Intergovernmental Oceanographic Commission
technical series

25

A framework for the implementation of the Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment

Unesco 1984

For bibliographic purposes this document should be cited as follows:
I.O.C. A framework for the implementation of the Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment. *IOC Tech. Ser.* 25, Unesco, 1984

ISBN 92-3-102256-3

French edition 92-3-202256-7
Spanish edition 92-3-302256-0
Russion edition 92-3-402256-4

Published in 1984
by the United Nations Educational,
Scientific and Cultural Organization,7, place de Fontenoy, 75700 Paris

Composed and printed in Unesco's Workshops

Preface

During the Fourth Session of the IOC Working Committee for the Global Investigation of Pollution in the Marine Environment (GIPME) (6-12 January 1982, New York), discussions were held and a sessional working paper was developed concerning the implementation of the Comprehensive Plan for GIPME. Subsequent to GIPME-IV, intersessional activity proceeded in further refining the document, which was reviewed and accepted by the Fifth Session of the IOC Group of Experts on Methods, Standards and Intercalibration (GEMSI) (14-17 June 1983, Paris). Its publication here can be considered as an action-oriented technical supplement to IOC Technical Series No. 14," A Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment and Baseline Study Guidelines." This publication is the result of the efforts put forth by GEMSI as a whole and individual scientists working intersessionally under the guidance of Dr. J.M. Bewers of the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. The assistance of these individuals is gratefully acknowledged, for, without their dedication and help, this publication and the advances being realized in the implementation of the Comprehensive Plan for GIPME would not be possible.

"When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind: it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science." Lord Kelvin

Abstract

This document has been prepared to provide guidance to the IOC and its Member States on the strategy required to implement the IOC/GIPME programme, particularly in the development of the Marine Pollution Monitoring System (MARPOLMON) and assigns priorities for future action within this programme. It provides an interpretation of the strategic implications of the Comprehensive Plan for GIPME (IOC, 1976) and develops a strategic framework for future activities within the GIPME programme. This framework is used to assign priorities to planned activities for each major class of contaminant. The current status of development of the entire GIPME programme is then examined in order to detect major omissions within planned activities and to emphasize the need to consider the relative priorities of programmes dealing with the major classes of contaminants (i.e. organohalogens, trace metals and petroleum hydrocarbons).

This report has been reviewed by the IOC Group of Experts on Methods, Standards and Intercalibration (GEMSI) as well as external peers.

Contents

1. Introduction

The Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment (GIPME) was published by the Intergovernmental Oceanographic Commission in 1976 (IOC Technical Series No. 14).It proposes a systematic scientific approach, or philosophy, to determine the extent of marine pollution through a set of distinct, 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, 1983).

The global nature of this IOC programme is comprised of regional activities, which when considered collectively will present a global picture on the state of marine environmental pollution. The programme covers all matters related to marine pollution research and associated monitoring activities required for the assessment of marine pollution and the development of a capability to predict the consequences of pollutant injections, as well as a general assessment of the Health of the Oceans. In this sense this programme is to a great extent concerned with chemical oceanography and provides the fundamental technical basis for the various regional monitoring activities that constitutes the Marine Pollution Monitoring Programme System (MARPOLMON) of the IOC.

During the Fourth Session of the Working Committee for GIPME (6-12 January 1982, New York), a number of questions arose with regard to the continued applicability of the Comprehensive Plan and the strategy and priorities associated with current and planned activities within the GIPME programme. A small sessional Sub-Group of the Working Committee reviewed the suitability of the Comprehensive Plan for providing continued guidance regarding activities within the GIPME programme. The Sub-Group also considered strategic questions related to such activities and suggested priorities for future action within the programme. The Sub-Group produced a short report which was annexed to the Summary Report of GIPME IV (Annex IV, IOC 1982a). The IOC considered it worthwhile to revise the Sub-Group Report for publication as a supplement to the Comprehensive Plan and this document constitutes that revision, which has been reviewed by the GIPME Group of Experts on Methods, Standards and Intercalibration (GEMSI) and external peers.

The following sections of this document contain 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. Current and planned activities within the GIPME Programme are then examined in the context of this strategic framework in order to assign priorities for future action and to identify inadequacies or omissions in currently planned GIPME programme components.

2. Provisions of the Comprehensive Plan for GIPME

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 number of components. The four major stages are mass-balance (which includes baseline measurements), contamination assessment, pollution assessment and regulatory action. These stages are intended to be addressed sequentially for any given potential marine contaminant. However, they are also linked by feedback loops that permit iteration of the procedures in individual stages of the plan. The procedures and components associated with each stage are discussed in the following sections.

2.1 Mass-balance stage

The first stage of the Comprehensive Plan is designed for the construction of mass-balances for individual contaminants in the marine environment and, therefore, a brief explanation of the nature of mass-balances is useful. In all cases, they concern fluxes into and out of the water column of the ocean. Thus, sedimentation and the constituent fluxes associated with this process, are treated as effluxes from the ocean. Diagrammatically, such mass balances are of the form shown in Figure 2, in which influxes include all net injection of material to the marine hydrosphere and the effluxes are the sum of all net removal fluxes. For purely natural constituents, the ocean should be in steady-state (i.e. the sum of influxes equaling the sum of effluxes), with the speed of each constituent through the system being represented by a 'residence time' (ζ) expressed as

$$\zeta = \frac{\text{Standing stock of constituent (mass)}}{\text{Influx or Efflux} \quad \text{(mass/time)}}$$

Obviously, if the influx of a constituent has increased, as a result of greater mobilization of that constituent by man, the influx may exceed the efflux if the ocean has not yet attained a new steady-state condition. The rate at which the ocean attains a new steady-state to an increased, but steady influx, is a function of that substance's residence time. For more details of the residence

