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(of UNESCO)

REPORT OF THE MEETING OF THE *AD HOC* PANEL FOR THE HEALTH OF THE OCEAN MODULE OF GOOS
Paris, 23-26 February 1993

1. OPENING

The Chairman of the Committee for GIPME, and Convener of the Meeting, Dr. Neil Andersen, called the meeting to order by 09.30, on 23 February 1993.

On behalf of the Secretary IOC, Dr. Chidi Ibe welcomed members of the *Ad hoc* Panel. He explained that the meeting had been convened by Dr. Andersen in consultation with the IOC Secretariat in order to prepare a draft plan for the development of the GOOS module on Assessment and Prediction of the Health of the Ocean. He noted that, of the five modules of GOOS, consideration of scientific requirements has only been given to the Climate module, by the Ocean Observing System Development Panel (OOSDP). This is the first Panel, even if *ad hoc,* to be constituted. He congratulated Dr. Andersen for this bold initiative and wished the members successful deliberations.

Dr. Andersen explained the sense of urgency he felt to constitute this Panel, even on an interim basis, to redress the disciplinary imbalance which favoured the physical-climatological aspects in the development of GOOS. He thanked the members of the *ad hoc* Panel, including those who were unable to come for the meeting, for making useful comments to earlier drafts of the preliminary plan which he had circulated. As a result, there was already in hand, a revised preliminary document which would be improved during this meeting and circulated on a limited basis during the Seventeenth Session of the IOC Assembly (25 February-11 March 1993).

A list of participants is attached as Annex 1.

2. ADMINISTRATIVE ARRANGEMENTS

2.1 ADOPTION OF THE AGENDA

A Provisional Agenda which had been circulated earlier to members was adopted with minor amendments as the Agenda for the meeting (Annex 2).

2.2 DESIGNATION OF THE RAPPORTEUR

Dr. J. Michael Bewers was designated Rapporteur for the meeting.

2.3 CONDUCT OF THE SESSION

The Technical Secretary introduced the documents and presented a timetable for the meeting.

3. BACKGROUND INFORMATION

3.1 RATIONALE FOR THE ESTABLISHMENT OF HOOP

The design of GOOS provided for the definition of five inter-related modules which represent user interests and applications.

Owing to the rat' 'r specialized nature of these modules, it was foreseen that an Advisory anel may be needed to plan the strategic, scientific and technical design of each of the five modules.

The *ad hoc* Health of the Ocean Panel (HOOP) had been constituted to plan the development of the module on Assessment and Prediction of the Health of the Ocean. This module aims to establish a framework for monitoring the levels and trends of pollution on global, as well as on regional, scales and for assessment and prediction of the health of the ocean, in particular the coastal and shelf areas. A primary objective is to monitor and assess contaminant loads in the marine environment with particular emphasis being given to the state and response of marine ecosystems relative to both anthropogenic impact and natural climate change, as well as the quality of the water. The data collection and analysis are to be based on the use of commonly agreed methods, standards and methodology. It will include national, regional and global components.

3.2 REPORT OF THE FIRST SESSION OF THE IOC COMMITTEE FOR GOOS

Dr. Wolfgang Scherer, Director of the GOOS Support Office at the IOC Secretariat, briefed the meeting on the outcome of the First Session of the IOC Committee for GOOS which was held in Paris, 16-19 February 1993. Representatives from twenty-six countries were in attendance.

The Committee reviewed the recent major activities relevant to GOOS development and gave particular attention to the structure of GOOS and to its relationship with other IOC activities and interested organizations. The Committee emphasized the importance of establishing effective efficient structures in view of the present and anticipated lack of resources at national and international levels. In this regard, the Committee expressed broad support for existing IOC systems and programmes and for the GOOS implementation strategy that focuses on these activities as a basis. A number of recommendations were made in pursuance of the above stated objectives and targets.

Dr. Scherer then referred to the submission made by the MPU Secretariat to the IOC Committee for GOOS on the need for the formal establishment of not only the Health of the Ocean Panel, but also the related advisory Panels on Marine Living Resources and Coastal Zone Environment and its Changes. He informed the meeting that every effort would be made to develop concurrently all the five modules of GOOS even though they would necessarily develop at different paces. He was pleased to note that HOOP had been initiated in a very timely and efficient manner.

The meeting took note of his Report.

The Meeting welcomed the urgency noted in the recommendation calling upon ICSU-SCOR to assist IOC in the establishment of scientific design panels for the GOOS modules, and urged that such actions be taken as soon as possible so that issues identified by HOOP requiring input from other groups could be resolved effectively.

4. HEALTH OF THE OCEAN (HOTO) MODULE FOR GOOS

4.1 REPORTING STRUCTURE

This Agenda Item was considered premature. It was noted that the reporting structure would depend on the Terms of Reference for HOOP and on the overall reporting structures for GOOS which are still to be agreed upon.

4.2 TERMS OF REFERENCE FOR HOOP

The Meeting modified the Terms of Reference proposed by the Secretariat as follows:

The HOOP will be responsible for:

(i) the strategic development and detailed scientific and technical design of the HOTO module of GOOS;

(ii) maintaining liaison with research activities to ensure that assessment and prediction of the health of the oceans is based on sound and contemporary scientific knowledge;

(iii) co-ordination with other modules of GOOS for the purposes of ensuring the compatible strategic and scientific development of all GOOS modules.

4.3 RELATIONSHIP TO GIPME INPUT TO GOOS

The Meeting recognized that with its three Groups of Experts (GEMSI, GEEP and GESREM) and its experience in coordinating an operational ocean observing system (MARPOLMON), even if with more limited objectives and coverage, GIPME was a resource to be utilized and built upon in the strategic development and scientific/technical design of the Health of the Ocean module. In addition, such a policy would conform with the expressed wish of the IOC Committee for GOOS to utilize and build upon existing structures and activities.

It was also recognized that the membership of the Panel, when formally established, should not be restricted to GIPME members but should draw from the wider scientific community and include representatives of the research programmes involved in climate change studies. The Chairman replied that this was indeed the case with the constitution of the *ad hoc* Panel. Nevertheless, the note of additional expertise will be needed to complete the present task, particularly with regard to molecular biomarkers.

4.4 INTERACTION WITH ADVISORY PANELS FOR OTHER GOOS MODULES

The Meeting noted the inter-related nature of all five GOOS modules and the need for their Advisory Panels to exchange ideas and experiences in the course of developing plans for the scientific and technical design of the various modules to ensure compatibility.

It was, however, emphasized that particular attention should be given by HOOP to its interaction with the Advisory Panels on Marine Living Resources and Coastal Zone Environment and its Changes. The greatest threat to the sustainability of marine-living organisms is posed by the effects of contaminants; such effects can also enormously impact the coastal zone.

4.5 RESOURCES AVAILABLE

The estimates of resources needed to develop GOOS and its modules are substantial. The Seventeenth Session of the IOC Assembly will address amounts and sources of funds to be made available. One of the recommendations made by the First Session of the IOC Committee for GOOS was the establishment of an IOC Trust Fund for GOOS.

The Meeting stressed the fact that the resources now allocated to the GIPME Programme from the Regular Budget and IOC Voluntary Contributions are too meager to be chanelled, even in part, toward the work of this Panel.

5. GOALS OF THE FIRST SESSION OF THE *AD HOC* PANEL

The Meeting agreed that the primary role of the First Session of the *ad hoc* Panel was to produce a draft of a plan for the strategic development and scientific/technical design of the Health of the Ocean Module of GOOS, using as the basic working document a preliminary draft circulated earlier by the Chairman to all members.

After a detailed discussion of Agenda Items 5.1 and 5.2, members of the *Ad hoc* Panel were assigned specific tasks aimed at updating the preliminary document in view of the specific and general comments that were made.

After discussion and unanimous agreement, the Chairman undertook the task of producing the final draft of the Plan. The document, which is not to be cited at this stage, will be reproduced and distributed for further comments during the Seventeenth Session of the IOC Assembly.

6. FUTURE ACTIVITIES

6.1 MEMBERSHIP/COMPOSITION

The Meeting considered the present membership of the *Ad hoc* Panel adequate to fulfill the tasks, noting however, that in order to obtain as broad a spectrum of opinion as possible, there will be a need to include and/or consult with other experts with affiliations other than those of IOC and its traditional partners, both within and outside the UN system, particularly with respect to measurements of molecular bio-indicators.

6.2 OBSERVERS (JGOFS, GLOBEC, LOICZ, etc.)

The Meeting took note of the importance to have, as observers, experts from research programmes such as JGOFS, GLOBEC, LOICZ, etc. and entrusted the Chairman with making the necessary contacts.

6.3 INTERACTION WITH ADVISORY PANELS OF OTHER GOOS MODULES

The Meeting reiterated the need for HOOP to be involved in the development and design of other modules of GOOS and *vice versa* to ensure compatible development of all five modules.

7. DATE AND VENUE FOR THE SECOND SESSION OF THE *AD HOC* HOOP

The Meeting decided to take advantage of the GIPME-VIII Session later in the year to organize a second meeting of the *ad hoc* Panel. It was proposed to convene a second meeting of HOOP in October/November 1993 at the Bermuda Biological Station for Research if GIPME VIII was deferred beyond 1993.

8. CLOSURE

The IOC Technical Secretary thanked the Chairman and members of the *Ad hoc* Panel for the time and effort they put into making the meeting a success.

The Chairman informed the Meeting that the review of the Draft Plan will be an ongoing process and hoped he could continue to count on the support of the members of the *Ad hoc* Panel now and after it has been formally established.

The Chairman closed the Meeting at 12.30, Friday, 26 February 1993.

ANNEX I

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ANNEX II

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The Strategic Development of The Health of the Ocean Module for GOOS

March 1993

I. Introduction

At the present time there are unprecedented pressures are being felt on our natural resources. Sustainable development of these resources is hindered by an inability to detect emerging environmental problems at an early stage when remedial measures are still possible. Nowhere is this inadequacy so pronounced as in the marine area. Global energy cycles and the biological processes upon which all life depend are critically influenced by the ocean. But knowledge of the ocean and humanity's impact on it is only now beginning to reveal the complexity and interdependence of all aspects of the system. Improved knowledge and predictive capabilities are required for more effective and sustained use of the marine environment, with the associated economic benefits.

The two conventions signed at the UNCED Conference require the establishment of an adequate observing system to help develop understanding and to monitor change. Many of the processes which control the variability and change of global climate are themselves controlled by processes in the ocean. Public perceptions of risk are only eased when governments are seen to be keeping a close watch on the environment, including the ocean.

