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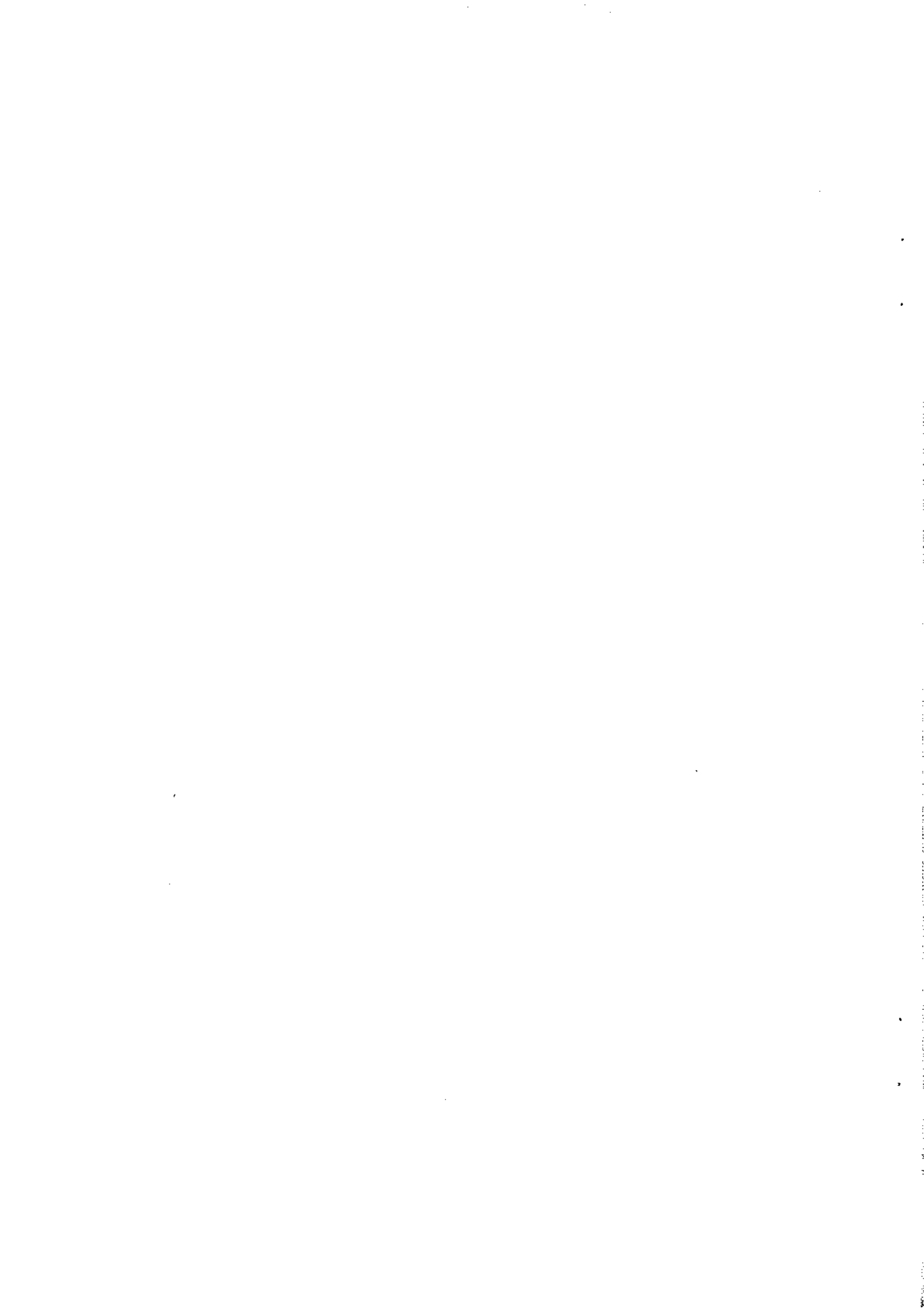
**IMO/FAO/UNESCO/WMO/IAEA/UN/UNEP
JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS
OF MARINE ENVIRONMENTAL PROTECTION
- GESAMP -**

REPORTS AND STUDIES

No. 51 **1993**
REPORT OF THE TWENTY-THIRD SESSION
LONDON, 19-23 APRIL 1993



INTERNATIONAL MARITIME ORGANIZATION



NOTES

- 1 **GESAMP is an advisory body consisting of specialized experts nominated by the Sponsoring Agencies (IMO, FAO, Unesco, WMO, WHO, IAEA, UN, UNEP). Its principal task is to provide scientific advice concerning the prevention, reduction and control of the degradation of the marine environment to the Sponsoring Agencies and to the Intergovernmental Oceanographic Commission (IOC).**
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**IMO/FAO/Unesco/WMO/WHO/IAEA/UNEP Joint Group of Experts on the
Scientific Aspects of Marine Environmental Protection (GESAMP)**

REPORT OF THE TWENTY-THIRD SESSION

London, 19-23 April 1993

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GESAMP Reports and Studies Publications

The following reports and studies are available from any of the Sponsoring Agencies of GESAMP.

Rep. & Stud. No.	Title	Date
1	Report of the Seventh Session	1975
2	Review of Harmful Substances	1976
3	Scientific Criteria for the Selection of Sites for Dumping of Wastes into the Sea	1975
4	Report of the Eighth Session	1976
5	Principles for Developing Coastal Water Quality Criteria	1976
6	Impact of Oil on the Marine Environment	1977
7	Scientific Aspects of Pollution Arising from the Exploration and Exploitation of the Sea-bed	1977
8	Report of the Ninth Session	1977
9	Report of the Tenth Session	1978
10	Report of the Eleventh Session	1980
11	Marine Pollution Implications of Coastal Area Development	1980
12	Monitoring Biological Variables Related to Marine Pollution	1980
13	Interchange of Pollutants between the Atmosphere and the Oceans	1980
14	Report of the Twelfth Session	1981
15	The Review of the Health of the Oceans	1982
16	Scientific Criteria for the Selection of Waste Disposal Sites at Sea	1982
17	The Evaluation of the Hazards of Harmful Substances Carried by Ships	1982
18	Report of the Thirteenth Session	1983
19	An Oceanographic Model for the Dispersion of Wastes Disposed of in the Deep Sea	1983
20	Marine Pollution Implications of Ocean Energy Development	1984
21	Report of the Fourteenth Session	1984
22	Review of Potentially Harmful Substances. Cadmium, Lead and Tin	1985
23	Interchange of Pollutants between the Atmosphere and the Oceans (second report)	1985
24	Thermal Discharges in the Marine Environment	1984
25	Report of the Fifteenth Session	1985

Rep. & Stud. No.	Title	Date
26	Atmospheric Transport of Contaminants into the Mediterranean Region	1985
27	Report of the Sixteenth Session	1986
28	Review of Potentially Harmful Substances. Arsenic, Mercury and Selenium	1986
29	Review of Potentially Harmful Substances. Organosilicon Compounds (Silanes and Siloxanes)	1986
30	Environmental Capacity: An approach to Marine Pollution Prevention	1986
31	Report of the Seventeenth Session	1987
32	Land-Sea Boundary Flux of Contaminants: Contributions from Rivers	1987
33	Report of the Eighteenth Session	1988
34	Review of Potentially Harmful Substances. Nutrients	1990
35	The Evaluation of the Hazards of Harmful Substances Carried by Ships: Revision of GESAMP Reports and Studies No.17	1990
36	Pollution Modification of Atmospheric and Oceanic Processes and Climate: Some Aspects of the Problem	1989
37	Report of the Nineteenth Session	1989
38	Atmospheric Input of Trace Species to the World Ocean	1989
39	The State of the Marine Environment	1990
40	Long-Term Ecological Consequences of Low-Level Contamination of the Marine Environment	1989
41	Report of the Twentieth Session	1990
42	Review of Potentially Harmful Substances. Choosing Priority	1990
43	Coastal Modelling	1990
44	Report of the Twenty-first Session	1991
45	Global Strategies for Marine Environmental Protection	1991
	<i>Addendum 1: Can there be a common framework for managing radioactive and non-radioactive substances to protect the marine environment?</i>	1992
46	Carcinogens: Their Significance as Marine Pollutants	1991
47	Reducing Environmental Impacts of Coastal Aquaculture	1991
48	Global Change and the Air/Sea Exchange of Chemicals	1991
49	Report of the Twenty-second Session	1992
50	Impact of Oil and Related Chemicals and Wastes on the Marine Environment	1993
51	Report of the Twenty-third Session	1993

GESAMP XXIII
(19-23 April 1993)

1 INTRODUCTION

1.1 The Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) held its twenty-third session at the Headquarters of the International Maritime Organization (IMO), under the chairmanship of Mr. J. Gray. Mr. O. Osibanjo was Vice-Chairman of the Group.

