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PRINCIPLES, METHODOLOGIES AND GUIDELINES for the PROTECTION OF THE MARINE ENVIRONMENT against POLLUTION FROM LAND-BASED SOURCES

Prepared in co-operation with:

FAO UNESCO WHO IMO IAEA

Note: This document is the reproduction of Part IV of the final report of the UNEP Ad Hoc Working Group of Experts on the Protection of the Marine Environment against Pollution from Land-based Sources (UNEP/WG.120/3) and of the Technical Report of the second session of the GESAMP Working Group on Methodologies and Guidelines for the Assessment of the Impact of Pollutants on the Marine Environment (GESAMP XV/6).

PREFACE

Pollution from land-based sources constitutes the most serious threat to the coastal waters and their resources. It is affecting human health, living marine and coastal resources as well as amenities.

Solutions to the problems created by pollution from land-based sources are increasingly sought through regional co-operation. Such co-operation requires agreement of neighbouring states on common principles, methodologies and guidelines applicable to the effective protection of the marine and coastal environment.

The United Nations Environment Programme (UNEP) through its Regional Seas Programme actively promotes all measures which may eliminate or mitigate the effects caused by pollutants from land-based sources. Such measures include the formulation of regional legal agreements to combat pollution from land-based sources; monitoring of the sources, levels and effects of pollutants; promotion of environmentally sound waste management and disposal policies and practices.

The obvious need for common principles, methodologies and guidelines, applicable in a variety of situations and under various geographic, climatic and socio-economic conditions, have been recognized in the early stages of UNEP's effort to protect the marine environment from land-based sources of pollution.

The Ad Hoc Meeting of Senior Government Officials Expert in Environmental Law, convened by UNEP in Montevideo from 26 October to 6 November 1981, recommended the preparation of guidelines or principles which could lead to a global convention on the protection of the marine environment from land-based sources of pollution, with a view in particular to co-ordinating the work undertaken within the framework of existing regional agreements.

The recommendation of the Montevideo meeting was endorsed by the subsequent meeting of UNEP's Governing Council. An Ad Hoc Working Group of Experts on the Protection of the Marine Environment against Pollution from Land-based Sources was set up to formulate the guidelines and principles. Three meetings of the Working Group were convened by UNEP (Geneva, 28 November - 2 December 1983; Geneva, 19-24 November 1984; Montreal, 11-19 April 1985). The final report of the Working Group (UNEP/WG.120/3) contains the "Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-based Sources" which are reproduced without editing in this document (pages 1-23).

Scientific concepts and methodologies for the assessment of the impact of pollutants on the marine environment are an indispensable tool for the meaningful application of the principles laid down in the Montreal

Guidelines. Therefore, in parallel with activities which resulted in the Guidelines, in 1983 UNEP initiated through the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) the preparation of guidelines for the scientific assessment of the waste receiving capacity of the marine environment and of the environmental impact of pollution on marine and coastal environment. Under the leadership of the Food and Agriculture Organization of the United Nations (FAO) and in co-opertion with UNEP, the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Maritime Organization (IMO) and the International Atomic Energy Agency (IAEA) a GESAMP Working Group on Methodology and Guidelines for the Assessment of the Impact of Pollutants on the Marine Environment was established.

The aim of the Working Group is to provide specific guidelines for the scientific assessment of the impact of potentially harmful substances released from land-based (coastal) sources into the marine environment. The guidelines should consist of:

(a) a short introduction outlining the basic concepts and premises;

(b) a description of parameters and processes to be taken into account in the assessment of the environmental impact of pollution relevant to human health, marine organisms, ecosystems and amenities;

(c) a description of techniques to be used in order to assess the magnitude of parameters and rates of processes and their importance in the overall evaluation of impacts.

The Working Group is also expected to test the applicability of guidelines on suitable and typical case studies.

After two meetings (Rome, 26-30 September 1983; Bangkok, 29 October - 9 November 1984) the Working Group presented its interim report (GESAMP XV/6) to the fifteenth session of GESAMP (New York, 25-29 March 1985) which endorsed its basic concept and contents. The technical part of the Working Group's report is reproduced in this document (pages 25 - 56).

It must be noted that the GESAMP Working Group did not complete its work yet. In the future the Working Group will concentrate on

- description of techniques how to identify critical processes and targets;

- quantification of parameters and critical rates used in the impact assessment process;

- general methodology how to apply in practical terms the guidelines for assessing potential impacts of development projects;

- illustrate the applicability of the guidelines to specific case studies.

Contents

MONTREAL GUIDELINES FOR THE PROTECTION OF THE MARINE ENVIRONMENT AGAINST POLLUTION FROM LAND-BASED SOURCES

Introduction

This set of guidelines is addressed to Governments with a view to assisting them in the process of developing appropriate bilateral, regional and multilateral agreements and national legislation for the protection of the marine environment against pollution from land-based sources. They have been prepared on the basis of common elements and principles drawn from relevant existing agreements and drawing upon experience already gained through their preparation and implementation. Principal among these agreements are the United Nations Convention on the Law of the Sea (Part XII), the Paris Convention for the Prevention of Marine Pollution from Land-Based Sources, the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area, and the Athens Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources.

These guidelines are suggested as a broad framework for the development of similar agreements in those regions where such agreements are called for; for the guidance of Governments in areas which may not presently be covered by any regional agreements; and for the preparation in the longer term, should the need arise, of a global convention on pollution from land-based sources designed to strengthen international institutional arrangements to ensure the harmonization and application of global and regional rules, criteria, standards and recommended practices and procedures and to review the effectiveness of measures taken.

The guidelines are of a recommendatory nature. They are presented as a checklist of basic provisions rather than a model agreement, from which Governments may select, adapt or elaborate, as appropriate, to meet the needs of specific regions. They are without prejudice to the elaboration of cross-sectoral guidelines/principles within the framework of the programme for the development and periodic review of environmental law, as recommended by the UNEP Ad Hoc Meeting of Senior Government Officials Expert in Environmental Law (Montevideo, 1981).

1. Definitions

For the purposes of these guidelines:

(a) "Pollution" means the introduction by man, directly or indirectly, of substances or energy into the marine environment which results or is likely to result in such deleterious effects as harm to living resources and marine ecosystems, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities.

(b) "Land-based sources" means:

(i) Municipal, industrial or agricultural sources, both fixed and mobile, on land, discharges from which reach the marine environment, in particular:

From the coast, including from outfalls discharging directly into the marine environment and through run-off;

Through rivers, canals or other watercourses, including underground watercourses; and

Via the atmosphere.

(ii) Sources of marine pollution from activities conducted on offshore fixed or mobile facilities within the limits of national jurisdiction, save to the extent that these sources are governed by appropriate international agreements.

(c) "Marine environment" means the maritime area extending, in the case of watercourses, up to the freshwater limit and including inter-tidal zones and salt-water marshes;

(d) "Freshwater limit" means the place in watercourses where, at low tide and in a period of low freshwater flow, there is an appreciable increase in salinity due to the presence of sea-water.

2. Basic obligation

States have the obligation to protect and preserve the marine environment. In exercising their sovereign right to exploit their natural resources, all States have the duty to prevent, reduce and control pollution of the marine environment.

3. Discharges affecting other States or areas beyond the limits of national jurisdiction

States have the duty to ensure that discharges from land-based sources within their territories do not cause pollution to the marine environment of other States or of areas beyond the limits of national jurisdiction.

4. Adoption of measures against pollution from land-based sources

1. States should adopt, individually or jointly, and in accordance with their capabilities, all measures necessary to prevent, reduce and control pollution from land-based sources, including those designed to minimize to the fullest possible extent the release of toxic, harmful or noxious substances, especially those which are persistent, into the marine environment. States should ensure that such measures take into account internationally agreed rules, criteria, standards and recommended practices and procedures.

2. In taking measures to prevent, reduce and control pollution from land-based sources, States should refrain, in accordance with international law, from unjustifiable interference with activities carried out by other States in the exercise of their sovereign rights and in pursuance of their duties in conformity with internationally agreed rules, criteria, standards and recommended practices and procedures.

5. Co-operation on a global, regional or bilateral basis

1. States should undertake, as appropriate, to establish internationally agreed rules, criteria, standards and recommended practices and procedures to prevent, reduce and control pollution from land-based sources, with a view to co-ordinating their policies in this connection, particularly at the local and regional level. Such rules, criteria, standards and recommended practices and procedures should take into account local ecological, geographical and physical characteristics, the economic capacity of States and their need for sustainable development and environmental protection, and the assimilative capacity of the marine environment, and should be reviewed from time to time as necessary.

2. States not bordering on the marine environment should co-operate in preventing, reducing and controlling pollution of the marine environment originating or partially originating from releases within their territory into or reaching water basins or watercourses flowing into the marine environment or via the atmosphere. To this end, States concerned should as far as possible and, as appropriate, in co-operation with competent international organizations, take necessary measures to prevent, reduce and control pollution of the marine environment from land-based sources.

3. If discharges from a watercourse which flows through the territories of two or more States or forms a boundary between them are likely to cause pollution of the marine environment, the States concerned should co-operate in taking necessary measures to prevent, reduce and control such pollution.

6. Duty not to transfer or transform pollution from land-based sources

In taking measures to prevent, reduce and control pollution from land-based sources, States have the duty to act so as not to transfer directly or indirectly, damage or hazards from one area to another or transform such pollution into another type of pollution.*/

*/ Guideline 6 does not prevent the transfer or transformation of pollution in order to prevent, reduce and control pollution of the enviornment as a whole.

7. Specially protected areas

1. States should, consistent with international law, take all appropriate measures, such as the establishment of marine sanctuaries and reserves, to protect certain areas to the fullest possible extent from pollution, including that from land-based sources, taking into account the relevant provisions of Annex I.

2. States should, as practicable, undertake to develop, jointly or individually, environmental quality objectives for specially protected areas, conforming with the intended uses, and strive to maintain or ameliorate existing conditions by comprehensive environmental managements practices.

8. Scientific and technical co-operation

States should co-operate, directly and/or through competent international organizations, in the fields of science and technology related to pollution from land-based sources, and exchange data and other scientific information for the purpose of preventing, reducing and controlling such pollution, taking into account national regulations regarding the protection of confidential information. They should, in particular, undertake to develop and co-ordinate to the fullest possible extent their national research programmes and to co-operate in the establishment and implementation of regional and other international research programmes.

9. Assistance to developing countries

1. States should, directly and/or through competent international organizations, promote programmes of assistance to developing countries in the fields of education, environmental and pollution awareness, training, scientific research, transfer of technology and know-how, for the purpose of improving the capacity of the developing countries to prevent, reduce and control pollution from land-based sources and to assess its effects on the marine environment.

2. Such assistance should include:

(a) Training of scientific and technical personnel;

(b) Facilitation of the participation of developing countries in relevant international programmes;

(c) Acquisition, utilization, maintenance and production by those countries of appropriate equipment; and

(d) Advice on, and development of, facilities for education, training, research, monitoring and other programmes.

3. States should, directly and/or through competent international organizations, promote programmes of assistance to developing countries for the establishment, as necessary, of infrastructure for the effective implementation of applicable

internationally agreed rules, criteria, standards and recommended practices and procedures related to the protection of the marine environment against pollution from land-based sources, including the provision of expert advice on the development of the necessary legal and administrative measures.

10. Development of a comprehensive environmental management approach

States should undertake to develop, as far as practicable, a comprehensive environmental management approach to the prevention, reduction and control of pollution from land-based sources, taking into account relevant existing programmes at the bilateral, regional or global level and the provisions of Annex I. Such a comprehensive approach should include the identification of desired and attainable water-use objectives for the specific marine enviornments.

11. Monitoring and data management

States should endeavour to establish directly or, whenever necessary, through competent international organizations, complementary or joint programmes for monitoring, storage and exchange of data, based, when possible, on compatible procedures and methods, taking into account relevant existing programmes at the bilateral, regional or global level and the provisions of Annex III, in order to:

(a) Collect data on natural conditions in the region concerned as regards its physical, biological and chemical characteristics;

(b) Collect data on input of substances or energy that causes or potentially causes pollution emanating from land-based sources, including information on the distribution of sources and the quantities introduced to the region concerned;

(c) Assess systematically the levels of pollution along their coasts emanating from land-based sources and the fate and effects of pollution in the region concerned; and

(d) Evaluate the effectiveness of measures in meeting the environmental objectives for specific marine environments.

12. Environmental assessment

States should assess the potential effects/impacts, including possible transboundary effects/impacts, of proposed major projects under their jurisdiction or control, particularly in coastal areas, which may cause pollution from land-based sources, so that appropriate measures may be taken to prevent or mitigate such pollution.

13. Development of control strategies

1. States should develop, adopt and implement programmes and measures for the prevention, reduction and control of pollution from land-based sources. They should employ an appropriate control strategy or combination of control strategies, taking into account relevant international or national experience, as described in Annex I.

2. States should, as appropriate, progressively formulate and adopt, in co-operation with competent international organizations, standards based on marine quality or on emissions, as well as recommended practices and procedures, taking into account the provisions of Annex I.

3. Where appropriate, States should undertake to establish priorities for action, based on lists of substances from which pollution should be eliminated and of substances from which pollution should be strictly limited on the basis of their toxicity, persistence, bioaccumulation and other criteria as elaborated in Annex II, or in relevant international agreements.

14. Pollution emergencies arising from land-based sources

States and, as appropriate, competent international organizations should take all necessary measures for preventing and dealing with marine pollution emergencies from land-based sources, however caused, and for reducing or eliminating damage or the threat of damage therefrom. To this end States should, as appropriate, individually or jointly, develop and promote national and international contingency plans for responding to incidents of pollution from land-based sources and should co-operate with one another and, whenever necessary, through competent international organizations.

15. Notification, information exchange and consultation

Whenever releases originating or likely to originate from land-based sources within the territory of a State are likely to cause pollution to the marine environment of one or more other States or of areas beyond the limits of national jurisdiction, that State should immediately notify such other State or States, as well as competent international organizations, and provide them with timely information that will enable them, where necessary, to take appropriate action to prevent, reduce and control such pollution. Furthermore, consultations deemed appropriate by States concerned should be undertaken with a view to preventing, reducing and controlling such pollution.

16. National laws and procedures

1. Each State should adopt and implement national laws and regulations for the protection and preservation of the marine environment against pollution from land-based sources, taking into account internationally agreed rules, criteria, standards and recommended practices and procedures, and take appropriate measures to ensure compliance with such laws and regulations.

2. Paragraph 1 is without prejudice to the right of States to take more stringent measures nationally or in co-operation with each other to prevent, reduce and control pollution from land-based sources under their jurisdiction or control.

3. Each State should, on a reciprocal basis, grant equal access to and non-discriminatory treatment in its courts, tribunals and administrative proceedings to persons in other States who are or may be affected by pollution from land-based sources under its jurisdiction or control.

17. Liability and compensation for pollution damage emanating from land-based sources

1. States should ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the marine environment by natural or juridical persons under their jurisdiction.

2. To this end, States should formulate and adopt appropriate procedures for the determination of liability for damage resulting from pollution from land-based sources. Such procedures should include measures for addressing damage caused by releases of a significant scale or by the substances referred to in guideline 13, paragraph 3.

18. Implementation reports

States should report, as appropriate, to other States concerned, directly or through competent international organizations, on measures taken, on results achieved and, if the case arises, on difficulties encountered in the implementation of applicable internationally agreed rules, criteria, standards and recommended practices and procedures. To this end, States should designate national authorities as focal points for the reporting of such measures, results and difficulties.

19. Institutional arrangements

1. States should ensure that adequate institutional arrangements are made at the appropriate regional or global level, for the purpose of achieving the objectives of these guidelines, and in particular for promoting the formulation, adoption and application of international rules, criteria, standards and recommended practices and procedures, and for monitoring the condition of the marine environment.

2. The function of such institutional arrangements should include:

(a) Periodic assessment of the state of the specific marine environment concerned;

(b) Formulation and adoption, as appropriate, of a comprehensive environmental management approach consistent with the provisions of guidelines 7 and 10;

(c) Adoption, review and revision, as necessary, of the lists referred to in guideline 13;

(d) Development and adoption, as appropriate, of programmes and measures consistent with the provisions of guidelines 10 and 13;

(e) Consideration, where necessary, of the reports and information submitted in accordance with guidelines 15 and 18;

(f) Recommendation of appropriate measures to be taken for the prevention, reduction and control of pollution from land-based sources, such as assistance to developing countries, the strengthening of regional mechanisms of co-operation, consideration of aspects of transboundary pollution, and the difficulties encountered in the implementation of agreed rules; and

(g) Review of the implementation of relevant internationally agreed rules, criteria, standards and recommended practices and procedures, and of the efficacy of the measures adopted and the advisability of any other measures.

