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Joint Group of Experts on the Scientific Aspects
of Marine Pollution (GESAMP)

# Global Strategies for Marine Environmental Protection

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# NOTES

1 GESAMP is an advisory body consisting of specialized experts nominated by the Sponsoring Agencies (IMO, FAO, UNESCO, WMO, WHO, IAEA, UN, UNEP). Its principal task is to provide scientific advice on marine pollution problems to the Sponsoring Agencies and to the Intergovernmental Oceanographic Commission (IOC).

2 This report is available in English from any of the Sponsoring Agencies.

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Definition of marine pollution by GESAMP:

**Pollution means the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and reduction of amenities.**

# Contents

# Foreword

This publication is a result of the GESAMP Working Group on "A Comprehensive Framework for the Assessment and Regulation of Waste Disposal in the Marine Environment" which was established by GESAMP following a proposal by the Consultative Meeting of Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the London Dumping Convention).

The Consultative Meeting requested GESAMP to examine regulatory approaches to, and environmental assessments of, the disposal of wastes in the marine environment and to identify opportunities for developing a common, comprehensive and holistic approach for the regulation of dumping at sea.

The Working Group is jointly sponsored by the International Maritime Organization (IMO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Atomic Energy Agency (IAEA), the United Nations (UN) and the United Nations Environment Programme (UNEP).

The Working Group met twice at IMO Headquarters, London, to prepare this report. The meetings were attended by Mr. R.G. Boelens (Chairman), Mr. J.M. Bewers, Mr. R. Ferm, Mr. H. Levenson, Mr. R. Lloyd, Mr. J.E. Portmann, Mr. P. Tortell and Mr. P.G. Wells. From the Sponsoring Agencies Mr. M. Nauke (IMO), Mr. D. Calmet (IAEA), Ms. G. Matthews (UN) and Mr. S. Keckes (UNEP) attended sessions of the Working Group. The Secretariat was provided by IMO.

This report was adopted by GESAMP at its twenty-first session (London, 18–22 February 1991) for publication in the GESAMP Reports and Studies series.

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# 1 Introduction

## 1.1 Background

It is now more than 30 years since the international community recognized the need for co-operative action in preventing marine pollution. Today, there are almost 50 agreements (including conventions and protocols) that are of regional or global scope ranging in focus from the control of specific contaminants, such as oil and radionuclides, to more broadly-based agreements on regional co-operation (e.g. conventions concluded under the Regional Seas Programme of UNEP).

The effectiveness of international initiatives to protect the seas from damage by human activities depends on a number of factors. These include geographical coverage and membership as well as the particular practices and emissions subject to control. Although good progress has been made, much work remains to be done in extending the scope and application of agreements to achieve more comprehensive control of environmental pollution worldwide.

Human activities cannot be managed successfully if they are dealt with individually or in isolation. Thus, legal instruments for protection of the environment need to take account of interactions, both between different practices and environments and between the various mechanisms developed for regulatory and protection purposes. This requires a process of planning and review that is not easily achieved in the international arena. Inter-relationships between the marine and other environments are of particular relevance to the control of pollution by wastes and substances. Where substances originate on land, their subsequent environmental distributions are strongly influenced both by human intervention and natural processes. Without appropriate management, any substance has the potential to cause unwanted effects in any sector of the environment. For these reasons, the operational elements of international agreements on marine pollution by wastes and other materials need to be implemented as part of integrated control procedures that are formulated and applied at national level.

## 1.2 Purpose of the study

This report responds to requests from the sponsoring agencies of GESAMP for an analysis of control strategies that deal with the assessment and management of waste disposal in the marine environment. The current heightened awareness of the oceans as a communal resource and as a vital link in the global energy cycle has increased international commitment towards strengthening and extending the protection afforded by international agreements. There is therefore a need to review the strategic approaches of these agreements in the light of experience and to identify any deficiencies.

There have been many recent advances in scientific knowledge concerning the properties and effects of marine contaminants and improvements in techniques for hazard assessment and monitoring. While the degree of scientific progress is encouraging, wider availability of environmental information has led to divergences in opinion regarding approaches to environmental management and greater emphasis is now placed on the uncertainties associated with scientific prediction. This matter needs to be addressed because rational approaches to the regulation of marine pollution are heavily dependent on scientific input.

## 1.3 Role of GESAMP

GESAMP, in accordance with its principal task of providing scientific advice on marine pollution problems to its sponsoring agencies, promotes the application of science in marine pollution control programmes. The advice presented by GESAMP reflects the latest advances in marine science relevant to protection and management of marine and coastal areas. There is good reason to believe that better use of scientific information will lead to greater success in the field of marine environmental protection.

## 1.4 Scope of report

GESAMP has approached the present task on the basis that the elements of pollution control strategies should be derived from a careful analysis of the underlying principles of environmental protection. This approach also provides a background against which the adequacy and practicality of existing strategies, and their scientific and technical components, might be assessed. The report is structured accordingly. GESAMP believes that the report is of relevance to policy-makers, legislators and managers with responsibilities for environmental matters as well as to informed members of the public and hopes that the advice provided will serve to make national and international measures for environmental protection more effective.

# 2 Environmental protection and management: principles and policies

## 2.1 Background

By developing and using technology, man has the ability to make far greater changes to the environment than any other species. However, man's need to control and stabilize parts of the environment in order to survive and develop must lead to inadvertent changes occurring elsewhere. Man's activities will add to the environmental changes caused by physical factors and by other species. Thus, although changes as a result of man's activities are unavoidable, in practice they must be regulated to prevent undesirable impacts.

## 2.2 Principles

The report of the United Nations Conference on the Human Environment, Stockholm, 1972, adopted 26 General Principles of environmental protection. These include:

- development in a manner that avoids prejudicing environmental amenities for future generations;
- avoidance of serious/irreversible damage to the environment;
- avoidance of measures that transfer damage from marine to other environments;
- concerted international action for environmental protection and preservation.

The role of science and technology was defined as follows:

> Science and technology, as part of their contribution to economic and social development, must be applied to the identification, avoidance and control of environmental risks and the solution of environmental problems and for the common good of mankind.

The need to control sources of contaminants to prevent environmental degradation is reflected in Principle 6:

> The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems.

The Conference endorsed a set of "Principles for assessment and control of marine pollution" (Annex III of the Stockholm Conference report) and forwarded them to the Law of the Sea Conference, then scheduled to convene in 1973. These principles were translated into General Obligations set forth in the Law of the Sea Convention, Part XII. The General Principles of Stockholm and the Law of the Sea Obligations must thus be seen as a coherent package. They recognize that States have the right to develop their own resources but they also emphasize the obligation of States to protect and preserve the marine environment.

An equally important principle is the requirement to plan and manage activities within a broader, holistic, perspective that considers all environments, viz. "States shall act so as not to transfer, directly or indirectly, damage or hazards from one area to another or transform one type of pollution into another" (Law of the Sea, Article 195).

One principle (Principle 7) deals specifically with the marine environment.

> States shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

The term "liable to create" implies a greater emphasis on prediction and prevention than the term "resulting in" used in the GESAMP definition of pollution. However, in applying its definition, GESAMP recognizes that scientific predictions can never be wholly accurate and that there is always some degree of uncertainty which requires the inclusion of an appropriate safety margin in the formulation of management action.

Balancing the benefits arising from economic and social development against the cost incurred as a result of inadvertent environmental effects is of primary importance. Used in the human health protection field this is known as "justification". The principle states that no practice should be adopted unless there are clear net benefits to society. Thus application of this principle requires that a prior assessment of both the benefits and the adverse consequences of investment in a new practice be carried out to ensure there will be a net social benefit. Ideally, a practice would constitute a proposed major development, such as investment in pesticides for agricultural purposes. However, the principle can be applied at lower hierarchical levels where it becomes similar to, although more comprehensive than, the process of environmental impact assessment which is an integral part of environmental protection and management.

The application of these principles must be flexible because States differ in their social, political and economic structures, and in the extent to which their coastal waters are vulnerable to environmental damage. Although they are clearly relevant to regulating the impact of substances introduced into the marine environment, the principles are equally applicable to the regulation of other human impacts such as coastal development, over-fishing, loss of wetlands, etc. These forms of impact need to be given equal consideration in protecting and managing the marine environment.

## 2.3 Policies

There are various policy statements reflecting differing approaches to marine environmental protection; however, analysis of these statements is complicated by ambiguity of terminology or lack of precise meaning. This is particularly apparent in the terms "precautionary principle" and "best available technology" and also in the use of certain technical terms such as "toxic", "hazardous" and "persistent". GESAMP has drawn particular attention to such difficulties in various parts of this document. It is therefore imperative to improve clarity of expression and care in use of terms, both scientific and political, in the environmental protection field. International action to clarify and agree the meaning of important terms is urgently needed.