Opening of the session

1.2 Mr. O. Khalimonov, Administrative Secretary of GESAMP and Director of the Marine Environment Division of IMO, on behalf of the Secretary-General of IMO, welcomed the Group to this session. Mr. Khalimonov emphasized the importance of the Group as a multidisciplinary and independent advisory scientific body. Since its establishment in 1969 the Organization has benefited from the work of GESAMP, in particular with regard to the development of scientific bases for regulating maritime transport of oil and other hazardous substances, and the disposal at sea of wastes and other matter. Mr. Khalimonov noted further that many of the recommendations of Agenda 21 of the United Nations Conference on Environment and Development (UNCED) convened in 1992, have a direct bearing on the future work of all the sponsoring agencies of GESAMP and that the role of GESAMP as their advisory body on marine pollution aspects would have to be reviewed accordingly. Finally, Mr. Khalimonov wished the Group every success during this session.

1.3 The Chairman thanked Mr. Khalimonov on behalf of the participants for his good wishes for the success of this session.

Adoption of the agenda

1.4 The agenda for this session as adopted by the Group is reproduced in Annex I. The list of documents considered at the session is given in Annex II. The list of participants is shown in Annex III.

2 REVIEW OF THE MANDATE OF GESAMP

Introduction

2.1 GESAMP was established in 1969 with a view to providing scientific advice on marine pollution problems to the Sponsoring Agencies. The terms of reference for the Group as established in 1969 and amended in 1977 are as follows:

- (a) to provide advice relating to the scientific aspects of marine pollution:
 - (i) to the Sponsoring Organizations and to the Intergovernmental Oceanographic Commission (IOC) on specific questions referred to it;
 - (ii) to the other organizations of the UN system and to member states of the UN organizations on particular problems referred to it through a Sponsoring Organization; and
 - (iii) to the executive heads of one or more of the Sponsoring Organizations on such other specific questions within the competence of the Joint Group which may be put to it;

- (b) to prepare periodic reviews of the state of the marine environment as regards marine pollution and to identify problem areas requiring special attention.

2.2 For several years GESAMP has recognized that management deficiencies, and not necessarily the limitations of science, are responsible for the continued degradation of marine and coastal environments. It has further pointed out that part of the problem was the way in which science was interpreted and applied for management purposes. Accordingly, the Group, when discussing the large variety of different subjects related to human activities in coastal areas, repeatedly raised questions as to the relationship between fundamental scientific findings and environmental protection and management generally and with integrated coastal zone management specifically. In this connection, the Group agreed that direct linkages between scientific research results and management decisions are essential.

2.3 The need of the Sponsoring Agencies for advice on management-related scientific issues makes it necessary to review the future role of GESAMP, particularly in light of the outcome of the United Nations Conference on Environment and Development (UNCED).

2.4 GESAMP recalled its earlier discussions on the future of GESAMP (GESAMP Reports and Studies No.49, report of the 22nd session, paragraph 10.3) and it noted that there had been a number of important developments since that time. In particular, Agenda 21 of UNCED contained specific recommendations for the acquisition and application of scientific advice for marine environmental protection. It also strongly endorsed science-based management of the marine environment. The Chairman and several members of GESAMP had corresponded intersessionally to develop proposals on how the Group might evolve in response to changing needs and circumstances. The informal papers resulting from this correspondence were provided to GESAMP by the IMO Technical Secretary (GESAMP XXIII/2).

2.5 The Group was informed that a meeting of the Inter-Secretariat for GESAMP, convened in advance of this session, had considered the above developments and had accepted that a broadening of the scope of GESAMP would now be appropriate and it decided on a change in the title of GESAMP - replacing the word "Pollution" in the title of the Group by the words "environmental Protection". It was noted that this change, by itself, did not necessarily imply any substantive alteration in the primary mandate of GESAMP. There were, however, clear implications for its composition (i.e., specialties represented among its members) and the nature and scope of its products.

Request by the sponsoring agencies

2.6 The Group was asked to consider its terms of reference in the light of the proposed change in scope and title. It was also asked to consider the utility of a definition or explanation of the word "protection". Finally, it was asked to examine UNCED Agenda 21, in particular its Chapters 17 and 35, to determine tasks to which GESAMP could make an important contribution to assist the UN agencies in follow-up activities to the Conference.

Conclusions of the Group's deliberations

2.7 The Group felt that its experience and competence with respect to complex scientific problems would be a solid point of departure to new challenges in marine environmental management and associated socio-economic issues. In this sense, the Group acknowledged the need for re-direction of its tasks and deliberations within new terms of reference.

2.8 GESAMP agreed to the change of its name from the "Group of Experts on the Scientific Aspects of Marine Pollution" to the "Group of Experts on the Scientific Aspects of Marine environmental Protection". However, it believed that it would be useful, and perhaps essential, to provide some explanation of the meaning of the word "protection" in this context. Such an explanation would enable the users of GESAMP Reports and Studies to comprehend the scope within which the Group operates.

2.9 Based on the wording of paragraph 17.22 of Agenda 21, the Group concluded that "protection", specifically marine environmental protection for the purposes of GESAMP, requires the acquisition and application of scientific knowledge to the prevention, reduction and control of the degradation of the marine environment to sustain its life support systems, resources and amenities.

2.10 The Group also agreed to propose slight amendments of its Terms of Reference by deletion of references to pollution in section (b). The Terms of Reference of the Group then would become:

- (a) to provide advice relating to the scientific aspects of marine environmental protection:
 - (i) to the sponsoring organizations and to the Intergovernmental Oceanographic Commission (IOC) on specific questions referred to it;
 - (ii) to the other organizations of the UN system and to Member States of the UN organizations on particular problems referred to it through a sponsoring organization; and
 - (iii) to the Executive Heads of one or more of the sponsoring organizations on such other specific questions within the competence of the Joint Group which may be put to it;
- (b) to prepare periodic reviews and assessments of the state of the marine environment and to identify problems and areas requiring special attention.

2.11 Accordingly, the primary role of GESAMP would be to provide scientific advice on the protection of the marine environment, as specified above, and to devise and conduct periodic reviews and assessments of the state of the marine environment.

2.12 The Group then examined the provisions and recommendations of UNCED Agenda 21, particularly Chapters 17 and 35, to determine the nature and extent of GESAMP activities that might usefully contribute to the process of implementing UNCED recommendations.

2.13 Chapter 17 of Agenda 21 of UNCED on "Protection of the Ocean, All Kinds of Seas, including Enclosed and Semi-enclosed Seas, and Coastal Areas and the Prevention, Rational Use and Development of their Living Resources" identifies seven programme areas, and associated objectives and activities, that have both explicit and implicit requirements for scientifically-based management action. The Group noted that topics such as hazard and risk assessment, uncertainties related to contaminant effects and climate change, identification of critical habitats, design of systematic approaches to measuring marine environmental quality (including causes and effects of marine degradation), development of predictive tools and environmental quality criteria, and "state of the environment" reporting had been, and should continue to be, major components of GESAMP's work programme.

2.14 Chapter 35 entitled "Science for Sustainable Development" specifies four scientific programme areas which harmonize with the conclusions and recommendations of the International Conference on

the Agenda for Science for Environment and Development into the 21st Century (ASCEND 21). These are:

- (a) Strengthening the scientific basis for sustainable management;
- (b) Enhancing scientific understanding;
- (c) Improving long-term scientific assessment; and
- (d) Building up scientific capacity and capability.

2.15 The descriptions of the above programme areas, particularly the first three, contain objectives and activities that are directly relevant to GESAMP's interests and responsibilities both in the context of its historical mandate and any revision of its mandate and direction.

Potential topics for specific future activities of GESAMP

2.16 The following list of topics derived from Agenda 21 is given as an illustration of issues that could be addressed by GESAMP. This list represents a selection of issues on which GESAMP could potentially make a significant contribution. These topics are categorized under four major headings comparable with those in Agenda 21.

