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Reports and Studies

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

Protecting the Oceans from Land-based Activities

Land-based sources and activities affecting the quality and uses of the marine, coastal and associated freshwater environment

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Contents

Executive Summary

Environmental processes are complex in nature. Interactions occur both within the biosphere and the abiotic environment and between them. Consequently, **environmental problems are inextricably linked to, or influenced by, one another** and do not recognise political boundaries. This is particularly the case for the problems of the marine environment. They cannot be remedied without taking into account the ecological interdependence of the oceans, the coastal areas and the freshwater systems associated with them.

Environmental processes and ecological systems are strongly influenced by social and economic systems and, in turn, influence them. A high proportion of the world's population lives in coastal areas, and many more of its people derive benefit from the use of marine and coastal resources, from employment linked with coastal and maritime activities, and from coastal recreational opportunities. However, **population pressure, consumption patterns, and increasing demands for space and resources - combined with poor economic performance and the impoverishment of a large part of the global population - undermine the sustainable use of oceans and coastal areas, and of their resources.**

Globally, both the environmental problems of the oceans and coastal areas, and their causes, have remained largely unchanged for several decades. Although there have been some notable successes in addressing problems caused by some forms of marine pollution, and in improving the quality of certain coastal areas, **on a global scale marine environmental degradation has continued and in many places even intensified.**

PERSISTENT PROBLEMS

Marine pollution stemming from land-based sources and activities has previously been of predominant concern. However, improved appreciation of the scale of other forms of damage and threats to the marine and coastal environment has resulted in a more balanced perspective. Today, aside from the impacts expected in the long-term from global climate change, the following are considered to be **the most serious problems affecting the quality and uses of the marine and coastal environment:**

- **alteration and destruction of habitats and ecosystems;**
- **effects of sewage on human health;**
- **widespread and increased eutrophication;**
- **decline of fish stocks and other renewable resources; and**
- **changes in sediment flows due to hydrological changes.**

Keeping in mind its specific purpose, this report focuses on issues defined as particularly relevant to the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA/LBA). Therefore, certain problems which, on balance, may be considered equally important (e.g., problems of fisheries) are not covered in any great detail in it.

Alteration and destruction of habitats and ecosystems

Increasing habitat destruction and ecosystem alteration either by physical (e.g., landfills, sedimentation), chemical (e.g., pollution) or biological means (e.g., the introduction of non-indigenous species) constitutes **the most widespread, frequently irreversible, human impact on the coastal zone.**

Poorly planned coastal urban and industrial development - including the indiscriminate exploitation of coastal resources and the development of recreational, harbour and aquaculture facilities - has considerably changed the natural coastline and reduced the areas previously covered by dunes, wetlands and mangroves. These ecosystems, and the wildlife inhabiting them, suffer all over the world. In many places fisheries are affected as a result, as fish spawning and nursery grounds are degraded.

Sewage and various chemical compounds released into the marine environment may significantly affect members of ecosystems: in extreme cases, this may lead to the destruction of whole ecosystems. The chemical compounds of pre-eminent contemporary concern are: nutrients; substances disrupting endocrine functions; a group of substances classified as persistent organic pollutants (POPs); petroleum hydrocarbons (largely from major accidental oil spills at sea); and, in a few cases, metallic compounds, such as those of mercury, cadmium, tin and copper.

The effects of the accidental or deliberate introduction of non-indigenous organisms include the reduction or even extinction of indigenous species, damage to fisheries, and wholesale changes to ecosystems. Documented economic losses caused by such introductions amount to hundreds of millions of US dollars.

Natural marine and coastal ecosystems represent tangible economic goods and provide valuable services, such as the treatment and assimilation of wastes, protection from storms, food production, raw materials, recreational amenities, genetic resources, and employment opportunities. **The global value of the goods and services provided by marine and coastal ecosystems is roughly double of value of those provided by terrestrial ecosystems, and is comparable with the level of global GDP.**

Effects of sewage on human health

Sewage contamination of the coastal marine environment leads to significant incidence of human disease - infectious diseases related to bathing and swimming in marine coastal waters and to the consumption of seafood harvested in coastal waters, and diseases associated with the contamination of shellfish and other seafood. In addition, human exposures to toxins associated with algae blooms impose significant risks. Apart from being an aesthetic nuisance - and from ruining amenity values in many coastal areas - sewage is a **major source of nutrients and pathogens, posing considerable risks to the health of bathers and consumers of marine foodstuffs**. Outbreaks of cholera, typhoid and other illnesses are frequently traced to pathogen-contaminated seafood and bathing waters. These health risks are particularly high in areas where carriers of pathogens are common among the local population and sewage treatment and disposal systems are inadequate.

Contaminated seafood and bathing waters are significant contributors to the human "global disease burden", measured as losses associated with premature death and with the length and severity of disabilities. The associated **economic losses are estimated to be among the major ones attributable to any specific diseases.**

Eutrophication

The input of nutrients (particularly nitrogen and phosphorous substances) to the sea from land-based activities is increasing globally and has led to eutrophication (i.e., increased biological production) of coastal and near-shore waters. This is **among potentially the most damaging of all human influences on the oceans, in terms both of scale and consequences**. The predominant anthropogenic sources of nutrients are agricultural and industrial activities (fertiliser residues, wastes from animal husbandry, sewage, industrial effluents and atmospheric emissions).

Eutrophication involves the increased growth of phytoplankton and can favour the growth of toxic, or otherwise harmful, species. The decay of excessive plankton biomass increases the consumption of oxygen dissolved in the sea and occasionally causes periodic or permanent oxygen depletion, leading to mass mortality of fish and other organisms. Algal blooms involving toxin-producing species are frequently the cause of very serious human health problems, when toxins are ingested through contaminated seafood.

Excessive nutrient inputs can turn marine areas into wastelands, while large reductions in natural inputs of nutrients (e.g., by damming rivers) can also adversely affect the productivity of coastal waters, including the abundance of fish.

Changes in sediment flows

Increased and decreased inputs of sediments from rivers, or other runoff into the sea, continue to **affect shorelines and habitats significantly**. Deforestation, soil erosion and the diversion of water courses increases sedimentation rates along the coast; in many places this adversely affects wetlands, deltaic habitats and bottom dwelling communities (e.g., coral reefs, seagrass beds). On the other hand, reduction of the natural supply of sediments (e.g., by the reduced flow of rivers) to coastal waters leads to accelerated coastal erosion.

CHANGING PERSPECTIVES

Scientific perspectives

Changing perspectives on the delivery of contaminants to the ocean. Increasing amounts of atmospherically-derived fixed nitrogen are entering the coastal zone and may be an important contributing factor to coastal eutrophication. Changing patterns in the production of reactive nitrogen from combustion and the generation and use of fertiliser may also cause increased nitrogen deposition to nitrogen-limited regions of the open ocean. Significant quantities of natural substances and contaminants, especially nutrients, are added to the coastal zone via submarine groundwater discharge in many regions of the world. These can bypass the normal estuarine "filtering" process that takes place for riverine inputs, and mix directly into coastal and off-shore waters.

Effects of other changes on marine biological systems. Human impacts on coral reefs have been increasing steadily. Concerns are being raised about the apparently increasing incidence of new coral reef diseases, unprecedented disease outbreaks, and diseases in new locations. In addition, coral bleaching is causing widespread mortality in reef communities and severely compromises their ability to recover from human-derived stress. Concern is also increasing over endocrine-disrupting chemicals (EDCs) - including PCBs, tributyl tin, and alkyl phenols - in the coastal environment. Caution is needed because of their chemical stability in the environment. However, more research is required to determine the relationship between these persistent chemicals and their effects on marine organisms.

Climate and global change. Significant changes to the marine environment are likely to accompany a projected mean surface temperature increase of 1-3.5 degrees C by 2100. Changes in the frequency of extreme meteorological events (droughts, floods, hurricanes) could lead to significant damage to nearshore ecosystems. Higher temperatures and humidity may lead to increased incidences of diseases and food-borne infections. Sea level changes may lead to the loss of low-lying coastal habitats. Changing ocean/atmosphere circulation patterns could affect the dynamics of fish populations. Changes in ice cover and stratospheric ozone may lead to increased stress on many polar species.

Regional perspectives

The regional programmes, including those specifically developed for the implementation of the GPA/LBA, are at different stages of development and are formulated in quite different terms. Regional priorities, for example, are variously expressed in terms of contaminant classes, source categories, or institutional actions. Several regions identify a set of priority issues but regard it as inappropriate to prioritise among them. Regions also vary considerably in the identification of objectives, strategies, and actions.

