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JOINT GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS  
OF MARINE POLLUTION  
- GESAMP -

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THE STATE OF THE MARINE ENVIRONMENT



UNITED NATIONS ENVIRONMENT PROGRAMME

IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts  
on the Scientific Aspects of Marine Pollution (GESAMP)

## THE STATE OF THE MARINE ENVIRONMENT

UNEP, 1990

#### NOTES

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#### DEFINITION OF MARINE POLLUTION BY GESAMP

"POLLUTION MEANS THE INTRODUCTION BY MAN, DIRECTLY OR INDIRECTLY, OF SUBSTANCES OR ENERGY INTO THE MARINE ENVIRONMENT (INCLUDING ESTUARIES) RESULTING IN SUCH DELETERIOUS EFFECTS AS HARM TO LIVING RESOURCES, HAZARDS TO HUMAN HEALTH, HINDRANCE TO MARINE ACTIVITIES INCLUDING FISHING, IMPAIRMENT OF QUALITY FOR USE OF SEA WATER AND REDUCTION OF AMENITIES."

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This document has also been issued by UNEP as UNEP Regional Seas Reports and Studies No. 115.

## PREFACE

Although the idea of summarizing the state of marine pollution in the world oceans is probably much older than one might imagine, the specific idea of reviewing the health of the oceans seems to have first arisen in the report of the ACMRR/SCORR/WMO Joint Working Party on Global Ocean Research (Ponza and Rome, 29 April - 7 May 1969).

This idea was taken up by the ACMRR/SCOR/ACOMR/GESAMP Joint Working Party on the Global Investigation of Pollution in the Marine Environment (San Marco di Castellabate and Rome, 11-18 October 1971).

The Action Plan adopted at the United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972) recommended that GESAMP should assemble scientific data and provide advice on scientific aspects of marine pollution especially those of an interdisciplinary nature.

The IOC International Co-ordination Group for GIPME at its first session (London, 2-6 April 1973) recommended that IOC retain a consultant to bring together the available data into a report on the Health of the Oceans. Professor E. D. Goldberg was asked to do this work, and his report was published by UNESCO in 1976.<sup>1</sup>

The fifteenth session of the Inter-Secretariat Committee on Scientific Programmes Relating to Oceanography (ICSPRO), recommended "...that GESAMP should be invited to advise agencies, and UNEP was asked to take the initiative, in consultation with other agencies, for the preparation of a detailed request to GESAMP for a critical examination of present and planned methods by which to generate a continuous authoritative review and assessment of the health of the oceans". The initiative requested of UNEP was taken up at the meeting of the GESAMP Joint Secretariat (Geneva, 4-5 June 1977) when it was decided that the preparation of "periodic reviews of the state of the marine environment as regards marine pollution" should become one of the main terms of reference for GESAMP.<sup>2</sup>

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<sup>1</sup> Goldberg, E. D. (1976). *The Health of the Oceans*. UNESCO, Paris.

<sup>2</sup> The Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) is an advisory body to the Heads of eight organizations of the United Nations System (UN, UNEP, FAO, Unesco, WHO, WMO, IMO, and IAEA).

The first review on the state of the marine environment was completed by GESAMP under the co-ordination of Professor Gunnar Kullenberg and was published by UNESCO and UNEP in 1982.<sup>3</sup>

The preparation of the second review on the state of the marine environment through GESAMP was initiated by UNEP in 1985. A Working Group (Appendix A) was established under the chairmanship of Professor Alasdair McIntyre to prepare the report under the overall guidance of GESAMP. The present document is the report, as endorsed by the 19th session of GESAMP (Athens, 8-12 May 1989, Appendix B).

The report is based on 16 technical annexes (Appendix C) written by individual experts commissioned by the Chairman of the Working Group. While GESAMP takes responsibility for the substance of the report, the annexes were endorsed by the Working Group, but are the responsibility of their individual authors. The technical annexes will be published by UNEP as a separate publication.

In addition to drawing on technical annexes and on other GESAMP reports (Appendix D), this report is also based on information culled from the open literature (Appendix E).

The Working Group was assisted in its task by the parallel but independent work of 12 UNEP-sponsored Task Teams which will result in the publication of 12 regional reviews on the state of the marine environment, written largely according to the layout of this report. The regional reviews are being published by UNEP.

