IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP
Joint Group of Experts on the Scientific Aspects
of Marine Environmental Protection (GESAMP)

Guidelines for Marine Environmental Assessments

IMO
London, 1994

Printed in the United Kingdom by
the International Maritime Organization

NOTES

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GESAMP – IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP): Guidelines for marine environmental assessments. 1994. Rep.Stud. GESAMP No.54 [40]pp.

CONTENTS

Preface vii

1 Introduction 1

2 Criteria for Environmental Quality 3

3 Content and Structure of the Assessment Report 5
3.1 Geography and Scope 5
3.2 Human Activities 6
3.3 Hydrography and Climate 6
3.4 Chemistry 7
3.5 Biology 8
3.6 Overall Evaluation 9
3.7 Conclusions 10
3.8 Recommendations for Action 10

4 Process 11
4.1 Introduction 11
4.2 Coordinating Body 11
4.3 Technical Steering Group and Sub-Groups 12
4.4 National Task Teams 13
4.5 Scope 13
4.6 Data Quality Considerations 14
4.7 Timetable 15
4.8 Sources of Information 15
4.9 Compilation and Evaluation of Data 16
4.10 Drafting and Finalization of the Report 17

5 Preparing the Action Plan 18
5.1 Management Measures 18
5.2 Information Needs 19
5.3 Performance Evaluation 19

Annex 1 Guide to information needed for assessing change and quality of marine areas.....21

Annex 2 Guide to quality assurance (QA) procedures for marine environmental data 24

Annex 3 Primary considerations in the design of marine monitoring programmes 26

PREFACE

One of the principal tasks of GESAMP is 'to prepare periodic reviews and assessments of the state of the marine environment, and to identify problems and areas requiring special attention'.

The last GESAMP review on the State of the Marine Environment was published by UNEP in 1990 as GESAMP Reports and Studies No. 39. In considering future activities in this field, GESAMP recalled the difficulties it had in obtaining comparable information from all regions and the associated problems of data relevance and quality.

In the light of these difficulties, GESAMP identified a need to develop a common basis for the conduct of regional assessments. In addition, guidance is needed by coastal States for the preparation of regular environmental assessments of the state of the environment of coastal and marine areas required by the United Nations Conference on Environment and Development (UNCED) (Agenda 21, chapter 17.8(c)).

Accordingly, in 1993 GESAMP established a Working Group on 'Design and Conduct of Marine Environmental Assessments' with the following terms of reference:

> 'Define the key elements for the design of regional marine assessments with specific reference to:
>
> - evaluating a common compatible format for assessments;
> - evaluating potential sources of marine degradation in specific marine areas including land-based sources; and
> - providing simple but effective procedures for assessing data and information quality relevant to assessments.'

It should be emphasized that 'marine environmental assessment' is the collection, analysis and interpretation of information with

the purpose of assessing the quality of marine areas. This is *not* the classical Environmental Impact Assessment (EIA) carried out to study the effects of proposed developments on the environment. Rather, it is a comprehensive process comprising the collection of reliable physical, chemical and biological information to assess the impact of human activities against a background of spatial and temporal variability. Whilst the Guidelines should assist in maximizing the benefits and cost-effectiveness of assessments, it was beyond the mandate of the Group to advise on the associated financial implications or requirements for capacity-building in technical and managerial fields.

GESAMP has emphasized the importance of assessments in providing a scientific basis and rationale for policy, planning, integrated management, and sustainable development of coastal and marine areas (GESAMP Reports & Studies No. 45, 1991).

The Working Group met twice in 1993 to prepare this report which was adopted by GESAMP for publication at its twenty-fourth session, New York, 21-25 March 1994.

The Working Group operated under the lead of IMO; co-sponsors were UN, UNEP and UNESCO-IOC.

The Working Group was chaired by Mr. R. Boelens and Mr. P. Tortell. Its members were Mr. V. Annikiev, Mr. J. M. Bewers, Mr. J. Campbell, Mr. E. Gomez, Mr. S. Nawadra and Mr. G. Topping. Mr. R. Amini (UNEP) and Mr. M. Nauke (IMO) acted as Secretaries of the Group.

GESAMP invites users and readers of these Guidelines to provide feedback on experience in the application of the Guidelines, on suggestions for their improvement, or on topics that might be included in future revisions. Written responses can be addressed directly to one of the GESAMP sponsoring organizations or to:

The Administrative Secretary of GESAMP
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1 INTRODUCTION

A marine environmental assessment is a compilation of current knowledge about a defined area of the sea, an evaluation of this information in relation to agreed criteria of environmental quality and a statement of the prevailing condition of the area. It should be clearly understood that a regional assessment utilizes accumulated data and information and does not depend on new data being collected during the assessment process.

Assessments should be regarded by managers and scientists as a normal part of the environmental protection process whether at local, national, regional and international level. If assessments are organized and prepared in a systematic and uniform manner, they provide a mechanism for inter-comparisons of national and regional environmental conditions and for assessing the nature and extent of anthropogenic influences on larger scales (*e.g.* global).

