting interpretations of legal and engineering requirements.

1. U. S. Water Quality Improvement Act of 1970.

The U. S. Water Quality Improvement Act of 1970 provides on a national basis the means for policing damage to the ecology of United States waters. This law, for example, prohibits discharges within the 12 mile limit and all spills or discharges must be reported to the U. S. Coast Guard. It imposes a clean-up liability of $100 per gross ton of the responsible vessel or $14 million, whichever is less. Willful violators are subject to a civil penalty of $10,000 for each offense plus the cost of cleaning up the spill. Every vessel over 300 GRT must obtain from the Federal Maritime Commission (FMC) a certificate of financial responsibility to meet the clean-up costs which could be imposed under the act. The act also forbids the discharge of improperly treated sewage from vessels into U. S. navigable waterways.

The federal regulations would permit discharge of waste from small craft after treatment with mascerator-chlorinator type devices. Such equipment can provide treatment at about the equivalent of primary treatment by municipal sewage plants. Most states, however, want the law strengthened to require holding tanks that are pumped out into shoreside facilities when the boat returns to its dock. They feel that, in general, the new federal law is too lenient insofar as the smaller craft are concerned.

The federal law which was enacted on April 3, 1970, provides that following the completion of research on waste disposal systems and a report to the U. S. Congress on this subject that the Executive Department, through the Environmental Protection Agency (EPA), shall promulgate standards for marine sanitation. New vessels must be equipped with approved devices within two years after the standards are adopted by EPA and existing vessels must be so equipped after five years. There have been several standards proposed to date by the EPA, but as of mid-1972 none had been officially adopted. This means that the two year and five year periods have not yet begun.

The Coast Guard is the United States federal agency which has the responsibility under this act for coastal and offshore pollution control and enforcement. It will be the agency responsible for imposing regulations and implementing the standards which are finally adopted and will be the final authority on the design, installation and operation of all marine treatment plants (10).

It should be noted that the Refuse Act of 1899 has been strongly enforced recently and prohibits discharges into navigable waters without a permit issued by the U. S. Army Corps of Engineers. Chemical spills, for example, come under this act. Attempts are being made to transfer this permit granting authority to the EPA. In a 1972 survey conducted by the American Association of Port Authorities, it was found that a total of $138,432,200 of construction work in various ports was being delayed due to general confusion in the permit granting process and because of administrative problems associated with the various pollution and environmental control agencies (11).

2. British oil in navigable waters bill.

This proposed legislation by the British government would provide for a fine of up to $120,000 for *any* transgression of pollution regulations in British waters.

Both Britain and South Africa now reserve the right to destroy and sink a grounded tanker threatening their coastlines.

(Many countries, however, are evidentally still relying on the old common law position that a tort feasor is liable for his negligent acts.)

3. Canada Shipping Act of 1971.

Under the Canada Shipping Act of 1971 a levy of 15¢ per tons has been placed on all oil shipments of over 1,000 tons, by vessel, both into and out of Canadian ports. This levy amounting to 2¢ per barrel will be used to build up a fund of from $15 to $20 million for the clean-up of any oil spills for which responsibility cannot be established (12).

4. Greek pollution control Act of 1971.

The Greek government under a shipping law passed last year is taking rather drastic steps against polluters which provides for fines by port authorities of up to $26,650 for spills in their areas. The Shipping Ministry which has authority over the ports, however, may levy fines of up to $1.65 million in exceptionally serious cases (13).

5. State of Maine oil transfer tax.

The State of Maine recently passed a law implementing a half cent a barrel tax on all oil transfers. This money would be used to finance a coastal protection fund that would pay for policing oil terminals and damage from tanker spills.

6. IMCO (Agency of the United Nations).

There are two Intergovernmental Maritime Consultative Organization (IMCO) conventions arising from the TORREY CANYON disaster agreed to by some 40 nations in November of 1969 as follows :

a) *Public Law Convention* — concerned with the powers of coastal states; to take action in the event of a major catastrophe even to the extent of destroying a vessel that poses a serious coastal pollution hazard.

b) *Civil Liability Convention* — concerns liability; with compensation to be paid for clean-up operations. This places on the shipowner a limit of $135 per gross ton up to a maximum of $14 million for any one disaster. All ships would have to be insured and carry certificates of insurance. By the terms of this convention the total quantity of oil discharged by a tanker on a ballast voyage must not exceed 1/15,000 of its total cargo carrying capacity. This would mean, for example, that for a 150,000 dwt tanker it could discharge 10 tons of oil into the oceans on a ballast voyage.

A new IMCO convention is scheduled for adoption at a conference to be held in London in October 1973. The primary objective of this 1973 conference will be to achieve by 1975, if possible, the complete elimination of intentional oily discharges into the seas by tankers and other vessels. It should be pointed out that a great deal of very valuable research work is now being carried out by various countries in preparation for the 1973 convention and involves at least 10 separate studies (14).

