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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION
(of Unesco)

THE MARINE POLLUTION RESEARCH AND MONITORING PROGRAMME OF THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

PRESENT AND PLANNED ACTIVITIES

Prepared by the

Intergovernmental Oceanographic Commission

(SC-83/WS/17)

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PREFACE

During the Twelfth Session of the Intergovernmental Oceanographic Commission (IOC) Assembly (Paris, 3-20 November 1982), it was decided to present a report to the United Nations Environment Programme (UNEP), at the next session of its Governing Council, on the ongoing and planned programmes of the Commisson in the field of marine pollution research and monitoring. The purpose of presenting such a report is to provide the UNEP Governing Council with an opportunity to review the Commission's efforts in this area, with a view to determining the extent to which UNEP is prepared to join with the IOC in co-sponsoring one or more of the programmes, and activities described. Extensive use has been made of previous documentation prepared by subsidiary bodies of the IOC Working Committee for the Global Investigation of Pollution in the Marine Environment (GIPME), particularly the Group of Experts on Methods, Standards and Intercalibration (GEMSI), and by various consultants. The assistance of these scientists is gratefully acknowledged, for, without their dedication and help, the advances being realized in the implementation of the Comprehensive Plan for GIPME would not be possible.

ABSTRACT

This report contains relevant information concerning the formation and development of the IOC's activities in the field of marine pollution research and monitoring, as well as the technical foundation upon which proposed tasks are based. The actions proposed are assigned to levels of priority which are determined by a strategic framework designed for the implementation of the Comprehensive Plan for GIPME, a global programme that comprises independent regional activities. As these regional activities increase, thus widening the monitoring of the world's oceans, regional seas and coastal areas, a broader base will be established for providing information for periodic assessments of the health of the oceans to be made as well as establishing levels and trends of selected pollutants in the marine environment. The strategic framework noted above is essentially a series of sequential steps or activities with each successive stage being dependent upon the results of the immediately preceeding stage, all of which are addressed in detail in the main body of the report. In this context, a time-table, priorities and resources required for planned GIPME activities are presented for the purpose of satisfying Resolution XII-21 of the Twelfth Session of the IOC Assembly, which decided "to present a report to sessions of the UNEP Governing Council, on ongoing and planned programmes and and other activities of the Commission in this field;" and invited "the UNEP Governing Council to review this report and to determine the extent to which UNEP is prepared to co-sponsor these programmes and activities with the IOC". In addition, the discussion and proposed actions can be used in considering Resolution XII-20 and Resolution EC-XV.3 which "invites UNEP to support the Working Committee for the Global Investigation of Pollution in the Marine Environment (GIPME) and the Marine Pollution Monitoring Programme". In particular, it is argued that the next effort to be mounted in implementing the Comprehensive Plan for GIPME should be a six month method development study, followed by an eighteen month pilot measurement programme on organohalogen compounds. It is also pointed out that required future work concerning petroleum hydrocarbons, namely an intercalibration workshop for dissolved/ dispersed petroleum hydrocarbons in seawater and the sea surface microlayer, could be mounted simultaneously with the organohalogen project. It is these programmes, therefore, that are assigned highest priority and are suggested to be the ones considered by UNEP for support as requested in the previously cited resolutions of IOC's governing bodies. These activities will, in certain cases, be conducted in the framework of IOC's regional subsidiary bodies in the Western Pacific and in the Caribbean and adjacent regions.

EXTENDED ABSTRACT

The purpose of this Extended Abstract is to provide the reader with highlights of the IOC's Programme in Marine Pollution Research and Monitoring. The scientific basis and detailed technical discussion of the subject matter contained herein can be found in the main body of this document. In addition, the reader who may not be familiar with the respective roles and functions of UNEP and the IOC is referred to Document IOC/INF-523 Add.

The Comprehensive Plan for GIPME was published by the IOC in 1976 (IOC, 1976a). It proposes a systematic scientific approach, or philosophy, to the determination of the extent of marine pollution through a set of discrete, sequential and iterative procedures. Implicit in the Plan is the use of mass-balance assessments to judge the degree of contemporary oceanic contamination. Such assessments may then be combined with knowledge of the biological effects of potential contaminants to define the extent of oceanic pollution. The terms 'pollution' and 'contamination' are used here in the manner defined by the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) and the Food and Agriculture Organization (FAO) (FAO 1976).

During the Fourth Session of the Working Committee for GIPME in January 1982, the continued applicability of the Comprehensive Plan and the strategy and priorities for current and planned activities within the GIPME Programme were questioned. The Working Committee decided (Annex IV) to the Summary Report of GIPME-IV (IOC, 1982a)), that, conceptually, the Comprehensive plan for GIPME is as valid and applicable today as it was when first published in 1976. Indeed it exemplifies a logical and intrinsically scientific approach to the problem of quantifying marine pollution. Neither its philosophical basis nor its approach requires revision. Consequently, the Working Committee for GIPME proposed a strategic plan for, and assigned priorities to, future activities within the initial phases of implementation.

The proposed activities of the IOC Marine Pollution Research and Monitoring Programme are presented in the context of this strategic framework, with the aim of providing the UNEP Governing Council an opportunity to review the Commission's efforts in this area, and to determine the extent to which UNEP is prepared to join with the IOC in co-sponsoring one or more of the programmes and activities described.

All the various components of the Comprehensive Plan for GIPME are depicted schematically in Figure 1. The Plan comprises four major stages, each of which contains a variable number of components. The four major stages are: (1) mass-balance (which includes baseline measurements), (2) contamination assessment, (3) pollution assessment and (4) regulatory action. All of these stages are intended to be addressed sequentially for any given potential marine contaminant, but they are also linked by feedback loops that permit iteration of the procedures in individual stages of the Plan.

There has, however, been a tendency for the rationale behind the Plan, as well as its implications, to become forgotten as the programmes originally conceived for its implementation have gathered their own momentum. The Comprehensive Plan advocates both regional and global activities and assessments. However, there exists at the present time far greater international (or multilateral) attention to regional activities compared with global or open-ocean studies. Nevertheless, it must be realized that both types of activities are required to facilitate the overall implementation of the Plan.

The Comprehensive Plan contains strategic implications and guidance. As pointed out above, it essentially reduces, in practice, to a series of sequential steps or activities with each successive stage being dependent upon the results of the immediately preceeding stage. However, in the first stage there exists pre-requisites for the collection of data for mass-balance computation that also have a logical sequence. These pre-requisites are, of course, the development and proving of techniques for the collection of baseline and boundary flux data for given contaminants. These activities comprise the following four components:

1. Development of techniques;
2. Testing of the techniques to assess their precision and accuracy;
3. Intercomparison of techniques and the selection of 'recommended' techniques; and
4. Preparation of manuals, and training of potential users.

Clearly, these steps must be carried out in sequence in order to facilitate the collection of data with which to construct mass-balances. This preparatory stage can then be referred to as stage 0, and it can be combined with the stages depicted in Figure 1. The sequence of stages 0 to 4 then represents the strategic framework of the Comprehensive Plan in practice, and can be used as the scientific basis upon which to plan GIPME activities.

For a given contaminant (or class of contaminants) that justifies attention in the context of oceanic contamination, highest priority must be given to the next stage of the strategic framework that needs to be addressed. Sequentially lower priorities may then be assigned to subsequent stages, which will only justify the assignment of highest priority when all previous stages have been completed. Thus, if, for a given contaminant, all methodological development and proving have been completed, highest priority would be assigned to training programmes and the preparation of manuals that disseminate the appropriate sampling and analytical knowledge for the subsequent collection of baseline and boundary flux data. Once these training aspects have been dealt with, highest priority would be assigned to the execution of baseline surveys and boundary flux measurements.

The Comprehensive Plan contains considerable reference and guidance to regional endeavours and, where appropriate, assessment of contamination and pollution in regional areas should take some priority. Nevertheless, for the regional activities to interface accurately with each other and with baseline measurements for the open ocean, it is essential that the methods used be sufficiently precise and accurate and, above all, intercomparable. Similarly, the use of regional programmes to acquire data on boundary and exchange fluxes for application to open ocean assessments and mass balances would need to be based upon the application of intercomparable techniques.

As a result of various activities undertaken by the IOC (GIPME) and the International Council for the Exploration of the Sea (ICES), there exist methods for the measurement of oceanic baselines concentrations of most of the trace metals considered as being of high priority. Furthermore, the general intercomparability of these methods has been established and, in most cases, the influences of sampling techniques on the results have been assessed (IOC, 1982b). It should be stressed, however, that these methods and measurements are primarily those that are applicable to the determination of open-ocean baselines. Current activities are being directed to the particular problems of coastal water baseline measurements. The coastal water situation is somewhat more complex because of the greater need to take account of metals in the suspended particulate, as well as the dissolved, forms. In the open-ocean, the proportion of most metals that is associated with suspended particulate material is relatively small, and baselines based either upon total or dissolved (i.e., filtered sample) analyses are generally adequate.

It remains for the open-ocean baseline methodology to be documented and disseminated through training programmes prior to the conduct of baseline surveys, proposals for which have already been made by GEMSI (IOC, 1980) to take place in conjunction with an Atlantic Ocean baseline programme. Once the refinement and testing of procedures for the measurement of coastal baselines have been carried out, similar dissemination of technical expertise will be required.

The current position of the GIPME programme activities with respect to these metals in the context of the provisions and components of the Comprehensive Plan is summarized in Table I.

Activities with respect to petroleum hydrocarbons have progressed well beyond those for the other classes of contaminants, primarily because of the Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP), which was developed under the IOC/WMO Integrated Global Ocean Services System (IGOSS), and included observations of floating oil slicks, measurements of the incidence of tar balls on the ocean surface and of dissolved/ dispersed petroleum residues in the water column, and the assessment of tar stranded on beaches. The project began in January 1975 and the final report was completed and issued in 1981 (IOC, 1981a). It must be stressed, however, that this programme had as its major objective an assessment of the feasibility of carrying out large scale marine pollution surveys through the concerted activities of the Member States of the IOC. For this reason, the methods and techniques chosen for the programme encompassed a wide range of levels of sophistication, but were relatively simple and straightforward procedures that could be employed by a large number of countries; this approach had certain inherent limitations. Even so, the results of this programme are impressive and constitute a substantial improvement in our knowledge of the incidence of hydrocarbons in the marine environment.

The data obtained under the MAPMOPP are less amenable to detailed interpretation than data acquired from the widespread application of more modern and sophisticated techniques. Particular deficiencies in the MAPMOPP data are the inability to determine the detailed composition of the hydrocarbons found in the ocean and the unsuitability of these data for application to mass-balance calculations. Recent developments in analytical techniques permit more detailed examination of the composition of this class of compound which, in turn, would permit better quantification of the hydrocarbon components found in the marine environment and better discrimination between potential sources of such compounds. Efforts are therefore being directed towards a re-examination of the procedures most suitable for hydrocarbon determinations with a view to providing more insight into the sources and fluxes of these compounds in the ocean (see, for example, IOC, 1981b and c, 1982d). As part of this effort, plans have been formulated for an Intercalibration Workshop during 1983 to assess the suitability and intercomparability of techniques for the measurement of dissolved/dispersed hydrocarbons in seawater and the hydrocarbon components contained in the sea-surface microlayer (see item 2 in Table II, and Table V). These activities are directly related to the IOC Marine Pollution Monitoring Programme for petroleum (MARPOLMON-Petroleum), which is a fully operational extension of MAPMOPP and devoted to establishing a spatially and chemically detailed baseline for petroleum hydrocarbons in the ocean.