The major oceanographic processes that regulate the ocean's role in determining how the Earth System functions have variabilities over periods of decadal time scales. These time scales exceed the anticipated lifetimes of the various global research programs that have been, and are being implemented to study ocean circulation (e.g.WOCE), chemical fluxes (e.g. JGOFS and LOICZ) and the dynamics of ecosystems (e.g. GLOBEC). These long term variations are associated with, *inter alia*, issues of climate change, the state of the health of the ocean, biological diversity, human health, coastal zone management and their socio-economic impacts. Thus, it is essential that as the coordinated research endeavors presently investigating the role of the ocean in the Earth System draw to a close, the relevant parameters continue to be measured. To do this, continuing systematic, long term global observations of marine physical, chemical and biological parameters, analogous to the World Weather Watch, operating under the auspices of the World Meteorological Organization (WMO), are required.

The observations that are made must have a character of being long term (i.e. time-series), systematic, relevant to the role the ocean plays in changes occurring in the Earth System, cost effective and routine. And, the data that is obtained must be intercomparable. Data collected from such an ocean observing system must be provided to the world community in a timely fashion and must be systematically managed and archived.

The purpose of this document is to put forth the strategy and detailed scientific and technical design for the Assessment and Prediction of the Health of the Ocean (HOTO) Module of the Global Ocean Observing System (GOOS).

II. International Agreements and Actions

The idea of observing the ocean from a global perspective is not new. In recognition of the need for a global system, a series of national and international reports beginning in the early 1970's laid out the elements for systematic long-term ocean measurements (e.g. SCOR Working Group No. 48, 1977; CCCO, 1984).

The Intergovernmental Oceanographic Commission (IOC) Assembly, at its XIVth Session in 1987, agreed to accelerate the development of ocean observing systems and at its XVth Session in 1989 adopted Resolution IOC-XV-4 to initiate development of a GOOS. The World Meteorological Organization (WMO), at its IXLst Executive Council in 1989 adopted a resolution to cooperate with the IOC on this initiative. Additionally, the Second World Climate Conference in 1991 concluded that there is an urgent need to create a Global Climate Observing System (GCOS), building upon existing systems to the extent possible, in particular, the Integrated Global Ocean Services System (IGOSS), the World Weather Watch (WWW), and the establishment of a GOOS. At its XVIth Assembly in 1991, the IOC re-confirmed its decision to undertake development of a GOOS. As a result of decisions by the WMO Congress and the United Nations Environment Program (UNEP) Governing Council in 1991, climate-related components will be developed jointly with the WMO as the ocean component of a GCOS, and coastal monitoring components will be developed jointly with UNEP and WMO. In addition, discussions are presently underway with the International Council of Scientific Unions (ICSU) for their co-sponsorship. The XXVth Session of the IOC Executive Council, in 1992, agreed to replace the Committee on Ocean Processes and Climate (OPC) with an Intergovernmental IOC Committee for GOOS and in the future establish a GOOS Technical and Scientific Advisory Panel (J-GOOS).

In 1992 the United Nations Conference on Environment and Development (UNCED) also called for a GOOS, in Agenda 21, the blueprint for action that was adopted at the United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992. In two chapters, those on Atmosphere and Oceans, the document stresses the importance of addressing the uncertainties and improving the scientific basis for decision making. Chapter 17 includes the following: "States should consider, *inter alia*,: Supporting the role of the IOC in cooperation with WMO, UNEP and other international organizations in the collection, analysis and distribution of data and information from the ocean and all seas, including, as appropriate, through the proposed Global Ocean Observing System (GOOS), giving special attention to the need for IOC to develop fully the strategy for providing training and technical assistance for developing countries through its Training, Education and Mutual Assistance (TEMA) Program.

The same chapter also cites threats posed by marine contamination (e.g. sewage, agricultural chemicals, synthetic organic compounds, litter, plastics, radioactive substances and hydrocarbons) and calls on States to set up systematic observation systems, expand existing systems such as the International Mussel Watch (see below), and establish a global profile and database for information on the source, types, amounts, and effects of marine pollutants.

GOOS will also contribute to two other agreements reached at UNCED; the Framework Convention on Climate Change and the Convention on Biological Diversity. For example, the Framework Convention on Climate Change requires contracting parties to "promote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system...". The Convention on Biological Diversity requires contracting parties to "monitor, through sampling and other techniques, the components of biological diversity" (defined as including "terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part").

III. The Concept of the Global Ocean Observing System (GOOS)

The goal of the GOOS is to provide a mechanism for the coordinated management of data and data products generated from satellite and *in situ* observations of the major physical, chemical and biological properties and processes of the ocean, including the coastal zone and enclosed and semi-enclosed seas. It is intended that GOOS will use a globally coordinated, scientifically based strategy to allow for coordinated monitoring and subsequent prediction of environmental and climate changes globally, regionally and nationally.

The GOOS will be established by Member States and implemented through nationally owned and operated facilities and services. Coordination will be provided by the IOC in cooperation with WMO, UNEP and ICSU. The GOOS is to be based on the principle that all countries should participate and that participants should make certain commitments, according to their capabilities to fulfill such commitments, so that all countries can benefit.

The GOOS will be developed from operational and scientific data gathering systems and activities already in place, such as IGOSS, MARPOLMON, IODE AND GLOSS, and JGOFS, WOCE and TOGA.

Observations should be :

o **Long term.** Measurements once begun should continue into the indefinite future; continuity in the observed quantity is to be sought, rather than in the method, as it is anticipated that more effective methods may become available in the future.

o **Systematic.** Measurements should be made in a rational fashion, with the spatial and temporal sampling as well as the precision and accuracy tuned to address the specific aspects of the GOOS.

o **Relevant to the global system.** Measurements should be made either to document the ocean parameters important to the issues underlying the modules of the GOOS, or to provide data needed to initialize and validate models that describe and predict these parameters on a seasonal to decdadal time scale and beyond.

o **Measurements should be cost effective.** Efforts should be made to maximize the return on available resources (financial as well as manpower) by applying observational methods that are economical and efficient.

o **Measurements should be routine.** The observations should be considered as part of the normal work load, with the acquisition, quality control, and dissemination of products to be carried out with regularity.

The GOOS will be comprised, *inter alia*, of:

o The maintenance and enhancement of research programs on key components of the ocean system, such as the World Climate Research Program (WCRP) and the International Geosphere-Biosphere Program (IGBP).

o Existing global, regional and national monitoring activities, including those sponsored by international organizations (e.g. the Global Sea Level Observing System (GLOSS), the Global Investigation of Pollution in the Marine Environment (GIPME) and its Marine Pollution Monitoring System (MARPOLMON), the Integrated Global Ocean Services System (IGOSS) and improved World Weather Watch (WWW) Systems).

o Data communication and other infrastructures necessary to support operational ocean forecasting.

Sponsors have agreed that GOOS is to be comprised of the following five "application modules", whose objectives may overlap and share some of the same data (e.g., the data and information generated from all modules will contribute to the needs of Coastal Zone Management and Development), but which have distinct purposes:

- o Climate, Monitoring, Assessment and Prediction, including seasonal and interannual variability
- o Monitoring and Assessment of Living Marine Resources
- o Coastal Zone Management and Development
- o Assessment and Prediction of the Health of the Ocean
- o Marine Meteorological and Oceanographic Services

IV. Status of International Planning for GOOS

Close interaction is taking place with relevant scientific groups in order to insure a sound scientific design. A joint SCOR-IOC-JSC Ocean Observing System Development Panel (OOSDP) is formulating the design of the aspects of the system which will contribute to climate prediction and is slated to complete its work in December 1994. A Joint GOOS Scientific and Technical Committee will be formed in cooperation with ICSU and its Scientific Committee on Oceanic Research (SCOR) with the following terms of reference:

a) To advise the IOC Committee for GOOS on all scientific and technical aspects of GOOS, including the plans for various aspects of GOOS;

b) To identify observational requirements, define design objectives and recommend coordinated actions by sponsoring and participating agencies and organizations, in order to optimize the system's performance and coherence, taking cognizance of the responsibilities, working arrangements and recommendations of established technical and scientific bodies of such organizations and agencies;

c) To collaborate with the Joint WMO-IOC-ICSU-UNEP Scientific and Technical Committee for GCOS;

d) To review and assess the development and implementation of the components of the GOOS, and report to the sponsoring organizations;

e) To facilitate the exchanges of information among sponsoring and participating organizations and agencies and in general, make the objectives, resource requirements and capabilities of GOOS known to relevant national and international bodies; and

f) To promote ocean research required for an improved understanding, modeling and prediction of the climate system.

In addition to physical parameters, being presently addressed by the OOSDP, biological and chemical variables of the ocean are needed. To address the chemical need, as well as certain biological requirements for addressing the effects of pollution, a second panel, the Health of the Oceans Panel (HOOP), has been established to design the module concentrating on the health of the ocean, making due consideration of the on-going work of, inter alia, the IOC-UNEP Program on the Global Investigation of Pollutants in the Marine Environment (GIPME). This is not meant to imply that chemical and biological parameters will not be considered by other modules (e.g. OOSDP includes CO_2 in their considerations because of the climate change connection and any module created to address living resources will be heavily biologically oriented) as inputs to GOOS.

The IOC Committee on GOOS (ICG) held its first meeting 16-19 February 1993. This group consists of representatives of governments who are responsible for promoting, coordinating, implementing and managing GOOS and for identifying necessary resources.

V. Examples of Existing Global and Interregional Programs Dealing with Marine Environmental Quality Issues

The first test of a global chemical contaminant monitoring system was MAPMOPP within IGOSS. Petroleum contamination was the parameter that was measured with the result being that it was demonstrated that the system worked.

Some ongoing ocean observing activities are presently underway, including the IOC-WMO Integrated Global Ocean Services System and the Global Sea Level Observing System, which presently largely serve major climate research programs. These systems are limited to measuring physical oceanographic parameters. The IOC-UNEP-IMO Marine Pollution Monitoring System (MARPOLMON) of GIPME is the combined assembly of regional operational data gathering activities for selected contaminants in the marine environment, with a view to providing a global assessment of marine contamination. It excludes work not specifically directed at regional issues such as the development of methods for widespread application, preparation of reference materials and all projects addressing open ocean issues. Training workshops and intercomparison exercises are convened in the various regions to promote their monitoring effectiveness. The level of activity varies between regions.

The Regional Seas Program of UNEP was initiated in 1974 as a global program implemented through its regional components. Presently there are thirteen regions with close to 140 coastal states and Territories participating. The program is under the over all coordination of the Oceans and Coastal Areas Program Activity Center (OCA/PAC) of UNEP. In the past, OCA/PAC activities traditionally consisted of two separate categories, The Regional Sea Program and other activities (i.e. global and general). The latter category included such subject matters as climate change, global monitoring, environmental impact assessment, living marine resources and marine mammals, etc. Recently, in order to respond effectively to the demands for integrated coastal area management on the basis of national priorities within a regional context, these two categories have been merged so that in each Regional Seas Program, as appropriate, relevant global issues and activities have been apportioned. Because UNEP is a co-sponsor of GIPME, the marine pollution programs of the IOC and UNEP are closely coordinated.