7. Convention for the prevention of marine pollution.

An agreement was signed in Oslo, Norway, on February 15, 1972, between 12 European nations called the « Convention for the Prevention of Marine Pollution » (15). By the fall of 1972 it is hoped that this will have the status of international law. The intent of this convention was to prohibit dumping of dangerous materials in the international waters of the seas extending from Greenland to Finland and from Gibraltar to the Arctic. The twelve countries concerned are Belgium, Denmark, France, West Germany, Finland, Iceland, Britain, the Netherlands, Norway, Spain, Portugal and Sweden. The agreement covers waste dumped from both ships and aircraft. The prohibition on dumping would cover durable plastics, mercury, cadmium, arsenic, lead, pesticides, scrap, metal, tar and many other products and compounds. Each country would be expected to prosecute its own nationals in the event of an offense.

It is anticipated that the United Nations environmental meeting to be held in Stockholm in mid-1972 will propose some additional restrictions based upon a previous convention prepared at Reykjavik, Iceland, in April of 1972 by the Intergovernmental Working Group on Marine Pollution.

8. **Proposed Mediterranean agreement.**

The Food and Agricultural Organization of the United Nations has worked out an anti-pollution program for the Mediterranean area which will eventually be submitted to the 16 Mediterranean countries for their approval (16).

9. **Pollution insurance.**

Pollution insurance may end up as war risk insurance has in that it will ultimately be too expensive for private industry to underwrite and could require some type of government sponsorship. Two industry groups that are attempting to provide their own insurance plans are the following :

a. *TOVALOP* (17).

The Tanker Owners' Voluntary Agreement Concerning Liability for Oil Pollution (TOVALOP) came into effect on October 6, 1969. It provides a form of joint liability insurance up to a maximum of $100 per gross ton of the vessel or $10,000,000 per tanker incident. Some authorities feel that if all tanker operators could be persuaded to join such a system voluntarily, much of the current international legislation would not be necessary.

Today, 96% of the world's tanker tonnage is operated by members of TOVALOP.

b. *CRISTAL* (17).

This is an agreement (Contract Regarding an Interim Supplement to Tanker Liability for Oil Pollution) composed of oil companies, as opposed to tanker owners, and relates to the cargo on board the vessel itself. In effect it is a self-insurance scheme which supplements the compensation payable by a shipowner which raises the total that can be paid for any single pollution incident to $30,000,000. It is available in all instances where the shipowner is a member of TOVALOP. It guarantees compensation to individual claimants who suffer damage from a tanker mishap, for example, fishermen and boat owners, as well as to governments.

C. POLLUTION DETECTION

Numerous devices and procedures are now being developed to monitor and control pollution. The most important factor in this regard is obviously to be able to identify the polluter and to do so in such a manner that a conviction can be obtained in a court of law.

Recent studies made at Woods Hole, Massachusetts, and by the U. S. Bureau of Mines have shown that every body of crude oil and the refined products made from it reveal a definite indentifiable composition or « fingerprint » which is different from all other oils and even from each oil within the same field, but from different horizons within the field. These « fingerprint » characteristics can be recognized by analysis with sophisticated, modern analytical techniques such as gas chromotography. If a catalogue could be developed of the world's different oil types, it would greatly aid in the prosecution of those responsible for major oil spills where positive identification is otherwise difficult, if not impossible to establish (18) (19).

The United States Coast Guard now has a radar like device which can be carried in planes or helicopters to spot oil slicks in fog or darkness in order to apprehend vessels which dump wastes when approaching port. This device is similar to a camera and is sensitive, not to visible light, but to microwave radiations, and is called a microwave radiometer.

Hallikainen Instruments has developed a small portable 300 pound floating oil detector to find minute traces of hydrocarbons on water which may not even be visible to the naked eye. The device utilizes a light reflecting principal and photocell for measuring the intensity of the reflected light. This detector gives off a signal of varying intensity depending upon the thickness of the oil spill (20).

Helicopters using infrared sensors have proven effective in determining sources of pollution particularly where small thermal differences are involved. As much as 1/10 of a degree in temperature differential can be detected with these devices. The measurements are translated into a picture of light and dark shading on a television screen in the helicopter cabin. The pattern clearly shows the total area which is being polluted and the evidence can be recorded on videotape for future use as evidence against a polluter.

The matter of « positive identification » is of extreme importance in assessing oil spill fines. Even the use of helicopters and photographs should probably be supplemented by a sample hoisted up to the helicopter for analysis and evidence of the spill, otherwise proof in court may be difficult to establish.

D. MECHANICAL CONTAINMENT DEVICES

For oil spills and some types of chemical spills the initial effort must be directed toward containing the spill so that it can be removed by sorbents or skimming devices. Some of the more widely used types of containment devices are the following :

1. **Spill Booms** — There are between thirty and forty different types of booms being marketed at present and they come in many shapes and sizes (21).

A bottom tension type oil containment boom capable of use in waves up to 20 feet, 2 knot currents and 60 knot winds has been developed by Humble Oil & Refining Co. for use in the Santa Barbara Channel and is now part of the standby equipment of Clean Seas Inc. for emergency use in the channel area. This boom is 500 feet long, has a 3.5 foot freeboard and a draft of about 4.5 feet.