ANNEX I

Strategies for protecting, preserving and enhancing the quality of the marine environment

INTRODUCTION

In controlling marine pollution from land-based sources, an overall approach to the uses and the natural values of the marine environment should be taken, while still considering the needs of populations and industries for waste disposal. It is important to note that for many types of waste, the use of the marine environment is only one option among several. However, in some instances, marine disposal may be a feasible alternative. This document describes a number of strategies which can be employed to protect the marine environment against pollution from land-based sources and, where necessary, restore areas that have been affected. The goal is to protect the marine ecosystem by maintaining its quality within acceptable levels as determined on the basis of scientific, institutional, social and economic factors. It should be recognized that there are many activities competing to derive benefits from the marine environment. None of these activities, save the perpetuation of a marine ecosystem as a vital component of global life support, should be regarded as having guaranteed rights. Compromise and consideration of all alternatives must always be considered. Consequently, in the course of the decision-making process determining the use of a particular sector of the marine environment, social, economic and political factors, as well as natural environmental factors must be taken into account.

Once decision-makers have determined the desired present, interim and long term uses, and associated objectives for a water body, a number of control strategies may be employed to achieve those objectives. Flexibility will be an important consideration in the strategies or regulatory instruments implemented for various water bodies, reflecting their different environmental capacities and other properties and differences in regional socio-economic conditions. The principal strategies in use are based on marine quality standards, on emission standards and on environmental planning. Experience shows that a combination of strategies is often needed. Practical constraints may prevent full implementation of a strategy based on quality standards. Where such an approach cannot be fully implemented, other strategies should be employed.

1.0 CONTROL STRATEGIES

Pollution control strategies in use have been categorized according to:

- those based on marine environmental quality standards,

- those based on emission standards,

- those based on environmental planning.

Priorities for control are often established by the classification of substances into a black and a grey list. Substances are assessed according to the criteria described in Annex II. States undertake to eliminate pollution by those substances in the black list and strictly to limit pollution by those in the grey list.

1.1 Strategies based on marine quality standards

Such strategies relate directly to quality of water, biota or sediments that must be maintained for a desired level of quality and intended use. Several applications of such quality-based strategies exist.

1.1.1 Direct derivation from quality objectives

Technical assessments are conducted to determine the maximum allowable inputs that will ensure the desired levels of environmental quality are met. The assessments consider the fates and effects of various contaminants, amounts of input, and the existing natural characteristics of the relevant marine ecosystem. Numerical standards are then established to which concentrations measured in the receiving environment may be compared. They are usually more restrictive than numbers derived from the technical assessment to allow for monitoring and enforcement capabilities and safety requirements. They may apply to water, sediment, fish or the tissues, health or community composition of organisms in the marine ecosystem.

Monitoring is required to detect changes and compliance with the standards. Changes in the items monitored, after adjustment for natural fluctuation, may signal a need further to reduce inputs and vary existing standards and controls.

1.1.2 No change above ambient

Standards are set based on existing levels which must not be exceeded. This strategy is employed in situations where the aim is to prevent any increase in prevailing specific contaminant levels. It is an interim strategy to allow time to develop a solid scientific base on which more precise quality criteria may be employed for a specific use. It does not imply an existing state of the environment that is satisfactory, nor does it eliminate the need for its improvement.

1.1.3 Dilution

Some contaminants discharged at the source are assumed to attenuate as they spread from that source. Dynamic characteristics of the receiving environment are employed to determine rate and level of dilution. Standards are derived from measured parameters taken at given distances from the discharging source. This strategy may accept short-term or local excess of a potential pollutant at the source of discharge. Application is generally used with effluent that is considered biodegradable, and avoided where scientific evidence suggests that the effluent may accumulate in a given receiving environment.

1.1.4 Loading allocations

These impose priority of control on the larger sources in consideration of the most cost-effective solution. Allowable discharges are measured in terms of the total allowable for an entire receiving environment regardless of specific site quality. Application is suited to relatively self-contained receiving environments such as lagoons and semi-enclosed bodies of water. It allows flexibility of contaminant output, in that certain sources may emit more than adjacent ones as long as loading limits are not exceeded. All these strategies may employ criteria for water, air or sediment quality, as well as criteria related to specific marine life. Receiving environment quality standards are most prevalent for uses, e.g., swimming, direct harvesting of fish for human consumption, where sound scientific criteria exist to determine levels of harm. Emissions of potential pollutants are usually controlled to ensure that the desired quality is achieved. If the quality needs to be upgraded, additional controls are placed on allowable emissions.

1.2 Strategies based on emission standards

These strategies may be based on:

- a general principle to control pollution,
- achievable technology,
- distribution of control costs,
- enforceability.

They differ from strategies based on marine quality in that the standards set are not primarily determined by the level of contaminant in the environment.

1.2.1 Technology-based standards

These standards are usually applied on a sectoral basis, thus providing a means of imposing similar costs across a particular sector. Alternatively, they may be determined on a case-by-case basis. The standards will need to be reviewed periodically in the light of developing technology.

Standards may be based on:

1.2.1.1 Best practicable technology

This reflects the application of demonstrable and sound treatment technology or spectrum of technologies which is affordable by the sector concerned.

1.2.1.2 Best available technology

This reflects state-of-art technology in use in contaminant control. In general, the standards set would reflect a more stringent level of control as compared to best practicable technology. Application is generally for the control of emissions of the most noxious substances or to protect a sensitive environmental use.

1.2.1.3 As low as reasonably achievable

This is mainly applied to radionuclides and is based on the principle of "optimization". This, as defined by the International Commission on Radiological Protection, requires radiation doses to be kept to levels that are "reasonably achievable", by technological improvements and by suitable choice among alternative options. "Reasonably achievable" takes into account both the ease with which the technology can be applied and the balance between the benefits, in terms of dose reduction, and social and economic costs of its application.

1.2.1.4 Zero discharge

In a situation where stringent protection of a sensitive marine environment is deemed appropriate, consideration may be given to the denial of any release of a contaminant to the environment.

1.2.2 Uniform regional emission standards

Such standards are usually applied in situations where there are existing pollution problems of a similar nature and there is urgent need to reduce pollution. They do not give primary consideration to the nature of sources, their economic base, or the receiving environment.

1.3 Planning strategies

This set of strategies draws in part on those mentioned in sections 1.1 and 1.2 above and will often be used to supplement them (a similar relationship exists vice versa). Planning strategies allow an approach to the management and protection of particular environments which may involve restrictions on, or modification of, activities and sites as well as discharges.

1.3.1 Activity management

Certain activities are deemed inappropriate or inconsistent with the value or uses of an environment. Consideration should be given to whether the activity is essential, and if so, whether it can be accommodated elsewhere or in a different manner.

1.3.1.1 Use designation

Use of the receiving environment is the determining factor for pollution control standards as well as the basis for regulations or guidelines affecting other activities. For example, if the desire is to maintain or develop a shellfish harvest (a socio-economic decision) then quality standards and uses are developed with this in mind.

The application may result from a perceived threat to an established economic base, or cultural value, or a conscious effort to change the existing use of a receiving environment.

1.3.1.2 Environmental assessment of activities

Siting of any activity significantly affecting the marine environment is subject to a comprehensive analysis and assessment of:

- the ecological characteristics of the receiving environment;
- the direct and indirect potential effects/impacts of the activity on the environment; and, as appropriate,
- the direct and indirect potential effects/impacts on the environment of any reasonable alternative to the activity.

1.3.2 Regional planning

Plans are drawn up for particular regions, taking into account socio-economic and ecological factors, which are then used as a basis for development.

1.3.2.1 Coastal zone management

The strategy employs planning capabilities to make best use of the coastal zone.

It is not use- or source-specific but area-specific. Potential activities are assessed as components of a coastal zone. Planning is based on regional socio-economic and ecological considerations. Zoning and other land-use restrictions or modifications are major regulatory tools. Many States employ the use of regional planning authorities or councils, given the task to manage overall resource planning within a particular coastal area.

1.3.2.2 Watershed or drainage basin planning

This strategy acknowledges that a large proportion of pollution enters the marine environment via watercourses. It does not necessarily account for inputs via the atmosphere, though air management areas have also been employed for control purposes.

Through consideration of socio-economic and environmental factors utilizing a drainage system as the boundary limit, the desired uses and level of quality that can be attained for any given marine water body are determined.

Pollution via watercourses is controlled through regulation of point and diffuse sources of such pollution within the given watershed.

1.3.2.3 Specially protected areas

This strategy involves the identification of unique or pristine areas, rare or fragile ecosystems, critical habitats and the habitat of depleted, threatened or endangered species and other forms of marine life.

Those areas to be protected or preserved from pollution, including that from land-based sources, are selected on the basis of a comprehensive evaluation of factors, including conservational, ecological, recreational, aesthetic and scientific values.

States should notify an appropriate international organization of the establishment of and any modification to such areas, with a view to that data being included in an inventory of specially protected areas.

2.0 CONTROL INSTRUMENTS

This section outlines the various types of mechanism which can be invoked to implement control strategies:

2.1 Regulations

Regulations are developed pursuant to establishing legislation and can exist in forms such as:

2.1.1 - Emissions standards (air/water)

Standards based on best practicable technology, best available technology, geographical area, etc.

2.1.2 - Environmental quality standards

Standards for the receiving environment which vary according to its intended use.

2.2 Guidelines/codes of practice

These are descriptions of practices and abatement technologies that may be developed to meet the pollution control needs of various point and non-point sources. They provide a listing of basic requirements that may be implemented or adopted by industry or local authorities.

2.3 Permits

Legislation may require a discharger to have a permit to satisfy the requirements for the release of pollutants. These requirements can be based on standards in the form of emission control regulations, guidelines, codes of practice or specific requirements derived from environmental quality standards prescribed to protect the receiving environment.

2.4 Equipment standards certification

Environmental considerations may be incorporated directly in association with particular equipment. To this end, the equipment, or configuration of equipment may be designed, manufactured, tested and certified to comply with the requirements for source releases of pollutants.

2.5 Product controls

If a particular substance, or assemblage of substances in the form of a commercial product is deemed to be of environmental significance, a restriction on the product in the form of production, use, as well as export/import may be implemented.

2.6 Planning restrictions

Under planning law or practice, restrictions may be placed on the use of certain land.

2.7 Economic measures

These may take a variety of forms, e.g. tax incentives, subsidies and effluent charges. To be effective, the incentive offered must be strong enough or the charge levied high enough to persuade the discharger or user that it is in his own financial interest to limit his discharge or use of the substance concerned.

3.0 FACTORS INFLUENCING CHOICE OF STRATEGIES AND CONTROL INSTRUMENTS

There is a wide range of strategies and control instruments which can be utilized by a State either individually or in combination to address pollution of the marine environment from land-based sources. A number of factors may influence such a choice. In general terms, they may be categorized as economic, scientific/technical or social/cultural/political.

3.1 Economic

- General economic conditions and trends (deficit, balance of trade, inflation, etc.),
- Availability of public financing,
- Availability of external funding,
- Unemployment,
- Economic viability of various sectors,
- Polluter-pays principle,
- Availability of institutions and infrastructure.

3.2 Scientific/technical

3.2.1 Availability/accessibility of scientific data, including:

- Physical characteristics affecting flushing and mixing,
- Natural nutrient cycles and geochemical cycles,
- Biological processes and nature of communities.

3.2.2 Availability/accessibility of technology, including:

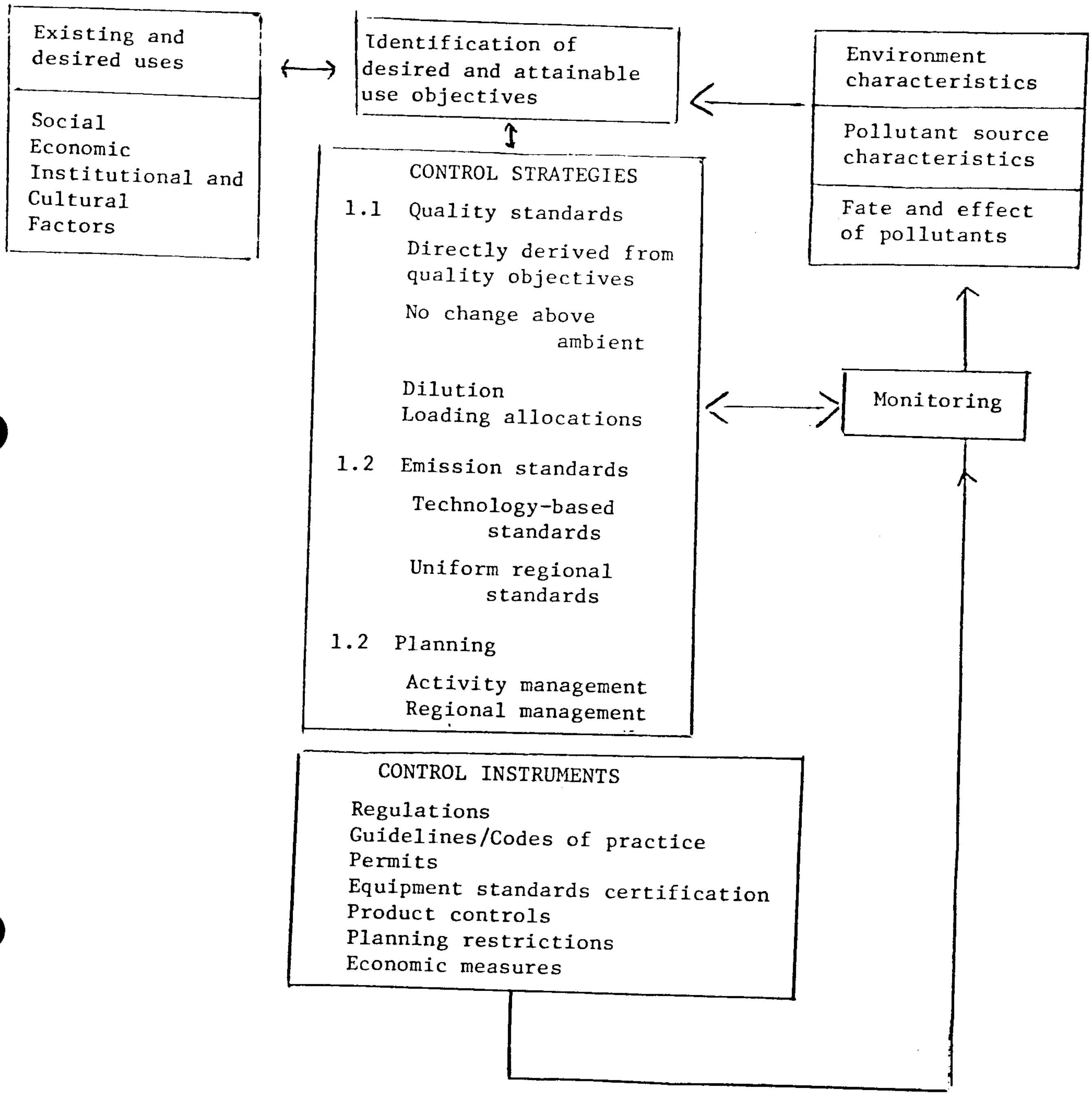
- Basic information on industry types, total effluent releases, and specific data on waste stream constituents.

- Availability of expertise,
- Capability for monitoring,
- Existing engineering infrastructure,
- Experience with implementation of strategies or instruments elsewhere,
- Sensitivity of ecosystems to be affected,
- Climatic considerations,
- Current level of pollution of the receiving environment and identified trends, in municipal agricultural and industrial waste releases.

3.3 Social/cultural/political

- Infrastructure,
- Existing and proposed uses of the marine environment,
- Political realities,
- Social/cultural awareness of the population,
- Perception of environmental, social and cultural values.

ENVIRONMENTAL PROTECTION



ANNEX II

Classification of substances

INTRODUCTION

Substances may be classified into a black list of those substances pollution from which should be eliminated and a grey list of those substances pollution from which should be strictly limited and reduced.

The basic criteria to be taken into account in allocating substances to one of these lists are:

a) persistence,

b) toxicity or other noxious properites,

c) tendency to bio-accumulation.

These criteria are not necessarily of equal importance for a particular substance or group of substances. Other factors such as location and quantities of the discharge may need to be considered.

1.0 BLACK LIST

Substances may be included in this list:

a) because they are not readily degradable or rendered harmless by natural processes; and

b) because they may either:

(i) give rise to dangerous accumulation of harmful material in the food chain, or

(ii) endanger the welfare of living organisms causing undesirable changes in the marine ecosystems, or

(iii) interfere seriously with the harvesting of sea foods or with other legitimate uses of the sea; and

c) because it is considered that pollution by these substances necessitates urgent action.