### *2.3.1 Environmental capacity*

This concept was first expressed in Principle 6 of the Stockholm Conference report (quoted above) and later amplified by GESAMP. It is based on discrimination between "contamination", meaning increased presence of substances in the environment as a result of human activities but with no significant adverse effects, and "pollution", signifying the occurrence of adverse effects. The distinction between the terms is important since it implies that environmental change resulting from human activities may, or may not, be judged to have adverse effects. The boundary between these two regimes requires a definition of "acceptability". Irrespective of where this boundary is drawn, the concept of acceptable change remains valid. In practice, all prior approvals for the introduction of material to the ocean, made on the basis that adverse effects are limited, reflect an acceptance of the assimilative capacity concept.

### 2.3.2 *Sustainable development*

The policy concept of sustainable development was reflected in the 1972 Stockholm Conference report (Principle 13) but was later developed and given particular emphasis in the report of the World Commission on Environment and Development, viz. social and economic development should "meet the needs of the present without compromising the ability of future generations to meet their own needs".

Sustainable growth would allow for social and economic development while protecting the long-term viability of renewable resources, e.g. by preventing their over-exploitation or destruction. Indeed, the concept of sustainable development reflects the aspiration that the total value of renewable resources should be passed on, intact or enhanced, to succeeding generations.

### 2.3.3 *Best available technology (BAT)*

This is a policy of restricting the dissemination of substances to the environment and reducing impacts on the environment through source reduction using the most refined and effective technology currently available. It plays a predominant role in current applications of the precautionary principle. There are numerous variants of BAT, usually involving different criteria for the term "available" and taking account of economic factors. BAT alone cannot be used for rational environmental management because it takes no account of either other sources or the level of environmental protection required.

### 2.3.4 *The* Vorsorgeprinzip, *or anticipatory environmental protection*

The most authoritative statement of this policy principle is in the "Guidelines on Anticipatory Environmental Protection" approved by the Government of the Federal Republic of Germany (FRG 1986). The FRG guidelines were developed in response to a request by the Bundestag for the Government to submit "the overall concept of a gradual and drastic reduction of emission levels of all substances introduced by man into the atmosphere, water or soil which disturb or destroy nature's ability to regenerate on a permanent basis". This policy document is a considered and logical statement that sets out principles and mechanisms for environmental protection to be adopted in Germany. The following passage illustrates the intent of the *Vorsorgeprinzip*:

> Environmental protection initially entails averting danger. The State must intervene with protective measures if it is possible to recognize that the input of substances is capable of threatening man and the environment. The State must also act if impairment of the natural balance, threat to natural resources or damage to material property is imminent. Protection from environmental burdens of this nature has always been an indispensable constituent of environmental policy. However, not every input of substances poses a threat. The assumption of a risk situation is dependent on the nature and scope of any possible damage as well as on the probability of its occurrence. Active measures will be taken if general experience or scientific findings indicate with sufficient probability that damage will be caused; any remote possibility that damage will be caused is not sufficient.

> Furthermore, not every imminent pollution of air, water or soil and not every impending material threat to plants and animals can be categorized as a risk. Only "considerable" burdens are of significance in assuming the existence of a risk. Consequently, measures must be taken based on the principle of averting dangers to prevent their occurrence as far as humanly possible.

The *Vorsorgeprinzip* is entirely consistent with the application of pessimism and conservatism in scientific evaluations. The intent is also compatible with the guidance and conclusions of the World Commission on Environment and Development. However, it really constitutes only an expression of the normal caution that is applied in ensuring that environmental management is based on adequately cautious assessments of risk and reasonable degrees of scientific conservatism.

### *2.3.5 The precautionary principle*

It is not clear whether the precautionary principle stems from the same roots as the *Vorsorgeprinzip,* but it is more widely referred to in international fora. Unfortunately, recently adopted expressions of the precautionary principle are not amenable to balanced scientific analysis. One of the most recent of these is the Ministerial Declaration from the Second International Conference on the North Sea held in London in November 1987, which states:

> Accepting that, in order to protect the North Sea from possible damaging effects of the most dangerous substances, a precautionary approach is necessary which may require action to control inputs of such substances even before a causal link has been established by absolutely clear scientific evidence.
>
> [The Governments] therefore agree to: accept the principle of safeguarding the marine ecosystem of the North Sea by reducing polluting emissions of substances that are persistent, toxic and liable to bio-accumulate at source by the use of the best available technology and other appopriate measures. This applies especially when there is reason to assume that certain damage or harmful effects on the living resources of the sea are likely to be caused by such substances, even where there is no scientific evidence to prove a causal link between emissions and effects ("the principle of precautionary action").

The Paris Commission, the Governing Council of the United Nations Environment Programme and the Nordic Council's International Conference on Pollution of the Seas all adopted statements of generally similar form during 1989. In many of these statements, there is a lack of clarity regarding what the precautionary principle (or "the principle of precautionary action" quoted specifically in the North Sea Conference and Paris Commission versions) means to those who have adopted it. Nevertheless, it is clear that the precautionary principle is frequently being interpreted as a requirement to proceed towards zero discharge for all materials excepting uncontaminated natural substances.

### *2.3.6 The best practicable environmental option (BPEO)*

This concept originated in the Third Report of the UK Royal Commission on Environmental Pollution. BPEO has been defined as "the optimal allocation of the waste spatially; the use of different sectors of the environment to minimize damage overall". It reflects the objective of minimizing damage to the environment as a whole. A *sequitur* to its employment is that all options for the disposal or destruction of waste need to be considered in assessing which option offers the least damage to the environment and human health.

These policy instruments merely represent a selection of those most commonly used for marine pollution prevention. None of them are comprehensive in the sense that they can be used individually to cover all facets of pollution prevention and waste management. It is clear that a single instrument, such as the precautionary principle, cannot deal adequately with the complexities of environmental management and human development. A balanced environmental policy requires a careful selection from all of these instruments to construct an integrated and comprehensive system.

## 2.4 Conclusions

The following principles, which are derived from the 1972 Stockholm Conference on the Human Environment, the Law of the Sea Convention, and the World Commission on Environment and Development, provide a rational basis for protection and management of the marine environment:

.1 **Sustainable development:** Social and economic development must be pursued in a manner that does not prejudice options available to future generations for the use of the sea and its amenities.

.2 **Prevention of harm:** All practical steps shall be taken to prevent, and correct, the harmful effects of anthropogenic activities on human health, on living resources, marine life, marine amenities and other legitimate uses of the sea.

.3 **Holistic considerations:** Action shall be taken to ensure that measures taken to mitigate harm, or to reduce the risks of harm, to the marine environment do not result in the transfer, directly or indirectly, of damage or hazards to other sectors of the environment, viz. land, air or fresh water.

.4 **International co-operation:** Co-operation among States, including the harmonization of protection measures, mutual exchange of information, co-ordination of monitoring and the provision of technical and financial assistance, is essential for achieving regional and global objectives for the preservation and protection of the marine environment.

Although the preservation of ecosystems is possibly the most important objective of environmental protection, the above principles nevertheless acknowledge the legitimacy, as well as the inevitability, of human interaction with ecosystems. They therefore form a suitable basis to define an overall goal for protection and management of the marine environment. Such a goal should be common to all jurisdictions and should constitute a unifying force in the design of marine environmental protection strategies. GESAMP suggests that this overall goal could be stated as follows:

**To protect the marine environment against the adverse effects of human activities so as to conserve marine ecosystems and to safeguard human health while providing for rational use of living and non-living resources.**

# 3 A strategic basis for controlling pollution by substances and wastes

In formulating solutions to environmental problems, statements of objective will greatly facilitate the development of appropriate strategies and subsequent evaluation of their performance. In the context of protecting the marine environment against substances and wastes, the objective needs to reflect the principles and policies appropriate to this field (section 2) and should give a clear indication of the measures best suited to achieving the objective and to evaluating progress.

The absence of clearly stated objectives may have contributed to the present unease regarding conventional approaches to waste management and marine pollution control. For example, there is a common perception that control measures for the prevention and control of marine pollution, including international agreements, have not been effective in preventing continued deterioration of the marine environment. However, not all sources of pollution are presently covered by formal agreements. Furthermore, the effectiveness of the controls imposed will depend to a considerable extent on the way in which the existing instruments are interpreted and, in this respect, some uncertainty is bound to arise from the rather general declarations of commitment which typify the articles and preambular texts of international agreements. In most cases, the primary purpose of regulating the specified practice is given as "the prevention and control of marine pollution". Such declarations do not adequately fulfill the requirement for a statement of objective, and they provide little guidance on the strategies to be employed or the criteria for judging success.