Reynolds Submarine Service Corporation has developed a light weight corrugated aluminium boom which can be stored on a small spool aboard a vessel or at a dock. It has about a 7-inch freeboard and maintains vertical flotation by means of a strip of nitrile rubber monocellular foam. Its use is restricted to rather calm waters.

2. **Air Barriers** — Underwater air barrier systems have proven highly effective in controlling oil spills in harbors and ports. Such a system is ideal for closing off a harbor or marina entrance (21). This method is similar to systems in use for artificially aerating water. The barrier consists of an underwater perforated pipe and a compressor attached to it. The pipe can either be suspended in the water or placed on the bottom. As the compressed air moves upward through the water from perforations in the pipe it generates an underwater barrier of excited air bubbles that forms a dike of interlocking columns of air and water on the surface. This forces the floating oil back from the line and keeps it from penetrating the barrier. Generally, these barriers can be used only in relatively calm waters.

A new type of floating air barrier device has been developed by Eric Rath of LaJolla, California. This unit can be used in rough waters. It comes in 40' lengths, each weighing about 5,000 pounds. They can be connected together and form a continuous barrier. In this system, a compressor which is mounted on each section feeds air to a manifold running the length of an angled underwater slope sheet. The air is then directed upward along the face of the slope forming an air and water barrier at the face of the device (39).

3. **Underwater tents** — A device for containing underwater oil seeps or to trap oil rising from a sunken hull is in use by Union Oil Company of California in the Santa Barbara Channel. This tent-like device was designed by the Firestone Coated Fabrics Company and can be built in varying sizes. The tent floats flat while on the surface and a flotation buoy raises the center of the tent into a shallow peak when it is submerged. There is a base connection at the peak to draw off the trapped oil. This fabric-dome tent is made of PVC over nylon fabric and weighs about 22 ounces per square yard (40).

4. **Seadragon** — An ambitious new concept called « Seadragon » for cleaning up oil spills from international waters is being developed and tested for the oil industry by the Garrett Corporation of Los Angeles under a contract with the American Petroleum Institute (API) (21). The Seadragon concept consists of four separate operations : *a*) sweeping, *b*) skimming, *c*) separating, and *d*) storing. It is hoped that this system can effectively clean up oil spills in 8-foot waves. One of the principal design criteria for Seadragon is that it be transportable by air and that it can be deployed to a spill site within four hours. The goal for this system is to be able to sweep an area at a minimum rate of 120 acres an hour and process a minimum of 25,000 gallons of oil and water per hour.

5. **Coast Guard** ADAPTS **System and Containment Barrier** — The United States Coast Guard Air Delivered Anti-pollution Transfer System

(ADAPTS) which has recently been tested in the open sea and is now being deployed for use is aimed at dramatically reducing the amount of oil entering the ocean from a wrecked or leaking tanker or other vessel. The primary element of the system consists of large rubber tanks and high speed pumps delivered by air to a wreck or leak location (23) (24).

In conjunction with the ADAPTS system, the Coast Guard recently tested a high seas oil containment barrier designed by Johns-Mansville Corporation. This barrier theoretically could operate in seas up to five feet, two knot currents and 20 mph winds and could be deployed in most U. S. coastal waters in four hours or less. In actual tests, however, it was found that current is a critical factor and that the 27-inch deep and 21-inch high barrier was not effective in currents over 1 1/2 knots. At these speeds the oil would actually go under the barrier and penetrate to depths as much as 20 feet.

The Coast Guard is now investigating three different devices to recover the oil trapped within the boom. These three methods are : *a*) belt, *b*) disc, *c*) weir.

All parts of the ADAPTS system, however, will undergo further testing, improvements, and modifications as it is used under actual spill conditions.

E. MECHANICAL RECOVERY DEVICE

Once the oil or other pollutant has been contained by a boom or other means a recovery device of some type is then employed to pick up the pollutant.

1. **Skimmers** — There are many mechanical skimmers on the market and, in general, they fall into three basic categories : *a*) simple settling tanks into which the oily or polluted mixture is transferred by the forward movement of the device (or as in one case, a paddle wheel), *b*) vacuum pumps to transfer the mixture to settling tanks within the device or to remote tanks, *c*) wiping devices consisting of polyurethane covered drums, rollers or endless belts to selectively remove oil from the water surface and transfer it to a storage tank. These skimmer devices, however, are extremely limited as to operational capability and, in general, wave heights of more than 6 inches prevent their effective use and waves of two feet generally prohibit utilization of even the largest units (21).

A popular skimmer is the catamaran hull type named the MOP-CAT. The distinguishing feature of the MOP-CAT is a drum which revolves between the two hulls and absorbs the oil in its plastic foam surface from which it is squeezed out into a containment vessel. In some ports the MOP-CAT does double duty as a fireboat, particularly in shallow water, and it is light enough so that it can be transported by helicopter. The MOP-CAT is water jet propelled and can move backwards, forwards or sideways (25).