As expected, **regional priorities are specific to the conditions in each region**, but there is general agreement among regions on the prioritisation of issues. **Sewage is clearly the highest priority in most regions.** In terms of GPA/LBA sources, agricultural runoff and industrial facilities are also high priorities. In terms of contaminant classes and physical alteration, the highest priorities after sewage are generally, in approximate rank order, nutrients, sediment mobilisation, POPs, heavy metals, and physical alteration. The regional programmes tend to give higher priority than GESAMP to POPs and heavy metals, and less to physical alteration. This may reflect an expectation of increasing trends in POPs and heavy metal contamination, a recognition that global transport of these contaminants may necessitate action even in the absence of major impacts within a region, or the widespread international attention being given to POPs and heavy metals.

The majority of the regional programmes examined state objectives, strategies, and actions in very broad terms: often the stated objective is simply to reduce or prevent degradation. Some regions do identify somewhat more concrete objectives (e.g. “complete an assessment based on existing data”). The generality of objectives in most regional programmes, however, is likely to make it difficult to assess their progress.

Common themes in regional strategies are: environmental planning and management frameworks; awareness and education; information systems; the development of regional guidelines, criteria, and standards; improved waste management systems; the adoption and transfer of technologies; the development of regional and international agreements; and the implementation of existing agreements, standards, and legislation. GESAMP considers these generally appropriate, and suggests that **particular emphasis should be placed on improved planning and management frameworks, on improved awareness and education, and, perhaps most importantly, on the enhanced implementation of existing mechanisms**.

Actions identified in the Regional Programmes of Action (RPAs) range from the quite specific (e.g., “identify gaps in existing legislation”) to the very general (e.g., “regional actions to be devised”). The degree to which actions are logically matched to specific identified strategies and objectives varies, but might be improved in a number of regions. Monitoring and assessment are among the most common actions in the RPAs. This is probably appropriate, as many regions have significant information constraints, but GESAMP suggests placing more emphasis on assessing environmental impacts in addition to contaminant releases or environmental concentrations. It is also important to note that **the information that is already available often provides a sufficient basis for action, and that this should not be postponed pending additional information.**

The time-frames envisaged by the regional programmes developed specifically for the GPA/LBA are, in general, relatively short when compared with similar programmes developed in the framework of some well established programmes (e.g., OSPAR). This reflects the need for **urgent action**, but also undue optimism. The longer and more realistic time frames adopted by the well established programmes reflect the need for long-term commitment.

STRATEGIES AND MEASURES

The **policies required for effective environmental management** will vary among countries, but there is a framework of common policy elements, including:

- **cross-sectoral, holistic management;**
- **rational, equitable, and sustainable allocation of resources;**
- **clear commitment by both government and the public;**
- **poverty alleviation; and**
- **regional and global international cooperation.**

Given an appropriate policy framework, there are many tools and measures that can be applied to address the impacts of LBAs upon the coastal and marine environment. The sustainable development of coastal and marine areas requires selecting a suite of these, tailored to local, national, and regional circumstances within a framework of cross-sectoral management. **The suitability of a given measure usually depends less upon its inherent technical merits than upon its benefits and costs relative to other measures, upon the priority of the issue that the measure addresses, and most importantly, upon the prospects for effective implementation.**

There are three main types of policy instruments to induce implementation: regulations; economic instruments; and instruments to induce voluntary action. Regulation is familiar, has a perceived high degree of certainty, and is compatible with existing legal frameworks. On the other hand, it imposes a high enforcement burden, is inflexible and often economically inefficient, and fails to provide incentives for continuing improvements. Economic instruments increase economic efficiency by devolving decision-making to the target sector, provide incentives for continuing improvement, increase flexibility, and in some cases reduce the enforcement burden. Their disadvantages include political barriers to setting charges and taxes high enough to alter environmentally damaging behaviour - or to providing subsidies and other incentives for desirable behaviour - and perceived uncertainty about their cost-effectiveness. Voluntary action by industry may also reduce the enforcement burden, increase economic efficiency, enhance flexibility, and allow the use of industry knowledge to develop industry-specific solutions consistent with business goals.

Other requirements and incentives to induce the implementation of environmental protection measures include: cost-effective and appropriate public and private investment; institutional measures, such as reorganisation, to promote cross-sectoral approaches; the establishment of environmental management agencies; the enactment of environmental legislation, and the reform of property rights; societal measures such as public education, consultation and participation, and access to courts to enable civil suits related to environmental protection; and the application of various management tools (e.g. cost-benefit analysis, Environmental Impact Assessment (EIA)).

The guiding principles in selecting from the available technical and management measures to address each of the GPA/LBA contaminant classes should be to identify and prioritise the environmental problems to be addressed, and to select measures that provide the highest overall net benefit. The measures must also have a high probability of successful and sustained implementation in a particular socio-economic and cultural setting.

During the last few decades, considerable progress has been made in understanding the nature, magnitude and threats stemming from human impacts on the marine and coastal environment. Although the level of uncertainty shrouding certain issues remains substantial, **today's knowledge and available technology generally provide an adequate basis for action to remedy the present situation, while still allowing the ocean to be used for socially beneficial purposes, including the controlled disposal of certain wastes.**

There are some differences of emphasis in this report from those in the GPA/LBA. One of these is the importance given by GESAMP to the need for the kinds of institutional strengthening required by developing countries to enable them to take measures to control land-based activities. Others concern the emphasis given within the GPA/LBA to two priority actions: the establishment of a clearing-house mechanism that would identify information needs and sources of information; and the mobilisation of funds.

CONCLUSIONS AND PRIORITIES FOR ACTION

The economic costs of failing to take action to control land based activities are enormous. The international dimensions of the problem are clear. There is wide recognition both of the global implications of the economic and biodiversity losses, and of the fact that financial and technical cooperation is needed between developed and developing countries to protect the marine environment. Moreover, the transboundary effects of land-based activities in many regions call for cooperation among the countries concerned.

Poverty, poorly managed social and economic development, and unsustainable consumption patterns are the root causes of marine environmental damage resulting from the negative effects of land-based activities. Institutional failure allows these conditions to have a powerful effect, most importantly when governments are unwilling or unable to correct the market failure that occurs when markets do not fully reflect the value of resources. A major part of the reason why governments fail to act is their reluctance to adopt the necessary measures that yield long-term benefits when pressed to meet short-term needs or to channel financial and human resources from other areas of government responsibility, such as defence.

At the global level, the most serious problems associated with land-based activities are: sewage; the physical alteration and destruction of habitat; excessive nutrient inputs; and sediment mobilisation. Litter, heavy metals, hydrocarbons and radionuclides - although often meriting a high priority at local levels - are not considered to rank as global priorities. Persistent organic pollutants are currently and deservedly receiving attention at the international level, but are not considered to merit as high a global priority as habitat destruction, sewage, eutrophication and changes in sediment mobilisation. The current preoccupation with POPs at the international level should not divert attention from anthropogenic causes of more immediate, serious and widespread damage to the marine environment.

At the technical, management and policy levels **the most urgent actions to control land-based activities** to improve the quality of the marine environment are:

- **preventing habitat destruction and the loss of biodiversity through education, combined with the development or enforcement of legal, institutional and economic measures appropriate to local circumstances; and establishing protected areas for habitats and sites of exceptional scenic beauty or cultural value;**
- **devoting primary management attention in the control of pollution to sewage, nutrients (especially nitrogen) and sediment mobilisation;**
- **designing national policies that take account of the economic value of environmental goods and services and provide for the internalisation of environmental costs; and**
- **integrating the management of coastal areas and associated watersheds.**

About this Publication

The preparation of the present report has been initiated by UNEP as a contribution to the first intergovernmental review meeting on the progress in the implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA/LBA[1]), which is planned for November 2001.

The report has been prepared by the Editorial Board of the Working Group on Marine Environmental Assessments, established within the framework of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), with valuable input from all members of the Working Group, contributions from additional experts and assistance of a professional editor. The Working Group was supported and co-sponsored by all eight bodies sponsoring GESAMP (United Nations – UN; United Nations Environment Programme – UNEP; Food and Agriculture Organisation of the United Nations – FAO; United Nations Educational, Scientific and Cultural Organisation and its Intergovernmental Oceanographic Commission - UNESCO/IOC; World Health Organisation – WHO; World Meteorological Organisation – WMO; International Maritime Organisation – IMO; and International Atomic Energy Agency – IAEA) and the Advisory Committee on Protection of the Sea (ACOPS). UNEP provided the technical secretariat of the Working Group.

