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JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS OF MARINE POLLUTION

(GESAMP)

REPORT OF THE FIFTH SESSION

held at
IAEA Headquarters, Vienna
18 - 23 June 1973

NOTES

1. GESAMP is an advisory body consisting of specialized experts nominated by the Sponsoring Agencies (IMCO, FAO, UNESCO, WMO, WHO, IAEA, UN). Its principal task is to provide scientific advice on marine pollution problems to the Sponsoring Agencies and to the Intergovernmental Oceaongraphic Commission (IOC).

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IAEA/IMCO/FAO/UNESCO/WMO/WHO/UN JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS OF MARINE POLLUTION

Report of the fifth session

(IAEA Headquarters, Vienna, 18 - 23 June 1973)

OPENING OF THE MEETING

1. The Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) held its fifth session at IAEA Headquarters, Vienna, from 18 - 23 June 1973. The Chairman of the Group, Dr. M. Waldichuk, opened the session.

2. Dr. Z. Wilhelmi, Acting Deputy Director General of IAEA, on behalf of the Director General of IAEA, welcomed the experts, the representatives of the sponsoring agencies and the observers from other organizations attending the session.

3. The agenda of the fifth session, as adopted by the Group, is attached as Annex I. A list of the documents considered by the Group under each agenda item is shown at Annex II. This also includes a list of information papers summarizing the recent activities of the sponsoring agencies in the field of marine pollution. In its deliberations, the Group kept in mind these activities, particularly those relating to the United Nations Environment Programme, the Law of the Sea Conference, the Ocean Dumping Convention and the 1973 IMCO Conference on Marine Pollution.

4. A list of participants, comprising the experts, the representatives of the sponsoring agencies and observers is shown at Annex III.

IDENTIFICATION OF POLLUTANTS OF INTERNATIONAL SIGNIFICANCE

(a) Review of Harmful Substances

5. In accordance with Recommendation 88 of the UN Conference on the Human Environment, the Group examined the Review of Harmful Substances (GESAMP III/19, Annex IV) with a view to elaborating further its assessment of sources, pathways and resulting risks of marine pollutants. Following consultations with industrial chemists in the United Kingdom, a Working Group under the Chairmanship of Dr. H. A. Cole, met during the intersessional period.

6. This Group assembled extensive factual information on certain groups of organic chemicals and prepared notes and hazard assessments for particular organic substances not previously covered by the Review. Attention was directed first to these substances known to be transported in greatest quantities and those attracting higher hazard ratings because of potential harm to living resources of the sea. The Working Group made use of the information which had been assembled during preparations for the 1973 IMCO

Conference. Numerous additional substances were also identified for further elaboration during the forthcoming interesessional period. (Notations are made in the Annex IV to indicate such future work).

7. During the session, a Working Group composed of Dr. H. A. Cole (Chairman), Dr. J. E. Portmann, Dr. P. G. Jeffery and Dr. J. B. Sprague, considered the Review in detail, introducing certain changes in the existing text in the light of new knowledge and incorporating the material which had been prepared intersessionally. GESAMP approved the Report of this Working Group, including the revised and updated review of Harmful Substances attached as Annex IV to this Report.

(b) Sewage and Industrial Waste Management Technologies and their Performances

8. The paper prepared during the fourth session on this subject (Annex VI, GESAMP IV/19) was discussed in terms of its possible further development, but also in terms of its value as an information document and its place as a GESAMP undertaking. A paper prepared by Prof. F. Valdez-Zamudio on sewage and industrial waste management technologies and their performances was noted with interest.

9. The Working Group which met under the Chairmanship of Dr. C. H. Thompson felt that the lack of clear direction from the sponsoring agencies placed it at a considerable disadvantage. The Annex V to this Report therefore consists in an evaluation of that paper of the fourth session, suggestions for its improvement (which would be undertaken during the intersessional period) and a number of further suggestions which sponsoring agencies may wish to take into account, not only for GESAMP's future work, but also for Agency programmes in the subject area.

(c) Hazard Evaluation of Noxious Substances Transported by Ships

10. At its fourth session, GESAMP approved, subject to certain considerations, the report of an Ad hoc Panel of IMCO and GESAMP Experts to Review the Environmental Hazards of Noxious Substances Other than Oil transported by Ships (GESAMP IV/19, paras. 9 - 13). Subsequent to that session, the Panel continued its work by developing hazard profiles for some 200 additional substances on the basis of the rationale contained in its Report. In response to a further request from IMCO, the Panel also prepared advice which would assist that organization in determining "insignificant levels" of concentration for substances in the most hazardous pollution category for the purpose of preparing certain regulations contained in the Draft International Convention for the Prevention of Pollution from Ships, 1973. It was noted that, at its 3rd meeting (22 - 26 January 1973), the Panel had reviewed its Report in order to include the additional hazard profiles and other information, and in particular, to take account of the comments and amendments which had been suggested by GESAMP at its fourth session

11. GESAMP approved of the changes made in the Report which, in its revised form (GESAMP IV/19/Supp. 1), has now been circulated to governments as a reference document for the IMCO Conference on Marine Pollution to be held in London from 8 October to 2 November 1973. In doing so, however, the Group took particular note that the hazard profiles had been prepared

on the basis of the particular conditions and circumstances in which the substances might be expected to be discharged from ships. The Report should not therefore be used in the control of discharges from other sources, particularly continuous discharges from stationary outfalls which are generally located in inshore waters. The Group stressed that this limitation should be made clear to users of the Report.

12. With regard to the list of substances and their hazard profiles, the Group noted that it was IMCO's intention after the conclusion of the 1973 Conference, to examine possible methods and to establish an appropriate mechanism for the future up-dating of the list on the basis of the provisions contained in the agreed Convention. The Group re-affirmed its readiness to assist in this work if requested.

PRINCIPLES FOR DEVELOPING COASTAL WATER QUALITY CRITERIA

13. Working papers prepared by Drs. J. S. Alabaster, E.E. Geldreich, S. Kêckês and Y. K. Strizhak and discussed at the meeting,are listed in the report of Working Group V (Annex VI).

14. The Group also received a verbal report from Dr. C. H. Thompson about establishing critical limits for industrial waste effluents containing toxic pollutants using an ecosystem approach.

15. Discussion on the above papers and the verbal presentation showed that there were different opinions of experts about the value of and, therefore, the need for defining specific figures related to the water quality of coastal water bodies, at least, with regard to its use for fisheries.

16. Doubts were expressed particularly with a view to bioaccumulation of substances in the food chain, to migration of fish in coastal waters and to the open sea, and to the value of mean figures which may be misleading, if peak values, times of exposure, etc. are not known or not taken sufficiently into account.

17. The Group took note that there was a definite appearance of diverging approaches to water pollution control. It is recommended that the Agencies take note and that considerable energies be dedicated to keeping communication lines open to minimize duplication of efforts in international bodies.

18. The Group discussed briefly the possibility of risk assessments following the ICRP critical pathway approach which has been applied so sucessfully for the definition of permissible levels of radioactive isotopes in food of marine origin. The opinion was expressed that the elaboration of principles governing the development of coastal water environmental quality criteria should not result in neglect of the potential values of the above critical pathway approach.

19. When discussing the report submitted by the Working Group V (Annex VI) the Group found that, under certain circumstances, it may be desirable

and feasible to develop justifiable criteria, and agreed with the setting up of a GESAMP Working Group as an interdisciplinary liaison group between various scientific groups already working on this and similar fields for specific uses of coastal water only, although reservations were expressed by some experts about the usefulness of the group at that stage. It was also stressed that the Working Group should not duplicate work already being carried out by other bodies.

20. It was strongly recommended that the Working Group in the initial phase of its work should specifically define what is meant by "coastal waters" and "coastal water quality criteria". The Working Group was also asked to examine and suggest a format for the criteria and to determine for whom these criteria are to be established.

21. Regarding health aspects, the Group discussed several of the critical factors that are essential for the development of coastal water quality criteria, i.e. increased persistence of pathogenic bacteria in these waters as the input of pollutional discharges increases, and the desirability to obtain more epidemiological evidence of increased risk of bather illness from ever more areas of the world. The Group came to the conclusion that field studies such as epidemiological investigations of health effects after exposure to polluted recreational waters should be used widely, together with laboratory experiments, while developing water quality criteria.

22. The Group discussed problems associated with the application of sanitary legislation in the control of coastal water quality. It was considered that hygienic criteria must assure the safety of water from the viewpoints of the prevention of infectious disease and toxic effects, and must also satisfy aesthetic considerations.

23. It was stressed that the total exposure to all environmental pollutants and other environmental hazards must be taken into account when examining the specific problem of the quality of coastal waters. Problems related to the planning and siting of industry, health resorts and residental areas on the sea coast were also discussed, and attention was drawn to the advisability of implementing sanitary protection zones for health resorts.

SCIENTIFIC PROBLEMS RELATED TO MARINE POLLUTION MONITORING SYSTEMS (IGOSS AND GIPME)

(a) Specification of Physical and Chemical Parameters to be Monitored in an evolving marine pollution monitoring system (IGOSS)

24. The work of this session of GESAMP on physical and chemical parameters was a continuation of similar work initiated in GESAMP III and continued in GESAMP IV. The IOC Secretariat presented a paper entitled "Marine Pollution Monitoring (Surveillance) under the Framework of IGOSS" which summarized the recent activities of the IOC, with particular reference to IOC/WMO Planning Group of IGOSS (IPLAN), the IOC Group of Experts on Oceanographic Research as it Relates to IGOSS (IRES) and other bodies, on the development of a marine pollution monitoring

programme under the framework of IGOSS, including the IGOSS Pilot Project for Marine Pollution Monitoring. During the first plenary session a request was made to distribute the document, entitled "Programme of the Global System for Investigation of Pollution of the World's Oceans" which was originally presented by the USSR to the first session of the ICG for GIPME earlier this year.

25. The Group discussed briefly the meaning of the term "global". Definitions ranged from a relatively restricted one (the open ocean, excluding coastal seas), limited to those pollutants of world-wide distribution, to an all-encompassing one (all seas and all significant pollutants). Nevertheless, it was recognized that within the definition of "global" a careful distinction should be made between coastal/national areas, regional areas (e.g. Baltic Sea) and international areas (e.g. Sargasso Sea).

26. There was some expression of doubt about the adequacy of present methodology, and sampling was considered to present significant difficulty, particularly from a statistical standpoint. This is especially so in radionuclide measurement, where within-sample, between-laboratory variability is alarmingly high under present procedures. The situation in oils was said to be even worse. To reduce as far as possible the problems of inter-calibration a high technical level of measurement, whether aboard a research vessel or in a laboratory, is essential.

27. Some reservation on the value of a global marine pollution monitoring system was expressed with respect to the data products and data uses, especially from the standpoint of practical applications

28. The question was raised of whether a new type, and hopefully simpler, methodology or procedure might develop if it was found desirable merely to determine whether the concentration of a pollutant was greater (or lesser) than some arbitrary level (e.g. "acceptable" level).

29. Attention was drawn to the problems of establishing suitable biological parameters, but the necessity of including these within a global monitoring system was emphasized. The difficulty of distinguishing the effects of natural, long-term, and possibly cyclical, changes in ecosystems from those ascribable to pollutants was also mentioned.

30. After the aforementioned general discussion, the Group set up a working group to consider the subject in more detail. The working group, under the Chairmanship of Dr. E. D. Goldberg, prepared a preliminary report, which dealt with such items as the main purpose of a global marine monitoring programme, the pollutants to be monitored, chemical parameters, physical parameters, sampling sites, sampling procedures, models and mass balances and research needs.

31. In examining the report of the working group, a number of experts expressed serious reservations on various statements made in the report, those relating to oil in particular. There was also an expression of serious concern that biological parameters were not covered by the working group. It was pointed out that agenda item 4.1 specifically excluded biological parameters from the working group's immediate purview; the group did not

have the benefit of a pollution biologist, nor did it have sufficient time to consider the parameters. In view of the broad scope of the report and the above-mentioned reservations, the Group was unable to review the report adequately. However, it agreed that the report should be used as a provisional working document. It was proposed that the working group develop the report in the intersessional period and recommended the inclusion of suitable biologists, at Dr. Goldberg's discretion, with a view to presenting a final document to the next session of GESAMP. Experts were invited to let Dr. Goldberg have their detailed views on this provisional report as soon as possible.

(b) Dispersion and Movement of Pollutants on and in the Sea by Natural Physical Processes

32. At its fourth session, the Group came to the conclusion that further studies of the physical processes responsible for the dispersal of pollutants in the sea were needed, and that priority should be given to the study of vertical mixing processes, and correlation of data on transport and dilution of pollutants in the sea with the results obtained by modelling. The need for a report on physical factors governing transport and dilution of pollutants was also indicated. In response to the above proposal, two papers were prepared for consideration at the fifth session: "Physical Factors Governing Transport and Dilution of Pollution in the Sea" by Dr. G. Kullenberg, (GESAMP V/4.2.1); and "Environmental Factors in Operations to Combat Oil Spills" by Mr. L. Otto, (GESAMP V/4.2.2.).

33. The Group noted with interest the progress made in the theoretical approach to the description of the dispersion of dynamically passive contaminants and oil spills by natural physical processes. The experts agreed with the evaluation of the present state of knowledge and the remaining scientific gaps regarding the physical processes involved in the dispersion and movement of pollutants on and in the sea. The Group came to the conclusion that further studies as they are indicated in the fourth session report of GESAMP (paragraph 28) are needed. Especially the importance of co-ordinating field experimental and modelling programmes was noted. It was recognized that physically adequate models are necessary to describe the dispersion of pollutants. The need for experimental investigations concerning physical - chemical - biological interaction phenomena in relation to the dispersion problem was stressed.

ENVIRONMENTAL EFFECTS OF ACTIVITIES CARRIED OUT ON THE SEA-BED AND OCEAN FLOOR

34. In continuing its work of this subject, the Group reviewed the survey made at its last session (GESAMP IV/19, Annex VII). The Group confirmed that most of the observations made at that time remained valid at the present time and saw no particular need to introduce substantial revisions of that document. It agreed, however, to form a small working group under the Chairmanship of Dr. Turekian to up-date certain parts of the document. A short note was prepared as given in Annex VII which constitutes an addendum to Annex VII of GESAMP IV/19.

PRELIMINARY DISCUSSION OF BASIC INFORMATION REQUIRED FOR THE SELECTION OF SITES FOR THE DISPOSAL OF WASTE INTO THE SEA

35. Following the progress achieved regarding international agreement on waste disposal at sea, the Group considered preliminarily scientific problems in connection with two conventions noted below, drafted an intergovernmental meetings in Oslo (January 1972) and London (October/November 1972), respectively:

(a) "Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft" (so-called Oslo Convention);

(b) "Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter" (so-called London Convention).

36. The discussion of the Group was based on information about the technical regulations contained in the above conventions and scientific problems in relation to them, which were contained in a paper submitted by FAO: "General considerations and conditions for the selection of dumping sites for the disposal of waste into the sea". Another paper informed the Group about the outcome of a panel meeting organized by IAEA in Vienna from 4 - 8 June 1973 following up on IAEA's responsibilities under the London Convention.

37. The Group studied the Annexes III of these conventions, both containing provisions governing the issue of special permits by State for the dumping of substances. Particular attention was given to the considerations therein, referring to the physical and chemical characteristics of dumping sites, as well as the characteristics of pollutants.

38. The Group agreed that from the scientific point of view there would be a need to critically review the scientific problems in order to enable Governments to make good judgments when permits for disposal of waste are requested from them according to Annexes II and III of the Conventions.

39. It was decided to establish a GESAMP Working Group for intersessional work with Dr. G. Kullenberg as Chairman, some GESAMP experts and a few experts from outside GESAMP, as members of the Group, final nomination being subject to decision as soon as better information is available about financial support from UNEP to GESAMP. FAO and UN were asked to provide secretarial assistance to this Working Group.

40. The Group agreed upon the following terms of reference for the Working Group on the Scientific Basis for Disposal of Waste into the Sea:

With reference to Annex III of the London Convention for the Prevention of Marine Pollution by Dumping of Wastesand Other Matter,

(1) to carry out a critical review of our present knowledge of those aspects of dispersion and physical, chemical and biological processes relevant to the selection of sites for discontinuous injection of wastes into the marine environment in both deep and shallow waters; and

(2) to identify gaps in our present knowledge, focus attention on urgent research needs, and suggest research priorities.

41. The Group noted activities taken up by IAEA due to the fact that the London Convention had given the Agency responsibilities to define criteria and standards for dealing with the sea disposal of radioactive waste. The Group was informed that the draft recommendations of the panel are still subject to review by the panel experts and the secretariat. Therefore, the report and the document should be understood to be of a preliminary nature.

42. It was reported that the panel unanimously adopted draft recommendations which include: (i) a definition of high-level radioactive or other high-level radioactive matter unsuitable for dumping at sea; (ii) proposals for environmental and ecological evaluations of dumping applications in accordance with the London Convention; and (iii) proposals for the operational control of the dumping of radioactive wastes not prohibited by the Convention.

43. The panel felt it was necessary to attach a covering note to these draft recommendations, which emphasized that they should not be understood as encouraging ocean dumping without full consideration of the alternatives.

OTHER MATTERS

(a) Oil

44. Referring to the findings of the FAO Technical Conference on Marine Pollution and its Effects on Living Resources and Fishing, as well as to the Seminar on Methods of Detection, Measurement and Monitoring of Pollution in the Marine Environment (both meetings held in Rome in December 1970) which classified oil and oil products as a pollutant harmful to living resources, the Technical Secretary of FAO pointed out that, more recently, some publications give the impression that the damaging effects of oil to living resources have been overestimated. He suggested to set up a Working Group aimed at discussing biological effects of oil to living resources in the light of recent scientific findings.