The organizations sponsoring GESAMP would like to acknowledge with appreciation the work of the drafting group (Dr. Gwyneth Howells, Professor Alasdair McIntyre and Dr. Francesco Sella) for their role in preparing the final version of this report.

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<sup>3</sup> Rep. Stud. GESAMP (15) and UNEP Regional Seas Reports and Studies No 16.

## LIST OF ABBREVIATIONS

CCCCO	Committee on Climate Change and the Ocean
CFC	Chlorofluorocarbons
DDE	1, 1 - dichloro - 2, 2 - bis (p-chlorophenyl) ethylene
DDT	1, 1, 1 - trichloro - 2, 2 - bis (p-chlorophenyl) ethylene
DSP	Diarrhoeic shellfish poisoning
EC	Environmental capacity
EQO	Environmental quality objective
FAO	Food and Agriculture Organization
GEEP	Group of Experts on Environmental Pollutants
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
grt	Gross registered tons
Gt	Gigatonne
HCB	Hexachlorobenzene
HCH	Hexachlorohexane
IAEA	International Atomic Energy Agency
ICES	International Council for the Exploration of the Seas
ICRP	International Commission for Radiological Protection
IMDG	International Maritime Dangerous Goods Code
IMO	International Maritime Organization
IOC	International Oceanographic Commission
JGOFS	Joint Global Ocean Flux Study
LDC	London Dumping Convention
MARPOL	International Convention for the Prevention of Pollution from Ships
mSv	Millisievert
Mt	Megatonne
OILPOL	International Convention for the Prevention of Pollution of the Sea by Oil
OTEC	Ocean thermal energy conversion
PAH	Polycyclic aromatic hydrocarbons
PBq	Petabecquerel
PCB	Polychlorinated biphenyls
ppb	parts per billion
ppm	parts per million
PSB	Paralytic shellfish poisoning
TBT	Tributyltin
TOGA	Tropical Ocean and Global Atmosphere Programme
UES	Uniform emission standard
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNSCEAR	United Nations Committee on the Effects of Atomic Radiation
UV	Ultraviolet
WCRP	World Climate Research Programme
WHO	World Health Organization
WMO	World Meteorological Organization
WOCE	World Ocean Circulation Experiment

## **APPENDICES**

- A. WORKING GROUP ON THE STATE OF THE MARINE ENVIRONMENT**
- B. GROUP OF EXPERTS ON THE SCIENTIFIC ASPECTS OF MARINE POLLUTION**
- C. ANNEXES TO THE REPORT**
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## EXECUTIVE SUMMARY

1. In 1989 man's fingerprint is found everywhere in the oceans. Chemical contamination and litter can be observed from the poles to the tropics and from beaches to abyssal depths. But conditions in the marine environment vary widely.

2. The open sea is still relatively clean. Low levels of lead, synthetic organic compounds and artificial radionuclides, though widely detectable, are biologically insignificant. Oil slicks and litter are common along sea lanes, but are, at present, of minor consequence to communities of organisms living in open-ocean waters.

3. In contrast to the open ocean, the margins of the sea are affected by man almost everywhere, and encroachment on coastal areas continues worldwide. Habitats are being lost irretrievably to the construction of harbours and industrial installations, to the development of tourist facilities and mariculture, and to the growth of settlements and cities. Although difficult to quantify, destruction of beaches, coral reefs and wetlands, including mangrove forests, as well as increasing erosion of the shore, are evident all over the world. If unchecked, this trend will lead to global deterioration in the quality and productivity of the marine environment.

4. The growing exploitation of the coast is a reflection of population increase, accelerating urbanization, greater affluence and faster transport - trends that will continue throughout the world. Controlling coastal development and protecting habitats will require changes in planning both inland and on the coast, often involving painful social and political choices.

5. A wide range of activities on land contributes to the release of contaminants to the sea either directly or carried by rivers and the atmosphere, while sea-borne activities make a minor addition. Only a small part of those contaminants has spread beyond the limits of the continental shelf. The bulk remains in coastal waters and, in places, particularly in poorly flushed areas, has built up to significant levels. Our views on these contaminants are summarized below in what is judged as their current order of importance.