In order to provide a mechanism ensuring globally available data quality assurance services for contaminant measurements, the IAEA, with support from UNEP and IOC established the Marine Environmental Studies Laboratory (MESL) in 1986 as a section of the then International Laboratory for Marine Radioactivity (ILMR) in Monaco. MESL organizes intercomparison exercises regionally and world-wide and acts as a center for testing and editing the UNEP Reference Methods for Marine Pollution Studies, with technical support from the GIPME expert groups. It organizes locally and regionally based specialized training courses, instrument maintenance services, pilot monitoring studies and acts as the Regional Analytical Center for the Mediterranean Action Plan. The experience gained in the operation of this center can be applied in the provision of similar services for GOOS, in general, and its HOTO Module, in particular.

Of relevance to integrated coastal area management, is the Unesco Coastal Marine Ecosystem (COMAR) Cooperation Program with its network of regional and inter-regional projects in Africa, Asia and the Pacific, Latin America and the Caribbean. A COMAR/International Union of Biological Science (IUBS) - International Association of Biological Oceanography (IABO) Task Force on Marine Biodiversity and Ecosystem Function and a UNEP/Unesco (COMAR) Task Team on the Impact of expected climate change on mangroves were set up.

An existing program that can be considered a prototype of continuing efforts needed internationally to monitor the health of the ocean is the IOC-GIPME International Mussel Watch Program, being carried out by the IOC, in collaboration with UNEP and the U.S. NOAA. Begun in 1991, this project includes the collection of bivalve samples in Central and South America to quantify the sources and rates of input of wastes for identifying the current status of ocean health in that region. With the continuation of the collection of samples and subsequent analyses by the participating laboratories in the countries, a data base will exist for identifying trends. Approximately 300 samples from 80 coastal sites on both east and west coasts of the region are presently being analyzed at two referee laboratories, the Geochemical and Environmental Research Group at Texas A&M University, College Station, Texas, U.S., and at the MESL, in Monaco, as well as national laboratories in the participating countries. Additional tissue samples will be available for further in-country analysis and inter-laboratory comparison. The project complements a U.S. NOAA Mussel Watch Program begun in 1984 to monitor the North American coastline, as a follow-on to a prototype program initiated by the U.S. EPA in 1976. Further, samples have been collected and provided by Canadian participants which effectively has the program covering the Americas. A meeting in Brazil is scheduled for April, 1993, where the results of this phase of the program will be discussed and subsequently published. Planning for the next phase, the Asia-Pacific Section, has begun and a meeting was convened in January, 1993, at the University of Tokyo to further develop plans for closing the Pacific Rim. In addition to generating high quality data on chlorinated hydrocarbon and PCB concentrations and a quasi-synoptic baseline of the contamination in this global area, the International Mussel Watch project is serving as a field test for a global chemical contaminant monitoring program.

In providing the details above for the International Mussel Watch Program, this should not be interpreted that there are not some fairly simple measurements that could be made at the land-sea interface and within the coastal zone that would provide valuable information for assessing the relative state of the coastal areas. In addition, more infrequent measurements in the offshore region would give some indication of trends in a more regional context (e.g. character of outflows from constrained regional sea areas). Also, use should be made of shelf transects that are included in the conceptual design of the Open Ocean Baseline Project of GIPME.

The above examples are important to note because GOOS will be built as far as possible on existing activities and bodies as well as on the progressive implementation of new elements and capabilities. It will be updated and improved in response to results of research programs and the development of new technology. Present national and international infrastructures and mechanisms that are the result of many years of effort and cooperation will be used. Because the experience of those who have developed present systems is a critical requirement, representatives of present programs are being asked to help in the development and planning of GOOS; essentially forming the collective scientific advisory resource.

VI. Development of the Health of the Ocean (HOTO) Module of GOOS

The objectives of the HOTO Module of GOOS are to provide assessments of the state and trends regarding contamination of the marine environment and its effects; and to this end, conduct monitoring of the marine environment, and incorporating necessary considerations relative to bioindicators.

This GOOS module aims to establish a framework for addressing the monitoring and assessment of the state of the marine environment and the detection of trends in contamination and pollution in a comprehensive manner, and including the coastal ocean, enclosed and semi-enclosed seas and the open ocean, to allow for a global assessment. A primary objective of the observations is to monitor and assess contaminant loads in the marine environment. The resulting data will be used in giving particular emphasis to determining the state and response of marine ecosystems relative to both anthropogenic impact and natural climate change as well as the quality of the water. This module of GOOS can be considered to be an early warning system.

The following set of terms of reference below for the HOOP has been constructed to meet the responsibility of developing the HOTO Module for GOOS.

Terms of Reference of HOOP

The HOOP will be responsible for:

- the strategic development and detailed scientific and technical design of the HOTO module of GOOS;
- maintaining liaison with research activities to ensure that assessments and predictions of the health of the oceans is based on sound and contemporary scientific knowledge;
- coordination with other modules of GOOS for the purposes of ensuring the compatible strategic and scientific development of all GOOS modules.

Central to the objective and terms of reference of the HOTO Module and Panel is a definition of the term "Health of the Oceans" and identification of the environmental health criteria, or bioindicators, that can serve as early warning symptoms of change in the quality of the marine environment.

The term "Health of the Oceans" is operationally defined for the purposes of the HOTO Module of GOOS as a reflection of the condition of the sea from the perspective of adverse effects caused both by the production and mobilization of contaminants by anthropogenic activities and other human activities. Such condition refers to the contemporary status of the ocean and the prognosis for improvement or deterioration in its quality.

The measurement of contaminant loads by itself cannot provide comprehensive quality criteria. Bioindicators will have to be identified at three levels: organisms/individuals; populations; and communities. Enzymatic disturbances and pathological manifestations will be needed to reflect responses at the individual organism level. At the population and community levels, pollution might manifest itself in changes in the scope for growth, the reproductive success of species, the disruption of the dynamic balance between producers and consumers, or deviations from the natural range of biomass variability leading to abnormal phytoplankton blooms or mono-specific swarms. Regional key ecosystems such as sea-grasses, soft bottom communities, mangroves, coral-reefs and others will require identification of more specific bioindicators. In all cases, bioindicators will have to be assessed against the background of natural variability. HOOP will benefit in this respect from the contribution of experts in this major aspect of its mandate and this will be considered in defining its composition.

It has been assumed that each GOOS Module will acquire data to fulfill its own objectives, particularly with regard to the delivery products. Thus, in the case of the HOTO Module for GOOS, data are to be acquired that enable assessments to be made of the state of, and trends in, contamination and pollution of the marine environment.

It is also assumed that each module delivers its data to the GOOS Core and can implicitly benefit from the receipt of data collected within other modules(See Figure 1). It is recognized that there may be significant overlaps (i.e. partial duplication) among the measurements required by individual modules and that this, given the correct type and level of coordination, offers economies in avoiding such duplication. Similarly, there will be elements of the interpretative products of individual modules that will be relevant to interpretative products of other modules. Again, appropriate coordination within GOOS should ensure both economy and effectiveness in the aggregate operational activities if GOOS.

These considerations emphasize the need for, and benefits of, coordination among the modules and that it is essential that the designs of each GOOS Module specify data and interpretation required from other modules.

VII. Previous Activities Relating to The Health of the Ocean in GOOS

GOOS planning efforts over the last three years have focused on the climate module through the efforts of the OOSDP. It is clear that attention now needs to be given to developing the GOOS module for assessing and predicting the health of the ocean, being based on the available scientific and technical knowledge that presently exists. For example, the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) concluded that in 1989 man's fingerprint was found everywhere in the oceans (GESAMP, 1990).

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. The open ocean is still relatively clean. Low, but anthropogenically enhanced levels of lead, synthetic organic compounds and artificial radionuclides, though widely detectable, are biologically insignificant. Oil slicks and liter are common along sea lanes, but are, at present, of minor consequence to communities of organisms living in open ocean waters. In contrast to the open ocean, the margins of the sea are affected by man almost everywhere, and encroachment on coastal areas continues worldwide.

The above are some of the problems on which action can be identified now. There are additional issues that cannot at present be fully assessed in relation to the oceans, 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 reduction of stratospheric ozone, which may affect marine resources through increased exposure to ultraviolet radiation.

GESAMP concluded that at the end of the 1980's, the major causes of immediate concern in the marine environment on a global basis were coastal development and the attendant destruction of habitats, eutrophication, microbial contamination of seafood and beaches, fouling of the oceans by plastic litter, progressive buildup of chlorinated hydrocarbons, especially in the tropics and subtropics, and accumulation of tar on beaches.

It is relevant to note here that the IOC Open Ocean Baseline Project, being carried out within GIPME, has corroborated the above views with regard to the open ocean in the early 1990's. The first phase of this project took place in 1990 where 4 deep water stations in the Cape Basin, Angola Basin, Cape Verde Abyssal Plain and Seine Abyssal Plain were sampled for at least 36 depths each. Additional samples were collected underway between the stations. Generally, very low levels of trace elements (i.e. Mn, Ni, Cu, Zn, Pb, Cd and Se)were found in filtered and unfiltered water samples from these very remote areas in the open Southeast Atlantic Ocean. A second expedition will take place in the Northwest Western

Atlantic Ocean in 1993, which will add to this open ocean baseline information base. In addition to trace metals, organics will be included in this endeavor.

Many of today's environmental problems stem from insufficient attention to the need for environmental protection in the course of large scale development. Often this inattention has been and still is caused by a fundamental lack of knowledge of the effects of human activities on our natural resources. We do not yet have sufficient understanding nor an adequate data base to accurately predict the future state of the environment, to effectively assimilate and analyze the increasing amounts of data on the global ecosystem, and to wisely decide the appropriate balance between economic development and environmental stability. The marine environment is a pronounced example of this lack of knowledge. We do not have an information base to decide the level of economic development that the marine environment and its resources can sustainably support.

What is known is that pollution in the marine environment has become an issue of grave concern to all coastal states. Ample evidence now exists that the oceans cannot provide an infinite sink for anthropogenic wastes. However, little attention has been given to the limits of capacity of coastal areas to assimilate wastes. Examples of fisheries closures, spoiled beaches, destroyed coral reefs and wildlife habitat, toxic blooms and lost coastal ecological communities can be found throughout the world. IOC-EC-XXV recognized the importance of giving attention to the coastal zone by giving instruction to the Secretary of the IOC to further co-ordinate international programs in the coastal zone so as to achieve a global, holistic and scientifically based approach to interdisciplinary coastal zone research, systematic observations and related capacity and capability building, in the service of the national management responsibilities.

About 80% of pollution reaching the oceans stems from land-based sources through the various pathways of the atmosphere, direct discharges, rivers and run-off. The problem is amplified by the fact that this major source of contamination impacts mostly on the relatively fragile coastal zone. Ocean disposal of wastes and the discharges from marine shipping and offshore activities and natural sources make up the remaining 20% This situation was recognized a major problem by UNCED in Agenda 21, Chapter 17.