45. The Group decided to set up a Working Group on the Impact of Oil on the Marine Environment with Dr. C. H. Thompson as Chairman and the following experts attending the fifth session of GESAMP as members: Dr. P. G. Jeffery, Prof. R. Johannes, Dr. M. Ehrhardt, Dr. J. E. Portmann. The Group also agreed that other experts from outside GESAMP should be appointed as members of this Working Group.

(b) Chemical Production Data

46. Dr. Goldberg expressed his concern that individual scientists had considerable difficulty in obtaining global production statistics on chemicals that pose a threat to man, especially the PCB and DDT groups.

47. Some possible solutions to this problem were indicated:

(i) a proposed International Referral System currently being developed by UNEP;

(ii) a proposed International Registry of Potentially Toxic Chemicals currently being developed by UNEP;

(iii) a programme in environmental statistics currently being developed by UNEP;

being developed by UNEP; and

(iv) and the efforts of the ICG for GIPME to stimulate the global interchange of such data.

(c) Availability of the UNEP Fund

48. The Group was informed by the representative from the United Nations Environmental Programme that the Governing Council of the UNEP was presently considering programme development and priorities, and procedures for the use and operation of the UNEP Fund, and that depending on the decision to be taken and general guidelines to be formulated by the Governing Council, it might be possible for all or part of the intersessional work envisaged in paragraphs 6,9,19,31,39 and 45 of this report to be financed by the Fund. The Administrative Secretary was requested to contact the UNEP in order to clarify the availability of, and the extent to which such support could be made available for GESAMP activities, as well as the procedures under which the fund could be used.

(d) Interaction between Atmosphere and Oceans

49. Regarding the pollution of the oceans and different sources of pollutants, the Group paid attention to the fact that the ocean itself may also be a source of pollution for the atmosphere over the ocean. It was noted that certain organic pollutants are altered and/or destroyed by ultra-violet light in the atmosphere and therefore present mass-balance problems. Interchange of pollutants between the oceans and the atmosphere has an important role in the description of the mass-balance of pollution in the oceans. Therefore, the Group requested the sponsoring organizations, in particular WMO, to prepare a report on the above subject for discussion at the next session of GESAMP. The pathways and estimation of pollutants exchanged between atmosphere and oceans, as well as methodology, should be reviewed in the report.

DATE AND PLACE OF NEXT SESSION

50. The Group was informed that WHO would act as host agency for the sixth session which was tentatively scheduled to be held in Geneva from 25 - 30 March 1974.

ELECTION OF CHAIRMAN AND VICE-CHAIRMAN FOR THE NEXT INTERSESSIONAL PERIOD AND FOR THE SIXTH SESSION

51. The Group unanimously elected Dr. G. Berge as Chairman and Prof. A. I. Simonov as Vice-Chairman for the next intersessional period and for the sixth session. In taking this decision, the Group expressed its sincere appreciation to the retiring Chairman, Dr. M. Waldichuk, and the retiring Vice-Chairman, Dr. H. A. Cole, for their efficient deliberations in these position.

CONSIDERATION AND APPROVAL OF THE REPORT

52. The present Report of the fifth session of the Group (GESAMP V/10) was considered and approved by the Group on the last day of the session.

ANNEXES

Annex I

AGENDA

Opening of the Meeting

1. Adoption of the Agenda
2. Identification and treatment of pollutants of international significance:
    - 2.1. Further elaboration of the review of harmful chemical substances
    - 2.2. Sewage and industrial waste management technologies and their performances
    - 2.3. Hazard evaluation of noxious substances transported by ships
3. Principles for developing coastal water quality criteria
4. Scientific problems related to marine pollution monitoring systems (IGOSS and GIPME)
    - 4.1. Specification of physical and chemical parameters to be monitored in an evolving marine pollution monitoring system (IGOSS)
    - 4.2. Dispersion and movement of pollutants on and in the sea by natural physical processes
5. Environmental effects of activities carried out on the sea-bed and ocean floor
6. Preliminary discussion of basic information required for the selection of sites for the disposal of waste into the sea
7. Date and place of next session
8. Other matters
    - 8.1. Oil
    - 8.2. Chemical Production Data
    - 8.3. Atmospheric pollutants
    - 8.4. UNEP Fund

9. Election of Chairman and Vice-Chairman for next intersessional period and for the sixth session

10. Consideration and approval of the report

Annex II

LIST OF DOCUMENTS

No.	Agenda item	Author	Title
GESAMP V/1	1		Provisional Agenda
" V/1/1	1		Annotations to the Provisional Agenda
" V/2.1	2.1	Working Group	Identification and Treatment of Pollutants of International Significance - Further Elaboration of the Review of Harmful Substances
" V/2.2	2.2	F. Valdez-Zamudio	Sewage and Industrial Waste Management Technologies and their Performance
" V/2.3	2.3	GESAMP Panel	Identification and Treatment of Pollutants of International significance - Hazard Evaluation of Noxious Substances Transported by Ships
" V/3	3	E. Geldreich	Principles for Developing Criteria for Coastal Bathing Waters
" V/3/1	3	J.S. Alabaster	The Development of Water Quality Criteria - FAO Marine Fisheries
" V/3/2	3	S. Kêckês	Techniques for Evaluating Lethal and Sub-Lethal Effects of Pollutants that occur in the Marine Environment
" V/3/3	3	E.K. Strizhak	Sanitary Questions concerning the Use of the Sea Coast for Recreational Purposes

No.		Agenda item	Author	Title
GESAMP	V/4.1	4.1	IOC Secretariat	Marine Pollution Monitoring (Surveillance under the Framework of IGOSS)
"	V/4.2.1	4.2	G. Kullenberg	Physical Factors Governing Transport and Dilution of Pollution in the Sea
"	V/4.2.2	4.2	L. Otto	WMO Report No. 8 on Marine Science Affairs - Environmental Factors in Operations to Combat Oil Spills
"	V/6	6	FAO Technical Secretary	General Considerations and Conditions for the Selection of Dumping Sites for the Disposal of Waste into the Sea
"	V/10	10		Report of the fifth session of GESAMP
"	V/INF.1		IMCO	Recent Activities of IMCO in the Field of Marine Pollution
"	V/INF.2		FAO	Summary Report of Activities of FAO in the Field of Marine Pollution
"	V/INF.3		UNESCO	Report on the Work Accomplished by IOC in Relation to Marine Pollution since the Fourth Session
"	V/INF.4		WMO	Recent Activities of the WMO in the Field of Marine Pollution
"	V/INF.5		WHO	Progress Report on WHO Activities in the field of Coastal Pollution and its Control 1973

No.	Agenda Item	Author	Title
" V/INF. 6	6	IAEA	Note by the IAEA Panel Experts and Draft Recommendation on the IAEA's Responsibilities under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (Preliminary Report of the IAEA panel, Vienna, 4 - 8 June 1973)
GESAMP V/INF.7		UN	Activities of the United Nations (1972/73)
" V/INF.8	4.1	ICG for the GIPME	Programme of the Global System for Investigation of Pollution of the World's Oceans presented by the USSR
" V/INF. 9	4.1	IOC	Preliminary Report on GIPME and IGOSS Marine Pollution Monitoring Programmes.
" V/INF. 10	5	FAO	Possible Adverse Effects of the Exploitation of the Sea-Bed beyond National Jurisdiction and Fishery Resources
" V/INF. 11	6	Y. Nishiwaki	Information Paper prepared for the Panel on the IAEA's Responsibilities under the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matters. (June 1973)

Annex III

LIST OF PARTICIPANTS

Members of GESAMP

Dr. T. Beasley
Director,
IAEA Laboratory of Marine Radioactivity
Musée Océanographique
Monaco, Principauté de Monaco.

Dr. G. Berge
Institute of Marine Research
Nordnesparken 2
Bergen, Norway

Dr. H.A. Cole
Controller of Fisheries Research and Development
Ministry of Agriculture
Fisheries and Food
Fisheries Laboratory
Lowestoft, Suffolk, England

Dr. R. Fukai
International Laboratory of Marine Radioactivity
Musée Océanographique
Monaco, Principauté de Monaco

Dr. E.E. Geldreich
Water Supply Programmes Division
Environmental Protection Agency
Cincinnati Water Supply Laboratory
Cincinnati, Ohio, U.S.A.

Professor E.D. Goldberg
Scripps Institution of Oceanography
University of California
La Jolla, California 92037, U.S.A.

Dr. P.G. Jeffery
Department of Trade and Industry
Warren Spring Laboratory
P.O.Box 20
Gunnels Wood Road
Stevenage, Hertfordshire SGI 2BX, England

Dr. S. Kečkeš,
Centre for Marine Research
Rudjer Boskovic Institute
Rovinj, Yugoslavia

Dr. G. Kullenberg
Institute of Physical Oceanography
University of Copenhagen
Haraldsgade 6, 2200 Copenhagen,N., Denmark

Dr. L. Otto
Oceanography Section
Netherlands Meteorological Institute
De Bilt, Netherlands

Dr. J. E. Portmann
Fisheries Laboratory
Ministry of Agriculture
Fisheries and Food
Burnham-on-Crouch, Essex, England

Professor A.I. Simonov
Oceanographic Institute
6, Kropotkinsky Pereulok
Moscow G-34, U.S.S.R.

Dr. J.B. Sprague
Associate Professor,
Dept. of Zoology
College of Biological Science
University of Guelph
Guelph, Ontario, Canada

Dr. Y.K. Strizhak
Chief,
Department of International Scientific Relations
Sysin Institute of General and Communal Hygiene
Pogodinskaya ul. 10
Moscow G-117, U.S.S.R.

Dr. C. Hugh Thompson
Chief,
Hazardous Materials Branch
United States Environmental Protection Agency
7819 Roswell Drive
Falls Church, Virginia 22043, U.S.A.

Professor K.K. Turekian
Department of Geology and Geophysics
Yale University
Box 2161
Yale Station, New Haven
Connecticut 06520, U.S.A.

Professor F. Valdez-Zamudio
Director General,
Scientific and Technological Research
Ministero de Pesqueria
Ave. Santa Cruz 1390
Lima 18, Peru

Dr. M. Waldichuk
Program Head,
Pacific Environment Institute
Fisheries Research Board of Canada
4160 Marine Drive
West Vancouver B.C., Canada

Dr. G.F. Weichart
Deutsches Hydrographisches Institut
Bernhard-Nocht-Strasse 78
2000 Hamburg 4
Federal Republic of Germany

SECRETARIAT AND REPRESENTATIVES OF THE UNITED NATIONS AND SPECIALIZED AGENCIES

United Nations (UN)

Miss G. Matthews (Technical Secretary of GESAMP)
Ocean Economics and Technology Branch
United Nations
New York, N.Y., U.S.A.

Miss S. Kuwabara
Secretariat of the UN Environment Programme (UNEP)
Palais des Nations
Geneva, Switzerland

Food and Agriculture Organization (FAO)

Dr. G. Tomczak (Technical Secretary of GESAMP)
Chief, Marine Environment Section
Marine Resources Division
Food and Agriculture Organization
Via delle Terme di Caracalla
Rome, Italy

United Nations Educational Scientific and Cultural Organization (UNESCO/IOC)

Dr. R.C. Griffiths (Technical Secretary of GESAMP)
Assistant Secretary
Intergovernmental Oceanographic Commission
UNESCO
Place de Fontenoy
Paris 7e, France

World Health Organization (WHO)

Dr. G.J. Cleary (**Acting Technical Secretary of GESAMP)**
Division of Environmental Health
World Health Organization
Avenue Appia
1211 Geneva, Switzerland

World Meteorological Organization (WMO)

Dr. G.N. Kostjanoj(Technical Secretary of GESAMP)
Scientific Officer,
Ocean Affairs Branch
Meteorological Applications Department
World Meteorological Organization
Case postale No. 5
CH-1211, Geneva 20, Switzerland

International Atomic Energy Agency (IAEA)

Professor Y. Nishiwaki (Technical Secretary of GESAMP)
Deputy Director
Division of Nuclear Safety and Environmental Protection
International Atomic Energy Agency
Kärntnerring 11, 1011 Vienna, Austria

Inter-Governmental Maritime Consultative Organization (IMCO)

Mr. Y. Sasamura (Administrative Secretary of GESAMP)
Head, Marine Science and Technology Division
Intergovernmental Maritime Consultative Organization
101-104 Piccadilly
London, W1V OAE, England

Mr. S.L.D. Young (Technical Secretary of GESAMP)
Head, Marine Science Section
Intergovernmental Maritime Consultative Organization
101-104 Piccadilly
London, W1V OAE, England

OBSERVERS FROM INTERNATIONAL ORGANIZATIONS

International Association on Water Pollution Research (IAWPR)

Mr. H. Fleckseder
Institut für Wasserversorgung
Abwasserreinigung und
Gewässerschutz der Technischen Hochschule Wien
Karlsplatz 13
Vienna 1040, Austria

International Council for the Exploration of the Sea (ICES)

Dr. H.A. Cole
Controller of Fisheries
Research and Development
Ministry of Agriculture, Fisheries and Food
Fisheries Laboratory
Lowestoft, Suffolk, England

International Co-ordination Group for the Global Investigations of Pollution of the Marine Environment (GIPME)

Professor A.I. Simonov
Oceanographic Institute
6, Kropotkinsky Pereulok
Moscow G-34, U.S.S.R.

European Inland Fisheries Advisory Commission (EIFAC)

Mr. J.S. Alabaster
Water Pollution Research Laboratory
Stevenage, Herts, U.K.

IOC Group of Experts on Oceanographic Research As It Relates to IGOSS (IOC/IRES)

Dr. M. Ehrhardt
Chairman of IOC/IRES Working Group on Oil
and Dissolved Constituents of Sea Water
Institut Meereskunde der Universität Kiel
Dunsternbrookerweg 20
23 Kiel, Federal Republic of Germany

Annex IV

REVISED REVIEW OF HARMFUL SUBSTANCES
(revised version of GESAMP III/19, Annex IV)

(Working Group 1 - Agenda Item 2.1)

Members of the Working Group:

Dr. H. A. Cole (Chairman)
Dr. P. G. Jeffery
Dr. J. B. Sprague
Dr. J. E. Portmann
Miss G. Matthews) (Technical Secretaries)
Mr. S. L. D. Young)

1 INTRODUCTION

1.1 UN General Assembly Resolution 2566 (XXIV) called for a Review of Harmful Substances which may have deleterious affects on man's health and his economic and cultural activities in the marine environment and coastal areas. The Review was intended to assist in preparations for the UN Conference on the Human Environment which was held in Stockholm in June, 1972.

1.2 In the light of this Resolution and with a view to illustrating the comparative importance of substances causing pollution tables were developed at the Second and Third Sessions of GESAMP showing major categories of pollutants and their relative effects in terms of:

(a) harm to living resources

(b) hazards to human health

(c) hindrance to maritime activities

(d) reduction of amenities

In view of later developments including the UN Conference on the Human Environment, which by Recommendation 88 called upon GESAMP to "re-examine the Review annually with a view to elaborating its assessment of sources, pathways and resulting risks of marine pollutants", the tables have since been extended by sub-division of certain of the more important categories of pollutants into their major constituents. The resulting tables therefore replace the earlier tables included in the Report of the Third Session of GESAMP (GESAMP III/19, Annex IV).
Nevertheless, it must still be emphasized that the tables can only be regarded as a general guide, since some categories are made up of many substances, some of which may have more pronounced effects than others.

1.3 With regard to the sources from which pollutants originate, it is generally agreed that this is where measures of prevention or control can be most effectively applied. To facilitate further consideration of the desirability and feasibility of national control measures and international agreements, the main routes by which marine pollutants reach the sea are indicates in Table 2.

1.4 Attention is also drawn to the fact that the cargoes carried by ships include a wide variety of noxious substances, falling within the categories listed in Table 1, which may be discharged into the sea either by accident (such as in collision, stranding, fire or storm damage) or deliberately such as in the tank cleaning and ballasting operations of a tanker or bulk carrying vessel. A particular pollutant may therefore be subject to control under separate regimes, one associated with transport by sea (e.g. IMCO) and the other with its use or production ashore. Because of differing conditions under which the discharge is made however each regime may be obliged to apply quite separate and distinct measures of control in respect of the substance in question. In response to a specific request from IMCO, a Panel of IMCO and GESAMP Experts was set up in 1972 to Review the Environmental Hazards of Noxious Substances other than Oil Transported by Ships. The Report of this Panel (GESAMP IV/19/Supp.1) has now been published and is being used as a reference document for the development of an International Convention for the Prevention of Pollution from Ships. It must be emphasized that that report relates only to the particular circumstances under which discharges occur in maritime transport and should not be used for other purposes particularly the control of continuous discharges from direct outfalls which are generally located in inshore waters.

1.5 The Group is not aware of any situation in which the release of radioactive materials to the sea by the nuclear energy industry has produced adverse biological effects. This situation has resulted from the very firm control imposed by national governments over this industry since its beginning. The work done on the study of the dispersion, effects and fate of radioactive materials in the marine environment has been and continues to be, extensive. It has had the result that the status of radioactive materials as potential pollutants of the marine environment is more clearly defined than that of most other materials recognized as serious pollutants.