Figure 1. Components and Logic of the GIPME Comprehensive Plan

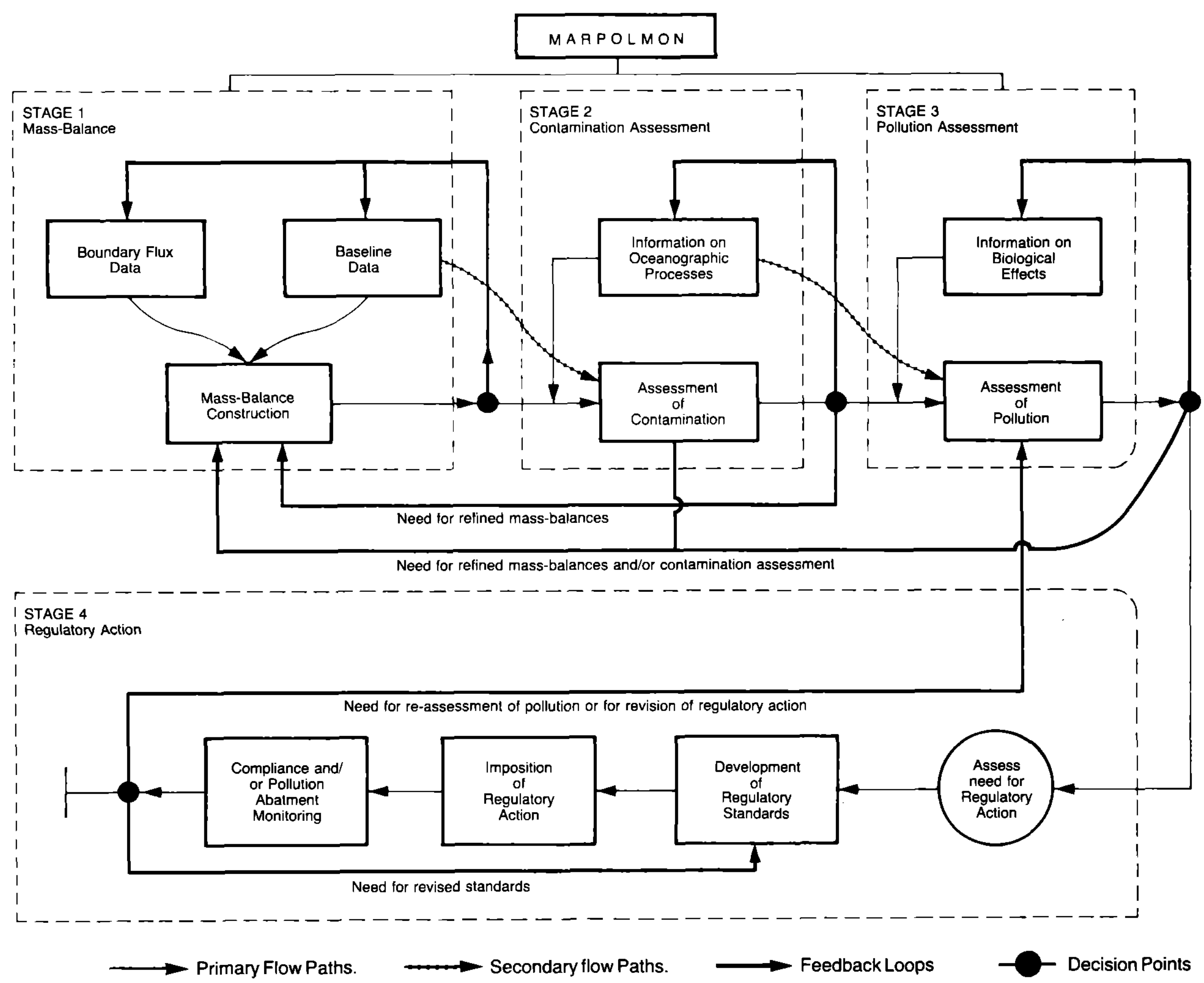
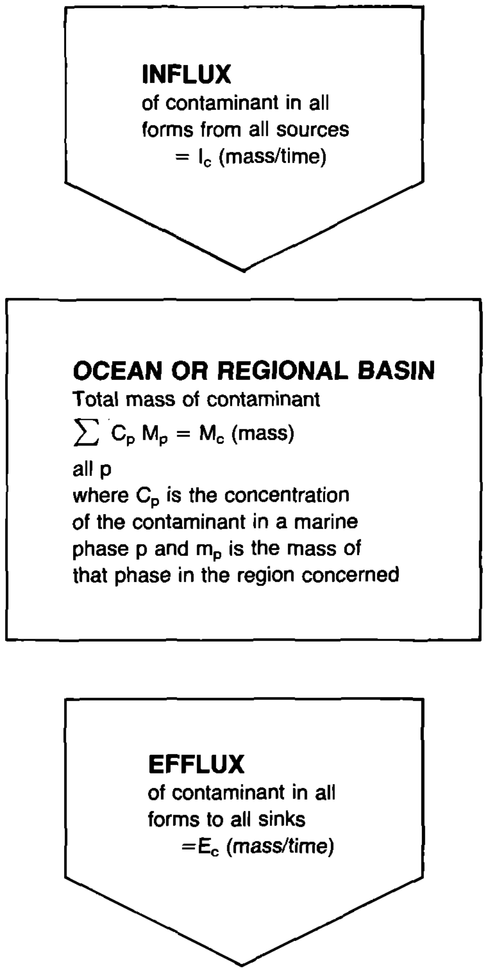


Figure 2 The mass-balance concept



If the contaminant, c, is in steady state distribution

$I_c = E_c$ and $\frac{M_c}{I_c} = \frac{M_c}{E_c}$ has units of time

and has quantity often referred to as residence time of the contaminant (τc).

time concept and the response of the ocean to altered influx conditions, the interested reader is referred to Li (1977).

Mass-balances are very useful in determining whether there is evidence for a greater influx of a potential contaminant to the ocean compared with its rate of removal. Construction of mass-balances allows a comparison of aggregate influx and efflux rates that may be compared to see if any evidence of inequality exists. The approach has already been used for some metals to determine whether evidence exists to support the results of surveys that suggest that there have been substantial increases in the oceanic influxes of certain metals as a result of recent anthropogenic activity.

Mass-balances may be constructed for the entire world ocean (i.e. global mass-balances), or for regional and marginal seas. The initial components comprise measurements, or estimates, of boundary fluxes and regional or global baselines. Boundary fluxes in this context include both influxes and effluxes. The two primary modes of input of terrestrial and anthropogenically 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 marine areas, but occur by way of estuaries and other nearshore environments. Thus, gross riverine discharges of contaminants do not represent the actual or net riverine influxes of contaminants to the ocean proper (i.e. the flux of those components of the gross riverine discharge that survive nearshore removal through chemical, biological and/or geological (sedimentation) processes).

Other important modes for the introduction of contaminants, especially for artificial substances, are through direct discharge from land via pipelines, through discharges from ships, and/or through sea dumping activities. In the cases of naturally occurring analogues of environmental contaminants, such as metals, there are natural influxes which must be quantified. These include emissions from subsea spreading centres and volcanoes, and influxes from runoff other than river, such as glaciers.

The effluxes of contaminants from the ocean are also needed for the construction of mass-balances. Therefore, it is important to identify potential oceanic sinks for contaminants and to estimate the corresponding rates of removal. In this respect the major modes of contaminant removal from the ocean are through sedimentation, volatilization and aerosol production processes. For organic compounds, degradation may also be a significant mechanism of removal. In general, it is the sedimentation flux that is the most important of these.

The Comprehensive Plan appears to play down the importance of oceanic efflux measurements or estimates by giving rather greater emphasis to influx measurements. This may, in fact, reflect an underlying conviction on the part of the authors of that document that contemporary knowledge of oceanic influxes is rather rudimentary, whereas reasonable estimates of global oceanic sedimentation can be made from existing data. Indeed, as far as the whole ocean is concerned, it is true that our knowledge of influxes is the most deficient. However, in the case of regional seas, estimates of influxes and effluxes are of comparable uncertainty.

Finally, it should be stressed that, in the case of contaminants having natural abundances, 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. For artificial compounds, most of which have only been disseminated by man during the last few decades, it is most probable that a steady-state 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.

Baseline measurements contaminants within the ocean or regional sea itself are also needed for mass-balance calculations. 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 in the ocean, the concentration and distribution of the contaminant has to be determined in water (the aqueous phase), organisms and suspended matter.

A basic mass-balance comprises estimates of aggregate influx and efflux of a contaminant and the total amount of the contaminant in the ocean or region of interest. Although the quality, and usefulness, of a mass-balance improves with the quality of these basic data, it is often beneficial to make a rather crude mass-balance based upon limited data. This will often serve to identify the weaker of the three data components (i.e. influx, efflux or baseline) required. It is then possible to acquire more, or better, data for those components and to reconstruct the mass- balance construction and interpretation that is reflected by the first feedback loop in Stage 1, shown in Figure 1.

The construction of initial mass-balances using the best data available from the literature is to be encouraged rather than discouraged. While the resulting mass-balances may not be sufficiently definitive for subsequent interpretation, they do provide a mechanism for evaluating the quantities and qualities of the component data. However, the ultimate aim of the initial procedures in the Comprehensive Plan's approach is to produce more refined mass-balances that may be interpreted and used for justifying the application of subsequent steps in the entire plan.

2.2 Contamination assessment stage

The next step (Stage 2) in the process is the assessment of contamination of the ocean, or the regional area of interest, using the mass-balance developed as a result of Stage 1. Once a mass-balance has been constructed it needs to be evaluated carefully in the context of contemporary knowledge of physical and biogeochemical processes operating in the ocean. The improvement of such knowledge, through fundamental research, 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 at this point, that processes of particulate transport and aqueous particulate exchanges, both 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 through sedimentation. As more information becomes available on the details of internal processes, it should be possible to further refine the mass-balances themselves to include the rates of transfer of contaminants between individual compartments of the marine environment, rather than simple aggregate through put rates.

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 geobiochemical research. They should now be applied, in a systematic manner, to the aims and objectives of the GIPME programme. The aim of these initial steps of the GIPME Comprehensive Plan is to provide an assessment of the nature and degree of oceanic contamination preparatory to the next stage in the procedure.

2.3 Pollution assessment stage

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 concerns the effects of contaminants upon marine organisms and man. The Comprehensive Plan defines the essential components of such knowledge 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. The first of these categories is similar to that used in radiological protection principles which have yet to be applied to non-radioactive contaminants in any systematic way. There are, however, a few examples in the literature of the application of these principles to marine contaminants (e.g. see Barry, 1979; O'Brien, 1979 and Preston and Portmann, 1981).

It should be noted that wider application of radiological protection principles to marine environmental pollution assessment is also being advocated independently (Templeton, 1982). Although the primary organism to be protected in this component is man, it must be stressed that attention to the effects of contaminants at acute, chronic and sub-lethal levels on marine organisms themselves also needs to be considered to ensure that adequate attention to the protection of other, possibly more sensitive, organisms is ensured. To a larger extent, this latter concern is dealt with as part of the second component of knowledge needed in the conversion process. This component deals with the effects of contaminants on the marine biological community.