The Oela-III oil skimmer is excellent for getting into hard-to-reach areas, such as underneath docks. It consists of a central rounded control float from which are extended four spoke-like arms with floats which balance the entire assemblage. It weighs only 110 pounds. As this device floats, the suction process skims the water, removing oil or other pollutants with a minimum of water content. It can be used from practically any type of open boat.

Another very effective skimmer is the Rheinwerft weir-type. It was developed in West Germany and is in widespread use in Europe and the United States. It utilizes a floating basin in the center of three perimeter floats in a triangular configuration. It can be built to almost any size and capacity desired. It is light and can be handled and maneuvered by light harbor craft.

2. **Vacuum Barges** — There are many vacuum barges (also classified as skimmers) in use and to a good many port personnel, they represent the simplest and most effective method of removing oil from water when the spill is of a rather minor nature. Generally, most vacuum barges are self-contained, self-propelled and have sufficient deck area for crew activities, storage tanks, pump equipment, chemical dispersant applicators and storage for chemicals and absorbent materials. They are usually of rather shallow draft and can be used in conjunction with other more sophisticated equipment. They can normally carry from 500 to 1,000 feet of lightweight containment boom in addition to other capabilities.

F. ABSORBENTS, SINKING AGENTS, CHEMICAL AND BACTERIOLOGICAL AGENTS (41)

1. **Absorbents** — For heavy crude oils, one of the best means of removal is by using straw as an absorbent. It must be recognized, however, that the problem of cleaning up the oil-soaked straw is oftentimes a difficult and time consuming operation. This problem was quite evident after the collision of the Standard Oil tankers ARIZONA STANDARD and OREGON STANDARD near the Golden Gate Bridge in San Francisco on January 18, 1971 (26) (22).

Sawdust is another good absorbent as well as perlite, expanded vermiculite, styrofoam, hay, rope, tree bark, peat moss, pine bark, zinc stearate coated talc, kelp, textile wastes, and polyurethane foam. Practically all of these materials are difficult to apply in high wind conditions and are sometimes difficult to recover in their entirely if dispersed over a wide area. To control their application, they must generally be applied by spraying them on to the surface in a slurry mixture with water. Their recovery on open water is often best effected on a large scale by the use of purse seiners outfitted with special nets.

Recent experiments indicate that cotton is a much better absorbent than straw. It obviously would do less harm to the ecosystem than chemicals where it cannot all be recovered after a spill. Furthermore, cotton, unlike straw, can be structured into a flexible felt-like matrix allowing maximum accessibility of oil to fiber surfaces. This belt-like matrix, in a continuous form, can remove oil from the water, have the oil squeezed free from it on a barge, and returned immediately to the water to absorb more oil. In addition, disposal by burning or burying, as in the case of oil-soaked straw, is not necessary. These additional advantages of a cotton absorbent as contrasted to straw would, in all probability, offset its greater cost. A continuous conveyor belt type system, for example, could be mounted on the front of a barge and propelled slowly through the slick with the oil being retrieved in a continuous process. An actual pilot project of this nature is now in operation for testing various types of cotton fibers at the Texas Research Center, Texas Technical University, at Lubbock, Texas (27).

2. **Sinking Agents** — Materials which have been used to sink floating oil have generally been fine grained, high density minerals in a natural or processed form. Some of these materials include sand, clay, fly ash and stearate-treated chalk.

The « sand-sink » method for coping with oil spills is quite effective. In this method, the sand has been previously treated to make the oil cling to the individual grains. It is then sprayed on the oil, the sand adheres to the oil carrying it to the bottom as it sinks. The ratio of sand to oil needed to effect sinking of the slick is about one to one by weight (28).

There is still considerable controversy as to whether the effectiveness of this system may not be offset by the bottom damage it might cause.

3. **Emulsifiers** — The dispersants and emulsifiers which are commercially available can be generally classified as water-based or organic solvent based. As a general rule, the solvent based dispersants are effective, over a wider range of conditions and petroleum products. They tend, however, to exhibit greater toxicity characteristics and have lower flash points, thus requiring greater care in handling. These agents generally require spray equipment of some type for application to the surface.

It is still somewhat of an open question as to whether the emulsifiers and surfactants available do more harm to the ecology than the oil itself.

4. **Microorganisms** — Considerable research work is now being done by a number of laboratories on various types of microorganisms that feed on crude oil (21). One of the obvious goals of this effort is the development of microorganisms suitable for use in cleaning up oil spills. The use of this approach to oil spill clean-up is being studied more with a view toward the cleaning up of thin oil coatings on beaches after major spills rather than as a solution to major accidents on open water where the greater part of the clean-up must be by other means.

The office of Naval Research at the Naval Civil Engineering Laboratory at Port Hueneme, California, is also conducting extensive research in attempts to isolate the various types of bacteria that have an appetite for oil (29).