1.6 The routes by which marine pollutants enter the sea have been identified under the following main headings:

(a) disposal of manufactured and industrial products or of the waste resulting from them by direct outfall or via rivers;

(b) disposal of domestic sewage by direct outfall or via rivers;

(c) run-off from the land of materials used in Forestry, Agriculture, or Public Health activities;

(d) deliberate dumping of material from ships;

(e) operational discharge of polluting materials by ships in the course of their normal tasks;

(f) accidental release of material from ships or submarine pipelines;

(g) exploitation of sea bed for petroleum or other mineral resources; and

(h) transfer of pollutants to the ocean from the atmosphere.

These descriptions are included in Table 2 and the importance of each of them as a route by which different categories of pollutants enter the sea has been shown by the use of a number of symbols. To aid in the study of Table 2 each category of pollutant is the subject of an explanatory note which gives, where appropriate, further information on main uses, principal sources and pathways to the marine environment, mode of occurence and distribution, toxicity, breakdown products, degree of persistence and accumulation in biological materials, and known effects.

1.7 Attention is called to the fact that there is an increasing number of harmful substances that may appear in effluents discharged into the marine environment. These substances are present in industrial wastes As a result of complex manufacturing processes. The present list of harmful materials is only tentative and will undoubtedly be extended as further investigations are made. In addition, some chemical substances may be altered by marine organisms or they may produce a synergistic effect, resulting in acute or low-level chronic toxicity. Little is known about the mechanism by which some of these processes take place. There is evidence that in some instances trace elements may trigger toxicity cycles in marine organisms; further information about ecological conditions leading to the production of biotoxins is highly desirable.

1.8 Although to an increasing extent measures of prevention and control, both national and international, are being introduced for certain pollutants, the Group recommends that further consideration be given especially to those categories shown in Table 1 as 'important' or 'significant' with a view to improving the effectiveness of existing legislation and, where necessary taking further action nationally and, where appropriate, internationally (e.g. on a regional basis) to limit or control their discharge into the sea.

2. CONTINUING REVISION AND EXPANSION OF THE REVIEW

It is the intention of GESAMP to continue to develop the Review in accordance with Recommendation 88 of the UN Conference on the Human Environment, and with a view to meeting possible future requests arising from international or regional agreements on the control of marine pollution.

For the immediate future, in preparation for the next session of GESAMP, it is proposed by intersessional activity:

(a) to extend the section on organic substances to include further examples;

(b) to revise the section dealing with metals, particularly with respect to mercury, cadmium, lead, copper and zinc, and to present this information in a more systematic way.

3. NOTES ON MAJOR CATEGORIES OF MARINE POLLUTION (TABLES 1 and 2)

3.1 Domestic Sewage

When discharged untreated, domestic sewage has five major characteristics:

(a) a high bacterial content, parasites and possibly presence of virus concentrations, contaminating molluscan shellfish (necessitating purification or heat sterilization) and limiting the use of bathing areas;

(b) dissolved organic and suspended constituents which give a high biochemical oxygen demand;

(c) settling solids (organic and inorganic) depositing on the bottom to undergo decay with consequent oxygen depletion;

(d) high nutrient concentrations (mainly phosphorus and nitrogen compounds) leading to enrichment of receiving waters and potential eutrophication;

(e) floatables, which may be organic or inorganic materials on the surface or in suspension, constituting a serious amenity problem and interfering with primary production and self-purification processes.

By reason of these characteristics sewage affects recreation, utilization of seafood, public health and general amenities. The production characteristics of the receiving waters may be altered and there is a possible connection with the production of toxic blooms of algae.

One of the reasons for the need to control pollution by sewage is the maintenance of shellfish quality. The standards of treatment and/or dilution required for this purpose are somewhat higher than those presently demanded for other public health or amenity purposes. Filter-feeding molluscan shellfish concentrate bacteria and viruses along with other particulate materials and the consumption of contaminated shellfish may give rise to enteric infections. The transmission of the viral disease, infectious hepatitis, by consumption of raw shellfish contaminated by sewage is well documented. Methods of purifying shellfish from the effects of bacterial contamination are available and are extensively used in many countries but are not yet fully acceptable in all situations.

Various degrees of treatment of domestic sewage eliminate or reduce some of the foregoing polluting characteristics: primary - normally eliminates the settleable solids and floatables and proportionally reduces the microflora; secondary - clarifies the effluent from the finer colloidal suspensions, mineralizes organic substances (reducing the biochemical oxygen demand) and disinfection can provide a further removal of pathogenic forms; tertiary - removes the plant nutrients by biological or chemical action, or by a combination of the two, and reduces the suspended solids still present as well as decolorising the effluent. Much coastally discharged sewage receives no treatment beyond comminution or maceration; this accelerates breakdown and is an improvement from the amenity standpoint but only marginally reduces bacterial or viral contamination and nutrient content. Where practicable, separation of storm water and foul sewage systems is very desirable, to prevent interference with treatment processes during periods of heavy rainfall.

Other household wastes which enter the municipal sewer, including detergents and optical whiteners (dealt with in another section of this report), pharmaceuticals, house and garden pesticides and incidental chemicals, and oily and other discharges from small businesses and garages, may also be important. However, apart from the considerations mentioned above, the major problems of municipal sewage disposal arise from the inclusion of industrial wastes with materials discharged from municipal sewers. The tendency to replace sewage treatment works by long outfalls, discharging well away from the shore into deeper water, has led to the inclusion of greater quantities of industrial wastes with domestic sewage. Such wastes may contain toxic and persistent materials (e.g. metallic wastes) in concentrations which, if they were accepted by a treatment plant would reduce its efficiency. Such pipeline discharges may adversely affect marine resources, particularly shellfish and young fish on coastal nursery grounds. Pre-treatment at source of industrial wastes before discharge to sewers should become standard practice. There has been a similar tendency to replace estuarine discharges by long trunk sewers leading to marine outfalls. Careful siting of all such outfalls in relation to dilution characteristics of receiving waters, other existing or projected outfalls, and presence of exploitable marine resources is essential.

The practice of disposing of sludge from coastal sewage treatment works by dumping at sea may be harmful because such wastes may contain significant amounts of adsorbed metals e.g. mercury, and also pesticide residues and other persistent chlorinated hydrocarbons. These factors and probable biological effects e.g. interference with benthic fauna, need to be considered in deciding disposal procedures for sewage sludges and the selection of dumping zones.

3.2 Pesticides

The term "pesticides" covers a wide range of substances of differing chemical composition and class of target organism. They are considered here under seven headings, organochlorine compounds, organophosphorus compounds, carbamate compounds, herbicides, mercurial compounds, miscellaneous metal-containing compounds and polychorinated biphenyls. The latter are not pesticides, but are widely used in industry and can conveniently be discussed in the same group as organochlorine pesticides.

3.2.1. Organochlorine compounds

Much information is available on this group of pesticides, some of which have been in use for more than 30 years. The most commonly used are probably DDT, BHC, Dieldrin, Endrin, Aldrin and Endosulfan; all are used as insecticides, either for agricultural or public health pest control. Use is frequently on a fairly large scale and spraying from the air is a common means of application in some areas. Not all the material sprayed will reach the target area (less than 50% in some instances) and some will inevitably be lost to the atmosphere. Of this, a proportion will reach the sea by exchange with the atmosphere, in rain or adsorbed on air-borne particulate matter. Since organochlorine compounds are strongly adsorbed on particulate matter and are relatively insoluble in water, it is unlikely that they will reach river systems except under flood conditions where soil particles are washed into rivers. Although comparatively non-volatile, organochlorine compounds may be lost from the soil by evaporation and particularly by codistillation with water. In addition, soil erosion by wind may carry a proportion of the applied chemical into the sea. Aerial transport accounts for at least 50% of the material reaching the sea.

Mothproofing of wools and woollen garments and carpets may lead to discharge of insecticidal formulations (e.g. Dieldrin) directly to rivers and hence to the sea. Recent analyses of sewage and sewage sludges suggest that these may also be an important route of entry of pesticides to the sea.

Estimates of the proportion of the annual production of organochlorine pesticides reaching the sea have ranged as high as 90% but a more accurate estimate may be 40-60%.

Once in the sea, organochlorine pesticides may be concentrated either in surface slicks or by marine organisms. Some will be carried to the sea bed on particulate material and a certain amount will remain dissolved in the sea water at a very low concentration. From analyses of marine animals, some of the organochlorine pesticides, particularly DDT, are known to be distributed on a world-wide basis. Concentrations in coastal waters can be determined, but oceanic waters contain levels below the normally accepted detectable level, i.e. 1 part in 10^{12}. Owing to the lipophilic/hydrophobic character of organchlorine pesticides, they are particularly likely to be concentrated in any oily material, e.g. fish oils. They are, therefore, found in appreciable concentrations in many marine organisms, especially those with a high lipid content and those organisms highest in the food chain. Residence time in the environment has not been accurately determined for all of them but seems to be generally of the order of years rather than months.

Although some have been used for more than 30 years, the precise mode of action of organochlorine pesticides is not fully understood. It is, however, generally accepted that they affect the transmission of impulses in the central nervous system. Recently, subtle sub-lethal side affects have been recognized, e.g. on calcium deposition in birds' eggs. Their acute toxicity to marine organisms is now fairly well documented. Crustacea are particularly sensitive; DDT concentrations as low as 0.003 ppm in water have been shown to be lethal to shrimps, but fish can tolerate concentrations up to two orders of magnitude higher - at least for a short time.

There is no evidence that the proper use of organochlorine pesticides has adversely affected human health, nor have there been any incidents where humans have been affected by eating fish contaminated with organochlorine pesticide residues. Effects on fish and shellfish populations have been demonstrated in certain estuarine environments, particularly in North America. Most of the incidents have been kills as a result of spray operations, but at least two instances have been reported where reduced breeding success of estuarine fish has been attributed to organochlorine pesticide residues arising from routine usage on the land. Predatory birds are particularly vulnerable; the reduction in numbers of brown pelicans, bald eagles and peregrine falcons in North America is attributed primarily to DDT and allied chlorinated hydrocarbons.

3.2.2. PCB's

Polychlorinated biphenyl compounds (PCB's) are sold under a variety of brand names. There is a variety of formulations depending upon the degree of chlorination of the biphenyl molecule; the greater the degree of clorination the higher the viscosity. PCB's have had a wide range of industrial uses, particularly in the electrical industry, Because range of industrial uses, particularly in the electrical industry. Because of wide_spread contamination of the environment,usage has now been restricted in a number of countries to applications where loss to the environment is unlikely. The routes of entry to the marine environment are still under investigation, but industrial use inevitably involves some losses which may reach the sea. Analysis of sewage sludges has revealed that most sewage contains some PCB's. The dumping of waste materials containing PCB's is probably largely on land. PCB's are highly resistant to burning and unless incineration is properly carried out (a temperature of over 800°C is required), burning of materials containing PCB's will simply release them to the atmosphere for subsequent rain out into the sea. Disposal by dumping in the sea of wastes containing PCB's, except as trace contaminants, is forbidden under the terms of the London Convention of 1972.

In occurrence and distribution, as well as persistence and accumulation, PCB's behave in much the same way as organochlorines and much that has been said above for these pesticides will also apply to PCB's. They have been in use for a slightly longer period and, at least in the marine environment, are just as widely spread as DDT and their persistence and concentration in marine biota is, if anything, greater rather than less than that of DDT.

The mode of action of PCB's is not well understood but may be similar to that of organochlorine insecticides. Certainly PCB's have been implicated in shell thinning of birds' eggs. The acute toxicity of PCB's is in general similar to that of organochlorine pesticides. There is some evidence to suggest that they have a high chronic toxicity, i.e. it may take a matter of weeks before a short-term low-level exposure takes effect. This may be attributable to impurities in certain formulations.

In incidents of accidental ingestion or gross industrial exposure, illness and even death have been reported in humans, but there are no known ill effects on man which can be associated with levels of PCB's in marine products. Even in estuarine environments, PCB's have not been implicated in any damage to marine life, although in some areas quite high levels have been reported in fish. The presence of high concentrations of PCB's in the livers of sea birds was suggested as a possible contributory cause in a large scale bird kill off the U.K. coast in 1969, but it is now generally accepted that natural causes played the major role in causing this bird mortality.

3.2.3. Organophosphorus compounds

This group of compounds includes Malathion, Parathion, Azinphos-methyl and Chlorfenvinphos and , with the carbamate compounds, is to some extent replacing the organochlorine insecticides. In chemical terms, they are more varied than the organochlorines, although they all contain phosphorus. They are relatively soluble in water, and may be carried into rivers, and hence the sea, in substantial amounts, by run-off from land. Spray losses and evaporation of sprayed material followed by rain out over the sea is a second probable route of entry to the marine viromnent. Industrial usage is probably small and therefore an insignificant source of pollution.

Most organophosphorus compounds are chemically less stable than the organochlorine type and they are therefore much less persistent in the environment. Most are hydrolysed on contact with water and they are much less hydrophobic than organochlorines. As a result bio-accumulation is likely to be unimportant.

Because they are less persistent and non-accumulative, not much effort has been exerted in studying the role of organophosphorus compounds in the sea. They are likely to be present in true solution and, since they are not particularly lipophilic, they are unlikely to be concentrated in surface slicks. Because they are not persistent, it seems unlikely that they will be found in ocean waters and there appear to be no reports of their occurrence in waters other than estuaries.

Organophosphorus compounds act on the nervous system by inhibition of cholinesterase activity. Their acute toxicity to marine animals is reasonably well documented and appears to differ widely according to the particular compound used, e.g. Azinphos-methyl was lethal to Crangon crangon at a concentration of 0.0003 ppm but Morphothion had no effect on the same species at 0.3 ppm. The mammalian toxicity of some organophosphorus compounds is high but residues have not so far been detected in marine organisms other than a few estuarine species and no cases of poisoning through the eating of organo-phosphorus pesticide contaminated fish have been reported or indeed seem likely to occur.

3.2.4. Carbamate compounds

These compounds, which are based on carbamic acid, are of two basic types, the N-dimethylcarbamates e.g. Isolan and Dimetan, and the N-methylcarbamates e.g. Carbaryl and Zectran. In general, they are less soluble in water than the organophosphorus compounds but more so than the organochlorides. Some of these materials, particularly carbaryl (Sevin), are now in fairly widespread use. They are likely to reach the sea by all the routes quoted for organophosphorus compounds. The main useage of carbamates is in agriculture but carbaryl is to some extent replacing DDT and may be used in future malaria control operations. It also has a small-scale role in mariculture as a means of controlling crustacean pests in shellfish cultivation programmes. This provides a direct route of entry to the marine environment.

None of the carbamate compounds is particularly stable; they are attacked by acids and alkalis and it is probable that slow hydrolysis will occur once they reach the sea. They can be relatively easily metabolised and the data available for marine animals suggest that, once taken in by, for example, a bivalve, they can be completely metabolised and/or excreted within about 2 -3 weeks. They are therefore unlikely to pose much of a hazard as a result of persistence or accumulation. Carbamate compounds have not been detected on a wide scale in sea waters or marine animals but they are known to be readily adsorbed on silt and small concentrations may be found in estuarine sediments following local use on land and in mariculture.

Carbamate compounds are cholinesterase inhibitors; a few also show activity against other enzyme systems. A few of these compounds are also used as herbicides and they might be expected to have minor effects on the phytoplankton in local areas. The toxicity of carbamate compounds to marine animals follows the same highly variable pattern depending on compound and species, which they exhibit in the terrestrial environment. Carbaryl is moderately toxic to crustaceans but not to fish or molluscs. With the exception of Isolan, all the carbamate compounds are of low mammalian toxicity, and harm to human health, either directly or indirectly, through eating fish or shellfish, seems improbable. Isolan is of a lower mammalian toxicity than the organophosphorus compounds.

3.2.5 Herbicides

Herbicides are a mixed group of compounds, most of which have water solubilities of the order of tens of ppm or more. They include urea-based compounds such as Linuron, dipyridyl compounds such as Diquat, and acid ester hormone type compounds such as MCPA and 2,4-D. The major routes to the marine environment are probably direct water transport from the land or spray drift and subsequent rain out over the sea. Most of these compounds are likely to be found in dissolved form but a few, e.g. Diquat, are strongly adsorbed by particulate matter and will be largely associated with sediments or suspended material. Very little attention has been paid to herbicide compounds to date and the extent of their distribution in the marine environment is a matter of speculation. Most are comparatively short-lived but a few, e.g. 2,4,5-T and Picloram, have half lives up to 5 years. The genetic damage attributed to 2,4,5-T is now generally considered to be due to the presence of impurities.

Few of the herbicides are particularly toxic to fish and it seems unlikely that appreciable effects would be noticed. The main effect of herbicides in the marine environment might be expected to be on the phytoplankton but very few data appear to be available on this subject. Tests with unialgal cultures at the U.K. Fisheries Laboratory, Burnham-on-Crouch with 2,4-D, Dalapon and two triazine compounds (Atrazine and Simazine) suggest that at least some herbicidal compounds tend to stimulate growth of algae rather than to kill them. Dalapon is used in Spartina grass control in salt marsh areas but does not seem to cause mortality of marine creatures. Paraquat has a high mammalian toxicity if directly ingested and there is no known antidote, but its toxicity to marine life is low and it is strongly adsorbed to particulate material.

3.2.6 Mercurial compounds

A variety of organic mercurial compounds is used in agriculture and horticulture for the control of seed-borne and fungal diseases. They have been used extensively in the past as slimicides in the paper industry. Calomel is used in some areas as a fungicide and insecticide.