A series of regional reports about the problems of the marine environment associated with land-based activities was prepared in the framework of the GPA/LBA. These reports, prepared under the aegis of UNEP Regional Seas Programme, together with reports and other documentation from regional seas bodies not linked to UNEP's Programme, were analysed and used as the basic source of information for the preparation of the present report (see Annex 4).

The draft of the report was peer reviewed by numerous specialists with different scientific backgrounds, managers and policy-makers. Their comments and suggestions were taken into account prior to endorsement of the report by the session of GESAMP in May 2000, and their contributions are hereby acknowledged with appreciation.

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[1] The GPA/LBA was adopted by an intergovernmental conference convened by UNEP in Washington D.C., 23 October - 3 November 1995. UNEP(OCA)/LBA/IG.2/7

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1
Introduction

The preparation of the present report was initiated by UNEP as a contribution to the first intergovernmental review meeting on the progress in the implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA/LBA)[1]. Therefore the structure and layout of the report largely follows the specific approach and terminology used by the GPA/LBA in relation to various land-based activities (LBAs) and waste categories.

Chapter 2 describes the causes, nature and severity of problems in the marine environment derived from land-based human activities, primarily from a scientific perspective. It covers all aspects of concern specified within the GPA/LBA with emphasis on scientific evaluations of the sources and effects of contaminants and physical alteration. It further specifies and delineates areas of concern, both those reflected in the GPA/LBA and others including: the effects of mariculture; expanding human populations and tourism; globalisation of the chemical industry; transfer of alien species; energy and turbidity changes in estuaries; trends in marine transport; and the deliberate and accidental disposal of military and commercial materials at sea.

In large part, this chapter revisits many of the issues addressed in the previous GESAMP review of the "State of the Marine Environment" in the context of more recent developments and new scientific information. The distinction between land-based and maritime activities is somewhat blurred because all human activities originate from terrestrial sites. Accordingly, the chapter covers, to a limited extent, issues such as fisheries and shipping that would largely be considered marine activities.

Chapter 2 deals with issues of a long-standing nature. It provides a basis for improved perspectives on the damage and threats arising from physical alteration of the environment and changes in sediment mobilisation in comparison to those associated with long-recognised or "classical" contaminants. The extent of damage caused by such classical contaminants is revisited to provide a contemporary perspective on priorities among them. This chapter also lays stress on threats posed by eutrophication, alien species transfers, the special problems of small islands and concerns about energy changes in estuaries.

[1] The GPA/LBA was adopted by an intergovernmental conference convened by UNEP in Washington D.C., 23 October – 3 November 1995 (UNEP(OCA)/LBA/IG.2/7.) The coordination of the implementation of the GPA/LBA was assigned to UNEP.

Chapter 3 covers emerging issues and those for which recent scientific assessments suggests that re-evaluation is warranted. Accordingly, it includes further analysis of some issues discussed in Chapter 2, but from differing perspectives. Together, Chapters 2 and 3 constitute the scientific component of this report and provide a basis for the consideration of social, economic and policy aspects of land-based activities affecting the marine environment, its resources and amenities.

Chapter 4 presents regional perspectives about threats posed by LBAs and attempts to synthesise them. It presents a diagnostic summary and analysis of fifteen regional programmes. The Chapter is divided into 3 sections. Section 1 provides brief background information about the history of regional efforts to control LBAs. Section 2 analyses the regional programmes and the available background documentation, attempting to compare and synthesise regional priorities and approaches to the control of LBAs. The scope of the analysis is limited because the various regions have proceeded in rather different ways in prioritising issues and courses of action, making it difficult to compare and contrast approaches. Section 3 of the chapter derives common elements of the regional and global perspectives as a basis for discussion, in Chapter 5 and 6, of strategies, measures and priorities for action.

Chapter 5 describes general organisational frameworks and legislative and policy matters that are of potential value in achieving the goals of the GPA/LBA. It examines, for each contaminant class and physical alteration, specific management and technical measures and the requirements and incentives to promote their implementation. The chapter is divided into 6 sections. Sections 1 and 2 describe general policy principles that underlie effective environmental management and summarises strategies for the control of the effects of LBAs on the marine and coastal environment. Section 3 provides an overview of measures to prevent, reduce or ameliorate degradation of the marine environment, as well as requirements and incentives for their implementation. Section 4 briefly examines technical options available to reduce the impacts of each of the GPA/LBA contaminant classes and the physical alteration of habitats, and assesses their costs and benefits. Section 5 considers needs for additional information and technical research and development and Section 6 describes institutional and policy requirements to implement the GPA/LBA.

Chapter 6 summarises the overall impact of various LBA activities and waste categories, as defined by the GPA/LBA, on the basis of informed scientific judgement, taking into account their geographic scale of impact and impact on food security, public health, coastal and marine resources and ecosystem health. Using this method and a set of criteria (adequacy of science, adversity of impact, ubiquity of source, ability to be managed, benefit/cost ratio), a priority ranking for the same LBA activities and waste categories is presented. Priority actions at the technical and management levels are categorised by the sources of contaminant, physical alteration, sediment mobilisation and litter. Institutional, legislative and policy priority actions are described at three levels: national, regional and international. These actions are drawn primarily from the considerations in Chapter 5 and the analysis of regional programmes in Chapter 4.

At the end of the report is: a **Glossary** of most commonly used terms; a list of **Abbreviations**; an **Index**: and four **Annexes**, one on Economic Valuation of Coastal and Marine Systems and Net Benefit Analysis, one listing the unpublished internal working documents prepared by the members of the Working Group, and two providing details relevant to regional implementation of the GPA/LBA.

2
Identification and Assessment of Problems

2.1. INTRODUCTION

This chapter describes long-standing marine environmental issues as a baseline for the later description of emerging issues that have come to the fore during the last decade. Its structure largely corresponds to that set down within the GPA/LBA. Inevitably, this results in some repetition because of the need to ensure the comprehensiveness of the discussion relating to activities, sources and contaminants. Attempts to minimize such repetition mean that the more detailed discussion of topics requiring scientific explanation has been concentrated under the discussion of contaminants. This chapter embodies the conclusions of previous GESAMP Reviews of the State of the Marine Environment, augmented by material drawn from a wide variety of other sources.

Estimating the costs of environmental damage is extremely difficult even under well-defined local conditions. It becomes even more prone to unreliability on larger scales because of the difficulties of assigning values to environmental resources and amenities and of estimating the scales of impact. This process of valuing the environment is extremely complex, and involves not only economic factors but also ecological, social, legal and cultural considerations. In the context of estimating detriment caused by anthropogenic activities, the issue is further compounded by the limited understanding of the direct and indirect linkages between human activities and their impacts on the environment. Accordingly, this chapter provides indications of the costs of environmental degradation as illustrations (i.e., as boxes) in instances where such costs have been evaluated elsewhere.

2.2. NATURE AND SEVERITY OF PROBLEMS

Specifying the nature and, particularly, the severity of problems (i.e., impacts on the marine coastal and freshwater environments resulting from land-based activities) has to be done on several scales. On local scales, problems can be perceived and prioritized differently than at larger (regional and global) ones. Each regional review has attempted to define the nature and relative importance of problems at the regional scale and, in many cases, specified the relative importance of specific problems at component (i.e., national) ones. From a global perspective, contemporary problems can be divided into two categories: (i) actual damage or compromise to marine resources and amenities; and (ii) potential threats of damage. At local and regional scales, the nature of problems is seldom sufficiently specific for it to be possible to make an unambiguous assignment to either of these categories. Eutrophication, for example, is invariably a concern within the regions; but it can seldom be determined reliably whether eutrophication is actually occurring on large scales - and, if so, how much damage has been done- or whether it merely represents a future threat to the area concerned. An attempt is made here to present views on the "top-down" or global problems within these two categories, realizing that an unambiguous assignment cannot always be made.

Any list of global concerns regarding the deterioration of the marine environment would contain the following entries. They are not presented in any implied order of severity or importance:

- eutrophication and associated anoxia;
- harmful algal blooms;
- the effects of classical contaminants (sewage, metals, persistent organic substances, petroleum hydrocarbons, radionuclides);
- the effects of deforestation;
- the effects of increased or decreased mobilization of sediments;
- the demise of coral reefs;
- the loss of wetlands;
- declines in mangroves;
- habitat destruction;
- the transfer of harmful species into coastal areas;
- climate change;
- sea-level rise;
- inundation as a consequence of physical alteration;
- increased risks to human health;
- reduced biodiversity;
- endocrine disrupting chemicals;
- overfishing;
- destructive fishing practices;
- the effects of the exploitation of coastal mineral resources, particularly sand and gravel; and
- litter.