The Comprehensive Plan states 'The most important effect of pollutants on marine ecosystems which can influence large areas of the ocean may be caused by long-term exposure of marine organisms to low levels of pollutants'. The plan then describes the experimental difficulties associated with determining disturbances of the marine biological community. These difficulties arise because of the spatial and temporal heterogeneities in marine ecosystems and the consequent problem of determining the population changes that exceed the natural variability. Furthermore, it is not always possible to identify the critical species in a heterogeneous food web. Nevertheless, the Comprehensive Plan does provide some guidance as to the types of experimental research that might be used to provide answers to these questions. It also stresses the need to understand the relationships between marine trophic levels, especially in the context of the transfer of contaminants within the food web.

It must be realized, that classical mortality experiments, designed to establish the LD 50 values for individual contaminants, are of limited applicability to assessing long-term sub-lethal effects. Invariably, the levels of contaminants in the marine environment resulting from anthropogenic activities are considerably lower than those commonly employed in toxicological experiments at the present time. In any event, the major need is for information on sub-lethal toxicological effects of contaminants on populations as a measure of the aggregate level of stress imposed by exposure to the contaminant, rather than information on the effects upon individuals within the population.

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 the entire matrix of components within earlier stages of the plan. For this reason there are 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 is then carried out.

2.4 Regulatory action stage

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. 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). There also exists an excellent discourse on the derivation and application of regulatory standards (Preston, 1982), which provides details of the entire approach to regulatory activities of the type referred to in the Comprehensive Plan.

The first component of the regulatory action stage is a consideration of the need for the imposition of regulatory controls. 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. The results of biological effects research that has previously been used to convert the assessment of contamination to an assessment of pollution can also be applied to the development of standards.

Once controls have been imposed upon the introduction of pollutants into the marine environment, it is usual to undertake some compliance (or pollution abatement) monitoring to ensure that the imposed controls are having the desired mitigating effect. Such monitoring may well include the monitoring of discharges (i.e. source monitoring) once appropriate limits or standards have been established.

Finally, feedback enables the results of monitoring to be used to assess the effectiveness of the regulatory action imposed. This involves repeating the regulatory stage and tightening or revising the standards, as deemed necessary.

3. 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 assessing and regulating 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. A recent document (SCOR, 1982) on Future Ocean Research prepared for the IOC by the Scientific Committee on Oceanic Research (SCOR) confirms 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, and its implications, to have 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 international activities related to marine pollution assessment. The discussion which follows attempts to carry out such an examination with a view to rationalizing current activities and plans within the GIPME programme in the context of the Comprehensive Plan.

The Comprehensive Plan advocates both regional and global activities and assessments, but today, attention and resources devoted to the former outweigh those allocated to the latter. This apparent inequality in the distribution of effort must, however, be tempered by the small number of successful, multi-lateral regional programmes that have been implemented as field activities. Both regional and global activities need to be pursued to facilitate the overall implementation of the plan if they are to be carried out for GIPME purposes.

4. Strategic framework for the implementation of the Comprehensive Plan

The Comprehensive Plan contains strategic implications and guidance. It advocates a series of sequential steps or activities with each successive stage being dependent upon the results of the immediately preceding stage. Thus, in order for the plan to be logically applied, each stage must be carried out in sequence for a given class of contaminant. Furthermore, in the first stage there exist pre-requisites to the collection of data for mass-balance construction that also have a logical sequence. These are, the development and proving of sampling and analytical techniques for the determination of baseline concentrations and boundary fluxes for given contaminants. These activities can be broken down into 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.
4. Preparation of manuals and the training of potential participants.

Clearly, these steps must be carried out in sequence and must be completed prior to the collection of data for the construction of mass-balances. This preparative stage can therefore be referred to as Stage 0, and can be combined with the stages depicted in Figure 1. The sequence of Stages 0 to 4 then represent in practice the strategic framework of the Comprehensive Plan . It can be used to examine where the programme stands with regard to the hierarchical progression of activities needed for the fulfillment of the Comprehensive Plan and if there are omissions or deficiencies in the list of current and planned activities within the GIPME programme.

For a given substance (or class of substances), 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 to the highest priority when all previous stages have been completed. Thus, for example, if for a given contaminant all methodological development and testing have been satisfactorily completed, highest priority would be assigned to training programmes and to the preparation of manuals that disseminate the appropriate sampling and analytical expertise and information 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 activities related to the GIPME programme are now examined in the context of this strategic framework to determine which of the proposed/planned activities should be given highest priority and to determine whether other components of the plan, having similar priority within the strategic framework, have been considered adequately. In carrying out this examination of GIPME programmes, some cognisance of the state of current oceanographic research and related activities of other organizations is taken.

5. Past, present and planned GIPME activities

With the exception of the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring (MAPMOPP), most of the GIPME related activities to date have been concerned with aspects of the GIPME Pilot Project on the Determination of Open Ocean Baselines. The latter project was designed to deal with the initial stages of the Comprehensive Plan that facilitate the construction of mass-balances for individual contaminants. The matters addressed within this GIPME activity are therefore the development, proving and dissemination of suitable techniques for the acquisition of baseline and boundary flux data.

The main vehicle for the execution of the GIPME Pilot Project has been the GIPME Group of Experts on Methods, Standards and Intercalibration (GEMSI) which has, since 1977, concentrated its efforts on developing and testing methods for the measurement of potential contaminants in the ocean, particularly trace metals and organohalogen compounds. Following the completion of MAPMOPP, GEMSI has assumed responsibility for the development and testing of techniques for hydrocarbon measurements particularly in respect to the preparation for the Marine Pollution Monitoring System for Petroleum (MARPOLMON-P). Having also received widened Terms of Reference from the Working Committee for GIPME at its Fourth Session (IOC, 1982a), GEMSI has broadened its interest to cover other aspects of the GIPME Pilot Project such as boundary flux measurements and the current state of knowledge regarding mass-balances for certain contaminants.

Several other organizations have programmes that have similar objectives to parts of the GIPME Comprehensive Plan. Historically, the organization most closely identified with such related activities is the International Council for the Exploration of the Sea (ICES). However, the activities within the United Nations Environment Programme (UNEP) Regional Seas Programme have aims and objectives that are close to those of the GIPME Comprehensive Plan, as applied to marginal seas and continental shelf areas. Equally, the IOC regional programmes, such as IOCARIBE and WESTPAC address questions similar to those of the UNEP Regional Seas Programme, and those of ICES with regard to coastal areas of the North Atlantic.

While this document does not discuss in detail the application of the Comprehensive Plan to regional areas, the approach is very similar to that for the global ocean, since in reality the global perspective is obtained through the assimilation of the products of regional activities. The major additional complexity, apart from the rather greater need for attention to heterogeneities in conditions in the coastal zone, is the necessity of defining the exchanges of contaminants across the marine boundaries between regional areas and the open-ocean, in the course of constructing 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". It is in this sense, that the regional bodies of the Intergovernmental Oceanographic Commission play a significant role in the contribution that is made to MARPOLMON. That is, by constantly operating within a single regional area, the complexities of the region can be more easily identified, particularly if they are of a transient nature. Moreover, continual assessments of the changing technological foundation of the region can be made, and appropriate action taken in the programme such that the regional inputs to MARPOLMON will be constantly upgraded.

The Comprehensive Plan contains considerable reference and guidance to regional endeavours and, where appropriate, assessments of contamination and pollution in regional areas should be pursued. Nevertheless, in order for the regional activities to accurately interface with each other and with baseline measurements for the open ocean, it is essential that the methods used be sufficiently precise, accurate and, in addition, 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.

Previous and planned GIPME activities are now addressed first in terms of specific groups of contaminants, and then to activities that deal with general questions regarding boundary exchanges and other aspects of the Comprehensive Plan.

5.1 Trace metals and metalloids

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

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

When the list was prepared, elements in the first group were believed to be environmentally important either because they were mobilized by anthropogenic activity on a scale comparable with natural fluxes, or they were believed to be intimately involved in biological processes in the open ocean. Elements in the second priority list were those for which baselines needed to be established although their role in biological processes and their rate of anthropogenic release to the oceans were considered to be less important. Although there are probably some reasons to reexamine 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 elemental contaminants need to be addressed within the GIPME Pilot Project.