Activities within the GIPME programme concerned with organohalogens are summarized in Table III. All such activities have been confined to the solution of sampling and analytical problems, particularly with respect to the measurement of baseline distributions in the ocean.

The approach to the measurement of organohalogen compounds in the environment has changed markedly during the last few years as a result of improvements in analytical techniques. As a result, the use of temperature-programmed, capillary-column gas chromatography, which provides much better resolution in the analysis of polychlorinated hydrocarbons, has been advocated in the GIPME Programme (IOC, 1981d). It also can be combined with mass spectrographic techniques to provide unambiguous identification and quantification of individual polychlorinated biphenyl (PCB) components.

Although preliminary work on the development of methods for PCB compounds, for the purposes of GIPME, was carried out using the packed-column method, since the intercalibration exercise held in Bermuda in January 1980 (IOC, 1982b), major emphasis has been placed on the development of more specific and refined procedures for baseline measurements. To this end, work is being conducted, and a developmental programme has been proposed on a trilateral basis between the Netherlands Institute for Sea Research, Texel, the Institute of Marine Research, Bergen, and the Bermuda Biological Station for Research, Inc. This programme comprises a six-month method development stage and a subsequent eighteen month pilot measurement programme at Panulirus Station (Ocean Station 'S') (see Table IV for details and resources required). Within this programme, attention is currently being directed to determining, through laboratory experiments, the most efficient means of extracting individual PCB components from seawater and to establishing the essential steps in qualitative and quantitative analysis of these compounds.

Most of the necessary preliminary steps have been taken to ensure the success of the proposed work on organohalogens noted in Table IV. It should be stressed that the combination of specialized knowledge and expertise of various laboratories, working together at the same location, has proven most successful (IOC, 1982b). The previously mentioned Bermuda workshop and its follow-up have produced the first publication reporting individual PCB components in seawater in the open refereed scientific literature. Former analyses of PCB's in seawater have all been carried out with the use of packed column chromatography. The new approach using temperature- programmed, capillary-column gas-chromatographic separation techniques has resulted in a new way of looking at the complex assemblage of problems connected with the study of sources, transport mechanisms, transformation processes, sinks and effects of individual organochlorine compounds. For example, following a recommendation of GEMSI, this approach has now been introduced into the activities of ICES, and considerably more laboratories are now equipped with the necessary equipment.

Once suitable procedures have been developed and tested through their application in the time-series measurement programme, proposed to be conducted at Bermuda, they will be incorporated into the proposed trace metal baseline survey for the Atlantic Ocean noted in Table IV. Since this latter programme was deferred until 1985 by the Working Committee for GIPME, adequate time exists to complete the developmental work and to document and disseminate the techniques for PCB measurement before mounting a combined trace metal/organohalogen baseline survey for the Atlantic Ocean.

As can be ascertained from the foregoing discussion, activities with respect to organohalogens are predominantly dealing with the methodological development required to undertake ocean baseline measurement and are proceeding well, but continued activity requires extra-budgetary resources. Once the sampling and analytical methods have been developed and tested they can then be applied to oceanic baseline measurements in conjunction with trace-metal baseline surveys.

The discussion contained in the main body of this report supplements the topics discussed above by addressing other GIPME concerns including regional components of MARPOLMON and technical aspects of work undertaken in the following specialized groups:

(a) GEMSI *ad hoc* Group on Marine Sediments;

(b) GEMSI *ad hoc* Group on Fluxes and Mass-Balance Calculations in Marine Systems;

(c) GEMSI *ad hoc* Group on River Inputs (in MARPOLMON);

(d) GEMSI *ad hoc* Group on the Use of Marine Organisms (in MARPOLMON);

(e) GIPME Group of Experts on the Effects of Pollutants (GEEP);

(f) IOC Programme Group for the Western Pacific (WESTPAC);

(g) IOC Sub-commission for the Caribbean and adjacent regions (IOCARIBE);

Table IV summarizes the planned activities within the GIPME programme for all classes of contaminants presently under consideration, including the resources required to mount them. Within this table, the designated priority assignments are based simply upon a comparison of the component of the Comprehensive Plan to which the activity corresponds, with the heirarchical provisions of the strategic framework noted previously. Thus, the priority assignments are by component, rather than stage, of the Comprehensive Plan; that is, assignment is made with respect to stage, and therefore all uncompleted components of stage 0 of the Plan are assigned equal and highest priority.

As may be deduced from Table IV, all items of highest priority apply to the methodological development stage (stage 0) of the strategic framework. Progress in stage 0 is more advanced for some contaminants (e.g., trace metals) than it is for others (e.g., organohalogens) and this might soon mean that baseline boundary exchange measurements would be undertaken for some contaminants while the work on others is still in the method development stage. Therefore, attention to the relative priority of each class of contaminants is justified and necessary.

The most effective approach to this problem would be to complete the development stage of the plan in its entirety for all classes of contaminants (viz. trace metals, petroleum hydrocarbons, and organohalogens) before proceeding to particular measurement phases of the Mass-balance Stage (stage 1). Such an approach would permit the most efficient use of resources for boundary-exchange measurements and particularly baseline surveys, since measurements for all classes of contaminants could then be made simultaneously. The decision by the Working Committee for GIPME to defer the baseline survey for trace metals in the North Atlantic Ocean, which will provide more time for the completion of the method development and proving for organohalogens and petroleum hydrocarbons in order so that baselines for these contaminants may be included, is entirely consistent with this approach. It therefore advocates that completion of the methodological development, proving and training and dissemination of components for all three current classes of contaminants be completed before the methods are applied to the collection of data in the Mass-balance Stage of the Plan.

Since attention to methods for the measurement of boundary exchanges have, until recently, received less attention than the primary effort on methods for ocean baseline measurements, it would be reasonable to delay the acquisition of baseline data until such measurements of boundary fluxes can be made. Therefore, in practical terms, it is logical to complete the development and dissemination of methods for baseline measurements for all three classes of contaminants prior to undertaking baseline surveys. The major thrust in method development should then be placed on methods for boundary- exchange measurements, and concerted attention to boundary- flux measurements should be deferred until methods for all three classes of contaminants can be applied simultaneously.

It is not necessary to adopt the same approach for subsequent stages of the Comprehensive Plan since these stages do not involve costly large scale surveys as the Mass-balance Stage does. Once the bulk of the data required for mass-balance construction has been acquired, attention to individual classes of contaminants for Contamination Assessment and subsequent stages of the Plan can be carried out independently.

THE MARINE POLLUTION RESEARCH AND MONITORING PROGRAMME OF THE INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION: PRESENT AND PLANNED ACTIVITIES

INTRODUCTION

IOC is an autonomous body within the United Nations Educational, Scientific and Cultural Organization (Unesco). Its purpose * is "to promote scientific investigation with a view to learning more about the nature and resources of the oceans through the concerted action of its Member States" (IOC, 1979). It further functions as the co-ordinating body within the United Nations system for marine science and related activities. Co-operative scientific investigations of the ocean as well as the provision of world-wide ocean services, combined with a programme of training, education and mutual assistance in the marine sciences (TEMA) form the chief components of IOC's work.

Membership in the Commission is open to any State that is a member of any of the organizations of the United Nations System. At present, 110 countries co-operate under this arrangement. The Secretariat of the IOC is located in Unesco Headquarters in Paris, France. The functions of IOC are to:

(i) define those problems the solution of which requires international co-operation in the field of scientific investigation of the oceans and review the results of such investigations;

(ii) develop, recommend, and co-ordinate international programmes for scientific investigation of the oceans and related services which call for concerted action by its members;

(iii) develop, recommend, and co-ordinate with interested international organizations, international programmes for scientific investigation of the oceans and related services which call for concerted action with interested organizations;

(iv) make recommendations to international organizations concerning activities of such organizations which relate to the Commission's programme;

(v) promote and make recommendations for the exchange of oceanographic data and the publication and dissemination of results of scientific investigation of the oceans;

(vi) make recommendations to strengthen education and training programmes in marine science and its technology;

(vii) develop and make recommendations for assistance programmes in marine science and its technology;

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* The reader interested in further information on the respective roles and functions of IOC and UNEP is referred to document IOC/INF.523 Add.

(viii) make recommendations and provide technical guidance as to the formulation and execution of the marine science programmes of the United Nations Educational, Scientific and Cultural Organization; and

(ix) promote freedom of scientific investigation of the oceans for the benefit of all of mankind, taking into account all interests and rights of coastal countries concerning scientific research in the zones under their jurisdiction.

All the functions mentioned above are relevant to GIPME and its marine pollution research and monitoring programme. However, four of them (i), (ii), (iii) and (viii), form the very foundation of the GIPME Programme's objectives, which cover all matters related to marine pollution research and associated monitoring activities required for the assessment of marine pollution and contributing to the development of a capability to predict the consequences of pollutant injections, as well as general assessment of the Health of the Oceans. This Programme is to a great extent concerned with chemical oceanography and includes the IOC marine pollution monitoring programme (MARPOLMON). IOC's activities under GIPME receive guidance and inputs from other IOC Programmes. For example, advice on the proper formating, reporting and management of data, which are essential components in any monitoring network, is provided through the IOC Working Committee on the International Oceanographic Data Exchange (IODE). In a similar manner, the IOC Working Committee for Training, Education and Mutual Assistance in the marine sciences (TEMA) co-operates closely in all GIPME Programmes. There are also close relationships between GIPME and the IOC Programmes on Ocean Science in Relation to Living Resources (OSLR) and Non-living Resources (OSNLR).

The IOC co-operates with several UN as well as non-UN organizations, especially the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the Food and Agriculture Organization (FAO), the International Atomic Energy Agency (IAEA), and the International Council for the Exploration of the Sea (ICES). The major co-operation with UNEP in the past has been to serve as a co-operating agency in UNEP's Programmes, being provided with resources accordingly. This is based on the fact that the overall co-ordination of all environmental activities within the UN system is one of the main objectives of UNEP.

The GIPME Programme is guided and co-ordinated through an intergovernmental Working Committee, which, as an IOC subsidiary body, reports to the Executive Council (EC) and Assembly of the IOC. The Working Committee has several subsidiary bodies which aid in implementing the various scientific aspects of GIPME. The identification of the various bodies within GIPME and their relationship are shown in Figure 2. The subsidiary bodies of the Working Committee for GIPME that can be considered to have a more or less permanent status are the Group for Policy, Planning and Strategy (GOPPS), the Group of Experts on the Effects of Pollution (GEEP) and the Group of Experts on Methods, Standards and Intercalibration (GEMSI). The two Groups of Experts may form various ad hoc Groups, depending on topics under study by the two Groups of Experts; the ad hoc Groups are dissolved when their assigned tasks are completed. The Terms of Reference for the two GIPME Groups of Experts are contained in Document IOC, 1982a.

THE GIPME COMPREHENSIVE PLAN

The Comprehensive Plan for GIPME was published by the IOC in 1976 (IOC, 1976a). It proposes a systematic scientific approach to, and conceptual framework for, the determination of the extent of marine pollution through a set of discrete, sequential and iterative procedures. Implicit in the Plan is the use of mass-balance assessments to judge the degree of contemporary oceanic contamination. Such assessments may then be combined with knowledge of the biological effects of potential contaminants to define the extent of oceanic pollution *).