The substances that fulfill these criteria may include:

1.1 Certain organic biocides (e.g. organohalogen compounds and substances which may form such compounds in the marine environment);

1.2 Persistent hydrocarbons of petroleum origin;

1.3 Certain metals and their compounds (e.g. mercury);

1.4 Persistent synthetic materials which may seriously interfere with any legitimate use of the sea;

1.5 Radioactive materials;

1.6 Substances in respect of which it has been proved that they possess carcinogenic properties in or via the acquatic environment;

1.7 Materials in whatever form (e.g. solids, liquids, semi-liquids, gases, or in a living state) produced for biolgocial and chemical warfare.

2.0 GREY LIST

Substances may be included in this list because, although exhibiting similar characteristics to the substances in the black list and requiring strict control, they seem less noxious or are more readily rendered harmless by natural processes. The substances to which this may apply include:

2.1 Organic biocides not included in the black list;

2.2 Hydrocarbons of petroleum origin and their derivatives not included in the black list;

2.3 Certain elements and their compounds (e.g. fluorides and cyanides);

2.4 Inorganic and synthetic organic materials, other than those included in the black list, which are likely to produce harmful effects on marine organisms or to make edible marine organisms unpalatable, as well as chemicals which may lead to the formation of such substances in the marine environment;

2.5 Acid and alkaline compounds of such composition and in such quantity that they may seriously impair the quality of the marine environment;

2.6 Substances which, though not producing toxic effects, may become harmful because of the concentrations or quantities in which they are discharged, or which are liable to reduce amenities seriously or to endanger human life or marine organisms or to impair other legitimate uses of the sea;

2.7 Pathogenic micro-organisms which are or may become harmful because of the concentrations and quantities in which they are discharged or which are liable to endanger human life or marine organisms, or to impair other legitimate uses of the marine environment and the coastal waters in particular.

ANNEX III

Monitoring and Data Management

1.0 MONITORING

In the protection of the marine environment against pollution from land-based sources, monitoring can be defined as the measurement of a pollutant or its effects on either man or elements of the marine resource for the purposes of assessing and controlling exposure to that pollutant. Thus monitoring is used first to assess the need for pollution prevention measures and subsequently the effectiveness of any protection measures introduced. If monitoring is to meet these objectives and be cost-effective it must be carefully designed and implemented.

1.1 Resources to be protected

One of the first things to ascertain is what resources need protecting in the area concerned and the various pollutant sources and ways in which each could possibly be threatened. For example, the well-being of a nature reserve, fish hatchery or fish resource might be threatened by a variety of substances. Similarly, the suitability of fish or shell-fish for human consumption might be affected by other substances such as mercury or arsenic which may adversely affect man, whilst not affecting fisheries.

1.2 Information on inputs

It is also important at an early stage to establish for each area the activities already practised and the pollutants likely to reach the sea via point, non-point and riverine sources.

A knowledge of the resources to be protected and which pollutants are most likely to affect them will allow attention to be focussed on those substances which appear most likely to be of concern, thereby reducing the amount of effort devoted to establishing a data base on inputs. Information on inputs can also be used to focus environmental monitoring efforts on those pollutants most likely to be encountered in each area. If possible the scale of input should also be established, at least in order of magnitude terms. This will normally be fairly easy but more accurate quantification will require improvements in the quality of data on both concentration and flow.

Information on inputs from direct discharges may be determined from descriptions of unit processes in use. If permit programmes have been established, information on controlled pollutants should be available from the permitting authority. Inputs from non-point sources are generally estimated by employing accepted formulae describing land use in the watershed and the associated run-off. In estimating point and non-point sources inputs, the pollutants of concern may include a broad range of substances, for example, toxicants and nutrients.

1.3 Establishing baseline concentrations

Having decided what needs to be monitored, on the basis of what resources must be protected and which pollutants are likely to be of interest, the concentrations actually present in the environment can be established. This information can then be used to assess those protection measures necessary and/or their effectiveness. The need for control measures may be judged either by comparison of the concentrations found with some form of water quality criteria, for example maximum permissible concentration, or with similar data from other areas known not to be contaminated.

When baseline concentrations are being ascertained, the most appropriate substrate should be selected. Three options exist: water, biota and sediments, only rarely should it be necessary to analyse samples of all three. The choice will depend on the pollutant concerned, the water quality criteria selected and the nature of the pathways exposed. For example, water would be most suitable for nutrients, biochemical oxygen demand (BOD), pH and certain metals, but biota would be more appropriate for polychlorinated biphenyls (PCBs) or mercury, and undisturbed sediments can be particularly useful in time or spatial trend assessments.

1.4 Ongoing monitoring

Monitoring will be required to establish the effectiveness of pollution protection measures. Even if no reductions in inputs are deemed necessary it may be desired to check that the situation does not deteriorate. Whatever their purpose, monitoring programmes should be designed to consider the receiving capacity of the environment as well as inputs. This means considering present water quality in relation to the desired quality, and the scale of environmental protection measures taken in relation to the existing concentrations, nature of the pollutants present, the scale of their input and their removal processes. On this basis it will be possible to define what should be monitored and with what frequency.

1.5 Sampling and analysis

The number of samples collected and their nature should represent the substrate being monitored. Water quality, biological tissues and sediments can all be very variable even over short distances and the sampling strategy should, when necessary, be tested statistically to ensure it is sound. The programme design should take account of the hydrographic characteristics of the area so as to avoid sampling the same body of water at different places as it moves under the influence of a current. Finally, the sample collected must be adjusted to the form in which the pollutant occurs in the environment or in the discharge streams.

Once a suitable sampling programme has been designed, it may be possible to bulk samples for analysis in order to reduce the analytical workload and costs. This will inevitably lead to the loss of some information and should only be considered if the complexity of the analytical technique demands it and/or the loss of information can be tolerated or if the monitoring is only to be used to pick up abnormalities such as in compliance monitoring.

1.6 Resource monitoring

In addition to monitoring the pollutants of interest in the selected substrate, it is essential that the state of the resource(s) be monitored. However, if adverse changes do occur it should not be assumed the protection measures taken were inadequate. For example, fish stocks decline due to fishing effort as well as pollution and undesirable plankton blooms occur for reasons other than nutrient enrichment. Biological effects monitoring is desirable but very few techniques can be applied routinely on a wide scale and most give unspecific responses. Once suitable effects monitoring techniques are available, they may be more attractive alternatives than purely chemical monitoring in environmental matrices.

2.0 DATA AND DATA MANAGEMENT

Before the data from any monitoring programme are used, it is important that confidence limits be established and reported in order to ensure that the confidence with which recorded numbers are handled and interpreted is not misplaced. It is also necessary to decide how the data should be handled for future reference and use.

2.1 Limitations in the data and the extent to which they can be tolerated

The results obtained from any monitoring programme will be subject to errors of accuracy and precision, the size of which must be quantified. If precision is high and accuracy poor then all results for a set of analyses of the same sample will be very close together, for example, differing by no more than one per cent though they may differ from the true result by much more, possibly by as much as an order of magnitude. Some errors will derive from the nature of the samples. These can be minimized by proper statistical design of the sampling procedures and attention to the collection of uncontaminated samples.

All analytical procedures have inherent errors in precision and accuracy. To a greater or lesser extent either or both types of error can be compounded by operator or laboratory errors, which are often not recognized. However, by use of good analytical equipment and methods and by following a rigorous analytical quality assurance scheme, it should be possible to achieve high accuracy and precision for all analytical data, and allow quantification of the scale errors.

2.2 Intercomparability requirements

In most cases where monitoring programmes are operated on a multilateral basis it is essential that the results obtained by all contributors are truly comparable. Establishing comparable monitoring programmes may prove difficult. However, it is desirable that targets be set for comparability of the data.

Analytical comparability is only one aspect of monitoring data. The actual programmes run by different countries must also be comparable. It obviously will not be possible to compare results from three countries if one analyzes water, another a fish species and another sediments. Even when agreement is reached on whether to sample water, biota or sediments it will be necessary to agree, for example, which species of fish should be used, whether the water should be filtered before analysis or whether whole sediment should be analyzed or only a particular size fraction.

2.3 Requirements for analytical quality control

It may be impossible to arrange that all contributors use identical analytical procedures. Even if they do, for the reasons given previously, intercomparability is not guaranteed. To establish whether differences do exist and to minimize them, a programme of intercalibration is essential. Each laboratory should assure the quality of its data by participating in intercalibration exercises and analyzing at intervals reference materials containing certified concentrations of the pollutants of interest in appropriate matrices and concentrations.

2.4 Data storage, retrieval and exchange

Depending on the scale of the monitoring programme various methods of data storage and transfer may be appropriate. It is essential that the design of the storage/retrieval system be carefully worked out to reflect the end use of the data both in its raw and interpreted form. The most efficient method in many respects is to use a computer. It is essential that the limitations of any set of data be instantly recognizable when it is retrieved. To this end, information such as performance in a recognized intercalibration exercise, analysis of reference materials, etc., should be retrievable with the data. Ideally the data should be freely accessible by all contributors and the scientific community in general. However, if a country or group of countries wish certain types of data to be available only to a limited audience that wish must be safeguarded.

2.5 Regions may exhibit different natural background or baseline concentrations, have different resources to be protected and be exposed to different pollutants. As a consequence their monitoring programmes might differ, for example, different fish species might be used as indicators, permissible limits might differ according to exposure patterns and different targets might be set for sampling and analytical accuracy. Therefore it will probably be more practical and effective, at least initially, to organize monitoring programmes and data storage on a regional rather than a global basis.

Once a satisfactory level of regional comparability has been achieved, inter-regional comparability should follow as a logical progression.

METHODOLOGIES AND GUIDELINES FOR THE ASSESSMENT OF THE IMPACT OF POLLUTANTS ON THE MARINE ENVIRONMENT

1. INTRODUCTION

1. Environmental management consists of formulating and applying strategies by which the resources of a given ecosystem can be utilized in an efficient and sustainable manner in the context of the overall and specific socio-economic and political goals of a society. These strategies should be based on a comprehensive scientific assessment of the local environment as well as on forecasting the potential effects that an activity might impose on that environment and human well-being dependent on it.

1.1 Recognizing the importance of social, economic and political consideration in the ultimate policy decisions, this document is an attempt to describe only an approach to a comprehensive scientific assessment with reference also to conditions in which 'hard' scientific information about local conditions is scarce or almost non existent.

1.2 The assessment process centres on a document known by different names - Environmental Impact Report, Environmental Impact Assessment, Environmental Impact Statement. These documents contain the results of wide-ranging investigation. Input is required from economists, social scientists, engineers, scientists and other specialists. The document is often put out for public comment and in most countries it is reviewed by a competent agency taking into account public views and wider specialist advice.

1.3 The type of assessment undertaken in environmental impact assessment can follow one of two approaches:

(1) to make a "deterministic" assessment of permissible effluent or water quality standards based on relatively simple techniques of applying arbitrary safety factors, and of making conservative assumptions where uncertainties exist (see Section 3.2).

(2) to perform a probabilistic assessment of the environmental capacity for the contaminant, based on the techniques described in Section 3.4. This permits an explicit weighing of risks associated with each effluent standard.

1.4 There can be many reasons for either choice, but the planners should be aware that the choice between these two separate approaches should be a conscious step in the management process. The second approach is preferable when the ability to explicitly balance costs and risk-taking is necessary.

1.5 The EIA process may be enhanced by ranking options in social preference so that the appropriate research emphasis for scientists is clear. It is also essential that monitoring is undertaken as a follow up of the initial assessments, once the project has been implemented.

1.6 An Environmental Impact Assessment document in itself does not remove the requirement for difficult and controversial decisions. The whole environmental impact assessment process can, nonetheless, help to clarify objectives, quantify potential impact, identify opportunities for reducing impact and assist the decision-making process by providing the information necessary for a broadly-based decision.

1.7 Scientific input to the process of environmental impact assessment may be required first when the scope of the investigations is being determined, secondly in the specific investigations required to provide the data to be used in the EIA document, thirdly as members of the general public comment on aspects of the published document and, finally, in direct advice to decision-makers in interpreting scientific data and in allaying public concern. Further scientific input is required as follow-up action such as monitoring and review.

1.8 The wastes of society can be placed on land, in the atmosphere or in the water. It seems only reasonable to consider the comparative consequences of disposal in each of these receiving environments and to choose between them on the basis of scientific, technical, economic and social grounds. GESAMP's brief is mainly limited to the scientific aspects of such discharges to the marine environment.

2. The disposal of wastes in the marine environment, even those produced by the best available technologies and after extensive treatment, may have an impact on the marine ecosystem and resources, human health, amenities and other legitimate uses of the marine environment.

3. Identifying and assessing such potential impacts in view of the characteristics of the wastes and of the receiving environment, as well as available waste management options, is basically a scientific exercise requiring close harmonization with other aspects of environmental management.

4. The scientific concepts and methodologies discussed in the following sections and the guidelines put forward are intended for the scientific assessment of the impacts produced or expected by the disposal of the wastes in the marine environment.

2. PREMISES, CONCEPTS AND DEFINITIONS

5. The basic premises are that:

(1) a certain level of some contaminants may not produce any undesirable effect on the marine environment and its various uses;

(2) the environment has a finite capacity to accommodate some wastes without unacceptable consequences;

(3) such capacity can be quantified.

2.1 Acceptability of Impact

6. Acceptability of impact is a subjective judgement often reflected in water quality standards and objectives which are set within the political process. However, it is possible to determine acceptability from a scientific perspective, based on the GESAMP definition of pollution. According to this definition, any discharge which does not cause pollution would be deemed as acceptable from the scientific point of view.

7. The concentration (level) of a substance (or waste) at which deleterious effects on one of the various components of the ecosystem or uses of the marine environment occur may be defined through toxicological, epidemiological or other similar studies.

8. In some cases, that concentration (level) may be based on the acceptability or risk of exceeding the point at which deleterious effects actually occur.

2.2 Environmental Capacity

9. Various terms are used to describe the extent to which the environment is able to accommodate waste without deleterious effects. For the purposes of this report Environmental Capacity is considered a property of the environment and can be defined as its ability to accommodate a particular activity or rate of activity (e.g. volume of discharge per unit time, quantity of dredgings dumped per unit time, quantity of minerals extracted per unit time) without unacceptable impact. This capacity includes physical processes such as dilution, dispersion, sedimentation and evaporation, as well as other processes which lead to degradation or other ways by which an activity loses its potential for unacceptable impact.

10. Environmental capacity will vary with the characteristics of each site and with the type or number of discharges or activities. Use of the capacity of an environment to assimilate a waste or activity must recognize the defined capacity as an upper limit. Proper management of the marine environment, giving attention to waste treatment and alternative means of disposal, should be successful in preventing excesses, as it has been where management of river water quality has been practised.

2.3 Recovery of Polluted Ecosystems

11. Although pollution impacts may severely damage the marine environment, corrective measures tending to eliminate or reduce the pollutant load should in general allow recovery albeit to an altered state. In cases where serious pollution has occurred, identification of the cause and the resulting remedial action, which only very rarely involved total cessation of the input, has resulted in recovery of the affected environment.

12. It is important to recognize that many ecosystems do have a potential to recover from pollution, including that caused by accidental releases of pollutants. The ability of the system to recover should be assessed before any discharge of waste is allowed to take place. Knowledge of detoxification processes and of recovery potential may help to optimize remedies if an accident occurs or damage is suddenly recognized.

3. SCIENTIFIC RATIONALE AND METHODOLOGY FOR THE ASSESSMENT OF THE IMPACT ON THE MARINE ENVIRONMENT

3.1 Approaches to Effluent Control

13. Waste management strategies should aim at selecting the disposal option which involves the least collective impact in terms of human health detriment, disturbance and/or damage to the natural environment and associated social and economic penalties.

13.1 The methodology recommended for the assessment of the impact of pollutants on the marine environment is schematically shown in Figure 1. It consists of three stages (decision loops): (i) the planning loop, (ii) the preliminary scientific assessment loop, and (iii) the monitoring and adaptation loop. The scheme recognizes scientific and socio-economic inputs as two parallel, interactive and complementary activities in decision-making in integral, environmentally compatible, development planning. It emphasizes the objectivity and independence of scientific assessments, but also its deep involvement in influencing socio-economic feasibility decision.

13.2 In the planning loop, socio-economic goals trigger an activity. Scientific assessment is needed in the identification of available present and future resources. The process requires initial consideration of alternative options.