Sustainable development of coastal areas

- a) the scientific basis for the application of preventive and precautionary approaches in project planning and implementation, including prior assessment and systematic observation of the impacts of major projects;
- b) the development of methods for environmental accounting of coastal and marine areas in relation to pollution, marine erosion, loss of resources and habitat destruction;
- c) determination of criteria for the identification of critical areas for preparation of coastal profiles;
- d) development of scientifically sound recommendations and methodologies for preparing contingency plans for climate change effects in coastal zones, and for effects of degradation and pollution including oil spills;
- e) the scientific basis for conservation and restoration of altered critical habitats;
- f) development of environmental indicators for the coastal zone;
- g) development of a format for regular environmental assessments of the coastal zone;
- h) assessments of inputs from terrigenous and atmospheric sources.

Evaluation of risks and conduct of environmental assessments

- a) the scientific basis for local, national and regional monitoring programmes, water quality criteria and standards for sewage and other effluent discharges, including atmospheric inputs;

- b) development of criteria for risk and environmental impact assessments;
- c) development of guidelines for assessing the state of eutrophication of coastal areas and the need for remedial action;
- d) devising guidelines for the systematic observation of marine environmental quality;
- e) hazard assessments of chemical substances carried by ships.

Sustainable use and conservation of marine living resources

- a) scientific criteria for the assessment of the potential for sustainable aquaculture in marine and coastal areas;
- b) development of monitoring and assessment programmes for marine ecosystems for areas of high biodiversity and/or critical habitats.

Critical uncertainties

- a) advising on the scientific utility of observation programmes for coastal and near-shore phenomena related to climate change;
- b) contributing to the development of globally accepted methodologies for assessment of coastal vulnerability and response strategies to climate change;
- c) assessing the scientific needs and programme necessary to study effects of ultraviolet radiation on marine biological systems;
- d) organization of periodic review and assessments of status and trends in oceans and all seas and coastal areas;
- e) assessment of the systematic observations that are necessary to measure the role of the oceans as sources and sinks of carbon and other substances.

2.17 It was evident that two of the most important elements of a revised mandate for GESAMP would be to increase the relevance and utility of GESAMP's advice for management purposes and, to the extent possible, to tailor this advice to the needs of countries and regions where the conditions and problems addressed were most acute.

2.18 Under the new mandate, GESAMP's activities will fall into two broad categories:

- a) evaluations of specific scientific issues, processes, and methodologies relevant to management actions for the protection of the marine environment; and
- b) periodic reviews and assessments of the state of the marine environment.

2.19 As regards (a) above, GESAMP firmly believed that preservation of independence and scientific integrity and the retention of its current expertise to compile, synthesize and review the science relevant to the identified topics were paramount. However, additional expertise would be needed to enable GESAMP to prepare advice on policy and managerial options taking into account technological and socio-economic factors.

2.20 As regards the preparation of reviews and assessments, GESAMP recalled the continuing difficulties in obtaining comparable data and information from all regions and the associated problems of data relevance and quality. It was clearly necessary to develop guidance on the design and content of marine environmental reviews and assessments in order to facilitate global scale comparison and interpretation. GESAMP is well-suited to this task and, bearing in mind that much of the necessary advice already existed, should be able to respond quickly to any request from the Sponsoring Organizations to prepare the guidance required.

2.21 In summary, the Group is of the opinion that, subject to an appropriate level of support, there are no substantive reasons why the GESAMP framework for preparing scientific advice cannot be adapted to meet the requirements of the UN Sponsoring Organizations for advice in relation to the implementation of Agenda 21 that is more directly relevant and useful to the management and protection of the marine environment.

3 IMPACTS OF ANTHROPOGENICALLY MOBILIZED SEDIMENTS IN THE COASTAL ENVIRONMENT

3.1 The Unesco Technical Secretary recalled that the Working Group on the Impacts of Anthropogenically Mobilized Sediments in the Coastal Environment had been established by a decision of GESAMP XIX in Athens in 1989 and that a first report of the Working Group (the so-called Penang report) produced under its Chairman, Mr. J. Gray, had been discussed during the twenty-second session of GESAMP.

3.2 As a result, new terms of reference were defined and approval was given for an additional meeting of the Working Group to allow for a holistic view of the problem, to take into account land-based activities in the watershed and the harmful effects of decreased sediment input to coastal areas due to anthropogenic activities.

3.3 These terms of reference were used by the Working Group meeting held in Savannah, USA, from 11 to 15 January 1993 under the chairmanship of Mr. H. Windom, who introduced the report of the meeting. He explained that a group of five experts had contributed to producing the report based on their personal experiences and a vast literature review and that the report of the Penang meeting had provided useful insights, particularly on related regional problems and issues. He added that the title of the report, "Anthropogenic influences on sediment discharge to the coastal zone and environmental consequences" accurately reflects the contents of the report which derived from the new terms of reference.

3.4 The Group expressed its view that the report represented an example of how science can provide a basis for formulating rational management decisions. The Group recommended that the report would benefit from the addition of an Executive Summary which should emphasize that its application goes beyond marine environmental protection to issues relating to deforestation, watershed management and environmental management in small islands.

3.5 The Group approved the document for publication under the GESAMP Reports and Studies series following acceptance by the Chairman of the Working Group to integrate in the final version of the report comments made by the Group at this session. The report will be published as Reports and Studies No.52. A summary and outline is shown in Annex IV.

3.6 With regard to the report of the Working Group considered at GESAMP XXII entitled "The Impacts of Anthropogenically Mobilized Sediments in the Coastal Environment" (Penang Report)

which contained, in particular, information on the biological effects of anthropogenically mobilized sediments in coastal areas, the Group agreed that an editorial group, including the Chairman of GESAMP, should review the relevant sections of the report and that after due consideration during GESAMP XXIV this could then be published as an addendum to the final report GESAMP Reports and Studies No.52.

4 EVALUATION OF THE HAZARDS OF HARMFUL SUBSTANCES CARRIED BY SHIPS

4.1 The IMO Technical Secretary informed GESAMP that the twenty-seventh and the twenty-eighth sessions of the Working Group on the Evaluation of the Hazards of Harmful Substances Carried by Ships had been held during the intersessional period. The results of the Working Group are being used by a number of IMO bodies in developing requirements for the maritime transport of individual hazardous substances and for operational discharges of their residues at sea, as well as in considerations related to liability and compensation for hazardous and noxious substances in cases of accidental damages to property or the environment. The IMO Technical Secretary then provided a summary of the main achievements made by the Working Group during its recent sessions as outlined in its session reports (GESAMP XXIII/4).

4.2 The Chairman of the Working Group, Mr. P.G. Wells, drew attention to the following issues considered by his Group:

- .1 Copper-based antifouling paints are increasingly used to replace organotin-based paints and the Working Group upon request by IMO has started to consider the hazards related to the release of copper and copper-compounds from such paints into the marine environment. A number of national institutions are currently carrying out relevant laboratory tests and the Working Group had received some data for evaluation. Additional information will be submitted to the Working Group during the next intersessional period for evaluation at its twenty-ninth session in February 1994.
- .2 In the absence of data from tests to identify the potential of many chemicals to taint seafood, the Working Group considered methods on how to evaluate tainting thresholds of substances by using known or calculated sensory detection thresholds of chemicals in water and air. In this connection, the Working Group estimated tainting properties of aliphatic ketones, and these were in good agreement with values derived from tainting tests. The procedure also worked well for straight chain alkanes. Sensory detection thresholds in water of alkyl benzenes were also predicted, but in this case there was no good agreement with the few values that were available.
- .3 Due to varying compositions of mixtures transported under the name "White Spirits", a wide range of hazards could be presented. The Working Group agreed to collect information from industry on the composition of mixtures actually transported under the common name "White Spirits" and to evaluate separately the hazards of groups of "White Spirits" mixtures.
- .4 No evidence could be found that there would be damage to marine organisms caused by the bioaccumulation of fluoride compounds. The respective hazard profiles were revised accordingly.
- .5 It was agreed to pay more attention to substances of low acute toxicity, low volatility and high viscosity which, after release from chemical tankers, may float on the sea

surface, affecting coastlines and damaging wildlife. They therefore need to be regulated. The hazards of these substances, including many of vegetable and animal origin, will be evaluated in the near future.

- .6 The hazard assessment procedure and working methodologies as currently contained in GESAMP Reports and Studies No.35 will be reviewed and updated, including more detailed advice on laboratory testing methodologies and reporting methods.
- .7 In response to a proposal made by GESAMP at its twenty-second session in March 1992, the Working Group will establish a new category 5 in the toxicity ratings, *viz.* "extremely toxic", i.e. with 96hr LC50 of less than 0.01 mg/l; the existing category 4 will be modified accordingly.