Most of the mercury compounds used have a low water solubility and in addition are strongly adsorbed on to soil particles. They are therefore only likely to find their way into the aquatic environment in times of flood. Mercury compounds are readily converted under anaerobic conditions to methyl mercury. There is some evidence to suggest that dimethyl mercury is readily volatilised and could subsequently find its way into the sea. The importance of this and other routes has still to be established and modes of entry into the marine environment are the subject of study at the present time.

Mercury occurs naturally in the marine environment as a result of the normal processes of weathering of rocks. The data available at present suggest a concentration of mercury in sea water in the range 0.03 to 0.3 ppb. **Methyl mercury concentrations are probably about** 1/1000 of this level. Locally higher concentrations have been recorded in coastal waters amd are attributed to industrial pollution. Most mercury compounds decompose to the inorganic form which is then available for methylation. Mercury as an element is a highly conservative and persistent substance in the marine environment. Although the inorganic form does not pose much of an accumulation hazard, methyl mercury is very readily taken up by marine organisms and accumulated in the food chain. (See Section 3.3.7)

Methyl mercury has a high mammalian toxicity and produces nervous disorders and death at low levels of dietary intake. One ppm of mercury is considered by many national governments to be an unacceptably high level for food fish. However, such levels appear to have no ill effects on the fish and in certain species are even considered to be the norm by some authorities. Only in instances of extremely high mercury pollution have definite ill effects been observed in marine organisms. Normal levels of mercury in fish are probably in the range 0.01 to 0.2ppm. Certain pelagic fish eg. tuna and swordfish, contain somewhat higher levels but these do not seem to have changed during this century.

3.2.7 Miscellaneous metal - containing pesticides

In addition to the compounds already discussed, there are a small number of metal salts and organo-metal compounds which are used as pesticides, e.g. Bordeaux mixture (copper salt), lead arsenate and Fentin acetate. These compounds have appreciable solubilities in water and are likely to be transported to the sea by land run-off and drainage. Their contribution in terms of quantity of metal ions or compounds added to the sea is negligible compared to those from other sources, e.g. lead from automobile fuels, copper from industrial wastes. It **seems unlikely, therefore, that harmful effect** in the marine environment, would arise from their use on the land. Most of the metal-containing pesticides are toxic to fish and improper use has caused fish kills in inland waters. It is **therefore, conceivable** that local damage may occur, e.g. in estuaries, but the risk to humans is negligible.

3.3 Inorganic Wastes

Most of the elements listed in the periodic table are present in sea water in at least one form of ion or complex and their introduction does not necessarily constitute pollution, although similar amounts discharged to fresh water areas might do so. In addition, because sea water is a relatively strong solution when compared to fres water it is able to absorb some inorganic pollutants, e.g. acids, with relatively little change in its overall chemical nature. These are two important factors which must be borne in mind when considering inorganic substances as marine pollutants.

Of the various inorganic compounds or ions which are likely to enter the marine environment a number can be selected as potential pollutants in certain circumstances - the remainder might, at the worst, be defined as contaminants.

3.3.1 Acids and Alkalis

The production of many inorganic chemicals and some organic chemicals may give rise to large quantities of waste acid or alkali which may be discharged to the marine environment. Sulphuric and hydrochloric acids are most likely to be discharged with smaller quantities of nitric acid. The effects of nitrate and sulphate are considered below but chloride, already present in large amounts in the sea, cannot be considered as a pollutant. The alkalis involved are lime, sodium hydroxide and, to a lesser extent, potassium hydroxide and ammonia. The ammonium cation is considered separately below but sodium and potassium fall into the same category as chloride.

Sea water has a considerable buffering capacity, i.e. it can absorb relatively large amounts of acid or alkali with comparatively small changes in pH. Discharges of unneutralised acid or alkaline affluents are frequently made into estuaries and quantitie of waste acids are dumped by barge away from the shore. A second major source of acid is the burning of fossil fuels which releases quantities of sulphur dioxide and acid oxides of nitrogen into the atmosphere (50-80 million tons annually). These may subsequently be rained out over the sea, but although rainfall containing sulphur dioxide (i.e. acidic) may have affected the pH of some Swedish lakes, a similar effect on the sea seems unlikely. Burning of chlorine-containing compounds, particularly substances such as PVC, gives rise to HCl gas, which on dissolution, e.g. in rainwater, is a further source of acid which may grow in importance.

Although the effect on the pH of sea water of acids from the atmosphere cannot be detected, pH changes can be detected over relatively small areas in the proximity of discharges of acid or alkaline wastes both in estuaries and in the open sea in the wake of a discharging barge. It must therefore be concluded that discharges of acids or alkalis have only a local effect and that their distribution , although possibly world-wide, is completely accommodated by the carbon dioxide buffer system and has no effect.

The acute toxicity of both acids and alkalis to some marine animals is documented and, presumably because of the buffering capacity of the sea water, moderately high concentrations - several hundreds of ppm - have no effect. Fish and small crustacea can detect concentrations of acids and alkalis below the acutely toxic level and will avoid such concentrations. The toxic action of both acids and alkalis is probably mainly associated with the effect that they have on the oxygen - carbon dioxide transfer across the gill surface. At higher concentrations their corrosive action would undoubtedly be lethal.

3.3.2 Nutrients and Ammonia

Phosphate enters the sea via rivers and directly from outfalls via sewage where its origin is largely polyphosphate from detergent formulations. Small amounts may also be discharged by industry and some will enter as runoff from agricultural land. Sewage effluents contain nitrate and ammonia + nitrate both of which are oxidized by bacteria to nitrate. Ammonia may reach the marine environment in sewage effluents and as a result of its use in industrial processes and in agriculture. In addition large quantities of ammonium aulphate are produced as by-products in certian industrial processes. Some of this is considered waste and is discharged to the sea.

The concentration of ammonium ion in sea water is low (generally of the order of 5-5µg/1) although locally it may be high near a discharge of nitrogen-containing waste Mg/1. It is one of the intermediates in the bacterial decomposition of nitrogen-containing compounds which eventually terminates at nitrate. Ammonia is not therefore a persistent substance and large-scale distribution of high concentrations is unlikely.
Nitrate and phosphate are essential nutrients in the productivity of the marine environment. Over-abundance of these ions in freshwaters can lead to eutrophication with blooms of phytoplankton , followed by deoxygenation and anaerobic decay. Such phenomena have been recorded in the marine environment in fjord and estuarine areas (e.g. Oslo fjord) and may become a problem in some enclosed seas. Both nitrate and phosphate are adsorbed on particulate matter and the sediments provide a reservoir and means of storage of excess nutrients. Although persistent, neither nitrate nor phosphate constitute accumulation hazards within marine animals and there is no evidence to suggest that concentrations less than grossly excessive would be toxic.

3.3.3 Cyanide

Wastes containing cyanide are discharged to rivers, estuaries and on open coasts from a variety of industrial premises, e.g. metal plating plants, gas works and coke ovens, and from the scrubbing of steel works gases as well as a number of chemical processes. Direct dischargos such as these account for most of the cyanide entering the marine environment. Whatever the form in which the cyanide is discharged, i.e. HCN,NaCN, etc. it readily takes the form of HCN with some dissociation to H^+ and CN^-
It is now generally accepted that HCN is much more toxic to aquatic life than CN^- and at pH 8 only about 7-10% of the HCN is dissociated. Cyanide is biodegradable and treatment methods are available which can eliminate the need to discharge cyanides. The bio-degradability of cyanide and the readiness with which it forms complexes with certain metal ions, e.g. copper and iron, means that large scale distribution of cyanide is unlikely and that any detrimental effects would be local in nature.

3.3.4 Sulphite

Sulphite may enter the marine environment in wastes from certain industrial processes e.g. the pulp industry and rayon manufacture. Sulphur dioxide produced from the burning of fossil fuels will also enter the sea as sulphite from the atmosphere. The sulphite ion is not stable in sea water; under normal aerobic conditions it will be oxidized to sulphate. Under anaerobic conditions sulphite and sulphate may be reduced by bacteria to sulphide which is toxic and obnoxious on amenity grounds. Sulphite is also toxic to marine life and, although not stable in the marine environment, is known to have caused damage to marine life near effluent discharges. Sulphate is not toxic to marine life and is present naturally in sea water in relatively high concentration (2.76g/l); it cannot therefore be considered to be a pollutant.

3.3.5 Phosphorus

Phosphorus is normally found in the sea in the form of phosphate, either particulate organic or inorganic. If discharged in elemental form, however, it remains largely in that state and is potentially highly toxic. There have been some instances of elemental phosphorus being discharged to the marine environment from factories producing phosphorus from phosphate ores and from ships carrying phosphorus both in bulk and in drums. Much of the phosphorus becomes locked in the sediments where it remains virtually unchanged for a considerable period; the fraction remaining in the water is slowly oxidized to phosphate. One large scale incidence of toxicity arose on the coast of Newfoundland from a factory discharge. Large numbers of herring, cod and other species were killed; in some species extensive haemolysis and reduction of haematocrits was observed.

3.3.6 Titanium dioxide wastes

The industrial production of titanium dioxide from titanium ores can give rise to large volumes of a waste which is characterised by its high proportion of acid and ferrous sulphate. This particular waste is considered worthy of special attention since in many instances the waste is discharged, completely untreated, into the sea either from a pipeline or from barges.

The ferrous ion is very rapidly oxidized to ferric ion which precipitates in collodial form as the hydrated hydroxide over a considerable area in the locality of the discharge or dumping. Although the effect of the acid is lost relatively rapidly, ferric hydroxide is persistent and remains in or on the sea bottom for considerable periods. No ill effects on human health or living resources, except in the immediate vicinity of the discharge, have been reported, but amenities might be affected in coastal areas owing to deposition of ferric hydroxide in the intertidal region. The nature of this waste is likely to change in the future as new methods replace the old sulphuric acid process. The sulphuric acid in the waste will be replaced to some extent by hydrochloric acid.

*3.3.7 Mercury

The mode of occurence, toxicity, distribution, etc. of mercury are discussed in Section 3.2. Agricultural usage of mercurial pesticides is, however, a relatively minor source of mercury to the environment, although industrial use of mercury compounds as slimicides has had an important effect on the environment in some areas, e.g. Sweden and Canada.

* This section is in process of revision

The annual world production of mercury is approximately 9,000 tons, the majority of which is used by industry, the most important single usage being in the chlor-alkali industry. In theory, no losses of mercury should occur, but in fact, typically 250 gm of mercury were lost per ton of chlorine produced. Much of this found its way into the marine environment either via rivers or from the atmosphere. Recently introduced methods of treatment of the effluents have greatly reduced the discharge of mercury from most of these plants. Other industrial usages of mercury are in the electrical industry in mercury switches and batteries and in the production of high grade antifouling paints. Mercury is also used as a catalyst in the production of acetaldehyde and vinyl chloride. It was this latter usage which led to the deaths of more than 40 people and lasting injuries to a great number at Minamata in Japan.

In addition to these sources of mercury, which between them probably account for 4-5,000 tons added to the sea per year, an amount possibly equivalent or greater is derived from the burning of oils and coal much of which may contain some mercury, albeit very low concentrations. This mercury is carried in the atmosphere and may be rained out over the sea.

Mercury is accumulated to approximately the same degree in bivalve molluscs and fish, in contrast to other metals such as zinc and copper.

*3.3.8 Lead

The annual world production of lead is approximately 3 million tons and the contribution of lead to the marine environment as a result of man's activities must now be greatly in excess of the natural supply. Over 10 percent of the present annual production of lead is used in leaded motor fuels where it functions as an 'anti-knock' agent. Much of the lead is released to the atmosphere in exhaust fumes and subsequently finds its way into the sea. Use of lead in this way is believed to introduce 2×10^5 tons of lead into the marine environment annually and is believed to be the cause of the elevated lead concentrations found in sea waters adjacent to industrial and populated coasts. Lead is also introduced in the effluents of many chemical factories and natural processes of weathering probably contribute a further 2×10^5 tons annually. The concentration of lead found in the surface layers of near-shore sediments is now considerably higher than that in sub-surface layers.

Lead accumulates in animal tissues and is only very slowly excreted. It is an enzyme inhibitor and impairs cell metabolism. In marine animals it is probable that, at least in acute exposures, lead acts by damaging gill surfaces and hence inhibits oxygen-carbon dioxide transfer. Lead is persistent in the marine environment and marine sediments are probably the main storage point. In common with other

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*This sections are in process of revision

'heavy metals' (except mercury) lead is specially prone to accumulate in bivalve molluscs and the elevated levels of lead found in near shore sediments are causing high lead concentrations in these shellfish. However, no ill effects have so far been recorded either in fish or shellfish and there appear to be no recorded instances of human poisoning by eating marine products with high lead contamination. The rapid increase in the level of lead in the surface layer of the sea in recent years must, however, be viewed with concern.

*3.3.9 Other Metals

A number of other metals besides lead and mercury are considered as potentially hazardous in a marine pollution context. These are copper and zinc, both of which are produced on a very large scale annually (5 million tons), chromium (annual production 2 million tons) and cadmium. Arsenic, antimony, bismuth and selenium may also be of interest in view of their toxicity to man.

Chromium is likely to enter the marine environment largely as a result of its use in the metal-plating industry. In addition, small quantities are used in pest control and in paints. Recently, large quantities have been used in road marking materials some of which must reach the marine environment via rivers. Copper and zinc are used in large quantities for water pipes and for plating of storage tanks respectively; zinc plating, galvanizing etc. is commonly used as a rust preventative and quantities of copper and zinc must be dissolved and run into rivers and sewers from all large towns. Sewage sludges, particularly from industrial areas, contain measurable amounts of both copper and zinc. In addition, both copper and zinc salts are used in a variety of industries and are found in many industrial waste discharges. Copper finds a small-scale usage in pesticide formulations. Cadmium is used largely in the plating and metallurgical industry in certain electrolytic processes. It is also a useful catalyst in some industrial processes; in addition, cadmium compounds are used as pigments. Probably the most important routes to the marine environment for all four of these metals are via rivers and sewage or industrial outfalls.

All four elements are found in sea water and some will be in the simple ionic form, others as ionic complexes. Levels of all four elements appear to be higher near to the land, probably partly due to natural weathering of rocks but also due to man's usage of these elements.

Some of the forms in which the elements occur in sea water are insoluble and it seems likely that a proportion of the annual loss to the marine environment enters the sediments. There is a definite evidence of accumulation by bivalves of very high concentrations of both copper and zinc, but marine fish appear to be less likely to accumulate these two elements. Cadmium is know to be accumulated by certain marine animals but data for chromium are lacking. There is evidence that cadmium , once in the human body, is only very slowly excreted, if at all.

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*This sections are in process of revision

*3.4 Radioactive Materials

Although as a result of fallout from nuclear explosions or weapon testing, radioactive materials may reach the marine environment in uncontrolled amounts, the development of the civil uses of nuclear energy is strictly controlled, usually by special legislation, so as to minimize the hazard to public health or damage to marine resources. The disposal of solid radioactive waste to the deep ocean will be governed by the provisions of the London Convention 1972. There are no known effects of introduced radioactivity in the natural environment on marine resources, except in the immediate vicinity of nuclear test sites.

3.5 Oil and Oil Dispersants

Prior to about 1950, petroleum was refined in the country of origin, and the world traffic was largely in refined products. The newer refineries have been built in the developed countries, giving rise to the growth of a new trade in the carriage of crude oil by sea from the oil producing areas to the user countries. The massive and continual rise in oil consumption has resulted in the construction of larger and larger vessels for this trade. At the present time the largest ships carry 0.5 million tons of oil, but ships to carry 0.7 million are actively being considered, and ships to carry 1.0 million tons are projected.

Annual world production has risen from 1,260 million tons in 1962 to 2,600 million tons in 1972; this is expected to rise to 3,500 million tons by 1980.

This rise in oil consumption has led to a world-wide search for newer sources of supply, and an increasing proportion of the world's needs is now and will continue to be met from off-shore oil fields. These will increasingly be sited on the deeper parts of the continental shelf, as the technology of deep-sea drilling develops.

These changes in the world's trade in petroleum and petroleum products since about 1950 resulted in a massive increase of oil pollution of the marine environment, especially of beaches, largely from shipping. There has been considerable national and international activity to limit, and where possible to prevent, this pollution by oil. An international convention for the prevention of oil pollution was adopted following the 1954 IMCO Conference. Amendments to this convention, designed to further limit the quantities of oil discharged at sea, were adopted in 1962 and 1969, although the latter has yet to be brought into force internationally. Further limitations on the operation of tankers and other vessels are likely to result from the 1973 IMCO conference and the 1973 Convention which is designed to achieve "the complete elimination of intentional pollution by oil and noxious substances other than oil and the minimization of accidental spills".

Oils and oil products can enter the marine environment from submarine seeps, from shipping operations and marine accidents, both on the high seas and in port (up to 1m tons per annum) and by discharge to rivers, sewers, and so finally to the sea. Aerial transport of oil derived from internal combustion engines may transfer substantial quantities to the sea.

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*This sections are in process of revision

In general, oil is lighter than water and tends to spread fairly rapidly, forming a thin layer which moves over the surface under the influence of winds and tides. Though found widely over the oceans it is most frequent around the main routes by which oil is carried from producing areas to the refineries and along trade routes and near the population centres they connect.

In temperate and tropical zones oils are biodegraded and also polymerized; under the action of light and oxygen density increases and the particles become dense enough to sink to the sea floor. In very cold waters such as the Arctic it is not known whether or not biodegradation occurs. A fresh crude oil can lose up to 30 percent by evaporation in 30 hours. A much smaller amount can dissolve in the water. These effects tend to increase the density to the sinking point.