Some of these can be easily assigned to the "existing damage" or "threat" categories without much ado. Others contain elements of both. For example, climate change represents a threat; there is, as yet, no evidence of associated damage having occurred. The related topic of "sea-level rise", on the other hand, clearly contains elements both of existing damage, because sea level has risen, and of the threat posed by the expansion of seawater associated with global climate change. The reason for this discourse is to stress the fact that setting priorities requires not only the measurement of existing observable damage and the recognition of (potential) threats, but also an equitable balancing of the assignment of priorities among them. It is fair to say that this is not a scientific requirement because, in the main, the judgment of relative priority is a socio-economic exercise; but science has to do its best to quantify existing damage, its trend, and pending threats.

All the concerns listed above - excepting fisheries issues that are mostly beyond the terms of reference of this study - are discussed in Chapters 2 and 3 of this document. Most of these concerns are dealt with as long-standing ones in Chapter 2 . Only climate change, associated sea-level rise, changing nitrogen influxes to the ocean, diseases and bleaching affecting coral reefs and the topic of endocrine disrupters have been addressed as "emerging issues" in Chapter 3.

It is the setting of priorities for action that will enable the elements and principles of the GPA/LBA to result in substantive and cost-effective improvements in the condition of the marine environment on national and regional scales, and thereby attain improvements at an overall global level. This is what makes the identification of priorities so important. Each of the regional areas has been specifically tasked with identifying regional priorities for action on the basis of a coordinated review of the region and its national components.

This chapter of the report deals with a brief explanation of predominantly long-standing problems regarding the condition of the seas. Inevitably, because the actual date at which specific issues became a matter of concern is often unclear, it also includes reference to more recent or "emerging" issues that fall primarily within the scope of Chapter 3. The following sections deal with four major categories of issues - food security, public health, ecosystem health and economic health, with the latter two issues including elements of biodiversity.

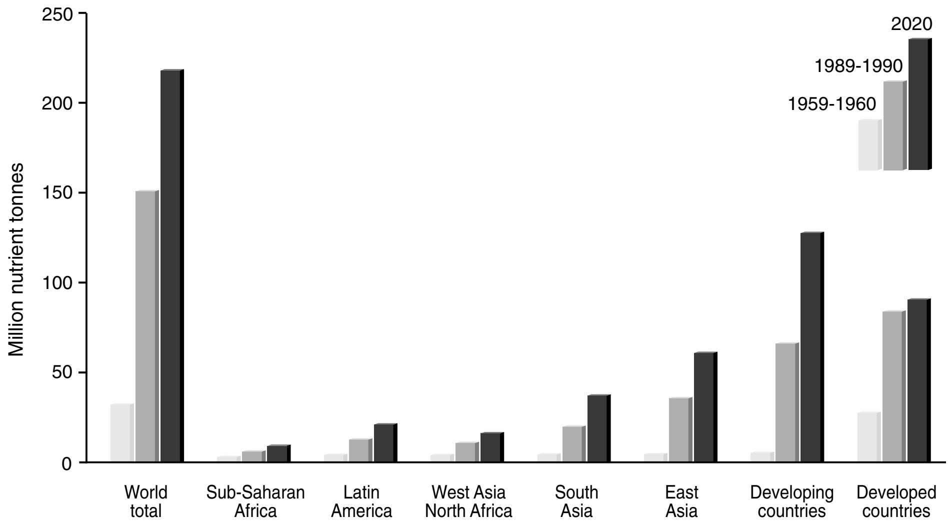
2.2.1 Food Security and Poverty Alleviation

Lack of food security - other than under certain conditions, such as natural disaster, war and civil insecurity - is driven primarily by poverty. Agriculture and fisheries have two distinct roles in the alleviation of poverty; through their contribution to incomes and through the supply of food. Some agricultural and fishing practices, however, can degrade coastal ecosystems and severely damage renewable resources causing adverse effects, directly or indirectly, on food security and the extent of poverty.

Agriculture is the backbone of local economies in the coastal areas of many countries providing employment, either directly or indirectly, in providing services to the industry. It also makes significant contributions to national economies. Its role in assuring food security is self-evident. Like any other industry, agricultural activities can produce harmful effects on coastal ecosystems. These activities include flood control and alterations to the flows of rivers, the use of pesticides and fertilisers, run-off of animal wastes, excessive use of water from coastal aquifers, overgrazing in watershed areas, and others. The increasing global use of fertilizers and pesticides during the latter half of the 20th Century is depicted in Figures 2.1 and 2.2 respectively. In many areas, marginal agriculture, often but not exclusively practised by landless farmers, is a significant source of damage to marine ecosystems. Marginal agricultural practices may include, for example,

FIGURE 2.1

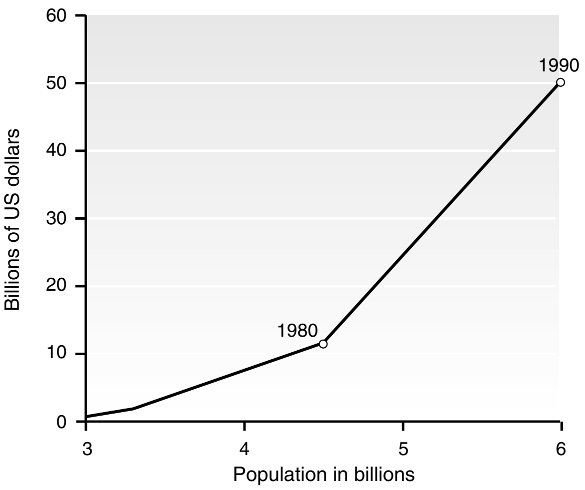
Estimated growth in fertilizer use, 1960-2020



Source: Bumb, B and C. Baanante. 1996. World trends in fertilizer use and projections to 2020. 2020 Brief No. 38 (International Food Policy Research Institute, Washington, DC, USA), Table 1, World Resources 1998-99.

FIGURE 2.2

World sales pesticides in relation to global population,1970-1990



Source: World Resources Institute (1998).

the "reclamation" of mangrove for rice paddies and the ploughing of steep hillsides causing severe soil erosion - but are not confined to these. Good agriculture extension work can mitigate much of the potential damage of the effects of such practices, while more intensive agriculture has a number of potential benefits, including the more efficient use of water and land and the creation of additional employment opportunities.

Coastal aquaculture - the farming of finfish, molluscs, crustaceans and aquatic plants in marine and brackish waters - contributes to food security through supplying food, and generating employment , rural development and increased national incomes. Coastal aquaculture in some regions includes the farming of relatively high-priced products, such as salmon, oysters and shrimp. As in agriculture, badly planned and managed mariculture can have serious adverse effects on marine ecosystems. Badly sited farms can result in the degradation of such ecosystems as mangroves and coral reefs, while effluents from fish farms can have adverse effects on exposed communities, especially benthos. However the adverse effects of mariculture can be largely avoided when good practice guidelines are followed in the siting of farms and their management.

The contribution of the fisheries sector to family incomes cannot be precisely quantified, but it provides income to fish workers in production, processing and distribution, as well as in ancillary industries, such as boat building and fishing gear manufacture, and in fisheries administration. Accurate employment statistics for the sector are not available but it has been estimated (FAO, 1995) that about 120 million people are directly employed within it and are wholly or partly economically dependent upon it. By far the greatest numbers of these are poor people in developing countries. If each of those directly employed in the sector has five dependents, about 700 million people depend directly on fisheries. Indirectly, the fisheries sector also positively influences food security through its impact at the macro-economic level.

While fish does not provide an important source of energy in the diet on a global scale, it does have an important role in providing for sound nutrition in the food supply of many countries, especially in the developing world. Fish protein is generally recognized as an important ingredient in a balanced diet. It contains essential amino acids not normally found in staple foods, and contributes valuable fatty acids necessary for the proper development of the brain and body. Fish is also a convenient and, for many, a relatively inexpensive, source of micronutrients such as calcium, iodine and some vitamins that are generally unavailable from staples. This is particularly important for the sound nutrition of children.