Dissatisfaction with the rate of progress in combating marine pollution is evident from statements issued by a number of international bodies over the past decade. The need to strengthen legal instruments and to intensify efforts to reduce and reverse degradation of the seas has been identified *inter alia* by the Declaration of the International Conference on the Protection of the North Sea (Bremen Conference, 1984) and further developed in subsequent declarations of North Sea Ministers (London Conference, 1987; The Hague Conference, 1990) and by the World Commission on Environment and Development. It is also implicit in a growing number of statements calling for a more precautionary approach to controlling discharges to the marine environment such as that by the Governing Council of the United Nations Environment Programme (UNEP 15th session, 1989).

One of the messages that emerges from reports and discussions of international bodies is that emissions of wastes and other substances should not be condoned unless the full environmental implications of these emissions are known. In some fora, such as the London Dumping Convention, which provides a legal regime for the global control of waste disposal at sea, this has led to a new, but so far informal, objective that substantially reduces dependence on case-by-case evaluations as the basis for regulating certain waste disposal practices. Within the London Dumping Convention, this has effectively ruled out the disposal at sea of low-level radioactive wastes, as well as a majority of industrial wastes and marine incineration.

This lack of confidence in the regulatory process stems in part from the different approaches, and varying degrees of restriction, applied by national authorities when implementing international requirements; this is another indication of the difficulties associated with interpretation of legal texts. It also reflects a widely held view that pollution control measures based on estimates of environmental capacity can lead to a rather permissive approach to waste disposal with consequent increases in contamination and risks of pollution. The preferred and frequently advocated alternative is to place increased emphasis on the reduction and containment of substances at source, to encourage the development and use of low-waste technologies and to discourage the authorization of emissions when these are based on uncertain estimates of effects within the receiving environment.

While GESAMP unequivocally supports the active pursuit of cleaner technologies, and endorses the concept that reduced contamination will contribute to better protection of the marine environment, it rejects the proposition that better waste management and stricter application of source controls will obviate the need for regulatory mechanisms that involve responsible use of scientifically based predictions. **However clean the technology, it is inevitable that some waste will continue to be produced. Accordingly, it is essential that informed decisions be made in selecting environmentally preferable means of disposal. Objectives for marine pollution control should recognize the need for, and encourage the development of, improved predictive capabilities.**

A characteristic of the recent trend towards stricter marine pollution control measures is reduced dependency on definitions of the term "pollution" as the basis for regulating the inputs of substances and wastes. Tomczak (1984), Hakapää (1981) and others have noted the differences between the GESAMP (1969) definition, in which pollution is contingent on the occurrence of "deleterious effects", on the one hand, and the slightly modified version of the GESAMP definition contained in the United Nations Law of the Sea (1983) and some international agreements, on the other, in which pollution may be inferred where experience indicates a certain probability of environmental damage. Neither version would appear to satisfy the desire for a working definition that recognizes the uncertainty of predictions and implicitly promotes an overall reduction in the kinds and amounts of material transported to the oceans as a result of human activity.

The possibilities for environmental change arising from human activity are almost limitless, but in practice most physical alterations of the environment are evaluated, accepted or rejected entirely on social or economic grounds. The scientific contribution is to advise society of consequences that may not be directly apparent, especially those which may influence human health or the long-term viability of renewable resources and ecosystems. It is to fulfill this function that scientists see a need to distinguish between chemical changes that do not have widespread or irreversible effects on natural systems (i.e. contamination) and those which are observed or predicted to do so. This is the basis for all definitions of pollution.

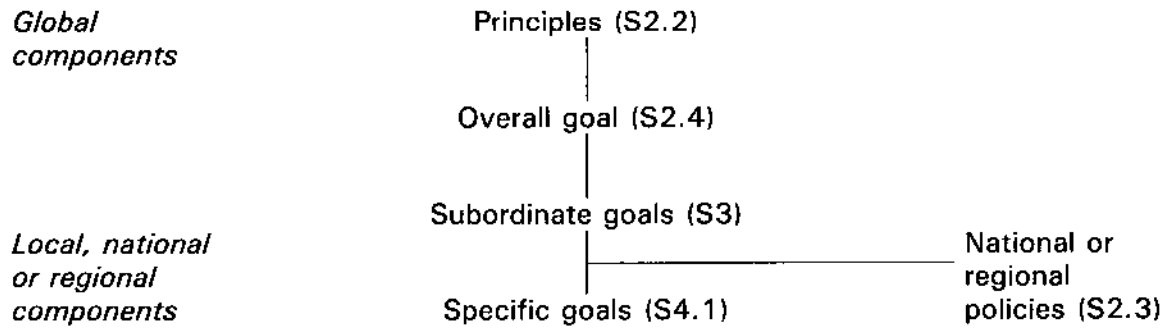
GESAMP does not believe that, for purposes of environmental protection, a definition of pollution can or should replace clear and carefully constructed statements of objective. Pollution, however, as it is defined for scientific purposes, is an unacceptable change to the environment and it is logical that the primary objective of pollution control should be one of prevention rather than simply of mitigation.

For these reasons, and taking account of the overall goal for marine environmental protection and management (section 2.4), GESAMP recommends the adoption of a subordinate goal specifically addressing the prevention of marine pollution by substances and wastes. This goal should stress the importance of management in reducing the overall extent of environmental contamination and might be expressed as follows:

> **To manage human activities and social development in a manner that will limit contamination of the marine environment by substances and wastes, and thereby to ensure that the viability of marine ecosystems and the legitimate uses of the sea are sustained for the benefit of present and future generations.**

In summary, it would seem logical that a comprehensive framework for marine environmental protection should be structured around a hierarchy of clearly stated goals. The higher level (i.e. the overall goal) reflects the fundamental objective of protecting the marine environment, its ecosystems, resources and amenities in the context of human development. Lower levels consist of subordinate goals dealing with particular human activities such as the production and emission of substances and wastes, land use (including coastal development) and exploitation of resources (e.g. fishing). Finally, for each activity a number of specific goals need to be defined for management purposes. These relationships are illustrated in Figure 1.

*Figure 1:* ***Components of a common approach to marine environmental protection***
*(S = relevant section of this report)*




The following two sections of the report build on the strategic framework presented above and identify the elements of environmental management that are essential for achieving the stipulated goals. Section 4 presents a comprehensive management framework and explains the regulatory elements of the framework, while section 5 describes key scientific inputs to the management process. Taken together, these sections cover the components of national programmes and international agreements that are needed to construct and implement effective strategies to protect marine and other environments.

# 4 Managerial elements of strategy

## 4.1 Management planning process

A comprehensive management framework for protection of marine and other environments is shown in Figure 2. The components of this framework are discussed in the following paragraphs.

The development of an effective strategy starts with the adoption of an overall goal as discussed above (Level 1) and a set of specific aims or goals (Level 2).