Comprehensive environmental assessments of coastal and marine areas are useful to both managers and scientists in the following ways:

- providing a compact summary of contemporary knowledge, status and trends in environmental quality and necessary management action;

- enabling the identification of significant gaps in knowledge and, accordingly, providing an authoritative basis for defining priorities for further scientific and other investigations;

- providing a basis for judging the effectiveness and adequacy of environmental protection measures and for making any necessary adjustments to these measures.

In summary, a marine environmental assessment is a process by which information is collected and evaluated, and undertaken

periodically to assess the state of knowledge. Its product is an Assessment Report which is a document synthesizing information, presenting the findings of the assessment and making recommendations for action for future work.

These Guidelines provide an explanation of the role of marine environmental assessments in coastal and marine environmental protection, an outline of their structure and a description of the assessment process at a regional level. However, they are equally applicable to assessments at national level.

2 CRITERIA FOR ENVIRONMENTAL QUALITY

An environmental assessment provides a means of summarizing existing information that can be used in forming opinions about the *quality* of the environment concerned. In this context, the most useful information will be that relating to changes in the natural features of the environment and the consequences of these changes.

Assessing the *quality* of marine environments is seldom easy and opinions on the importance, or acceptability, of the changes that have occurred can differ widely. For this reason, when subjective terms such as 'acceptable', 'significant' or 'harmful' are used to describe a particular environmental condition it is always better if the term can be related to some agreed criterion (*viz* standard, objective, reference value, etc.) for the condition in question.

In principle, quality criteria can be developed for any feature or component of the marine environment (*i.e.* physical, chemical or biological) and for any appropriate area, time period or use. Because environmental quality can affect all members of society, the task of developing criteria should not be confined to scientists but should involve close collaboration among scientists, environmental managers and a broad range of individuals representing different users of the sea and its resources. Ideally, the criteria will be consistent with principles, policies and goals adopted by governments for the purposes of marine environmental protection.

Criteria for marine environmental quality may be either qualitative (i.e. descriptive), quantitative or both. Quantitative criteria may be more amenable to comparison with scientific measurements. For example, many countries have imposed limits on the concentrations of certain substances in environmental media; determining compliance with these limits is a relatively straight-

forward process. It is equally important to develop criteria for biological features of the environment, such as the proportion of particular habitats that should be preserved to maintain desirable species and communities or indicators of the physiological condition of particular species.

A common criterion for marine environmental quality is one that specifies that there should be no change (typically *no increase*) in the level or incidence of conditions symptomatic of environmental degradation *e.g.* contaminant concentrations, oxygen depletion, blooms of toxin-producing algae. Before such criteria are set, it is imperative that sufficient scientific information is obtained to enable the appropriate *reference* (*e.g.* current, background, normal) values to be defined. These reference values must take account of natural variability (see Annex 3).

Setting quality criteria for marine areas is probably the most important step in managing human activities that affect the productivity and ecological condition of these areas. Clearly stated criteria, whether descriptive or numerical, provide the basis of specific objectives governing the collection of environmental data needed for management purposes. Specific objectives are essential for designing scientific studies that will yield relevant and interpretable data.'

3 CONTENT AND STRUCTURE OF THE ASSESSMENT REPORT

This chapter of the Guidelines illustrates how an assessment is constructed and what it might reasonably be expected to achieve. Each of the following sections corresponds to a section or chapter in the Assessment Report. For each section of the Assessment Report, guidance is given on the structure, the types of information needed and how the information should be presented and discussed.

More comprehensive guidance on the scientific information that would help to improve the basis of regional assessments is provided in Annex 1. This guidance will also indicate the scientific studies that may be needed to supplement existing research and monitoring programmes.

3.1 Geography and Scope

The geographical boundaries and scope (*i.e.* the environmental features, habitats and human activities to be covered) of the assessment must be clearly defined at the beginning of the report. The definition of boundaries should cover the landward limits of the assessment, including its extension into rivers and catchment areas, as well as marine boundaries.

The environmental features to be addressed will encompass the major components of the sea (i.e. seawater, sediments and biota) but might also include the overlying atmosphere and geological features beneath the surficial sediments and around the coasts. It would be helpful to clarify whether animals that are not wholly dependent on the sea, such as certain fish, birds and mammals, will be regarded as marine biota and which migratory species will be included in the assessment.

3.2 Human Activities

This section should summarize demographic data and trends in human activities throughout the region. These could include the extent of urban and rural communities at the coast or dependent on it; commercial, subsistence, and traditional (indigenous) fishing and food gathering; industries other than fishing which are dependent on the coastal and marine environment and the employment opportunities they provide; health statistics of coastal dwellers and any significant variation from the rest of the population, etc.

Ideally, all human activities within the coastal zone being assessed, including its catchments, that have the potential to damage or modify the marine environment, should be identified. However, special attention should be given to practices that, due to their nature and scale, pose the greatest potential threats. It is therefore desirable to include activities such as port development, navigational dredging, industrial and domestic waste disposal, coastal construction (*e.g.* reclamations, causeways), tourism and recreational developments, shipping, forestry, fishing, aquaculture, agriculture (including agro-chemical use), mineral exploitation and power generation.