VIII. The GOOS Assessment and Prediction of the Health of the Ocean Module

The Climate Monitoring, Assessment and Prediction; Monitoring and Assessment of Marine Living Resources; and Assessment and Prediction of the Health of the Oceans Modules of GOOS constitute the basic scientific elements that have both contributory and delivery responsibilities. Each should be designed from a global scientific perspective to acquire data and information as a contribution to GOOS. Each also has to have delivery responsibility in terms of assessments of state and change. The Marine Meteorological and Oceanographic Services should be developed, again from a global perspective, to provide additional data in relation to improving short and medium term weather prediction. Thus, it again constitutes a contributory and an evaluation role in relation to forecasting.

It is assumed here that The Coastal Zone Environment Module plays a somewhat different role in GOOS. Its delivery responsibilities are clear in the sense that assessments of the state and change deal only with coastal margins which include both marine and terrigenous components. Therefore, it should be primarily a beneficiary of the data and information provided to GOOS by the other four modules. Its contributory role would appear to be limited to measurements made in the coastal zone for assessment and management purposes. These would seem to include primarily information of a demographic, socio-economic and political nature, predominantly in the regional context, to enable the effects of change, the potential for sustainable development, and compromise of existing amenities to be determined. Accordingly, it is suggested that this module should differ somewhat from the other GOOS Modules in terms of its perspective and its beneficiary and contributory roles within GOOS. Axiomatically, because the coastal zone module needs to use data provided by the other modules, its development should be based on, and follow, the design of the other four modules.

The extent of existing pollution in the marine environment is not quantitatively and precisely defined because of the absence of comprehensive information on the presence of contaminants and their effects. This, in turn, is due to the inefficiency and lack of uniformity in monitoring and assessment programs in many parts of the world's oceans. Because of this lack there are many problems that are poorly documented, many for which the impact is not recognized and certainly some that are not even realized. This lack of knowledge has resulted in such extreme events as the deaths from mercury poisoning in Japan many years ago to more recent events such as deaths caused by algal blooms and shellfish poisoning, and the extensive hypoxia realized in coastal waters such as the Middle Atlantic Bight and the Louisiana Inner Shelf.

Data collection and analysis in the HOOP Module must be based on the use of methods, standards and collection strategies that produce globally comparable data, archived in common formats, that allow ready access to users (e.g. modelers). Sampling must also be sufficiently intensive and of sufficient duration to determine the long-term mean (climatology) and anomalies or deviations from that mean. It is also argued by some that often the effect of an increased contaminant load on biological systems is to increase variance, while the mean stays the same. Unfortunately, this fact is not generally appreciated and monitoring systems hardly ever take this into consideration. As a result, sample designs must take account of this. Nevertheless, it will never be possible to sample the ocean densely enough in space and time to provide an adequate description by measurement alone. Ideally the monitoring programs will include efforts to understand processes to the point that conceptual and numerical models can be developed so that these models, along with reasonable real time data inputs, can predict the impacts of increased inputs, or controls on them. Only by assimilating the data into suitable models will maximum advantage be taken of the data. Thus, the design of Health of the Oceans Module should include considerations of what data are most desirable for assimilation into models.

The module will aim at providing basic information on key ecosystems and on the levels of contamination and pollution in the marine environment. Preliminary emphasis will be on measurements being made in coastal regions and on the related biological effects including population and community changes, with the results being also useful in considerations on, *inter alia*, human health, seafood safety, and coastal and river/estuarine drainage basin land use and development. Regional elements will include observational networks focusing on specific problems within each region, presently being identified by GIPME, as well as elements allowing equitable comparison among regions as to the effects of more ubiquitously distributed contaminants. This will allow catastrophic events (e.g. fish kills and outbreaks of harmful algal blooms) to be evaluated within the background of climatology derived from the continuous program.

The regional elements, which are to cover all geographic areas, in turn, will be linked to a less dense network of oceanic observations to provide a global oceanic perspective, detect broad trends, and provide an early warning capability. Retrospective studies for variables to be monitored (e.g., by using sediment records) should be developed to allow establishment of an initial climatology and allow interpretation of present day levels of these variables in terms of anomalies in respect to it. The products will also serve the needs for effective national and international implementation of aspects of the UN Convention on the Law of the Sea and provisions of the Montreal Guidelines for the Protection of the Marine Environment against pollution from Land-Based Sources as well as other agreements and conventions dealing with pollution of the marine environment.

Difficulties cannot be overstated in determining causes and effects of marine contaminants. A study in the United States (National Research Council, 1990) concluded that many environmental monitoring programs have failed to provide the information needed to understand the condition of the marine environment or the effects of human activity on it. Three reasons were cited: a) monitoring programs may be poorly designed and the technology inappropriately applied; b) information is rarely presented in a form that is useful in developing broad public policy or evaluating specific control strategies; and c) there is presently limited scientific knowledge and predictive capability about these complex chemical, biological and physical interactions. A consideration that exacerbates the latter situation is that it is not clear that adequate effort has been devoted to evaluating the results of all the existing monitoring programs to determine if they are meeting their goals or need revision in order to improve their cost effectiveness.

One such program, the IOC/UNEP/IMO Global Investigation of Pollution in the Marine Environment (GIPME) is intended to provide one contribution to this module of GOOS through the delivery of marine scientific data on conditions in the marine environment reacting primarily to chemical characteristics, fluxes and effects that constitute essential elements of the program as originally conceived IOC Tech. Ser. No. 14, 1976) and strategically developed (IOC Tech. Ser. No. 25, 1983). GIPME, as jointly sponsored by the IOC, UNEP and IMO, has two major objectives as illustrated in Figure 2. These are 1) To provide assessments of the State of the Marine Environment and 2) To provide data and information to GOOS, to satisfy the requirements of GOOS and, indirectly, those of Earthwatch and GCOS. However, GIPME has an additional responsibility to develop improved understanding of the processes involving sources, transport, behavior, fate and effects of contaminants in the marine environment. Such improved understanding will also provide benefits to the HOTO Module and GOOS in improving the reliability of assessments and the modeling of GOOS data. It should be noted that GESAMP has also produced periodic assessments of the health or state of the marine environments at the request of its sponsoring UN Organizations.

In view of the foreseen requirement for GIPME to contribute to GOOS, in addition to assessments of the "State of the Marine Environment", there exists a need to reconsider the strategic requirements of GIPME in the specific context of GOOS. This needs to be completed before the harmonization of the respective UNEP and IOC activities relating to GIPME is undertaken to ensure that the combined program fully anticipates its responsibilities and achieves its goals. Therefore it is imperative that HOOP and GIPME work in close collaboration to ensure all requirements of both the Goos Module addressing the health of the ocean and the GIPME Program are met.

IX. Phenomena of Concern Respecting the HOTO Module of GOOS

A. Analytes/Contaminants

The following set of basic variables has been selected in order to describe the state of the marine environment. Additional parameters reflecting the effects of contaminants are required in order to assess the Health of the Oceans and will be introduced in subsequent sections of this report.

Aquatic Toxins

This group of organic compounds consist of those toxic substances produced by marine organisms on a sufficiently large scale in order to induce adverse effects on the human population or on the integrity of communities of higher marine organisms. Examples of these are toxins causing Paralytic Shellfish Poisoning (PSP), fish kills (eg. Gymnodinium toxins); dihorretic shellfish poisoning (DSP), Ciguatera poisoning etc. There is strong evidence to suggest that certain blooms of phytoplankton producing these toxins are induced or sustained as a result of anthropogenic destabilization of marine ecosystems (such as from the consequences of eutrophication).

Artificial Radionuclides

This group consists of radionuclides produced as a consequence of artificially induced nuclear fission or fusion. The radionuclides largely consist of direct products of fission (e.g. Cs-137, Sr-90, I-131) or activation products of the nuclear fuel cladding or weapons casings in order to contain the reaction. Historically major sources of radionuclides are from nuclear weapons testing but currently, significant quantities of these contaminants are restricted to controlled or accidental release of effluents from nuclear power reactors, fuel reprocessing plants and waste material dumped at sea.

Pesticides/Herbicides

This group includes all the insecticides, herbicides and fungicides. The environmental half-life of the several hundred individual compounds in these categories varies from days (e.g. Malathion) to decades (primary degradation products of DDT). The group thus embodies an enormous range of chemical properties (partitioning, solubility, volatility etc.) and effects. Many of these have only partially been studied and there is considerable uncertainty on the nature and quantity of the threat that they pose to the marine environment.

Litter

Litter arises principally from the improper disposal of solid waste as well as the accidental, but common, introduction of such materials as fishing gear (including drift nets). The Panel have also included Tar balls and hospital waste. This category of contaminants may thus have coastal sources (garbage disposal at coastal sites or beach littering) of offshore sources (for ships or for the exploitation of marine resources). Most beaches and shallower areas are impacted to varying degrees by material from both sources.

Pathogens

Pathogens in the present context consist of all terrestrial microorganisms which may cause adverse human health effects and which are introduced to the marine environment as a result of human activity. This category includes bacterial pathogens (e.g. Streptococcus, Vibrio), viruses (eg. hepatitis virus) and enteric parasites. There is currently considerable concern and uncertainty regarding the persistence and viability of pathogens and viruses particularly and their passage though the marine food chain. Major sources of such materials are human sewage disposal and the inappropriate disposal of hospital wastes.

Nutrients

Nutrients include all the bioavailable forms of nitrogen, phosphorous and silicon which are introduced to the sea as a direct or indirect consequence of human activity. Though relatively simple parameters to quantify , it is difficult to distinguish between natural and anthropogenic sources and also to identify and quantify non-point sources of these substances. Point sources include sewage, plant outfalls and fertilizer factories. Non-point sources comprise run-off from agriculture, deposition of atmospheric contaminants, upland municipal sources etc. Additionally, re-cycled nutrients from sedimentary reservoirs may have anthropogenic origins. The major consequence of nutrient inputs is in promoting eutrophication and the disturbance in the structure of marine organisms.

Oxygen

The level of oxygen in surface and near surface seawater is an important tool for measuring the state of the health of the aquatic marine environment. Oxygen levels become depressed as a result of the inability of natural processes (physical diffusion and primary production) to supply oxygen at the rate demanded for the oxidation of organic matter of for reduced chemical substances. Oxygen deficiency is particularly acute in the case of eutrophication, discharge of sewage (and the offshore disposal of sewage sludge) and the discharge of organic industrial and agricultural effluents (eg. pulp mill wastes, food processing plants, etc.) The consequences of oxygen deficiency can, in the worst instance result in elimination of all higher life forms. Even moderately sub-oxic conditions have serious consequences upon the benthic animals and may thus restrict the accumulative capacity of coastal waters for other potential pollutants.