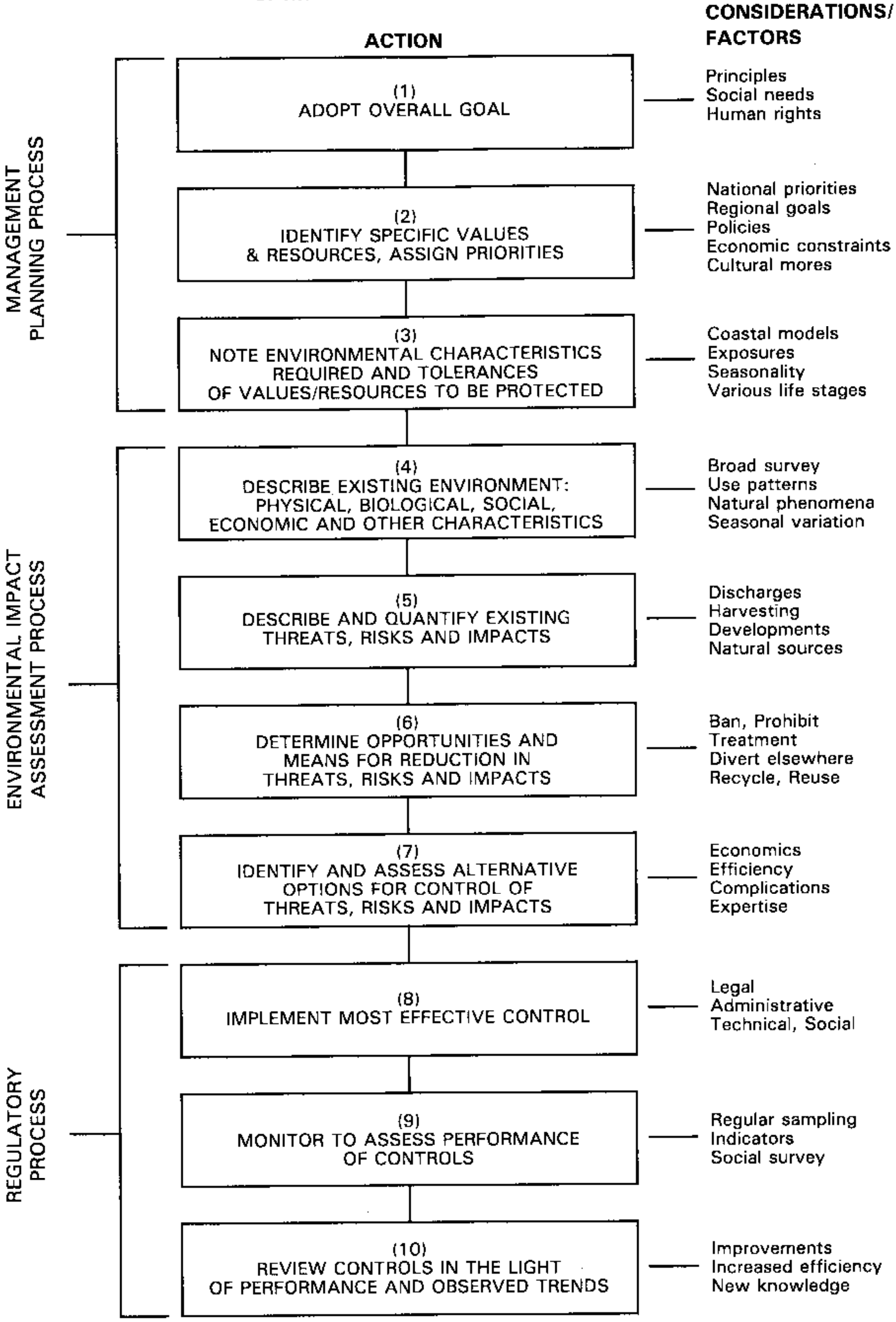
Specific goals are a selection of benefits or desired conditions that are to be preserved in specific marine environments. These goals are influenced by national or regional aspirations, existing political commitments and obligations, and the characteristics of the area in question. In the formulation of specific goals, conflicts will frequently arise and these must be resolved by means of a suitable consultative process before proceeding further. Examples of specific goals could include:

- the areas of specific types of habitat such as estuaries, wetlands, coral reefs and fish spawning grounds that need to be conserved to ensure the sustainability of resources and ecosystems;
- the minimum proportion of coastlines that should be designated for beach recreation and swimming and the required characteristics of beaches and seawater used for these purposes;
- the maximum sustainable yields from exploited populations of marine species and the criteria by which these should be determined; and
- the levels of man-made contaminants in edible species below which the risks to human health would be deemed insignificant (the basis for this determination should be stated. It will vary with fish consumption).

The next task is to determine the environmental characteristics (Level 3) that sustain the specified values and resources, and the extent to which these can be changed without causing harm. These limiting values are normally expressed as environmental quality criteria that can be used to formulate standards. For example, standards can be set for the minimum allowable dissolved oxygen level, maximum coliform levels, the acceptable range of water clarity, etc.

Environmental-quality criteria have been difficult to develop in some instances because of difficulties in comparing hazards and risks from multiple substances, sources and exposure pathways. For this reason, environmental-quality criteria should normally be used in conjunction with emission controls. These should by implication be set so as to ensure that the desired environmental quality is maintained, preferably with a large and calculated safety margin. In practice it is not always possible to assess what will be a safe level of input and emission controls may then be set simply on the basis of best production and treatment technologies for a particular operation; there are numerous variants, such as best available technology (BAT). This type of approach also plays an obvious role in applications of the precautionary principle, wherein regulatory decisions are based on what is technically possible rather than on the basis of scientifically derived assessments. The driving force for such uniform emission standards is often to harmonize waste treatment costs throughout an industry. Generally, the same emission standard is applied regardless of the size of plant

*Figure 2:* ***Comprehensive management framework for protection of marine and other environments***



and the condition and size of the receiving system. It should be recognized that it is probable that in some cases the application of uniform emission standards will overprotect the environment and in others they may fail to offer the necessary degree of protection. It is essential, therefore, that where they are applied they do not circumvent an obligation to monitor the receiving environment.

### 4.2 Environmental impact assessment process

The next step is to assess the existing situation (Level 4) by surveying the appropriate physical, chemical, biological and sociological characteristics of the area. This will provide an indication of the existing level of contamination.

At Level 5 the existing and potential inputs to the environment are identified and quantified. Inputs which are already causing damage need to be assigned a priority rating for action. In addition to these inputs the inventory should include all the factors which have an impact on the goal including physical, chemical, biological, economic and social/behavioural factors.

If it appears that a specific goal cannot be achieved, because the area or resource concerned is in danger of being overloaded, development should cease and the manager must reassess the capacity for further use (Level 6). If, on the other hand, it appears that there is an adequate safety margin, the capacity for additional uses could either be utilized, or opportunity taken to reduce unnecessary inputs and thereby increase the safety margin and perhaps provide additional capacity for future use.

At Level 7 all the identified control options are compared to identify those that are most effective and efficient in meeting specific goals and priorities.

### 4.3 Regulatory process

Operational and corrective action is taken at Level 8; controls are applied to any or all of the activities identified at Level 5. Actions could range from limits on the chemical concentrations in discharge streams, to the banning of certain products or practices. They could also involve cost incentives or disincentives, fines, subsidies or other financial considerations. Improved control could also be effected through social pressures such as consumer education, recycling programmes, and company/industry sponsorship arrangements.

It is essential that the effectiveness of these controls should be measured. Level 9 establishes monitoring programmes with two aims — first, to ensure compliance with controls imposed on certain activities; and second, to regularly measure those variables that are being used to indicate that the goal is being achieved.

Finally, there needs to be a commitment to act if the monitoring programme indicates either that there is a lack of compliance with controls, or that they are ineffective, or a trend indicates that limiting criteria are in danger of being approached. Such action following monitoring (Level 10) completes the management loop.

### 4.4 The rational use of precaution

Strategies for the protection and management of the marine environment are, in effect, strategies for controlling human use of the marine environment. Among all such uses and activities, the GESAMP State of the Marine Environment report (GESAMP 1990a) identified coastal development and municipal waste disposal as the most threatening. The framework illustrated here shows the steps whereby these activities can be identified, assessed, controlled and monitored; that is, managed to reduce or eliminate their impact.

Some recent policy initiatives (e.g. "precautionary principle") have been adopted within international bodies that impose reductions in emissions (Level 8) without reference to other levels in this framework. In part, these initiatives stem from a lack of confidence in predictions of the impacts of numerous substances and activities, particularly on large temporal and spatial scales. This stimulates action to reduce as far as practicable the overall burden of human activities on the environment irrespective of the nature and severity of adverse effects. This is relatively easy where emissions can be reduced at little or no financial cost.

The reduction of inputs wherever possible has received very strong endorsement by many countries. Although this method of regulation will help to achieve the common goal of human health and environmental protection, it disregards the benefits derived from the use of rational scientific and management techniques and the overriding need for human development. In contrast, the proposed framework recognizes these benefits and needs and explicitly directs managers towards achieving the goal in a logical and holistic manner. Above all, it enables the financial resources available for environmental improvement to be concentrated on measures that ensure the most effective returns.

Application of the framework systematically identifies those practices, as well as substances, which require some level of control based on comparison with rigorously selected criteria for protecting human health and the marine environment. It should be appreciated that this is a framework for **managing the rational use of the marine environment; as such, the management processes it describes are continuous institutional functions rather than functions that are triggered by individual development proposals.**

In contrast, an institutionalized process that bypasses the scientific elements of the management process in favour of precaution must rely exclusively on waste reduction or prevention. However, such a process could still provide officially sanctioned guidelines which specify the conditions under which the scientific framework can or should be applied and also the technical and financial assistance necessary for appropriate scientific research, risk assessment and monitoring activities. A precautionary approach alone does not ensure that the environmental goals will be achieved or maintained; the removal of a specific input may be of minor consequence when compared with other factors which affect the resource.

The framework is capable of accommodating most, if not all, the commonly applied policies of marine environmental protection. In the case of developing countries, it encourages the development of indigenous management capabilities and can be adopted to the needs of social and economic progress.

## 4.5 Regulatory elements

### *4.5.1 Holistic approaches to marine environmental management*

Many national statutes and regulations and international treaties and conventions protect single environmental sectors (e.g. air, land, water) or address single waste management activities (e.g. ocean dumping).