Oils with high wax content or which are very viscous do not degrade so rapidly and are frequently found on beaches as lumps or smears of so-called "tar" . "Tar balls" are ubiquitous in many ocean areas, particularly on major tanker routes, and may be derived from tanker washings.

When highly dispersed,oil may be moderately toxic to marine life but under normal field conditions toxicity is low. The species most at risk are those living in the littoral zone where oil may be deposited on a falling tide. In such circumstances, shellfish have become tainted and edible seaweeds both reduced in growth and made unsaleable. Experiments in temperate zones have shown that a single heavy contamination of the flora and fauna of the intertidal zone has a negligible effect though repeated applications (every tide) of a much smaller amount - a hardly visible film - eventually leads to a reduction in the number of species and in some cases, absence of life. In tropical areas marine life may be more sensitive to damage by oil.

In inland estuarine waters or enclosed bays or similar situations, the effect of the more toxic aromatic fractions, together with the reduction in dissolved oxygen resulting from biodegradation, may produce more marked mortality in many species.

It is believed that traces of hydrocarbons may affect fish behaviour such as the return of salmon to the "home" river. Some oils contain carcinogens and their reported occurrence in organisms in the food chain as the result of oil pollution could, if proven, lead to some risk to man as the ultimate consumer.

Oil pollution is popularly regarded as an important contaminant of the ocean very largely because it is visible, and is a great despoiler of coastal amenities. It also kills sea birds, particularly the diving birds, which, being washed ashore in an oiled condition, arouse great concern.

Considerable attention continues to be paid to methods for the recovery of oil from the sea surface. Satisfactory methods are now available for confined waters under calm conditions but it is still difficult to apply such methods to the open sea. Sinking techniques are now regarded as less desirable because of the tendency of sunken oil to return to the surface or to move substantial distances and so affect living resources. However, it may be necessary to use such methods as an emergency measure in the event of a massive release of oil such as could occur following a tanker casualty

Improvements have been made in the formulation and usage of dispersants. Those now available are of low toxicity to marine life and are more effective at lower concentration, enabling better use to be made of new and more efficient application equipment. The use of absorbents for removing surface oil, although well developed for inland waters, has not proved of value in open sea conditions.

3.6 Organic chemicals

The number of organic chemicals known to man at the present time exceeds 1 million. A wide range of these substances occur naturally in animals and plants and in natural products such as petroleum. Only a small proportion of the total is used by man in the pure state and only a comparatively few compounds are produced in large quantities. Currently 70 per cent of the world's organic chemicals are produced directly or indirectly from petroleum and it is estimated that the proportion will exceed 90 per cent by 1980.

As a starting point in the review of the potential pollution risk posed by organic chemicals, the Working Group selected a number of substances each of which are known to be carried in large quantities by ship (more than 25000 tons per year) or which might create a hazard to marine life if released to the sea. In making their selection, the Working Group has used the Report of an Ad Hoc Panel of IMCO and GESAMP Experts to Review the Environmental Hazards of Noxious Substances other than Oil Transported by Ships (GESAMP IV/19/Supp. 1) and a study by Norway for IMCO on the bulk carriage of chemicals by sea. The Norwegian study was prepared as a background document for the 1973 IMCO Marine Pollution Conference and summarises the replies to a questionnaire on the quantities, type of ship, etc. involved in bulk transport of chemicals. Because replies to the questionnaire were not received from all countries, the totals given for annual carriage cannot be regarded as the complete world wide carriage figures. They do, however, provide a satisfactory basis for an assessment of the marine pollution hazard arising from the bulk carriage of chemicals. Where the amount carried is said to be in excess of 25000 tons per annum, the chemical was regarded as a candidate for the review and the Norwegian study data on quantities shipped are quoted.

In considering the selected organic chemicals as harmful substances, the Working Group took the view that the major risk to the marine environment arises as a result of chronic exposure to continuous discharges from factories, etc. However, where it is known that substantial amounts ($>$ 25000 tons per annum) are moved by sea, there is a significant risk of severe short-term pollution following spillage of ships' cargo. Comments are made on the effect such a spillage might have; these are equally applicable to accidental massive losses from a factory or storage facility. Where marine transport is known to be important for other substances listed in this review, similar notes will be added as part of the continuing process of revision and updating.

The Working Group has been unable to cite world production figures of organic chemicals but noted that other groups, especially GIPME, had recognised the need to establish these wherever possible.

In compiling notes on the organic substances included in the Review, the Working Group assembled information on the following points:

1. Nature of the substance and principal purposes for which it is used;

2. Extent to which it is transported by sea;

3. Principal ways in which it may reach the marine environment, e.g. as waste from particular industrial processes or uses, from tank washings, by aerial transport, etc;

4. Effects on marine life including bio-accumulation, or tainting;

5. Hazard to human health by ingestion directly or via sea food, by skin or eye contact or inhalation, for example when bathing in an area affected by a substantial spillage;

6. Effects on amenities, e.g. by interference with leisure activities, objectionable smell or persistence;

7. Nature of breakdown products produced in the marine environment, their toxicity and persistence.

Acetone CH_3COCH_3 dimethyl ketone, 2-propanone

Acetone is a very widely used solvent, especially in paints, varnishes and the pharmaceutical industry; it is also used as a delustrant in cellulose acetate fibre manufacture and as a general degreasing agent. The compound is manufactured on a world wide scale, with plants in most developed countries.

Because of its very wide scale usage as a solvent, substantial amounts are likely to enter the sea in effluents discharged to rivers or via pipelines.

Transport by sea is largely in chemical tankers.

Acetone is readily miscible with water, highly volatile (B.P.56°C) and inflammable (F.P. - 20°C); the vapour will ignite above water solutions of 2 - 3%.

Its acute toxicity (LC50) to aquatic life is in the range 100 - 1000 ppm. It is readily degradable and is unlikely to be persistent in the marine environment; its degradation products are unlikely to be more toxic than the parent compound.

Exposure to concentrations of vapour well above those that are recognisable by odour may cause eye, nose and throat irritation; the liquid produces transient eye irritation.

Even a substantial spillage would be unlikely to create an amenity problem. Its smell is not objectionable (it is used in many paints).

Acrylonitrile $CH_2 = CHCN$ propene nitrile, vinyl cyanide

This substance is mainly used in the manufacture of synthetic rubber and plastics and, as a synthetic fibre for textiles (e.g. "Acrilan" and"Courtelle"); it is also employed as a grain fumigant.

Small quantities are found in wastes from manufacturing plants. Some may be lost to the air during manufacture.

It is transported in bulk by sea on a world-wide scale, mainly between developed countries. (Amount carried in 1970 - 93,453 tons: maximum cargo ca. 800 t; 200 t per tank. Maximum release from rupture of two tanks possibly 400 tons).

Although lighter than sea water (SG 0.80), it is soluble in water (31 g/l in fresh water) and is unlikely to remain on the surface of the sea due to its solubility and volatility (BP 77.3°C). However, hydrolysis is unlikely to be rapid at the pH of sea water. A substantial spillage, resulting for example from a collision at sea, would create a fire and explosion hazard (F.P. 0°C explosive limits 3-17%).

If released to the marine environment in substantial quantities, it would constitute a significant hazard to marine life, (LC50 1-10 ppm) It is not bio-accumulated but longer term low level effects are uncertain. Breakdown products in the sea are likely to be less toxic than acrylonitrile.

The vapour is acutely poisonous and beaches affected by a spillage would have to be cleared. It would, however, evaporate rapidly in favourable circumstances, e.g. high temperatures and breezes. The polymer is harmless but acrylonitrile is unlikely to polymerise on the beach.

Benzene C_6H_6 benzol

Benzene has many industrial uses: for example, in solvents; as a starting material for the manufacture of "hard" detergents and of cumene used in the production of resins; as a lube-oil additive and in the making of nylon; as a chemical intermediate in the production of acetone and phenol.

Benzene is carried in bulk by sea on a world-wide basis (amount carried in 1970 - 279,852 tons).

Its solubility in seawater (2000 ppm) is somewhat above toluene; its flashpoint is very low (-17°C) and it is also an explosive hazard (explos limits 1-8%). If spilt, it floats on the sea (S.G. 0.88) and evaporates readily (B.P. 80°C).

Benzene has an acute toxicity to marine life (LC50) in the range 10-100 ppm but it is not bio-accumulated. Breakdown products are less toxic than the benzene which is a human hazard because it damages liver and bone marrow. It is metabolised and excreted by human beings. Frequent exposure may lead to leukaemia; high concentrations of vapour have a narcotic effect.

It has a strong but not highly objectionable smell. A nearby spillage might cause a fire or explosive hazard on a beach, but this would be a short-lived situation.

Carbon disulphide CS_2 Carbon bisulphide

This substance is mainly used for the production of rayon and cellulose films and in the manufacture of carbon tetrachloride and xanthates which are employed as flotation agents. It is also widely used in small quantities as a solvent for a number of elements.

Small quantities only are shipped in bulk (amount carried in 1970 - 595 tons); extreme care is required when moved in drums.

It is heavier than seawater (S.G. 1.26), very volatile (B.P.46°C) and highly inflammable (F.P. -30°C). It presents an acute fire and explosive hazard and may ignite spontaneously at 100°C, e.g. by contact with hot steam pipes. It is very slightly soluble in seawater (ca. 0.3%).

Carbon disulphide has an acute toxicity (LC50) to marine life of less than 1 ppm and it is bio-accumulated. It decomposes in the sea by oxidation.

The liquid is an irritant to the skin and eyes and is absorbed through the skin. The vapour is absorbed rapidly on inhalation; its ingestion then causes vomiting, liver and kidney damage and respiration failure. It can also cause permanent damage to the nervous system. The presence of the liquid or vapour on beaches would present a major health hazard.

Carbon tetrachloride CCl_4 tetrachloromethane, perchloromethane

It is used in the manufacture of aerosol propellants and refrigerants; and as a solvent, degreasing agent and agricultural fumigant. It is also used in the chlorination of paraffin wax to produce "Gerochlors", plasticisers for paints, etc. Usage is world-wide, principally among industrialized countries.

It is not a problem in effluents, the main losses being to the air by evaporation (B.P. 77°C) where it may be broken down by ultraviolet light.

Carbon tetrachloride is carried in bulk tankers (amount carried in 1970 - 114,203 tons; maximum load about 1000 tons; usually small chemical tankers).

Solubility in fresh water is 750 ppm and probably less in sea water. It is heavier than sea water (S.G. 1.59) and it is not inflammable. Acute toxicity to marine life (LC50) is in the range of 10-100 ppm, with rapid uptake and loss from the tissues. The observed concentration in Irish Sea coastal water was 1 x 10^{-10} or 10^{-11}; concentration in fish showed a higher degree of magnitude in the same area. Some difficulties, however, were experienced in identifying peaks in GLC records. Muds may take up carbon tetrachloride to the extent of x2 in the immediate vicinity of effluent discharge. The breakdown products of carbon tetrachloride in the sea are not fully known.

The liquid can be absorbed through the skin and the vapour, which is heavier than air, may be inhaled. Exposure to either liquid or vapour may cause severe liver damage.

The smell is distinctive but not highly objectionable. Following a major spillage, carbon tetrachloride might be driven up on to the beach over a period.

Chlorobenzene C_6H_5Cl monochlorobenzene, benzene chloride, phenyl chloride

This is a liquid used as an intermediate in the production of phenol from benzene, as a starting material in dyestuffs manufacture, and in the production of fine chemicals. It is also employed as a solvent and as a heat transfer medium.

It reaches the environment largely by evaporation but may be present at the level of a few ppm in some liquid industrial effluents.

It is transported by road and rail and in ships, but not in bulk.

Chlorobenzene is moderately volatile (B.P. 132°C), heavier than water (S.G. 1.11), inflammable (F.P. 28°C), and explosive (explosive limits 1.8 - 9.6%).

Its acute toxicity to marine life is rather high (96 Hr.LC50 ca. 2.5 ppm) and it can accumulate rapidly in fish, largely in the liver. Chlorobenzene is broken down by microorganisms to hydrochloric acid and phenol, which eventually breaks down to carbon dioxide and water. In the atmosphere it is broken down by ultraviolet light in about two weeks. It may accumulate in sediments depending upon organic content and concentration in the overlying water.

Ingestion of the liquid and inhalation of high concentrations of the vapour can depress the nervous system and cause liver damage; the vapour is slightly irritant.

There is likely to be a health hazard only in areas close to a large spillage.

Chloroform $CHCl_3$ trichloromethane

Chloroform has many uses: in toothpastes and pharmaceutical products; as a flavouring in foods; as a solvent; and in making aerosol propellants and refrigerants. It presents a minor fire hazard and is, therefore, not used in major industrial processes, but it is employed in small amounts in a wide variety of ways.

An important route to the marine environment may be through the atmosphere.

It is mostly carried in small drums (25 litres) with ethanol as a stabiliser and there is little bulk carriage (amount carried in 1970 - 3621 tons).

Chloroform is more volatile than carbon tetrachloride (B.P. 61°C) and more soluble in seawater (ca. 1.5%). It is heavier than seawater (S.G. 1.49).

Its effects on marine life, so far as they have been assessed, are similar to those of carbon tetrachloride (96 hour LC50 ca 30 ppm). The breakdown products of chloroform in the marine environment are likely to be less toxic than the parent compound.

Ingestion of liquid and inhalation of vapour depress the nervous system and cause liver damage. The liquid is only slightly irritant to the skin but can cause severe eye injury. Health is likely to be affected only following a spillage close to a beach onto which the liquid might be brought by successive tides.

Cresol $CH_3C_6H_4OH$ methylphenol, cresylic acid, tricresol

This substance is normally a mixture of 3 isomers 1,2, 1,3 and 1,4 hydroxymethylbenzene. Cresols have a very wide usage, mainly in the manufacture of disinfectants and synthetic resins, but also in the production of tricresyl phosphate, salicylaldehyde, coumarin and herbicides. They are produced in many countries.

Trade is world-wide and includes carriage in bulk (amount carried in 1970 - 25,697 tons).

These substances are marginally heavier than seawater (S.G. 1.03 - 1.05). They are slightly volatile (B.P. 195 -205°C) and soluble in water (ca. 2%). They are inflammable (F.P. 80-86°C) but do not present a major fire risk.

They have an acute toxicity to marine life (LC50) in the range 1-10 ppm and are liable to taint fish and shellfish at very low concentrations with consequent interference with marketing. They are biodegradable, the breakdown products being less toxic than the parent compound.

Cresols are highly irritant and rapidly damage skin; they are hazardous to human beings on oral ingestion or following absorption through the skin. Solutions are somewhat less harmful.

A large spillage near a beach would create an amenity problem.

Crotonaldehyde $CH_3CH : CH\ CHO$ Methyl acrolein, crotonic aldehyde

This is used mainly for making 2-ethyl-hexanol and acetate solvents; and is widely used as a chemical intermediate.

Main routes to the sea are via industrial effluents and leakages.

It is not known to be transported on a large scale.

It is lighter than sea water (S.G. 0.86), moderately volatile (BP 102°C), soluble in water (ca 15.5%) and inflammable (FP 13°C), but has low vapour pressure; explosive and fire hazards are minor.

Acute toxicity to marine life (LC50) is in the range 1-10 ppm, it is biodegradable but not bioaccumulated. Breakdown products are less toxic than the parent compound.

Both liquid and vapour are strongly irritant; splashes of liquid in the eye may cause blindness. Exposure to liquid, vapour (TL_v 2 ppm) and solutions is extremely hazardous and beaches affected by a spillage would have to be cleared for a period. It has a pungent smell.

Cumene $C_6H_5CH(CH_3)_2$ isopropylbenzene, cumol

This is an intermediate in the production of phenol and acetone. It is also used in the manufacture of plastics and as a solvent.

World wide carriage is in bulk (amount carried in 1970 - 151,075 tons).

Cumene is lighter than seawater (S.G. 0.86) and practically insoluble. It is moderately volatile (B.P. 152°C) and highly inflammable (F.P. 45°C).

Its acute toxicity (LC50) to marine life is in the range 10-100 ppm. If released to the sea, the bulk will be lost by evaporation; any that dissolved would be degraded.

Although very high concentrations of the vapour are narcotic, cumene is unlikely to harm human health.

A large spillage near a beach might create a short lived amenity problem because of the fire risk.

o-Dichlorobenzene $C_6H_4Cl_2$ 1,2-dichlorobenzene

This substance is used in the manufacture of isocyanates and dyestuffs, as a solvent and in the production of paint-strippers, as a pesticide and also as a degreasing agent for metals, wool and leather.

Losses to the environment will occur via effluents from industrial use, discarding of used solvents and paint strippers and by evaporation.

It is transported by road and rail tankers and by ships but not in bulk.

It is only slightly volatile (B.P. 180°C), heavier than seawater (S.G. 1.31) and practically insoluble (ca 100 ppm in seawater). It is inflammable (F.P. 65°C).

o-Dichlorobenzene is highly toxic to fish (LC50 ca 1 ppm) and is accumulated and lost very rapidly (within one week), with high concentrations in the liver, but very much less in the flesh. It may also accumulate in sediments, depending on organic content and concentration in overlying waters. There is very little information on bio-degradability or breakdown products in the sea but it can be metabolised and excreted by mammals.

Although high concentrations of both vapour and liquid can lead to depression of the nervous system and liver and kidney damage, a human health hazard is unlikely except from prolonged or frequent contact with liquid which might be washed up on beaches.