5. **Jelling and Polymerization** — In these types of applications there is a physical change of state of the oil, typified by jelling or by polymerization or

otherwise stabilizing the physical form of an oil spill. Petro-Form Industries, Inc. of Houston has developed a chemical which, when sprayed on the oil, causes it to solidify into a sponge-like mass which can be manually picked up from the water as with normal floating debris.

6. **Surface Applicants** — An interesting new concept for burning oil off the surface of water is the small cellulated glass nodules called « Sea Beads » which have been developed at Pittsburg Corning Corporation (21). These are light-weight and buoyant nodules about one-quarter inch in diameter which float on the surface along with the oil. Their textured surface quickly becomes covered with oil as a result of capillary action. The oil can then be ignited with an ordinary blow torch or other incendiary device. They can be dropped from planes or spread on the surface by ships. They can be collected by mechanical means for re-use again or merely left to disintegrate on the shoreline.

The Shell Oil Company recently introduced a new surface active chemical agent to aid in the containment and clean-up of oil spills called « oil herder ». It has been officially classified by the Environmental Protection Agency (EPA) as a « surface collecting agent » in accordance with definitions outlined in their standards and criteria. The oil herder chemical is applied to the periphery of the spill and tends to herd it into a small area from which it can be collected by conventional skimmers or suction lines (30).

G. OTHER MEANS OF LIMITING POLLUTION

1. **Vessel Construction** — Several methods have been proposed to eliminate ballast waste problems from tankers. One of these proposals is the building of more clean water ballast tanks into new tankers so that cargo tanks are not used for ballast purposes. The cost of such a scheme, however, would probably add about $1 billion to tanker construction costs for the 1975-1980 period alone. Double hulls have also been proposed by some persons, while others feel that an added risk for potential explosions is created by double walls.

2. **Accident Prevention** — Accident prevention is of paramount importance and preventive measures can bring results. For example, one-half of all the world's vessel collisions occur between Dover, England, and the Elbe River. Clearly, better navigational and traffic control could bring definite improvements to such an area.

3. **Shoreside Waste Reception Facilities** — The use of holding tanks on board vessels points out the need for facilities at ports to accommodate wastes.

Several ports are reported to be embarking on programs of tying their sanitary sewer lines into city sewer systems thereby eliminating any vessel discharge directly into the harbor waters and also eliminating the need for holding tanks or special treatment plants on port property.

Burns Waterway Harbor at Portage, Indiana, is probably the first U. S. port that has provided specially built waste treatment facilities for ship and industrial wastes. The activated sludge secondary treatment facility for this new port complex was completed in 1970 at a cost of almost $700,000. It will be used to treat polluted water from ships bilges, ballast tanks and ship's sanitary discharges and industrial wastes.

Another major shoreside waste reception facility which was recently completed is that at the Sembawang Shipyard in Singapore. This facility was installed as a result of that Republic's « Clean Seas Act of 1971 ».

4. **Load-on-top Procedure** — The load-on-top procedure is a method of handling retained washings in oil tankers rather than pumping them overboard at sea. This procedure retains the tank washings and/or demulsifiers on board and congregates it in one tank where it remains for the ballast voyage. A new load of crude is then placed in that tank on top of the tank washings.

The load-on-top system for the larger tankers has brought about a striking reduction in operational pollution. It was adopted in 1964 and is now used by about 80% of the world's tanker fleet (31). Prior to that time, an average 40,000 ton tanker discharged about 83 tons of oil with each flushing of its tanks. With the load-on-top-procedure this is reduced to something on the order of three tons.

5. **Harbor Flushing** — Numerous schemes have been proposed from time to time for mechanical means of flushing harbors. A proposal for a flushing scheme for the Southern San Francisco Bay area was recently patented by an Oakland, California, contractor. This system is essentially a dike, gate and channel system which provides for impounding at high tide and opening of gates to discharge the water at low tide providing a flushing action through the harbor (32).

6. **Aeration** — One of the more obvious solutions to pollution problems caused by a lack of dissolved oxygen in the water is the mechanical aerator. One of the more successful recent efforts involving mechanical aeration is that provided by the Thames Board Mills Ltd. on the Thames in London which discharges some 5 MGD of water used in its paperboard making process (33). The Port of London Authority is imposing more strict requirements on the amount of suspended solids permitted in plant effluents along the Thames which was the reason for the installation of this aeration device. This particular machine has a capacity of introducing about five tons of oxygen per day into the river waters at the effluent outfall.

7. **Shipboard Waste Treatment** (34) — There are basically four different types of shipboard sewage and waste treatment schemes or devices which are either in use or are proposed for vessel use. These include the following :

a) Holding tanks.

b) Macerator-chlorinators.

c) Incineration.

d) Aerobic digesters.