Fish makes up about 19% of the total animal protein consumption of developing countries as a whole, and just over 5% of their protein from both animal and plant origin. In many developing countries, fisheries are important for the food security of populations living in coastal areas and along major rivers and lakes. Fish is also particularly important as a source of food for many small island populations, particularly in the Pacific and Indian Oceans.

In general, fish appears to be most important for the poorest people. It appears to be significantly more important in the diets of Low Income Food Deficit Countries (LIFDCs)[1] as a group than in those of non-LIFDCs. Importantly, however, there is less fish available, *per capita*, in the LIFDCs than in other countries (FAO, 1995).

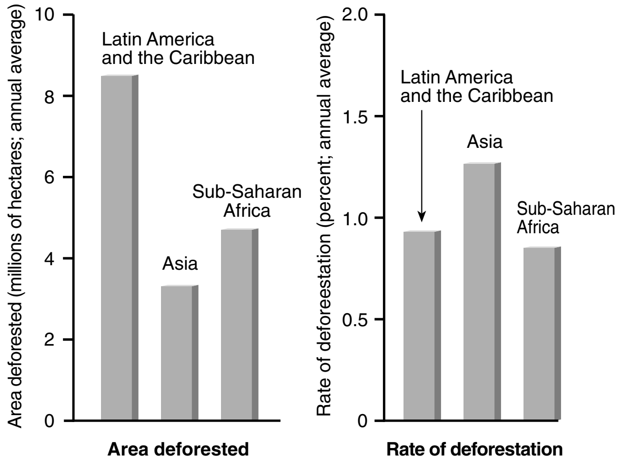
It is difficult to determine the relative importance of the different categories and types of land-based activities that have adverse effects on the productivity of fisheries and consequently on food security and poverty alleviation. It is, however, possible to define some of the "driving forces" for such adverse effects. Take, for example, deforestation. During the period 1980-1990, substantial reductions in forested areas took place in developing regions with rates of deforestation in the 0.8% to 1.6% range (see Figure 2.3).

It is difficult also to assess the impact at a global level on incomes, and the consequent threat to food security, of other types of land-based activities. These include: poor

[1] The list of low-income food-deficit countries (LIFDCs) was developed by FAO in the late 1970s to assist in analysing and discussing food security issues. LIFDCs are currently defined as nations that are:
• poor - with a net income per person that falls below the level used by the World Bank to determine eligibility for IDA assistance. At present, that means that their net income amounts to less than US$1,505 per person.
• net importers of food - with imports of basic foodstuffs outweighing exports over the past three years. In many cases, particularly in Africa, these countries cannot produce enough food to meet their all their needs and lack sufficient foreign exchange to fill the gap by purchasing food on the international market.

FIGURE 2.3

Loss of tropical forest in developing regions, 1980-1990



Source: FAO, Rome.

land-use and forestry practices that can result in increased runoff of sediment, leading in turn to the loss of fish habitat through the smothering of seagrass beds and the siltation of coral reefs; the physical destruction of reefs by tourism or mining; and poor water management practices that can have adverse effects on, for example, certain estuary fish or impede the spawning of anadromous fish. Nevertheless, there is adequate information at the local level to show that such environmental changes can have severe adverse effects on fish workers' incomes (Hodgson and Dixon, 1988). As fishermen and their families are among the poorest people in many countries, these land-based activities may often pose a threat to food security although they may not be quantified.

Specific coastal and marine ecosystems of concern in tropical regions include estuaries, coral reefs, mangrove forests and seagrass beds. As most countries in these regions are still underdeveloped or developing, the livelihood of their coastal populations is best characterized as artisanal, with a tight dependence on coastal and marine resources to support a hand-to-mouth existence. The main use of such resources is to provide an income for the fishermen and food for local populations. Degradation of these habitats by land-based activities causes a reduction in their productivity and, consequently, diminished harvests of economically important organisms. This has obvious implications for food security and for the worsening of poverty. The infestation of some waterways by floating weed presents a threat to the food security of local populations, but the factors contributing to the infestations' rapid spread remain unclear.

In general, the kinds and amounts of pollutants from land-based sources are related to the levels of industrialization and urbanization, and to the intensity of agricultural activities. The contamination of near-shore waters from coastal urban communities and industrial development has significant impacts on local coastal fisheries. The limited available information on such impacts comes mostly from the developed industrialized countries where the impact on food security has been negligible. Among developing regions, the crash of the entire fisheries economy of the Black Sea at the end of the 1980s as a result of the combined effects of riverborne contaminants, mostly nutrients, over-fishing and the more recent introduction of the alien species *Mnemiopsis leidyi* has been well documented (GESAMP, 1997a).

In many developed countries, levels of air and water contamination have declined over the last two decades because of the introduction of strict environmental legislation and the use of cleaner production technologies. By contrast, levels of air and water contamination appear to be high in many poor and medium income countries in East and South-east Asia, the Indian sub-continent and Latin America, where there is significant industrial development, particularly of heavy industry. To these areas may be added eastern Europe and northern Asia in which the legacy of the previous industrial development of several countries in economic transition has resulted in pockets of serious contamination. A large part of the negative impact of such contamination on the productivity of fisheries goes unnoticed because monitoring facilities are poor or absent and because consumers are inadequately protected from contaminated seafood. In general it is likely that effects on the incomes of fish workers are mitigated by the high demand for fish in urban markets near to industrial centres.

2.2.2 Public Health

The two primary forms of exposure to the marine environment that give rise to human health concerns are: direct contact through bathing and boating activities; and indirect contact through the consumption of seafoods. The field of thalassogenic infections of the first two categories, defined as "human infections whose source is the sea", has been reviewed by Shuval (1986).

Shuval (1986) in his conclusions stated "*after many years of uncertainty and active debate, it now appears that there finally is a vast amount of firm data providing strong evidence that bathing in sewage polluted seawater (...) can cause a significant excess of credible gastro-intestinal disease and that the disease rates show a high degree of correlation with enterococci and E. coli concentrations in the seawater*." He discusses the transmission of typhoid fever, viral diseases and ear, nose, throat and respiratory infections putatively associated with direct exposure to contamination in bathing water. Only in the case of ear, nose, throat and respiratory infections does the evidence for an unambiguous assignment to water contamination appear to be equivocal because the transmission may be by person-to-person contact, or even organ-to-organ transfer within an individual, while bathing. Nevertheless, there is adequate information on the nature of both real and putative dose-response relationships to derive criteria for the relative (conservatively estimated) risks posed by enteric organism concentrations in bathing water, thereby allowing health protection standards to be derived. It is interesting to note in this context that 75-90% of the bathing zones in the North Sea comply with the European Union standard for fæcal coliforms (Jeftic, 1998f (Annex 2)). Recognizing that this implies that between 10% and 25% of the bathing zones do not comply with EU standards, it suggests that conditions in sewage-receiving areas of less developed countries are likely to be far below such standards.

Three main categories of threats to human health posed by the consumption of seafood can be identified: microbial, chemical and radiological. Microbiological, natural poisonous organic agents and anthropogenic contaminants would fall within the chemical category: natural poisons, such as shellfish poisons, are discussed in Chapter 3. Threats posed by chemicals and radionuclides of anthropogenic origin are considered in relation to the adverse effects both on the environment and human health throughout this chapter. Shuval (1986) deals with typhoid fever, infectious hepatitis types A and B, polio virus and cholera transmission through shellfish consumption. Results of the application of more recent approaches to estimating the public health detriment associated with exposures to bathing water and the consumption of shellfish are presented and discussed in Chapter 3.

The Minamata incident, involving the poisoning of both animals and humans through exposures to seafood contaminated by mercury, is one of the most striking demonstrations of the potential for exposures to anthropogenic contaminants to affects on human health. Similarly, itai itai disease was partly a manifestation of high cadmium consumption through seafood. Increased risks to human health resulting from the chemical contamination of the ocean remains a major concern. However, apart from these two extreme cases, it is doubtful that inorganic chemicals such as the transition metals are the most serious marine contaminants from public health perspectives. Some known cases in the tropics pertain to heavy metal accumulation in bivalves and even finfish inhabiting the vicinity of ore extraction installations, such as copper mines. Fortunately, for most such metals, the allowable daily intakes are relatively well established and it is possible to provide basic human health protection through appropriate monitoring programmes. Various countries have established standards and tolerances for imported seafood, and this stimulates increased surveillance of the products of exporting countries. Nevertheless, the inspection of seafood for human consumption is neither universal nor always sufficiently rigorous. There is a clear linkage between the risks posed to human health by chemical contaminants and the land-based activities from which they are predominantly derived.