For example, one activity that may be looked at in some detail is tourism. This information might comprise the number of hotels, number of beds, occupancy rates, number of staff employed, etc. It could also include the number of ancillary services provided to tourists such as yacht marinas and anchorages, car hire, restaurants, tour operations, cultural events, souvenir sales, etc.

3.3 Hydrography and Climate

The first part of this section should summarize water exchanges and circulation and their temporal variability (*e.g.* seasonal) at both local and regional levels. Hydrographic and climatic (*e.g.* wind action, storm events) information should be used to estimate water movement across the geographical boundaries of the area (*i.e.* river discharges, transports to offshore areas and exchanges across marine boundaries) and to assess potential contaminant dispersion. For completeness, a quantitative description of the precipitation-evaporation balance might also be included.

The second part should contain an assessment of the movement and fate of particulate material within the system through such mechanisms as water circulation, river discharge, coastal erosion, sedimentation and sediment resuspension.

The third part should contain a summary of specific anthropogenic practices that directly or indirectly have the potential for modifying the movement of water and particulate materials such as the construction of barrages, coastal engineering, dredging, urban development and deforestation. The potential for effects associated with climate change should also be considered.

The final part should evaluate the degree to which there is evidence of such modifications having resulted in changes to productivity, habitats, the capacity for waste assimilation and the erosion-sedimentation balance.

3.4 Chemistry

The first part should contain data on the distribution and concentrations of naturally-occurring substances that directly influence the growth, composition and sustainability of marine plants and animals such as dissolved oxygen and dissolved and particulate nutrient elements (e.g. N, P and Si).

The second part should provide information on the inputs of chemical substances to the region from both natural and anthropogenic sources including atmospheric inputs. This should include information on the variability of inputs and the quantities and forms (i.e. dissolved/suspended) of individual substances.

The third part should contain data on the distribution and concentration of natural and man-made (*viz* synthetic, artificial) substances that have the potential to detrimentally affect man and/or marine life by either direct or indirect exposure pathways. These data should cover the distributions of both dissolved and particulate forms of the chemicals in the water column, in appropriate tissues of edible marine organisms, in various trophic levels of the marine food web, and in relevant grain-size fractions of sediments.

The fourth part should outline information on the transport, cyc-

ling and fate of chemicals in the subject area in the context of the physical oceanographic features described in the preceding section of the document. This information should then be used to summarize contemporary understanding of the biogeochemical processes that determine the fates and pathways of natural and artificial substances introduced to the area.

The fifth part should examine the scales of human activities (*e.g.* dredging, storm-water drainage, aggregate and mineral extraction, and aerial emissions) that may have influenced the distribution of substances in the area.

The final part of this section should identify changes that have occurred in the chemical characteristics of the area and relate them to specific inputs of substances and/or human activities, or natural processes. These changes should be evaluated in the context of the known hydrographic and geochemical characteristics of the area and the processes controlling the transport, behaviour and fate of substances.

3.5 Biology

This section should deal with biological characteristics of the area including the influence of human activities on biota and human health.

The first part should provide an inventory of the biology and ecology of the region; this should be as comprehensive as possible. It should describe typical habitat types, representative communities within these habitats, predator/prey relationships and measures of the abundance of dominant, indicator and other key species present. The inventory should also identify the exploited living marine resources (fish, shellfish, seaweeds, etc.) of the region and, when possible, should summarize stock sizes, the location of spawning, nursery and feeding grounds and the food species upon which these resources depend.

The second part should review information on temporal and spatial fluctuations in the populations of exploited or other key species, the displacement of species from particular habitats, and distinguish between natural perturbations and those that might result from human activity. It should also consider factors

such as the sensitivities of particular habitats and communities, the incidence of fish diseases and effects on biota of algal toxins. This information could be gleaned from research as well as from anecdotal evidence.

A third part should attempt to describe any modifications to the entire ecosystem or major habitats and identify causes. These changes may have occurred in response to a particular activity (such as fishing techniques or coastal and inshore development) and manifested through the destruction of habitats (such as mangroves, coral reefs or inter-tidal flats) or be an indirect consequence of alterations to natural processes such as water exchange and sedimentation.

It should also be possible to assess the impacts of contamination and other changes induced by humans on marine life and human health. This will apply, for instance, to contaminants from domestic and industrial sources (including shipping) that are found in measurable amounts in the tissues of exploited and non-exploited species. Where there is doubt about the environmental significance of a particular practice, it would be appropriate to subject the practice to some form of risk assessment. It will also be necessary to assess risks to human health through exposures to chemical residues in seafood, to microorganisms (bacteria and viruses) and algal toxins.

3.6 Overall Evaluation

This is probably the most critical chapter of the Assessment Report because it identifies the major problems and thus establishes the priorities for action.