13.3 In the next stage the essence of the assessment process is to translate the defined environmental quality objectives (EQO) into the maximum allowable inputs. The assessment process proceeds through the identification of development activities, and of present and expected future contaminants. The process of adoption of water quality criteria will involve choice of the most sensitive target to be protected and investigation of the critical pathway of the contaminant to it. This accomplished, by use of toxicity data for the target and the contaminant along with a proper application factor, water quality criteria can be derived. If a single contaminant input is expected, the strategy of uniform emission standards can be applied, and allowed inputs defined. In the case of multiple inputs, the strategy based on environmental capacity is necessary. Using environmental data and end points based on water quality criteria, the assessment of the environmental capacity, and apportionment of a fraction of it for the particular project, enables setting up of allowable inputs. Such a procedure will always involve several sources of uncertainty, mandating approximations based on experience.

13.4 This final and most important stage is shown in the monitoring and adaptation loop. Monitoring provides a test of whether the environmental capacity is (i) balanced, thus allowing the project to become operational. If monitoring shows that environmental capacity is (ii) exceeded, the project must undergo adaptation or would require alternative technology, primarily in the waste and effluent treatment. If no economically or technologically viable alternative is available, environmental consideration would require cancellation of the project. If in conservative assessments too low applications factors (see 3.2.1) were used, the environmental capacity might be found (iii) under-utilized. If economic and development needs dictate, allowed inputs may be increased, but only with caution and relying on long-time series monitoring data.

3.1.1 Removal/reduction of contaminant levels by effluent treatment

14. From a purely technical standpoint it is possible to devise treatment processes to deal with most contaminants in most types of effluent. Treatment processes already exist for many industrial wastes, and methods are available to reduce the impact of such activities as dredging and sea-bed resource exploitation. The capital and running costs of effluent treatment usually increase the greater the degree of contaminant removal achieved. However, there may be a cost return in addition to environmental benefit if potentially re-usable or saleable materials are recovered or generated by the waste treatment process.

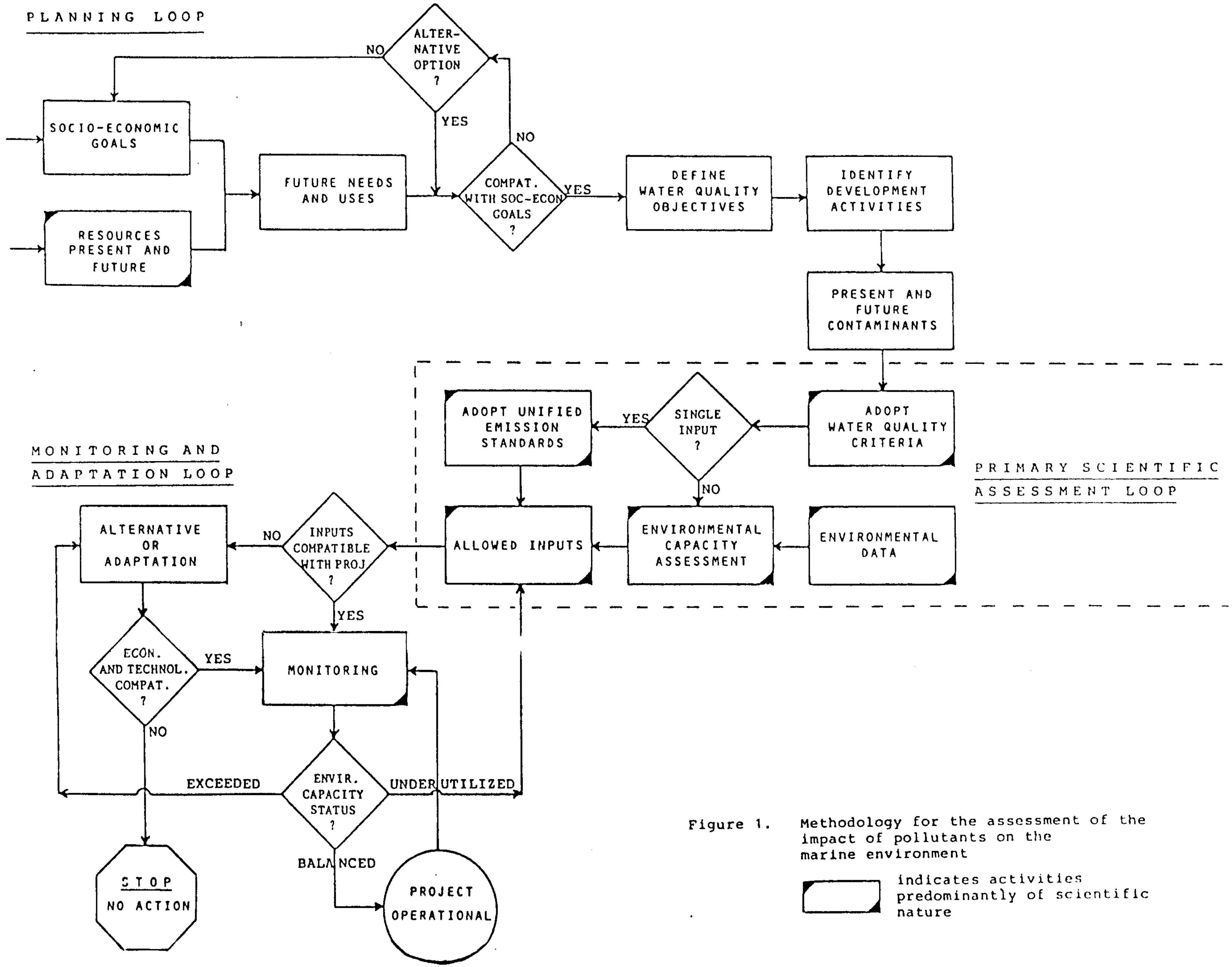


Figure 1. Methodology for the assessment of the impact of pollutants on the marine environment

indicates activities predominantly of scientific nature

15. Given that there is to be a discharge, the greatest level of environmental protection is provided if the effluent is treated with the best available technology (BAT), i.e. that which allows the maximum removal of the substance in question, regardless of costs. If economic factors are taken into consideration the level of treatment called for may be less. This option, which takes account of economic aspects, is often described as using the best practicable means available (BPMA).

16. This type of approach to environmental protection has been adopted by the European Economic Community in pursuance of its Dangerous Substances Directive. This Directive seeks to eliminate pollution of surface waters, including estuaries and coastal waters, by various so-called black-list substances and to reduce pollution by so-called grey-list substances. The approach takes account of what is achievable in terms of effluent quality by use of best practicable means available and sets limits on the concentrations of particular substances concerned. This approach is called the uniform emission standards (UES) approach because the same limits are applied to all discharges of the substance in question or all processes of a particular type. The limits are usually set in terms of the concentrations allowed in the effluent and, in the case of a particular process, in terms of the amount of product produced. For example, the limits for mercury arising from chlor-alkali production are expressed both in terms of grams of Hg per ton of chlorine produced and mg/l of the effluent.

17. These approaches to environmental protection can reduce the potential impact of contaminants on the marine environment by reducing the input of wastes. They have the additional advantage of being relatively easy to organize, administer and monitor, and they do not require detailed investigation of environmental variables, which inevitably vary from site to site. If UES is applied, it is claimed to prevent cost differences arising between plants because different plants must all treat their effluents to the same extent. However, this ignores the fact that other costs may differ considerably from plant to plant, e.g. raw materials, transport and labour.

18. It must be recognized that these approaches to environmental protection may require costly technology to be used, because they do not take account of the extent to which the environment can assimilate wastes. Consequently, although effluent treatment (whether BAT or BPMA) may reduce pollution in most situations, pollution avoidance is not guaranteed. Thus, for example, the discharge from an extremely large plant may cause pollution, even though that from a small one may not. Equally, a small plant discharging to a small river or estuary may have a disastrous effect whilst several quite large plants discharging to a large river, estuary or open coastline may have no effect at all. In many situations where emission standards are applied, monitoring is carried out only on effluent quality and not on the quality of the receiving environment.

3.1.2 Water quality classification systems/water quality criteria

19. An approach to environmental protection which takes environmental capacity into account involves the adoption of environmental quality criteria. These may be adopted as standards within a legal framework of control. In their simplest form water quality criteria are derived so as to protect aquatic and human life, the more stringent of the two usually being applied. The use of water quality criteria within an overall environmental quality objective framework is discussed in detail in paragraphs 22 and 23.

20. Protection of aquatic life is sought by assessment of all available toxicity data from both acute and chronic exposure tests. If data are sparse it may be necessary to apply a safety factor or to otherwise accommodate uncertainties. Implementation of the resulting value as the maximum allowable concentration (MAC) in the aquatic environment would normally protect aquatic life. Different criteria may be derived for marine and freshwater life and may be further sub-divided, e.g. into standards to protect crustacea, molluscs or fish.

21. A similar procedure is used to ensure that human health is not at risk through use of the water for drinking purposes or use of fish from the impacted area for food - sea food organisms may accumulate the substance of concern and whilst not at risk themselves may be dangerous to man. In deriving criteria to protect man, the consumption rates used will be those of the most exposed group, i.e. those who drink the most water or usually eat large amounts of sea food. They are usually set on the basis of the habits of an average member of the most critically exposed group of the population (Hunt et al., 1982).

22. A further dimension of the water quality criteria approach is that which permits the derivation of criteria to meet a whole series of Water Quality Objectives. Such a system acknowledges that,

for a variety of reasons, it may not be desirable or practicable to require criteria to protect human health or aquatic life in every sector of the aquatic environment. Similarly it may be decided that the most important use of a particular stretch of water is for navigation or irrigation and that protection of fish or other aquatic life is less important. To this end, different standards may be adopted to protect the various possible uses of the water. Those usually considered in a marine environmental protection context are:

- abstraction of water for desalination for drinking water purposes
- as a source of food for man
- abstraction of water for industrial purposes
- as an environment which supports a normal population and diversity of aquatic life
- as a recreational medium, i.e. for bathing and other water sports
- as an environment which is aesthetically pleasing
- as an environment which supports an exceptionally rich, productive, diverse or rare population of aquatic life.

23. Apart from the additional complication of having to derive separate standards to protect each of these uses, decisions also have to be made as to what single or multiple use is desired for the particular stretch of water. This clearly involved much more than inputs by scientists and will entail various value judgements being made.

24. The main advantage of the water quality objectives approach is that standards can be set according to the particular use of the environment. It provides a set of management goals upon which further decisions can be based.

25. The main disadvantages are that, in order to derive the criteria, a considerable amount of basic information may be required on the substances concerned and their behaviour in the environment, including their interaction with other substances. The application of water quality criteria also requires discharge limits to be set with regard to use and characteristics of the area into which each discharge is to be made. Discharge limits may be more relaxed than would be required under the best practical technology type approaches. However, discharge limits would normally be set to ensure that the water quality criteria are met with adequate safety margins. The extent of the safety margin would be determined by economic and other factors. Situations will also arise where the discharge limits may be such that they simply cannot be achieved even using best available technology and the project has to be abandoned, or moved elsewhere. This is particularly likely to arise if several similar discharges are already being made to a particular area, especially if the principle of setting individual discharge standards as low as reasonably achievable was not followed for the earlier plants. Also, for political reasons, the same water quality criteria could be adopted for all water bodies of a country, resulting in a diversion of discharges from already polluted areas to still undisturbed environments of a higher ecological value.

26. Water quality criteria have been set up at international and national levels. These can be used as guidelines for application elsewhere. It should, however, be recognized that such criteria were derived with the particular needs of those regions' and countries' environments in mind. They may not therefore be sufficient to protect particularly sensitive ecosystems, but may be too restrictive for regions where economic and social factors are weighted differently.

27. The criteria selected to ensure that water is suitable for the use desired will be a major component in the process of calculating the environmental capacity. This will include the amount of the contaminant which can be added to a particular body of water without the level defined by the criteria being exceeded.

3.2 Quantification and Derivation of Environmental Capacity

28. Any assessment of the capacity of the environment to assimilate wastes will require Maximum Allowable Concentrations or Water Quality Criteria to be set. At least some data have to be available for both these aspects and the level of precision of the evaluation is dependent on the quality of data available. In the absence of sufficient data, assumptions increase and the evaluation may have little value.

29. The quantification of capacity involves the following main components:

- toxicological characteristics of the contaminant

- environmental distribution

- environmental fate

- definition of boundaries of the impacted ecosystem.

3.2.1 Characteristics of the contaminant

30. The most significant characteristic of the contaminant is its toxicological properties. The scientific basis for water pollution control regulations is the definition of water quality requirements. Depending on the intended use of the water, human utilization and aquatic life are the most demanding uses. Although most examples quoted in the following sections refer to freshwater experience, the same approaches have been used for coastal and marine waters, for example by EPA in the United States of America (U.S. EPA, 1980) and by the European Communities.

31. The criteria are defined by reviewing available scientific information and critically defining a limit not to be exceeded. This procedure can be applied only to thoroughly studied, well-known substances but, at least in fresh waters, its usefulness has been clearly demonstrated. According to EIFAC (1964), criteria for freshwater fish should satisfy the following needs:

> 'Water quality criteria for freshwater fish should ideally permit all stages in the life cycles to be successfully completed and, in addition, should not produce conditions in a river which would either taint the flesh of the fish or cause them to avoid a stretch of river water where they would otherwise be present, or give rise to accumulation of deleterious substances in fish to such a degree that they are potentially harmful when consumed. Indirect factors like those affecting fish-food organisms must also be considered, should these prove to be important'.

32. Each toxicant is usually reviewed on the basis of its chemistry in water, sublethal effects, type of toxic action, factors which influence lethal levels, field observations in polluted waters, data regarding toxicity on algae and invertebrates. Tentative quality criteria for aquatic life are subsequently published. In the few cases where validation was possible, the results were consistent.

33. When data are scarce, several other approaches are helpful, depending on the type of information available. For example, in the U.S.A. the maximum acceptable toxicant concentration (MATC) (Mount and Stephan, 1967) is experimentally determined as that concentration which allows for the full life cycle of target organisms, usually fish, to be completed successfully (from egg to egg). Another way to identify a non-dangerous concentration is the no observed effect level (NOEL) approach which is used where a few consistent data are available, including some long-term exposures, but where full toxicity information is lacking. In some circumstances, a number of acute toxicity tests have been completed at various levels of biological organization. These provide the basis for evaluation of ecotoxicological characteristics of the substance in question by means of an integrated rating system (IRS) (Weber, 1977; Calamari et al., 1980; Schmidt-Bleek et al., 1982). This method involves the summation of arbitrary but consistent toxicological "scores" by which the substance can be ranked among others with known properties. In the case of necessity, therefore, this method allows tentative water quality criteria to be derived from the few data available on the basis of analogy.

34. A further approach when data are scarce, and there is uncertainty, is the use of an application factor (AF) (Lloyd, 1979). For example, the usual toxicity curves showing the relationship of concentration with time of response for a chemical substance or an effluent will allow the identification of an appropriate application factor. For example, in Figure 2, the curve (A) shows a well defined threshold of response (or incipient effect level) while curve (B) shows only a tendency to a threshold, whereas (C) has no threshold for the period of time tested. In this case, the application factors could be 0.1, 0.05, 0.01. The allowable concentration is then the effective concentration multiplied by the application factor.

35. Some kind of factor may also need to be used to take account of different patterns of response so as to provide additional safety. The common relationship between effect and concentration is represented in Figure 3 by curve (D) which shows little effect at lower concentrations but a sharply increasing response at some higher concentration. Curve (E), on the other hand shows a sharp response at lower concentrations, but minimal response thereafter. This, therefore, could be

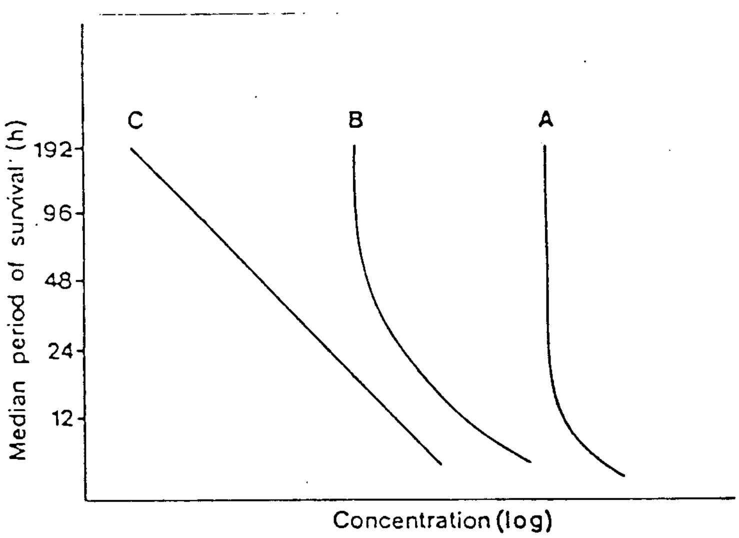


Figure 2. Different types of relationships between concentration and time of effect. A threshold of effect is evident in curve (A), a tendency to a threshold in curve (B), while none in shown by curve (C)
(From Lloyd, 1977. Reproduced with kind permission of Aston University, Birmingham. 1977)

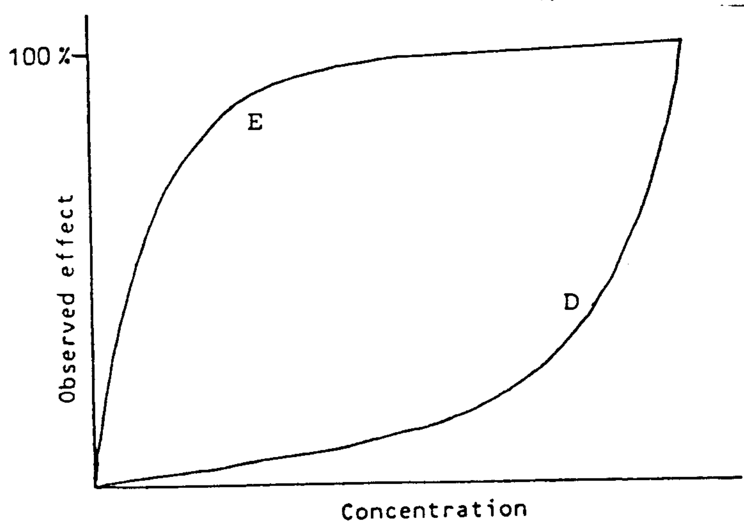


Figure 3. The response to increasing concentration of a contaminant may be represented by curve (D) or curve (E). The latter would be that for a more sensitive target

regarded as a more sensitive system requiring a lower application factor. In the absence of evidence to the contrary, curve (E) should be assumed so as to ensure protection.