6. The rate of introduction of nutrients, chiefly nitrates but sometimes also phosphates, is increasing, and areas of eutrophication are expanding, along with enhanced frequency and scale of unusual plankton blooms and excessive seaweed growth. The two major sources of nutrients to coastal waters are sewage disposal and agricultural run-off from fertilizer-treated fields and from intensive stock raising. The degree of damage varies from area to area, reflecting site conditions and nutrient load. Nutrient contamination is costly in terms of lost resources and spoiled amenity but effective remedial action is difficult. It will involve large investments in treatment plants and in sludge and effluent disposal, and major changes in agricultural practices. It is also difficult to relate these inputs to the occurrence of blooms because the quantitative relations between nutrient input and eutrophication are unclear and because of the confounding role of other ecological factors and of climatic variations.

7. Microbial contamination from sewage causes many human diseases, including cholera and hepatitis A. Control requires proper design and siting of outfalls, coupled with rigorous surveillance of shellfish beds and their marketed products, and the timely banning of contaminated seafood. Microbial contamination of sea water

is also responsible for widespread outbreaks of gastro-intestinal diseases at ill-protected and crowded beaches and is a suspected cause of respiratory, ear, and skin infections among bathers.

8. The haphazard disposal of plastic material on land and from ships results in littering of beaches and seriously damages marine wildlife, particularly sea mammals, diving birds and reptiles. These may be injured by the ingestion of plastic fragments, or entrapped in plastic packing and fishing gear. Enforcement of existing regulations on land and at sea, and increased public education, should reduce considerably the amount of plastic refuse, while better design and utilization of plastics for packing and fishing purposes would minimize the risk to marine organisms.

9. Among synthetic organic compounds of concern, chlorinated hydrocarbons, though still high in the sediments of industrial coastal areas and in fatty tissue of top predators such as seals, are now decreasing in some northern temperate areas where restrictions on their use have been enforced long enough. Current levels have not caused widespread harm to marine life so far, with the exception of impaired reproduction in some mammals and fish-eating birds. Contamination appears to be rising in tropical and sub-tropical areas owing to the continued use of chlorinated pesticides there. Because chlorinated hydrocarbons persist in sediments, from which they may be reintroduced to the wider ecosystem, monitoring of organisms and sediments should continue. Recent recognition of the toxicity of the anti-fouling agent TBT for a number of species has resulted in early action to control its use in a few countries, and this control should be extended.

10. Oil is a highly visible contaminant. Notwithstanding the impact of large accidental spills, its main global impact is due to tar balls which, although generally harmless to marine organisms, may foul beaches and interfere with recreational activities, sometimes with major economic consequences in tourist areas. The presence of petroleum hydrocarbons in sea water and particularly in sediments, however, continues to be a matter of concern locally after accidents have released large amounts of oil that accumulate in sheltered areas, affecting amenity and living resources, especially bird life. While the damage is not irreversible, recovery can be slow.

11. Trace elements such as cadmium, lead and mercury, which occur in the marine environment both naturally and as a result of human activities, are now of less concern, except where high levels occur near contamination sources. Their discharge, however, should be kept under surveillance and monitoring should be continued to ensure compliance with current acceptable limits.

12. Radioactive contamination generates widespread public fears. Although artificial radionuclides from a number of sources, including nuclear installations, fall-out from weapon testing and, more recently, from the accident at Chernobyl, have added to the levels naturally occurring in sea water, these additions have had insignificant effects on man and other organisms. Planned discharges of radioactive effluents (e.g. from reprocessing plants) are tightly regulated and monitored, and the amounts currently released are decreasing.

13. While attention is focused mainly on contaminants that are clearly detectable in the sea, there is concern that very low concentrations of toxic substances may produce effects at the sublethal level that could build up over long periods with significant damage to ecosystems. It is recommended that the special studies required to address this problem be encouraged.

14. The global yield of fisheries has continued to increase in the past decade partly by exploiting new stocks, but a combination of overfishing and stock fluctuations due to natural events has led to the decline of certain fisheries and to instability of others. Toxic and microbial agents have not so far affected exploitable living resources on a wide scale, although some stocks, especially of shellfish in limited areas, have been declared

unfit for human consumption. However, coastal nursery grounds and shallow waters are being increasingly degraded, and marine resources, both wild and farmed, could eventually be damaged on a global scale. In addition, the exploitation of living marine resources may degrade the environment by damaging habitats and altering food webs, while mariculture, which is rapidly expanding, generates its own local pollution and may upset the ecological balance by the introduction of exotic species and diseases.