It is otherwise unlikely to create an amenity problem; the smell is penetrating, but not unpleasant.

p-Dichlorobenzene $C_6H_4Cl_2$ 1,4-dichlorobenzene

This substance is a solid (M.P. 53°C). Its main uses are as a deodorant, moth repellent and soil fumigant, and in the manufacture of dyestuffs and fine chemicals.

Losses to the environment will occur mainly by evaporation (it is widely used as a deodorant).

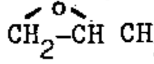
It is transported largely in drums.

It is heavier than seawater (S.G. 1.46), slightly volatile (B.P. 174°C) and practically insoluble (ca 75 ppm). It is inflammable (F.P. 65°C).

p-Dichlorobenzene has an acute toxicity to fish (LC50) of ca 1.5 ppm; there is no information regarding its bioaccumulation but it is probably similar to o-dichlorobenzene. Bio-degradability and breakdown products have not been investigated.

The risks of injury to human health are extremely low although any drums cast up on the shore would represent a hazard since ingestion may lead to liver damage.

It is otherwise unlikely to create an amenity problem.

Epichlorohydrin  $\overset{O}{CH_2-CH}\ CH_2Cl$, γ-chloropropylene oxide

The biggest single use of this chemical is in the production of epoxy and phenoxy resins; smaller quantities are used as a solvent for cellulose esters in the manufacture of glycerol and in curing propylene based paints.

Trade is mainly between the developed countries (amount carried in 1970 - 2445 tons). The maximum ship consignment is likely to be around 500 tons, with a maximum tank size (normally stainless steel) of 200 tons. The bulk of the material transported is carried in drums.

Epichlorohydrin is heavier than water (S.G. 1.18), moderately volatile (B.P. 118°C) and inflammable (F.P. 34°C); it is slightly soluble in water (ca. 1%) and if released in small quantities in factory effluents will probably be completely dissolved. Accidental spillages of larger amounts will sink.

Although its acute toxicity (LC50) to marine life is in the range 1-10 ppm, it is unlikely to be accumulated by marine animals and is probably readily broken down by bacteria and other aquatic life. The final breakdown products and intermediates are likely to be of lower toxicity than the parent compound.

Repeated contact with the liquid may cause allergic sensitization.

Because of its volatility and strongly irritant vapour, a large spillage would cause a short term but substantial amenity problem.

Ethyl alcohol C_2H_5OH ethanol, alcohol

Ethyl alcohol is produced in many countries. Its main uses are in the production of acetaldehyde as a solvent and in production of alcoholic drinks. It has many minor uses and is consequently present in small quantities in many industrial effluents.

Trade is world wide; sea transport is in bulk (amount carried in 1970 - 59,477 tons) and in demountable tanks.

Ethyl alcohol is lighter than (S.G. 0.80) but completely miscible with seawater. It is volatile (B.P. 78°C) and inflammable (F.P. 9-11°C).

Its acute toxicity to marine life (LC50) is in the range 10-100 ppm. It is not accumulated but is rapidly biodegraded to substances which are harmless. A major spillage might result in a deoxygenation problem in confined waters.

No human health hazard or amenity problem is likely to arise from the release of ethyl alcohol to the marine environment.

Ethylbenzene $C_6H_5C_2H_5$ phenylethane

This substance is used in the production of styrene monomer and as a solvent.

Its main route to the sea will be in wastes from manufacturing plants and possibly by transport through the atmosphere.

It is transported in bulk chemical tankers (amount carried in 1970 - 125,726 tons), mainly in the North Atlantic.

It is lighter than sea water (S.G. 0.87), practically insoluble, moderately volatile (B.P. 136°C) and highly inflammable (F.P. 20°C).

Its acute toxicity to marine life (LC50) is in the range 10-100 ppm, it is not likely to be bioaccumulated and the breakdown products are expected to be less toxic than the parent compound.

Liquid and high concentrations of vapour are somewhat irritant to skin and eyes and prolonged exposure will depress nervous activity.

Health is unlikely to be harmed except on prolonged exposure to liquid.

Apart from deposition of liquid on beaches resulting from a substantial nearby spillage, there would be no amenity problem.

Ethylene dichloride $CH_2Cl.CH_2Cl$ 1.2 dichloroethane

This substance is a solvent for gums, fats and waxes. It is used in the manufacture of paints, varnishes and other surface coatings and in the production of artificial fibres and plastics, e.g. acetyl cellulose, vinyl chloride and PVC. It is also used in the production of automobile anti-knock compounds.

The principal source of contamination of the marine environment is from wastes arising from industrial processes; tanker washings are relatively unimportant.

Worldwide tanker trade is in bulk (amount carried in 1970 - 241,356 tons).

It is heavier than seawater (S.G. 1.26), slightly soluble (ca 1%), and volatile (B.P. 85°C); spillage could create a fire risk (F.P. 15°C).

Acute toxicity to marine life (LC50) lies above 100 ppm, with short term accumulation only. This substance cannot be detected in the marine environment by present analytical methods. Breakdown products in the marine environment are likely to be less toxic than ethylene dichloride.

The vapour irritates the eyes, nose and throat and exposure to either liquid or vapour causes nervous system depression and liver and kidney damage. There is likely to be a health hazard only in areas close to large spillage.

If spillage occurs close to a beach there would be a minor amenity problem, since ethylene dichloride, though heavier than water, might be brought ashore by successive tides.

Ethylene glycol $CH_2OH.CH_2OH$ 1.2 ethanediol

This compound is the simplest of the glycols. Its major uses are as a coolant and an antifreeze and deicing compound; but recently large amounts of ethylene glycol of high purity have been used in the manufacture of Terylene. Smaller quantities are widely used, e.g. in cosmetics, printing inks, brake fluids and laminate plastics.

Because of its low volatility (B.P. 197°C), the major route to the sea is likely to be via effluent discharges from factories or in town sewers (from car radiators) or by direct spillage and chemical tanker washings.

World trade is extensive, especially of the high purity fibre grade compounds; large amounts are carried in ordinary chemical tankers (amount carried in 1970 - 169,167 tons) with a maximum tank size of 500 tons.

Ethylene glycol is heavier than water (S.G. 1.12) but is very soluble in water and has a low volatility. It is, however, readily degradable and has an acute toxicity to aquatic life (LC50) above 1000 ppm. The final products of biodegradation and any intermediates will be of low toxicity to marine life.

The liquid is not harmful to human skin but 60 ml is reported to be a fatal dose when taken by mouth. Harmful concentrations of vapour are unlikely to occur at sea.

Except where large amounts are spilt in enclosed bays or estuaries when deoxygenation may occur, the material does not seem likely to cause any problem in the marine environment.

Methyl alcohol CH_3OH methanol, carbinol, wood alcohol

This substance is used as an industrial solvent, as raw material for formaldehyde and methyl ester production and as an antifreeze in automobiles. It is employed as a denaturant for ethyl alcohol.

It is produced in many countries; world-wide carriage is in bulk chemical tankers (amount carried in 1970 - 617,601 tons).

Methyl alcohol is lighter than sea water (S.G. 0.79), volatile (B.P. 65°C), completely miscible with water, highly inflammable (F.P. 12°C) and explosive (explosive limits 6-37%).

It has an acute toxicity to marine life (LC50) above 1000 ppm. It is not bioaccumulated and the breakdown products in the sea will be harmless. A substantial spillage in confined waters might produce deoxygenation.

Although ingestion of liquid and inhalation of high concentrations of vapour depress the nervous system and cause respiratory failure and blindness (which may be permanent), methyl alcohol is unlikely to present a health hazard under conditions which may be encountered following spillage at sea.

There is no amenity problem.

Methylene chloride CH_2Cl_2 methylene dichloride, dichloromethane

This is a solvent used in the spinning of acetate yarn and as a paint stripper, both industrially and domestically.

It is usually recovered from cellulose acetate yarn processing and main losses will be by evaporation.

It is transported on a world wide scale (amount carried in 1970 - 30,329 tons).

It is heavier than water (S.G. 1.33) but is soluble in water (ca 2%) and very volatile (B.P. 40°C). It is inflammable.

It is not bioaccumulated and acute toxicity to marine life (LC50) is more than 100 ppm. There is no information on bio-degradability, but photochemical breakdown in ultraviolet light is rapid. It cannot be found in the marine environment by present methods of analysis. The breakdown products are likely to be less toxic than methylene chloride.

This substance depresses the nervous system and the vapour has been used as an anaesthetic. Because of its high volatility, spillage in the sea is unlikely to present a health hazard.

Naphthenic acid

This is a mixture of carboxylic acids mainly with cyclic structures obtained from crude petroleum by alkali extraction. They are used in the production of metal naphthenates which are subsequently used as rot preventatives in wood, cellulose products and natural fibre ropes, and as paint driers. The commercial grade is normally dark in colour with a strong unpleasant smell.

This substance is mostly moved in drums, but occasionally in bulk tankers (amount carried in 1970 - 1,963 tons).

It is lighter than sea water and practically insoluble; it is not volatile.

Acute toxicity to marine life (LC50) is in the range 1-10 ppm; it may possibly result in tainting of fish and shellfish. It is likely to be biodegraded, the breakdown products possibly having a similar toxicity.

Naphthenic acid is unlikely to be harmful to man, but because of its strong persistent smell, a substantial spillage could create an amenity problem.

Phenol C_6H_5OH Carbolic acid

This is a single substance with no isomers. Its former main source, coal tar distillation, has now been largely superseded by synthesis from benzene. It is generally used as a chemical intermediate, for example in production of resins, including bakelite-type and epoxy resins, and is also used in the production of pharmaceuticals, disinfectants, herbicides (2, 4-D type) and lube additives. It has many industrial uses and is contained also in a number of household products. It may, therefore, be present in many industrial and domestic wastes. It is detectable at very low levels.

Carried in road and rail tankers and in ships (amount carried in 1970 - 28,970 tons); it may be molten or as a 60% solution in water or as a solid.

It can be very objectionable as a contaminant of potential water supplies, e.g. from desalination and can be tasted at concentrations as low as 20 ppb after chlorination. Disposal of wastes containing phenol is usually carefully controlled in developed countries.

Heavier than seawater (S.G. 1.07) but miscible and very soluble, phenol is a significant hazard to marine life, (LC50 10-100 ppm). Tainting of fish and shellfish may occur at very low concentrations and can produce severe difficulties in marketing. Although chemically stable, phenol is bio-degradable but the speed of this process in the sea is not known. It will react with proteins but action on marine life has not been closely studied. Breakdown products are likely to be less toxic than phenol.

High concentrations are caustic and hazardous to human beings on oral ingestion or on contact with the skin through which it can be absorbed. Dilution markedly reduces the hazard.

A large spillage near a beach would create a significant but short-lived amenity problem.

Phthalate esters

These are esters of o-phthalic acid (1,2 - $C_6H_4(COOH_2)$) and alcohols ranging from C_1 to C_{13} with various isomers. They are used mainly as plasticisers in the production of PVC, polyvinyl acetate, cellulose nitrate and a few other plastics where flexibility is required. They are also used as solvents, insect repellants, alcohol denaturants and in cosmetics.

The main routes to the sea will be effluents from manufacturing plants and from plastic production. They are present in domestic sewage.

They are transported in road tankers and containers and in bulk shipments (approx. 126,000 tons), the latter mainly as di-octyl phthalate.

Some phthalates will float on the sea but others will sink slowly. They are not volatile (B.P. above 283°C), practically insoluble in water and virtually non inflammable.

Although widely found, the toxicity to marine life of phthalates is in general very low but will vary with the alcohol used. One of the most widely used - di-octyl phthalate - has a very low acute toxicity but work on di-butyl phthalate shows a 96 hour LC50 in the range 1-10 ppm. Di-octyl and di-butyl phthalates are accumulated by some invertebrates and fish from water by factors of 1400 to 3600 times. There are indications that natural synthesis can occur in biological material. Hydrolysis and metabolism of the alcohol part of the molecule are likely to occur but the fate of the phthalic acid in the sea is not known. The rate of breakdown will vary between esters.

Human health is unlikely to be harmed by direct contact with the esters, and there is no evidence that fish contaminated with small quantities are a danger to human health.

An amenity problem might arise from a substantial spillage in close proximity to a beach because of their physical nature and persistence.

Styrene monomer $C_6H_5CH: CH_2$ vinyl benzene or phenylethylene

This compound is used in the production of polystyrene and other plastics, artificial rubbers and resins. The monomer is unstable and is normally shipped with small quantities of para tertiary butyl catechol added as a stabiliser (20 ppm). It is shipped in bulk on a world wide scale (amount carried in 1970 - 476,206 tons), maximum single shipment being 1000 tons.

Small quantities of the monomer may enter the sea in effluents or in chemical tanker washings but the most commonly encountered form is the expanded polymer which is widely used in thermal insulation and as a packaging material.

The monomer is a colourless inflammable liquid (F.P. 32°C) which is lighter than water (S.G. 0.91) and practically insoluble. It would float on sea water and, because the stabiliser is readily soluble in water, the monomer would probably polymerise to a solid unless dispersed by wave action. It is moderatly volatile (B.P. 145°C).

Styrene monomer has an acute toxicity to marine life (LC50) in the range 10 - 100 ppm. The polymerised material is not toxic to man and is only very slowly degraded. Degradation products of the polymer and the monomer in the marine environment are not fully known, but are unlikely to be more toxic than the parent compound. The familiar expanded polystyrene beads are produced by heating small beads of polystyrene containing occluded pentene. These beads are almost neutrally buoyant in sea water and have been found in several areas of the world, e.g. U.S. and U.K. They have been found in the gut of fish where they may cause blockages and have been reported to absorb compounds such as PCB's.

<u>Toluene</u> $C_6H_5CH_3$ Methyl benzene, phenylmethane, toluol

This substance is widely used in industry, especially as a solvent and chemical intermediate, and is also used in the manufacture of explosives (TNT).

It is carried in bulk by sea on a world wide scale (amount carried in 1970 - 366,441 tons).

It is more volatile than xylene, highly inflammable (F.P. 4°C), and has a similar explosive risk (explosive limits 1-7%). It is lighter than seawater and only slightly soluble, though more so than xylene.

The biological properties of toluene are not well known, its acute toxicity to marine life (LC50) being in the range 10 - 100 ppm. It is slightly more hazardous to human beings than xylene but does not have the toxic properties of benzene. It is not a skin irritant.

Amenity risks from a spillage would be similar to those of xylene.

<u>Toluene diisocyante</u> $CH_3C_6H_3(NCO)_2$ tolylene diisocyanate

The normal commercial product is a mixture of the 2,4 and 2,6 isomers. It is used mainly in the production of polyurethane foams which are employed in upholstery and in refrigeration as thermal insulators. It is also used as a cross linking agent for nylon 6.

Trade is world-wide and the normal means of transport is in drums; in future some may be transported in bulk.

It has a sharp pungent odour, is slightly volatile (B.P. 251°C) and is heavier than water (S.G. 1.22) with which it reacts to evolve CO_2 and form phenyl ureas which are solids. It may be a solid or liquid (MP ca 20°C).

The pure substance would be toxic to marine life (LC50 in the range 1-10 ppm), but if released to the marine environment would react with sea water producing substances which are not harmful.

The liquid and vapour are markedly irritant and highly toxic to man; the vapour is harmful at a very low concentration(TLv 0.02). Because it is widely regarded as a particularly hazardous substance to man, great care is necessary in handling. Losses in manufacture or use are likely to be very small.

Losses of drum-sized quantities could, however, cause serious amenity problems at least for a short time.

Trichlorobenzenes $C_6H_3Cl_3$

There are 3 isomers, 1.2.3, 1.2.4 and 1.3.5 trichlorobenzene: the 1.2.3 and 1.3.5 isomers are solids; the 1.2.4 isomer is a liquid at ordinary temperatures (M.P. 17°C); and there is a commercial grade consisting of a mixture of isomers. They are formed as intermediates in dyestuffs manufacture and the liquid isomer is used as a solvent.

They are transported in drums but the liquid 1.2.4 isomer is also moved in tanks.

Little is known about possible losses to the environment, but these will include evaporation.

These substances are heavier than sea water (S.G. 1.5 - 1.7), practically insoluble (ca 30 ppm in freshwater) and only slightly volatile (B.P. 208 - 218°C).

Trichlorobenzenes are similar to dichlorobenzenes in their toxicity to fish. The 1.2.4 isomer, the most harmful; appears to have an LC50 of about 1 ppm. There is no information on bio-accumulation or breakdown products but the degree of bioaccumulation is likely to be at least as great as for o-dichlorobenzene. The 1.3.5 is likely to be the most stable.

The human health hazard is unlikely except by ingestion of the chemical washed up on a beach.

An amenity problem is unlikely to arise.

Vinyl acetate $CH_3COOCH: CH_2$

This substance is used in the manufacture of plastics, films, lacquers and paints.

It is carried in bulk chemical tankers (amount carried in 1970 - 85,162 tons) on a world-wide scale with added stabilizing substances, usually hydroquinone or diphenylamine.

It is moderately volatile (B.P. 72°C) and very inflammable (F.P. 1%), and presents a serious fire risk. It will float on the sea (S.G. 0.93) and is moderately soluble (ca 2%).

Acute toxicity to marine life (LC50) is in range 100 - 1000 ppm. and it is readily bio-degradable.

The liquid monomer and its vapour are of low toxicity and neither the monomer nor polymer are likely to present a health hazard.

Vinyl acetate may polymerise in air and in the sea and create a nuisance on beaches if carried ashore after spillage. Such polymerised material is likely to resist breakdown but is less persistent than PVC.