Synthetic Organic Compounds

This is a loosely defined group of substances which includes all synthetic substances other than pesticides, petroleum hydrocarbons and polyaromatic hydrocarbons, introduced to the sea as a result of human activities. The major portion of these substances result from industrial activities but their introduction to the marine environment may arise from direct discharge (point sources), discharge to municipal sewage systems or rivers and discharge to the atmosphere. The substances are best classified in terms of (a) their toxicity, (b) their persistence, (c) there tendency to bioaccumulate, (d) their bioavailabiltiy and (e), their source functions (size of the land-based sources). Substances of particular concern include PCB's, dioxins and some industrial solvents. The current level of the scientific research into this group of substances is very limited however new priority substances are likely to be revealed in the future. Some synthetic organic compounds of concern are also produced within the marine environment particularly by the practice of chlorination of sewage and by the introduction of free chlorine into the cooling waters of power stations.

Petroleum Hydrocarbons

Petroleum hydrocarbons comprise all constituents of crude oil and its refined derivatives. Deliberate pathways for the introduction of oil to the marine environment include ship deballasting operations, refinery effluents, the discharge of lubricating oils to municipal sewage systems, and seepage from oil production platforms. In the accident scenario, the introduction of massive amounts of oil to the marine environment may often have a locally catastrophic effects on sensitive marine ecosystems though there is evidence to suggest that a complete natural recovery occurs within a decadal timescale. Non-accident of repeated accidents (e.g. regular operational discharge) introduction of oil to the marine environment may lead to the long term exposure of marine organisms and the human population to the toxic constituents of oil, particularly the aromatic hydrocarbons, with consequent negative biological effects.

Polycyclic Aromatic Hydrocarbons (PAHs)

This group of substances are all derived from thermal transformation of fossil fuels, particularly petroleum. PAHs constitute natural components of oil formed as a result of relatively low temperature metamorphic processes. More importantly they are also produced as combustion products of oil and coal. PAHs are introduced to the marine environment as a constituent of municipal or industrial effluents or via atmospheric pathways from industrial emissions, exhaust fumes of internal combustion engines or domestic heating systems. Interest in PAHs is mostly derived from the carcinogenic properties of some individual PAH compounds.

Suspended Particulate Matter

Suspended particulate matter, in the context of the present report, comprises of all non-living particulate material present in the water column at a given site. SPM is naturally present in all instances but its loading may be a direct consequence of human activities, particularly those in adjacent terrestrial areas. There is compelling evidence to suggest that SPM loading is increasing in tropical seas as a result of deforestation or in-appropriate agricultural practices and that this is resulting in deleterious effects on sensitive marine ecosystems (eg coral reefs) and reduction of light leading to a decrease in productivity. SPM increase also results from upland erosion of soils, into rivers and dredging operations, dumping etc.

Trace Metals

Trace metals comprise of all metal and metalloid oligoelements and their and their compounds in the marine environment. It is important to distinguish between those trace metals introduced as a result of anthropogenic activities and those which are introduced and are present as a result of the natural weathering of minerals. In practice, such a distinction requires the measurement of a set of metals which includes elements representative of weathering and unlikely to have anthropogenic sources. Although trace metals in the marine environment have large and very diverse sources (elevated trace metal levels accompany almost every type of effluent), there is little evidence of widespread biological consequences. Elevated levels of dissolved trace metals are unlikely in seawater (other than in the immediate area of sources) due to their rapid removal by adsorption or to suspended particulate material. In the special case of certain organic trace metal elements the situation is quite different. Tributyl tin (used as a constituent in anti-fouling paints on boats) and methyl mercury (formed by the microbiological methylation of mercury) are two highly toxic compounds which have been responsible for well recorded, though transitory, marine pollution incidents. Special attention may be required for other forms of trace metals in the future.

Plankton/Pigments

The presence of abnormally dense blooms of phytoplankton is a direct consequence of eutrophication (though they of course occur naturally). Moreover, the nature of the blooms also reflects the state of the health of the marine environment. As eutrophication intensifies, the species composition of populations contributing to phytoplankton blooms gradually changes as the ecosystem simplifies itself and adjusts for the optimal utilization of the source nutrients. Some of the blooms may, in their own right, represent a hazard to the marine environment (eg. foaming associated with phaeocystis destroys some fisheries resources and lowers the aesthetic value of the environment, red tide blooms of dinoflagellates are often toxic). Measurements of phytoplankton populations, either directly or via the quantification of pigments, allow for these processes to be quantified. Proper coordination of these efforts is needed if trends are to be elucidated.

Pharmaceuticals

Concern has been expressed in some fora (including the mass media) regarding the introduction of pharmaceutical products to coastal waters. Pharmaceuticals include all substances used in preventing of alleviating human or animal diseases. The mode of introduction of these bioactive compounds is via municipal sewerage systems or, in the specific case of aquaculture, by direct introduction into fish enclosures. Except in the latter case there is no conclusive evidence of significant pollution of coastal waters but research on this topic is continuing.

B. Issues

The Panel identified a number of issues that, in global terms, are of concern in respect to the health of the oceans. These are: climate change; endangered species; biodiversity; human health; tourism; and eutrophication. All of these issues are reflected in UNCED Agenda 21 and each has been correlated against analytes/contaminants in Table 1. The following is an explanation of the issues identified in this matrix.

Climate Change

The increase of radiatively active, or "greenhouse" gases in the atmosphere could lead to a change in climate. This topic is within the purview of the Climate Module of GOOS but some effects of climate change will need to be considered in the development of the HOTO module. These effects could include changes in the frequency and diversity of toxic algal blooms, changes in nutrient influxes and oxygen conditions in coastal areas, altered influxes of suspended matter and changes in atmospheric precipitation patterns. The role of the oceans as a source, sink and regulator of gases such as dimethyl sulphide, and carbon dioxide is being addressed by major research programmes addressing climate change such as WOCE, JGOFS, LOICZ and GLOBEC.

Endangered Species

Marine mammals, birds and other wildlife can be affected by natural and anthropogenic toxins, by compounds that can reduce reproductive success (e.g., organochlorines), by litter that strangles or drowns marine organisms, and by hydrocarbons from oil spills causing smothering or hypothermia. In addition, habitat change and loss through physical disturbance and chemical effects has a direct impact on biological diversity and can endanger species.

Human Health

A variety of contaminants can impose risks to human health through seafood consumption or through seawater ingestion or direct exposure, while swimming for example. To a great extent the degree to which human health consequences are of concern relates to the nature of the contaminant and its toxicological properties. Many marine contaminants such as radionuclides and some organics are assumed to impose increasing risk of adverse effects with increasing exposure. Thus, knowing the levels of exposure becomes important to estimating and comparing risks to the health of those consuming seafood and otherwise exposed to the marine environment. Other substances, such as essential elements, have exposure thresholds for the induction of toxic effects and it only becomes necessary to ensure that exposures are kept below these thresholds. Pathogens in sewage discharged to the marine environment can cause health effects in swimmers and others directly exposed to seawater. The use of pharmaceutical in aquaculture remains a concern of an unknown magnitude.

Biodiversity

There exists a global concern about reductions in biodiversity in the natural environment. There are a number of marine contaminants that can affect biodiversity on small and large scales. Litter in the ocean from both marine and terrigenous sources can directly and adversely affect biota and have the potential to change biodiversity. Changes in nutrient influxes can alter primary production, the species composition of plankton, alter dissolved oxygen levels and, accordingly, biodiversity. The presence of contaminants like oil from chronic discharges and increased influxes of suspended matter to the ocean can also alter biological communities through, for example, adverse effects on coral reefs and mangroves. The use of pharmaceutical in aquaculture can change bacterial assemblages and has the potential for affecting wild fish resistance to disease. Direct physical disturbance of habitats through sediment mobilization, fishing and marine mineral exploitation can also cause changes in biological diversity.

Tourism

The maintenance and development of tourism is an issue of considerable concern to large areas of the world. The presence of litter, including tar balls, sewage and sewage contaminants, on beaches has a major aesthetic impact on tourism. The levels of sewage bacteria contamination in water, especially if regularly measured and subject to regulation, are a major issue of public interest. Visually clean water is also a desirable feature of seaside areas wanting to increase tourism as a source of revenue. Inferred deterioration in the quality of fish, whether through fish kills, suggestions that fish are contaminated with pathogens or other chemicals, or that fisheries are closed because of pathogenic contamination or the presence of algal toxins can all have a severe effect on the attractiveness of coastal areas.

Eutrophication

This phenomenon occurs worldwide and results in serious changes to the coastal areas of regions. In some cases it can lead to outbreaks of aquatic toxins, significant changes in ecological community structure, increased turbidity, decreased water clarity and anoxia.

C. Studies of Pollution Effects

The HOTO Module of GOOS must balance information on levels and trends with information on their biological effects in order to permit global and regional pollution assessments. The specific list of measurements will be presented in a subsequent edition of this document following detailed consultations with relevant experts. In broad terms, the following fields will be examined:

Biomarker Studies and Biochemical Measurements of Stress at the Organism Level.

The application of biochemical measurements of pollution-specific stress on organisms will be pursued. The studies may include specific enzymes (e.g. EROD techniques) or enzyme inhibition (e.g. cholinesterase inhibition techniques to assess the impact of orgqnophosphorous pesticides). It would also include measurements of cytochrome P450. Promising new biological techniques are being evaluated by GEEP (of GIPME) and will be incorporated in the strategy when they are satisfactorily tested.

Physiological and Morphometric Studies.

The approach includes techniques such as "Scope for Growth" for specific bivalves or studies of imposex for gastropcds. In some cases these measurements can specifically reflect the presence and effect of individual pollutants.

Studies of Genetic Alteration.

The most sophisticated biochemical techniques in current development involve measurements of the presence of DNA adducts. These techniques are still in the development phase but may become more widely available in the forthcoming decade.

Community Structure Studies.

Quantitative and repeated surveys of selected sensitive ecosystems involving diversity/biomass structure will be required. Much of this work can be facilitated by the application of modern technology ranging from PC-based species identification keys and reporting forms in the simplest case to fully automated ROV observation devices and geographical information systems in the most sophisticated surveys. Particular attention will be required on such communities as coral reefs, algal and seagrass beds and mangrove stands.

"Whole Community" Studies.

This approach is probably susceptible to remote sensing studies. For example, changes in the overall magnitude of phytoplankton blooms (i.e. by color scanning) or the size of seagrass beds, living coral reefs and mangrove extensions (by aerial surveys, etc.).

D. Practices

The Panel identified various practices that significantly mobilize the analytes/contaminants listed above. These have been identified by the Panel as Fisheries, Aquaculture, Coastal Development, Marine Transportation, Industrial Discharges, Sea Dumping, Agricultural practices, Mineral Extraction Processes and Municipal and Urbal Waste. There are also physical effects caused by these practices which have a direct effect on the marine environment and these are being taken into account in the development of the HOTO Module. The relationship of these to the anlalytes are depicted in Table 2.