4.3 The Group endorsed the reports of the twenty-seventh and twenty-eighth meetings of its Working Group for the Evaluation of the Hazards of Harmful Substances Carried by Ships and, in particular, approved the hazard profiles that had been reviewed or established during the intersessional period.

4.4 The Group welcomed the progress of work achieved as outlined above. With regard to the methodologies developed for the identification of the potential of chemicals to taint seafood (paragraph 4.2.2 above), the Group suggested that in cases where data on new products were submitted for evaluation by the Group, the chemical manufacturer should be requested to include physical data necessary for the estimation of tainting properties, i.e. vapour pressure, solubility, air/water partition coefficient, and octanol/water partition coefficient.

4.5 With regard to the evaluation of copper-based antifouling paints (paragraph 4.2.1 above), members of GESAMP undertook to submit any information or new test data that becomes available to them, to the IMO Technical Secretary.

4.6 The Chairman of the Working Group noted that Mr. Paul Jeffery and Mr. Roy Blackman, who had been involved in the work of the Group for many years, had asked to be released from their duties. The Group expressed appreciation for their outstanding work and wished them luck and success in the future.

4.7 A summary of the above intersessional reports is shown in Annex V.

5 INDICATORS OF MARINE ECOSYSTEM HEALTH

5.1 The UNEP Technical Secretary recalled the discussion on this item which took place at the twenty-second session. At that session it was agreed to establish a working group which should focus on biological responses that are detectable in relation to environmental change, emphasizing their potential and limitations. He stressed the importance of the outcome of this working group for the UNEP's Regional Seas Programme and Earthwatch.

5.2 Outlining the achievements of the first meeting of a task force that was held in Geneva at the UNEP Regional Office for Europe from 23 to 27 November 1992, the UNEP Technical Secretary underlined the importance of the ecosystem approach in order to assess large scale effects and to compare the health of different ecosystems.

5.3 The Chairman of the Working Group, Mr. John Gray, introduced a document (GESAMP XXIII/5) which had been prepared at the Geneva meeting, by a task force of six scientists.

He explained that the document was only an outline and much work needed to be done on the detail by a working group.

5.4 Members of GESAMP commented on the above document "Indicators of marine ecosystem health". Their comments and suggestions were as follows:

- .1 The document is well structured. The final version of the document should not be much longer than the preliminary one.
- .2 The section of the report relating to chemical analyses and bioassays needs substantial redrafting.
- .3 The contents of the section concerned with procedures to correlate physico-chemical environmental variables to the pattern in structures of assemblages of organizations needs redrafting.
- .4 The report should reflect relations between natural variability and anthropogenically introduced variability.
- .5 In the introduction, the interpretation of the mandate of the Working Group and definitions should be included, in particular the term "marine ecosystem health" should be discussed. Similarly, relations of this report to international programmes and Agenda 21 of UNCED should be added.
- .7 Under Global Scale Indicators, it was pointed out that some local indicators can be used to assess the health of ecosystems on the global scale. The report should consider such indicators and redraft this section accordingly, perhaps deleting the present aspects.

5.5 The Group noted that substantial progress has been made by the Working Group and recommended that it should convene during the intersessional period in order to finalize the report for submission to the next session of GESAMP for approval. Some additional expertise will be required to cover gaps identified in the report.

5.6 The Group emphasized that a good working relationship with the Oslo and Paris Commissions should be established, taking into account similar activities carried out by these Commissions and their well advanced monitoring programmes. The IMO Secretariat undertook to inform them accordingly.

5.7 A summary of the report prepared by the task force is shown in Annex VI.

6 ENVIRONMENTAL IMPACTS OF COASTAL AQUACULTURE

6.1 In the absence of Mr. Chua Thia-Eng, Chairman of the Working Group on Environmental Impacts of Coastal Aquaculture, the FAO Technical Secretary informed the Group of the current situation. Heavy workload and additional commitments by the Chairman and other Working Group members resulted in little progress made since the twenty-second session of GESAMP. However, several high-priority issues, requiring urgent expert advice, have been emphasized by the active

Working Group members in consultation with the FAO Technical Secretariat. The following tasks were strongly recommended for future work of this Working Group:

- .1 the establishment of scientifically-based monitoring requirements and procedures for aquaculture pollutants leading to the assessment of the environmental capacity of existing and planned coastal aquaculture operations;
- .2 the preparation of review and guidance documentation for the safe use of chemicals in coastal aquaculture; and
- .3 the review of concepts and experiences related to the integration of aquaculture into coastal area management schemes.

6.2 It was suggested that the Working Group should first concentrate its efforts on the preparation of a report on the requirements and procedures for the monitoring of coastal aquaculture pollutants. This report would be discussed and finalized during a Working Group meeting to be convened in January/February 1994. The Working Group would, however, continue to compile and review relevant information on other priority issues, in particular on above items .2 and .3 which would need to be discussed at that Working Group meeting.

6.3 GESAMP agreed to the activities proposed above by the FAO Technical Secretary.

7 SEA SURFACE MICROLAYER

7.1 The WMO Technical Secretary introduced a proposal to establish a Working Group on the Sea-Surface Microlayer (GESAMP XXIII/7). He recalled that at its twenty-second session the Group had expressed concern about the surface microlayer as a source of contaminant accumulation, its modification and significance for biological processes and air/sea exchanges. In line with this concern a meeting of an ad hoc group of experts chaired by Mr. R. Duce was convened by WMO to determine whether an in-depth review was warranted, and if so, to determine the scope, objectives and nature of such a review. The opinion of the ad hoc group was that there was a real need for an in-depth review of physical, biological and chemical processes that occur at the sea-surface microlayer and their relevance to global change and effect on the marine environment and its living resources; it accordingly proposed that this work should be carried out by a GESAMP Working Group.

7.2 The scientific justification for the proposed study had been prepared by Mr. J. Hardy, a member of the ad hoc group, (summarized in Annex VII to this report). Mr. Hardy explained in some detail what is known and what is not known about the biology of the microlayer:

- .1 microbiological studies indicate that microlayers are generally greatly enriched in the abundance (density) of microorganisms compared with subsurface water. A few studies suggest high biochemical activity in surface films. However, the effects of this microbial activity on air-sea exchange rates of radiatively important gases or other materials is unknown;
- .2 phytoneston (microalgae) of many species occur in high densities compared with phytoplankton in most ocean areas examined. A few studies have shown higher rates of photosynthetic carbon fixation in microlayers compared with subsurface water. Blooms of neustonic *Trichodesmium* (possibly fixing atmospheric N₂) are common in the tropics. However, the overall regional or global importance of phytoneston on CO₂ (or other gas) exchange from the atmosphere to the ocean is not known.

Furthermore, the effects of ultraviolet radiation or microlayer contamination on phytoneuston is unknown; and

- .3 with regard to ichthyoneuston, many pelagic fish species of commercial importance have floating egg and/or larval stages, that develop in contact with the microlayer. Experience in the laboratories has shown that contaminated microlayers can have toxic effects on fish embryos and larvae. Also, a few studies have shown that neustonic fish embryos, collected in surface skimming nets, from contaminated areas, have a higher incidence of chromosome abnormalities compared with those from less contaminated areas. However, the effects of microlayer contamination on fisheries recruitment at the population level remain unknown.

7.3 Mr. P. Liss, another member of the ad hoc group, commented that from multidisciplinary perspectives the time was now opportune for establishing the proposed Working Group. For example, there is evidence that the lower temperature of the sea-surface microlayer compared with the bulk water can lead to a significant increase in our estimates of the ability of the oceans to take up atmospheric carbon dioxide. Further, the current controversy over the magnitude of the transfer rate for gas exchange across the sea-surface may be resolved by the existence of specific catalysts for carbon dioxide transfer occurring at enhanced concentrations in the microlayer.

7.4 In the discussion following presentation of the proposal, GESAMP members raised a number of additional issues which should be considered. Specifically, relevant information should be gathered and evaluated regarding the following:

- .1 temporal and spatial variability of chemical and biological enrichment in the microlayer;
- .2 intercomparability of microlayer samples collected by different investigators using different techniques;
- .3 the actual exposure hazard in situ of indigenous neuston species to microlayer contamination;
- .4 quantitative estimates of how natural microlayers alter air-sea transfer compared with models which do not include a microlayer;
- .5 biology and chemistry of surface layers in freshwater environments;
- .6 exposure of aquatic surface layer communities to ultraviolet-B radiation and its implications for global change;
- .7 the horizontal transport of surface slicks and their deposition in coastal zones; and
- .8 physico-chemical data on the behaviour of micelles and data on engineering flotation processes.