The work of GEMSI in the development and proving of methods for oceanic baseline measurements has been greatly assisted by the rapid improvement in the capabilities for metal determinations in the ocean that has occurred in the last few years. These improvements are well reflected in the scientific literature and stimulated Goldberg (1981) to comment that they constitute "a revolution" in marine chemistry. Further assistance has been provided by the various intercalibrations conducted under ICES auspices since 1976. ICES had recognized the need to assess the intercomparability of techniques for trace contaminant measurements in both seawater and marine biological tissues in order to improve its own co-operative monitoring studies. Through the activities of its Sub-Group on Trace Metals in Seawater and subsequently its Working Group on Marine Chemistry, it has carried out a series of intercalibrations for trace metals in seawater that have sequentially addressed standardization, detection limits, precision and spike recovery of analytical methods. The results of these experiments have also reflected a general improvement in the capability of the participants and the intercomparability of data.

Both GEMSI and the ICES Marine Chemistry Working Group decided that the next stage in this process of methodological assessment should be an examination of sampling techniques for the collection of seawater samples for trace metal analysis. This experiment was subsequently conducted under IOC/WMO/UNEP auspices as part of the IOC/WMO/UNEP Workshop on the Intercalibration of Sampling Procedures that was held in Bermuda in 1980 (IOC,1980a and 1982b). Subsequently, ICES undertook the next experiment in its current series of intercalibrations. This experiment involved the intercomparison of filtration procedures for the separation of dissolved and particulate phases from coastal waters and it took place in Nantes, France, in September 1982. Both the Bermuda and Nantes experiments provide strong examples of de-facto co-operation in studies of common interest between ICES and IOC. The programmes of the ICES Marine Chemistry Working Group and GEMSI have been closely interrelated as a consequence of their having several common members. Both parent organizations have benefitted from this cooperation by the faster achievement of their respective objectives.

As a result of these various activities, methods exist for the measurement, at oceanic baseline levels, of most of the trace elements in the priority list. 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. It should be stressed, however, that these methods and measurements are primarily those that are applicable to the determination of open-ocean baselines. Attention is now being directed to dealing with the particular problems of coastal water baseline measurements. These measurements are 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 elements associated with suspended particulate material is relatively small and baselines based either upon total or dissolved (filtered sample) analyses are generally adequate.

It remains for the open-ocean baseline methodology to be documented and disseminated through training programmes preparatory to conducting baseline surveys. GEMSI has already made proposals for such training activities to take place in conjunction with an Atlantic Ocean baseline programme (see IOC, 1980b). GEMSI has also considered the application of baseline measurement techniques to a baseline survey of the North Atlantic and has made recommendations as to the approach to be used (IOC,1980b). Once the refinement and testing of procedures for the measurement of coastal baselines has been carried out, similar dissemination of the relevant technical expertise would be required.

The current position with regard to GIPME programme activities, in the context of the provisions and components of the Comprehensive Plan, is summarized in Table 1. The most important omissions from these activities appear to be those related to boundary flux measurement techniques. The measurement of atmospheric deposition into the ocean is difficult and is a rather specialized area of current marine research. Nevertheless, the results of certain research programmes, particularly those of the US National Science Foundation's study on Sea-Air Exchanges (SEAREX) and the air and precipitation measurement programme of the Atomic Energy Research Establishment, Harwell, UK, that involve, inter-alia, measurements of atmospheric deposition and examination of the sources of atmospheric constituents, will continue to provide valuable information on fluxes at this boundary.

At GEMSI-IV a GEMSI Ad Hoc Group on the Use of Marine Sediments for Pollution Monitoring was established. This group has, within its Terms of Reference, a requirement to consider sediment/water boundary exchanges in the context of mass-balance construction. Thus, in regard to these two major boundary exchanges, sea/air and sea/sediment, activities are in place that will help to provide some data for the purposes of mass-balance construction for metals.

The one boundary that is of great importance in mass-balance construction, 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 route of supply to the ocean of chemical substances from both natural and anthropogenic sources. The International SCOPE (Scientific Commitee on Problems of the Environment) River Project and recent studies of river composition (e.g. Yeats and Bewers, 1982) are starting to rectify deficiences in river compositional data. Under its revised terms of reference, GEMSI has established an ad hoc group to examine gaps in the studies needed to produce data for mass-balance purposes. It is already apparent that early attention to precise and accurate

Table 1
GIPME activities - trace metals and metalloids

GIPME COMPREHENSIVE PLAN COMPONENT		RELATED GIPME ACTIVITIES GLOBAL/OPEN-OCEAN	REGIONAL	NOTES
1. Development of techniques	Baselines	Completed	(a)	a) For caostal baselines, discrimination between particulate and dissolved phases is required. ICES has carried out an assessment of filtration and particulate analysis procedures.
	Boundary fluxes	Under consideration by GEMSI (b)	(b)	b) GEMSI is currently considering methods for measuring gross riverine inputs. This work relates also to the interests of the ICES Marine Chemistry WG, SCOR WG.46 and GESAMP.
2. Proving of techniques	Baselines	Completed	(a)	
	Boundary fluxes	(b)	(b)	
3. Dissemination of expertise/ training	Baselines	Proposed (see Table 4)	(c)	c) Training for regional baselines and boundary flux measurements would be designed once the appropriate sampling and analytical procedures have been developed and proven.
	Boundary fluxes	(c)	(c)	
4. Data acquisition	Baselines	Proposed (see Table 4)	(d)	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.
	Boundary fluxes	(d)	(d)	
5. Construction of mass-balances		Under consideration by GEMSI (e)	(e)	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.
6. Contamination assessment				
7. Pollution assessment		(f)	(f)	f) Biological effects of contaminants and the process of pollution assessment will be considered by GEEP.
8. Regulatory action		This is not a GIPME function		

measurements of river composition will be needed both for regional and open-ocean mass balance assessments.

5.2 Petroleum hydrocarbons

Activities in respect to petroleum hydrocarbons have progressed beyond those for the other classes of contaminants, primarily because of MAPMOPP. This programme involved observations of floating slicks, measurements of the incidence of particulate tar on the ocean surface, dissolved/dispersed petroleum residues in seawater , 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 of 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, Md., USA, in 1974.

The project began in January 1975 and the final report was completed and issued in 1981 (IOC, 1981a). One of the major objectives of this programme was to assess 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 predominantly relatively simple and straightforward procedures that could be employed by a large number of countries. Although the primary objective of the activity was to test the effectiveness of the system being employed for the collection of information, the results of the programme (IOC, 1981a) provided, in addition, a substantial improvement in our authoritative knowledge of the incidence of hydrocarbons in the marine environment.

It has become evident, however, that the MAPMOPP data are less amenable to detailed interpretation than data acquired from the application of more modern and sophisticated techniques (e.g. gas chromatography/mass spectrometry). One limitation of the MAPMOPP data is the inability to determine the detailed composition of the hydrocarbons found in the ocean and the limited applicability of these data to mass-balance calculations. Recent developments in analytical technology permit more detailed examination of the composition of this class of compounds 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. GEMSI (IOC, 1981b), therefore, reexamined the procedures suitable for hydrocarbon determinations with a view to providing more insight into the sources and fluxes of these compounds in the ocean. To this end, GEMSI has formulated plans for an Intercalibration Workshop to assess the suitability and intercomparability of techniques for the measurement of both dissolved/dispersed hydrocarbons in seawater and the hydrocarbon components of the sea-surface microlayer.

These activities are directly related to MARPOLMON-P which will be a fully operational extension of MAPMOPP and devoted to establishing a spatially and chemically detailed baseline for petroleum hydrocarbons in the ocean, subject to the formulation and acceptance of its final Terms of Reference. It should be noted in this context, however, that the presently conceived methods likely to be applied in MARPOLMON-P (i.e. determination by fluorescence) will not yield a chemically detailed baseline for petroleum hydrocarbons.

A great deal of ocean baseline work has been, and is being carried out for hydrocarbons. Relatively little coordinated attention has been paid to boundary flux measurements, although some mass-balance assessments, based upon limited data, have been carried out by organizations such as the US National Academy of Sciences (NAS, 1975). River runoff appears to be second only to leakage from shipping as a source of petroleum hydrocarbons in the ocean. However, as with trace metals, a systematic evaluation of riverine influxes of hydrocarbons is urgently needed. Atmospheric deposition is a tertiary source of such compounds and seems to be comparable with the rate of natural petroleum seepage from the seabed.