E. Matrices

The Panel identified the matrices where many of the analytes/contaminants are measured and presented an evaluation of the present state of measurement in these matrices (Table 3). Three category's of difficulty were determined. The first are relatively easy measurements and can be carried out with individuals with training using routine measurements. These have been assigned a '1'. The second group were defined by the Panel as those that required more specialized equipment or training but could be analyzed by monitoring laboratories within most nations. These have been assigned a '2'. The third group required more sophisticated measurements and these would most probably be made by research laboratories that perhaps do not exist in all countries. These have been assigned a '3'. The matrices chosen were seawater, groundwater and freshwater, suspended particulate matter and fish/seafood. The Panel also added beaches - to represent the fact that litter and oil spills impact these areas. Precipitation was also added as this is a mode of entry to the marine environment of some of the analytes discussed above.

F. Considerations for Monitoring

The panel evaluated the analytes/contaminants for degree of impact versus difficulty of measurement. As discussed in the previous section, different matrices present different challenges. However, the analysis is represented in Figure 3. The analytes fall into three distinct categories.

Category 1 analytes are those judged to have high impact and are relatively easy to measure, such as nutrients, pathogens, suspended particulate matter and plant pigments. Also included in this category are ancillary properties for the characterization of the sapling regime such as salinity, temperature and oxygen content. Litter and petroleum also have a high impact near sources (spills and dump sites) as well as some distance from the sources. These are relatively easy to measure and also belong to Category 1. These analytes are also judged to be useful for international training programmes such as TEMA.

Category 2 analytes were judged to be difficult to measure and have a lesser impact. Trace metals, PAH's, artificial radionuclides and phamaceuticals. These analytes require sophisticated instrumentation, considerable training and specialized standards and reference materials. It is worth noting that the Panels' result is contrary to public perception of the impact of these compounds.

Category 3 analytes were judged to be high impact and are presently difficult to measure. These are aquatic toxins, synthetic organics and herbicides and pesticides. From a global monitoring perspective, it is imperative that efforts should be made to reduce the difficulty of measurement of these components.

G. Regional Evaluations

The Panel selected a number of geographic areas where contaminant assessments could be made and attempted to assign a priority to contaminants within the region (Table 4). This is by no means a complete list and is based on the expertise within the panel that was on hand. A zero was assigned to analytes of little regional interest and low medium and high were ascribed to other analytes. In the selection of areas for evaluation, it was apparent that enclosed or semi-enclosed seas having some uniformity in characteristics and concerns, such as the Mediterranean and Baltic Seas, were easier to assess than those that have long open coastlines such as West Africa. The Panel has benefitted from the results of some of long-standing regional monitoring programmes.

In an attempt to achieve a summary the Panel assigned points to the rankings assigning 1 point for low, 2 points for medium and 3 points for high. The point ratings for both contaminant/analytes and specific regional marine areas were summed and appear at the right hand side and foot of the table respectively. The aggregate point ratings for contaminants, while not globally comprehensive, show that Category 1 contaminants appear to be high priority within most of the regions and focus upon them would appear to be a good starting point for a HOTO programme.

The aggregate point ratings for the regional marine areas included in this Table are also revealing. While the precision of the assignments may not be high, it clearly reflects the necessity for primary attention to semi-enclosed marine coastal areas and that the open-ocean oligotrophic areas are of lesser priority.

X. Time and Space Scales

Factors that bear upon time and space scales for measurements are of three types. First are managerial considerations that involve the requirements of customers of the interpretative products from the HOTO module. Second are scientific considerations relating to the scales of change following changes in the locations and rates of introduction of substances and the locations and rates of physical disturbances of the marine environment. Third are also scientific considerations relating to the scales of natural variability in the marine environment for those substances that have natural as well as anthropogenic sources.

Managerial Considerations: Assessments of the state and trends in environmental conditions are required for local, regional and global purposes. For local conditions, the highest spatial and temporal resolution will be required. Such resolution is reduced for regional requirements and reduced further for global purposes.

Scientific Considerations: The scales of change resulting from anthropogenic introductions of contaminants are an important consideration in selecting spatial and temporal frequencies of measurement for the HOTO module. The spatial and temporal resolution required to detect and understand conditions and change will be greatest near to sources and lowest furthest from the sources. This aspect of measurement frequency is further discussed below. For contaminants having natural components, it will be necessary to define the envelope of variability against which anthropogenically induced change can be detected. This will be contaminant-specific but likely to impose higher spatial and temporal measurement frequencies in coastal areas than in regional and deep ocean areas.

Figure 4 attempts to define measurement intervals (i.e., the inverse of measurement frequencies) appropriate for monitoring different contaminants in the context of distance from their sources. It has been formulated on the basis of scientific considerations relating to the likelihood and value of making measurements of change for both local human health protection purposes, for example, and for detecting change at locations more remote from sources.

XI. Data Management

The HOOP evaluated the major data reporting requirement for the HOTO Module and based its evaluation on the assumption that all data, whether derived from research projects, regional monitoring activities, fisheries research and evaluation as well as past classified data from military activities, needs to be made available. The past and present practices need to be changed for the HOTO Module to have the impact required.

Ocean data collection is but the first step which ends with user access and application. A great deal of data exists that is not readily available, not centrally archived, which points to the need for increased national, regional and international cooperation in data management.Protocols for data receipt, verification and validation will need to be developed in order to ensure that the GOOS data archive contains reliable data to assess the health of the ocean. In addition, the Panel feels that data should be available for no more that the cost of reproduction and distribution.

Presently, methods and standards for data archiving and exchange are in use for physical oceanographic data but are lacking for biological and chemical oceanographic data. Although some efforts have begun such as the work of GIPME's Group of Experts on Methods, Standards and Intercalibration (GEMSI), much more attention needs to be focused on setting international policies and procedures that facilitate data access and usability, including procedures for quality assurance.

XII. Science and Technology for Environmental Protection

Ocean measurement problems are formidable. Available technology now makes systematic observation and analysis of the global ocean possible, but many improvements are possible. GOOS will foster and exploit the development of new technology to increase the cost efficiency of marine observations and increase the production rate and quality of data products. The HOOP identified various needs required for new technology and noted that these technologies must not only apply to chemical and physical measurements but also to biological ones extending, for example, to devices to better determine community structure of ecosystems as an important element of this module.

There needs to be continuous evaluation of technological developments offering the potential for improving the reliability, diversity and frequency of ocean measurements relevant to GOOS. The HOTO module of GOOS must include measurements of both contaminants and responses in the oceans.

Contemporary technology for contaminant measurement is largely based on sampling from platforms followed by laboratory analysis of samples. There are great opportunities for applying new technologies to overcome the limitations of this traditional approach for many contaminants. As part of GOOS, the extent of such opportunities in relation to the needs of modules requires to be aggressively evaluated. Such technologies include development of sensors, remote sensing, unattended moorings with or without real-time data telemetering, and autonomous underwater vehicles.

For response measurements, the identification of sensitive indicators that can be mechanistically linked to specific contaminant exposures is essential. This would then permit evaluations of the potential of new technologies for making more frequent, more ubiquitous and more synoptic measurements. Such technologies that might offer application to biological response measurement include remote methods of assessing community structure, density and diversity, molecular biomarkers and engineered organisms for sensor development. Currently, limitations in the measurement of biological responses in the marine environment is the most severe limitation to the development and implementation of the HOTO module.

Systems that already exist could be improved such as networks of marine laboratories, existing time-series programmes in the coastal ocean and mussel watch activities. New camera systems for benthic surveys, remote submarines, and networks of sensors near major point sources are just some of the tools that will be part of HOTO.

Having provided routine atmospheric observations for over two decades, satellites will carry instruments over the next decade which will provide tremendous amounts of ocean data. In the 1990's sensors will be launched to study ocean circulation and pigment distribution, for example, parameters of basic importance to considerations on the health of the oceans. The SeaWiFS (Sea-viewing Wide Field-of-View Sensor) mission, presently scheduled to begin in August 1993, includes determining the spatial and temporal distributions of phytoplankton blooms, understanding the fate of fluvial nutrients and acquiring global data on marine optical properties. This sensor replaces the Coastal Zone Color Scanner which operated experimentally from 1978 to 1986.

The panel noted the need for expansion of this technology section and this will be available in more detail in the final report of HOOP.

XIII. Conventional Measurements

It will always be necessary to make measurements in the water column. A basic assumption that has been made with regard to the analytes/contaminants discussed earlier is that in all cases where these measurements will be made, associated standard hydrographic measurements will also be made.

THIS NEEDS FURTHER DEVELOPMENT

XIV. National Commitments and Capabilities

GOOS will foster the collection and dissemination of ocean data. It will be implemented and managed through national and regional services and facilities. Adequately funded national organizations that cooperate actively with international organizations are required. Today there are few of these, but support will hopefully grow.

Initial emphasis will be on strengthening IGOSS and other IOC activities. A major commitment needs to be made by all countries to effectively implement GOOS. Governments must be encouraged to:

a) Make existing data available

b) Distribute data products

c) Facilitate data exchange

d) Develop data networks

e) Support the collection of satellite and in situ data

f) Support data collection by volunteer ships and data buoys

Because all countries must be involved, substantial training and assistance must be provided to developing countries. Partnerships between developed and developing countries are to be encouraged. Close collaboration is also required among relevant international organizations for proper implementation. Most countries, for example, do not have access to or capabilities for using the large volume of remotely sensed data becoming available. The greatly increased availability of small, inexpensive computers will allow more users to manipulate data and prepare products. Training is needed in new sensor parameters and in how to apply the data to local needs.

GOOS is to be based on the principle that all countries should meet certain commitments, according to their capabilities to fulfill such commitments, in the agreed global plan, so that all countries may benefit. The UNCED process established criteria for capacity building:

o The capacity needs to be developed nationally and in the long term to become self-sustaining

o It needs to be based in the short term on international, regional, and bi-lateral collaboration to insure accelerated development, technology transfer and economies of scale

o It needs to be developed only as fast as it can be used effectively

o It requires sustained action over a long period

XV. Recommendations

HOOP recommends that attention be given to implement the following as soon as possible:

1) Conduct a global inventory of measurement capabilities and existing national programs.

2) Initiate quality assurance procedures for those measurements HOOP considers to be of the highest priority.

3) Request relevant bodies (e.g. GIPME) to reevaluate those methods for Category 2 parameters, with a view toward stimulating their inclusion in national and regional plans.

4) Reliable measures of body response, which can be applied world-wide, should be further identified and developed.

5) Completion of the current IOC/UNEP International Mussel Watch Program, the evaluation of its results should be facilitated and urgent consideration should be made of its extension to other matrices (e.g. sediments) and variables.