7.5 In general, it was agreed that the work should be broadly scoped, include information on the aquatic surface layer with regard to both air-sea exchange and living marine resources and assess how each of these might be altered by human activities.

7.6 After detailed discussion of the proposal and the clarifications thereto, GESAMP decided to establish a Working Group on the Sea-Surface Microlayer with the following terms of reference:

To prepare a report on current understanding of the physics, chemistry and biology of the sea-surface microlayer with particular reference to its role in global environmental changes and as a marine habitat, including:

- .1 a review of physical processes in the microlayer and their relation to changes in heat, momentum and mass exchange;
- .2 a critical assessment of interaction of the biology and chemistry (including radiochemistry) in the microlayer including reference to the effects on living marine resources;
- .3 a quantitative consideration of the effects of the sea-surface microlayer on air/sea exchange of gases;
- .4 an assessment of the effects of solar radiation and photochemical reactions on the chemistry and biology of the microlayer; and
- .5 an evaluation of existing and potential new techniques for investigating the surface layer of the ocean.

8 FUTURE WORK PROGRAMME

The ecosystem of the Black Sea

8.1 The UNEP Technical Secretary recalled the concern of the Group expressed at its twenty-second session on the state of the Black Sea. Further information regarding a devastation of the ecosystem of the Black Sea is reflected in section 9 of this report. The UNEP Technical Secretary requested that a small Task Force be established to study causes that might have led to changes in the ecosystem, in particular those caused by the population explosion of a ctenophora species.

8.2 The Group agreed that work should be carried out by a small group of experts under the following terms of reference:

- .1 To assess the probable causes of the ctenophore outbreaks and their connection with other destabilizing factors and developments;
- .2 To assess the reproductive biology and physiological features of the intruder ctenophore, its ability to compete for food with pelagic fish, and control of its population by predators in its natural habitat;
- .3 To develop a strategy, and to recommend measures, to overcome the ctenophore and similar invasions, using the Black Sea as an example.

Guidance for the design of assessments of marine environmental conditions

8.3 Several members of the Group proposed that intersessional work be carried out with a view to preparing guidance on the design and conduct of assessments of marine environmental conditions. The background, rationale, purpose and terms of reference as proposed to the Group are reflected below.

Background

8.4 Periodic assessments of the condition of marine environments at regional and sub-regional levels are required by many international agreements established for the protection of the marine environment. Experience has shown that the quality and value of these assessments may be seriously restricted by a paucity of relevant and reliable data that are amenable to comparison and interpretation and by a lack of uniformity in the assessments themselves.

8.5 The timetable for review of the implementation of Agenda 21 makes it necessary to consider the preparation of status reports on the condition of regional sea areas within the next three to four year period. With this in mind, and taking into account the Group's experience in conducting global assessments as well as a knowledge of previous assessments at regional level, there is an urgent need for a uniform approach to both the design and conduct of scientific investigations that generate data for assessment purposes. A case for the involvement of GESAMP in the preparation of guidance that would facilitate improvements in the quality and uniformity of marine environmental assessments is presented as follows.

Rationale

8.6 Marine environmental assessments require physical, chemical and biological information from all environmental compartments and must include evaluations of spatial and temporal variability. The measurements required are sometimes complex and often demanding in terms of time and resources. Thus, the choice of variables to be measured, the locations, frequencies and methods of measurement must be linked to clearly-defined objectives and must yield data that are amenable to interpretation.

8.7 The reliability and precision of data must always be known. Otherwise it may not be possible to compare data sets, to ascertain spatial distributions or to elucidate temporal trends. Quality assurance specifications are accordingly essential.

8.8 Data interpretation is strongly dependent on signal:noise ratios and the requirement for the detection of significant variability in environmental terms. For these reason, considerable care is needed in the selection of variables to be measured. Not all environmental variables thought to be of relevance or interest will be amenable to measurements that are useful for either scientific or management purposes.

8.9 The international scientific community has begun to develop detailed guidance on the design and conduct of assessments that reflects up-to-date scientific knowledge, methodologies and capabilities. However, most of this guidance has so far been directed at assessment activities in specific marine regions. GESAMP should recognize that the time is opportune to develop guidance for global application.

Proposal

8.10 It is proposed, subject to the approval and support of the sponsoring agencies, that GESAMP should establish a Task Group to prepare intersessionally *Guidelines on the Design and Conduct of Assessments of Marine Environmental Conditions*. This Group would require a small number of experts familiar with current advice in this field but could usefully be supplemented by experts representing a number of regional sea areas. Although at least one meeting would be necessary to agree the format and content of the report, much of the work could be undertaken through correspondence. In view of the importance and urgency of this topic, the aim should be to complete the report for consideration at the twenty-fourth session of GESAMP in 1994.

Purposes of this task

8.11 The purposes of this task are twofold:

- .1 to enhance the compatibility of assessments for regional and sub-regional areas to simplify the assembly of information on larger geographical scales and comparisons among areas; and
- .2 to enable GESAMP to assist bodies involved in regional assessments in maximizing the benefits of assessments and achieving greater cost effectiveness in resources devoted to associated measurements.

Terms of reference

8.12 The Task Group would define the key elements for the design of regional marine assessments with specific reference to:

- .1 creating a common compatible format for assessments;
- .2 evaluating potential sources of marine degradation in specific marine areas including land-based sources; and
- .3 providing simple but effective procedures for assessing data and information quality relevant to assessments.

8.13 GESAMP supported the proposal as described above, and concurred with the view that a considerable part of the work concerned could be accomplished through correspondence.

Intersessional work

8.14 Taking into account the above decisions of the Group, intersessional work will be carried out in the framework shown below:

- .1 Evaluation of the hazards of harmful substances carried by ships (Working Group 1)

Lead agency: IMO
Co-sponsor: UNEP
Chairman: P. Wells

A meeting of the Working Group will be held in February 1994.

.2 Impacts of anthropogenically mobilized sediments in the coastal environment
(Working Group 30)

Lead agency: Unesco
Co-sponsors: UN, UNEP, FAO, IMO
Chairman: J. Gray

An editorial group including the Chairman will review a document submitted to GESAMP XXII in 1992 with a view to preparing a revised version, covering in particular biological effects, for consideration at GESAMP XXIV.

.3 Environmental impacts of coastal aquaculture (Working Group 31)

Lead agency: FAO
Co-sponsors: UNEP, Unesco
Chairman: To be determined

The Working Group will prepare a report on scientifically-based monitoring requirements and procedures for aquaculture pollutants leading to the assessment of the environmental capacity of existing and planned coastal aquaculture operations.

.4 Indicators of marine ecosystem "health" (Working Group 33)

Lead agency: UNEP
Co-sponsors: UN, FAO, Unesco, IMO, IAEA
Chairman: J. Gray

A meeting of the Working Group will be held in late 1993 in order to finalize the report.

.5 Sea-surface microlayer (Working Group 34)

Lead agency: WMO
Co-sponsors: UNEP, Unesco, IMO, IAEA
Chairmen: R. A. Duce and P. Liss

A first meeting of the Working Group will be held in early 1994.

.6 Opportunistic settlers and problem of ctenophore *Mnemiopsis leidyi* in the Black Sea
(Task Team)

Lead agency: UNEP
Co-sponsors: IMO, FAO, Unesco
Chairmen: Y. Sorokin and P. Wells

A meeting of a task force of 5 experts will be convened in late 1993.

.7 Assessment of the condition of marine environments (Task Team)

Lead agency: IMO
Co-sponsors: UN, Unesco, UNEP
Chairmen: P. Tortell, R. Boelens

A meeting of a task force of 4 experts will be held in London in late 1993 or early 1994 to prepare an annotated outline of guidelines on the design and conduct of assessments of marine environmental conditions.

9 OTHER MATTERS

Emerging issues of concern

The Chairman asked members of the Group to introduce issues which had come to their notice during the intersessional period and which they considered worthy of special emphasis in the Group's report. Topics considered by GESAMP under this item are reflected in the following paragraphs:

9.1 Disposal of radioactive wastes into Arctic Seas

9.1.1 GESAMP noted the concerns being raised about the recently-revealed dumping of radioactive wastes at sea by the former Soviet Union. Authoritative details of these activities have yet to be released through the medium of the Report by a Commission of Enquiry on Dumping of Radioactive Waste in Sea established by the President of the Russian Federation - the so-called Yablokov Report. Nevertheless, it appears that reactor assemblies and solid wastes have been dumped in the Barents and Kara Seas.