The foregoing emphasizes the importance of gaining quantitative information on such boundary exchanges to more fully describe the supply of petroleum hydrocarbons to the ocean. Equally important are measurements of the rates of hydrocarbon sedimentation in the ocean, and these are particularly important in the context of calculating regional mass-balances. Clearly, more effort should be focused upon hydrocarbon distributions in sediments and the corresponding rates of sedimentation. GEMSI is presently undertaking an examination of deficiencies in current data for mass-balance purposes and is proposing to pay particular attention to river discharge fluxes in its future activities. These efforts are entirely consistent and compatible with both the needs for further work and the objectives of current GIPME activities. The overall situation with regard to GIPME activities concerning petroleum hydrocarbons in the context of the strategic framework is summarized in Table 2.

Table 2
GIPME activities - petroleum hydrocarbons

GIPME COMPREHENSIVE PLAN COMPONENT			RELATED GIPME ACTIVITIES GLOBAL/OPEN-OCEAN	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.

As for other contaminants, the interest in hydrocarbons in the ocean are shared by other organizations, particularly ICES and UNEP. Many of the UNEP Regional Seas studies (UNEP, 1982) have assessments of marine contamination by petroleum hydrocarbons as one of their objectives. The ICES Working Groups on Marine Chemistry and on Pollution Baseline and Monitoring Studies in the North Atlantic continue to be concerned with contaminants such as hydrocarbons, but have increasingly focussed upon subclasses of these substances that are of concern from toxicological or bio-accumulative perspectives.

Invariably, these groups experience the same difficulties as those faced by IOC within this part of the GIPME programme and it is to be hoped that, wherever possible, common approaches can be developed for mutual advantage. With the current overlapping membership of GEMSI and the two ICES Working Groups, there appears every reason to believe that the technical approaches used for the respective GIPME and ICES regional activities will be wholly compatible, and a recently executed Memorandum of Understanding by ICES and IOC will further insure that this will happen. A similar commonality of approach between the UNEP Regional Seas Programme and GIPME could prove to be as equally rewarding.

5.3 Organohalogen compounds

Activities within the GIPME programme concerned with organohalogens are summarized in Table 3. All such activities have been confined to the solution of sampling and analytical problems, particularly in 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 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 such as AROCLOR-1254 and 1260. This procedure has a number of inherent difficulties that give rise to ambiguous data and thus incomparability in the results obtained from various laboratories. As a result, GEMSI (IOC,1981c) has advocated the use of temperature-programmed, capillary-column gas chromatography, using individual chlorinated biphenyls as standards. This approach will provide much better resolution of the compounds of interest, in particular, of poly- chlorinated hydrocarbons.

Table 3
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, SCOR WG.46 and GESAMP.
2. Proving of techniques	Baselines	In progress. Further activities proposed (see Table 4).	(c)	c) Proving of measurement techniques for OHs in both particulate and dissolved phases of seawater is being undertaken. 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 4).		
	Boundary fluxes	(d)	(d)	d) (see c in Table 1)
				e) Measurements of boundary fluxes for OHs are very limited. Greater attention to both atmosperic and riverine influxes of OHs is needed.
4. Data acquisition	Baselines	Proposed (see Table 4).		
	Boundary fluxes	(e)	(e)	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.
5. Construction of mass-balances		(f)	(f)	
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)	
8. Regulatory action		This is not a GIPME function.		h) Biological effects of contaminants and the process of pollution assessment will be considered by GEEP.

It can also be combined with mass spectrometric techniques to provide unambiguous identification and quantification of several individual PCB components (see Annex V of the report of the Third Session of GEMSI (IOC, 1980b)).

Preliminary work on methods development for PCB compounds for GIPME purposes was carried out using the packed-column method. However, since the Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO/UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters that was held in Bermuda in January 1980 (IOC, 1980a and 1982b), GEMSI has placed major emphasis on the development of more specific and refined procedures for baseline measurements of PCBs in seawater. To this end a developmental programme is being undertaken 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. This programme, which is described in Annex V of 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,1981c), comprises a six-month method development stage and a subsequent eighteen-month pilot measurement programme at Panulirus Station (Ocean Station 'S'). Currently within this programme attention is being directed to 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. Once suitable procedures have been developed and tested, through their application in the time-series measurement programme at Bermuda, it is planned to incorporate them into the proposed trace metal baseline survey for the Atlantic Ocean.

The approach adopted by GEMSI for the purposes of the GIPME programme in respect to organohalogens, and that adopted within ICES for the analysis of biological tissues are totally consistent. Similar concerns about the utility of packed column gas chromatographic results to the study of PCB compounds in the marine environment have been voiced within the ICES Marine Chemistry Working Group and, to a large extent, future developmental work in respect to the detection and analysis of these compounds is likely to be similar to that within GEMSI. ICES remains interested in the incidence of PCB compounds in North Atlantic coastal regions and it seems likely that procedures used for ICES and GIPME purposes will be entirely compatible. As in the case of petroleum hydrocarbonsm it is rather less certain that such compatibility between the procedures used for organohalogen baseline measurements in GIPME and the UNEP Regional Seas Programme can be assured at the present time, although efforts are continually being made to insure that such will be the case.

Activities with respect to organohalogens are predominantly restricted to the methodological development required to undertake ocean baseline measurements and are proceeding (e.g. see IOC 1983a and b). Once the sampling and analytical methods have been developed and tested they will be applied to making oceanic baseline measurements in conjunction with trace metal baseline surveys.

Since the work on organohalogens is very much at the developmental stages and has not yet reached the stage of mass-balance construction, the question as to whether boundary flux measurements have been overlooked does not apply. However, 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 assessments and, through ad hoc group activities, to examine procedures for river flux measurements and sediment boundary exchanges for all types of contaminants. Thus, past, present and planned actions within the GIPME programme for organohalogens are logically conceived and proceeding , albiet not as rapidly as would be possible with increased resources.

5.4 Other activities within the GIPME Programme

This summary of activities would not be complete without reference to certain other initiatives that involve all classes of potential marine contaminants. Although some of these initiatives have been referred to in the description of activities directly related to specific classes of contaminants, it is useful to describe briefly these other projects that stem largely from GEMSI proposals.

(a) GEMSI Ad Hoc Group on Marine Sediments

This group has been established to assess the feasibility, within the context of the Comprehensive Plan for GIPME, of using marine sediments to detect, quantify, assess and control contamination. Its Terms of Reference (see Annex IX of the Fourth Session of GEMSI, IOC, 1982c) also require the group to examine certain additional and specific questions related to methodological approaches and the application of sedimentary data to mass balance calculations. The group commenced its work in 1983 and has provided GEMSI with a preliminary assessment on the use of marine sediments in marine pollution monitoring (IOC, 1983a).

(b) GEMSI Ad Hoc Group on the Identification of Gaps in Fluxes and Mass-Balance Calculation in Marine Systems

This group was formed during the Fourth Session of GEMSI (IOC,1982c). 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 type information for the various classes of contaminants in the world ocean and in some regional marine areas. Its work will include assessing the current state of knowledge on the fluxes of contaminants in the world ocean; evaluating approaches that have previously been used for mass-balance calculations and identifying weaknesses and data deficiencies that restrict the applicability of these approaches for the purposes of the Comprehensive Plan; and outlining requirements for the construction of mass-balances for regional marine areas.

(c) GEMSI Ad Hoc Group on the Use of Marine Organisms in MARPOLMON

This group was established in 1981 to investigate the utility of incorporating analyses of marine organisms into MARPOLMON. A preliminary report was submitted to GEMSI for review during its Fourth Session.The ad hoc group had concluded that marine organisms could be included in MARPOLMON and that guidelines for the sampling and analyses of organisms could be devised for application to the monitoring of contaminants for public health and water quality purposes. However, it had evidence that the ability and facilities for the collection and analyses of organisms were insufficiently ubiquitous to justify their immediate inclusion in MARPOLMON. It was therefore recommended that a programme of intercomparison and training be initiated to enable a broader international community to achieve the levels of accuracy and precision necessary for making use of organisms in marine pollution monitoring.

Appropriate plans for such intercomparison and training activities were drawn up and IOC convened a Training Workshop on the Use of Marine Organisms in Marine Pollution Monitoring at the Marine Sciences Laboratory in Queenscliff, Australia, 20 August-11 September, 1983. It was designed to give training in, and standardization of, present-day methods. The first part of the workshop dealt with the strategy of using marine organisms as sentinels of pollution and addressed problems of sampling and sample preparation, together with a treatment of methods employed to describe ancillary biological parameters necessary for pollution-data interpretation. The second part of the workshop dealt with the analytical aspects, trouble-shooting and operation of atomic absorption spectrophotometers, and was a practical "hands-on" exercise on mussels gathered during the early part of the workshop. Standard reference materials and second-round intercalibration samples were prepared and distributed during the workshop.