15. These are problems on which action can be identified now. There are additional issues that cannot at present be fully assessed in relation to the seas, namely, the effects of climate change, including a possible rise in sea level resulting from global warming due to increases in greenhouse gases, and the impact of a reduction of stratospheric ozone, which may affect marine resources through increased exposure to ultraviolet radiation.

16. A number of international agreements now supplement national regulations aimed at protecting the seas. They concern mainly pollution from sea-borne sources and have played a role in reducing ocean pollution, particularly by oil residues. However, much remains to be done to control land-based sources, the main contributors to contamination of the sea.

17. We conclude that, at the end of the 1980s, the major causes of immediate concern in the marine environment on a global basis are coastal development and the attendant destruction of habitats, eutrophication, microbial contamination of seafood and beaches, fouling of the seas by plastic litter, progressive build-up of chlorinated hydrocarbons, especially in the tropics and the subtropics, and accumulation of tar on beaches. However, concerns may differ from region to region, reflecting local situations and priorities. Furthermore, throughout the world, public perception may still accord greater importance to other contaminants such as radionuclides, trace elements and oil. These were highlighted in the 1982 GESAMP Review and are considered again in the present report, but we now regard them as being of lesser concern.

18. While no areas of the ocean and none of its principal resources appear to be irrevocably damaged, and most are still unpolluted, while there are encouraging signs that in some areas marine contamination is decreasing, we are concerned that too little is being done to correct or anticipate situations that call for action, that not enough consideration is being given to the consequences for the oceans of coastal development, and that activities on land continue with little regard to their effects in coastal waters. We fear, especially in view of the continuing growth of human populations, that the marine environment could deteriorate significantly in the next decade unless strong, co-ordinated national and international action is taken now. At the national level in particular, the concerted application of measures to reduce wastes and to conserve raw materials will be essential. The efforts will be great and the costs high, but nothing less will ensure the continued health of the sea and the maintenance of its resources.

## INTRODUCTION

### AIMS AND COVERAGE OF THE REVIEW

1. The need to ensure the wholesome condition of the oceans is now generally recognized. As we move into the 1990s it may seem that a reassuring index of the health of the marine environment is provided by the most recent fisheries information from the UN Food and Agriculture Organization, showing that the annual global catch rose in 1987 to a new record of 92.7 million tonnes, with a confident forecast that 100 million tonnes will be reached before the end of the century. However, this yield is attained against the background of overstressed stocks, increasing fishing effort, and a switching to less desirable species, as well as a deterioration of inshore nursery grounds.

2. Semi-enclosed areas are increasingly showing signs of pollution, raising the question of whether all coastal zones, including well-flushed areas, will become damaged to the same degree, and whether eventually even the open ocean will be affected. An adequate assessment of the present state of the marine environment must take into account all the pressures on the world's seas, the changes in our understanding of marine ecology and pollution, and the new attitudes to environmental quality that are emerging.

3. While acknowledging that marine pollution arises from the actions of man, it is becoming clear that it cannot be attributed solely to activities performed directly in the oceans. This report, then, begins by identifying and discussing the main human activities that affect the marine environment. These involve a diversity of operations along the coastline, as well as the manipulation of the hydrological cycle and various land-use practices often carried out far inland; they include offshore activities such as waste disposal and marine transportation, and also the exploitation of marine resources, living and non-living.

4. Since these activities are often associated with the production of chemical wastes, the report goes on to examine the concentration and distribution of chemical contaminants in the sea. The validity of many earlier measurements is questioned, and the difficulties of obtaining reliable data that can be used to detect changes and recognize long-term trends in time and space are highlighted. The general inadequacy of the data base is emphasised, in particular the paucity of information for the open ocean and for inshore areas in some parts of the world. The significance of the observed contaminant levels is discussed, and special attention is paid to a number of substances of common concern at present, including synthetic biocides, radioactive materials and oil residues.