9.1.2 Many concerns were raised about the potential consequences for marine life and about the health effects for the human population in connection with the Arctic marine environment, because of the nature of these wastes and the specific characteristics of the marine environment at the disposal sites with depths of less than 1,000 metres. Additional concerns have been expressed about the mobilization of radionuclides in the terrestrial environment of the former Soviet Union and associated transport of radionuclides into the adjacent marine environment.

9.1.3 In this respect, GESAMP took note of the planned International Arctic Sea Assessment Project (IASAP) to be carried out by the IAEA in the period 1993-1996. This project has been formulated to provide a comprehensive assessment of the effects of previously disposed radioactive wastes in the Russian Arctic Seas, and involves field studies, modelling and assessment activities. This should enable the IAEA to assess the risks to human health and the environment posed by these wastes and to determine the nature and desirability of any remedial actions.

9.1.4 In February 1993, in a first review of published data on radioactivity measurements of the various components of the Arctic ecosystem, there has been no indication of contamination by artificial radionuclides that can be linked to releases of radionuclides from the disposed wastes. Nevertheless, specific research cruises have been planned to collect site-specific information on the radioactivity contamination as well as on oceanographic data. The first cruise was carried out in August - September 1992. This information, as well as the precise radionuclide composition and radionuclide release rates, is necessary to improve the reliability of the impact assessment and to calibrate models which are designed for this purpose.

9.1.5 GESAMP endorsed this activity and would like to be kept informed, at its future sessions, of progress in this work.

9.2 The "Braer" incident

9.2.1 GESAMP is aware that there are a number of oil spill incidents from shipping around the world each year that can have significant impacts in the coastal marine environment. One such incident during the past year was the grounding of the tanker "Braer" on the southern Shetland Islands, north of Scotland. This released 85,000 tonnes of light crude oil into the sea. This release has been different from many others in several ways and serves to emphasize the range of impacts that may occur from such incidents.

9.2.2 The scientific monitoring programme initiated by the Scottish Office Agriculture and Fisheries Department (SOAFD) in the wake of the incident was guided by an understanding of the hydrography of the region. The early scientific response demonstrated how pathways, sinks and effects can often be revealed that may not be readily traceable at a later stage. An estimated 30% of the original cargo can be traced to the sediments, both close to the spill and to the northeast of the spill.

9.2.3 The "Braer" oil spill had a number of unusual features, in particular the characteristic of the oil and the exceptionally rough sea conditions that existed at the time the oil was released. The mechanisms of oil transport in the water column and deposition in the sediments warrant further investigation. The examination of monitoring data will allow an assessment of the level of longer term damage to organisms.

9.3 Collapse of the ecosystem of the Black Sea

9.3.1 The ecosystems of the Black, Azov and Marmara Seas, which are economically important, have been experiencing an ecological catastrophe over the last three to four years caused by the massive population explosion in them of the intruder - ctenophore *Mnemiopsis leidyi*. This voracious ctenophore appeared in the Black Sea in the early 1980s, being most probably introduced by tanker ballast water from the U.S. eastern coast, where this ctenophore is a common component of coastal plankton.

9.3.2 A massive rise in the *Mnemiopsis* biomass started in 1988-89 in the Black Sea and then rapidly entered the Sea of Azov, and in 1993 - the Marmara Sea. By its mass development in these basins it attained an enormous biomass of 2-5 kgm⁻². Sometimes it reached up to 12 kgm⁻². Being a predator on zooplankton, on fish larvae and on fish eggs, the *Mnemiopsis* severely reduced the population of zooplankton due to its mass population explosion. During the events of 1988-92 when the development of this ctenophore reached its maximum, the biomass of zooplankton, accessible as food for fish, dropped from 15 gm⁻² in 1989 down to 200-300 mgm⁻² in 1989-1991. The biomass of Sagitta - the most valuable food for fish - decreased 30-fold during this period. Only inhabitants of deeper waters such as *Calanus ponticus* maintained its abundance, but only until 1990 when its biomass started decreasing, and by the end of 1990 it had dropped from 8 gm⁻² to about 1 gm⁻², because the ctenophores consumed them in deep waters under the thermocline.

9.3.3 Because of the drastic decrease in the zooplankton the stock of pelagic fish (*Engraulis*, *Clupeonella*, *Trachurus*) decreased 10 to 100-fold in 1990. The total fish catch decreased 8-10-fold: the stock of *Clupeonella* decreased 400-fold. The catch of *Trachurus* was in 1990 only 100 tons, while in 1984 it was 50,000 to 70,000 tons.

9.3.4 The intrusion of ctenophore not only caused a collapse of fishing in the Black, Marmara and Azov Seas but also resulted in other unfavourable developments in their ecosystems. The severe depletion of zooplankton transformed the food web in these seas and diverted the processes of biofiltration, self-purification and nutrient regeneration, in the pelagic communities. In summer to autumn a mass of jelly-like material and mucus filled all the water column down to depths of 200-300 m (in the Marmara Sea). It enhanced the acceleration of deoxygenation processes and processes of sulphide production. These developments are extremely dangerous in the Black Sea, where they could result in a rise of the redox boundary.

9.3.5 The Group considered a proposal to establish a small group of experts to assess the above situation in more detail as described under section 8 of this report.

9.4 Other issues that may warrant further consideration

9.4.1 GESAMP members are asked to use the following list of emerging issues of concern as the basis of a continuing list of issues for members' consideration and contributions. This is a draft list from one member and is meant only as a starting point; it is not a definitive or prioritized list, nor has there been any agreement yet as to its content:

- .1 Global occurrence and consequences of marine toxic blooms;
- .2 Vessel impacts with marine cetaceans - occurrence and consequences;
- .3 Land-based sources of oils, particularly used lubricating oils and industrial oils;
- .4 Restoration and rehabilitation of chemically perturbed marine habitats and ecosystems - methodologies and progress;
- .5 Impacts of coastal development on shoreline habitats in tropical and subtropical regions;
- .6 Impacts of selected "priority" toxic chemicals on reproductive and developmental processes of selected marine invertebrates and fish of commercial importance;
- .7 Marine sediment ecotoxicology - a critique of current methods, with an emphasis on realistic exposures; and
- .8 Understanding pollutant action at oceanic interfaces - concepts, predictions and applications.

9.4.2 GESAMP members were invited to add to the above list as they see fit and direct any submissions on these and other topics to the Chairman, Mr. J. Gray, at their earliest convenience during the intersessional period.

10 DATE AND PLACE OF NEXT SESSION

The Group noted that the twenty-fourth session of GESAMP would be hosted by the United Nations and convened from 21 to 25 March 1994.

11 ELECTION OF CHAIRMAN AND VICE-CHAIRMAN

The Group unanimously re-elected Mr. J. Gray as Chairman and Mr. O. Osibanjo as Vice-Chairman for the next intersessional period and for the twenty-fourth session of GESAMP.

12 CONSIDERATION AND APPROVAL OF THE REPORT OF THE TWENTY-THIRD SESSION

12.1 The report of the twenty-third session of GESAMP was considered and approved by the Group on the last day of the session. It contains, in Annexes IV to VII, summaries of reports prepared by Working Groups and other Sub-Groups. These summaries are included for information and were not considered by the Group with a view to approval.