The Fourth Session of the Working Committee for GIPME, in January 1982, considered and reviewed the continued applicability of the Comprehensive Plan and the priorities and strategy for the current and planned activities within the GIPME Programme. The Working Committee established a Subgroup to undertake, sessionally, a review of the Comprehensive Plan, judge its suitability for providing continued guidance on activities within the GIPME Programme, to consider related strategic questions and to make recommendations for the assignment of priorities for future action within the programme. The Subgroup produced a report which proposes a strategic plan for, and assigns priorities to, future activities within the GIPME programme, particularly those within the initial phases of implementation (Annex IV of IOC 1982a). This document, which contains an outline of the components and essential features of the Comprehensive Plan, an assessment of the validity of the approach advocated in it, and a strategic framework for GIPME activities, draws heavily from this report. Moreover, the current and planned activities under the IOC Marine Pollution Research and Monitoring Programme are presented in the context of this strategic framework in order to assign priorities for the future action being recommended and to identify inadequacies or omissions in currently-planned GIPME Programme components.

PROVISIONS OF THE COMPREHENSIVE PLAN

All the various components of the Comprehensive Plan for GIPME are depicted schematically in Figure 1. The Plan comprises four major stages, each of which contains a variable number of components. The four major stages are: (1) mass-balance determination (which includes baseline measurements), (2) contamination assessment, (3) pollution assessment and (4) regulatory action. All of these stages are intended to be addressed sequentially for any given potential marine contaminant, but they are also linked by feedback loops that permit iteration of the procedures in individual stages of the Plan.

*) The terms 'pollution' and 'contamination' are used here in the manner defined by the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) and the Food and Agriculture Organization (FAO 1976).

Mass-Balance Stage

The first major stage of the Comprehensive Plan is the establishment of mass-balances for individual contaminants in the marine environment. Mass-balances are very useful in determining whether there is evidence that the influx of a potential contaminant to the ocean is greater than the removal. Construction of mass-balances allows for a comparison to be made of aggregate influx and efflux rates to show any inequality. The approach has already been used for some metals to determine whether evidence exists to support data that suggest that there has been a substantial increase in the oceanic influxes of certain metals as a result of human activity.

These mass-balances may comprise the entire world ocean (i.e., global mass-balances), or they can be constructed for regional or marginal sea areas. The initial phase consists of measurements, or estimates, of boundary fluxes and regional or global baselines. It is therefore important to clarify what is meant by boundary fluxes in terms of their application to mass-balance assessments. Such fluxes include influxes and effluxes.

The two primary modes of input of terrestrial and man-mobilized material into the ocean are through atmospheric transport and deposition, and river discharge. However, in the case of riverine transport, these influxes are not directly into the offshore waters of regional seas or global oceans, but occur by way of estuaries and other nearshore environments. Thus, gross riverine discharges of contaminants do not represent the actual riverine influxes of contaminants to the ocean proper. For the purposes of the GIPME Programme, data are needed from measurements, or estimates, of the net fluxes of contaminants from rivers to the ocean (i.e., the flux of those components of the gross riverine discharge that survive nearshore removal through chemical, biological and/or geological (i.e., sedimentation) processes). Other important modes for the introduction of contaminants, especially for wholly artificial substances, are through direct discharge from land via pipelines and through dumping by ships at sea. In the case of naturally occurring contaminants, such as metals, there are natural influxes that are important to quantify. These include emissions from tectonic spreading centres and hydrothermal vents and influxes from runoff other than rivers, such as glaciers.

Data pertaining to effluxes of contaminants from the ocean are also needed for the construction of mass-balances. It is, therefore, important to identify potential sinks for contaminants and to estimate the corresponding rates of removal from the ocean. In this respect the major modes of contaminant removal from the ocean are through sedimentation, volatilization and aerosol production; in general, the sedimentation flux is the most important of these. Estimates of influxes and effluxes for regional seas are of comparable uncertainty, and for the whole ocean, our knowledge of influxes is poorer.

In the case of contaminants having natural abundances, knowledge of the balance, or lack of balance, between influxes and effluxes is essential for determining whether the contaminant is, or is not, in approximately steady-state condition. For wholly artificial compounds that have been disseminated by man predominantly during the last few decades, it is most probable that a steady-state balance does not exist. In such cases, rather greater reliance has to be placed upon knowledge of the distribution and transport of these substances within the marine environment than upon mass-balances, for determining the extent of probable contamination.

The other type of data needed for mass-balance calculations consists of baseline measurements of contaminants within the ocean or in a regional sea. The purpose of these measurements is to determine the 'standing stock' of contaminants in the marine environment. This represents the storage term in the mass-balance calculation. Since a given contaminant will be distributed among a number of phases or materials in the ocean, the concentration and distribution of the contaminant has to be determined in water (the aqueous phase), marine organisms and suspended matter. As a result, baseline measurements, on a large scale, are required before mass-balance calculations can be made.

Contamination Assessment

Stage 2 in the process is the assessment of contamination of the ocean, or the regional area of interest, using the mass-balances determined as a result of the initial steps of the approach. Once a mass-balance has been constructed, it must be evaluated carefully in the context of the current state of knowledge of biogeochemical processes occurring in the ocean. The improvement of such knowledge is also an essential facet of the overall strategy advocated in the Comprehensive Plan. This research should address, *inter alia*, internal cycling processes and potential sources and sinks of contaminants, in order to ensure that the mass-balance is comprehensive, and to determine whether the balance is one of steady, or non-steady, state. It needs to be emphasized that processes of particulate transport and aqueous/particulate exchanges, within and at the boundaries of the marine environment, are of great importance in establishing the fluxes of contaminants between dissolved and particulate phases in the ocean and in determining the modes and rates of removal of contaminants from the ocean through sedimentation. As more information becomes available on the details of internal processes, it should be possible to refine further the mass-balances themselves to include the rates of transfer of contaminants between individual compartments of the marine environment. Since the Comprehensive Plan was published in 1976, a great deal of insight into the nature of internal oceanic cycling and removal processes has been gained and some detailed mass-balances, including transports between sub-compartments of the marine environment, have been constructed. These advances have largely been made through the normal progression of marine research and they urgently need to be applied, in a systematic manner, to the aims and objectives of the GIPME programme.

The ultimate aim of these initial steps of the GIPME Comprehensive Plan is to provide an assessment of the nature and degree of oceanic contamination which is required for the next stage in the procedure.

Pollution Assessment

The next stage (stage 3) in the Plan involves the conversion of the contamination assessment into a pollution assessment. The principle knowledge needed for this conversion process concerns the effects of contaminants upon marine organisms and man, and is indeed one of the driving forces that led to the establishment of the GIPME Group of Experts on the Effects of Pollutants (GEEP). The Comprehensive Plan defines the essential components of such knowledge, which must be gained through research, as (a) the relationships between contaminant levels in the marine environment and the associated levels of risk (somatic and genetic) to man through the ingestion of seafoods and direct exposure, and (b) the long-term effects of contaminants on the stability of marine ecosystems.

Once the assessment of pollution has been made, a decision as to its adequacy is required. If the assessment is unsatisfactory, the Plan requires that previous stages of the procedure be repeated. This iteration may be required for individual stages that appear to be the weakest links in the procedure, or it may apply to an entire matrix of components in earlier stages of the Plan. This is the reason for the existence of the various feedback loops in Figure 1. If the assessment of pollution appears adequate and indicates a need for regulatory action to be taken, the final stage of the procedure, regulatory action, can then be carried out.

Regulatory Action

This stage covers both the decision whether or not regulatory action needs to be taken and the procedures for the implementation of regulation. This is the final stage in the procedure outlined in the Comprehensive Plan and, generally, has not yet been addressed as far as marine pollution is concerned. However, a good example of an area in which similar procedures have been adopted is that of radioactive waste management, including the regulation of coastal discharges to the marine environment (see IAEA, 1982). The first component of the regulatory action stage is the decision making step at which the need for the impositon of regulatory controls is assessed. This must be done by a duly authorized legal body, for, if the imposition of regulation is deemed to be necessary, the next step is to develop regulatory standards and impose controls in line with those standards. In the development of standards it is necessary to use the results of research on biological effects that have previously been used in converting the assessment of contamination to an assessment of pollution within the previous stage of the procedure. Once controls have been imposed upon the introduction of pollutants into the marine environment, it is then logical, in most cases, to undertake some compliance (or pollution abatement) monitoring to ensure that the imposed controls are having the desired effect upon the levels of the pollutant within the marine environment. Such monitoring may well also include the monitoring of discharges (i.e., source monitoring) once limits or standards have been established. Finally, there is a need to include some feedback so that the results of monitoring are used to assess the effectiveness of the regulatory action imposed. Thus, there exists a feedback loop to the first component of the regulatory action stage to enable this action to be revised. This then involves repeating the regulatory stage and tightening or relaxing the controls, or revising the standards, as deemed necessary.

CURRENT STATUS OF THE COMPREHENSIVE PLAN

Conceptually, the Comprehensive Plan for GIPME is as valid and applicable today as it was when it was first published in 1976. Indeed, it exemplifies a logical and intrinsically scientific approach to the problem of quantifying marine pollution. Neither its philosophical basis nor its approach require revision, despite the rapid growth in knowledge that has occurred during the last five years. Indeed, a recent document (SCOR, 1982) on Future Ocean Research, prepared for the IOC by the Scientific Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions (ICSU) reconfirms the validity of the mass-balance approach and the need for greater understanding of marine processes in order to assemble a quantitative chemical description of the ocean. There has, however, been a tendency for the rationale behind the plan, as well as its implications, to become forgotten as the programmes, originally conceived for its implementation, have gathered their own momentum. It is, therefore, most useful to re-examine the strategic aspects of the Plan in the context of current and planned GIPME activities related to marine pollution assessment. The Comprehensive Plan advocates regional and global activities and assessments. However, there exists at the present time far greater international (or multilateral) attention to regional activities than to global or open-ocean studies. Nevertheless, it must be realized that both types of activities are required to facilitate the overall implementation of the Plan.

In the first stage of the Comprehensive Plan there are pre-requisites to the collection of data for mass-balance construction that also have a logical sequence. These pre-requisites are the development and proving of techniques for the collection of baseline and boundary flux data for given contaminants. These activities comprise the following four components:

1. Development of techniques;
2. Testing of the techniques to assess their precision and accuracy;
3. Intercomparison of techniques and the selection of 'recommended' techniques; and
4. Preparation of manuals and training potential users.

Clearly, these steps must be carried out in sequence in order to facilitate the collection of data with which to construct mass-balances. This preparatory stage can then be referred to as stage 0 and it can be combined with the stages depicted in Figure 1. The sequence of stages 0 to 4 then represents the strategic framework of the Comprehensive Plan in practice, and can be used to examine the extent of progress within the various activities of GIPME. Most particularly, such an examination should reveal where the GIPME Programme stands with respect to the heirarchical progression of activities needed for the fulfilment of the Comprehensive Plan and whether there are omissions or deficiencies in the list of current and planned activities within the GIPME Programme.