Vinyl chloride CH_2: CH Cl chlor ethylene

This is a gas (B.P. 13.8°C) carried as a liquid under pressure. Vinyl chloride monomer is used for polyvinyl chloride (90% of its use). It is also used in the manufacture of polyvinylidene and co-polymers for fibres and as a refrigerant. It is transported by road and ship.

Escape from manufacturing plants could result in some contamination by aerial transport.

Highly volatile and inflammable (F.P. 78°C), it poses an explosion risk (explosive limits 4-22%).

Because of its high vapour pressure and low solubility in water it would probably not remain in the sea long enough to affect marine life.

A health hazard is likely to occur only on exposure to concentrations of gas which might occur in the immediate proximity of a major release.

Apart from the explosion hazard it is unlikely to create an amenity problem.

Xylene $C_6H_4(CH_3)_2$ dimethylbenzene, xylol

Xylene exists as 3 isomers: ortho-, meta- and para-xylene. It is widely used as solvents in the manufacture of paints and other surface coatings and in the synthesis of organic chemicals. Orthozylene is used in the manufacture of phthalate plasticisers (Phthalates are now made in most developed countries). Paraxylene is used in making "Terylene", a synthetic fibre.

Main routes to the sea are by spillage, leakage from manufacturing plants and tank washings. The bulk of the xylene used in paints evaporates and there may be some transfer from the air to the sea.

Xylene is carried in bulk by sea in large quantities on a world-wide scale (amount shipped in 1970 - 603,297 tons). Bulk cargoes may be either single substances or mixtures.

It will float on water (S.G. 0.86), is practically insoluble, and evaporation will occur rapidly (B.P. 137 -140°C). It is volatile and highly inflammable (F.P. 29°C) and explosive (1% lower explosive limit). A substantial spillage will create a fire and explosion hazard.

Xylenes are relatively stable substances whose chemical breakdown is slow, but the resulting products are less toxic. Toxicity to marine life is not well established but is not high unless emulsified into the water with other chemicals. Further investigations are needed. Xylenes are not likely to be bio-accumulated.

They are oxidised and excreted by the human body. They are mildly irritant and have a strong but only slightly objectionable smell.

Xylene would not present a serous amenity problem if spilt near a beach.

3.7 Organic industrial wastes

1. Pulp and Paper Mill waste

These wastes can be harmful to receiving waters for four reasons:

(a) toxicity
(b) biochemical oxygen demand (BOD)
(c) suspended solids
(d) colour

The toxicity of pulp mill wastes is usually associated with sulphur-containing compounds, arising from the wood digestion process, and chlorinated phenolic compounds created by bleaching the pulp and paper.

High BOD is a characteristic of untreated sulphite pulp effluents and many fish kills have occurred because of oxygen depletion in waters receiving these high BOD wastes. Stabilization ponds with aeration and activated sludge systems are common forms of treatment.

The solid fractions of pulp and paper mill wastes may accumulate in sludge beds to produce local nuisances. These undergo decomposition and remove dissolved oxygen from water. They often form noxious gases. In addition, large areas of the bottom of receiving bodies of water may be covered with a layer of settled organic material having undesirable effects on benthic communities. By the use of improved in-plant facilities, more efficient screening and better retention in clarifiers and/or ponds solids losses can be reduced. The effects of pulp and paper mill wastes on the higher forms of marine flora and fauna are often sub-lethal rather than acute. For example, oyster quality is known to have declined in many pulpmill areas, although there is little documentation on actual mortality. The food supply of these sedentary organisms can be markedly altered owing to decline of phytoplankton caused by toxicity, turbidity and colour

2) Other high-BOD wastes.

Certain simple organic chemicals, e.g. straight chain alcohols and wastes from food processing, breweries, distilleries, etc. exert a high biochemical oxygen demand. This characteristic is often of greater practical importance in the marine environment than their direct toxicities. Fish kills may occur in restricted bays and estuaries, especially in tropical areas, owing to decomposition, and if the wastes contain a high proportion of solids, local sludge deposits may result. When deoxygenation occurs, noxious gases are evolved and amenities are likely to be affected. Provided the wastes are adequately diluted and dispersed and local accumulations are prevented, direct acute toxicity problems can be avoided. Chronic toxicity is unlikely except in the immediate vicinity of outfalls where dispersive processes are poor.

3.8 Military wastes

The dumping of military wastes may be a significant factor in the pollution of national and international waters. These wastes may consist of organic material, biological and chemical warfare agents, heavy metals, petrochemicals, out-dated explosives, defoliating agents, pesticides, solid objects, dredging spoils and other miscellaneous inorganic materials peculiar to the military establishment. Because of the classified aspects of military operations, the exact chemical and toxicological nature of these materials is frequently unknown. Moreover, details concerning the dumping of these materials are not generally available. Nevertheless, it should be pointed out, that the dumping of many of these materials may be contrary to sound conservation practice and should so far as practicable conform to the recognized conventions.

3.9 Heat

Thermal pollution has specific economic associations since many industrial activities are developing in coastal areas partly because of the availability of cheap cooling water.

Increase in temperature arising from thermal pollution may cause two main types of undesirable effects; it decreases oxygen solubility in water and increases metabolic activities of microflora and fauna generally, which in turn may result in higher BOD and eutrophication. When the discharge of wastes of high BOD, from domestic sources, is accompanied by thermal pollution a local environmental degradation may result affecting natural self-purification capacity. Fluctuating water temperatures may produce changes in biological communities. The effects of this form of pollution naturally depend on the recipient sea water temperature and that of the effluents.

In certain circumstances thermal pollution has made estuaries and enclosed reef areas unsuitable for various commercial species of fish and shellfish and, on the other hand, may lead to the introduction and establishment of undesirable forms such as timber boring organisms. Special care is needed in siting power stations employing seawater for cooling in tropical areas where animals and plants may have a rather narrow range of temperature tolerance.

3.10 Detergents

Pollution qualities of detergents have been related to:

(1) non-biodegradability, resulting in foaming of receiving waters;

(2) phosphate content, leading to enrichment of receiving waters; and

(3) to a lesser degree, direct toxicity of the ingredients. Virtually all domestic detergents on the world markets today are biodegradable, as a result of conversion by manufacturers from the "hard" alkyl benzene sulfonate (ABS) to the "soft" lauryl alkyl sulfonate (LAS) form. The former are, however, still widely used in industry. Sodium polyphosphates remain as a major constituent (20-60%) in detergents. Because they perform vital functions related to cleaning efficiency and no generally acceptable substitute is available, manufacturers are reluctant to eliminate or even reduce the amount of phosphate in detergents. NTA (sodium salt of nitrilotriacetate) has been used as a substitute for phosphate in detergents but recently some doubts have been expressed as to the wisdom of this; its environmental effects are not fully known. Optical whiteners, added to most detergents, appear to persist in the environment and their effects should be studied.

3.11 Solid objects

Any solid objects, heavier than seawater, dumped on the continental shelves or slopes may interfere with and damage bottom trawls or seine nets. Under the terms of the London Convention (1972) on the Dumping of Wastes at Sea, the deposit of "persistent-plastics and other synthetic materials, for example netting and ropes, which may float or remain in suspension in the sea in such a manner as to interfere materially with fishing, navigation or other legitimate uses of the sea" is forbidden. The dumping of containers, scrap metal and other bulky wastes liable to sink to the sea bottom and to present a serious obstacle to fishing or navigation requires a special permit under the terms of this Convention.

In granting such special permits one of the factors to be considered is the suitability of the proposed disposal site in relation to, for example, exploitable resources and fishing areas.

Many of the synthetic plastics are virtually indestructible. Their main effect is to interfere with navigation and fishing operations and when washed up on shores, they reduce amenities. For example, pieces of synthetic ropes and fishing nets are commonly found floating in areas of intense fishing activity, such as the North Sea, and they can immobilize vessels by getting wound round propeller shafts. Again, plastic bottles and containers thrown overboard and washed ashore are a common feature of beaches in many parts of the world. There is also increasing evidence of damage to sea birds due to their getting entangled in pieces of floating fishing net. Sunken objects may also interfere with fishing operations and some areas have been reported as being unfishable after offshore oil drilling operations on account of the rubbish left behind. In some cases, the dumping of objects has been on such a scale as to affect the habitat of bottom-living animals.

Wastes enclosed in containers may be dumped in very deep water beyond the edge of the continental shelf. Under the terms of the Oslo Convention 1972 such deep water must be not less than 2000 metres in depth and not less than 150 nautical miles from the nearest land.

3.12. Dredging spoil and inert wastes

Inert wastes are introduced into the marine environment in very large quantities via rivers and pipelines, by dredging and mining operations and from barges. In shallow **coastal seas** dispersal away from the coast may be seriously hampered by various types of sediment traps. Frequently, solid matter discharged into the sea returns to neighbouring shores or estuarine waters, thus threatening areas where important marine, plant and animal populations are located.

Dredging and mining operations can create an excessively high sedimentation factor which can reduce the supply of light for plants, smother fish eggs, larvae, invertebrates and micro-organisms, thereby interfering with the normal bottom component of biological energy cycling. These effects may be particularly disastrous in tropical reef areas where many reef organisms such as corals, sponges and coelenterates are especially sensitive to increased sedimentation. There is a need for accurate quantitative data regarding the effects of increased sedimentation on marine fauna and flora.

In addition to sand and silt dredged from navigable channels and harbours, and dumped at sea, there are industrial activities which result in a large volume of inert waste which may either reach the sea by pipeline as a slurry, be dumped from barges, or merely tipped on the shore. Examples are china clay, gypsum, fly-ash from power stations and colliery waste. These materials are usually inert and non-toxic but may affect marine life by settling on the sea bed, and so modifying the ecosystem, or by creating turbid conditions and reducing light penetration. Primary production may be decreased, fish spawning grounds may be destroyed and the settlement of molluscs prevented. The bottom may be rendered unsuitable for crustacea such as lobsters, crabs and prawns, but new communities of bottom animals may be produced which may provide additional food for fish. Where dredging includes a substantial quantity of organic material, an additional BOD may be created locally and nutrients may be added. Where material is dredged from industrial harbours or estuaries it may contain significant quantities of absorbed pollutants, e.g. metals.

Table 1

MAJOR CATEGORIES OF MARINE POLLUTION

Category	Harm to living resources	Hazards to human health	Hindrance to maritime activities	Reduction of amentities
1) <u>Domestic sewage</u>	++	++	(+)	++
2) <u>Pesticides</u>				
Organochlorine compounds	++	(+)	-	-
Organophosphorus compounds	+	-	-	-
Carbamate compounds	+	(+)	-	-
Herbicides	+	(+)	-	-
Mercurial compounds	++	++	-	-
Miscellaneous metal-based opds.	+	+	-	-
PCBs	++	(+)	-	-
3) <u>Inorganic wastes</u>				
Acids and alkalis	(+)	-	+	-
Nutrients and Ammonia	(+)	(+)	-	(+)
Cyanide	(+)	(+)	-	-
Sulphite	(+)	-	-	(+)
Titanium dioxide wastes	(+)	-	-	(+)
Mercury	++	++	-	-
Lead	(+)	(+)	-	-
Copper	+	?	-	-
Zinc	+	-	-	-
Chromium	(+)	?	-	-
Cadium	(+)	?	-	-
Arsenic	(+)	-	-	-
4) <u>Radioactive materials</u>	-	+	-	-
5) <u>Oil</u>	+	?	+	++
6) <u>Organic chemicals</u>				
Acetone	-	-	-	-
Acrylonitrile	+	+	(+)	++
Benzene	(+)	-	(+)	-
Carbon disulphide	++	+	+	+
Carbon tetrachloride	+	+	-	+
Chlorobenzene	++	-	-	(+)
Chloroform	(+)	(+)	-	(+)
Cresol	+	-	-	+
Crotonaldehyde	+	+	(+)	+
Cumene	(+)	-	(+)	-
o-Dichlorobenzene	++	-	-	(+)
p-Dichlorobenzene	++	-	-	(+)
Epichlorohydrin	+	(+)	-	+
Ethyl Alcohol	-	-	-	-
Ethylbenzene	(+)	-	(+)	-

Table 1 (cont'd)

Category	Harm to living resources	Hazards to human health	Hindrance to maritime activities	Reduction of amenities
Ethylene dichloride	(+)	(+)	-	(+)
Ethylene glycol	-	-	-	-
Methyl Alcohol	-	-	-	-
Methylene chloride	(+)	-	-	-
Naphthenic acid	+	-	-	(+)
Phenol	+	-	-	-
Phthalate Esters	?	-	-	(+)
Styrene monomer	(+)	-	-	+ [1]
Toluene	(+)	-	(+)	-
Toluene diisocyanate	+	+	-	++
Trichlorobenzenes	++	-	-	(+)
Vinyl acetate	(+)	-	-	+
Vinyl chloride	-	(+)	-	(+)
Xylene	(+)	-	(+)	-
7) <u>Organic wastes</u>				
(1) pulp and paper wastes	++	-	(+)	+
(2) other high BOD wastes	+	-	-	++
8) <u>Military wastes</u>	?	?	-	-
9) <u>Heat</u>	+	-	-	-
10) <u>Detergents</u>	?	-	-	-
11) <u>Solid objects</u>	(+)	-	++	++
12) <u>Dredging spoil and inert wastes</u>	+	-	(+)	+

Key to symbols:
++ important
\+ significant
(+) slight
? uncertain
\- negligible

INDICATION FOR CONTROL

In relation to the prevention and control of marine pollution, the symbols in Table 1 would generally imply the following:

++ - restrictive or preventive measures recommended

\+ - restrictive or preventive measures should be considered

? - further investigations required pending which caution is recommended

(+) - no special action indicated

\- - no special action indicated

****

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[1] Relates to polymer

TABLE 2

RELATIVE IMPORTANCE OF THE DIFFERENT ROUTES BY WHICH POLLUTANTS ENTER THE SEA

Category of pollutant	(a) Manufacture and use of industrial products – disposal via direct outfalls and rivers	(b) Domestic wastes – disposal via direct outfalls and rivers	(c) Agriculture, forestry, public health – via run-off from land	(d) Deliberate dumping from ships	(e) Operational discharge from ships in course of duties	(f) Accidental release from ships and submarine pipelines	(g) Exploitation of sea-bed mineral resources	(h) Transfer from the atmosphere
1. Domestic Sewage	0	3	0	2	1	0	0	0
2. Pesticides								
Organo-chlorine compounds	2	2	2	0	0	P	0	3
Organo-phosphorus compounds	2	1	2	0	0	P	0	3
Carbamate compounds	2	1	2	0	0	P	0	?
Herbicides	2	1	2	0	0	P	0	?
Mercurial compounds	2	0	3	0	0	P	0	?
Miscellaneous metal – containing compounds	2	1	1	0	0	P	0	?
PCB's	3	0	0	0	0	P	?	3
3. Inorganic Wastes								
Acids and Alkalis	3	0	0	2	1	P	0	0
Sulphite	2	0	0	0	0	0	0	2
Titanium dioxide wastes	3	0	0	3	0	0	0	0
Mercury	3	2	0	0	0	P	0	3
Lead	2	1	0	?	0	0	0	3
Copper	3	2	1	1	0	0	0	0
Zinc	3	2	0	1	0	0	0	0
Chromium	3	0	0	1	0	0	0	0
Cadmium	3	0	0	0	0	0	0	?
Arsenic	3	0	1	1	0	0	0	0
4. Radioactive materials	3	0	0	1	0	P	0	P*
5. Oil	3	1	0	1	3	2	1	?

TABLE 2 (continued)

RELATIVE IMPORTANCE OF THE DIFFERENT ROUTES BY WHICH POLLUTANTS ENTER THE SEA

Category of pollutant	(a) Manufacture and use of industrial products - disposal via direct outfalls and rivers	(b) Domestic wastes - disposal via direct outfalls and rivers	(c) Agriculture, forestry, public health-via run-off from land	(d) Deliberate dumping from ships	(e) Operational discharge from ships in course of duties	(f) Accidental release from ships and submarine pipelines	(g) Exploitation of sea-bed mineral resources	(h) Transfer from the atmosphere
<u>6. Organic chemicals</u>								
Acetone	3	0	0	1	0	0	0	0
Acrylonitrile	3	0	0	P	P	P	0	?
Benzene	3	0	0	P	P	P	0	?
Carbon disulphide	3	0	0	P	0	P	0	0
Carbon tetrachloride	3	0	0	P	0	P	0	?
Chlorobenzene	3	0	0	0	0	P	0	?
Chloroform	3	0	0	0	0	0	0	?
Cresol	3	2	2	1	1	P	0	0
Crotonaldehyde	3	0	0	0	0	P	0	0
Cumene	3	0	0	0	1	P	0	?
o-Dichlorobenzene	3	0	0	0	0	P	0	?
p-Dichlorobenzene	3	2	0	0	0	P	0	?
Epichlorohydrin	3	0	0	0	0	P	0	0
Ethyl Alcohol	3	0	0	0	0	0	0	0
Ethylbenzene	3	0	0	0	0	P	0	?