36. When more than one chemical substance is present in a water body, possible interactions have to be taken into account, in the event that more than additive effects (synergism) or less than additive effects (antagonism) can occur. However, in the vast majority of cases for which data exist the response is simply additive. This was the clear conclusion reached in a review of the toxicity of mixtures to freshwater organisms made by the EIFAC Working Party on Water Quality Criteria (Alabaster and Lloyd, 1982). Although most of the available data relate to freshwater organisms and very few to marine organisms, as a first approximation it is reasonable to assume that synergistic or antagonistic effects will arise equally rarely in the marine environment.

37. However, it is still a matter of debate among scientists whether or not the effect of concentrations below the no-observed effect level are additive. The EIFAC Working Party concluded, on the basis of their extensive review, that this is unlikely (Alabaster and Lloyd, 1982). Other groups (e.g. EPA in the U.S.A.) ask for a reduction in the established acceptable levels when more than one substance is present. Obviously in all cases where the acceptable levels have been defined without sufficient information it is advisable to consider concentrations to be additive in their effect.

38. In the case of accumulative substances, control of the concentration in water may not be the best means to protect the ecosystem or any of its components, including man. A few metals, radionuclides and some organic substances are selectively retained in the living tissues of organisms where they may cause direct effects, or may be transferred via the food chain to other organisms. In these cases, the concentration in the tissues should be measured and used to derive control measures. For example, the level of mercury in aquatic organisms has been used in the U.K. to arrive at a maximum allowable discharge of mercury to coastal waters (Preston and Portmann, 1981). A second example of indirect protection of fish-eating sea birds against the effects of accumulative chemicals is the definition of an acceptable level of induced enzyme activity (e.g. acetyl-choline-esterase and mixed function oxidases) in bird liver. Tainting of seafood by phenols can also be used as "early warning" of pollution from petrochemical complexes. Therefore, the bioconcentration factor (BCF) can be used as an instrument of control.

39. Potential bioconcentration factors for organic substances can now be predicted on the basis of physico-chemical properties, using water solubility and/or partition coefficients in n-octanol/water (Neely et al., 1974); see Figure 4. In some instances, where biodegradation occurs, the BCF derived from physico-chemical properties may be too high. In contrast, where biomagnification via the food chain occurs, the derived BCF will be too low. However, this is only significant for substances having poor elimination rates. It should be understood that the phenomenological bioconcentration factor is only a simplified, pragmatic substitute when data on biogeochemical cycles are missing.

3.2.2 Classification of pollutants

40. Several authors have attempted to classify pollutants by a variety of systems (see, for instance, Page, 1983; Morel and Schiff, 1983; U.S. EPA, 1984). Methodologies could proceed along one of two pathways or, possibly in some cases, simultaneously: (a) a whole effluent approach, and (b) a chemical-specific approach. The simultaneous application of both approaches might be needed where (a) is appropriate for a portion of the input and (b) is more appropriate for certain contaminants contained in the discharge. The choice of the most appropriate pathway can be made by identifying the classes of contaminants in the discharge.

41. Wastewater contaminants can be divided into four classes according to Page (1983):

Class I - nutrients and natural organic materials in the form of suspended solids, ammonia and other natural oxygen-demanding materials. These materials naturally cycle through ecosystems in large quantities. Heat discharges would fall into this category.

Class II - pathogens: bacteria and viruses.

Class III - heavy metals such as lead and cadmium in far greater concentrations than appear in natural systems.

Class IV - toxic chemicals which, by affecting the genetic code (genotoxic) may cause carcinogenic, mutagenic and teratogenic (CMT) effects and diseases. Many synthetic organics and radioactive materials fall into this class.

42. In general, the environmental uncertainty increases from Class I to Class IV. This is due to a greater knowledge regarding the lower classes and relatively less knowledge regarding Class IV.

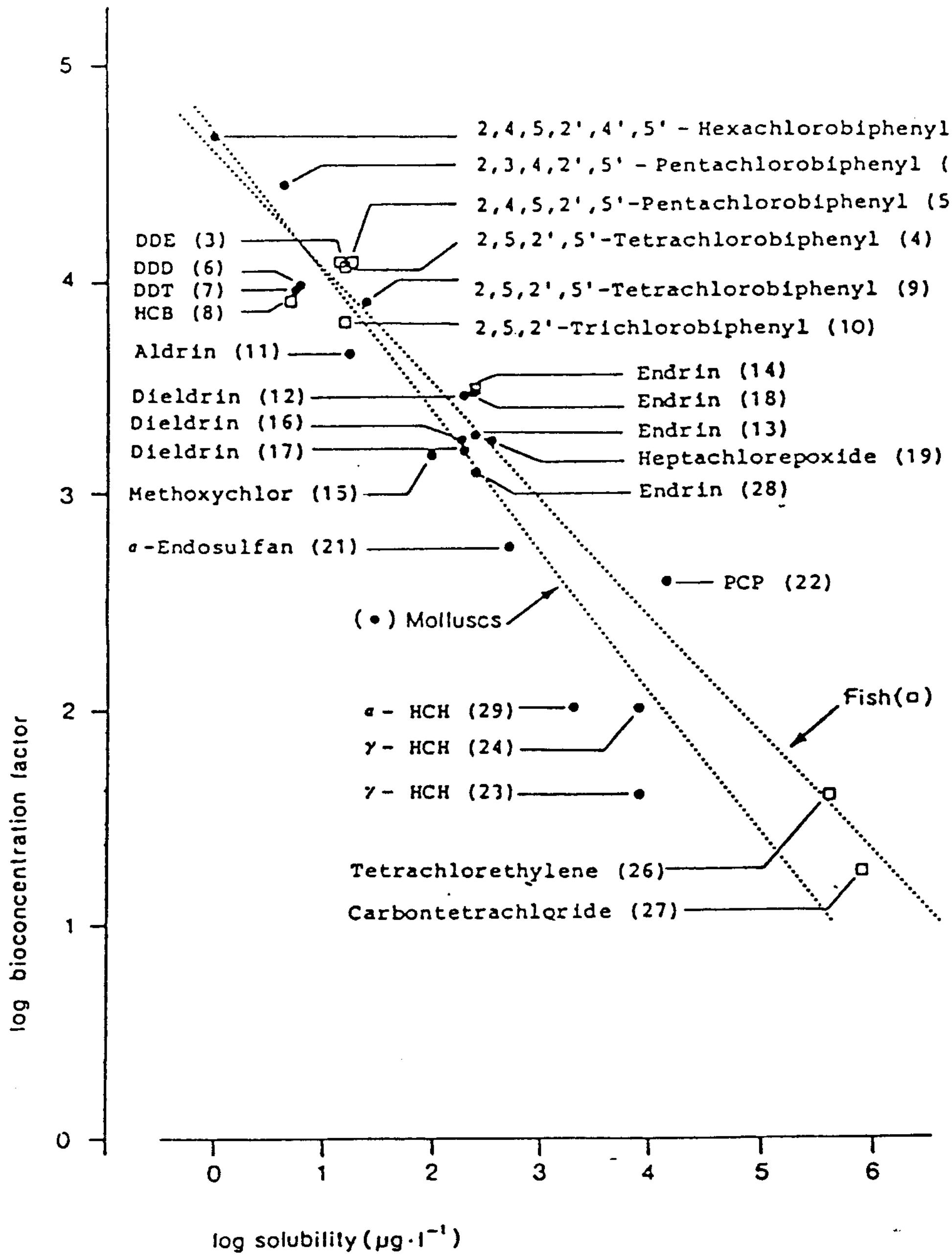
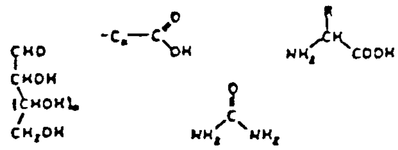
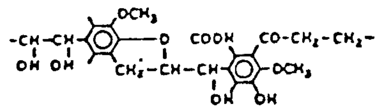
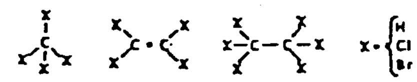
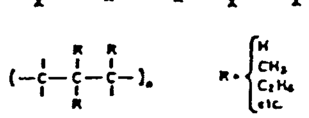
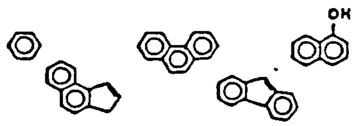
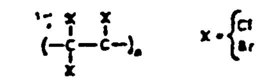
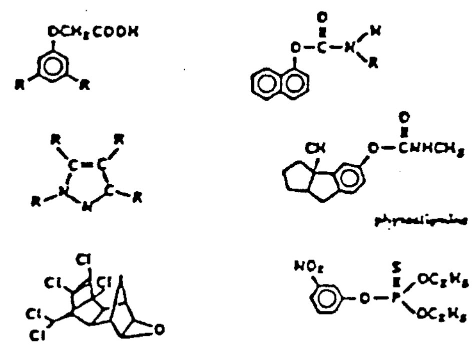
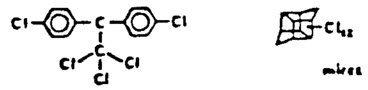
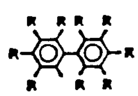


Figure 4. Correlation between water solubility and bioconcentration factors of organic substances in fishes and bivalves
(From Ernst, 1980; reproduced with kind permission of the Biologische Anstalt Helgoland. 1980)

43. Page's classification includes a range of constituent classes, covering the spectrum from (traditional) constituents which have been part of the evolutionary experience to the non-traditional which have not. These reflect a gradient in environmental concern. The former have been accommodated by marine systems throughout history, but are now being added in amounts exceeding

Table I

Classification of components in wastewater
(From Mc l and Schiff, 1983. Reproduced with kind permission of)

Family of Compounds	Examples of Structures	Examples of Compounds
Class I. Easily Degradable (Environmental half-life < ½ year)	Used by living organisms for energy and building components.	
amino acids volatile acids sugars urea fatty acids		– glycine – acetic acid, propionic acid, butyric acid – glucose – oleic acid
Class II. Moderately Persistent Compounds (Environmental half-life ½ to 5 years)		
a. biogenic humic acids lignin chitin		biogenetically produced polymers/ naturally synthesized polymers
b. xenobiotic LMHH – low molecular weight halogenated hydrocarbons		chloroform, CCl_4, 1,1,1-trichloroethane, tetrachloroethane, CH_3Br, dichloroethanes (some of these may be produced by algae)
PHC – petroleum hydrocarbons		alkanes, branched or cyclic hydrocarbons
aromatic hydrocarbons		benzene, alkylbenzenes, naphthalene, anthracene, 3,4-benzopyrene, benzofluoranthenes, dibenzanthracenes, indenopyrenes, phenols, chrysenes, cresols
HPHC – halogenated petroleum hydrocarbons		chlorinated paraffins, polyvinyl chloride
some pesticides	 physostigmine dieldrin parathion	methoxychlor, heptachlor, chlordane, endosulfan & metabolites, endrin & metabolites, aldrin, dieldrin, 2,4-D, silvex
Class III. Very Persistent (Environmental Degradation half-life > 5 years)		
a. non-xenobiotic kerogen		biogenetically produced polymers; few reactive functional groups
b. xenobiotics some pesticides	 mirex	DDT, DDE and metabolites, kepone, mirex
CB – chlorinated benzenes and other chlorinated aromatic compounds		
PCB's – polychlorinated biphenyls		Aroclor 1254, Aroclor 1242

the rate at which they can be accommodated in some situations. The latter are relatively new and may not have biogeochemical systems that can accommodate them without adverse effects.

44. Morel and Schiff (1983) proposed a general framework for understanding the environmental pathways of organic compounds that should prove useful in assessing environmental threat in classifying them primarily on reactivity or residence time (an inverse function of the reactivity) (Table I). Although the classification (I - easily degradable, II - moderately resistant and III -very resistant to degradation) does not per se provide an unqualified indication, risk generally increases from Class I to Class III.

45. This discussion suggests that some environmental risk will have to be assumed in the disposal of any contaminant to the marine environment. For traditional contaminants, there is a greater understanding and water quality standards developed and tested through experience seem adequate. For other contaminants (i.e. Class IV), a calculation of the assimilative capacity and an evaluation of risk within the context of Decision Analysis would be appropriate.

3.2.3 Environmental distribution

46. Knowledge of both the environmental and discharge characteristics is necessary in tracing the possible distribution of a contaminant from source to ecosystem. Some valuable information regarding the behaviour of a chemical released into the environment can be obtained through study of biogeochemical processes. However, in cases where only limited environmental data are available, the physico-chemical properties of the substance, including partition coefficients for the equilibrium distribution between phases, are valuable in predicting its probable behaviour. In particular, those environmental components in which the substance is likely to accumulate and those exposure pathways which will probably be the most important can be identified.

47. Over the last few years, it has become possible to establish the degree of affinity of chemicals to the fundamental environmental compartments (water, air, soil, biota) on the basis of four physico-chemical properties: S - water solubility; H - Henry constant; K - soil absorption coefficient; K - n-octanol/water partition coefficient. The values for these parameters can both be measured experimentally or calculated by means of property-property correlation equations (Kenaga and Goring, 1980). On the basis of these simple approaches, more complex calculations can be made using relatively simple models such as the fugacity model of Mackay and Peterson (1981), which allows the predicted environmental distribution (PED) to be calculated. More complex models based on the same principles have been developed. A limiting feature of these models is that, being based on thermodynamic principles, kinetic aspects of pollutant distribution have been largely neglected.