12.2 The twenty-third session of GESAMP was closed by the Chairman of the Group at 12.00 a.m. on 23 April 1993.

ANNEX I

AGENDA

- 1 Adoption of the provisional agenda
- 2 Review of the mandate of GESAMP
- 3 Impacts of anthropogenically mobilized sediments in the coastal environment
- 4 Evaluation of the hazards of harmful substances carried by ships
- 5 Indicators of marine ecosystem health
- 6 Environmental impacts of coastal aquaculture
- 7 Sea surface microlayer
- 8 Future work programme
- 9 Other matters
- 10 Date and place of next session
- 11 Election of Chairman and Vice-Chairman
- 12 Consideration and approval of the report of the twenty-third session

ANNEX II

LIST OF DOCUMENTS

Agenda Item	Document	Submitted by	Title
1	GESAMP XXIII/1	Administrative Secretary	Provisional Agenda
2	GESAMP XXIII/2	IMO	Review of the mandate of GESAMP
	GESAMP XXIII/2/Add.1	IMO and FAO	Review of the mandate of GESAMP
	GESAMP XXIII/WP.1	Working Group	Report of the Working Group on the Review of the Mandate of GESAMP
3	GESAMP XXIII/3	Unesco	Anthropogenic influences on sediment discharge to the coastal zone and environmental consequences
4	GESAMP XXIII/4	IMO	Evaluation of the hazards of harmful substances carried by ships - Reports of the twenty-seventh and twenty-eighth meetings
5	GESAMP XXIII/5	UNEP	Indicators of marine ecosystem health - Report of the first meeting of the Working Group
6	GESAMP XXIII/6	FAO	Briefing notes on GESAMP WG 31
7	GESAMP XXIII/7	WMO	Sea-surface microlayer
8	GESAMP XXIII/WP.2	Drafting Group	Proposal for intersessional work to prepare guidance on the design of marine environmental assessments
9	GESAMP XXIII/9/Rev.1	UNEP	Emerging issues of concern: Catastrophic collapse of the ecosystem of the Black Sea

Information documents

2	GESAMP XXIII/INF.1	Chairman	Review of the mandate of GESAMP
2	GESAMP XXIII/INF.2	Chairman	Review of the mandate of GESAMP
9	GESAMP XXIII/INF.3	IAEA	Emerging issues of concern: Dumping of Radioactive Wastes at Arctic Seas: The IAEA Working Plan for the International Arctic Sea Assessment Project (IASAP) (1993-1996)

ANNEX III

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ANNEX IV

ANTHROPOGENIC INFLUENCES ON SEDIMENT DISCHARGE TO THE COASTAL ZONE AND ENVIRONMENTAL CONSEQUENCES

Summary of the report of the Working Group on the Impacts of Anthropogenically Mobilized Sediments in the Coastal Environment

Changes in sediment delivery to the coastal zone due to man's activity on land can have deleterious effects on the marine environment. Both decreases and increases in sediment delivery of a watershed from its natural rate can be detrimental.

Recognizing that this is a potential problem of concern to regions throughout the world, GESAMP formed a Working Group on the Impacts of Anthropogenically Mobilized Sediments in the Coastal Environment (WG 30) to assess this problem. This report represents the culmination of the activities of this Working Group and was reviewed and recommended for publication by the Joint Group of Experts on the Scientific Aspects of Marine Pollution at its twenty-third meeting in London during April 1993.

GESAMP XXIII emphasized that this report contains numerous elements of importance, not only for Chapter 17, but also for other chapters of Agenda 21 (UNCED, 1992), including Chapters 11 (deforestation) and 18 (freshwater resources), because of its holistic consideration of the problem linking watershed activities to the coastal environment and the implications to managements. Because of this GESAMP requested that the responsible organizations ensure that the report is brought to the attention of the UN Secretariat for the Commission on Sustainable Development.

Natural characteristics of watersheds that influence sediment yields (i.e., sediment transport per unit area of watershed) are size and elevation (which are surrogates for tectonic oversteepening and soil erodibility). Thus small, steep watersheds are most susceptible to increased sediment yields due to human intervention.

Human activities that have the greatest influence of sediment delivery to the coastal marine environment are deforestation, followed by crop farming, and the construction of dams and reservoirs. Deforestation, followed by the replacement of the forested areas with croplands or grazing lands, is the human activity most responsible for increased sediment yields of watersheds. Other activities that increase sediment yields, but which are globally less important, are surface mining and urbanization. The construction of dams and reservoirs have the greatest impact on decreasing sediment yields on a global scale. Channel stabilization works such as channel deepening, straightening and armouring also lead to decreased sediment yields.

Both increased and decreased sediment delivery to the coastal zone have geomorphological effects. Increased sediment delivery can result in shoaling and increased navigational hazards due to the blocking of inlets and river mouths. Increased delivery also leads to the smothering of coastal benthic habitats and to increased turbidity which affects water column production and the migration of pelagic organisms. Decreased sediment delivery can result in accelerated beach erosion, increased susceptibility to coastal flooding and the loss of coastal wetlands. Increased coastal erosion would also threaten the loss of deltaic environments.

Time scales relating cause and effect depend on the ability of watershed to store sediments. For very large systems having large storage capacities associated with river flood plains, the time period separating cause and effect can be centuries to millennia. For smaller systems and watersheds time scales are in the order of decades or less.

Regional trends in deforestation and dam construction, coupled with natural watershed characteristics are major factors which determine the risk of changed sediment yield. Globally, the rate of deforestation followed by crop farming is most significant in the tropics. Trends in the rate of dam construction suggest that they will be greater in developing regions. Based on these trends and regional characteristics of watershed, it is concluded that the areas of the world at greatest risk to changed sediment delivery to the coastal zone are located in the tropics.

ANNEX V

EVALUATION OF THE HAZARDS OF HARMFUL SUBSTANCES
CARRIED BY SHIPS

Summary of the reports of the 27th and 28th meetings of the
Working Group on the Evaluation of the Hazards
of Harmful Substances Carried by Ships

- 1 The Working Group held its 27th meeting from 17 to 21 February 1992 and its 28th meeting from 15 to 19 February 1993. Both meetings were convened under the chairmanship of Dr. P. G. Wells. The main work carried out during the meetings consisted of the review of existing hazard profiles and the establishment of new profiles for substances that have recently been proposed for carriage by ships either as bulk liquid chemicals, bulk solids or as packaged goods.
- 2 In addition to the hazard evaluation of individual substances the Working Group reviewed the following classes of compounds:
 - Alkylbenzenes
 - Alkenylbenzenes
 - Ketones
 - Fluorides
- 3 The Working Group considered the impact of copper and copper compounds used in marine anti-fouling materials which increasingly replace tin-based anti-fouling formulations.
- 4 With regard to the potential of chemicals to taint seafood when spilled at sea, the Working Group considered methods on how to evaluate tainting thresholds of the chemicals concerned by using their sensory detection thresholds in water or air.
- 5 Considerable progress has been made by the University of Trondheim, Norway, in developing the computerized data base containing the 2,500 substances evaluated so far by the Working Group.
- 6 The hazard assessment procedures and methodologies used by the Working Group as contained in GESAMP Reports and Studies No.35, published by IMO in 1989, are being reviewed and updated, taking into account new data and testing methods developed since that publication.
- 7 The Working Group agreed on its future work programme. It recognized that there was a backlog of substances that urgently need to be evaluated or reviewed. However, owing to the financial constraints it is not possible for the sponsoring organizations to convene meetings more often than once per year. The next meeting will be held from 14 to 18 February 1994.
- 8 The reports of the 27th and 28th meetings of the Working Group have also been issued as Circulars of the Sub-Committee on Bulk Chemicals (BCH/Circ.33 and BCH/Circ.34). They can be made available by IMO on request.

TERMS OF REFERENCE

To examine and evaluate available data and to provide such other advice as may be requested, particularly by IMO, for evaluating the environmental hazards of harmful substances carried by ships, in accordance with the rationale approved by GESAMP for this purpose.

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ANNEX VI

INDICATORS OF MARINE ECOSYSTEM HEALTH

Summary of the report of the first meeting of the Working Group on Indicators of Marine Ecosystem Health

- 1 The first meeting of the GESAMP Working Group (Task Force) on Indicators of Marine Ecosystem Health was held in Geneva at the UNEP Regional Office for Europe from 23 to 27 November 1992. Mr. John Gray acted as Chairman and Rapporteur of the meeting. Support for the work of the Group was provided by IMO, FAO, UNESCO, IAEA and UN. The full report of the meeting (UNEP(OCA)/GES.WG.33.1/5) was distributed to the participants of this session of GESAMP.
- 2 The Group has approached its terms of reference by concentrating on indicators of exposure and effects which have been well tested and which the Group was confident can be applied globally. However, the Group was aware that these indicators were best able to express local-scale impacts and there was a need to assess broader-scale effects, such as habitat destruction, and impact on fisheries in the context of resource management. The Group did not have expertise to cover either of these issues.
- 3 The term "pollution" embraces the effects of anthropogenic factors (such as chemical contamination, physical disturbances, organic enrichment) on biological processes. A considerable amount of research has inevitably been devoted to deriving the means by which such effects can be measured, with a reasonable likelihood of detecting change due to anthropogenic factors. These research efforts have naturally focused on different levels within the biological hierarchy, where the different inherent properties have led to a wide diversity of approaches to the common objective, namely to determine the effects of stress on the marine environment. As these various strands of research have come to be evaluated for operational use within programmes specifically designed to measure changes due to anthropogenic intrusion, the first priority has been to ensure that the various indices of response may indeed be deployed in the field situation.
- 4 Evaluation of the relative merits of different techniques was constrained by the perception that relevant measurements made at different levels in the biological hierarchy ("from molecules to ecosystems") should constitute a cascade of cause/effect relationships and therefore provide a predictive capability from evidence of impact on cells, for example, to the consequences for the functioning of populations of individuals. This is not only an unachievable objective (at least within realistic time-scales) but also it is an unnecessary one. Rather, measurements of effect on cells, tissues or individuals, say, will all contain different information, expressing different facets of stress response and all equally valid and significant in the evaluation of environmental impact. Molecular biomarkers of exposure will help to quantify the links between chemical contamination and the first stages of biological response. It is not necessary to require that such measurements also provide information on the performance of the individual organism, or if not lined, change in reproductive potential within the target population.
- 5 It is equally important that predictive capability of response indices should not be extended beyond the boundaries of the operational measurement and its quantitative relationship to the relevant environmental stimulus.