The impacts on human health of persistent organic pollutants (POPs) - the main focus of international negotiations leading to a new convention (see Box 2.1)- are of doubtful significance at contemporary environmental background levels. There are, however, areas and media that reflect accumulation of these compounds. Particular concerns have been expressed about the possibility of immuno-suppression in mammals from both acute and chronic low-dose exposures. No consensus has, however, been reached on the extent to which low-dose exposures might cause immuno-suppression affecting the health of the public at large. The possibility of these substances giving rise to probabilistic (stochastic) effects at low doses has been widely debated but clearly not ruled out. Experience over the last decade in the Arctic has clearly shown the importance of developing fair and respectful communication with the populations at risk to implement risk abatement measures.

In 1993, the International Atomic Energy Agency conducted an evaluation of the comparative risks associated with ingesting chemical carcinogens and radionuclides through consuming seafood (IAEA, 1993). This was prompted by a desire to place the risks posed by the dumping of low-level radioactive waste at sea in a suitable context. The presence of naturally occurring radionuclides, principally 210Po, can pose a greater risk to individuals within common critical groups of seafood consumers than that corresponding to the dose limit for members of the public set by the International Commission on Radiological Protection from practices involving the production, use and disposal of radioactive materials. The additional cancer risks associated with the contamination of seafood from sea disposal of low-level radioactive wastes are about five orders of magnitude lower. It appears that the presence of PCBs could represent a similar risk to that arising from naturally-occurring radionuclides. The other chemicals considered (DDT, HCB, chlordane, benzo-*a*-pyrene and dieldrin) present risks that are lower, than that that posed by PCBs, but still much larger, by more than two orders of magnitude, than those arising from sea disposal of radioactive wastes. The average risks among large (i.e., European Community and global) populations posed by chemicals that are now ubiquitously present in seafood are of a similar magnitude to those associated with the discharge of low-level liquid radioactive waste to coastal waters, the testing of nuclear weapons, and the Chernobyl accident. By comparison, the incremental risk arising from sea dumping of radioactive wastes is three to four orders of magnitude lower.

There are additional sources of risk to humans that are not so ubiquitously distributed. For example, the effects of increased UV-B radiation resulting from stratospheric ozone depletion are most severe at the poles, with the population of the Arctic being of primary concern. Similarly, because of their habits, especially the use of local or "country" foods, members of indigenous arctic communities frequently have increased exposures to persistent lipophyllic organic substances in the blubber of higher organisms such

Estimates of Detriment Based on Human Health Impacts

In instances where degradation of the marine environment has a direct bearing on human health, estimates can be made of the cost in terms of loss of life or the costs associated with morbidity using a number of simple techniques. This has been done in the section on the impacts of pollution on tourists and seafood consumers in the following section.

The single field in which the costs of detriment have been routinely quantified in relation to human health has been that of radiological protection where collective detriment (i.e., that to a population of humans) is estimated in units that can be directly converted to the incidence of fatality. It is then a simple matter, given an estimate of the value of a human life lost, to calculate in monetary terms, the magnitude of the detriment.

In the foregoing discussion, there is reference to an IAEA study (IAEA, 1993) of the risks posed by low-level radioactive waste dumping in the ocean with the risks posed by human exposures through seafood consumption of a range of organic marine contaminants. These risks are those associated with fatal cancer induction by hazardous constituents of seafood based on an assumption of stochastic effects without threshold*. The established relationship between risk and exposure for ionizing radiation (ICRP, 1990) and those proposed by the US Environmental Protection Agency for the “potency” of some organic compounds were used for estimating the probability of fatalities in exposed populations. The collective detriment from such exposures can be estimated for both the European (i.e., the European Community) and global populations. These are given in the following table using an arbitrary value of US$20,000 per life lost.

Substance/Source	Estimated health detriment through fatal cancer induction			
	European Community		Global Community	
	Fatalities	Cost (USD)	Fatalities	Cost (USD)
Civil nuclear discharges	170	3,400,000	3700	74,000,000
ΣDDT	131	2,600,000	170	3,400,000
Dieldrin	-	-	102	2,040,000
ΣPCB	17	340,000	38	760,000
HCB	-	-	4.2	84,000
Chlordane	-	-	3.8	76,000
Peak exposures from past sea dumping of low level radioactive waste	0.0045	90	0.0075	150

* It should be noted that the assumption of zero threshold in the case of cancer induction by chemical exposures and extrapolation of the dose-response relationship from observable ranges to very low dose regimes is controversial.

as whales, seals and polar bears (AMAP, 1998). Furthermore, their relatively high consumption of caribou/reindeer results in increased radiation exposures to natural (particularly 210Po), and artificial, (particularly 137Cs) radionuclides (AMAP, 1998). Only the risks posed by the consumption of foods derived from the marine environment are pertinent here.

2.2.3 Ecosystem Health, Including Biodiversity

The overall health or well-being of marine ecosystems, especially detailed taxonomic knowledge of various communities and the population status of heavily utilized or otherwise impacted species, is slowly becoming known for many marine regions. A number of suitable ecosystem health indicators exist, ranging from subcellular measures of chemical exposure and effects through to indices of community species diversity. For example, many contaminants are assimilated by marine organisms and can affect their viability and/or reproductive capability. If the afflicted organisms play critical roles in the functioning of ecosystems, reductions in their populations will take a toll on overall ecosystem health and performance.

Nutrients discharged in large quantities into coastal waters promote blooms of planktonic and benthic algae. Phytoplankton blooms contribute to increased water turbidity, reducing light penetration and adversely affecting pelagic and benthic biological communities. Coral reefs and seagrass beds can be impacted in this way. Even in naturally oligotrophic systems, such as the Mediterranean, eutrophication is a severe problem in several sub-regional areas (Jeftic, 1998e (Annex 2)). In the North Sea (Jeftic, 1998f (Annex 2)) both eutrophication *per se*, and changes in the ratios among nutrients in aggregate discharge, have had pronounced effects - including increased production in the nearshore and coastal waters of the German Bight and along the Dutch coast, and increased biomass and changes in the species composition of zoobenthos in the Wadden Sea, the German Bight, the northern Dogger Bank, the Kattegat and eastern Skagerrak. These follow a shift from a predominance of diatoms to a dominance of flagellates in the second seasonal phytoplankton bloom along the mainland European coast as a result of reductions in the silicate supply from impounded watersheds draining into the North Sea (Wollast, 1983; Lancelot *et al.*, 1987). Some of the most severe effects of eutrophication have been evident in the Black Sea (Jeftic, 1998c (Annex 2)). The reduction in light penetration affects sea grasses and benthos that are essential components of the sensitive ecosystem in the sea's north-western shelf. The entire ecosystem began to collapse even before the onset of other pressures such as the irrational exploitation of fish stocks and the invasion of the comb jellyfish (*Mnemiopsis leidyi*) in the mid 1980s. From regional perspectives, only in the Arctic does eutrophication not appear to be a priority issue (Jeftic, 1998a (Annex 2)).

Costs of Eutrophication

Nutrient inputs are associated with a range of conditions, including harmful algal blooms (HABs). For HABs alone the costs include those of routine toxin monitoring programmes for shellfish and other potentially affected resources, the lost opportunity costs of short-term and permanent closure of fishing areas, the value of damage to wild fish and shellfish stocks, damage to submerged aquatic vegetation and coral reefs, reductions in tourism and associated industries, and medical treatment of exposed individuals.

The estimated annual cost to the United States in 1987-93 was over US$ 35 million and, when economic multipliers are taken into account, over US$ 100 million. Similar experience has been reported for Japan. Extrapolation of US and Japanese experience to the more than 50 countries with HAB problems indicates that global costs are very significant in economic terms.

Habitat loss is of increasing concern in respect to ecosystem health and biodiversity. While it appears that the geographical extent to which habitat is being lost is not yet large enough to threaten diversity on a global scale, there could be a threshold in habitat loss beyond which diversity would decline exponentially.

In some coral reefs, the proliferation of benthic algae caused by enhanced nutrient inputs has led to competition with the hard corals, which the corals have lost. Thus, there can be a change in community structure from a hard coral-dominated to an algal-dominated system.

Overharvesting has been a specific threat to biodiversity. In some instances, it has led to local extinctions of species (e.g., marine turtles, giant clams, and certain species of reef fish collected for the aquarium trade). Such human activities are not normally regarded as land-based despite the fact that much of the activity is promulgated on land and the resources recovered by these means are destined for use there.