For a given contaminant (or class of contaminants), which justifies attention in the context of oceanic contamination, highest priority must be given to the next stage of the strategic framework that needs to be addressed. Sequentially lower priorities may then be assigned to subsequent stages, which will only justify the assignment of highest priority when all previous stages have been completed. Thus, if, for a given contaminant, all methodological development and proving have been completed, highest priority would be assigned to training programmes and the preparation of manuals that disseminate the appropriate sampling and analytical knowledge for the subsequent collection of baseline and boundary flux data. Once these training aspects have been dealt with, highest priority would be assigned to the execution of baseline surveys and boundary flux measurements.

The approach of applying the Comprehensive Plan to different ocean regions areas is very similar to that for the global ocean. The major additional complexity in such application is, however, apart from the rather greater need for attention to heterogeneities in conditions in the coastal zone, the necessity of defining the exchanges of contaminants across the marine boundaries between regional areas and the open-ocean for the construction of regional mass-balances. This is a rather severe constraint that can give rise to considerably greater difficulty in the construction of regional mass-balances as compared with global ocean balances. The arguments generally put forward for the study of regional areas, as opposed to open-ocean areas, in the context of marine contamination and pollution, are similar to those used to justify the UNEP Regional Seas Programme (UNEP, 1982) which are succinctly stated as "Although there is still an interest in levels of contamination in the open ocean and in major oceanic processes, the danger of the open ocean becoming severely polluted is now considered to be less acute, and it is evident that existing problems, and the first effects of new ones, are most likely to arise in waters close to land. Attention is therefore being concentrated on protecting the health of the coastal waters, especially in enclosed and semi-enclosed seas. The continued growth of human settlements along the coast, the increase in coastal recreation, the concentration of industrial development in coastal areas and the wealth of exploitable living marine resources in coastal waters, all justify the concern currently felt for the quality of the coastal marine environment and its resources." The Comprehensive Plan refers abundantly to regional endeavours and, where appropriate, assessment of contamination and pollution in regional areas should take some priority. Nevertheless, for the regional activities to interface effectively with each other and with baseline measurements for the open ocean, it is essential that the methods used be sufficiently well defined and correctly applied, and above all, intercomparable. Similarly, the use of regional programmes to acquire data on boundary-fluxes, for application to open ocean assessments and mass-balances would also need to be based upon the application of intercomparable techniques.

PAST, PRESENT AND PLANNED GIPME ACTIVITIES

The activities of the GIPME Programme will now be described in the context of the strategic framework just discussed, identifying which of the proposed/planned activities should be given highest priority. A detailed examination of these activities will be given first in terms of specific groups of contaminants, and then in terms of activities that deal with general questions regarding boundary exchanges and other aspects of the Comprehensive Plan.

Trace Metals and Metalloids

At its Second Session in Bergen (IOC, 1978), GEMSI formulated a list of metallic contaminants that needed to be addressed in the development of analytical procedures for oceanic baseline surveys. This list is:

First priority: Hg, Cd, Pb, Cu, Zn, Ni, Se, Co
Second priority: Cr, As, Mn, Fe, Sn, Mo, V

Elements in the first priority list are environmentally important either because they are mobilized by human activity on a scale comparable with natural fluxes, or are believed to be intimately involved in biological processes in the open ocean. Elements in the second priority list are those for which baselines need to be established although their role in biological processes and their rate of release by man to the oceans are probably less important. Although there are probably some reasons to re-examine this list in the light of recent research results, it is still sufficiently comprehensive to have been used by GEMSI for guidance as to which metallic contaminants need to be addressed within Phase I of the GIPME Pilot Project on Assessing the Feasibility of Determining Baseline Levels of Selected Pollutants in Open Ocean Waters, an activity to which the UNEP Regional Seas Programme provided partial support. It should be stressed at this point that the monitoring of open-ocean baselines is not being advocated.

The work of GEMSI in the development and proving of methods for oceanic baseline measurements has been greatly assisted by the rapid improvement in capability to measure the metal content of seawater that has occurred in the last few years, and which is reflected by the scientific literature during the last decade. Goldberg (1981) has referred to these improvements as 'a revolution' in marine chemistry. Further assistance has been provided by the various intercalibrations conducted under ICES auspices since 1976. GEMSI and the ICES Marine Chemistry Working Group simultaneously decided that the next stage in the process of methodological assessment should be an examination of sampling techniques for the collection of seawater samples for trace metal analysis. This experiment, Phase I of the GIPME Pilot Project noted in the previous paragraph, was subsequently conducted in Bermuda in 1980 (IOC, 1982b). Subsequently, ICES decided to undertake the next, and possibly final, experiment in its current series of intercalibrations. This experiment, involving the intercomparison of filtration procedures for the separation of dissolved and particulate phases from coastal waters, was conducted in Nantes, France, in September 1982.

As a result of these various activities, there are now methods for the measurement of oceanic baselines within the GIPME Programme for most of the trace metals in the priority list. Furthermore, the general intercomparabilty of these methods has been established and, in most cases, the influences of sampling techniques on the results have been assessed (see IOC, 1982b). <u>It should be stressed, however, that these methods and measurements are primarily those that are applicable to the determination of open-ocean baselines.</u> Current activities are being directed to dealing with the particular problems of coastal water baseline measurements (e.g., the ICES activity noted above). The coastal water situation is somehwat more complex because of the greater need to take account of metals in the suspended particulate, as well as the dissolved form. In the open-ocean, the proportion of most metals that are associated with suspended particulate material is relatively small, and baselines based on total or dissolved (i.e., filtered sample) analyses are generally adequate to define a baseline.

It remains for the open-ocean baseline methodology to be documented and disseminated through training programmes preparatory to the conduct of baseline surveys, proposals for which have already been made by GEMSI (IOC, 1980) to take place in conjunction with an Atlantic Ocean baseline programme. Once the refinement and testing of procedures for the measurement of coastal baselines have been carried out, similar dissemination of technical expertise will be required.

The current position with regard to GIPME Programme activities on trace metals in the context of the provisions and components of the Comprehensive Plan is summarized in Table I. The most important omissions from these activities might appear to be those related to boundary-flux measurement techniques. While the measurement of atmospheric deposition onto the ocean is difficult and a rather specialized area of current marine research, the results of certain research programmes, particularly a study on Sea-Air Exchange (SEAREX), sponsored by the US National Science Foundation (NSF), that involve, inter alia, measurements of atmospheric deposition and examination of the sources of atmospheric constituents, will provide valuable information on fluxes at this boundary. Also, at its most recent meeting, GEMSI endorsed the establishment of an ad hoc Group on the Use of Marine Sediments for Pollution Monitoring (IOC, 1982c) which has, in its Terms of Reference, a requirement to consider the data for sediment/water boundary exchanges that would be needed for mass-balance construction. Thus, in regard to these two major boundary exchanges, sea/air and sea/sediment, activities that will help to provide some data for the purposes of mass-balance assessments for metals are being carried out.

The one boundary that is of great importance in mass-balance considerations and which appears to have been largely neglected, is the river/ocean boundary. The composition of global runoff for trace constituents is very poorly understood, and yet rivers are a major contributor to the natural and human inputs of chemical substances to the ocean. Under its revised Terms of Reference, GEMSI established an ad hoc Group on Fluxes and Mass Balances, to examine gaps in our knowledge for producing data for mass-balance purposes. This Group will work inter-sessionally and is expected to develop some conclusions in the near future that bear on this subject. Nevertheless, it is clear that early attention to precise and accurate measurements of river composition is required for regional and for open-ocean mass-balance assessments.

Petroleum Hydrocarbons

Activities with respect to petroleum hydrocarbons have progressed well beyond those for the other classes of contaminants, primarily because of the Marine Pollution (Petroleum) Monitoring Pilot Project (MAPMOPP), which was developed under the IOC/WMO Integrated Global Ocean Services System (IGOSS), and included observations of floating slicks, measurements of the incidence of tar balls on the ocean surface and dissolved/ dispersed petroleum residues in the water column, and the assessment of tar stranded on beaches. The foundations of this programme were laid down by an ad hoc Group on Oil and Dissolved Constituents in Seawater that was established by the IOC Group of Experts on Oceanographic Research as it Relates to IGOSS (IRES). The ad hoc Group developed the procedures for sampling and analysis for use within the programme with the final preparations being completed at a Symposium and Workshop on Marine Pollution Monitoring (Petroleum) held at Gaithersburg, Maryland, USA, in 1974. The project began in January 1975 and the final report was completed and issued in 1981 (IOC, 1981a). It must be stressed that this programme had as its major objective an assessment of the feasibility of carrying out large-scale marine pollution surveys through the concerted activities of the Member States of the IOC. For this reason, the methods and techniques chosen for the programme encompassed a wide range of levels of sophistication, but were relatively simple and straightforward procedures that could be employed by a large number of countries, and this had certain limitations. Even so, the results of this programme are impressive and constitute a substantial improvement in our authoritative knowledge of the incidence of hydrocarbons in the marine environment.

The data obtained by the MAPMOPP Programme are less amenable to detailed interpretation than data acquired from the widespread application of more modern and sophisticated techniques. Particular deficiencies in the MAPMOPP data are the inability to determine the detailed composition of the hydrocarbons found in the ocean and the unsuitability of these data for application to mass-balance calculations. Recent developments in analytical technology permit more detailed examination of the composition of this class of compound which, in turn, would permit better quantification of the hydrocarbon components found in the marine environment and better discrimination between potential sources of such compounds. A re-examination of the procedures most suitable for hydrocarbon determinations has therefore been made, with a view to providing more insight into the sources and fluxes of these compounds in the ocean (see for example IOC, 1981b and c, 1982d). As part of this effort, GEMSI has formulated plans for an Intercalibration Workshop during 1983 to assess the suitability and intercomparability of techniques for the measurement of dissolved/dispersed hydrocarbons in seawater and of the hydrocarbon components in the sea-surface microlayer (see item 2 in Table II and Table IV). These activities are directly related to the IOC Marine Pollution Monitoring Programme for petroleum (MARPOLMON-Petroleum) which is a fully operational extension of MAPMOPP and devoted to establishing a spatially and chemically detailed baseline for petroleum hydrocarbons in the ocean, regional seas and coastal areas.

Thus, a great deal of ocean baseline work has been, and is being carried out for petroleum hydrocarbons. However, relatively little co-ordinated attention has been given to boundary- flux measurements, although some mass-balance assessments, based upon limited data, have been carried out (e.g., NAS, 1975). River runoff appears to be second only to marine transportation as a source of petroleum hydrocarbons in the ocean, while the atmospheric deposition of such compounds seems comparable with the rate of natural petroleum seepage from the seabed. This emphasizes the importance of boundary exchanges to the supply of petroleum hydrocarbons to the ocean. Equally important are measurements of the rates of hydrocarbon sedimentation in the ocean, and this is particularly important in the context of mass-balances for regional seas. As with trace metals, a systematic evaluation of riverine influxes of hydrocarbons is urgently needed, and more effort should be focussed upon hydrocarbon distributions in sediments and the corresponding rates of sedimentation. GEMSI, in undertaking an examination of deficiencies in current data for mass-balance purposes as an inter-sessional activity, will pay particular attention to river discharge fluxes in its future activities. These efforts are entirely consistent and compatible with the needs for further work and the objectives of current GIPME activities. The state of GIPME activities on petroleum hydrocarbons in the context of the strategic framework is summarized in Table II.