(d) GEMSI Ad Hoc Group on River Inputs

At its Fourth Session, GEMSI made recommendations for the establishment of an ad hoc group to consider approaches to define the influx of contaminants through river runoff. This has been a matter of concern within GEMSI for some time but, with the recent revision of its Terms of Reference, it became possible for GEMSI to deal with the subject in the context of future GIPME activities. The current state of data on river composition for trace constituents, which include the major classes of contaminants, is extremely poor, both in terms of coverage and reliability. Urgent attention to redress these deficiencies is needed and for this reason this group was proposed. It is anticipated that it will start its work during 1983. In the interim, steps have been taken to ensure close contact with the SCOR Working Group No. 46 on River Inputs to Ocean Systems that has some similar interests in the topic.

It should be stressed again here that it must be fully appreciated that the flux of material 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 imposed by estuarine processes.Nevertheless, the poor state of knowledge with regard to gross river discharges requires that this aspect of runoff fluxes be addressed first, before the more complicated problem of net riverine influxes to the ocean is addressed. It should be noted here that IOC and ICES, together with the United States National Oceanic and Atmospheric Administration, are jointly sponsoring a Symposium on Contaminant Fluxes through the Coastal Zone, to be held in Nantes, France in 1984. The results of this symposium should constitute a benchmark for our knowledge of this important area of study.

6. Timetable and priorities for future GIPME activities

Table 4 summarizes planned activities within the GIPME programme for all classes of contaminants presently being considered. Within Table 4, priority assignment is based simply upon a comparison of the component of the Comprehensive Plan to which the activity corresponds with the hierarchical provisions of the strategic framework. Thus, the priority assignments are by component, rather than stage of the Comprehensive Plan. In the Fourth Session of the Working Committee for GIPME, at which these priorities were first considered (IOC 1982a Annex IV), assignment was made with respect to stage, and therefore all uncompleted components of Stage 0 of the Plan were assigned equal and highest priority.

As may be deducted from Table 4, 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 and boundary exchange measurements could be undertaken for some contaminants while the work on others would remain in the method development stage. Therefore, some attention to the relative priority of each class of contaminants is justified and necessary. Such decisions are the responsibility of the Working Committee for GIPME; however some guidance on the subject is offered here.

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). This would permit the most efficient use of resources for boundary exchange measurements and particularly baseline surveys since measurements for all classes of contaminants could be made simultaneously. The decision to defer the baseline survey for trace metals in the North Atlantic, which will provide more time for the completion of the method development and proving for both organohalogens and petroleum hydrocarbons, in order for baselines for all classes of contaminants to be carried out simultaneously 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.

However, since attention to methods for the measurement of boundary exchanges have, until recently, received less emphasis than the primary effort on methods for ocean baseline measurements, 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 would be logical to complete the development and dissemination of methods for baseline measurements for all three classes of contaminants preparatory to the conduct of baseline surveys. The major thrust in method development should then be placed on methods for boundary exchange measurements. Likewise, concerted attention to boundary flux measurements should be deferred until suitable methods for the measurement of 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 the costly, large-scale surveys required by the mass-balance stage. Once most of the data required for mass-balance construction have been acquired, attention to individual classes of contaminants for contamination assessment and subsequent stages of the plan can be carried out independently.

Table 4
Action plan
Timetable and priorities for future GIPME activities

Comprehensive Plan Stage	Comprehensive Plan Component	Class of Contaminant (Petroleum Hydrocarbons / Trace Metals / Organo-halogens)	Time Scale (1983 / 1984 / 1985 / 1986 / 1987)	Priority Assignment
0	Technique Development	IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.2 Methods Development	1983–1984	1
0	Proving of Technique	IOC/GGE(MSI)-III/3 Suppl.3 Recom.I.2 Time-series and intercalibration	1984–1985	2
0	Proving of Technique	IOC/GGE(MSI)-III/3 Suppl.1, Recom.3,4, 6,7,9. Diss./Disp. PH intercalibration	1984–1985	1
0	Proving of Technique	IOC/GGE(MSI)-III/3 Suppl.2, Recom.2. Surface microlayer intercalibration	1984	1
0	Dissemin-ation & Training	IOC/GGE(MSI)-III/3 Suppl.1, Recom.3,4, 7,8,9. Diss./Disp. PH training & demonst.	1984	2
0	Dissemin-ation & Training	IOC/GGE(MSI)-III/3 Suppl.2, Recom.2. Surface microlayer training & demonst.	1984–1985	2
0	Dissemin-ation & Training	WESTPAC Workshop IOC/GCE (MSI)-III/3 Suppl.3, Recom.I.12 Training & Demonst.	1984; 1985–1986	1
0	Dissemin-ation & Training	3rd Workshop on Marine Poll. Mon. Floating Particles	1985	3
0	Dissemin-ation & Training	IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.12 Training	1985–1986	3
1	Open-Ocean Baselines	MARPOLMON-P Diss./Disp. Floating Part. TB on beaches	MEMBER STATE ACTIVITIES (1986–1987)	3
1	Open-Ocean Baselines	IOC/GGE(MSI)-III/3 Suppl.3, Recom.I.1 N. Atl. Baseline	1986–1987	2
1	Open-Ocean Baselines	IOC/GGE(MSI)-III/3 Suppl.3. Recom.I.3 N. Atl. Baseline	1986–1987	4
1	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.	1983 - - - 1985 - - →	2 (Tr. Met.) 3 (Pet. Hyd.) 4 (OHs)
1	Regional Baselines	- - - - - - - - see text - - - - - - - - - - - - -	1986–1987	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	- - - - - - →	Previous stage plus 1
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		

7. Deficiencies in planned GIPME activities

At the time of the Fourth Session of the Working Committee for GIPME, when both the strategy and priorities for future work in the GIPME programme were examined, the major deficiency in the planned activities was *a lack of attention to bounday* exchange processes and fluxes that form an essential part of the mass-balance approach advocated in the Comprehensive Plan. However, the changes to the Terms of Reference of GEMSI that were approved at this meeting allowed GEMSI to pay appropriate attention to boundary exchanges at its Fourth Session in March 1982.

At that meeting, GEMSI established intersessional ad hoc groups on river inputs, sediments and current data deficiencies in mass-balance assessments. As the work of these groups proceeds, approaches to the acquisition of boundary flux data for contaminants should be refined and method development programmes should be devised to provide the methodological tools with which to facilitate concerted measurement of these fluxes. It nevertheless seems clear that the ability to measure boundary exchanges will lag behind the capability for baseline measurements and it is for this reason that it was considered unreasonable to delay the acquisition of baseline data until methods for the measurement of boundary exchanges had been developed and disseminated. Accelerated methodological development and proving for the measurement of boundary fluxes, particularly river inputs and sediment effluxes, can be expected to occur after the completion of Stage 0 of the strategic framework for baseline measurements. Thus, the acquisition of baseline data *should go* hand-in-hand with the completion of boundary exchange methods development with the result that boundary exchange measurements could be undertaken soon after the initial ocean baseline work.

The need for boundary exchange measurements is particularly acute in the case of regional programmes where local runoff influxes and sedimentary effluxes of contaminants will be crucial to the construction of mass-balances. Such measurements do not seem to be being made within current multilateral regional programmes and some greater attention to these aspects needs to be encouraged. Sufficient rudimentary understanding of ocean-boundary fluxes already exists to enable crude mass-balances to be constructed for the global ocean. However, the smaller the subdivisions of the ocean that receive attention from regional perspectives become, the greater is the need for localized boundary flux information.

In other respects, the GIPME programme appears to be comprehensive and it matches well with the requirements of the Comprehensive Plan. The establishment of the Group of Experts on the Effects of Pollutants, during the Fourth Session of the Working Committee for GIPME, will ensure that attention will be paid to the biological effects of contaminants. This will permit the pollution assessment stage of the Comprehensive Plan to be carried out expeditiously once the contamination assessment stage has been completed.

GEMSI continues to be very effective in its prosecution of method development and proving work as well as recognizing the broader issues that impinge on the successful execution of the Comprehensive Plan. GEMSI needs, however, to pay greater attention to the preparation of manuals describing methods that have been developed and tested for particular applications, such as baseline and boundary flux measurements.