TABLE 2 (continued)

RELATIVE IMPORTANCE OF THE DIFFERENT ROUTES BY WHICH POLLUTANTS ENTER THE SEA

Category of pollutant	(a) Manufacture and use of industrial products - disposal via direct outfalls and rivers	(b) Domestic wastes - disposal via direct outfalls and rivers	(c) Agriculture, forestry, public health - via run-off from land	(d) Deliberate dumping from ships	(e) Operational discharge from ships in course of duties	(f) Accidental release from ships and submarine pipelines	(g) Exploitation of sea-bed mineral resources	(h) Transfer from the atmosphere
<u>**Organic chemicals**</u> (continued)								
Ethylene dichloride	3	1	0	1	2	P	0	?
Ethylene glycol	2	2	0	0	1	0	0	0
Methyl Alcohol	3	0	0	1	0	0	0	0
Methylene chloride	3	0	0	1	0	0	0	?
Naphthenic acid	3	0	0	0	0	0	0	0
Phenol	3	1	1	1	1	P	0	0
Phthalate Esters	3	2	0	0	1	P	0	?
Styrene monomer	3	0	0	0	1	P	0	0
Toluene	3	0	0	P	P	P	0	?
Toluene diisocyanate	3	0	0	0	0	P	0	0
Trichlorobenzenes	3	0	0	0	0	P	0	?
Vinyl acetate	3	0	0	0	0	0	0	0
Vinyl chloride	3	0	0	0	0	0	0	?
Xylene	3	0	0	P	P	P	0	?

TABLE 2 (continued)

RELATIVE IMPORTANCE OF THE DIFFERENT ROUTES BY WHICH POLLUTANTS REACH THE SEA

Category of pollutant	(a) Manufacture and use of industrial products— disposal via direct outfalls and rivers	(b) Domestic wastes — disposal via direct outfalls and rivers	(c) Agriculture, forestry, public health —via run-off from land	(d) Deliberate dumping from ships	(e) Operational discharge from ships in course of duties	(f) Accidental release from ships and sub-marine pipelines	(g) Exploitation of sea-bed mineral resources	(h) Transfer from the atmosphere
7. Organic Wastes (i) pulp and paper wastes	3	0	0	0	0	0	0	0
(ii) other high BOD wastes	3	2	2	0	P	P	0	0
8. Military Wastes	?	0	0	?	?	?	0	0
9. Heat	3	0	0	0	0	0	0	0
10. Detergents	2	3	1	0	1	0	1	0
11. Solid Objects	2	1	0	3	3	1	1	0
12. Dredging spoil and inert wastes	2	0	1	3	0	0	3	0

Key to Symbols

3	important
2	significant
1	slight
?	uncertain
0	negligible
P	potentially important
*	dependent on extent of weapons testing

MANAGEMENT OF WASTE DISPOSAL

(Working Group 2 - Agenda Item 2.2)

Members of the Working Group:

Dr. C. H. Thompson (Chairman)
Dr. F. Valdez-Zamudio
Miss G. Matthews (Technical Secretary)

INTRODUCTION

1. Following discussion in the Joint Group as to the kind of work which might most usefully be undertaken under Agenda item 2.2, the Working Group met to evaluate the report prepared during the fourth session of GESAMP (Annex VI, GESAMP IV/19) and to consider what its best course of action might be in the future. The Working Group felt handicapped by the small number of experts available to form it at this session. Future work in this area will require greater support and it suggested that efforts should be made to involve the Water Pollution Research Laboratory, X Stevenage, U.K., in this work.

2. While the Working Group recognized that methods of waste disposal were pertinent to several subjects currently of concern to GESAMP, e.g. the review of harmful substances and ocean dumping, it felt increasingly constrained by the lack of clear direction in the requests made by sponsoring agencies. In that situation, it was not possible to adopt a logical approach to Waste Disposal Management as a distinct and manageable topic for the Group to develop; nor was it possible to make the best use of the Group's resources.

3. The information presented in Annex VI of the fourth session report was considered valuable primarily as it might provide a readily available reference for those persons who find that the detailed technical literature is either confusing or is not easily available. Being aware of the types of studies under way in a number of industrially developed countries and the extent of documentation currently available on treatment techniques or methodology from those countries, the Working Group could not visualize further useful work on the Annex other than that as outlined below under section A.

4. The preparation of a fully detailed and documented manual (or series of manuals) on all available waste treatment techniques was not considered to be within GESAMP's capacity, or indeed, to be a proper use of the Group's expertise. The revision of Annex VI would therefore be limited to the extent that the Annex would serve as a basic guide or summary of available techniques. Where appropriate, stress can be placed on systems which might be economically attractive in developing country

situations.

5. Above all, the Annex should satisfy the requirements of the administrator in developing countries. Such personnel will need to be able to appreciate the symptoms of damage in the marine environment; to draw a correlation with problem sources in a given area; to make a preliminary selection of potentially effective treatment methods; and to decide on the degree of treatment required to minimize the damage. In so doing, he will also need to appreciate the flexibility or lack thereof in choosing from the variety of treatment systems available to handle the wastes in question. There must be reliable evidence of a method's effectiveness, including its capacity to accommodate future changes in urban/industrial areas. The administrator should be further aware of the controlling factors which will influence both his short and long-term investments for construction and operations; he must be able to determine priorities in handling different types of wastes according to their severity. An understanding of the complexity of the problem will be of great benefit when such personnel request technical assistance. He would be in a better position to specify with reasonable accuracy what the needs are, to know what types of methods are best suited to the particular situation, and to evaluate the various proposals which may be suggested by those providing assistance.

6. As an important consideration for future work in the general area of waste management treatment, the Working Group suggests that the sponsoring agencies investigate the possibility of preparing detailed technical/economic studies, utilizing GESAMP, as appropriate. These suggestions are contained in Section B below.

7. This outline of areas of consideration for management of waste disposal was created in an attempt to respond to an increasing need for general technical information to be used by interested countries. This need goes further than data supply, however, and exposes a framework of alternatives which should be useful to the UN system in trying to assist these nations. For example, certain problems were discussed in the Working Group which relate to the more long-term economic and social factors underlying waste management. It was felt that the Group might be able to offer useful guidance to sponsoring agencies and possibly to incorporate some of the considerations, as discussed in Section C below, in the revised Annex.

A. Revision of Annex VI (GESAMP IV/19)

(1) Editing of present text;

(2) Insertion of general economic analyses, with reference to illustrate the advantages and limitations of each unit operation and unit process according to possible application in interested countries;

(3) Inclusion of notations, where possible, on relative capital and operational expenditures;

(4) Documentation af especially appropriate sources of available information for easy reference by technical personnel in interested countries.

B. Preparation of detailed technical/economic studies

8. The Working Group is convinced of the need for a series of detailed studies in the field of waste management, a task which might be undertaken by UN agencies. A possible approach might be (i) to identify industrial discharges as they relate to the priority substances given in the Review of Harmful Substances; (ii) to give examples of plant systems which might be used by developing countries to handle those types of wastes; (iii) to compile typical cost data giving cost ranges for the identified treatment systems and illustrating dependence upon factors such as volume and strength of waste; (iv) to indicate how available cost data (normally derived from developed countries) can be converted into data more relevant to areas with different labour and construction costs, availability of skilled operation, etc.

C. Evaluation of waste management methods in the long term

9. Without embarking on an exercise in "technology assessment" as it might apply to optimum waste management, it is suggested that the Group might assist in illustrating, for interested countries, the long range economic effects of investing in different waste disposal methods. Consideration could be given in particular to the planning strategies of coastal zone management, expected industrial and urban growth and available bilateral and multilateral support. The Working Group had noted, in this report, that the often used simple treatment system designed to handle waste water of primarily domestic origin can be a poor investment for nations giving high priority to industrial development.

10. Similarly, advice might be given for the prediction of changes which occur both in environment and in the habits of local populations as more improved waste treatment methods are employed. Numerous subtle factors can come into play: personal hygiene habits, municipal operational and administrative changes, land use changes, misuse of newly constructed systems and the possibility of increased taxes, etc. One example which might be given concerns the decisions that must be made once the disposal of certain wastes by ocean dumping is either restricted or prohibited: the choice of an alternative method such as extended contact stabilization or oxidation lagoons would need to be made with a full understanding of the implications. Examples of the implications and a procedure for their evaluation could be provided.

Annex VI

PRINCIPLES FOR DEVELOPING COASTAL WATER QUALITY CRITERIA

(Working Group 5 - Agenda Item 3)

Members of the Working Group:

Dr. G. Berge (Chairman)
Mr. J. S. Alabaster (Rapporteur)
Dr. E. E. Geldreich
Mr. H. Fleckseder
Dr. S. Kêckês
Dr. Y. K. Strizhak
Dr. G. F. Weichart
Dr. G. J. Cleary) Technical Secretaries
Dr. G. Tomczak)

CONTENTS OF REPORT

Annex VI

1. INTRODUCTION

The Group noted GESAMP IV/19 which considered principles of developing coastal water quality criteria and reviewed four GESAMP V papers: "The Development of Water Quality Criteria for Marine Fisheries" by J. S. Alabaster, which outlined the approach to the problem made by EIFAC for freshwater fisheries, "Principles for Developing Criteria for Coastal Bathing Waters" by E. E. Geldreich, which summarized epidemiological and bacteriological studies of health risks associated with bathing in polluted sea water, "Techniques for Evaluating Lethal and Sub-Lethal Effects of Pollution that Occur in the Marine Environment" by S. Keckes and "Sanitary Questions Concerning the Use of the Sea Coast for Recreational Purposes" by Y. K. Strizhak. The Group considered that these papers provided a valuable basis for future development of criteria.

2. TERMS OF REFERENCE

The Group agreed the following terms of reference:

To consider the desirability and feasibility of developing coastal water quality criteria for:

(1) living marine resources

(2) fishing activities

(3) human health

(4) amenity

3. DESIRABILITY OF WATER QUALITY CRITERIA

The Group considered that under certain circumstances it would be desirable to formulate independent water quality criteria for each of the main uses of coastal waters. The main purpose of these criteria should be to facilitate the control of pollution and to improve water quality. Where the quality was already better than that necessary for a given water use it would be desirable to maintain this condition.

4. FEASIBILITY OF ESTABLISHING WATER QUALITY CRITERIA

The Group considered that the feasibility of developing justifiable criteria depends upon establishing relationships between reduced water quality and adverse effects on the coastal water uses. The Group realized that the establishment of such criteria would be made more difficult where interaction of different sources of pollution might influence their values. The Group recognized that control of the quality of edible marine products could also be achieved independently of water quality control.

5. STUDIES NEEDED FOR DEVELOPING WATER QUALITY CRITERIA

The Group emphasized the importance of field studies designed to develop water quality criteria for living marine resources and the need for epidemiological studies of health effects associated with consumption of contaminated sea food and with bathing in polluted water. It was considered that more effort should be given to these in the future. The Group also recognized the value of refined bioassay techniques as one possible means of establishing water quality criteria; special investigations of the combined effect of several pollutants acting together would need to be intensified.

The Group stressed the need to base the criteria upon critical and thorough reviews of the literature and the examination of unpublished sources of information. It recognized that the task is a demanding one involving a considerable amount of work by an expert scientific group during intersessional periods over several years and requiring continual reviewing and updating in the light of new information. It recommended that such a working group be set up by GESAMP.

6. RECOMMENDATIONS

The Group recommended that the terms of reference of the GESAMP Working Group should be:

(1) to evaluate the nature and extent of problem areas in order to establish an order of priority of coastal water quality characteristics which should be considered for the formulation of coastal water quality criteria;

(2) to consider past and current work and to identify gaps in our knowledge; and

(3) to formulate tentative coastal water quality criteria.

The Group envisaged that it would be most expedient to consider living marine resources and fishing separately from human health and amenity.

The Group noted that ACMRR/IABO had set up a working group on the Biological Effects of Pollutants whose terms of reference were closely related to its own as regards fishery resources, and that WHO had recently considered water quality criteria for the protection of human health and amenity in recreational coastal waters and was elaborating a guide to public health aspects of coastal water quality. It recommended that close liaison should be maintained between the GESAMP group and these other groups, including EIFAC, to avoid duplication.

Annex VII

THE CONSEQUENCES OF THE HUMAN PERTURBATION OF THE DEEP-SEA FLOOR
ADDENDUM

(Working Group 4 - Agenda Item 5)

Members of the Working Group:

Dr. R. Fukai
Prof. K. K. Turekian (Chairman
Dr. M. Waldichuk
Prof. Y. Nishiwaki (Technical Secretary)

CONTENTS OF REPORT

1. INTRODUCTION

This is an Addendum to GESAMP IV/19, Annex VII. Most of the observations made 8 months ago remain valid at the present time. We have, however, tried to update the basis of some of our conclusions made at that time.

2. THE STABILITY OF THE OCEAN BOTTOM

As was established in GESAMP IV/19, Annex VII, the sediments at the bottom of the ocean are not necessarily quiescent once deposited but can, under certain conditions, be mobilized. This sedimentary record contains abundant chemical and sedimentalogical evidence of this mobilization.

We can assign bottom sediment mobilization to one of four categories:

(1) Episodic erosion

(2) Mass deposition of episodically slumped material

(3) Continuous sedimentation

(4) Redistribution by bottom currents

Some of these natural modes are simulated by man's activities in the nearshore aras affecting the ocean floor. These activities include dumping of solid wastes, dredging, and construction of submarine structures, such as oil well rigs.

The following observations on the natural system may be important for the assessment of the impact of man's perturbation of the ocean floor:

(1) A study of a sediment "wedge" known to be deposited episodically, probably by storm action, in Long Island Sound indicates that the metals Pb, Zn, Cd and Cu were not released in the 20 years since the deposition of the sediment wedge from adjacent sources probably polluted by metals. Indeed, the only metal studied that showed marked release from the sediment was uranium. In Long Island Sound, as in many estuaries, the sediment below 2cm is reducing and contains H_2S whereas the overlying water is rarely, if ever, anoxic. The bioturbation brings reduced sediments to the sediment-water interface, and interstitial Fe^{+2} and Mn^{+2} are oxidized and redeposited as oxides coprecipitating most metals that might also have been released. Uranium, however, forms $UO_2\,(CO_3)_3^{-4}$ which, being highly soluble, is released to the overlying water. Some actinide elements might follow a pattern similar to uranium, although this aspect has yet to be proven. Recent data by Noshkin and Bowen (1973, IAEA, STI/PUB/313) show definite downward transfer of ^{239}Pu from the ocean surface and accumulation at the bottom in both near-shore and deep-sea sediments. Although not experimentally confirmed, it may be that Mo and Cr might also be released as highly soluble anion complexes.

If indeed these observations are applicable to the deep-sea environment, certain metals are unlikely to be easily released to overlying water as the result of man's disturbance of the ocean bottom.

(2) A common feature of deposition in the rugged topography of the mid-oceanic ridge areas is slumping from high points to deeper areas. The sediment accumulating on the topographically higher parts of the ridge is primarily calcium carbonate. This material can episodically cascade or avalanche down into the deeper intermontagne areas and the deep trenches made by the transform faults perpendicular to the crest line of the ridge. Results to date indicate the length of time between episodes can by anywhere from 1000 to 100,000 years

The significance of this observation is that the mid-oceanic ridge areas should be considered as potentially viable spots for dumping, provided that dumping is in those deeps most often receiving slumped sediment. Alternatively, sites in the ridge area might be assayed by exploration submersibles to identify deeps adjacent to thick sediment piles on hills. These sites would then be capable of artificial avalanching, thus guaranteeing burial of containerized dumped material.

Certainly such options seem more reasonable when long-term containment is desired, than dumping in areas along the continental margin or abyssal plain where current dispersal may contaminate a large area of the ocean floor.

3. DISPERSAL MECHANISMS

Dispersal mechanisms in the sea over the continental margin vary according to a number of factors, among which are depth, topography, permanent currents, tides, winds, waves and runoff. Clearly the relative influence of each of these factors on dispersion is largely related to the distance from shore and the depth.

In the coastal zone, dispersion is affected mainly by river runoff, tides, waves and winds. In addition, internal waves may be an important contributor to mixing and dispersion processes. Understanding of these processes is important in determining the general dispersion patterns of fine grained materials away from the point of human activity, whether it be sand and gravel dredging or the dumping of dredge spoils.

The proposed U.S. Project NOME in Massachusetts Bay is one in which a pilot controlled sand and gravel dredging experiment is being followed to assess the dispersion of fines and the effects on the biota of such processes. An experiment in the New York Bight (MESA) is also being executed to understand the dispersive processes in areas of heavy shipping and dumping, as well as potential sand and gravel dredging. Both of these experiments are under the lead management of the U.S. National Oceanographic and Atmospheric Administration (NOAA). Although mainly a national problem, some of the results may be of significance to areas of international interest where dumping or dredging may occur.

Although the tidal effect diminishes with distance from the coast, it is still important to the edge of the continental shelf. The continental slope and rise are subjected to a somewhat different regime of dispersion. For example, so-called slope currents may be a permanent feature along the continental slope, varying in intensity seasonally and from year to year. A unique characteristic of the continental slope is its propensity toward submarine slides of accumulated sediments which can lead to turbidity currents of considerable magnitude, as discussed in GESAMP II/11, Annex IV and GESAMP IV/19, Annex VII. Certainly the slope and continental rise are not recommended areas for deposition of waste materials, if long-term containment is desired.

Although it is conceivable that mining of materials in the sediments of the continental rise may be eventually attempted, the technological problems of exploration and economic recovery seem to be so complex as to defer any serious consideration of the exploitation of this possible resource to the rather distant future. By the time it becomes a more viable option than at present, it is likely that the problems of turbidity currents and other dispersive processes and their consequences for the biological resources of the area will be better understood, as a result of continued search for petroleum.

The present state of knowledge on dispersive processes in the sea has been fully reviewed at this Session by Kullenberg (GESAMP V/4.2), and the information gaps, where more research is needed, have been identified. We have nothing new to add to GESAMP IV/19, Annex VII, on dispersive processes in the deep sea.