Organohalogen Compounds

Activities under the GIPME Programme on organohalogens are summarized in Table III. All such activities have been confined to the solution of sampling and analytical problems, particularly with respect to the measurement of baseline distributions in the ocean.

The approach to the measurement of organohalogen compounds in the environment has changed markedly during the last few years as a result of improvements in analytical technology. The vast majority of data collected on the incidence and distribution of polychlorinated biphenyls (PCBs) in the environment has been obtained through the use of packed-column gas chromatography. In this procedure, quantification is achieved by comparing chromatograms obtained from environmental samples with those obtained from certain common technical formulations (e.g., AROCHLOR-1254). This procedure has some difficulties that give rise to incomparability in the results obtained from various laboratories. As a result, GEMSI (IOC, 1981 d) has advocated the use of temperature-programmed, capillary-column gas chromatography which provides much better resolution in the analysis of polychlorinated hydrocarbons. It also can be combined with mass-spectrographic techniques to provide unambiguous identification and quantification of individual PCB components. The entire subject is dealt with in detail in Annex V of the Summary Report of the Third Session of GEMSI (IOC, 1980).

Although preliminary work on method development for PCB compounds for GIPME purposes was carried out, using the packed-column method, since the intercalibration exercise that was held in Bermuda in January 1980 (IOC, 1982b), GEMSI has placed its major emphasis on the development of more specific and refined procedures for baseline measurement purposes. To this end, work is being conducted and a developmental programme has been proposed on a trilateral basis between the Netherlands Institute for Sea Research, Texel, the Institute of Marine Research, Bergen, and the Bermuda Biological Station for Research, Inc. This programme, which is described in Annex V of IOC, 1981d, comprises a six-month method development stage and a subsequent eighteen-month pilot measurement programme at Panulirus Station (Ocean Station 'S') (see Table IV for details and resources required). Currently, within this programme, attention is being directed through laboratory experiments in determining the most efficient means of extracting individual PCB components from seawater and to establishing the essential steps in qualitative and quantitative analysis of these components, and will be outlined here for completeness.

Organohalogen compounds in seawater usually occur at extremely low concentrations. Moreover, they are present in a complex mixture with other organic compounds, having considerably higher concentrations. Thus, analytical schemes for their determination require (a) a concentration step of the compounds of interest, over many orders of magnitude, in order to bring their concentration above the detection limits; (b) the separation of organohalogen compounds from interfering organic compounds; and (c) the separation of the various organohalogen compounds to allow the qualitative and quantitative analysis of each compound.

The extremely low concentrations at which these compounds occur in the open-ocean, in combination with their ubiquitous presence, require extreme care to be exercised to avoid contamination of the samples during all steps of the analytical procedure, including pre-shipboard activities (cleaning of equipment), on-board activities during sampling and processing, and work in the laboratory. The identification and quantification of compounds require the availability of the compounds of interest in pure form or in solutions of known composition and concentrations, conditions that are not yet satisfied for all components detected in seawater. The presence of particles in seawater requires their separation and individual analysis. This is a well known general problem for which no scientifically sound solution is yet available, but an operationally defined distinction (e.g., filtration) is generally accepted. This extra step in the analytical procedure for organohalogen measurement is a potentially serious source of contamination. The main problems in conducting the analysis are related to (a) the elimination of blank problems in the use of adsorbent columns; (b) the resolution of peaks in the PCB fraction into contributions of individual components; and (c) the role of particles in seawater suspension.

In view of the above, a GEMSI ad hoc Group recommended that other extraction techniques be investigated, in addition to using XAD-2 columns, in order to improve blanks and to study the role of particles (IOC, 1981d). It was felt that maximum profit could be gained from the previously noted 6- and 18-month research programmes, if, prior to the start of this project, these outstanding questions had been solved.

The laboratory experiments being conducted in response to the above-mentioned recommendation have resulted in considerable progress in solving the previously noted problems. The results obtained to date are related to the following:

(i) The testing and application of air-lift sampling systems in the Sargasso and the North Sea.

(ii) The analysis of dissolved, as well as particulate, organohalogen concentrations in these waters. Horizontal and vertical distributions (i.e., profiles) have been studied. The role of particles has been studied in low- and high-seston concentration regimes. This has resulted in a reasonable insight into the fractionation of various PCB components into solution and suspension. In particular, it has turned out to be necessary to analyse both compartments separately.

(iii) The production of a standard mixture containing all available components of PCBs. The three laboratories noted previously have exchanged this sample for independent analysis.

(iv) The purchase and distribution of identical capillary columns to be used by the three laboratories noted previously.

(v) The development, testing and application of a new continuous liquid-liquid extraction system.

(vi) The analysis of a series of technical formulations by GC-ECD * and GC-MS ** techniques, allowing more accurate analysis of PCBs in environmental samples.

(vii) The distribution of Ahnhoff and Josefsson extractors to various institutes.

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* Gas chromatography employing an electron capture detector
** Gas chromatography-mass spectrometry

Most of the necessary preliminary steps have been taken to make the proposed activities regarding organochlorines, noted in Table IV, a success. It should be stressed, however, that the combination of specialized knowledge and expertise of various laboratories, working together at the same location, has already proven highly successful (IOC, 1982b). It generated the first publication reporting individual PCB components in seawater, in the open refereed scientific literature (Duinker et al, 1980). Former analyses of PCBs in seawater have all been carried out with the use of packed-column chromatography. The new approach using temperature-programmed capillary-column gas-chromatographic separation techniques has resulted in a new way of looking at the complex assemblage of problems connected with the study of sources, transport mechanisms, transformation processes, sinks and effects of individual organochlorine compounds in the marine environment. For example, following a recommendation of GEMSI, this approach has now been introduced into the activities of ICES, and many more laboratories are now equipped with the necessary equipment.

Once suitable procedures have been developed and tested, through their application in the time-series measurement programme proposed to be conducted at Bermuda, they will be incorporated into the proposed trace-metal baseline survey for the Atlantic Ocean, noted in Table IV. Since this latter programme has been deferred until 1985 by the Working Committee for GIPME, there is enough time to complete the developmental work and to document and disseminate the techniques for PCB measurement before mounting a combined trace metal/organohalogen baseline measurement survey for the Atlantic Ocean.

As can be ascertained from the foregoing discussion, activities with respect to organohalogens are predominantly dealing with the methodological development required to undertake oceanic baseline measurements and are proceeding well, but continued activity requires extra-budgetary resources. Once the sampling and analytical methods have been developed and tested, only then can they be applied to oceanic baseline measurements in conjunction with trace metal baseline surveys.

Attention to boundary fluxes for organohalogens has not been overlooked, as appears to have been the case trace metals and petroleum hydrocarbons, since the work on organohalogens is still very much at the developmental stage. Following the revision of the Terms of Reference of GEMSI to broaden their responsibilities under the GIPME Programme, GEMSI has made plans to examine data deficiencies in mass-balance assessment and to examine procedures for river-flux measurements and sediment boundary exchanges for all types of contaminants.

Other GIPME Activities

There are certain other GIPME activities that relate to all classes of potential marine contaminants; some of these activities have previously been referred to in connection with specific classes of contaminants.

(a) GEMSI *ad hoc* Group on Marine Sediments.

This group was established to work intersessionally to assess the feasibility, within the context of the Comprehensive Plan for GIPME, of using marine sediments to locate, quantifiy, assess and control contamination. Its Terms of Reference (see Annex XII, IOC, 1982c) also direct the group to address certain specific questions related to methodological approaches and the application of sedimentary data to mass balance calculations. The group commenced its work early in 1983 and will draw information from a sister GEMSI ad hoc Group whose strategies are more advanced (see of below) to avoid duplication of effort.

(b) GEMSI *ad hoc* Group on the Identification of Gaps in Fluxes and Mass-Balance Calculations in Marine Systems

This Group was formed during the Fourth Session of GEMSI (IOC, 1982c) and is continuing its work intersessionally. Its formation was a logical first step in meeting the requirements of the broadened Terms of Reference of GEMSI. Its objectives are to identify existing gaps in mass-balance/flux information for the various classes of contaminants in the world ocean and in some regional marine areas. The intersessional work, following GEMSI-IV, comprises the assessment of the current state of knowledge on the fluxes of contaminants in the world ocean; evaluation of previous approaches to mass-balance calculations and identification of weaknesses and data deficiencies that restrict the applicability of these approaches for the purposes of the Comprehensive Plan; and evaluation of the specific requirements for constructing mass-balances for regional marine areas.

(c) GEMSI *ad hoc* Group on River Inputs

GEMSI, at its Fourth Session, recommended the establishment of an ad hoc Group to consider approaches to defining the influx of contaminants through river runoff. This has been a matter of concern within GEMSI for some time, and, with the recent revision of its Terms of Reference, it became possible for GEMSI to deal with the topic in the context of future GIPME activities.

The current situation of data on trace constituent compositions for rivers, which include the major classes of contaminants, is extremely poor, in terms of coverage and reliability. Urgent attention to redressing these deficiencies is needed, and this group was formed for this reason. It is anticipated that it will start its work during 1983, but, in the interim, steps have been taken to ensure close contact with the SCOR Working Group No. 46 on River Inputs to Ocean Systems, which has similar interests in the topic. As stated previously, the flux of materials discharged by rivers does not necessarily correspond to the influx of these same materials to the ocean through river runoff because of the modifications to gross river discharges by estuarine processes. Nevertheless, the poor state of knowledge of gross river discharges will require that this aspect of runoff fluxes be addressed first, before the more complicated problem of net riverine influxes to the ocean is considered in more detail. Provisions have been made in the IOC Programme for 1984 (i.e., coastal processes) to catalyse the efforts of GEMSI, the implementation of the recommendations of SCOR WG 46 (River Inputs to Ocean Systems) and the Coastal Programme activities of the Division of Marine Science (Unesco), since, for all these programmes or activities, an upgraded assessment of pollutant loads carried by rivers, the modes of exchange of these materials between the sources and the regional seas via estuaries, and an estimate of the deposition of the materials in the nearshore environment, are required for subsequent construction of regional and global mass-balances.

(d) GEMSI ad hoc Working Group on the Use of Marine Organisms in MARPOLMON

This group was established in 1981 to investigate the need for incorporating analyses of marine organisms into MARPOLMON. While the ad hoc Group had concluded that marine organisms could be included in the MARPOLMON programme, and that guidelines for sampling and analyses of organisms could be devised for application to the monitoring of contaminants for public health and water quality purposes, it had evidence that the capability and facilities for the collection and analysis of organisms were insufficiently widespread to justify their immediate inclusion in MARPOLMON. The Group therefore recommended that a programme of intercomparison and training be instituted to enable a broad international community to achieve the desired levels of accuracy and precision necessary for the use of organisms in monitoring. The work of this Group will be further detailed below in the discussion of activities of the IOC Programme Group for the Western Pacific (WESTPAC) on marine pollution.

(e) GIPME Group of Experts on the Effects of Pollutants (GEEP)

The formation of this GIPME Group of Experts was recommended by the Working Committee for GIPME at its Fourth Session (IOC, 1982a). The initial task of GEEP will be to conduct case studies of IOC regional activities, with a view to identifying potential areas of expansion of GIPME activities, including the identification of pollutants to be considered, levels to be anticipated, and the precision required for their measurement. This may include ecological considerations of effects, as well as an assessment of the use of different water masses in the regions as a means of evaluating a pollution problem.