The opportunity to carry out training of the kind referred to earlier with regard to marine organisms within specific regional areas in which countries have expressed interest in conducting multilateral marine environmental studies should be accelerated.

8. Collaboration with, and involvement of, other multilateral and international organizations

The extent of communication, at technical levels, between IOC and ICES in subjects and interests related to the GIPME programme is currently very good. The primary interfaces for such communication within the IOC are the Working Committee for GIPME and GEMSI. The corresponding interfaces in ICES are the Working Groups on Pollution Baseline and Monitoring Studies in the North Atlantic (MPNA) and Marine Chemistry Working Group (MCWG), but secondary interfaces are provided by the more senior Marine Environmental Quality Committee (MEQC) and the Advisory Committee on Marine Pollution (ACMP). Several of these groups within both parent organizations draw common members from the marine scientific community. Nowhere have the similar interests of IOC/GIPME and ICES been better exemplified than in the tasks and activities of GEMSI and the ICES MCWG. A formal Memorandum of Agreement now exists between ICES and IOC regarding their common interests in marine pollution matters and their desire to co-operate.

The previous de facto co-operation between IOC and ICES provides a model of how similar levels of co-operation might be engendered between IOC and other multilateral and international organizations. The ICES area includes most of the North Atlantic Ocean which represents a significant portion of the GIPME sphere of interest. ICES has thus far largely concentrated its marine pollution activities in the coastal and marginal sea areas within its region. These areas adjoin the North Atlantic and the opportunity for interfacing ICES and IOC activities to the benefit of the GIPME programme has not been overlooked. Through the common membership of MCWG and GEMSI, each organization has built upon the other's activities in the development and proving of methodology intended for application to baseline survey programmes.

The stage of refinement in regional area studies carried out by ICES is probably better than that for any other region receiving multilateral attention. ICES has nevertheless been quick to appreciate the shortcomings of existing technology and has continued to refine its contaminant surveys including those within its Coordinated Monitoring Programme. Thus, cooperation with ICES holds the promise of testing the degree to which large-scale programmes, such as the open-ocean baseline study proposed by GEMSI, can be interfaced with those addressing smaller, regional areas.

The heterogeneity in the distributions of many contaminants is expected to be greater in the North Atlantic compared with most other open-ocean basins since it is a more dynamic ocean and receives proportionally larger quantities of freshwater runoff than other oceans. Such considerations make the North Atlantic an attractive choice for preliminary baseline work from a scientific perspective, but the abundance of regional activities at the periphery of this ocean, carried out under the aegis of ICES, provided additional weight to the decision taken.

Since the planned GIPME open-ocean baseline study has been postponed (IOC,1982a) it is likely to coincide with the ICES, and ICES/SCOR Baltic Working Group's baseline surveys which are also planned for the future. This coincidence should facilitate the interfacing of large-scale and regional baseline surveys under the most favourable of circumstances. If this venture is successful, future open-ocean baseline surveys in other areas could be used to stimulate concurrent multilateral activities in peripheral coastal zone and marginal sea areas.Indeed, such an approach would offer some advantages of economy and efficiency in the use of resources and it should be given due consideration in the development of future plans and the assignment of priorities.

ICES has recently placed a great deal of emphasis on the effects of contaminants in the marine environment, both in terms of assessing environmental data pertinent to this issue and in terms of devising more authoritative, and statistically significant ways of measuring such effects. This activity will no doubt be of direct interest to the IOC Group of Experts on the Effects of Pollutants (GEEP) whose work will commence shortly.

ICES and IOC also maintains close contacts with the Helsinki, Oslo and Paris Commissions that administer regional conventions for the prevention of marine pollution in the Baltic and Northeast Atlantic. The Joint Monitoring Group (JMG) of the Oslo and Paris Commissions has regularly sought advice from ICES on marine pollution matters including contaminant measurement procedures, biological monitoring and the biogeochemistry of contaminants. Such advice is routed back to JMG through ACMP. Recently, JMG asked for advice on procedures for the measurement of contaminant discharges from rivers. The MCWG prepared a document pointing out the contemporary deficiencies in information on river discharges of contaminants and outlining procedures for the measurement of trace metal and organohalogen discharges from rivers (ICES, 1983). This document should stimulate greater attention to river flux measurements for the purposes of the Commissions and should result in the acquisition of better data for mass-balance assessments for the North Atlantic and various ICES sub-areas.

There seems little need to promote greater co-operation between IOC and ICES since both organizations are obtaining considerable benefit from the current level of collaboration. As long as the present extent of common membership of their respective technical groups is maintained, there appears to be no need for new initiatives to increase the level of co-operation between these organizations.

Co-operation between IOC and other organizations has been of a different nature to that with ICES. The predominant communication interfaces between IOC and other organizations have been at administrative rather than at technical and operational levels. Nevertheless, IOC has obtained substantial support from UNEP and WMO for the conduct of the MAPMOPP project (IOC, 1981a) and the Bermuda Intercalibration Workshop (IOC, 1982b). IOC and UNEP are currently collaborating on the formulation of a pilot programme for the development and testing of methods for organohalogen baseline measurements in the marine environment. UNEP has recently requested IOC to have the drafts of methodological handbooks, prepared as part of individual UNEP Regional Seas Programmes, reviewed by GEMSI.

Although such exchanges are useful, the more extensive and successful cooperation with ICES suggests that greater co-operation between UNEP and IOC at technical and operational levels would greatly benefit both organizations. For example, more intimate involvement of IOC technical and scientific personnel in UNEP Regional Seas Programmes would be of direct benefit to both IOC and UNEP as well as to their participating Member States. Similarly, the involvement in GEMSI activities of UNEP-nominated technical and scientific personnel, who are themselves deeply involved in the scientific aspects of UNEP Regional Seas studies, should be encouraged. The potential assistance to both organizations engendered by such exchanges would amply justify the expenses incurred.

In this connection a certain degree of progress has been made. A report was presented by IOC to the Eleventh Session of UNEP's Governing Council in Kenya, Nairobi, 9-25 May, 1983. This report provided the Governing Council with a review of the Commission's ongoing and planned programmes in the field of marine pollution, so that the Council could determine to what extent UNEP would be prepared to co-sponsor any of the programmes or activities described. Specifically, the report contains the present and planned activities of the IOC Marine Pollution Research and Monitoring Programme in the context of the strategic framework of the Comprehensive Plan for GIPME. The Governing Council passed a decision which : (1) notes the co-operation existing since 1975 between the IOC and UNEP; (2) encourages the IOC to continue to report periodically to the Governing Council on the work of the Commission and its subsidiary bodies, particularly on matters concerning the marine environment; and (3) encourages the further co-operation and co-ordination within available resources between the Programme and the Commission on projects of mutual interest on a global basis, such as the Regional Seas Programme, the Programme on Global Investigation of the Marine Environment and the Marine Pollution Monitoring System.

Finally, IOC could provide assistance to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (The London Dumping Convention or LDC) on issues of a more pragmatic nature than those normally referred to the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). IOC should follow closely the activities of the Consultative Committee and the Scientific Group on Dumping of the LDC and provide assistance through the GIPME programme where appropriate.

9. IOC and Member States' responsibilities and contributions to the GIPME Programme

IOC should seek the logistical and financial support for the various constituent activities of the GIPME programme in order of their priority within the strategic framework.

The most urgent activity is the completion of the preparative methodological development, proving and training components of the preliminary stage (Stage 0) of the plan. To this end, IOC should endeavour to obtain support for the conduct of the Organohalogen Pilot Program (IOC, 1981c) and the planned Workshop for the Intercalibration of Petroleum Hydrocarbon Measurement Techniques proposed by GEMSI (IOC, 1982c). IOC should also seek donations of shiptime for the conduct of a North Atlantic baseline survey in either 1985 or 1986. In this connection, GEMSI should keep abreast of ICES baseline survey plans and endeavour to ensure adequate interfacing of these latter activities with the open-ocean baseline survey. GEMSI should also persevere with its boundary exchange initiatives while proceeding with the completion of its method development activities.

In order to disseminate more effectively the expertise for determination of contaminants in the marine environment, IOC should encourage greater TEMA involvement and organization in training exercises using the expertise available within GEMSI to best advantage. To facilitate greater TEMA involvement in training components of the GIPME programme, GEMSI should endeavour to separate methodological development and proving activities, including methodological intercomparison exercises, from purely training activities. Separation of these components should improve the efficiency, and reduce the costs, of methodological development work thereby permitting faster completion of the critical component of the strategic framework.