5. The biological impact of man's activities is considered, particularly the effects of wastewater discharges on human health, and the changes of inshore ecosystems caused by nutrient inputs. The increasing loss of natural coastal habitats around the world is documented, with special reference to wetlands such as mangrove forests, to seagrass beds and to the very sensitive coral ecosystems. Longer-term problems include the possibility of subtle effects of persistent low levels of contamination, as well as the effects of an increased ultraviolet flux due to depletion of the stratospheric ozone layer, and the consequences of increases in the "greenhouse" gases which are expected to produce a rise in sea level and a change in climate patterns with unknown effects on marine ecosystems.

6. The increasing world population, its preferential settlement in the coastal zone and the resulting industrialization of that area will only exacerbate the problems at the margins of the seas, in contrast to the open oceans. These problems arise at a time of increasing environmental awareness, and it is important that a broad and balanced view be taken of how best to protect the environment. The essential linkage between terrestrial, aquatic and marine compartments should be recognized, and all available options considered.

7. At the same time it is important to distinguish between perceived and real problems, recognizing that the assessment of an issue by the scientific community may differ from that of the general public. While public perceptions, however insubstantial, must be taken seriously, and while it is entirely proper that political action should take account of them, efforts should be made to provide rational explanations and ensure that the public is well informed about the state of the current knowledge. It should also be recognized that what is possible and indeed mandatory for an industrialized country may need to be viewed in a different light in the developing world.

8. Against this background, the report considers the existing mechanisms for protecting the marine environment and controlling pollution. It refers to their national and international aspects and concludes with an overview of the most important problems facing the seas.

9. Almost ten years have now passed since GESAMP presented its first report on the Health of the Oceans. It is relevant to note briefly some of the changes that have taken place in that decade. Analytical techniques have been improved, satellite observations have come into use for large scale studies, techniques for process control and pollution abatement have been further developed, new national legislation and regulations have been introduced, and international agreements reached on a wide range of environmental issues. Significant changes have occurred in the pattern of energy use, with associated reductions in the amount of oil transported at sea. Finally, there have been some major accidents involving shipping, the chemical industry and nuclear installations. The scientific literature on marine pollution has increased by at least 50 per cent. A greater degree of public interest and sensitivity to the environment has developed, raising expectations and causing changes in priorities for action. These are reflected in the discussions that follow.

10. The purpose of the report is to document and assess the current state of the marine environment, and to identify the major global concerns and priorities for action in both the short and the medium term. Longer-term issues associated with increases in levels of atmospheric CO<sub>2</sub> and other greenhouse gases are being dealt with by a number of other international groups and are only briefly reviewed here.

11. While primarily addressed to the Executive Heads of the organizations that support GESAMP, the report also aims at providing a balanced assessment of the state of the marine environment for other national and international policy-makers, and for the concerned lay public in general.



## **I. HUMAN ACTIVITIES AFFECTING THE SEA**

12. In discussing the state of the oceans it is appropriate to focus on those human activities that are likely to affect the marine environment. This chapter examines the most important of them. For some the impact is a matter of immediate concern, particularly where human health is involved, and prompt action is required. For others, there will be consequences only in the medium or long term, but it is none the less important to recognize problems as early as possible so that effective measures can be initiated before damage occurs.

### **A. DEVELOPMENT OF COASTAL AREAS**

13. The coastline is a complex region comprising bays, estuaries, and large semi-enclosed areas where human populations and industrial development are concentrated. It is the focus for contaminants from inland areas as well as from developments along its length. Most of the sources of contamination discussed in this chapter contribute directly or indirectly to problems in the immediate coastal zone, and arise from activities specifically located there.

14. Although a relationship between human population increase and environmental change has long been recognized, attempts have been made only recently to assess the cumulative impacts of land development in the coastal zone by recording their physical, chemical and biological consequences. This requires knowledge of trends in water quality, and an understanding of the management of aquatic habitats. Equally important is the economic analysis of damage to natural resources and human health against which the cost of control measures will need to be justified. Many of the impacts recorded are common to most coastal developments, but it is useful to consider industrial and recreational activities separately.

15. The development and maintenance of ports and harbours is of prime concern to human populations. Water exchange in these areas is often limited and shipping activities introduce contaminants, including oily wastes, cargo escapement and human wastes released from shipboard. These are subject to national and international regulations, but contamination at ports is difficult to control since it enters the sea by many routes, including discharges from pipes, run-off from streets, roofs and parking areas, and inputs from the atmosphere. Also, harbours are the first point of contact with the sea for many rivers, which add a wide variety and large quantity of land-derived material.