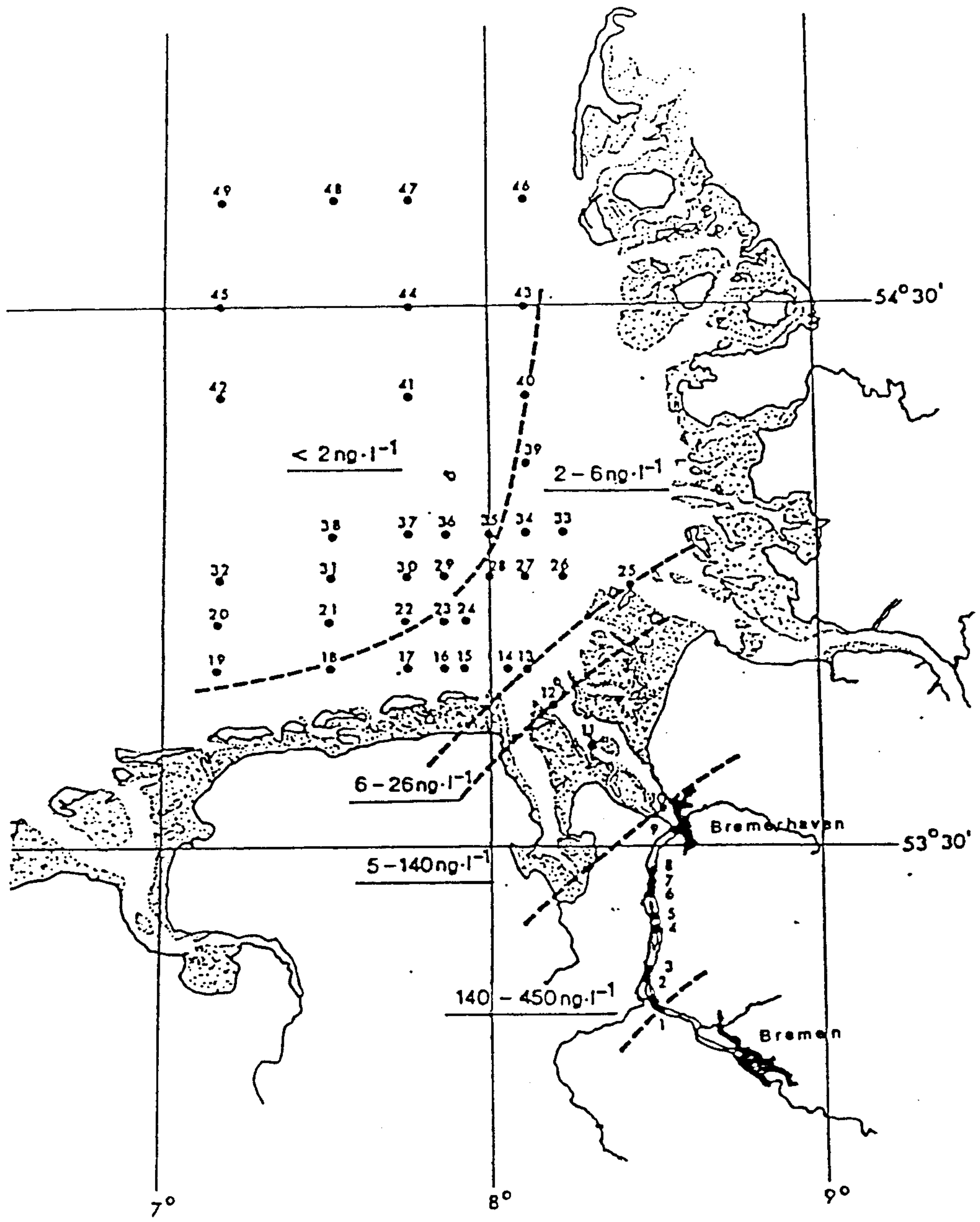
48. The extent to which physical processes contribute to the pollutant dispersion will be determined by topographic characteristics (shore lines, bottom slopes, existence of sills) and oceanographic characteristics (currents, rate of exchange with offshore waters, vertical gradients and stratification plumes, fronts, etc.), and the characteristics of the discharge itself (coastal, surface or deep water pipeline, jet or diffused discharge, etc.). Further consideration of physical processes will be found in subsection 3.2.5.

3.2.4 Environmental fate

49. Persistence in the environment of a given substance strongly depends on the characteristics of both the substance and the environment. Certain substances may be removed from the marine environment or rendered harmless by chemical transformation into naturally-occurring substances. Some of the removal processes involved are photolysis and photo-oxidation, biodegradation and metabolization, sedimentation and sediment burial, transfer into the atmosphere, etc.

50. Other substances, particularly some of the synthetically-produced organic chemicals may not be readily removed from the environment and thus become a potential threat in view of their persistence.

51. Few attempts have been made to obtain the data on organic chemicals needed to predict their environmental fate; however, some information is available. For further details, reference may be made to Haque (1980), Ernst (1984) and Hutzinger (1980, 1982). Many more data are available on degradability (references in Calamari et al., 1980) and for a number of substances their persistence is predictable, although the problem is still controversial, particularly on methods for studying biodegradation (Gerike and Fisher, 1979, 1981) and in the application of laboratory data to the field.



'igure 5. Distribution of pentachlorophenol in the Weser Estuary and the German Bight (After Ernst and Weber, 1978. Reproduced with kind permission of Institut für Meeresforschung, Bremerhaven. 1978)

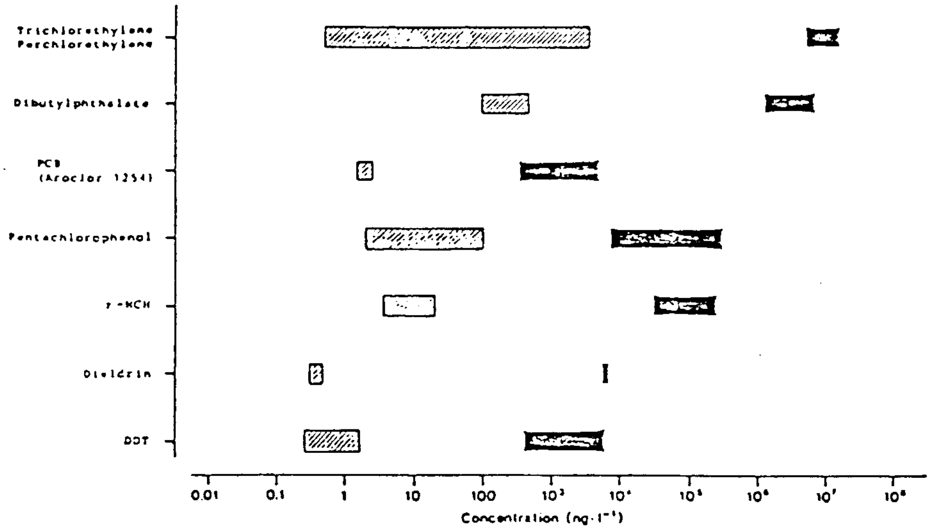


Figure 6. Reported concentrations of chemicals in sea water (hatched bars) and their experimentally-derived toxic concentrations (black bars). Left ends of bars refer to most sensitive species, and open-ocean concentrations. Right-hand ends of hatched bars refer to estuarine levels.
(From Ernst, 1980; reproduced by kind permission of the Biologische Anstalt Helgoland. 1980)

52. Although most organic components exhibit significant rates of degradation in laboratory tests, their degradation under marine conditions is likely to be lower, owing to the lower concentration of heterotrophic biomass in coastal water and the open sea. On the other hand, dilution processes in estuaries and coastal water occur (see Figure 5).

53. Metabolism, in organisms, plays a minor role in the transformation of environmental contaminants. This may lead to concentrations in the field which slowly accumulate so long as addition continues, with the consequence that observed environmental concentrations are not far below those known to cause effects (Figure 6). When data are available a transformation matrix can be prepared, and with data on time of persistence (see subsection 4.2.5), a predicted environmental concentration can be calculated.

54. Biological processes in various components of an ecosystem may hinder or enhance the mobility of contaminants, thus influencing the size of the impacted area. In the water column, primary production or bacteriological oxidation-reduction may enhance the removal or degradation of contaminants. Likewise, processes such as bioturbation and sediment irrigation by macro infauna or microbial oxidation-reduction may mobilize sediment-bound pollutants.

55. A quantitative description of the kinetics of interacting processes responsible for decay and/or dispersal of contaminants in the system is needed. The kinetic coefficients will determine the concentration of contaminants at steady state and changes with time. Alternatively they can be expressed either as mean life times of decaying substances or as mean residence times of entities which are subject to a conservation law (e.g. mass, amounts of chemical elements). However, all time-related parameters must be defined precisely and in operational units. It is important to distinguish between mean life of a chemical and mean residence time of a chemical (subsection 3.2.6). Whenever non-steady state conditions prevail crude approximations might be necessary but care should be exercised in applying them.

3.2.5 Definition of boundaries of the impacted ecosystem

56. An essential step in assessing the environmental impact of a discharge is the recognition of the boundaries within which the ecosystem might be impacted. The diversity of site-dependent factors and of the physical and biogeochemical characteristics of both the ecosystem and substance as well as their time and space variability makes the definition of boundaries difficult.

57. At least three types of sites can be distinguished:

(1) An enclosed type (e.g. lagoon or gulf). This usually has restricted exchange of water and is most amenable to definition of boundaries of the impacted ecosystem. In its simplest form, it can be modelled as a lake.

(2) A semi-enclosed type (e.g. estuary or river mouth) will be amenable to mathematical descriptions similar to those used in determining a plume or sediment dispersion, or of the salinity or density field in the mixing region. The magnitude and potential influence of tidal exchange must be taken into account.

(3) The open coast type, especially if it is subject to strong long-shore and off-shore currents, the boundary might extend far along the coast on either side of the site of discharge and perhaps far out to the open ocean.

In all cases a further extension of the boundaries to coastal wetlands may be expected under strong tidal regimes.

58. In the case of suspended particulate materials, heat and other such contaminants, the impacted area is basically determined by hydrodynamic processes. For other contaminants, high persistence, toxicity and hydrodynamic or ecological mobility will tend to extend their impacting area, while easy removal or accumulation in sediments and sessile organisms will do the contrary. For a given amount of a substance, the larger the area impacted the lesser the intensity of the impact and vice versa.

59. A discharge may occur as continuous, intermittent, occasional or accidental releases, and may be from both point or non-point sources. For continuous releases, the boundaries will be determined mostly by considerations of contaminant persistence, system hydrodynamics and biogeochemical cycles. Whether operational, non-point source or accidental, intermittent releases present the greatest difficulties. Furthermore, many of the characteristics of an aquatic ecosystem (mean residual current velocity, temperature, density and salinity, biological activity) are subject to diurnal, seasonal and annual fluctuations.

60. From the viewpoint of hydrodynamics, the boundary may be defined on the basis of topography, currents, and gradients of physical properties. A preliminary study using simple physical or mathematical models may provide an adequate estimate of concentration distribution.

61. In the absence of sufficient information, an arbitrary boundary developed from successive approximations may be used, although eventually careful data acquisition and/or modelling must be performed to take account of seasonal variability of the phenomena. In most cases, contaminants escape from the impacted ecosystem, and an assessment of the fluxes exported is required.

62. Other factors which influence the size of the impacted area include:

- biological processes which hinder or enhance the mobility of contaminants;

- geochemical processes such as precipitation, dissolution, absorption and desorption which influence the residence time of a chemical contaminant in the water column,

- physico-chemical processes, such as oxidation-reduction and photochemical reactions which can accelerate the degradation of some organic contaminants.

3.2.6 On the calculation of environmental capacity

63. The environmental capacity of an ecosystem can be calculated using the information listed above. An impacted area may for convenience be divided into zones, for instance near- and far-field. Starting from a simple steady-state box model a preliminary calculation can be made and progressively refined by the inclusion of more parameters and variables.

64. Mean life of a chemical species is the ratio between the amount of this species (in mol or kg) in a given closed system and its rate of disappearance in this system (in mol/s or kg/s). Mean residence time of a material (e.g. of a chemical element) in an open system at steady state is the ratio between the amount of this material in the system (in mol or kg) and the rate of throughput (in mol/s or kg/s). It is important to distinguish these two different quantities.

65. Simple mass balance models such as those using the mean residence time concept may provide a good insight, although more complex models may have to be applied if a greater degree of accuracy is required. Numerical and/or probabilistic models might be helpful when various degrees of complexity and uncertainty are evident.

66. For a closed system, the environmental capacity is given by the total load, which is the volume of the system multiplied by the difference between the maximum allowable concentration and the existing concentration in the system. This input will bring the system up to the maximum allowable concentration after which any further input would be unacceptable.

67. For an open system, the environmental capacity is given by the sum of the capacity of a closed system and the flow-through capacity output of the substance being introduced.

68. Therefore, in a steady state condition, when the maximum allowable concentration is reached, the environmental capacity remaining is a function of the flow-through rate or the mean residence time.

69. An application, a posteriori, of the mass balance calculation has been made by Schwarzenbach et al. (1979) for Lake Zurich, using distribution, residence times and fluxes of 1.4-dichlorobenzene and tetrachloroethylene. The seasonal distribution of these compounds reflects lake circulation and is compatible with the assumption from laboratory studies that mass transfer to atmosphere is the principal elimination process. A mass balance has been established and an average residence time found for the chemicals. By applying a single box, steady-state model, a mass transfer coefficient has been obtained. However, the model used was somewhat conservative because the value obtained was smaller by more than an order of magnitude than those found typically in the laboratory, and for the open ocean.

70. Using this approach as an initial step and allowing for and considering possible limitations, similar calculations can be made for other, non-conservative, molecules.

71. More complex models based on the same principles are the QWASI (Quantitative Water, Air, Sediment Interaction Model) (Mackay et al., 1983, 1983a) or that produced by EPA, the EXAMS (Exposure Analysis Modelling System) (Burns et al., 1981). The QWASI model describes the fate of a chemical in a lake system comprising water, bottom sediments and suspended matter, and air. Equilibrium is quantified using the fugacity concept and fugacity capacity. Fugacity is defined as the tendency of a chemical to transfer from one compartment to another. Equations are derived from processes of advective flow, volatilization, sediment deposition and resuspension, atmospheric deposition and degrading reactions (Fig. 7). Similar calculations have been employed in Italy for preparing a strategy of control of phosphorus to prevent eutrophication in the Adriatic Sea (Chiaudani et al., 1983).

72. Their model for the prediction of the trophic state in a marine coastal area assumes a single river input with high load, and the parameters considered are phosphorus concentration in river and sea water and salinity distribution in the sea. When applied to Northern Adriatic coastal waters, the calculated chlorophyll concentrations show good agreement with experimental data. Then, different possibilities of reduction of phosphorus loading in the river basin are used to derive estimates of trophic state attainable in the given conditions.

73. These examples demonstrate that environmental capacity can be calculated using different models. The degree of complexity of the models will be determined by the needs identified by the users. In some instances, a satisfactory model may not be possible due to the particular complexity of the case under examination.

3.3. Choice of Objectives, Targets and Pathways

74. If water quality criteria are adopted they will usually serve to protect the water use desired. However, an assumption is normally made as to which use is likely to require the most stringent criteria. If this proves inaccurate, other water uses may be at risk. Accordingly, a variety of pathways and targets should be examined to decide which is most sensitive.

75. This has been done in a number of cases for a variety of contaminants, but it is most thoroughly conducted in the field of radiological protection where the process is known as critical pathway analysis (CPA). The CPA method is internationally accepted as a means of defining the quantity or rate of discharge of a particular radioisotope which can be discharged to a particular environment (Slansky, 1971; IAEA, 1978).

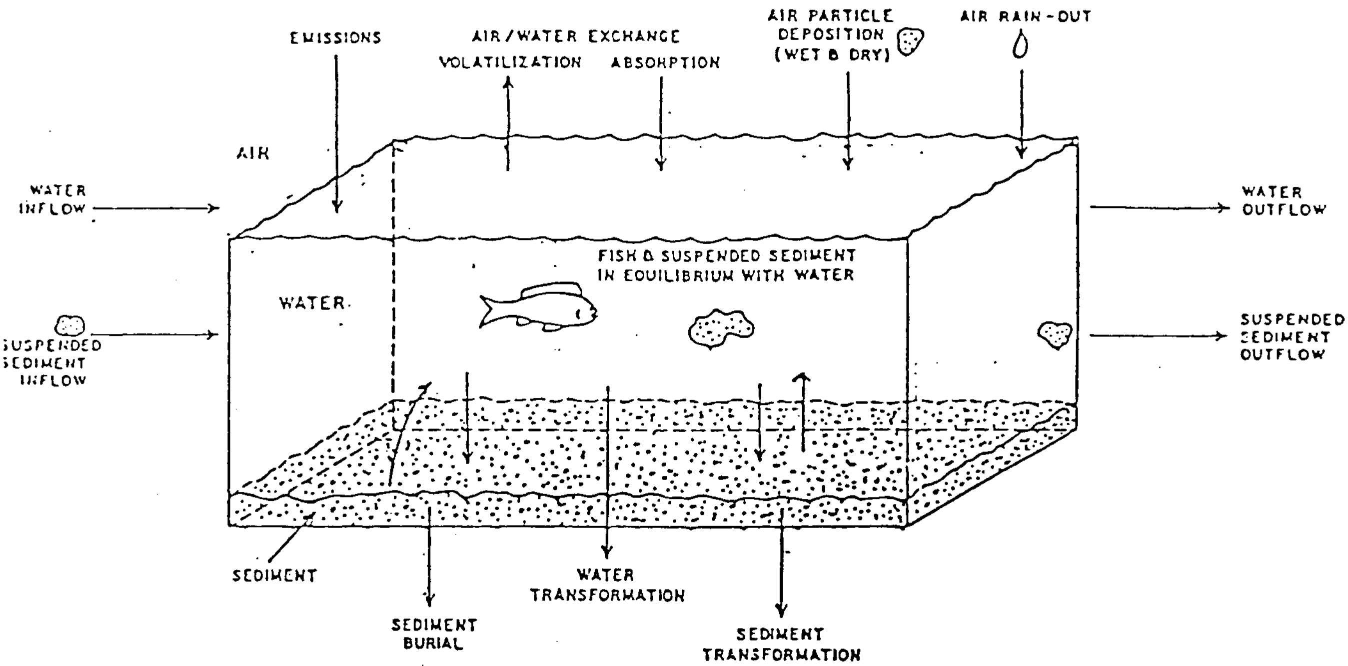


Figure 7. Diagram of QWASI river Section
(After Mackay et al., 1983a. Reproduced with kind permission of Pergamon Press. 1983)

76. For a radionuclide it can usually be assumed that man is the target of greatest concern and also considered most likely to be affected . The group most at risk and the route or routes by which exposure occurs can then be identified. This allows the dose to be calculated and exposure limits defined. Internationally-agreed Radiological Protection Standards have been specified and are used to set discharge limits. These are usually based on what can reasonably be achieved commensurate with minimal exposure to the critical group, i.e. as low as reasonably achievable (ALARA).