6 In the report the critical requirement for robust sampling design is given a specific emphasis.

7 There is a further aspect to the statistical constraints on sampling design that, when linked to the operational nature of proposed deployment of techniques, provides added power to the recommended approaches. That is, the concept of hypothesis testing in environmental impact assessment. With the correct combination of experimental design and measured "endpoints", it is possible to construct specific hypotheses which are based on a priori expectations and which may then be put to the test in a monitoring programme. This approach introduces a needed element of scientific rigour but also, importantly, provides information that is then couched in terms most likely to support appropriate management action.

8 An hypothesis that says that a site (or habitat, or coastal system) is impacted by a particular hazard to a particular degree, measurable in terms of specific indices of known properties, may or may not then be supported by the data. If supported, then management action may be structured on the formal statements of hazard and quantitative response. If not supported, the hypothesis may, as a management tool, then be modified to consider a different category of hazard, a different suite of response end-points, or it may be rejected in favour of a decision that no further action is required. In any case, the close interaction between the management concern and the scientific data, effected via the process of hypothesis testing, provides a powerful and transparent approach to environment assessment.

9 A consideration of this interface between scientific analysis and environmental management raises the question of the role of modelling since it is often the model (rather than the scientific data generated to make any wider function) which is the preferred tool of environmental decision-making. Over the last two decades there have been various approaches to ecological modelling and some of these have been considered in the specific context of pollution effects studies. This topic will be addressed further, but the preliminary discussions have led to a view that the approach of general ecosystems modelling, in which many processes, interactions, and forcing functions are represented in a simple simulation, has little to offer in the context of immediate concerns. Rather, the approach of more specific process modelling whereby a particular feature of stress response is formulated as a model which is, in turn constructed around a specific hypothesis (or set of hypotheses), can be extremely valuable. This value lies both in the light that may be thrown by such models on specific aspects of environmental impact, and in their utility in guiding management action and in facilitating "what if?" approaches to particular environmental situations. This is a topic that will be evaluated further by the Working Group.

TERMS OF REFERENCE

- identify characteristics of components of marine ecosystems that can generally be used to indicate the normal functioning of those ecosystems;
- consider the origin and value, for these purposes, of terms such as stress, population, community and ecosystem with specific reference to space and time scales and energy flow in the marine environment;
- review the methods used to detect stress on marine populations, communities and ecosystems and assess their value and limitations;
- review the methods used to detect stress on individual marine organisms, in a field situation and assess their value and limitations;
- identify, on the basis of the above, suites of indicators of the state of marine ecosystems that can be used to assess the impact of anthropogenically induced change of the marine environment.

ANNEX VII

SEA SURFACE MICROLAYER

Proposal for the establishment of the GESAMP Working Group on Sea-Surface Microlayer

- 1 There has been considerable new research on the sea-surface microlayer over the past 5-10 years. It is known to concentrate many chemical substances, particularly those that are surface active, and many organisms live and/or find food there. It is obviously the interface through which all gaseous and particulate material must pass when exchanging between the ocean and the atmosphere. For purposes of the proposed study, the term "microlayer" is used in its operational meaning to refer to roughly the uppermost millimetre, where properties are most altered relative to deeper waters.
- 2 Natural surface-active substances are often enriched in the sea surface compared to subsurface water. Amino acids, proteins, fatty acids, lipids, phenols, and a great variety of other organic compounds collect on the surface. The biota of the water column below are the source for most of the enrichment of natural (non-pollutant) chemicals. Plankton produce dissolved compounds as products of their metabolism. Air bubbles, rising through the water column, scavenge these organic materials and bring them to the surface. Also as plankton die and disintegrate some particles and many of the breakdown products (oils, fats, and proteins, etc.) float to the surface.
- 3 The accumulation of natural organic chemicals modifies the physical and optical properties of the sea surface. Thin organic films, invisible to the naked eye, are ubiquitous in aquatic systems. In areas where currents converge, thicker films accumulate. Under light to moderate wind conditions, areas of accumulated film dampen small waves and become visible as "surface slicks". Strong surface tension forces exist, creating a boundary region where turbulent mixing is much reduced.
- 4 Growing population and industrialization have resulted in increasing atmospheric transport of pollutant materials over the ocean. Atmospheric deposition of this material and of naturally occurring substances represents an important source of inorganic and organic chemicals to the sea-surface microlayer. Many of these substances are surface active and contribute to increased concentrations in the surface microlayer and could result in increasing incidence of coherent films or slicks in both coastal and open ocean regions. High concentrations of toxic chemicals are also often found in the surface microlayer compared to the subsurface bulkwater.
- 5 Global decreases in stratospheric ozone resulting from CFC and halon releases have led to increased levels of solar ultraviolet-B (UV-B, 290 to 320 nm) radiation reaching the earth's surface. Because of the long residence times of different CFC compounds in the atmosphere (8 to 380 years), stratospheric ozone depletion and increases in UV-B are expected to continue well into the 21st century.
- 6 The global changes mentioned above have raised several important and interrelated questions concerning global marine impacts, including:
 - (a) Could continuing or increased deposition of toxic chemicals and surface active agents, and/or increased UV-B alter either physically or biologically mediated

fluxes or radiatively active and atmospheric chemically important trace gases between the ocean and atmosphere and vice versa?

- (b) What is the likely impact of chemical enrichment of the sea surface, along with increased UV-B, on the health of biological communities, including the egg and larval stages of many commercially important fish species?

7 It is believed necessary to expand these specific concerns to address, in general, the fundamental physical, chemical and biological processes in the surface of the ocean that may affect or be affected by global change. Much new information has been generated recently about the chemical composition and structure of the surface layer and the types and rates of reactions occurring there (particularly photochemical reactions). This new information provides an important foundation on which to base an understanding of the importance of this issue, but there are many processes which may be of global importance, but for which we still have incomplete or virtually no information. In addition, there has been no comprehensive review of our understanding of the surface microlayer for almost a decade.

8 It is proposed that the GESAMP Working Group on Sea Surface Microlayer be established to conduct an in-depth review of the physical, biological, and chemical processes that occur at the extreme surface of the ocean (the surface microlayer) and the possible relationships of these processes to global change. It is also proposed that the work of the Working Group be structured around the following outline:

- 1 Physical processes in the microlayer and their relation to changes in heat, momentum and mass exchange:
 - (a) Review of physical processes and their relation to air/sea exchange;
 - (b) Capillary waves and organic slicks;
 - (c) Turbulent boundary layer versus film replacement;
 - (d) Non-equilibrium thermodynamics;
 - (e) Bubbles and aerosol production.
- 2 Biological effects of chemical change in the microlayer:
 - (a) Review of the biology of the surface layer;
 - (b) Chemical enrichment of anthropogenic (including radioactive) substances at the surface;
 - (c) Biological effects of sea surface contamination.
- 3 Air/sea exchange of trace gases across the microlayer:
 - (a) Radiatively active trace gases (CO₂, CH₄, N₂O etc.);
 - (b) Gases important to atmospheric chemistry (DMS, COS, CS₂, light halo- and hydro-carbons, ammonia and methylamines etc.);
 - (c) Input of reactive gases to the microlayer.

- 4 **Effects of solar radiation and photochemical reactions on the chemistry and biology of the microlayer:**
 - (a) **Photochemistry;**
 - (b) **Photobiology.**

- 5 **New techniques for investigating the surface layer of the ocean:**
 - (a) **In-situ techniques;**
 - (b) **Remote techniques.**