It is expected that, inter alia, the product of GEEP's initial activities will be as follows:

(i) Advice to GEMSI on results of the case studies, so as to have an assessment made of what accuracy and precision can now be achieved analytically for selected pollutants and what must be achieved in the near future in the establishment of monitoring networks to satisfy the needs of Member States in the region under consideration.

(ii) Advising GIPME of the course to be followed vis-a-vis the Action Plan developed at GIPME-IV (IOC, 1982a) and later refined as a Supplement to 'The Comprehensive Plan' for GIPME (IOC, 1983).

(f) IOC Programme Group for the Western Pacific (WESTPAC)

In March 1981, the WESTPAC ad hoc Task Team on Marine Pollution Research and Monitoring Using Commercially Exploited Shellfish as Determinants developed a scientifically sound programme as an important regional component of MARPOLMON (IOC, 1981e). Recommendations were made on sampling design, choice of organisms and ancilliary environmental data required for an approach comparable to that of the US Mussel Watch Programme. A priority list of environmental pollutants was drawn up; the high priority list for trace metals was to include cadmium, copper, lead, mercury and zinc, with secondary consideration being given to other trace metals. Subsequent priority was given to chlorinated hydrocarbons and petroleum hydrocarbons in that order. The priorities were, in part, governed by the technical capabilities and facilities available in the region.

In addressing the question of intercomparability of results between laboratories, a plan of action was adopted to ensure the quality and intercomparability of the results of the monitoring programmes of participating countries. Elements of this plan included the distribution of standard reference material to participating laboratories, firstly in the form of the US National Bureau of Standard's Oyster Reference Material, together with certified inorganic reference solutions for trace metals and, subsequently, analysis of a suitable biological reference material (preferably mussel tissue). The WESTPAC ad hoc Task Team recommended that the IOC seek advice and guidance from its GEMSI for this exercise and that potential laboratories in the WESTPAC region that might participate in the intercalibration be identified and requested to complete a questionnaire indicating their facilities, capabilities and monitoring stations. Upon receipt of the intercalibration results, the Task Team would then make recommendations as to the most practical course of action for improvement of the analytical capabilities, decide upon necessary recalibration and consider the needs for on-the-spot assistance or training.

After satisfactory completion of the initial trace metal intercalibration exercise (envisaged to take two years) a WESTPAC International Mussel Sampling Year (WIMSY) was to be instituted. Chlorinated hydrocarbon and petroleum hydrocarbon intercalibration exercises would follow as soon as possible.

Since GEMSI was identified as the formal source of guidance on pollution monitoring in the WESTPAC region, consideration was given to implementing a monitoring programme employing marine organisms, not only in the WESTPAC region, but also for the Caribbean Sea (IOCARIBE), as laid down in the recommendation of the GEMSI ad hoc Group on the Use of Marine Organisms in MARPOLMON, made in Paris, 8-12 February 1982 (Annex Vd of IOC, 1982c). A questionnaire addressed to laboratories prior to this date had not fulfilled all the requirements for initiating the first intercalibration exercise. Therefore, a second questionnaire, sent world-wide, elicited more detailed information on current analytical facilities in laboratories, and intercalibration samples were duly despatched. A wide-spread interest in co-operating with the proposed training and monitoring programmes has been demonstrated for the WESTPAC Region, and the initial intercomparison exercise, using an ICES standard, has been completed.

It is clear that extensive intercalibration and training programmes are required before a monitoring programme using marine organisms may be realized, this being particularly acute for organochlorines and hydrocarbons. Nonetheless, it is cost-effective to endeavour to intercalibrate and monitor all three groups of pollutants, and forthcoming training programmes will be backed by detailed manuals covering all aspects of sampling, preparation and analyses required for the design and implementation of a monitoring programme based on the analysis of biological tissue for all three pollutant groups.

Arrangements for the implementation of a training programme in the WESTPAC Region, and an intercomparison exercise are under way. A co-ordinating group to carry out the training workshop and supervise the intercalibration exercises has been identified; it includes experts on monitoring, utilizing bivalves and other marine organisms, as well as experts on the analysis of trace metals, organochlorines and fossil hydrocarbons in marine organisms. A recent mission to the region located and evaluated the facilities available for the proposed workshop. The Australian Government has indicated a strong interest in hosting the training workshop and all efforts are being made to finalize the arrangements before summer 1983. It is felt that the trainees will participate in a second intercomparison exercise along with ICES participants in the 1983/1984 ICES Comprehensive Intercomparison Exercise for Trace Metals, Organochlorines and Hydrocarbons. Plans for this are also under development. However, it should be pointed out that strict adherence to the training schedule and intercomparison timetable recommended by GEMSI is vital if the WESTPAC Region is to take advantage of the common ICES reference materials used in the proposed global intercomparison exercises.

The real cost projection for the initial training workshop and pre-intercalibration activities, based on the participation of 30 trainees in three sub-groups for the specified pollutants, and four co-ordinators with chosen technicians, is estimated to be US$121,000 for the pre-workshop, workshop and post-workshop period.

The establishment of the WESTPAC pollution monitoring programme based on the chemical analysis of marine organisms, with an International Mussel Watch character, as a longer term objective of GIPME, can follow from the successful outcome of this first training/intercalibration exercise and after intercalibration at an international level has been achieved.

(g) The IOC Sub-Commission for the Caribbean and Adjacent Regions (IOCARIBE)

The main IOC marine pollution research and monitoring activity in the the Caribbean Sea consists of the implementation of a recommendation of the Second Session of IOCARIBE; this constitutes the IOCARIBE Action Plan for Marine Pollution Monitoring and is known as CARIPOL. It is a field monitoring programme for petroleum, which is identified as the number one priority pollutant in the region by the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, held in Trinidad, 13-17 December 1976 (IOC, 1976b). The programme basically consists of implementing a regional programme using procedures defined for MAPMOPP, which is now part of the Petroleum Pollution Monitoring Component of MARPOLMON (MARPOLMON-P). Three categories of petroleum pollution are monitored:

(a) floating particulate petroleum residues (tar balls);
(b) tar and oil on beaches;
(c) dissolved/dispersed petroleum hydrocarbons in seawater by spectrofluorimetry.

The CARIPOL Programme has been identified as pertinent to the needs of individual IOCARIBE Member States with a potential for providing a regional data base which will allow development of information on the extent and sources of marine petroleum pollution in the IOCARIBE area.

Efforts over the past three years have been directed towards the achievement of the following five goals;

- identifying resources and personnel, including training of personnel identified by Member States;
- initiating a field programme;
- archiving data received in machine readable format;
- developing useful data output products; and
- reporting results of the programme in professional journals.

As a first step toward accomplishing these goals, a CARIPOL Programme Director was appointed and a Steering Committee consisting of scientists working in the region was formed to guide the programme. Personnel have been identified by Member States throughout the region for participation in the project. In September 1980, two ten-day training workshops were conducted for identified personnel, one being conducted in English, the other in Spanish. The workshops were convened in the Environmental Chemistry Laboratory of the University of Costa Rica in San Jose, Costa Rica, and consisted of classroom instruction as well as laboratory and field activities. Participants (trainees and instructors) came from Belize (1), Cayman Islands (1), Columbia (1), Costa Rica (4), Cuba (1), Dominican Republic (2), Jamaica (2), Guatemala (2), Guyana (2), Mexico (4), Netherlands Antilles (2), Panama (1), Puerto Rico (1), St. Lucia (1) Trinidad and Tobago (2), United States (3), and Venezuela (2), a total of 32, representing 18 Member States in the region. Since spectrofluorimeters are required for the measurement of dissolved/dispersed petroleum in seawater an effort was made to locate, or procure, instruments for interested Member States. Instruments have been placed in Mexico, Costa Rica, Jamaica, Cuba, and the Cayman Islands. CARIPOL has also located instruments owned by other institutions in Martinique, Trinidad and Tobago, the United States and Venezuela. At present, there is a reasonable, but sparse, distribution of spectrofluorimeters in the region and more instruments are being sought for subsequent placement within Member States.

Prior to the September 1980 training workshops, a limited CARIPOL field programme was initiated by the USA in the Gulf of Mexico and along the coast of the State of Florida. This was designed as a pilot field project to gain experience in MARPOLMON procedures and demonstrate their utility. This pilot effort was completely successful and resulted in the accumulation of a one-year data set for the area mentioned, for all three CARIPOL parameters. The pilot effort also provided a basis of experience for conducting the training workshops. On the basis of this experience and the training workshops, a CARIPOL petroleum pollution monitoring manual has been developed based on the IOC/WMO Manuals and Guides No. 7, which specifically addressed the needs of the region. This manual has been printed in English and Spanish and distributed to all participants.

Full implementation of the CARIPOL petroleum pollution monitoring effort has been accomplished, and the programme can now be considered operational. Data have been received to date from the United States, Jamaica, Cayman Islands, Mexico, Puerto Rico, the Netherland Antilles and Trinidad and Tobago. As of October 1982, these data comprise over 3600 individual observations, all of which have been archived in machine-readable format at the IOCARIBE Responsible National Oceanographic Data Centre (RNODC); i.e., NODC, Washington, D.C.

(h) Co-operation with International and National Organizations

To avoid duplication of effort between IOC's MARPOLMON Programmes for WESTPAC and IOCARIBE, collaboration with UNEP's Regional Seas Programme's East Asian Seas and the Wider Caribbean Action Plans and the Governments of the relevant regions is being pursued. The offer of the government of Japan (IOC, 1981e), that the Japan Oceanographic Data Centre would assume responsibilities for the collection of data for the WESTPAC Region, will benefit the monitoring programme in its subsequent stages. Mention has already been made of co-operation with ICES. Finally, co-operation and collaboration is also being pursued with the International Maritime Organization (IMO), the Paris and Oslo Commissions and the London Dumping Convention.

TIME-TABLE, PRIORITIES AND RESOURCES REQUIRED FOR PLANNED GIPME OPERATIONS

Table IV summarizes the planned activities within the GIPME Programme for all classes of contaminants presently under consideration, including the resources required. Within this Table, the designated priority assignments are based upon a comparison of the component of the Comprehensive Plan to which the activity corresponds with the heirarchical provisions of the strategic framework discussed previously. Thus, the priority assignments are by component, rather than stage, of the Comprehensive Plan; that is, assignment is made with respect to stage and therefore all uncompleted components of Stage 0 of the Plan are assigned equal and highest priority.

As may be deduced from Table IV, all items of highest priority apply to the methodological development stage (stage 0) of the strategic framework. Progress in stage 0 is more advanced for some contaminants (e.g., trace metals) than it is for others (e.g., organohalogens) and this could favour the argument that baseline and boundary- exchange measurements should be undertaken for some contaminants while the work on others is still in the method development stage. Therefore, attention to the relative priority of each class of contaminants is justified and necessary.