6) Regional analytical centers should be established in order to provide technical focal points for training, data evaluation, capacity building and introduction of new techniques. The capacity building needs to be developed nationally and in the long term become self sustaining. It also needs to be based in the short term on international, regional and bi-lateral collaboration to ensure accelerated development, technology transfer and economies of scale.

7) Efforts should be made for the provision of PC optical disc based ocean color interpretation acquired by satellite remotely sensed data and requisite training.

8) A comprehensive pilot program should be implemented as an integral part of the over-all GOOS implementation.

9) Every two years, convene a workshop/symposium for the reevaluation of marine contaminants and effects, with emphasis being placed on new research information and technology developments.

XVI. References

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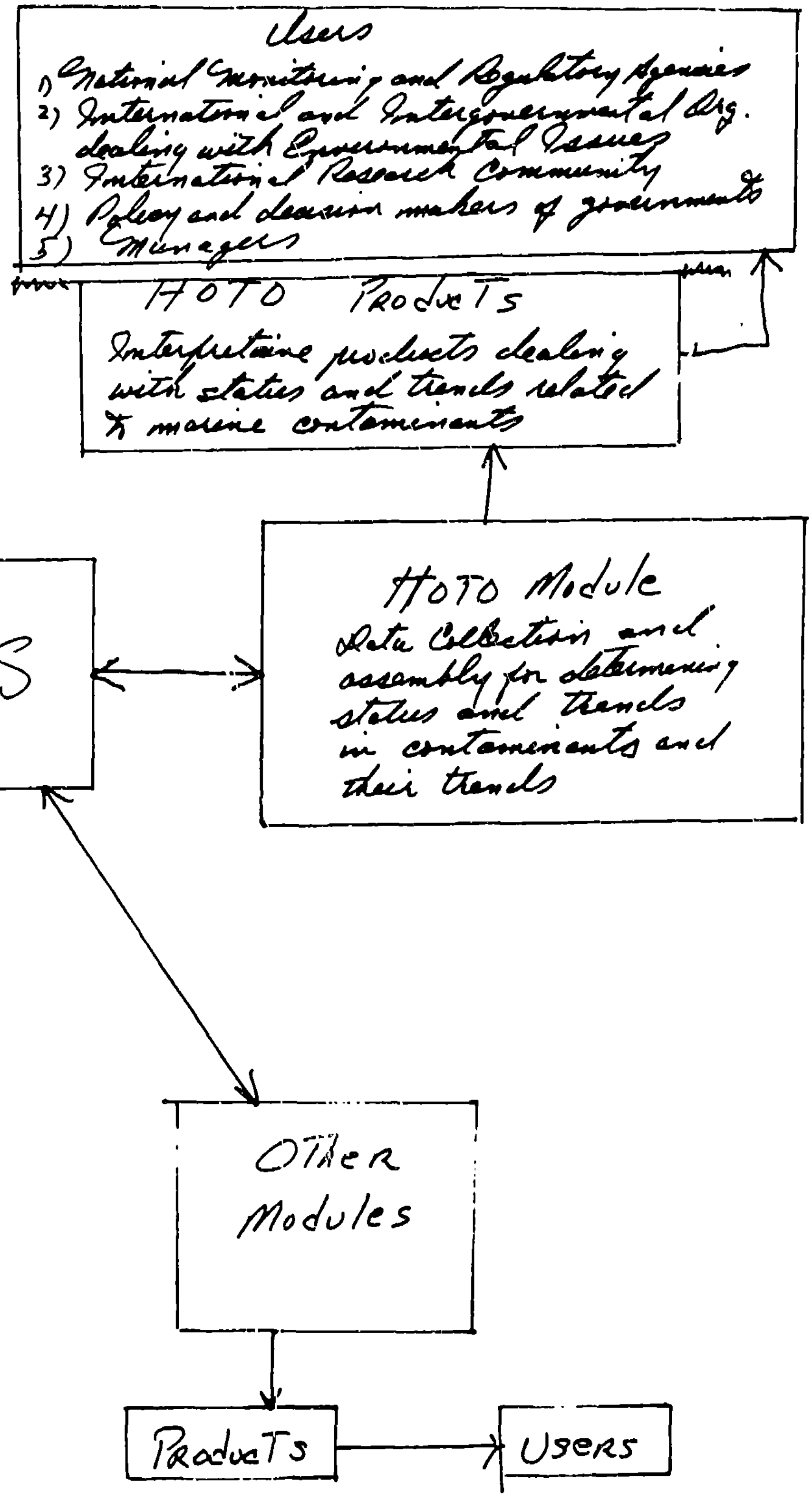

Delivery Paths of HOTO Module
Figure 1

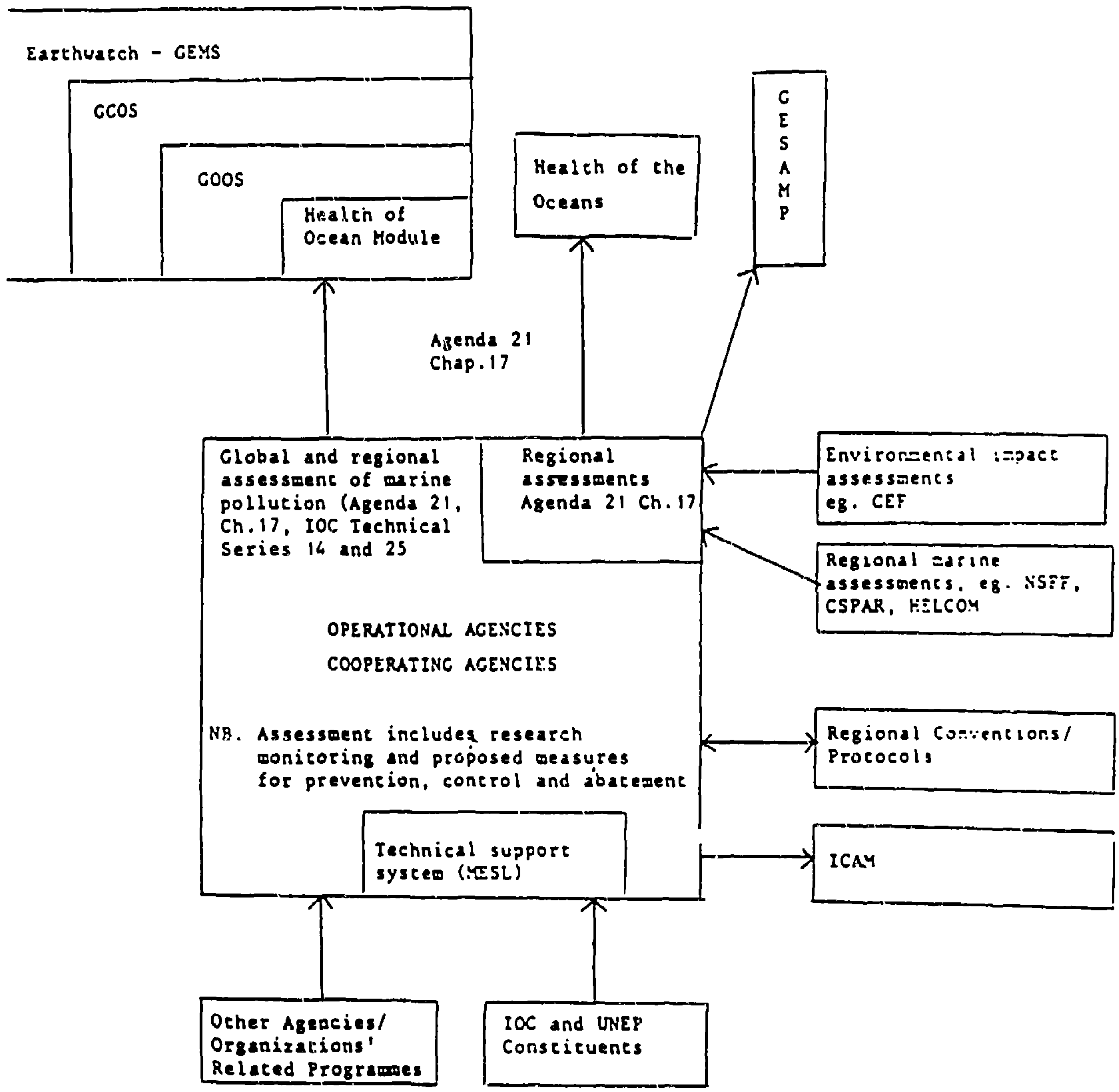

FIGURE 2

Strategic elements of GIPME

FIGURE 3 — IMPACT/DIFFICULTY OF MEASUREMENT FOR ANALYTES/CONTAMINANTS

N = NUTRIENTS; P = PATHOGENS; S O T = SALINITY, OXYGEN, TEMP
PIG = PLANT PIGMENTS; SPM = SUSPENDED PARTICULATE MATTER;
L = LITTER, Pe = PETROLEUM; TM = TRACE METALS;
PAH = POLYNUCLEAR AROMATIC HYDROCARBONS; ARN = ART. RADIO
NUCLIDES; Pha = Pharmaceuticals, H/P = HERBICIDES/PESTICIDES
SO = SYNTHETIC ORGANICS; AQT = AQUATIC TOXINS