77. It has been suggested that the same formal approach can be applied in a much wider context to other types of contaminants (see e.g. Templeton and Preston, 1982; Preston, 1982). An example of such an application was that adopted by the U.K. in regulating the discharge of mercury to its coastal waters (Preston and Portmann, 1981).

78. The application of the CPA type of approach to pollutant classes other than radionuclides may call for some modification of these procedures. A single target (e.g. man or commercially-valuable fish, or a threatened, rare species) may not necessarily be identified, and a natural community or ecosystem may be threatened, or a combination of contaminants may interact. This latter condition is, indeed, likely to be the reality at sites of coastal development where there are usually discharges from energy generation, sewage discharge and complex industrial activity.

79. In general terms, the choice of targets might follow a similar approach to that adopted for radionuclides. An example of a pathway to man or marine organisms is given in Figure 8 where a unidirectional sequence of steps is shown. Various feedback loops can be superimposed to allow for regulatory control, the results of environmental surveillance of monitoring undertaken to assure the validity of prediction, or revision of standards in the light of new information. Other targets to be protected are sensitive and commercially important species, rare and endangered species or communities. It should also be assured that important biological processes such as photosynthesis (primary production) or essential enzymatic processes will not be disturbed. Organic synthetic compounds deserve special attention since they are usually present in complex mixtures of components with different physico-chemical properties.

80. The selection of the most sensitive target and/or pathway may not always be revealed by a strictly deterministic approach. This problem can be resolved by techniques such as decision analysis, probabilistic analysis and iterative reassessment (see section 3.4).

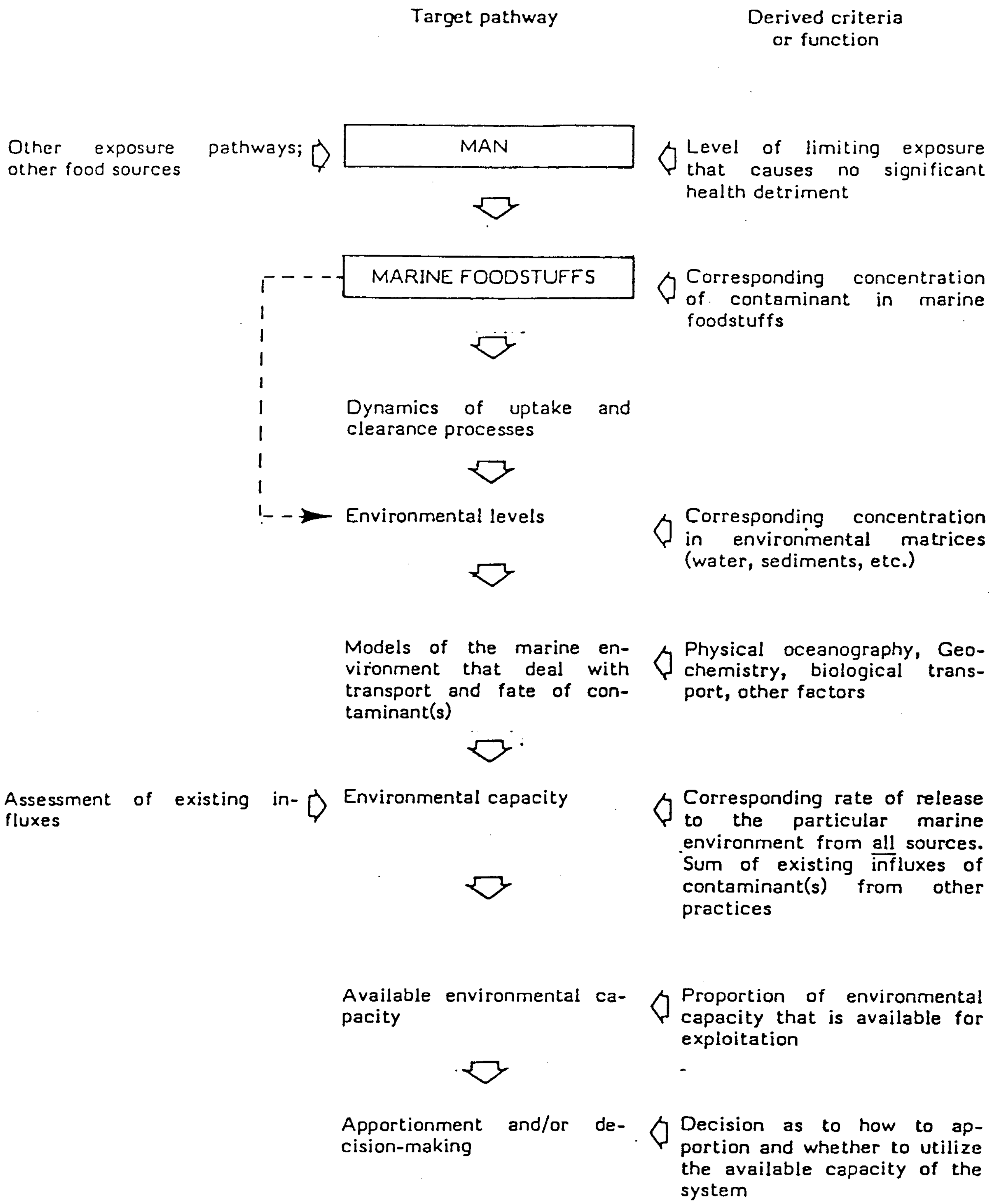


Figure 8. An example of radionuclide pathway, which will be followed in assessing marine environmental capacity, that takes into account detriment to human health through ingestion

Data and assessment needs	Target pathway	Derived criteria or function
Community structure and size, sensitive components	BENTHIC ORGANISMS OR COMMUNITIES AND HABITATS	Level and duration of exposure that allows continued community maintenance in the area. Availability of similar habitats nearby
Site characteristics. Nature of discharge(s). Size and timing of discharges	Deposition loading	Acceptable level will depend on local bottom/shore conditions and interactions with other exposures (BOD, temperature, toxic chemicals) needed
	Water column loading	
Dynamics of sediment behaviour. Dose-response functions. Validation in field	Models of sediment behaviour and biological responses. Prediction of extent and timing of effects	Physical oceanography. Geochemistry. Biological reactions
	Environmental capacity	Rate of release of similar discharges. Background of natural releases. Interactive effects of other discharges
Assessment of existing discharges	Available capacity for new discharges	Proportion available for new discharge. Define acceptable level of discharge load and any limiting conditions
Decision Analysis	Apportionment of capacity. Decision on control, timing, or alternative disposal route	Alternative actions - reduce load from other sources, reduce interactions, divert waste to less sensitive site

Figure 9. Pathway for assessment of sediment discharges

Data and assessment needs	Target pathway	Derived criteria or function
Community size and structure; sensitive species or life stages	BIOLOGICAL COMMUNITIES, SPECIES	Level and duration of exposure that is acceptable to community/species maintenance
Site characteristics. Discharge characteristics, including timing	System heat budget	Define heat increment acceptable for location, season, habitat
Validation of modelled heat loss. Dose-response functions. Validation in field	Model heat dispersion by advection, mixing, loss to atmosphere. Model biological response, both species and communities	Physical oceanography. Meteorological and climate data. Biological reactions
Assessment of existing discharges	Environmental capacity	Rate of release of similar discharges. Release of natural thermal inputs to system. Interactive effects, e.g. O_2 and sediments
	Available capacity for new discharges	Define acceptable rate of release and any limiting conditions (e.g. season)
Decision Analysis	Apportionment of capacity. Decision on control, timing, Alternatives	Alternative discharge via cooling towers, ponds, canals. Alternative discharge limits and costs

Figure 10. Pathway for assessment of heated discharges

81. In some instances it will be impossible to solve all the identified difficulties or to fill the gaps in information quickly enough to allow full application to the problem in question. This may be the case where new developments are proposed in a developing country. If a project nonetheless is to proceed, other methods (e.g. BPMA, Section 3.1.1) may still be applied.

82. The application of this approach to some common discharges is illustrated in Figures 9, 10 and 11.

83. For sediment discharges or disturbance, littoral or benthic communities may be at risk only through their physical effects. However, significant interactions with other contaminants may have to be taken into account.

84. Thermal discharges have been dealt with by GESAMP (1984). As a contaminant, heat is transitory and may influence the fate and behaviour of other contaminants. Significant latitudinal and seasonal differences will influence the potential capacity of shore environments to accumulate discharges of heated water.

Data and assessment needs	Target pathway	Derived criteria or function
Community size and structure; sensitive species and life stage; sensitive processes	BIOLOGICAL COMMUNITIES, SPECIES, BIOLOGICAL PROCESSES, MAN - amenity and waste disposal	Lower limiting concentration and duration of BOD acceptable to biological communities or species
Site characteristics. Discharge characteristics	Oxygen budget and transfers	Define organic discharge loads acceptable for location
Validation of model in field. Dose-response functions. Validation in field	Model physico-chemical oxygenation processes. Model oxygen dependent biological processes	Atmospheric exchanges. Physical oceanography. Chemical oxygen demand. Biochemical oxygen demand
Assessment of existing discharges	Environmental capacity	Rate of release of other discharges, including natural inputs. Interactive effects, e.g. temperature
	Available capacity for new discharges	Define acceptable release rate
Decision analysis	Apportionment of capacity. Decision on control systems, alternatives	Alternative systems and costs

Figure 11. Pathway for assessment of BOD in discharges

85. Discharges of organic matter are commonly associated with any development. The retention of oxygen and oxidative capacity in a receiving environment is essential both for its biota and for important biological processes which are involved in assimilation of other contaminants.

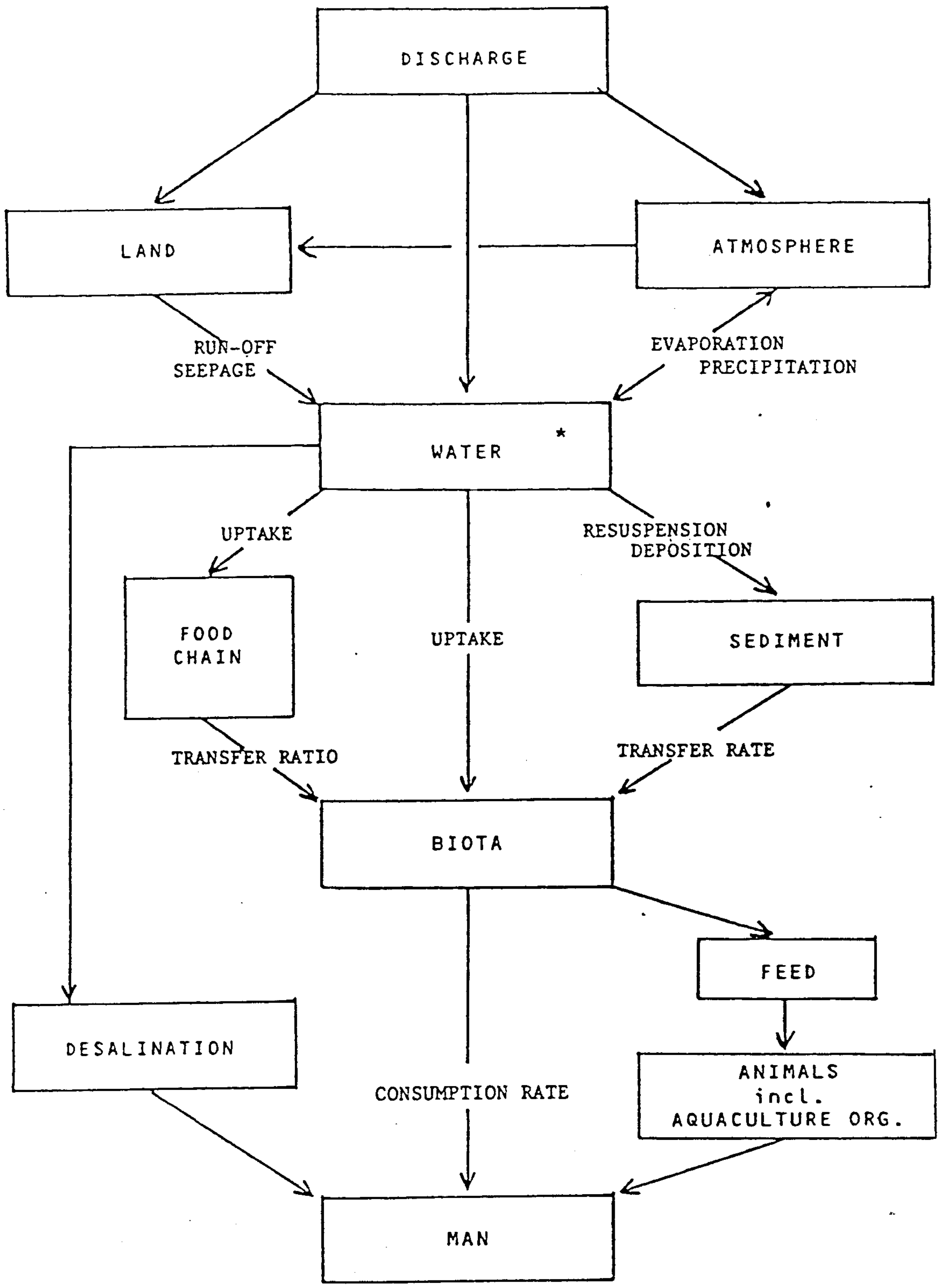
86. These fall into a class of contaminants that have some of the characteristics of non-conservative material (Fig. 12), but their persistent residues may be concentrated rather than dispersed by the natural ecosystems. In some cases they may be further concentrated by sequestration in particular tissues (like radionuclides). They are much more diverse in nature, however, and may not be as easily measured as radionuclides or other elemental body burdens.

87. Sediments and suspended matter may exert, according to their particle size, significant sorption potentials for organic compounds and should be taken into account to protect bottom living and sediment-feeding fauna. Effects of organic compounds on marine species or ecosystems might be expected after long-term exposure at the low concentrations actually present, assuming that there is no threshold of effect.

88. In the past, the hazard of such materials has been recognized only when harm is evident (though not necessarily irreversible). Knowledge of the chemical nature of these substances and

Data and assessment needs	Target pathway	Derived criteria or function
Communities, size and structure; sensitive processes	TARGETS OTHER THAN MAN	
Site characteristics, e.g. bay, lagoon, sediment-type	Loading capacity for defined receiving environment	No-effect level, derived from laboratory test, including safety factor
	Model of fate and environmental distribution	Transformation, degradation, bioconcentration, biomagnification, geoaccumulation. Physical oceanography (hydrodynamic regime)
Background levels	Environmental capacity for compound in question	Rate and characteristics of other discharges

Figure 12. Pathway of assessment of organic synthetic compounds (targets other than man)



* Starting from levels of compounds in water, derived from "environmental capacity" concept

Figure 13. Schematic pathway of pollutants to man

their chemical transformations and biological responses (especially cmt effects) will help to identify their real or potential risks. This may allay the fears perceived in the absence of information by an exposed human population and may result in demands for costly and/or ineffective controls or alternatives even where risk is low. In this case the CPA type of approach seems appropriate. Particular attention should be given to susceptible stages in life histories where exposure is greatest or sensitivity critical, for example accumulation of fat-soluble pestide residues in birds eggs and associated egg-shell thinning.

89. As far as man is concerned as consumer of sea food, residues of organic compounds have to be established as being safe for human consumption according to legislation of the different countries (Figure 13 illustrates some of the pathways and identifies several targets).

3.4 Probabilistic Analysis as Applied to the Assessment of Environmental Capacity

90. Probabilistic analysis is an alternative approach to risk avoidance, traditionally exercised by making conservative assumptions. This type of analysis can be derived from the procedures of DA (Howard, 1966, 1975; Hietamaki et al., 1982). It would not by itself be a proper decision analysis which is designed to cope with an overall decision rather than do a probabilistic assessment alone.

91. In the application of a probabilistic assessment to this problem, the decision rule would be that the risk of exceeding the environmental capacity should not be more than some critical level of probability. The acceptable risk would have to be predefined.