The most effective approach to this problem would be to complete the developmental stage of the plan in its entirety for all classes of contaminants (viz., trace metals, petroleum hydrocarbons, and organohalogens) before proceeding to particular measurement phases of the Mass-balance Stage (stage 1). Such an approach would permit the most efficient use of resources for boundary-exchange measurements and particularly baseline surveys, since measurements for all classes of contaminants could thenbe made simultaneously. The decision by the Working Committee for GIPME to defer the baseline survey for trace metals in the North Atlantic Ocean will provide more time for the completion of the method development and proving for organohalogens and petroleum hydrocarbons, so that baselines for these contaminants may be included, is entirely consistent with this approach. It is therefore advocated that completion of the methodological development, proving and training and dissemination components for all three current classes of contaminants be completed before the methods are applied to the collection of data in the Mass-Balance Stage of the Plan.

Since attention to methods for the measurement of boundary exchanges have, until recently, received less attention than the primary effort on methods for ocean baseline measurement, it would be unreasonable to delay the acquisition of baseline data until such measurements of boundary fluxes can be made. Therefore, in practical terms, it is also logical to complete the develoment and dissemination of methods for baseline measurements for all three classes of contaminants prior to undertaking baseline surveys. The major thrust in method development should then be placed on methods for boundary-exchange measurements, and concerted attention to boundary-flux measurements should be deferred until methods for all three classes of contaminants can be applied simultaneously.

It is not necessary to adopt the same approach for subsequent stages of the Comprehensive Plan, since these stages do not involve costly large scale surveys as the Mass-Balance Stage does. Once the bulk of the data required for mass-balance construction has been acquired, attention to individual classes of contaminants for contamination assessment and subsequent stages of the Plan can be carried out independently.

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TABLE I

GIPME ACTIVITIES - TRACE METALS AND METALLOIDS

GIPME COMPREHENSIVE PLAN COMPONENT		RELATED GIPME ACTIVITIES: GLOBAL/OPEN-OCEAN	RELATED GIPME ACTIVITIES: REGIONAL
1. Development of techniques	Baselines	Completed	(a)
	Boundary fluxes	Under consideration by GEMSI (b)	(b)
2. Proving of techniques	Baselines	Completed	(a)
	Boundary fluxes	(b)	(b)
3. Dissemination of expertise/ training	Baselines	Proposed (see Table IV)	(c)
	Boundary fluxes	(c)	(c)
4. Data acquisition	Baselines	Proposed (see Table IV)	(d)
	Boundary fluxes	(d)	(d)
5. Construction of mass-balances		Under consideration by GEMSI (e)	(e)
6. Contamination assessment			
7. Pollution assessment		(f)	(f)
8. Regulatory action		This is not a GIPME function	

NOTES

a) For caostal baselines, discrimination between particulate and dissolved phases is required. ICES has carried out an assessment of filtration and particulate analysis procedures.

b) GEMSI is currently considering methods for measuring gross riverine inputs. This work relates also to the interests of the ICES Marine Chemistry WG and SCOR WG.46.

c) Training for regional baselines and boundary flux measurements would be designed once the appropriate sampling and analytical procedures have been developed and proven.

d). Some open-ocean baseline data are available from the literature. Regional baseline coverage is generally poor. Flux measurements for boundary exchanges at the air/sea interface for some substances are available from the SEAREX Programme. Some riverine flux data are also available but coverage and data reliability are generally poor.

e) Mass-balances for some elements (e.g. Pb and Cd) have been constructed for the global ocean. GEMSI proposes to study current status of metal mass-balances and the needs for data in the construction of both global and regional mass-balances.

f) Biological effects of contaminants and the process of pollution assessment will be considered by GEEP.

TABLE II

GIPME ACTIVITIES - PETROLEUM HYDROCARBONS

GIPME COMPREHENSIVE PLAN COMPONENT			RELATED GIPME ACTIVITIES: GLOBAL/OPEN-OCEAN	RELATED GIPME ACTIVITIES: REGIONAL
1. Development of techniques	Baselines	Floating TB	Completed/MAPMOPP	
		TB on beaches	Completed/MAPMOPP	
		Diss./Disp.	Completed/MAPMOPP (a)	
		Microlayer	Completed/MAPMOPP (c)	
	Boundary fluxes		(b)	(b)
2. Proving of techniques	Baselines	Floating TB	Completed/MAPMOPP	
		TB on beaches	Completed/MAPMOPP	
		Diss./Disp.	Completed/MAPMOPP (a)	
		Microlayer	Completed/MAPMOPP (c)	
	Boundary fluxes		(b)	(b)
3. Dissemination of expertise/training	Baselines	Floating TB	Completed/MAPMOPP	
		TB on beaches	Completed/MAPMOPP	
		Diss./Disp.	Proposed	
		Microlayer	Proposed	
	Boundary fluxes		(b)	(b)
4. Data acquisition	Baselines	Floating TB	MARPOLMON-P	
		TB on beaches	MARPOLMON-P	
		Diss./Disp.	MARPOLMON-P	
		Microlayer	MARPOLMON-P	
	Boundary fluxes		-	-
5. Construction of mass-balances			(d)	-
6. Contamination assessment			(e)	(e)
7. Pollution assessment			(f)	(f)
8. Regulatory action			This is not a GIPME function	

NOTES

a) Previous measurements of dissolved/dispersed and sea-surface microlayer hydrocarbons have been made using Fluorescence techniques that yield data of limited quantitative interpretability and of limited value in mass-balance calculations. More specific methods are being developed for the measurement of dissolved/dispersed and sea-surface microlayer hydrocarbons that will enable more reliable quantitative interpretation.

b) Techniques for hydrocarbon boundary flux measurements will need to be developed to obtain data consistent with that obtained for oceanic baselines. GEMSI is considering river input measurements.

c) Floating slicks were measured visually and recorded as part of MAPMOPP. Direct measurements of hydrocarbon concentrations in the sea-surface microlayer are to be included in MARPOLMON (see a)

d) Hydrocarbon mass-balances have been constructed. (See for example NAS,1975)

e) Some assessment of oceanic contamination by (petroleum) hydrocarbons has been made from the results of the MAPMOPP programme.

f) Biological effects of contaminants and the process of pollution assessment will be considered by GEEP.

TABLE III

GIPME ACTIVITIES - ORGANOHALOGEN COMPOUNDS

GIPME COMPREHENSIVE PLAN COMPONENT		RELATED GIPME ACTIVITIES GLOBAL/OPEN-OCEAN	REGIONAL	NOTES
1. Development of techniques	Baselines	In progress. Further activities proposed by GEMSI-III.	In progress in the North Sea (a)	a) Regional baseline for the North Sea/Baltic area is a current interest of ICES and SCOR Baltic WG
	Boundary fluxes	Under consideration by GEMSI.	(b)	b) GEMSI is proposing to develop procedures for measuring riverine boundary fluxes. This is also an interest of the ICES Marine Chemistry WG and SCOR WG.46.
2. Proving of techniques	Baselines	In progress. Further activities proposed (see Table IV).	(c)	c)Proving of measurement techniques for OHs in both particulate and dissolved phases of seawater is being undertaken by Norway and the Netherlands as a bilteral programme. Proposals for additional effort have been made by GEMSI.
	Boundary fluxes	Under consideration by GEMSI.	(b)	
3. Dissemination of expertise/training	Baselines	Proposed (see Table IV).		
	Boundary fluxes	(d)	(d)	d) (see c in Table I)
4. Data acquisition	Baselines	Proposed (see Table IV).		
	Boundary fluxes	(e)	(e)	e) Measurements of boundary fluxes for OHs are very limited. Greater attention to both atmosperic and riverine influxes of OHs is needed.
5. Construction of mass-balances		(f)	(f)	f) Construction of mass-balances for the global ocean will be very difficult because of the time-dependancy of OH dissemination and the lack of data concerning the removal rate of these compounds through sedimentation. Greater attention to OHs in regional sediments will be needed for the construction of regional mass-balances.
6. Contamination assessment		(g)	(g)	g) For wholly artificial compounds, such as OHs, contamination assessment may be made on the basis of incidence and distribution in the marine environment.
7. Pollution assessment		(h)	(h)	h) Biological effects of contaminants and the process of pollution assessment will be considered by GEEP.
8. Regulatory action		This is not a GIPME function.		

TABLE IV

ACTION PLAN

TIMETABLE AND PRIORITIES FOR FUTURE GIPME ACTIVITIES

Comprehensive Plan Stage	Comprehensive Plan Component	Class of Contaminant: Petroleum Hydrocarbons	Class of Contaminant: Trace Metals	Class of Contaminant: Organo-halogens	Time Scale: 1982	Time Scale: 1983	Time Scale: 1984	Time Scale: 1985	Time Scale: 1986	Priority Assignment
0	Technique Development			IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.2 Methods Development	$59.3K					1
	Proving of Technique			IOC/GGE(MSI)-III/3 Suppl.3 Recom.I.2 Time-series and intercalibration		$83.1K				2
0	Proving of Technique	IOC/GGE(MSI)-III/3 Suppl.1, Recom.3,4, 6,7,9. Diss./Disp. PH intercalibration				$160K				1
	Proving of Technique	IOC/GGE(MSI)-III/3 Suppl.2, Recom.2. Surface microlayer intercalibration								1
	Dissemination & Training	IOC/GGE(MSI)-III/3 Suppl.1, Recom.3,4, 7,8,9. Diss./Disp. PH training & demonst.								2
0	Dissemination & Training	IOC/GGE(MSI)-III/3 Suppl.2, Recom.2. Surface microlayer training & demonst.								2
	Dissemination & Training		WESTPAC Workshop IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.12 Training & Demonst.			$121K	$40K			1
	Dissemination & Training	3rd Workshop on Marine Poll. Mon. Floating Particles					$30K			3

TABLE IV (Continued)

ACTION PLAN

TIMETABLE AND PRIORITIES FOR FUTURE GIPME ACTIVITIES

Comprehensive Plan Stage	Component	Class of Contaminant: Petroleum Hydrocarbons	Class of Contaminant: Trace Metals	Class of Contaminant: Organo-halogens	Time Scale (1982, 1983, 1984, 1985, 1986)	Priority Assignment
0	Dissemin-ation & Training			IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.12 Training	$18K (1984)	3
1	Open-Ocean Baselines	MARPOLMON-P Diss./Disp. Floating Part. TB on beaches			MEMBER STATE ACTIVITIES (1985–1986)	3
	Open-Ocean Baselines		IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.1 N. Atl. Baseline		$620K (1985–1986)	2
	Open-Ocean Baselines			IOC/GGE(MSI)-III/3 Suppl.3. Recom.I.3 N. Atl. Baseline	$124K (1985–1986)	4
	Boundary Exchanges	No firm proposals at present. Subject is being considered by GEMSI in respect to Riverine sources and sedimentary sinks. IOC/GGE(MSI)-IV. Annex II, Recom.21 and Annex IX respectively.			? (1982–1986)	2 (Tr. Met.) 3 (Pet. Hyd.) 4 (OHs)
	Regional Baselines	- - - - - - - - see text - - - - - - - - - - - - - -			? (1985–1986)	2 (Tr. Met.) 3 (Pet. Hyd.) 4 (OHs)
1	Global Mass-balances	GEMSI is commencing detailed consideration of mass-balances for both global-ocean and regional basins for all classes of contaminants - particularly in respect to current data availability and deficiencies.			? (1982–1986)	Previous stage plus 1
	Regional Mass-balances					Previous stage plus 1
2	Contamination Assessment	No firm proposals at present. Would follow baseline and boundary exchange surveys.				
3	Pollution Assessment	Group of Experts on Effects of Pollutants (GEEP) will be considering biological effects information				

TABLE IV (Continued)

ACTION PLAN

TIME TABLE AND PRIORITIES FOR FUTURE GIPME ACTIVITIES

Notes

IOC/GGE(MSI)-III	Refers to the report of the Third Session of GEMSI, Monterey (IOC, 1980)
IOC/GGE(MSI)-III/3, Suppl. 1.	Refers to the report of the GEMSI Ad Hoc Working Group on the Analysis of Dissolved/Dispersed Petroleum Hydrocarbons in Seawater (IOC, 1981b)
IOC/GGE(MSI)-III/3, Suppl. 2.	Refers to the report of the GEMSI Ad Hoc Working Group on Sampling of the Sea-Surface Microlayer (IOC, 1981c)
IOC/GGE(MSI)-III/3, Suppl. 3.	Refers to the report of the GEMSI Ad Hoc Working Group on Future Action under the IOC/WMO/UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters (IOC, 1981d)
IOC/GGE(MSI)-IV	Refers to the report of the Fourth Session of GEMSI, Curacao (IOC, 1982c)

Priority Assignments:

The Saquence 1,2,3,4 etc. is in decreasing order of priority

In this table, all priority assignments are made within individual classes of contaminant with respect to components of the Comprehensive Plan

Overall, irrespective of the class of contaminant, the highest priority should be assigned to outstanding items of Stage 0 of the strategic framework. Subsequent stages should then be assigned sequentially lower priorities.