Each of these systems has its liabilities as well as its assets. The holding tanks, for example, could occupy considerable space aboard a vessel and require expensive on-board piping and pump installation, regardless of whether the tanks contents are ultimately dumped at sea or pumped ashore to treatment facilities. The macerator-chlorinator has most of the same difficulties. Incinerators not only contribute to air pollution, but the fuel costs to operate them could become excessive. Aerobic digesters would create an additional problem of how to dispose of the chemicals used in the digester. The overall problem, however, is compounded by the proliferation of local, state and federal legislation which may make an expensive shipboard treatment installation obsolete shortly after it has been installed.

8. **Shipboard Solid Waste Compactor** — The recently developed Hydra Pack Mark III solid waste compactor has the capability of handling galley and all other shipboard solid waste in a vessel carrying a crew of 40 men. It reduces the waste to a 2 1/2 cu. ft. compacted slug weighing about 50 pounds which can be put into a plastic bag for off-loading in port.

H. PORT CLEAN-UP OPERATIONS AND CONTINGENCY PLANS (42)

Throughout the United States and most of the world, a dedicated effort is definitely being made to control pollution on the world's coastlines and ports. It is indeed worthy of note that some of the smaller ports have actually taken the lead in this field and are pointing the way for their larger counterparts.

1. **Oil Spill Oo-ops** — According to a recent survey of the American Petroleum Institute (API), there were some 67 oil spill clean-up cooperatives operating in the coastal and inland waterways of the United States in 1971. There are 22 additional co-ops in the process of being organized. Of the 1971 total, 25 became operational in 1971 (35).

2. **Port of Portland** — One of the more active and successful co-op groups is the Swan Island Safety Pollution Control Committee of Portland, Oregon. They have even developed their own patented proto-type skimmer which is said to be somewhat more effective than other types. It has the capability of skimming 5,000 gallons per minute and was developed to clean up medium to large spills. This group works closely and sometimes jointly with the Oregon Oil Spill Cooperative which is made up of all major oil companies in Oregon (36).

3. **Ports of San Francisco and Oakland** — San Francisco Bay now has an industry sponsored organization known as « Clean Bay Inc. » to handle major oil spills of the magnitude that recently occured there. This group is in the process of acquiring and assembling the necessary equipment and expertise to handle a spill of up to 20,000 barrels within a five or six day period. There are six such groups, such as « Clean Bay Inc., » on the West Coast which now can cover an oil spill anywhere from Mexico to Canada (39). The Clean Bay Inc.

group can muster a force of 225 men within about 2 hours. They will also have a total of 22 skimmers available plus other equipment. Their long range plans call for the ability to handle a 100,000 bbl spill by 1974. They plan to have two second generation ocean class skimmers of massive size and 1,000 feet of 7.5 foot high containment boom by that time. The previous problems related to the use of volunteer help for the care of oil soaked birds and injured wild animals would be taken over in future spills by the Resources Agency of the State of California. The Clean Bay Inc. group is supported primarily by the ten major oil companies with facilities in the bay area.

4. **Fremantle Port Authority** — The Fremantle Port Authority of Australia has recently purchased a portable floating boom which can be transported to almost any location in the perimeter of the harbor on its own specially designed trailer. This unit can be moved quickly to the scene of a spill.

5. **Port of Baltimore** — The Port of Baltimore is beginning to assemble quite an array of pollution control equipment which includes a recently donated Kaiser Oela III oil skimmer. In addition, the port has three spill control vessels, about 3,000 feet of containment boom and a considerable supply of absorbent materials. The Maryland Petroleum Association has donated a considerable part of this equipment to the port.

6. **Port of Boston** — The Boston Harbor Pollution Committee sponsored by the Massachusetts Port Authorithy has proven the effectiveness of a voluntary association in organizing and coordinating the efforts of more than two dozen organizations involved in activity aimed at pollution control in Boston Harbor. This committee meets monthly and includes in its membership cognizant federal, state, and municipal agencies as well as civic groups.

7. **Port of Mobile** — The Port of Mobile has recently completed plans for the installation of a sanitary sewage collection system for shipboard wastes and hopes to get construction of this system underway shortly so that it can be in operation by 1973.

8. **Norfolk Port and Industrial Authority** — The Hampton Roads Maritime Association has prepared a contingency plan of a cooperative nature for the prevention, containment and cleanup of oil and hazardous materials for the Hampton Roads area. Their equipment includes vacuum barges, skimmers, chemical agents, septic tanks, pumper truck, mechanical pick-up devices and several hundred feet of commercial booms. In addition, booms from various other agencies, in the immediate vicinity such as the U. S. Navy and Coast Guard are available. There are also three oil spill recovery vessels available to augment the pollution control equipment.

9. **Port of Hong Kong** — The Port of Hong Kong has taken extensive measures to respond to oil pollution and keeps approximately 10,000 gallons of emulsifier available for immediate use at any time. These chemicals are stored at key locations throughout the harbor so that they can be brought to any oil polluted

spot in a minimum of time. In addition, they have several hundred feet of boom available for rapid deployment.