The IOC should endeavour to maintain closer contact with UNEP Regional Seas Programme activities, especially at technical and operational levels, giving due consideration to the mechanisms suggested in the preceding section of this document.

National contributions to the GIPME programme can greatly simplify both the IOC's task and the speedy attainment of progress in the execution of components of the Comprehensive Plan. Too much reliance is placed upon financial support from IOC's working budget and other international agencies in furthering the GIPME programme. Technically advanced IOC Member States that have made a commitment to the GIPME Pilot Project should endeavour to provide greater support to their marine researchers involved in the methodological development work which currently merits highest priority. The search for improved techniques for the determination of contaminants in the marine environment is bound to benefit these states as well as the GIPME programme, thus justifying greater support of the GIPME Pilot Project through national contributions.

As increased attention is paid to boundary flux measurements, IOC Member States can also make more substantial contributions to the GIPME programme through activities within their own borders. A particularly good example of such activities that will be important to the GIPME programme and to national authorities alike is the measurement of contaminant fluxes in river discharge. If reliable and uniform techniques for the measurement of contaminants in river discharge can be developed, IOC Member States can make an invaluable contribution to the aims and objectives of the Comprehensive Plan by applying those techniques to major rivers within their own borders. The presently poor understanding of river discharges to the sea is due partly to the limited study of major world rivers, particularly in developing areas, and partly to the variety and unreliability of methods applied to such measurements. The GIPME programme could provide a mechanism for the standardization of techniques and, in the long term, a vastly improved understanding of both river composition and discharge. Since gross river flux measurements are one of the more useful forms of data for gauging temporal changes in contaminant fluxes to sensitive coastal areas, it is surprising that greater attention has not been devoted to them.

Similarly, the development of techniques and approaches to the use of marine organisms and sediments for the assessment of contamination of marine areas should be of immense benefit to coastal states since these can then be applied to making comparative estimates of the extent of contamination of local and regional areas throughout the world.

Finally, it must be emphasized that this and other reviews (e.g. UNEP, 1982) clearly indicate the need for greater co-ordination of national approaches to inter-related international activities. Specifically, there is a need for national representatives to GIPME (particularly the Working Committee for GIPME) to be aware of, and have their positions co-ordinated with, the representatives that deal with related issues in UNEP. It appears that such problems as different perspectives on marine environmental issues being presented at different fora do not arise in the national positions related to ICES and IOC but that they do occur between IOC and the UNEP Regional Seas Programme. Member States should, therefore, make strenuous efforts to ensure good co-ordination in the development of their positions with regard to these and similarly related international activities.

10. References

Barry, P.J., 1979. An introduction to the exposure commitment concept with reference to environmental mercury. Monitoring and Assessment Research Centre (MARC) Report No. 12. Chelsea College, University of London.

GESAMP, 1983. Report of the Thirteenth Session, Geneva, 28 February - 4 March 1983, GESAMP Reports and Studies No. 18.

Goldberg, E.D.,1981. Editors and revolutions. Marine Pollution Bulletin 12, 225.

IAEA, 1982. Control of radioactive waste disposal into the marine environment, IAEA Safety Series (In Press).

ICES, 1982. Report of the Advisory Committee on Marine Pollution 1981. ICES Cooperative Report Series No. 112, international Council for the Exploration of the Sea, Copenhagen 67pp.

ICES, 1983. Report of the ICES Advisory Committee on Marine Pollution, 1982. ICES Cooperative Research Report Series No. 120, International Council for the Exploration of the Sea, Copenhagen, 74 pp.

IOC, 1976. A Comprehensive Plan for the Global Investigation of Pollution in the Marine Environment and Baseline Study Guidelines. IOC Technical Series No. 14. Unesco.

IOC, 1978. Global Investigation of Pollution in the Marine Environment : Group of Experts on Methods, Standards and Intercalibration, Second Session, Bergen, Norway, 1-4 May, 1978. Summary Report. Document No. IOC/GGE(MSI)-II/3.

IOC, 1980a. Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO/UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-ocean Waters, Bermuda, 11-26 January, 1980. IOC Workshop Report No. 25.

IOC, 1980b. Global Investigation of Pollution in the Marine Environment : Group of Experts on Methods, Standards and Intercalibration, Third Session, Monterey, U.S.A., 8-12 September,1980. Summary Report. Document No. IOC/GGE(MSI)-III/3.

IOC, 1981a. Global Oil Pollution : Results of MAPMOPP, the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring. Unesco.

IOC, 1981b. GEMSI Ad Hoc Group on the Analysis of Dissolved/ Dispersed Petroleum Hydrocarbons in Seawater, First Session, Woods Hole, U.S.A., 16-18 March, 1981. Summary Report. Document No. IOC/GGE(MSI)-III/3 Suppl. 1.

IOC, 1981c. GEMSI Ad Hoc Group on Future Action under the IOC/WMO/UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, First Session, Bermuda, 19-23 May, 1981. Summary Report. Document No. IOC/GGE(MSI)- III/3 Suppl. 3.

IOC, 1981d. GEMSI Ad Hoc Group on Sampling of the Sea-surface Microlayer, First Session, Miami, U.S.A., 3-5 March, 1981. Document No. IOC/GGE/(MSI)-III/3 Suppl. 2.

IOC, 1982a. 4th. Session of the Working Committee for the Global Investigation of Pollution in the Marine Environment, Fourth Session, UN Headquarters, New York, U.S.A., 6-12 January, 1982. Summary Report. Document No. IOC/WC-GIPME-IV/3.

IOC, 1982b. Scientific Report of the Intercalibration Exercise, the IOC/WMO/UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open Ocean Waters, IOC. Technical Series No. 22.

IOC, 1982c. Global Investigation of Pollution in the Marine Environment : Group of Experts on Methods, Standards and Intercalibration, Fourth Session, Curacao, Netherlands Antilles, 25-31 March, 1982. Summary Report. Document No. IOC/GGE(MSI)-IV/3.

IOC, 1983a. Global Investigation of Pollution in the Marine Environment : Group of Experts on Methods, Standards and Intercalibration, Fifth Session, Paris, 14-17 June 1983. Summary Report, Document No. IOC/GGE(MSI)-V/3.

IOC, 1983b. The Determination of PCB Components in Open Ocean Waters. IOC Technical Series No. 26. (In Press).

Li, Y-H., 1977. Confusion of Mathematical Notation for Defining Residence Time. Geochimica et Cosmochimica Acta 41, 555.

NAS, 1975. Petroleum in the Marine Environment : Workshop on Inputs, Fates and the Effects of Petroleum in the Marine Environment, Airlie, U.S.A., 21-25 May, 1973. National Academy of Sciences, Washington, D.C.

O'Brian, B.J.,1979. The Exposure Commitment Method with Application to Exposure of Man to Lead Pollution. Monitoring and Assessment Research Centre (MARC) Report No. 13. Chelsea College, University of London.

Preston, A., 1982. Standards and Environmental Criteria : An idealised framework for their derivation and application to the regulation of marine environmental quality and the control of pollution. In Report of the Advisory Committee on Marine Pollution 1981 ICES Cooperative Reports Series No. 112, International Council for the Exploration of the Sea, Copenhagen. pp. 29-40.

Preston, A., and J.E. Portmann, 1981. Critical Pathway Analysis Applied to the Control of J. Portmann, 1981 Mercury Inputs to UK Coastal Waters. Environmental Pollution Series B. Vol. 2, 451.

SCOR, 1982. Future Ocean Research: A Preliminary Report on an Inquiry by the Scientific Committee on Oceanic Research and the Advisory Committee on Marine Research for the Intergovernmental Oceanographic Commission. Scientific Committee on Oceanic Research, Halifax, Canada.

Templeton, W.L., 1982. Lessons from Radioactive Waste Disposal Applied to 1982 Other Pollutants. In Wastes in the Ocean, Volume 3: Radioactive Waste and the Ocean, (P.K. Park, D.R. Kester, I.W. Duedall, B.H. Ketchum, Eds.) John Wiley and Sons, New-York, (In press).

UNEP, 1982. Achievements and Planned Development of UNEP's Regional Seas Programme and Comparable Programmes Sponsored by Other Bodies. UNEP Regional Seas Reports and Studies No. 1.

Yeats, P.A., and J.M. Bewers, 1982. Discharge of Metals from the St. Lawrence River. J.M. Bewers, 1982. Canadian Journal of Earth Sciences 19, 982-992.