FIGURE I

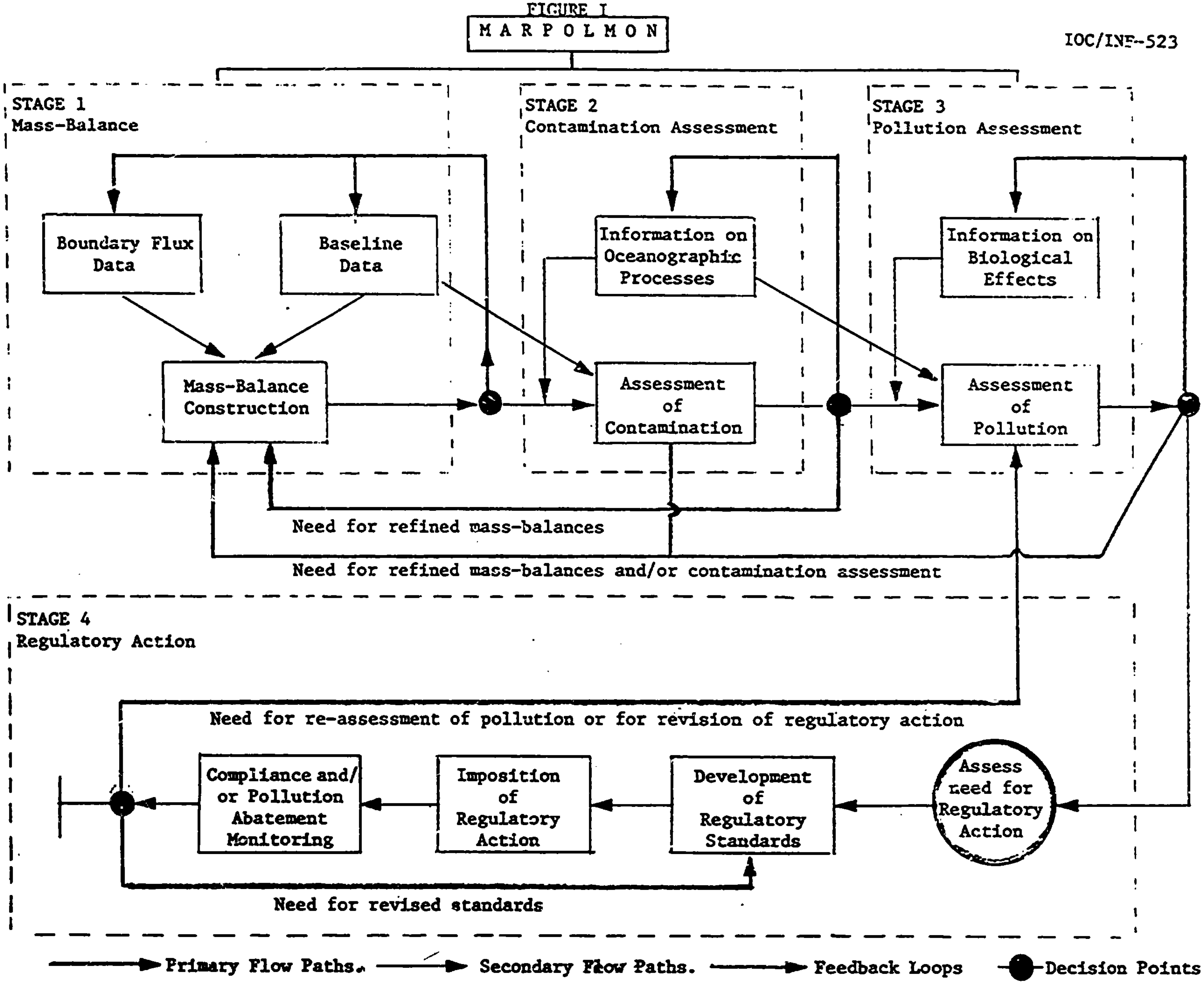
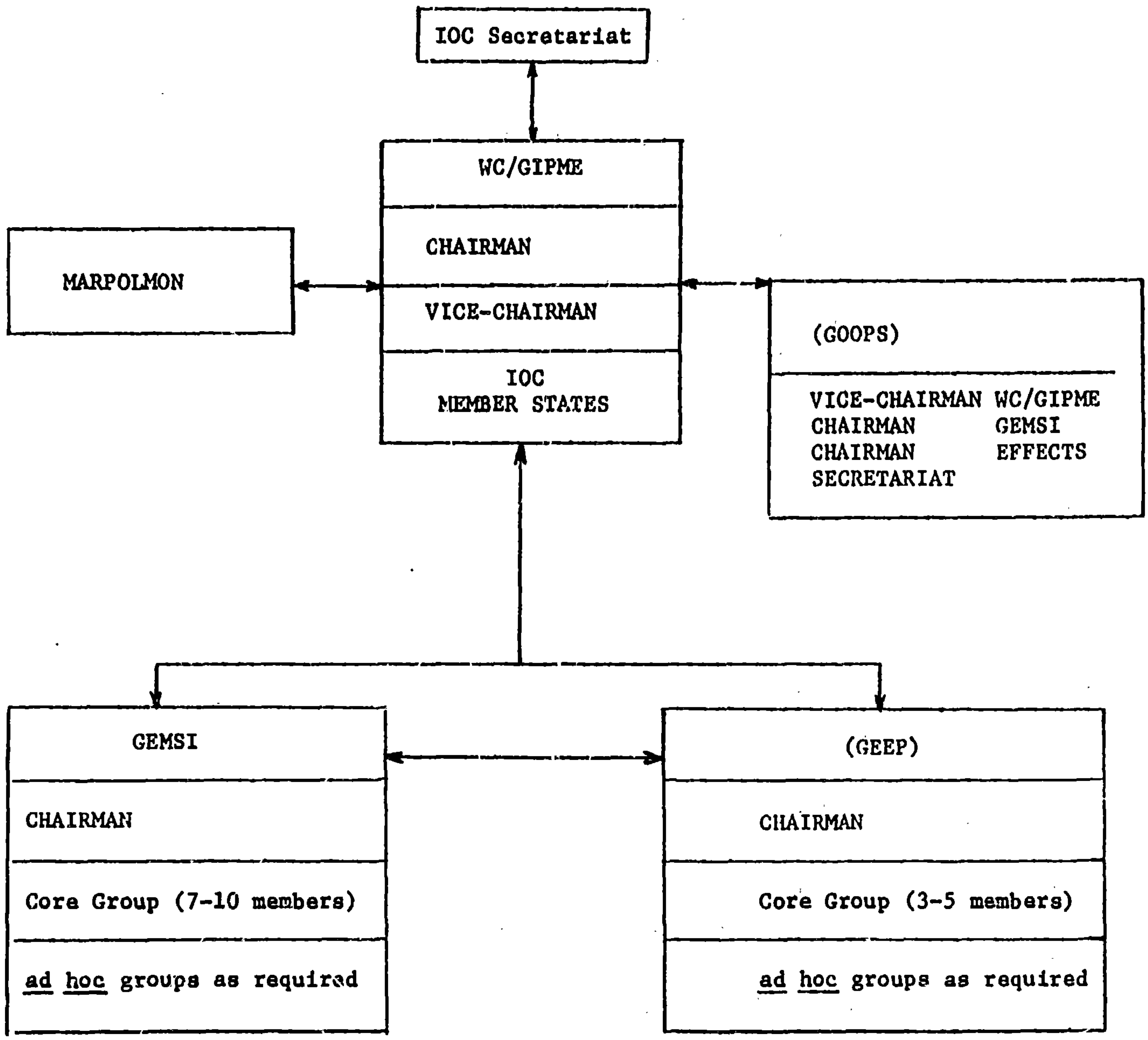


Figure 1. Components and Logic of the GIPME Comprehensive Plan.

FIGURE II

STRUCTURE OF THE IOC GIPME PROGRAMME



LIST OF ACRONYMS

CARIPOL	Caribbean Petroleum Monitoring Programme (IOCARIBE)
EC	Executive Council (IOC)
FAO	Food and Agriculture Organization (of the UN)
GC-ECD	Gas Chromatography employing an Electron Capture Detector
GC-MS	Gas Chromatography-Mass Spectrometry
GEEP	Group of Experts on the Effects of Pollutants (of GIPME)
GEMSI	Group of Experts on Methods, Standards and Intercalibration (of GIPME)
GESAMP	Group of Experts on the Scientific Aspects of Marine Pollution
GIPME	Global Investigation of Pollution in the Marine Environment
GOPPS	Group on Policy, Planning and Strategy (of GIPME)
IAEA	International Atomic Energy Agency
ICES	International Council for the Exploration of the Sea
ICSU	International Council of Scientific Unions
IGOSS	Integrated Global Ocean Services System (IOC/WMO)
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Association for the Caribbean and Adjacent Regions
IODE	International Oceanographic Data Exchange (of IOC)
IRES	IOC Group of Experts on Oceanographic Research as it relates to IGOSS
MAPMOPP	Marine Pollution (Petroleum) Monitoring Pilot Project (IGOSS)
MARPOLMON	Marine Pollution Monitoring Programme (GIPME)
MARPOLMON-P	Petroleum Pollution Monitoring Component of MARPOLMON
NAS	National Academy of Sciences
NSF	National Science Foundation
NODC	National Oceanographic Data Centre
OSLR	Ocean Science in Relation to Living Resources
OSNLR	Ocean Science in Relation to Non-Living Resources
PCB	Polychlorinated biphenyl
RNODC	Responsible National Oceanographic Data Centre
SCOR	Scientific Committee on Oceanic Research (of ICSU)
SEAREX	Sea-Air Exchange
TEMA	Training, Education and Mutual Assistance in the marine sciences (of IOC)
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNEP	United Nations Environment Programme
USA	United States of America
WESTPAC	Western Pacific (IOC Working Committee for the Western Pacific)
WIMSY	WESTPAC International Mussel Sampling Year
WMO	World Meteorological Organization