The overall evaluation should consist of a detailed discussion and analysis of the findings in the contexts of prevailing management concerns and established environmental goals and quality criteria. Where quality criteria have clearly been exceeded, some judgement needs to be made on the prospects for recovery (*i.e.* extent and time-scale). It should also address any new or impending problems revealed by the assessment including those that might arise from future development within the region such as the introduction of new industry and increased coastal resource utilization. It should identify deficiencies in scientific

and socio-economic information necessary to resolve these problems and improve the predictive capability and the assessment of risks. The effectiveness of any previous management action taken to protect the marine environment should be evaluated. The need for new management action to address risks to human health and adverse effects on ecosystems should be specified.

3.7 Conclusions

The conclusions of the assessment should comprise a series of concise statements summarizing the results of the discussion and analysis given in the preceding section.

3.8 Recommendations for Action

The assessment process, and the Assessment Report itself, will have identified various environmental threats or conditions that clearly warrant management action to prevent or mitigate subsequent damage. They will also have revealed gaps in existing knowledge concerning human activities, natural processes and environmental conditions. Thus, the final chapter of the Report should contain recommendations for action comprising:

- a statement of priority management actions necessary to address environmental quality deterioration identified in the assessment;
- a statement of the priority actions required to fill gaps in information identified by the present assessment and to address management concerns;
- establishment of a time frame for these activities leading to a subsequent assessment of regional environmental quality.

More detailed guidance on the preparation of the Action Plan is given in Chapter 5.

4 PROCESS

4.1 Introduction

This chapter gives step-by-step guidance on the sequence of events leading to the production of the assessment report. It deals primarily with the organizational and administrative aspects of the process and provides concise explanations of the functions and key decisions at each stage.

The efficiency and success of the regional assessment process will depend to a considerable extent on good co-ordination and adherence to a previously agreed timetable. The advice provided in this section is intended to make the process as straightforward as possible.

4.2 Co-ordinating Body

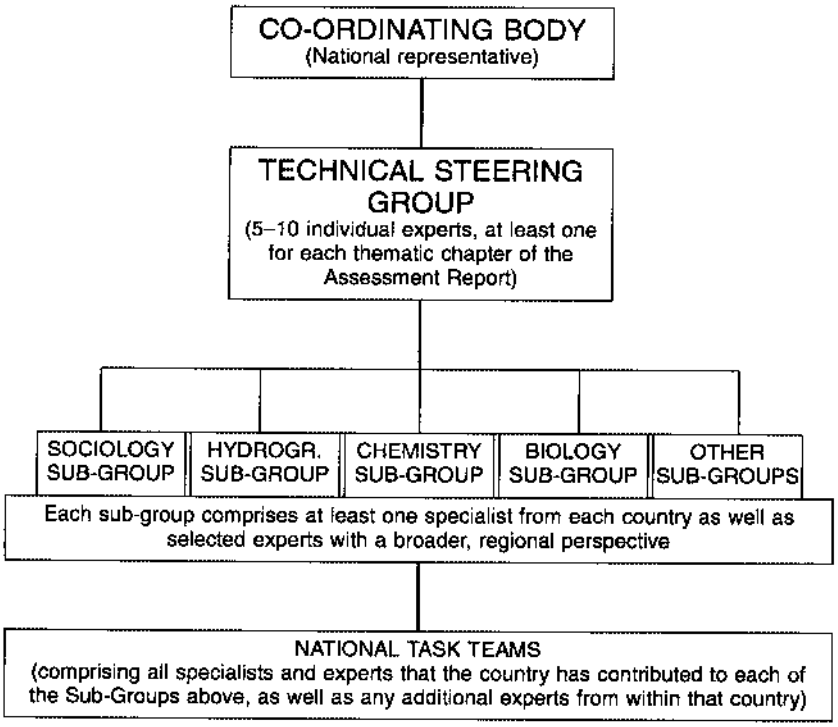
A single organization should be given responsibility for the co-ordination of the assessment process at the regional level, including arrangements for logistical and financial support. The various bodies of UNEP Regional Seas Programmes as well as those set up under other regional marine protection agreements and regional IOC Committees would seem suitable for this purpose.

The first task of the Co-ordinating Body should be to define the boundaries of the Assessment Area. Such boundaries will include demarcation lines at all marine, estuarine, riverine and land boundaries so as to enclose the subject area completely. Where there exist convenient and well-recognized physical geographic boundaries, these are preferable to boundaries based on political geography (see Section 3.1). The Co-ordinating Body, with the advice of any existing technical sub-committees, must then establish a Technical Steering Group to conduct the regional assessment. A key function of the Co-ordinating Body will be to ensure that the time schedule set for the assessment is strictly observed.

4.3 Technical Steering Group and Sub-Groups

The composition of the Technical Steering Group is critical for the smooth conduct of the assessment process and for achieving a high standard in the final report. Membership of the Technical Steering Group may be drawn from appropriate scientific disciplines, from environmental protection and regulatory authorities and from relevant interest groups so that the combined expertise of the Group covers the entire scope of the Assessment. Members should be of sufficient standing and seniority to ensure that the entire assessment process is conducted efficiently and in accordance with the agreed time-scales.