For the sake of clarity and conformity with the GPA/LBA, this chapter deals with forms, causes and targets of marine environmental degradation individually. However, in many locations, especially near to coasts, there are multiple sources of degradation. The actual changes in such areas are therefore the result of various human activities acting in combination. When aquatic systems are subject to several stresses at a time (e.g., physical alteration and depressed dissolved oxygen concentrations), the net impact on communities and their component species may differ from what is expected when individual stressors act alone. Similarly, the net effect of the exposure of organisms to several chemical contaminants in combination can be of concern. Experience suggests that such effects are seldom greater than additive and that additivity occurs when the induction-response mechanisms for contaminants are similar. There are known cases of antigonism, (when one contaminant mitigates the effect of another), but few instances where synergism, (where the combined effects of more than one contaminant exceed that expected on the basis of additivity) has been inferred.

2.2.4 Economic and Social Benefits and Uses, Including Cultural Values

Many of the environmental changes originating from land-based activities are associated either with damaging effects on habitats or with toxicity. Both reduce the abundance of resources, while the latter may also adversely affect the quality of seafood.

The degradation of habitats adversely affects fish abundance and often, therefore the contribution that the fisheries sector makes to food security and human welfare. Only in a few cases has there been a cost-benefit analysis of the impact of a land-based activity on a fishery through the degradation of habitat: one study - of the impact of logging on a fishery in the Philippines - found considerable economic benefits from a limited logging ban to prevent siltation of a coral reef (Hodgson and Dixon, 1988).

The economic case for protecting the fisheries sector against the adverse effects of environmental changes caused by land-based activities is often accepted by default - thus intrinsically recognizing that extracting living resources from the sea is, in some way, a privileged activity compared to others. This privileged status may also cause society to ignore the adverse effects caused by fishing itself, including those on habitats and other marine species. Surprisingly, society exhibits less concern about the adverse effects of fishing activities than those of other practices.

While the impact of habitat degradation on coastal marine fisheries can be severe, the adverse effects upon fish that spend much of their lives offshore but depend on the nearshore marine environment for at least part of their life-cycle, remain largely unknown - as does the extent of the economic benefits that are foregone as a consequence. The maintenance of resources of cultural significance in the face of environmental threats also deserves attention. This has been clearly recognized in the Arctic where representatives of the indigenous communities have been included in the conduct of assessments and in the formulation of action plans. Gaps in contemporary knowledge call for ecological research combined with broader social and economic evaluation.

Pollutants originating from land-based activities may also be responsible for fish kills. These occur ubiquitously and on local scales. They are often associated with low dissolved oxygen concentrations and algal blooms. The associated lower levels of commercial and recreational fishing and, most significantly, the closure of fisheries because of increased risks to human health from contaminated fish, result in economic costs. The latter situation is particularly prevalent in mollusc fisheries. It is not possible, without substantial further investigation, to quantify the economic costs of these effects. They are, however, considerable, as indicated for the United States in reports published under the aegis of the U.S. National Estuary Program.

Environmental changes caused by land-based activities may also be responsible for the breakdown of traditional cultures of fishing communities; this occasionally leads to conflict when traditional measures for fishery resource allocation have been undermined. In north-west Mexico, for example, the impact on oyster fishermen of large-scale agricultural projects, and the consequent diversion of water and migration of agricultural workers into the coastal zone, has been well documented (McGoodwin, 1994). The ecological shifts that occurred as a result of the diversion of water rendered some formerly important fishing sites unproductive and created new fishing sites in areas where there were no precedents regarding use rights. New migrants knew nothing of local customs regarding marine resource conservation and exploitation and conflicts broke out between the newcomers and the traditional fishing communities. The impact of industrial pollution on fishing communities is also well documented. For example, the effect of industrial waste constituents on the oyster fishing communities in Chesapeake Bay and along the coast of Alabama (Durrenberger, 1992) has been to erode the traditional culture of the fishermen who depended on the resource.

Mineral resources, such as sand and gravel and crude oil, also are recovered in economically significant amounts from the coastal zone. Other, less easily quantified, values are of much greater significance as they include the latent benefits of marine ecosystem processes that sustain life and human welfare. An attempt has been made by Costanza *et al.* (1997) to estimate the value of ecosystem services such as atmospheric gas regulation, climate regulation, water supply and regulation, soil maintenance, nutrient cycling, waste treatment, food production, and the provision of recreational and cultural opportunities. The estimated value of such ecosystem services for the entire biosphere is in the range US$16-54 trillion. Implicitly, many of these services lie outside the conventional market economy. There is general agreement on the desirability of increasing the incorporation of environmental amenities into mainstream economic and social calculations. The bio-economic modelling techniques for handling these questions are being constantly improved. A practical problem in many situations is that the requirement for supporting scientific information is considerable and there are limits to current institutional capacities for applying these techniques.

2.3. SOURCES OF DEGRADATION

2.3.1 Coastal and Upstream Point Sources

Coastal and upstream point sources are usually specific industrial plants, sewage discharges and development sites such as land clearance and excavation. Contaminants of concern from industrial discharges are nutrients, heavy metals, specific organic compounds, radionuclides and, sometimes, the physico-chemical properties of the discharge such as pH, salinity and oxygen demand. The constituents of sewage are human pathogens, nutrients, organic carbon and - if the source of the sewage is combined - oils, greases and industrially-derived chemicals that enter the sewage stream both from household use and stormwater runoff. Industrial contributions to sewage include organic-rich wastes from animal processing plants, tanneries, canneries and breweries. Other point sources include development activities that result in discharges of sediment or the interruption of stream flow, which sometimes results in the trapping of contaminants in a watercourse.

Virtually every marine region identifies industrial discharges to rivers and the marine environment as a source of identifiable - if frequently local - impact. This is especially true of discharges containing high concentrations of metals, oil, polycyclic aromatic hydrocarbons (PAHs) and nutrients. Thus, essentially all regional areas have evidence of discharges exceeding the capacity of the receiving environment to accommodate them without adverse effect. There are many examples of extreme contamination of the marine environment with metals, some of the most notable are in the Arctic, both on land and in freshwater, in the vicinity of smelting operations in the Russian north (e.g., Norilsk and Nikel) and in places where the marine environment has been used as a repository for mine wastes such as at Maarmorilik, Greenland.

In developed areas, the adverse effects of such practices on the marine environment and its resources have already been identified and, in many cases, rectified through the imposition of source controls. It is, however, unfortunate that in many instances such controls have been imposed following the recognition of problems rather than in the discharge authorization process, or the prior assessment procedure has not been adequately conservative *(*i.e., precautionary). Nevertheless, the fact that most localized problems rapidly become evident provides some confidence that the most extreme ones are being addressed. It is the less obvious subtle and chronic effects that require greater attention by developed states.

All industrial wastes contain natural and artificial radionuclides from atmospheric fallout. The major authorized releases of radionuclides to the sea are those from nuclear fuel cycle installations, particularly spent fuel reprocessing plants. Reprocessing plants are located at Sellafield (U.K.), La Hague and Marcoule (now shut down) (France), Trombay (India) and Tokai-Mura (Japan). The areas under the direct influence of discharges from Sellafield and La Hague, such as the Irish Sea and the North Sea, have been the subject of comprehensive evaluations for many years. In addition, ongoing scientific studies of larger "downstream" water bodies, including the Norwegian Current, the Baltic, the Barents Sea and the Arctic Ocean, have provided enough basic information to identify and quantify public health risks. Nuclear power reactors discharge small quantities of radionuclides and represent point sources both on coasts and within river catchments, but these are generally well-regulated and should seldom be of concern, even locally, under normal operating conditions.

Mariculture facilities, common to both developed and developing countries, comprise other point sources within the coastal marine environment itself. Wastes entering coastal waters from certain mariculture facilities include fæcal matter and unconsumed feeds, both containing residues from pharmaceutical and other treatment agents (GESAMP, 1997b).

2.3.2 Coastal and Upstream Non-point (Diffuse) Sources

Diffuse sources result from broad-scale activities that cannot be discriminated as readily as single, site-specific discharges. The most obvious of these activities is agriculture, which results in the runoff of crop treatment residues and animal wastes. These often result in the contamination of groundwater, with associated diffuse leakage into rivers and coastal waters. Wide-scale forestry also contributes to diffuse-source transport of nutrients and soils to the marine environment. Major or widespread development activities resulting in the increased mobilization of soils would also fall into this category. Nutrients and particulate materials are the constituents of diffuse sources contributing to drainage into rivers and the marine environment that are of the greatest concern.