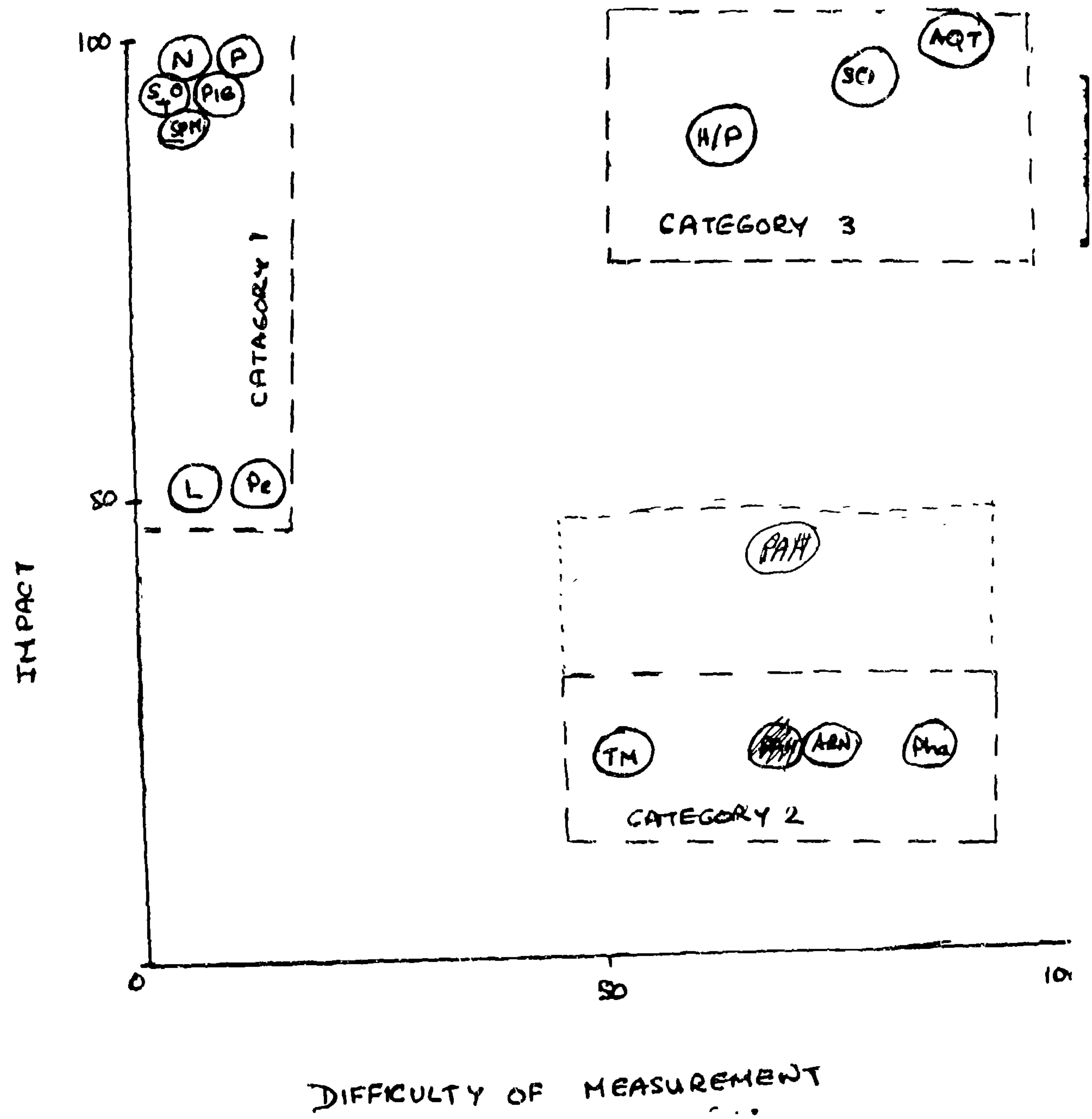

Figure 4 . Spatio-temporal aspects of monitoring of contaminants for health of the oceans assessments

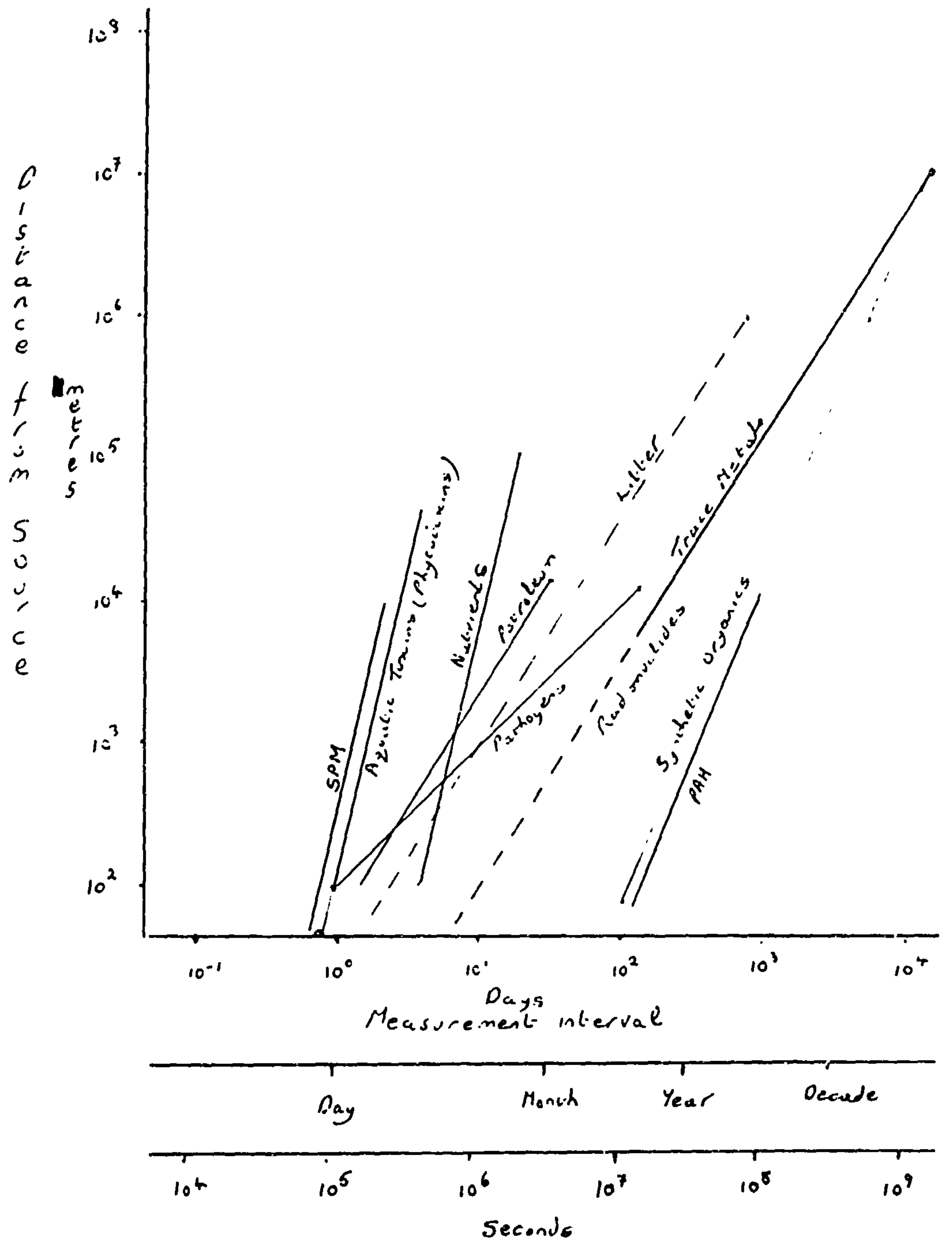

TABLE 1.
RELATIONSHIPS AMONG GLOBAL ISSUES AND CONTAMINANTS/ANALYTES

	CLIMATE CHANGE	ENDANGERED SP	HUMAN HEALTH	BIODIVERSITY	TOURISM	EUTROPHICATION
Aquatic Toxins	•	•	•		•	•
Artificial Radionuclides			•			
Herbicides/Pesticides		•	•	•		
Litter		•		•	•	
Pathogens			•		•	
Nutrients	•			•		•
Oxygen	•			•		•
Synthetic Organics		•	•			•
Petroleum		•		•	•	
PAHs			•			
Suspended Particulate Matter	•			•		
Trace Metals			•			
Plankton Pigments	•		•	•	•	•
Pharmaceuticals			•	•		

TABLE 2.
RELATIONSHIPS BETWEEN ANTHROPOGENIC PRACTICES AND ANALYTES/CONTAMINANTS

	FISHERIES	AQUACULTURE	COASTAL DEVT	MARINE TRANSP	INDUSTR DISCH	SEA DUMPING	AGRICULTURE	MINERAL EXPLTN	MUNICIP DISCH
Aquatic Toxins	•	•					•		•
Artificial Radionuclides	•				•	•			
Herbicides/Pesticides	•	•			•	•	•		
Litter	•		•	•	•	•	•		•
Pathogens	•	•	•			•	•		•
Nutrients		•	•		•	•	•		•
Oxygen	•	•	•		•	•			•
Synthetic Organics	•				•	•			
Petroleum			•	•	•	•		•	•
PAHs	•		•		•	•			•
Suspended Particulate Matter		•	•		•	•	•	•	•
Trace Metals	•		•		•	•		•	•
Plankton Pigments	•	•					•		•
Pharmaceuticals									

TABLE 3.
MEASUREMENT PHASES FOR CONTAMINANTS/ANALYTES

	SEAWATER	FRESHWATER	SUSP PART MAT	FISH TISSUES	SEDIMENTS	BEACHS	PRECIPITATION
Aquatic Toxins	3			3			
Artificial Radionuclides	3		3	3	2		3
Herbicides/Pesticides	3	3	2	2	2		3
Litter			•			1	
Pathogens	2	2	1	1			
Nutrients	1	1	?				2
Oxygen	1	1					
Synthetic Organics	3	3	2	2	2		3
Petroleum	1	1	1	2	2		3
PAHs		2	2	2	2		3
Suspended Particulate Matter	1	1	1				
Trace Metals	2	2	2	2	2		3
Plankton Pigments	1		1		3		
Pharmaceuticals	3	3		3	3		

TABLE 4.

PRIORITIES FOR CONTAMINANTS IN SPECIFIC MARINE AREAS

	CARIBBEAN	NORTH FSU	OLIGOTROPHIC GYRE	NORTH SEA	WEST AFRICA	BALTIC SEA	MEDITERRANEAN	RED SEA	THE GULF	ASEAN SEAS	BLACK SEA	SUMMARY	GREAT LAKES
Aquatic Toxins	H	O	O	M	O	M	M	L	L	H	M	16	?
Artificial Radionuclides	O	H	O	M	O	L	L	O	O	O	H	10	L
Herbicides/Pesticides	H	L	L	M	H	H	M	O	O	H	H	21	H
Litter	M	M	L	L	H	M	H	M	L	M	H	22	H
Pathogens	H	L	O	H	H	M	H	M	H	H	H	26	H
Nutrients	H	L	H	H	H	H	H	L	H	H	H	29	H
Oxygen			L		M	H	M	O		M	H		H
Synthetic Organics	L	M	L	M	M	M	M	L	L	L	H	21	H
Petroleum	H	M	L	M	M	L	M	H	H	H	H	25	L
PAHs	L	M	L	M	M	M	M	H	H	M	M	22	M
Suspended Particulate Matter	H	L	O	L	M	M	L	L	H	H	M	19	L
Trace Metals	L	L	L	M	L	L	L	L	L	L	M	13	M
Plankton Pigments	M	L	O	H	L	H	M	L	O	H	H	19	H
Pharmaceuticals	O	O	O	M	L	L	L	O	L	L	L	8	L
Totals	25	18	10	27	25	29	27	16	20	30	37		29

The entries in this table reflect priorities of different contaminants bearing in mind the severity of their effects in a selection of marine regions. The assignments and their numerical weightings are:

O = Insignificant; Numerical Weighting 0
L = Low priority; Numerical Weighting 1
M = Medium priority; Numerical Weighting 2
H = High priority; Numerical weighting 3

The numerical weighting for both contaminants and marine areas have been summed and appear respectively at the right and foot of the table.

The Great Lakes, although not a marine area, has been included in the table for illustrative purposes but excluded from the summations of weightings.