Recommended organizational relationships are illustrated below–



The Technical Steering Group will prepare terms of reference for sub-groups reflecting the thematic chapters of the Assessment Report and whose role will be to compile and evaluate the information. Sub-groups will normally be headed by a member of the Technical Steering Group and comprise representatives of all the participating countries together with other invited experts with broader regional perspectives. Sub-groups are responsible for producing the initial drafts of relevant chapters of the Report. Good liaison among sub-groups is essential.

The terms of reference for sub-groups will clearly set out the kinds of information required, reporting formats, prescriptions on quality control and the timetable for the conduct and completion of the tasks assigned. In the above figure, allowance has been made for the creation of other sub-groups focussing on topics of particular regional importance *e.g.* human health. Nevertheless, care should be exercised to ensure that the total number of sub-groups is kept to a reasonable number commensurate with the scope of the assessment.

4.4 National Task Teams

It is advisable that experts from the same country who form part of the various thematic sub-groups, should meet under a National Convenor who coordinates activities at national level. These national task teams can be augmented as necessary by further experts.

4.5 Scope

A statement on the scope (i.e. the environmental features and human activities to be covered) of the assessment should be prepared by the Technical Steering Group and this should be generally accepted by the Co-ordinating Body. This statement will form an important part of the guidance provided to Sub-Groups dealing with different aspects of the assessment. The main topics to be considered in defining the scope of the assessment are described in Section 3.1.

Although the geographical scope of the assessment will extend to the entire Assessment Area, it may be decided that initial assessments should give priority to environmental sectors that are considered to be most at risk from human activities. Thus,

for example, estuaries, semi-enclosed bays, reef systems and shallow coastal waters might be assessed in greater detail (*e.g.* on a finer scale) than the deeper open-sea areas. If necessary, the area subject to detailed study can be extended progressively in subsequent assessments as the understanding of regional conditions improves.

The statement on the scope of the assessment should incorporate the environmental criteria against which the information collected is to be assessed and the level of quality assurance necessary to ensure the comparability of data and the reliability of the assessment (see Section 4.6 below).

4.6 Data Quality Considerations

The success of marine environmental research and monitoring programmes is directly related to the collection and interpretation of relevant and reliable data. Good data are those that meet the criteria laid down by the investigator to achieve the stipulated aims of the study and that are shown to be statistically reliable. However, it should always be remembered that the reliability of any dataset should initially only be judged in the context of the purpose for which it was collected.

In addition to employing well-planned sampling programmes, and appropriate collection, preservation, storage and transport procedures, it is vital that investigators have in place a system of data quality assurance. This consists of:

- analytical procedures with the required performance characteristics – accuracy, precision and detection limit;
- regular in-house checks on accuracy and precision with appropriate reference materials (control charts);
- participation in inter-laboratory comparison exercises;
- skilled staff, properly equipped and well-maintained laboratory facilities, regularly maintained instrumentation, use of appropriate quality reagents and appropriately graded and calibrated labware.

4.7 Timetable

The preparation of, and adherence to, a realistic timetable is an essential element of the assessment process. Whereas it is beneficial to provide guidance on the time frame for the conduct of regional assessments, it is clearly not appropriate to stipulate the interval between successive assessments.

In preparing the timetable, the Co-ordinating Body and the Technical Steering Group will need to take into account the number of countries participating in a regional assessment and any anticipated difficulties in communication within the region, the diversity of information that will need to be assessed and the expected volume of information that will be assembled. Subject to the constraints imposed by the timetable, the Technical Steering Group will need to allocate realistic periods to the several phases of the assessment including the collection, collation and validation of data, technical analysis and interpretation, and the drafting, editing, review and adoption of the report.

It should be remembered that a regional assessment is primarily an evaluation of existing data. Accordingly, an upper limit of eighteen months for the completion of an assessment, from the establishment of the co-ordinating body to the completion and presentation of the assessment document, appears both realistic and appropriate.

4.8 Sources of Information

Information for the regional assessment, collected by the Technical Steering Group or its sub-groups will be gleaned from a wide range of sources. These will include the scientific literature, libraries, national archives and registers, government research institutes, research organizations in the private sector, industry, academic institutions and other professional associations and environmental organizations. In addition, the Technical Steering Group will be able to search international databases for locally relevant scientific information.

Descriptions of natural conditions (physical, chemical and biological) within the region will be available from open, peer-reviewed scientific literature as well as literature generated locally by research laboratories and central and local govern-

ment departments. The Technical Steering Group will need to make a concise summary of this information.

Information on human activities, encompassing industrial development, waste disposal and discharge, shipping, fisheries, military activities, tourism, coastal development, offshore mineral extraction (including exploitation of petroleum hydrocarbon reserves) will generally be found through central or local government agencies and from intergovernmental sources. Information on current conservation and pollution control measures will also be available from governmental sources.

To facilitate retrieval of information, the Technical Steering Group will need to establish mechanisms for the request and return of data and associated quality assurance documentation. This will involve the design, distribution and return of succinct data reporting forms clearly indicating what information is required and the time frame within which it should be supplied.