Measures to protect the marine environment must include mechanisms for comparing benefits and costs of alternatives to using the sea for waste disposal. **However, where waste generation is unavoidable, it is important to accept in principle that use of marine environments for waste disposal is both rational and legitimate, even if these environments are increasingly controlled to avoid pollution.**

As noted by ICES (1989), "strategies for assessing and controlling human impact on the environment will not be effective if they permit the development of an unrestricted array of new practices, products, and waste materials". Waste management should instead be developed and conducted as part of a broad holistic approach — one that considers all environmental sectors and that minimizes the impact of anthropogenic activities on the environment as a whole. Programmes for waste reduction, and incentives to develop and use low-waste or "clean" technologies, must be a central and permanent feature of national strategies for environmental protection — a principle adopted by the 1972 UN Conference on the Human Environment and others. The success of managerial and regulatory elements in protecting marine and other environments from remaining substances and wastes will be contingent on these measures.

### *4.5.2 Institutional functions*

A holistic approach to marine environmental protection also requires institutional arrangements that systematically integrate managerial and regulatory elements for assessing and controlling waste production. Specifically, an institutional structure should have the ability to implement the management framework outlined in section 3.2 involving the following activities:

.1 establishing specific environmental goals;

.2 delineating allowable environmental conditions;

.3 comparing the ability of different options to meet these goals and conditions and to minimize overall environmental effects;

.4 establishing formal regulatory requirements for given activities; and

.5 conducting compliance assessment and environmental monitoring as part of an overall auditing procedure.

To accomplish this, governmental agencies responsible for environmental management must be vested with sufficient authority, funding, and trained personnel on a long-term, continuous basis. The achievement of environmental goals will not be facilitated by frequent changes in environmental planning or environmental policy.

Governments should require local administrations to include provisions for protecting specific coastal marine environments in local management plans. Such plans have a primary role in integrating the managerial and regulatory elements listed above and in providing general guidance on development policies within the watersheds and shorelines under local jurisdiction. In essence, they can approach planning on an ecosystem-wide basis to establish site-specific goals and identify the most environmentally and economically effective means of achieving those goals.

### *4.5.3 Applying environmental criteria*

Specific environmental goals (section 4.1) lay down the range of desired conditions that, in essence, codify the aims of a nation's environmental protection policy. At the level of an individual body of water, these goals represent a determination of what are considered the most valuable uses for that body of water. The environmental manager must determine the environmental conditions needed to meet the specific goals and provide the desired level of protection to humans, other organisms, amenities and resources. In some cases, this may require the development of scientific criteria that link the resources to be protected with data on the physical, chemical and biological conditions needed to ensure their viability. Where the specific goals have been defined in a sufficiently descriptive manner, the criteria for determining compliance may already be self-evident.

Marine environmental management entails the considered and selective application of control measures to meet specific objectives in a limited geographical and environmental context. It is implicit, therefore, that environmental quality criteria should be applied to designated areas of marine and coastal environments and strictly enforced at the boundaries of these areas. Where emissions are concerned, environmental criteria should always be used in conjunction with appropriate source controls such as technologically achievable emission standards and restrictions on load.

### *4.5.4 Comparison of management options*

Environmental impact assessments (EIAs), as currently practised, should identify the best overall means of meeting the enunciated goals. Comparative assessment requires an analysis of the relative advantages and disadvantages of realistically available alternatives; it does not mean that every conceivable alternative must be subject to detailed assessment. Comparative assessments are the operational expression of the "justification" principle (section 2.2) — i.e. that no practice should be adopted that does not offer net benefits to society.

While political factors may dictate that certain options should not be used, scientific and economic analyses allow decision-makers to understand the consequences of not permitting those options. In principle, economic analyses should include the entire range of environmental costs and benefits (e.g. effects on bio-diversity, aesthetics, recreation; and implementation costs). Defining this range and conducting meaningful analyses is often difficult. Data may be unavailable even if agreement can be reached in principle on the range of benefits and costs to address and on appropriate methodologies for valuing them; also, assigning costs is often controversial. Even first approximations of these costs would be an improvement over the typically prevailing situation. Where more refined analyses are feasible, they can provide a rational basis for considering the use of economic incentives as management tools (i.e. taxes or fees to make waste generators meet established goals).

In practice, comparative assessments have been carried out when information, expertise, time, and agreement on underlying assumptions have permitted them to be conducted properly. While such favourable circumstances cannot always be expected to exist, institutional structures which facilitate broad comparisons can help to ensure that scientific elements are incorporated as far as possible into the decision-making processes.

### *4.5.5 Classification of hazardous substances*

Various lists of priority pollutants have been constructed in order to focus the attention of regulatory authorities on those chemicals in greatest need of rigorous control. The scientific basis of such selection is sometimes obscure, and may depend more on the hazardous properties of the chemical than on the risk of environmental damage (section 4). Some schemes include factors such as production tonnage and type of use, but these are very crude indicators of environmental risk and carry considerable uncertainties.

However, once identified, substances or groups of substances on such lists are more liable to be regulated merely by emission standards. This is not a rational approach to product control; ideally, listed chemicals should be subjected to a scientific hazard assessment (Figure 2) in order to establish their potential for causing environmental harm.

### *4.5.6 Compliance assessment and environmental monitoring*

Two types of monitoring are required for purposes of marine environmental management — compliance and environmental. Monitoring for compliance assessment should verify that the regulatory conditions for a given activity are being met. It can include conducting inspections, reviewing reports submitted by permittees, verifying industry-reported data, and compiling data to assess compliance. Enforcement includes actions taken in response to an identified instance of non-compliance, establishing the appropriate response and escalating the response until compliance is achieved.

In contrast, environmental monitoring is needed to ensure that specific goals and criteria established for a given area are being met. It can verify that initial assumptions were correct and it can be designed to detect new hazards and unknown sources or pathways.

Many monitoring programmes unfortunately do not provide adequate information on the state of the environment or on the effects of anthropogenic activities. **Environmental managers must place greater emphasis on specifying goals and objectives, formulating testable hypotheses, encouraging better quality-control procedures and statistical designs, and conducting periodic scientific and administrative reviews (e.g. NRC, 1990).**

### *4.5.7 Further opportunities for environmental protection*

The achievement of sustainable development requires that use of materials, fates of products, and environmental implications of waste generation be considered an integral part of every human activity or practice, whether planned or in progress. Thus, environmental management should focus on how to use and dispose of materials and products throughout their lifespan — from the extraction of materials (e.g. from mines, forests, oilfields, waste streams) and their incorporation into manufacturing, to the nature and distribution of products and the management of wastes from each of these steps.

This focus affords important opportunities to innovate improved approaches to waste management practices on a global basis. Guidelines or codes of practice could be drawn up for specific activities giving current guidance on good technological and environmental practices for the activity concerned. Possible examples include guidelines on: industrial processes that generate hazardous wastes, design and disposal of consumer products that make up municipal solid waste (US Congress, 1989), and agricultural practices (e.g. fertilizer and pesticide application, manure storage) that lead to groundwater and surface water contamination. Environmental managers could tailor them to local conditions. In some cases, this might reduce the need for detailed comparative assessments of all options, so long as the guidelines are periodically reviewed and revised to reflect new information on the status of the environment.

Some guidelines of this sort have been developed by various OECD countries. They could be of great utility for developing countries, which are trying to simultaneously achieve the twin goals of sustainable economic growth and preservation of their natural-resource base. **To this end, greater attention could be given to establishing bilateral and multilateral advisory services for education and training and for the transfer of clean technologies into national development programmes.** These services should be linked to institutional frameworks that provide for comparative environmental assessments of all major developments.

# 5 Scientific elements of the strategy

### 5.1 Categories of scientific knowledge required to support marine environmental protection

This section outlines the key scientific issues and elements that can contribute to a comprehensive strategy for marine environmental protection. These fall into two related categories:

- the sources, transport, transformation, and fate of substances introduced to the marine environment;
- the effects of these substances on organisms, including man, and resources and amenities in the marine environment.

In the first category, the distribution of substances within the marine environment is related to their sources. This involves physical, chemical and biological science with major emphasis on physical and chemical oceanography. The second category involves the translation of the resulting exposures into their effects on animals, amenities, and man; the primary components are toxicology and biological effects. Both categories have an important role in predicting and evaluating environmental change.

The knowledge available in these areas determines the extent to which scientists can assess and predict the consequences of human activities involving the introduction of substances (intentionally or unintentionally) into the marine environment.

### 5.2 Limitations of science

All scientific studies, conclusions and predictions contain an element of uncertainty, either because it is a fundamental property of the science, or because of the limitations of accuracy and precision inherent in contemporary methodologies. Accordingly, the environmental manager must recognize that scientific uncertainty exists and that it must be allowed for in the management framework. In effect, assessments and predictions must be sufficiently pessimistic (i.e. "conservative" in scientific parlance) to allow for these uncertainties.