10. **Port of Toledo** — The Port of Toledo could well serve as a model for many smaller ports to follow, particularly in terms of contingency planning to handle spills. The Toledo Harbor Spill Committee is made up of a good cross section of both industry and port representatives. They hold periodic meetings to discuss such matters as boom replacement and disposition, hold oil spill drills, maintain a comprehensive inventory of spill control equipment and keep an up to date roster of available personnel. Many companies have purchased booms and related equipment, dispersants, absorbents, small boats, pumps and other tools which are available for spill emergencies. Each year since 1968 periodic drills, training exercises and demonstrations have been held and each time something new is learned about safety and effectively containing and cleaning up spills.

11. **Port of Los Angeles** — The Port of Los Angeles has achieved significant results in its pollution clean-up campaigns primarily by stricter enforcement and policing of pollution laws and regulations. In 1971, for example, port personnel spent some 7,200 man hours in direct regulatory control plus about 100 hours of air surveillance. There were some 321 investigations of possible pollution made which resulted in the filing of 36 complaints against polluters and 34 substantial fines for violations were paid (37).

To serve the various classes of vessels, the Port of Los Angeles will, in the future, provide barges for receiving sanitary waste discharges from vessels. In addition, the port will construct and install one or more shore facilities for receiving wastes from vessels for transfer to the city sewer system.

There have been several rather extensive environmental studies made within recent months related to the port's environmental and pollution problems. One recent three volume study by Engineering Science Inc. provided some rather interesting concepts on ecosystem management. One of these described as the Environmental Parameter Index (EPI) Concept, sets up in matrix and tabular form mixes of stimulants (phosphorus, nitrogen and dissolved oxygen, etc.) versus the permissible mix of toxicants (lead, copper, pesticides, radioactive material, etc.) that could be permitted to sustain various levels of marine life (38). This system would require extensive monitoring but it could provide early warnings as to when an ecosystem is in danger and indicate what steps should be taken to preserve it.

I. GOALS AND RECOMMENDATIONS

It is obvious from the foregoing that many things are being done to reduce pollution and to clean up the environment. Some specific suggestions and objectives that the author feels would be beneficial include the following :

1. The formation of additional cooperatives for the pooling of equipment and resources is highly recommended and these cooperative efforts should insofar as possible be extended to include joint usage of shoreside treatment and retention facilities.

2. Vessels should carry some type of identifying marks, colors or flag signals as to the type of commodity they are carrying. This would apply particularly to oil and chemical tankers.

3. The use of superships should be confined to a relatively few ports so that the maximum amount of clean-up equipment can be confined to a relatively few locations.

4. Ports should develop a better knowledge of the physical properties of some of the commodities they handle, such as their solubility in sea water, reaction on water contact, volatability, toxic strength, decomposition rate and other characteristics.

5. The « multidisciplinary approach » should be used in studying port environmental problems in order to view them from a broad perspective viewpoint as contrasted to a narrow single problem approach. Marine construction can no longer be looked at as purely isolated engineering projects as has been the case for so many years.

6. Every harbor should implement a data collection program and provide monitoring stations in order to develop a comprehensive data base from which future environmental planning can be accomplished. This should include chemical, biological, geological, hydrological (currents, tidal measurements, temperature, salinity, turbidity, etc.) data.

7. Shipping should be recognized as an international activity and all nations should join in the control and monitoring of the transport of substances that can and do cause pollution in international waters. The international conventions being proposed by IMCO and others should be adopted as quickly as possible.

8. In order to continue to improve the management and control of water pollution, additional research and development is needed; however, it is strongly recommended that this research be directed to solutions of real problems and not merely to satisfy academic curiosity. There definitely needs to be better dissemination of the vast amounts of research data already available. In all fairness to the researchers, they should be given better guidance on the information and research needs of the decision makers.

9. With the larger and more powerful ships now coming into service, overdredging to minimize propeller turbidity should be considered.

10. Full time staff environmentalists are now a necessity for most ports and they should be provided with the proper level of management support to effectively deal with pollution and environmental problems on a sound and continuing basis.

11. New and more effective techniques should be developed for detecting pollution along coastlines and on the seas possibly utilizing earth satellites and/or other sophisticated techniques.
12. Intensive general education programs relative to pollution, its causes and effects, should be carried out within the shipping world in order to effectively obtain cooperation and compliance at all levels of industrial and maritime activity.
13. Realistic standards for water quality should be established so that those to whom the requirements are directed can economically phase their compliance to fit their financial capabilities insofar as it is practical to do so. Penalties should be sufficiently realistic to enforce compliance but not be confiscatory. A distinction should always be made between penalties for accidental and intentional pollution.
14. More consideration should be given to replacing the multiplicity of single purpose agencies with single multi-purpose regulatory agencies. This would undoubtedly help to expedite the present overly complex reviews and permits procedures.
15. The communications gap which now exists between the academic world and the lawmakers on the one hand, and the practical decision makers of the business community on the other, must be corrected if the further loss of valuable time in implementing effective pollution control measures is to be avoided.