Whereas the Assessment is not reliant on the acquisition of new data, there may be cases where such new data can be obtained without undue investment of time and effort and will serve to fill obvious gaps in the existing dataset. However, the acquisition of new data should not result in any delay to the agreed timetable for the completion of the Assessment Report.

Where available, electronic and hard-copy maps, aerial photographs and satellite imagery can form useful tools for the recording and assessing of information. Maps of a comprehensive nature (*e.g.* integrated coastal zone planning maps and coastal resources maps, GIS products) may be particularly useful.

4.9 Compilation and Evaluation of Data

Each sub-group will have the responsibility of compiling datasets from the contributing organizations and for preparing appropriate (*i.e.* sub-regional, thematic) reports to the Technical Steering Group. At the outset, the sub-groups must reach agreement with the Technical Steering Group that only data adhering to the specified Quality Assurance guidelines, and submitted by agreed deadlines, will be included in the Assessment. Experience has shown that in the absence of such an agreement the whole

process of data compilation and evaluation can be seriously delayed and the quality of the final report significantly reduced. Further guidance on Quality Assurance procedures is given in Annex 2.

On completion of the data evaluation and the preparation of a preliminary assessment for each section, the main tasks of the sub-groups are complete. It is then the job of the Technical Steering Group to finalize the various sections dealing with the physics, chemistry and biology and to prepare the overall evaluation and conclusions. In compiling recommendations for action, it may be necessary for the Technical Steering Group to consult the relevant sub-groups.

4.10 Drafting and Finalization of the Report

Final editing of the document should be carried out by a single person. This enables a common style of presentation to be maintained throughout the report and ensures coherence among the different scientific sections. The 'Conclusions' section should constitute a concise summary of the main findings of the assessment to which the 'Recommendations for Action' can be directly related. The penultimate, and perhaps preceding, drafts of the report should be exposed to review by those involved in the preparation of individual sections and external referees. Section authors can ensure that the complete document faithfully reflects the content of their own sections; external referees can evaluate the perspective on regional issues that the document will convey to eventual readers and point out any ambiguities, or potential misconceptions, that might require correction. For this reason, the external reviewers should be drawn from scientific, management and policy sectors, and community representatives.

5 PREPARING THE ACTION PLAN

As described in Section 3.8 of the Guidelines, the final part of the Assessment Report should recommend actions derived from, and consistent with, the evaluations and conclusions contained in the body of the Report. These recommendations will form the basis of an Action plan to be formulated by governments shortly after the Report is completed. This Action plan, issued as a separate document, should specify

- any necessary measures for preventing or reducing environmental damage, or for redressing damage that has already occurred;

- any studies, scientific research or monitoring needed to fill gaps in knowledge of regional conditions;

- evaluation of the effectiveness of existing environmental protection measures.

In addition to specifying the programmes and measures which are to be implemented, the Action Plan must also specify the associated time-frames (*e.g.* in relation to the timing of the next Assessment).

The following paragraphs note some of the more important considerations when preparing the Action plan.

5.1 Management Measures

The Action Plan should clearly identify the problems and conditions that warrant management attention, the causes of these problems and conditions, the consequences of failing to adopt preventative or remedial measures, and assign priorities to the proposed actions. The Action Plan needs to be quite specific – for each action or proposal, it must identify :

- responsible agency
- results expected/performance indicators
- target dates
- resources required

5.2 Information Needs

This part of the Action Plan should highlight human activities and environmental conditions about which little is known or for which the existing information is clearly insufficient for firm conclusions to be drawn. It should be as specific as possible about the kinds of data and other information required to fill these gaps and the investigations (*i.e.* research or monitoring) that would be best suited to providing the information. Annex 1 gives guidance on scientific information relevant to assessments; this may help in designing any necessary supplemental studies.

These guidelines give advice of a general nature regarding the content of marine science programmes that facilitate periodic assessments of marine environmental quality. Nevertheless, the experience of locally-based scientists will often be of most value in identifying priorities for scientific studies in the region and appropriate methodologies.

If the assessment indicates that further monitoring is necessary to provide additional data on the spatial or temporal patterns of chemical, physical or biological parameters within the sea itself, very careful attention should be given to the *design* of such monitoring. Experience has shown that not all environmental conditions of interest or concern are amenable to monitoring in a way that provides relevant and cost-effective data. Annex 3 contains short notes on the most important considerations in the design of marine monitoring programmes.

It may also be useful to consider the advantages of potential linkages between monitoring for assessment purposes and monitoring as part of global research programmes.

5.3 Performance Evaluation

An element of environmental management that seldom receives adequate attention is the effectiveness of measures and programmes employed to date. The environmental assessment

process presents an ideal opportunity to examine the performance of both scientific and management activities (and associated investments) aimed at evaluating and maintaining environmental quality. For example, it has frequently been recommended by those who appraise marine environmental monitoring programmes that the usefulness of monitoring activities should be individually assessed and, if warranted, scrapped or revised. Such recommendations have seldom been observed in practice. The assessment process provides an opportunity to evaluate the contributions of all existing monitoring, survey and research activities in furthering national and regional objectives for marine environmental protection. The inclusion of such evaluations would promote increased attention to cost-effectiveness and more efficient use of scientific and technical resources.