One of the commonly recognized uncertainties is the prediction of effects on natural populations using data from a limited number of laboratory experiments on a few species. This problem is similar in some respects to that encountered with carcinogens, in which data from laboratory animals exposed to high dose rates are used to calculate the risk to human health of exposure to much lower dose rates. This is not necessarily an insuperable problem and ecotoxicologists are increasingly confident that they can avoid underestimates, providing a certain minimum data set is available (OECD 1990).

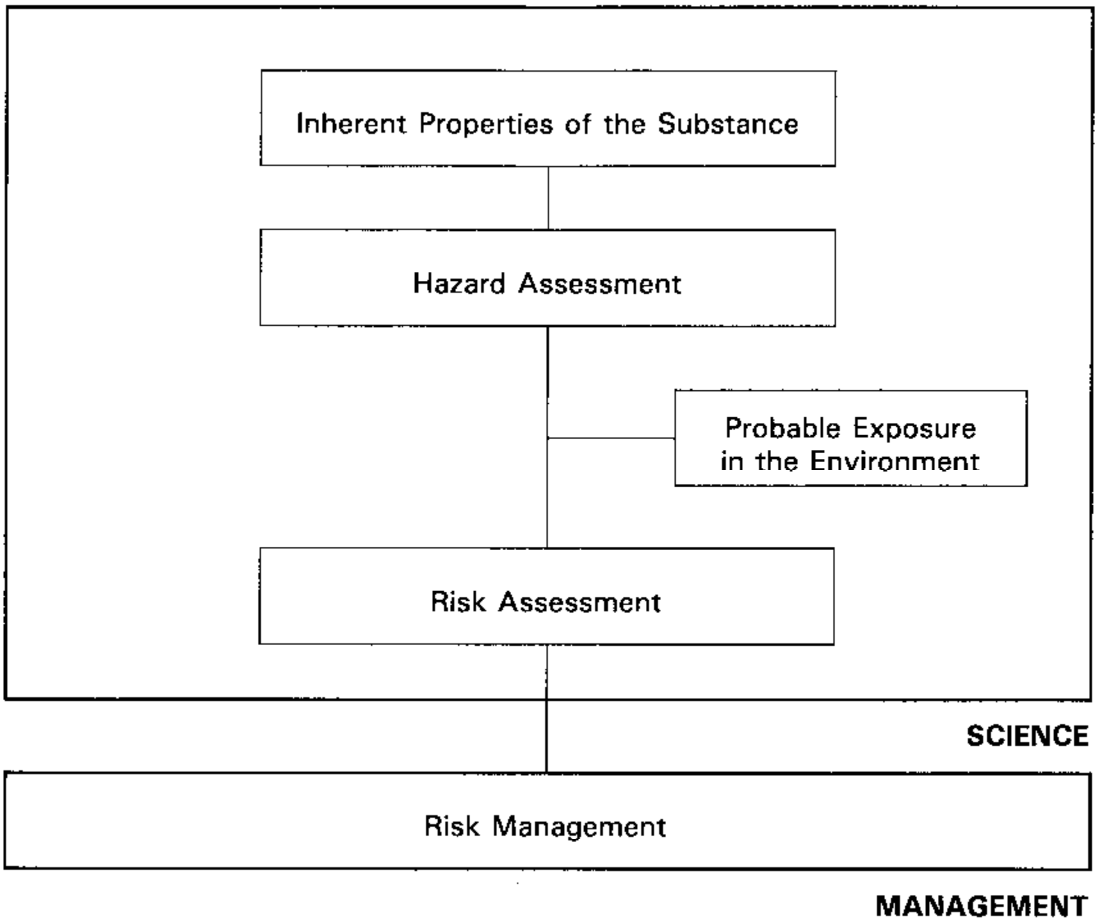
In all such cases, the uncertainties involved can be incorporated into suitably pessimistic assumptions about the nature of the dose–response relationship. A greater understanding of the sources of variability and of the underlying principles involved has reduced these uncertainties and therefore improved the accuracy of predictions and assumptions.

## 5.3 Progress in science

### *5.3.1 Impact prediction*

Hazard and risk assessment, and their application to risk management, are vital components of a marine environmental protection strategy, as shown in Figure 3. Hazard assessment identifies the potentially adverse effects of substances on the basis of their inherent properties. The risk of environmental damage to organisms depends on the probability of exposures to such substances. Validated information on the concentration–response relationship for many chemicals and a range of organisms can be readily obtained from a number of data banks. Considerable use is now made of models (see 5.3.5) to predict the environmental distribution and concentration of chemicals, based on data on production, use, discharge patterns, sources and loads, and information on their physico-chemical characteristics and partitioning between environmental compartments. Development of both these initiatives has improved the accuracy of impact prediction.

*Figure 3:* ***Relationship between hazard and risk assessment and risk management***




*Note:* There are no generally accepted definitions of the terms "hazard" and "risk assessment"; GESAMP has agreed that the usage in this document is the most appropriate.

### *5.3.2 Chemical fluxes in the environment*

During the last decade there have been considerable advances in many branches of science that contribute to the assessment and prediction of marine pollution. Physical and chemical oceanography, in particular, has advanced to the point that our understanding of ocean circulation and the transport and fate of many classes of contaminants is now adequate for predicting and assessing impacts within specified margins of uncertainty (GESAMP 1990b).

Significant improvements have been made in the ability to construct regional and global mass-balance models for chemical substances. These provide essential insight into the natural transport and cycling of substances. Mass balances are extremely useful tools for identifying weaknesses in existing data, indicating imbalances that may be due to anthropogenic activity, and ensuring that an overall assessment of the transport, residence times, and fate of substances "makes sense". Above all, they have vastly improved our understanding of particle–water interactions and the role that solid particles play in controlling the transport and distribution of chemicals in the marine environment.

### *5.3.3 Ecotoxicology*

Perhaps the most significant and relevant scientific advances have been made in ecotoxicology. A rapidly increasing body of information on concentration–response relationships has been assembled for a large number of chemicals and a wide range of species. The improved accuracy and precision of laboratory data, due to the use of standard techniques, the control of important variables, and the inclusion of reference toxicants, has enabled an analysis of the information to provide new insights into the underlying principles of ecotoxicology.

One of the criticisms directed at the validity of environmental criteria for aquatic life has been the uncertainty involved in extrapolating a limiting concentration applicable to many species from toxicity data obtained for a very few species. Some chemicals which have specific toxic actions have been developed as pesticides because some species are very sensitive to them. The species most sensitive to these substances are therefore known. For example, the antifouling compound TBT was developed as a molluscicide and it is not surprising that bivalves and gastropods are the most sensitive marine organisms to this pesticide. For non-pesticidal chemicals the range of species sensitivity can be much less, especially for a large number of organic chemicals which have a non-specific toxic action. This knowledge has substantially reduced uncertainty in predicting the propensity of different types of chemicals to affect marine communities. Research in this field has been reinforced by the use of controlled mesocosms in which the response of marine communities to added chemicals can be assessed and compared to results obtained from single-species laboratory tests.

A second problem is the rapidly increasing number of chemicals for which environmental criteria are required. This has been overcome to some extent by the development of quantitative structure–activity relationships (QSARs), by which the toxic potential of a chemical can be ascribed to its molecular structure and physico-chemical properties. Comparisons can be made with the properties of other similar chemicals whose toxicological behaviour has been widely investigated. GESAMP has used a QSAR approach to identify the 77 potentially most harmful substances from a list of 720 organochlorine compounds (GESAMP 1990c). The development of this science has improved understanding of the mechanisms of toxic action and reduced the number of tests required to accurately establish the toxic potential of new chemicals. Similar QSARs can also be used to measure other properties, such as the potential for biodegradation. In many cases, QSARs can be used to predict the harmful properties of chemicals with a sufficient accuracy for impact assessments; in other cases, supporting data on effects are required to reinforce the predictions.

Environmental quality criteria are set for individual chemicals and, by implication, in the absence of other harmful substances. Substantial progress has been made in the field of evaluating the combined action of chemical mixtures on aquatic life. It is now known that chemicals of identical toxic action (i.e. a common QSAR) have additive effects at all concentrations and this has to be taken into account when setting quality criteria for these substances. Chemicals of dissimilar toxic action may also be additive at concentrations close to those causing death but not at concentrations acceptable in the environment; quality criteria for these substances need not be modified when several are present together within the environment. Synergistic effects have rarely been found to exist at realistic environmental concentrations.

### *5.3.4 Monitoring*

Through various forms of monitoring, scientists can provide environmental managers with information on whether individual operators are complying with regulatory requirements and whether the condition of the marine environment is improving or deteriorating. These are essential elements of marine environmental protection.