J. SUMMARY AND CONCLUSIONS

Perhaps the greatest tragedy of the world pollution problem and its development to date has been that the leadership for its resolution has been lacking from the professions most directly affected. It is now time for those who must get the job done and who have a practical and firsthand knowledge of the economic, engineering, social and political considerations involved to assume leadership roles in the clean-up effort. There is some evidence that a change in this regard is now taking place, but this trend should be accelerated before vast sums of money in the name of anti-pollution campaigns are spent on impractical and uneconomical academic ideas.

Disregarding the maze of conflicting laws and regulations with which we are now faced, the author can only conclude after having investigated the many sources from which the material in this paper was derived that the world in general is making definite progress in anti-pollution programs. It is within the realm of possibility to predict that by 1975 the necessary international legal machinery and hardware will be available to control pollution along the world's coastlines and harbors as well as on the high seas throughout the world. To accomplish this goal, an impressive array of anti-pollution devices and chemical agents are being developed and marketed for pollution control. In addition, a genuine effort is being made by those in responsible authority to understand the complexities of pollution and environmental problems and to attempt to sort out the academic vs. the practical realities of the issues raised by these problems.

The cooperative organizations that have been formed and which are in the process of formation on local, regional, national and international levels would appear to be the only practical means of approaching the problem and of minimizing individual investments in clean-up equipment. It is also probably the most effective way to monitor and control the sources of pollution. This cooperative effort, hopefully, will be extended to the use of shoreside waste retention and treatment plants in order to minimize investments in facilities of this type and to prevent needless duplication.

A great deal of basic research still needs to be done on environmental and pollution problems but the necessary levels of research knowledge have already been accomplished and the results, if applied, could provide for the resolution of most of our pollution problems. Unfortunately, many ports are still lacking even basic inventory information on their marine environments and ecosystems. This only leads to lengthy delays in the future when environmental impact statements and related reports are required to implement port improvement programs. The time has come for every port or agency with responsibility in environmental problems to have full-time qualified employees to handle the ever increasing complexities of this problem.

As a final remark, no one should attempt to mislead the public into believing that pollution control systems can be installed or made available which will provide absolute guarantees and safeguards against pollution in all its forms. On the other hand, they should counsel the public that it must be accepted that some pollution and some destruction of the environment in the development and operation of commercial harbors cannot be avoided. Only in rare instances should the public expect a port authority to maintain a commercial harbor in the same state as it was when man first appeared on the scene. It is thus the duty of those in authority and who are responsible for the operations of harbors to set levels of water quality that are technically feasible and economically practical.

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RÉSUMÉ

Ce document couvre essentiellement les points dominants de la pollution portuaire et côtière telle qu'elle existe actuellement à travers le monde; les moyens disponibles pour la contrôler; les actions entreprises par quelques-uns des ports dans le monde en matière de contrôle de la pollution et enfin les recommandations et conclusions de l'auteur sur les mesures complémentaires qui pourraient être prises pour contribuer à résoudre les problèmes de la pollution marine dans le monde.

L'auteur souligne que l'incident du Torrey Canyon, pétrolier qui coula le 18 mars 1967, a le plus fait pour susciter une prise de conscience internationale du problème. Cette catastrophe fut suivie d'une profusion de lois et de règlements dont une grande partie représente un double

emploi entre les efforts de divers organismes dont la juridiction en la matière restait dans bien des cas sujette à caution.

L'assurance contre la pollution est un problème sérieux et coûteux et les plans d'auto-assurance de TOVALOP et CRISTAL constituent une excellente solution au problème.

De nombreux dispositifs de détection très élaborés sont à présent en usage. On trouve aussi trente à quarante différentes sortes de « spill-booms » sur le marché. Deux très importants systèmes de nettoyage des marées noires, actuellement soumis à test, comprennent le « Seadragon » pour l'A.P.I. et « Adapts » pour les Services américains de la protection des côtes.

Tous deux conviennent à des opérations en mer agitée. De considérables travaux de recherche doivent encore être réalisés dans le domaine des produits absorbants, des agents immersifs, des agents chimiques et bactériologiques. On peut se demander si les produits émulseurs et les dissolvants actuellement disponibles ne nuisent pas davantage à l'environnement que le pétrole lui-même.

En ce qui concerne les résidus des navires, le procédé de chargement par le haut apporte une amélioration substantielle aux fuites émanant d'une cagaison pétrolière. Des coopératives contre les marées noires et la mise en commun d'un équipement de nettoyage deviennent à présent très répandues et cette forme de lutte contre la pollution est fortement recommandée par l'auteur. La mise en place d'installations de récupération et de traitement du genre coopérative, le long des côtes, présenterait également des avantages. Dans le document, un bref résumé est donné de ce que quelques-uns des ports dans le monde entreprennent comme efforts de nettoyage.

L'auteur termine sur une note d'optimisme quant aux perspectives d'avenir, en déclarant qu'il est du domaine des probabilités que d'ici 1975 le dispositif international, juridique aussi bien que mécanique, sera en place pour contrôler la pollution le long des côtes et dans les ports à travers le monde.

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