It is useful to remember that recommendations may range from those that propose new actions to those that propose that certain measures be terminated because they are not achieving the expected benefits.

ANNEX 1:

Guide to information needed for assessing change and quality of marine areas

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1 Human and Industrial Practices

- the nature and distribution of human and industrial sources potentially affecting the area;
- the kinds and locations of effluent releases from industrial and municipal sources into the marine environment and freshwater areas flowing into the marine area;
- industrial and municipal effluent composition and flow rates.

2 Human Health Risks

- human health risks associated with exposures to substances (including toxins) and micro-organisms in seawater and marine products;
- relevant standards relating to human health protection from direct (*e.g.* bathing) and indirect exposures (*e.g.* seafood consumption) resulting from marine pathways.

3 Hydrographic Properties

- circulation, structure, physical transport (both aqueous and particulate);
- hydrographic conditions, their temporal and spatial variability.

4 Chemical and Geochemical Properties

- characterisation of input and output fluxes, spatial distribution patterns and boundary-exchanges of nutrients, trace elements and other chemical substances;

- definition of the structure, composition and dynamics of fine sediments including gross and net riverine fluxes;

- identification of areas with high rates of sediment accumulation and those of sediment remobilization;

- beach and cliff erosion and the fate of eroded material;

- accumulation of beach material and its sources.

- identification of offshore processes affecting resuspension of sediments and associated contaminants.

5 Contamination

- the distribution of hazardous (*i.e.* classified) contaminants and other hazardous chemicals in water, sediments, and biota;

- flux inventories of nutrients and hazardous substances (heavy metals and natural and synthetic organic substances) entering the regional area from the land, the atmosphere, maritime activities, and adjacent offshore areas;

- toxicity, persistence and bioaccumulation of priority substances;

- exposures and responses of indigenous organisms;
- the incidence, distribution and origin of litter on beaches, floating materials and other marine debris.

6 Marine Life (Biology)

- the occurrence and distribution of flora and fauna including species distributions, assemblages and habitat dependencies;

- classification of coastal, littoral and sub-littoral habitats and community structures (*i.e.* biotopes) that enable identification of dominant or key species;

- identification of species and assemblages which, by virtue of their abundance, biomass, seasonality or location are likely to play a major role in energy transfer, and cycles of production or decay;

- the elucidation of population dynamics and behaviour of species and the structures of communities;

- the identification of trends or abnormalities and the factors and risks involved;

- determination of the extent, significance and causes of temporal changes in habitats of ecologically and/or commercially important species and biological communities.

7 Bio-processes

- processes that regulate and sustain the productivity and diversity of ecosystems;

- development of systems for simulating and predicting variations in these processes over time.

ANNEX 2:

Guide to quality assurance (QA) procedures for marine environmental data

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Checking the Quality of Existing Data

Adequate time must be allowed for the compilation and validation of data prior to data assessment. It is incumbent upon laboratories contributing data to an assessment that they are able to demonstrate that they have submitted valid data by the inclusion of convincing quality assurance and quality control information. This information should demonstrate that:

1 samples have been properly collected and analysed using appropriate analytical procedures;

2 analytical procedures have been routinely checked to ensure that measurements are within acceptable limits of accuracy and precision;

3 analytical capability has been confirmed through an independent mechanism or by a competent organisation.

Quality Assurance in the Design and Conduct of New Scientific Studies

Quality assurance of scientific activities that are commissioned as a result of the recommendations for action should take account of the objectives of the study and include an agreed quality assurance approach comprising:

1 the conduct of appropriate intercomparison activities both prior to and during the period of the scientific programme;

2 the use of appropriate reference materials;

3 procedures for assessing the ability of laboratories to produce reliable and comparable data prior to their participation in the scientific programme; and

4 criteria (*e.g.* accuracy and precision) to be applied in the assessment of resulting data.

Where several laboratories are involved, the establishment of procedures for the periodic review of progress and compliance with quality assurance requirements is strongly recommended.

Although the above guidance is provided in relation to chemical measurements, it provides a basis for developing quality assurance requirements for all types of scientific study.

ANNEX 3:

Primary considerations in the design of marine monitoring programmes

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Foreword

Recent reviews of marine environmental monitoring have shown that deficiencies in the planning and design of monitoring programmes have resulted in data of questionable relevance and reliability. Although the precise extent of the problem is difficult to assess, there is no doubt that without careful attention to design parameters monitoring may not fulfil expectations and may be wasteful of scientific resources. Projects that focus on indicators of environmental *quality* may be particularly vulnerable in this regard. Such projects are an important component of regional assessments.

Certain critical factors in the design of monitoring programmes have been elucidated. Because they are of fundamental relevance to reviews of existing programmes and future requirements they are discussed briefly below.