*Chemical monitoring*

The design of any monitoring programme should be based on clearly defined objectives and the formulation of testable hypotheses. Since monitoring is costly, data should only be collected that (a) are required to satisfy the objectives, (b) are amenable to meaningful interpretation, and (c) have known precision and accuracy. Otherwise, technical and financial resources will be wasted and, in the case of compliance monitoring, the production of data of doubtful quality may limit their legal acceptance. When environmental chemical concentrations are close to the limits of analytical detection, there is the greatest uncertainty in the accuracy of the data obtained.

The marine scientific community has developed, and continues to improve, advice on quality assurance procedures for all aspects of monitoring. The increased availability of marine reference materials and opportunities for participation in intercomparison exercises (e.g. those conducted by ICES and IOC/GEMSI) offer significant benefits to laboratories wishing to develop and improve their monitoring capabilities.

*Biological monitoring*

Biological monitoring can provide a measurement of the direct effect of adverse water and sediment quality on marine organisms. The basis of such monitoring is measuring the extent to which a specific biological response deviates from a normal value. Measurement of effects at the individual whole animal level include reduced growth rates, susceptibility to disease, or mortality of sensitive life stages. Such effects can be caused by a wide range of chemicals. Measurements of community structure changes can be readily equated with harm, particularly if species of commercial, scientific or conservation value have been reduced in number.

At the cellular level there are reactions which are specific to certain groups of chemicals. Responses such as the induction of metallothionein by heavy metals and mixed-function oxygenases by organic compounds have the potential to be very sensitive and therefore act as "early warning" indicators. Ascribing the effect to a cause is simpler if the response diminishes away from a source. There is an understandable tendency to equate changes from normality at the cellular and sub-cellular level with a harmful effect on the organism. This is not a valid extrapolation from the data.

It is essential that biological monitoring should be integrated with chemical monitoring, so that the extent to which the measured effects can be ascribed to specific chemicals can be established. This is true also of the monitoring of those chemicals that can be accumulated in the tissues of organisms, particularly those harvested for human consumption. The main objective is to evaluate the concentrations found in the context of relevant acceptable daily intakes. But the data should also provide information on the potential harmfulness of such concentrations on the organisms themselves; at present, many concentration–effect relationships established for organisms are based on levels of chemicals in the ambient water and not on the amounts accumulated in the tissues.

### *5.3.5 Modelling*

Modelling has an important place in environmental protection and management. There are two major categories of models essential for these purposes. The first is the environmental model that represents the transport and distribution of a substance or the influence of a practice on the environment itself (GESAMP Reports and Studies No. 43). The second category includes models that represent the pathway by which critical target organisms, including man, are exposed to substances (e.g. through the food chain). These two types of models will often be coupled, or interfaced, to provide realistic projections of the effects of practices or substances on the environment.

Exposure-pathway models have been most thoroughly developed for radiation protection purposes, including assessments of the safety of radioactive waste disposal at sea. Comparable models should be developed for other types of exposure, especially chemical exposures, to organisms and man. Such models are usually relatively simple and use representations of extremely exposed individuals or groups of individuals (critical groups) to make reasonably conservative assessments of risks.

There is a common perception that modelling is always expensive and time-consuming and is of limited practical value to environmental managers operating at local level. This is by no means the case. Relatively simple models of single-source inputs, their pathways and exposure fields have been designed for general application in coastal environments. With basic information on local hydrographic conditions, models can provide managers with rapid predictions of environmental distributions at low cost.

# 6 International measures for the prevention of marine pollution: a review of strategic, regulatory and scientific components

GESAMP has examined a list of 16 international agreements, protocols and guidelines pertaining to the prevention and control of marine pollution to determine the extent to which they contain the elements of environmental management presented in this report. This review also provided an opportunity to assess the range of human activities covered by these instruments and their approximate geographical coverage. A list of international agreements, protocols and guidelines, together with a table showing their coverage, is given at annex.

Few of the conventions listed in the table relate to more than one type of practice. The practices indicated in the table are based strictly on the wording of the agreement or convention. It is accepted that, in a few cases, this has subsequently been interpreted to include other, perhaps closely related, practices. For example, the Oslo Convention now includes, by consensus, the disposal of offshore structures such as oil/gas exploitation platforms, even though this is not specifically mentioned in the Convention text. Similarly the Paris Convention, as amended, now considers atmospheric inputs to the sea, thus enabling future regulation. Such additional coverage was not envisaged at the negotiation stage and is not specifically referred to in the Convention text.

As anticipated, the review has shown that some elements, such as monitoring and pre-operational impact assessment, are prescribed, at least in general terms, in the majority of instruments but some important associated components, such as risk assessment (component of impact assessment), and the setting of specific objectives (component of monitoring *and* risk assessment) are not clearly identified as requirements within the articles or technical annexes of the instruments. However, it has to be acknowledged that the basic texts of international agreements are generally supplemented by decisions or regulations that contain additional elements of protection and management in the form of operational control measures for specific practices.

Of greater relevance, however, is the tendency for international instruments to express an "overall goal" in the form of a commitment to prevent marine pollution (generally defined as a harmful effect or propensity to cause a harmful effect) without clearly linking this goal to the basic principles of environmental protection. Thus, the occurrence or risk of pollution becomes the major criterion for regulatory action. This would be entirely reasonable if the definition of marine pollution were amenable to uniform interpretation; however, this is not the case at present, nor is it likely that an alternative definition would overcome this difficulty. Thus, by divorcing the principles of environmental protection from the stated overall goal, there is no obvious mandate to make decisions that achieve a balance between protection of the marine environment, the protection of other environmental sectors and the need for socio-economic development.

None of the conventions dealing with the release of harmful substances (from non-ship sources), and certainly with waste disposal (dumping), go very far beyond the general provision that measures to prevent or control marine pollution should avoid transferring or transforming pollution to other environmental sectors. While the Oslo and London Dumping conventions, for example, state that before a particular disposal practice is allowed, alternative disposal options, including methods of minimizing the waste, must be explored, little attention is given to the acceptability of the alternatives, either in overall cost benefit terms or even the consequences for other environmental sectors.

Socio-economic values can be assigned to most human practices. Providing there is general acceptance that a practice will lead to some environmental change, limits of acceptability can be set to control their extent (i.e. to prevent them becoming unacceptably harmful). These limits will differ according to the values assigned to the practice and to the reduced value of the resources or amenities affected. Few of the existing conventions or their supplementary rules and regulations actually set limits of acceptability in either descriptive or numerical terms. However, under the Paris Convention it has been agreed that discharge limits may be set either in terms of emission standards (for the effluent) or environmental-quality criteria (relating to the receiving environment); some have been agreed by all parties and are regarded as legally binding. Whilst it would be unrealistic for all conventions to be negotiated with limits of acceptability defined for all activities or substances involved, provisions calling for the development and use of such limits would, in most cases, obviate the need to prohibit a practice entirely. In the absence of limits, greater reliance needs to be placed on broadly based environmental impact assessments.

Many of these international instruments adopt a regulatory approach which relies heavily on the classification of harmful substances. In some cases particular types of compounds are listed, e.g. organohalogen compounds, while in others it may be according to particular characteristics of the substances, e.g. persistent plastics. In practice there can be difficulties in applying classification criteria that are related to toxicity, persistence and bioaccumulation (see section 4.5.5). These are unlikely to be resolved while conventions deal exclusively with the properties of substances without regard to other factors such as quantity, local ecological characteristics and dispersion patterns.

Most instruments also call for some sort of compliance assessment but this is only in the context of a broad undertaking, either to monitor the particular source, or to monitor the general quality of the environment. Rarely is this required in combination. The result is that pollution, i.e. unacceptable effects on a resource, may be detectable, but not attributable to a specific cause. Only if goals are precisely defined and the cause of impact identified will it be feasible to conduct meaningful and useful monitoring.

Collectively, existing instruments represent a considerable achievement. However, there are demonstrable problems in the level of their acceptance, implementation and enforcement. At the present time, there is a strong interest in making traditional treaty approaches more responsive to these problems and in introducing certain innovations, including more effective means of integrating science, technology, and economics with the decision-making processes involved and ensuring adaptation to scientific and technical progress. It is also widely acknowledged that many deficiencies in implementation and enforcement can be attributed to the inability of many developing countries to apply stringent rules and standards; international law should therefore take specific account of the different economic situations and development needs of such States. Such innovations as differentiated objectives and standards and different timetables for compliance are indicated (e.g. Montreal Protocol on the Ozone Layer).

Thus, it will be both desirable and opportune to introduce more-specific goals for international co-operation and to modify regulatory approaches and methodologies to render them more effective in terms of environmental protection and sustainable development. To this end, GESAMP believes that the strategic framework for marine environmental protection and management presented in this report, which contains elements that are essential to national programmes, should also be reflected in the structure and content of relevant international agreements.