92. The decision analyst and scientist together would model the environmental capacity using one of the methods described above. Using sensitivity analysis, the analyst would then determine what parameters and/or components of the preliminary model most change the measure of environmental capacity. These 'sensitive' variables would be encoded as a probability density function (pdf) over its range of possible values. This function would be based on structural interviews (Spetzler and Staël von Holstein, 1975) with expert scientists identified by the policy makers. By stating sensitive variables probabilistically, the analysis of environmental capacity produces a statement of the risk of exceeding the environmental capacity for each water contaminant of concern.

93. With such a probabilistic analysis, the policy maker can then set water quality standards just tightly enough so that society is willing to accept the remaining risk that unacceptable pollution will actually occur. Thus excessive expenditures or overly conservative control technologies can be avoided better than with an approach using non-probabilistic conservative assumptions.

94. If the control technology which is indicated as necessary to avoid excessive risk is too extensive or unavailable, then the policy maker must reconsider the socio-economic goals and alternative marine uses. If this does not result in reconsideration of water use and a revised classification then the decision must be either to accept greater risks of unacceptable pollution or not to allow the polluting activity to develop.

95. If, on the other hand, the necessary technology of control is less stringent than practicable, then the policy makers can allow the activity to develop with the higher effluent levels than BPMA would provide. This assumes that the social goals were currently identified at the start and all present and future activities were accounted for. Some may argue that more stringent control measures should be applied simply because they are feasible or because a pristine environment is a goal in its own right. Such arguments are economically unsound and analytically contradictory if the social goals originally identified were correct. Any decision to justify more stringent control should therefore be directed toward a re-examination of the relative social values of environment and economic development, and of the social attitudes towards acceptable levels of risk. This is primarily the job of the policy maker, not of the scientist.

96. A word of caution is needed concerning the interpretation of a probabilistic assessment of environmental capacity. The resulting probability density functions are not predictions of future events. Rather, they are expressions of an expert's subjective beliefs of the likelihood that each particular value is the true value for a range of possible values. This parameter usually has an exact fixed value for which the true probability is unity. However, the uncertainty which surrounds the location of the true value induces subjective opinions which effectively create a density function for the true value's probability. With research, the subjective probability density function should converge to the pdf of unity at the true value.

97. A probability density function is a prediction only when it is a repeatable stochastic event for which each outcome will occur with some measurable frequency. Since the outcome is repeatable,

then a correct pdf for that stochastic process will emerge and will predict the relative frequencies of various outcomes (although it will not predict the order of these outcomes). A subjective pdf on a parameter which is not stochastic but simply unknown at present can have no such predictive power. It is only a formal expression of the extent of that uncertainty. Since experts embody the most information on the particular parameter, then their beliefs would provide the best basis for such a pdf, and ultimately their views should be the best guidance for the decision-maker wishing to make use of scientific advice.

3.5 Presentation of Scientific Results

98. The presentation of scientific results is often the weak link between those tendering advice and those receiving it. Decision-makers, and the public at large, are rarely specialists and usually not conversant with scientific technology. Decision-makers are also often in the difficult position of having to take into account advice and information from a variety of sources, at times incompatible. The results of scientific studies should, therefore, be clear and concise, and expressed in non-technical language. Advice for scientists who are writing for non-specialists is available (Rathbone and Stone, 1962; NAS, 1970). Similarly, standard texts exist on oral presentation.

99. An effective method of presenting the results from a variety of studies in a comprehensive manner is through the use of graphic techniques. These can be used in conjunction with other methods and techniques such as geographic information systems, remote sensing, predictive modelling and computer-assisted data analysis. A cumulative, visual presentation of results will highlight the interrelationship of data and place specialist input against the overall context. Summaries of information and data, evaluation of risks, identification of hazards and assessment of impact, can all be presented graphically in map form. Such maps, which can show spatial distribution of abstract and hidden data, can range from a resource atlas, to vulnerability indices and hazard maps (U.S. National Ocean Survey, 1981; Tortell, 1981). They could take the form of a series of transparent overlays on a base map or the total data can be depicted on a single map. All data, including graphics, should be prepared in a manner suitable for computer storage and retrieval. Whatever the method used, the aim is to provide a cumulative, comprehensive picture without the need for a decision-maker to refer to different sources or sets of data.

4. VERIFICATION OF THE ASSESSMENT MADE AND ENVIRONMENTAL QUALITY CRITERIA ADOPTED

100. Once the acceptable level of input has been established, monitoring will be necessary both within a purely control framework and as an essential feedback mechanism to validate the model used. Thus, monitoring should be regarded as the measurement of a contaminant or its effects for reasons related to the assessment or control of exposure to that contaminant of either man or some other target. Two monitoring requirements will need to be fulfilled:

- measurement of the levels and/or effects in the environment,
- measurement of the rate of input to the environment.

4.1 Monitoring of Primary and/or Other Targets

101. Monitoring of levels of contaminants will usually start with a baseline survey to establish existing levels. This will be essential if previous introductions of the contaminant in question have already taken place either naturally or from man's activities. It may occasionally be possible to look for the first signs of effects of pollution, e.g. in sensitive areas, by biological monitoring. More usual, however, will be chemical measurement of the level of the contaminant in the water, sediments or biological tissue.

102. The levels found are then compared to the water quality criteria or relevant standards. In some cases, the comparison may be direct, e.g. the criteria for a metal in sea water but it may be more practical to use an indirect target as an indicator of the level of exposure of the primary target. For example standards for organochlorine pesticides to protect aquatic organisms will usually be expressed as a concentration in water but it will be more practicable to measure the pesticide in the tissue of the organism concerned or in its food. Such monitoring requires the definition of secondary standards. Once the primary standard and exposure pathways have been defined, this is usually comparatively easy to achieve.

4.2 Monitoring of Qualities and Quantities of Effluent

103. After discharge limits are set, it is essential that the extent of compliance be monitored. Such monitoring will also be necessary in order to verify the validity of the model and/or exposure routes assumed in establishing environmental capacity and safe input levels. If such data are not collected and the selected criteria or standards are exceeded there will be no way of knowing whether this is due to an error in the model or its assumptions or whether it was due to the developer failing to observe the discharge limits.

104. The pursuit of environmental monitoring without the ability to interpret the data generated will rarely be profitable, unless it is undertaken in the context of a basic scientific investigation of spatial and temporal trends and statistically designed to answer certain key questions. If the latter is the case, the frequency of surveys can usually be substantially reduced compared to that of regulatory monitoring programmes.

4.3 Incorporation of New Information and Reassessment

105. It is rare that a development proceeds and continues exactly as initially planned. The user demand may change, resulting in either expanded or reduced production or even in the need for a new process. Process technology is continuously developing and chemical plant life is usually not longer than ten to twenty years. Monitoring programmes should therefore be planned on an appropriate time scale. Other developments may take place in the general vicinity of that which was first considered and populations of people and animals may change substantially. Social habits and values may also change, e.g. a marine organism which was previously not exploited may find a new use either as a food or for some other purpose (e.g. fertilizer). Furthermore, scientific knowledge and understanding is generally expanding and improving and may, with time, justify reassessment.

106. All these changes may require a reassessment of the impact. Reassessment may lead either to a tightening or a relaxation of the control measures necessary. In some cases it may even reveal a new, more sensitive target than was originally perceived or identified. In such a case a complete reappraisal of the situation will be necessary.

5. GUIDELINES FOR THE SCIENTIFIC ASSESSMENT OF THE IMPACT OF POLLUTANTS ON THE MARINE ENVIRONMENT

107. These guidelines are intended to assist scientists who have been given the task of determining the potential impact of discharges into the marine environment from a particular industrial development or other human activity. Other specialists will also be assigned parallel tasks in order to assist the decision-maker. Interaction between them will assist in the decision as to whether a development or activity should proceed and under what conditions. The input of the scientist will be directed toward the development of measures to restrict impacts within acceptable limits (Chapter 3.). Some guidance is also provided on the presentation of results and for undertaking monitoring studies (Sections 3.5 and 4.1-2).

5.1 Descriptive Studies (Information Collection Phase)

5.1.1 Factors related to the project, to be identified

108. (1) Type of activity, physical size, site requirements, physical location of development or activity and infrastructure in relation to the marine environment.

(2) Stage of commitment, timing, options, necessary approvals.

(3) Technical/engineering processes involved, options.

(4) Resource requirements likely to lead to inputs: energy, water, routes of import and export of raw materials and products for the site (port, jetties, etc.).

(5) Potential environmental hazards - Collect information on environmental behaviour, toxicity and fate of raw materials, products, by-products and other associated releases such as:

- organic materials subject to rapid degradation
- nutrients
- persistent organic materials (including halogenated organics)

- radionuclides
- metals and other inorganic materials
- particulate materials
- pathogenic micro-organisms or nuisance organisms
- energy (heated effluents or radiation)
- petroleum hydrocarbons and petrochemicals.

(6) Collect information on the interaction of discharges with the receiving environment and with each other.

(7) Collect information on any existing environmental quality objectives, criteria or standards applicable locally.

5.1.2 Information related to the existing environment

109. Before embarking on the indiscriminate collection of data on the existing environment, the likely impact and relevant goals should be identified. These should reflect 'acceptable' levels of contamination and risk assigned by a wider group than the scientists alone. They should also serve the needs of any models which might be used (Section 3.2). Uncertainties may be addressed either by an explicit evaluation of the risk involved in exceeding acceptable levels or through the adoption of conservative assumptions and safety factors (Section 3.4). Subsection 5.1.3 is an indicative list of the parameters to be taken into account. The particular circumstances will determine what is appropriate. Some data would normally be readily available, other data may require detailed investigation, perhaps over a substantial time scale before they can be obtained. Wherever applicable, seasonality should be taken into account. If an urgent response is called for, crude approximations may be required.

5.1.3 Environmental variables to be measured

110. (1) Climatology: wind direction and speed, gust strength; rainfall distribution, periods of precipitation longer than 24 hours; storm events.

(2) Terrestrial geology: land types/uses, topography, vegetation cover, erosion, accretion; volcanicity, seismicity; special features.

(3) Marine geology: bathymetry; sediment types and other characteristics; stability, seismicity; littoral drift (transport), erosion, accretion; special features.

(4) Marine and coastal hydrography and physico-chemical characteristics: tidal regime, currents, wave patterns, circulation; temperature, salinity, density, dissolved oxygen, alkalinity, pH; nutrients, particulate organic matter, other suspended solids.

(5) Biology: rare and endangered species; species diversity and habitats; population structure and trophic interrelationships; biomass, productivity, biochemical constituents and essential processes.

(6) Human values and uses: fishing for food and other products; aquaculture, transport and communications; sand or gravel extraction, other mineral extraction in the coastal zone from the sea bed; salt extraction; desalination for water supply, other mineral extraction from the water; waste discharges, existing and potential, domestic and industrial; archaeological, historical, aesthetic values; recreation, tourism; reserves and other special designations, demography and human health.

5.2 <u>Assessment of Pollutant Impacts</u>

111. From a knowledge of the contaminant substances and the quantities to be discharged, existing background levels, as well as biota and human uses at risk and bearing in mind existing water quality criteria or standards, the extent of impact on the receiving environment can be assessed. This will involve some, or all, of the following steps.

5.2.1 Definition of boundary conditions

112. Determine environmental boundaries: based on environmental characteristics, specific site, hydrodynamics, existing uses; properties of contaminants, biogeochemical processes, kinetic parameters.

5.2.2 Identification of targets

113. Consider protection of:

- human health;
- natural resources;
- amenities contributory to man's well-being;
- functioning of the natural environment.

Possible targets at risk: human population, habitat, food, livelihood, well-being, quality of life; plankton, intertidal species, shellfish, benthos, pelagic or demersal fish, marine birds, marine mammals, marine reptiles; egg, larval and juvenile stages; rare, endangered species or critical habitats.

5.2.3 Pathways by which the pollutant may reach the target at risk

114. The following steps are identified:

(1) Identify possible pathways through which contaminants may endanger ecosystems, human health and resources deemed to be at risk: persistent or ephemeral contaminants; food chains, bioconcentration, biomagnification.

(2) Consider also the ways in which the impact or activity of the pollutant may be modified during transfer through water, sediment or biota. This will involve determination of rate of transfer, partition coefficients, rates of removal, degradability of contaminant, mean-life or mean residence time.

(3) Where practicable, use the critical pathway type of approach to identify the most probable route by which the pollutants involved affect the targets. It may be necessary to follow several pathways to several targets in order to establish which is the most sensitive to the impact of the development or activity. This may involve some arbitrary assumptions or the use of the probabilistic approach (Section 3.4).

5.2.4 Selection or derivation of standards

115. Where specific appropriate effluent standards or water quality criteria or other specific standards exist these may be used directly. Where none exist these may be derived from data from similar cases elsewhere or generated by simple toxicity testing under appropriate conditions (subsection 3.2.1).

5.2.5 Calculation of environmental capacity

116. Environmental capacity will have to be assessed on the basis of the environmental standard selected, boundary conditions, removal processes, etc. (Details of how this calculation can be made are given in subsection 3.2.6). This will involve construction of some form of model which might range from a simple conceptual model based on mean residence time for example, to more complex ones requiring numerical or probabilistic approaches. Reiteration of the procedure may be advisable to refine some of the assumptions that may have been made in a first approximation.

5.2.6 Determination of acceptable discharge rates

117. Based on the derived environmental capacity, define an allowable input rate. This will equate to the maximum allowable rate of discharge. Depending upon the degree of certainty with which the calculation was made, scientific prudence may lead to recommending that only a fraction of the input rate initially calculated should be discharged.

5.2.7 Design and treatment options

118. Assess available on-site options with respect to technology, effluent and waste treatment, to mitigate and decrease input of the pollutant still further.

5.3 Further Action Necessary

5.3.1 Decision taking

19. This will involve the planner or decision-maker assessing the information collected by the cientist and other specialists. If a decision is taken to proceed, follow-up action by the scientist ill be necessary in two areas: monitoring and reassessment.

5.3.2 Monitoring

20. Monitor the quality and quantity of the effluent discharge and the quality of the receiving nvironment in relation to the primary or secondary standards applied (Sections 4.1 and 4.2).

5.3.3 Reassessment

21. Reassess the position in the light of monitoring and other results; evaluate new treatment echnologies; refine earlier assumptions; confirm initial impact assessment; review and revise egulatory procedure (Section 4.3).

22. Contingency plans: identify likely malfunctions and emergencies; plan to reduce impact.

5.4 Presentation of Results

23. Scientific data must be communicated effectively at various levels of the decision-making rocess. Methodologies for written, graphic and oral presentation of scientific results are available Section 3.5).

6. CONCLUSIONS

24. Environmental Capacity, the potential of the environment to receive and accommodate ontaminants, is a property which can be determined, utilized and apportioned. Application of this oncept requires considerable data and understanding of the ecosystem to which protection and tilization it is applied. It will necessarily involve formulation of environmental quality objectives nd criteria. The primary advantage of the environmental capacity concept is that, if properly pplied, it would become a basic tool for environmentally compatible development planning.

25. Each and every development project imposes an environmental load and extracts a price in the oss of amenities or restriction of some other activities. Scientific research, analysis and monitoring nethodologies are capable of providing objective assessments of hazards associated with such evelopment projects, and provide alternative technological solutions for risk reduction. However, etermination of acceptable risk and tolerated levels of pollution are socio-political responsibilities equiring public involvement and take into account national and international considerations.

26. Assessment methodologies, such as the critical pathway analysis and similar techniques in nvironmental toxicology can be used to determine the impact of a contaminant release on a target n need of protection. They can be applied to both conservative and non-conservative contaminants s well as for any well-defined target, besides, and in addition to, human health and well-being.

27. The determination of environmental capacity will always involve several sources of uncertainies. Crude approximations, such as single-box models, or averaging over a larger time scale, or ssumptions of steady-states, can be used in initial stages. Probabilistic analysis, a component of ne methodology of Decision Analysis, could be applied in ensuing refinements which, in turn, would ead to values for environmental capacity, usable in development planning and project implementtion.

28. A set of general guidelines for the scientific assessment of the impact of pollutants in the narine environment are presented. It involves pathway analysis, selection and application of tandards of environmental quality, calculation of environmental capacity and determination of cientifically acceptable discharge rates. Monitoring and reassessment procedures are an essential art of the recommended methodologies. Elaboration of specific guidelines will require additional vork, based on several selected case studies and different classes of contaminants.

29. In considering all components of the process of assessment of the impact of the pollutants on ne marine environment, the need for a free, independent and multidisciplinary scientific approach is ssential. It was also recognized that the results of scientific research assessment have to be resented in a clear, simple language and by multiple inputs to ensure their effective use in the ecision-making process.

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