Objectives

It is not uncommon for studies to be initiated before the objectives have been fully and clearly specified. This is by far the most important factor limiting the effectiveness of monitoring. Objectives dictate what should be monitored, how, when and where *i.e.* they determine the **design** of the programme. Of equal importance, they are the main criterion for interpreting the results of monitoring. Thus, objectives need to be drafted with great care and clarity, ideally in the form of specific questions or hypotheses, and in the knowledge that available methodologies are adequate for the purpose.

Natural variability

Scientific measurements are often based on samples that represent relatively small intervals in space and time. Thus, to identify patterns and trends, it has to be assumed that measurements represent larger areas, volumes and time periods than is actually the case. But the constituents of the sea are not uniformly distributed and the patterns are constantly changing. Without some prior knowledge of this natural variability for the locality concerned, small, but perhaps environmentally important **signals** may be indistinguishable from the background **noise**. Understanding variability is therefore a pre-requisite to monitoring.

Trends

Closely linked with the problem of natural variability is the problem of how to determine environmental trends related to human activities – for example, trends in contaminant concentrations. Many contaminants concentrate in sediments and biological tissues, therefore sampling tends to be directed at these materials. But due to natural variability coupled to variability in contaminant distribution, it may be many years before a trend in concentration is discernible, if at all. Most sediments will be subject to movement and/or mixing, and populations of organisms sampled will undergo changes in abundance, age structure and size structure. Thus, where the characteristics (*i.e.* the medium) of successive samples differ, contaminant data will not be comparable unless they are subject to some form of normalization. Only where comparability can be assured does trend monitoring warrant the investments involved.

Data quality

The need for both in-house and external reference samples, and for periodic external assessment, is now accepted as a routine part of marine sample analysis. Analytical experience indicates that, at very low concentrations, some substances are far more difficult to quantify in certain marine media (*i.e.* water, sediment, tissue) than in others. The keynote here is that no laboratory should undertake routine measurements of any substance in any material for which it has not demonstrated an acceptable degree of accuracy and precision. Unless this principle is adhered to, the reliability, comparability and reproducibility of

data cannot be assured. A number of organizations and co-operative schemes have been established to assist laboratories in various aspects of data quality assurance (QA).

Links between research and monitoring

The above points indicate that not all environmental conditions of interest or concern are necessarily amenable to monitoring, and that because monitoring implicitly involves the use of repeated measurements, it must be demonstrated in advance that the techniques applied are suitable for routine use. Research is needed not only to develop methods, but also to test and validate methods before they are accepted for use in monitoring. In cases where information is required on an environmental variable not previously subject to monitoring, a pilot research project to test potential sampling and analytical techniques is a sensible precursor.

GESAMP Reports and Studies Publications

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

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

Rep. & Stud. No.	Title	Date
22	Review of Potentially Harmful Substances. Cadmium, Lead and Tin	1985
23	Interchange of Pollutants between the Atmosphere and the Oceans (second report)	1985
24	Thermal Discharges in the Marine Environment	1984
25	Report of the Fifteenth Session	1985
26	Atmospheric Transport of Contaminants into the Mediterranean Region	1985
27	Report of the Sixteenth Session	1986
28	Review of Potentially Harmful Substances. Arsenic, Mercury and Selenium	1986
29	Review of Potentially Harmful Substances. Organosilicon Compounds (Silanes and Siloxanes)	1986
30	Environmental Capacity: An Approach to Marine Pollution Prevention	1986
31	Report of the Seventeenth Session	1987
32	Land-Sea Boundary Flux of Contaminants: Contributions from Rivers	1987
33	Report of the Eighteenth Session	1988
34	Review of Potentially Harmful Substances. Nutrients	1990
35	The Evaluation of the Hazards of Harmful Substances Carried by Ships: Revision of GESAMP Reports and Studies No. 17	1990
36	Pollutant Modification of Atmospheric and Oceanic Processes and Climate: Some Aspects of the Problem	1989
37	Report of the Nineteenth Session	1989
38	Atmospheric Input of Trace Species to the World Ocean	1989
39	The State of the Marine Environment	1990
40	Long-Term Ecological Consequences of Low-Level Contamination of the Marine Environment	1989
41	Report of the Twentieth Session	1990

Rep. & Stud. No.	Title	Date
42	Review of Potentially Harmful Substances. Choosing Priority Organochlorines for Marine Hazard Assessment	1990
43	Coastal Modelling	1990
44	Report of the Twenty-first Session	1991
45	Global Strategies for Marine Environmental Protection	1991
	Addendum 1: Can there be a common framework for managing radioactive and non-radioactive substances to protect the marine environment?	1992
46	Carcinogens: Their Significance as Marine Pollutants	1991
47	Reducing Environmental Impacts of Coastal Aquaculture	1991
48	Global Change and the Air/Sea Exchange of Chemicals	1991
49	Report of the Twenty-second Session	1992
50	Impact of Oil and Related Chemicals and Wastes on the Marine Environment	1993
51	Report of the Twenty-third Session	1993
52	Anthropogenic Influences on Sediment Discharge to the Coastal Zone and Environmental Consequences	1994
53	Report of the Twenty-fourth Session	1994
54	Guidelines for Marine Environmental Assessments	1994