# 7 Conclusions

An examination of existing international instruments for marine environmental protection reveals a somewhat piecemeal and uncoordinated system of control strategies. The thesis of this document is that **the parallel aims of further human development and environmental protection can only be satisfied through the adoption of an integrated and comprehensive management strategy, based on common principles, agreed goals, and scientific methods.**

## 7.1 Principles

The following principles, derived from the 1972 Stockholm Conference on the Human Environment, the Law of the Sea Convention and the World Commission on Environment and Development, should form the basis for comprehensive protection and management of the marine environment:

.1 **Sustainable development:** Social and economic development must be pursued in a manner that does not prejudice options available to future generations for the use of the sea and its amenities.

.2 **Prevention of harm:** All practical steps shall be taken to prevent, and correct, the harmful effects of anthropogenic activities on human health, on living resources, marine life, marine amenities and other legitimate uses of the sea.

.3 **Holistic considerations:** Measures taken to mitigate harm, or to reduce the risks of harm, to the marine environment must not result in the transfer, directly or indirectly, of damage or hazards to other sectors of the environment.

.4 **International co-operation:** Co-operation among States, including the harmonization of protection measures, mutual exchange of information, co-ordination of monitoring and the provision of technical and financial assistance, is essential for achieving regional and global objectives for the preservation and protection of the marine environment.

## 7.2 Goals

An appropriate overall goal for protection and management of the marine environment would be:

> **To protect the marine environment against the adverse effects of human activities so as to conserve marine ecosystems and to safeguard human health while providing for rational use of living and non-living resources.**

A number of subordinate goals can be formulated to deal with various types of physical, chemical and biological modifications to the marine environment by man. Accordingly, an appropriate goal for the prevention of pollution by substances and wastes introduced to the marine environment would be:

> **To manage human activities and social and economic development in a manner that limits contamination of the marine environment by substances and wastes, thereby ensuring that the viability of marine ecosystems and the legitimate uses of the sea are sustained for the benefit of present and future generations.**

## 7.3 Comprehensive and integrated (holistic) management

There is a need to manage all forms of human activity which potentially affect the marine environment, whether these occur at sea, in coastal areas, in the atmosphere, or in the hinterland of continents. This implies that the international community should aim for better integration of the design, as well as the implementation, of environmental protection measures. Accordingly:

> **Effective marine environmental protection requires the adoption of a global and holistic environmental protection strategy that deals with all sectors of the natural environment. This strategy should embody a common set of fundamental principles, goals and major policy elements.**

A central theme of comprehensive and integrated management, implicit in the strategy presented here, is that where there are legitimate choices with regard to the location or environmental medium to be used for necessary development or waste disposal purposes, all such options should be evaluated.

## 7.4 Essential elements of management and science

GESAMP concludes that inadequate use of basic environmental management procedures, and a tendency to manage environmental sectors and practices separately, are indirectly responsible for much of the continued degradation of the environment. These deficiencies outweigh any existing inadequacies in national and international instruments for marine environmental protection. Thus, GESAMP specifically draws attention to the management framework depicted in Figure 2. It should be appreciated that this framework and the management processes it describes are continuous institutional functions and not functions that are triggered only by individual development proposals.

It will be evident that a number of management and scientific requirements are built into this framework. Most important among these are:

.1 **Environmental planning:** There is a requirement for co-ordinated multi-sectoral planning of developments that have the potential to affect the marine environment. This should include the assignment of environmental goals and priorities, resource allocations, and the preparation of integrated management plans for all relevant environmental sectors.

.2 **Environmental impact assessments:** All proposed developments and large-scale investments that are likely to have direct or indirect effects on the marine environment must be subject to a prior assessment. This assessment should encompass physical, chemical and biological changes, risks to human health, amenities and resources and, particularly, the benefits and detriments of the proposal to the satisfaction of environmental and development goals. Where transboundary impacts are likely to occur, notification and opportunities for consultation should be provided to the affected States.

.3 **The need for precaution:** Precaution is integral to scientific risk assessment. A pessimistic approach is essential to allow for uncertainties in measurements and calculations incorporated into predictions. Science should be used to resolve and reduce these uncertainties by providing accurate information on the relationship between the practice and its effect on marine resources. In this way, science becomes a component of environmental management. A further, and entirely complementary, use of precaution is to take all practical and economically feasible measures to minimize environmental contamination through *inter alia* good housekeeping and the application of efficient and low-waste technologies. Such approaches are the basis of a management system that protects the marine environment while providing for rational uses of the environment that are necessary for social and economic development.

.4 **Acceptance of change:** Implicit in this framework is an acceptance that change is both a feature of the natural environment and an inevitable consequence of human activities and social development. Human intervention to limit and control such changes is both necessary and legitimate.

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# Annex
## List of international agreements, protocols and guidelines

**Global**

1 United Nations Convention on the Law of the Sea, 1982

2 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)

3 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972 (London Dumping Convention)

4 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, 1989 (Basel Convention)

**Regional**

5 Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft, 1972 (Oslo Convention)

6 Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1974 (Helsinki Convention)

7 Convention on the Prevention of Marine Pollution from Land-based Sources, 1974 (Paris Convention) — 1988 Amendment

8 Convention for the Protection of the Mediterranean Sea against Pollution, 1976 (Barcelona Convention) — 3 protocols

9 Convention for the Protection of the Natural Resources and Environment of the South Pacific Region, Noumea, 1986 (SPREP Convention) — 2 protocols

10 Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, 1978 (Kuwait Convention) — 2 protocols

11 Convention for the Protection of the Marine Environment and Coastal Area of the South-East Pacific, 1988 (Lima Convention) — 4 protocols

12 Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, 1981 (Abidjan Convention) — 1 protocol

13 Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, 1985 (Nairobi Convention) — 1 protocol

14 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, 1983 (Cartagena Convention) — 2 protocols

15 Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982 (Jeddah Convention) — 1 protocol

16 Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources (Montreal Guidelines, 1985)

*Table:* ***Coverage of Existing International Agreements and Guidelines***

| Agreement/Guidelines | Shipping, Emergencies | Dumping | Land-based emissions | Emissions to air | Oil/gas offshore exploitation | Other activities |
|---|---|---|---|---|---|---|
| 1 Law of the Sea Convention, 1982 | Global | Global | Global | Global | Global | |
| 2 MARPOL 73/78 | Global | | | [a] | | |
| 3 London Dumping Convention, 1972 | | Global | | [b] | | [b] |
| 4 Basel Convention, 1989 | Global [c] | | | | | [d] |
| 5 Oslo Convention, 1972 | | Regional NE Atlantic | | | [e] | |
| 6 Helsinki Convention, 1974 | Regional Baltic Sea | Regional Baltic Sea | Regional Baltic Sea | Regional Baltic Sea | Regional Baltic Sea | |
| 7 Paris Convention, 1974 | | | Regional NE Atlantic | Regional [f] NE Atlantic | Regional [g] NE Atlantic | |
| 8 Barcelona Convention, 1976 | Regional Mediterranean | Regional Mediterranean | Regional Mediterranean | | [h] | |
| 9 South Pacific Regional Environment Programme Convention, Noumea, 1986 | Regional South Pacific | Regional South Pacific | | | | [i] |
| 10 Kuwait Convention, 1978 | Regional Arabian Gulf | | | | Regional Arabian Gulf | |
| 11 Lima Convention, 1988 | Regional SE Pacific | Regional [k] SE Pacific | Regional SE Pacific | | | |
| 12 Abidjan Convention, 1981 | Regional W & C Africa | | | | | |
| 13 Nairobi Convention, 1985 | Regional E Africa | | | | | |
| 14 Cartagena Convention, 1983 | Regional Caribbean | | | | | |
| 15 Jeddah Convention, 1982 | Regional Red Sea Gulf of Aden | | | | | |
| 16 Montreal Guidelines, 1985 | | | Global [j] | | | |

**Annotations to Table**

a Air emissions from ships considered for inclusion.

b Including incineration of wastes at sea and the storage/disposal of wastes into the sea-bed.

c Besides covering administrative arrangements for the transboundary movement of wastes, also provides for the sound disposal of hazardous and other wastes.

d Land disposal, treatment, reuse, recycling.

e Disposal at sea of offshore platforms and installations considered for inclusion.

f Included in the Convention by agreement of Contracting Parties.

g Discharges from man-made structures placed under the jurisdiction of a Contracting Party are considered as coming from land-based sources.

h Protocol in preparation.

i Testing of nuclear devices; storage of radioactive wastes in the Convention area.

j No specific provisions – guidelines only.

k Confined to radioactive substances.

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