2.3.3 Atmospheric Deposition

Atmospheric deposition can be divided into two categories: substances with short atmospheric residence times and those with long ones. Short residence time materials are likely to be deposited fairly close to such sources as releases of metals from metalliferous smelting activities. Long residence time components will be widely distributed on regional, or even global, scales.

More volatile substances are among those of greatest concern in relation to the atmospheric pathway to the aquatic environment. These include mercury and lead, among the inorganic chemicals, and a range of organic substances. Of particular concern are the semi-volatile and persistent substances such as the polychlorinated biphenyls (PCBs), a number of pesticides and some inadvertent by-products of combustion, namely polychlorinated dibenzo-*p*-dioxins and dibenzo furans. These have all been included in a group of compounds categorized as "persistent organic pollutants" (POPs) and are sometimes referred to as the "dirty dozen" (see Box 2.1). These semi-volatile substances can undergo an iterative process of deposition, remobilization into the atmosphere and redeposition. This "global distillation" (Mackay and Wania, 1995) has been given as a reason for their prevalence in polar regions and is a consequence of the gradient in ambient temperature between the equator and the poles. The role of the atmosphere in the transport of nutrients, especially nitrogen, has also long been of interest. This topic and the most recent developments within it are discussed in Chapter 3.

Box 2.1. The 12 Persistent Organic Pollutants (POPs) selected for negotiations under the International Negotiating Committee (INC) on POPs

Pesticides
- aldrin
- chlordane
- DDT
- dieldrin
- endrin
- heptachlor
- mirex
- toxaphene

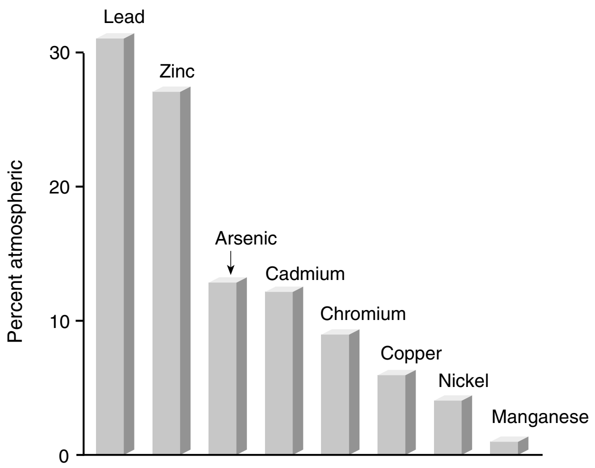
Industrial Chemicals
- hexachlrobenzene (also a pesticide)
- polychlorinated biphenyls (PCBs)

Unintended Byproducts
- polychlorinated dibenzo-*p*-dioxins (PCDDs)
- heptachlor - polychlorinated dibenzo-furans (PCDFs)

There have been a number of studies of the atmospheric input to coastal waters, particularly in North America and Europe: in most other regions of the world it has largely

FIGURE 2.4

Input of heavy metals to Chesapeake Bay (U.S.A.) from the atmosphere



Source: adapted from Scudlark *et al.* (1994).

been ignored. Figure 2.4 presents the percentage of the total input that has come from the atmosphere for a number of heavy metals entering Chesapeake Bay in the United States. The percentages represent deposition directly onto the Bay surface and range from 1% for manganese to 30% for lead.

Toxaphene, a persistent organic pollutant (POP) that has become widely distributed within the marine environment, can be used as an example. A complex mixture of polychlorinated terpenes, predominantly chlorobornanes, it has been used extensively as a pesticide in North and South America, Russia and Asia (Saleh, 1991), though not in Europe. With the recognition of significant global transport of volatile contaminants generally, a number of studies have investigated toxaphene in biota from marine waters. Two regional examples are summarized in Boxes 2.2 and 2.3.

Table 2.1. Median concentrations for S3 chlorobornanes (toxaphene) in herring from the Northeast Atlantic (Alder *et al.*, 1995)

Sampling site	Number of samples	Concentrations (g/kg lipid)
West of Ireland	3	87 - 181
Rockall Trough	1	102
West of Norway	2	102 - 170
Central North Sea	11	16 - 613
Skagerrak	3	7 - 19
Baltic Sea	5	132 - 258

Box 2.2. POPs in the Canadian Arctic

The Canadian Arctic Contaminants Assessment Programme (Jensen *et al.*, 1997) has investigated a number of POPs, including toxaphene, in the Arctic regions of Canada. Particulate matter under the ice, planktonic and benthic invertebrate tissues, and abyssal and coastal marine fish were investigated. The main focus has been on piscivorous fish such as turbot, lake trout, northern pike and Arctic char, because of their importance in the traditional subsistence fishery and because of the interest in possible biomagnification to top predators. While toxaphene and PCBs had the highest concentrations, DDT and chlordane-related compounds were also important. The highest concentrations in Arctic fish were found in turbot (Greenland halibut). These predacious, bottom-feeding fish have relatively fatty muscle compared with whitefish, char or sculpins. Samples from the eastern Canadian Arctic and the eastern Beaufort Sea both had mean toxaphene concentrations three to five times higher than in ocean char muscle and 15 to 20 times higher than in Arctic cod (whole fish). Fish is the primary food for the indigenous people in the Canadian Arctic, and high concentrations of toxaphene have been found in the breast milk of indigenous mothers in this region - significantly higher than that of mothers living in large Canadian cities.

Data for Arctic marine mammals show a similar proportionality in abundance between these classes of POPs (Norstrom and Muir, 1994), although toxaphene does not biomagnify to polar bears to the same extent as PCBs or some chlordane components. A study of 586 polar bears in 18 Arctic regions (Norstrom and Muir, 1994) showed a relatively uniform distribution of POP levels over much of the study area, clearly indicating extensive transport and deposition of POPs to wide areas of the Arctic and subarctic. The atmosphere is the dominant transport path for toxaphene and PCBs to the Arctic although local sources such as dumped electric equipment are the dominant PCB source within radii of a few tens of km of the dumpsites. An evaluation using criteria established to protect fish-eating wildlife suggests that there is not a large margin of safety for arctic marine or freshwater piscivores. Using these same criteria, carnivores such as polar bears would be at risk due to the consumption of ringed seal tissues.

Box 2.3. Toxaphene Around Great Britain and Ireland

In a study conducted between 1990 and 1992, fish samples were obtained for total toxaphene analysis from waters adjacent to Ireland and Great Britain (de Boer and Wester, 1993). As can be seen in Figure 2.5, significant concentrations of toxaphene are evident in mackerel flesh and in whitefish liver. The highest concentrations are west of Britain and Ireland, with lower concentrations in the North Sea. Alder *et al.* (1995) analyzed three specific toxaphene congeners in whole fish samples from widely separated locations, predominantly in the Northeast Atlantic. They found that this group of toxaphene congeners are most prevalent in larger, slow growing fish species e.g., halibut and redfish, and that there is a strong positive correlation between length and residue concentration in herring taken from the North Sea. As the data for herring provides the best geographic coverage, these are presented in Table 2.1. However, because these data are not normalized for age and length of fish, they may not be a true reflection of toxaphene distributions. Nevertheless, these data show that toxaphene is a widespread contaminant in fish from the Northeast Atlantic and, because concentrations are generally higher than PCB levels in similar species, toxaphene may be the dominant organochlorine contaminant in fish from the region. To date, there are no data on toxaphene levels in the tissues of marine mammals from this area.

In relation to consumer health, it should be noted that there is still uncertainty regarding the appropriate limits for toxaphene in fish flesh, partly because existing toxicological data relate to different suites of toxaphene congenors. Nevertheless, most of the concentrations of toxaphene are higher than the maximum limit for food (100 mg/kg lipid) set in Germany in 1994 (Deutscher Bundesrat, 1994). Moreover, the maximum acceptable daily intake of 1 mg/kg body weight per day (U.S. Department of Health and Human Services, 1990) would have been exceeded by light to moderate intakes of fish from these areas. It is likely that toxaphene, along with other volatile contaminants such as mercury and PCBs, is transported from the American continent by a combination of atmospheric and oceanic processes. Although the use of toxaphene has been banned in the United States since 1986, its continued use in Central and South America may lead to persistent elevations of this pesticide in fish near Great Britain for the foreseeable future. Certainly, further data are required on the status and transport pathways of this pesticide in the North Atlantic generally.

FIGURE 2.5

Total toxaphene concentrations in fish tissues sampled around Ireland and Britain 1990-1992

Source: de Boer and Wester (1993).

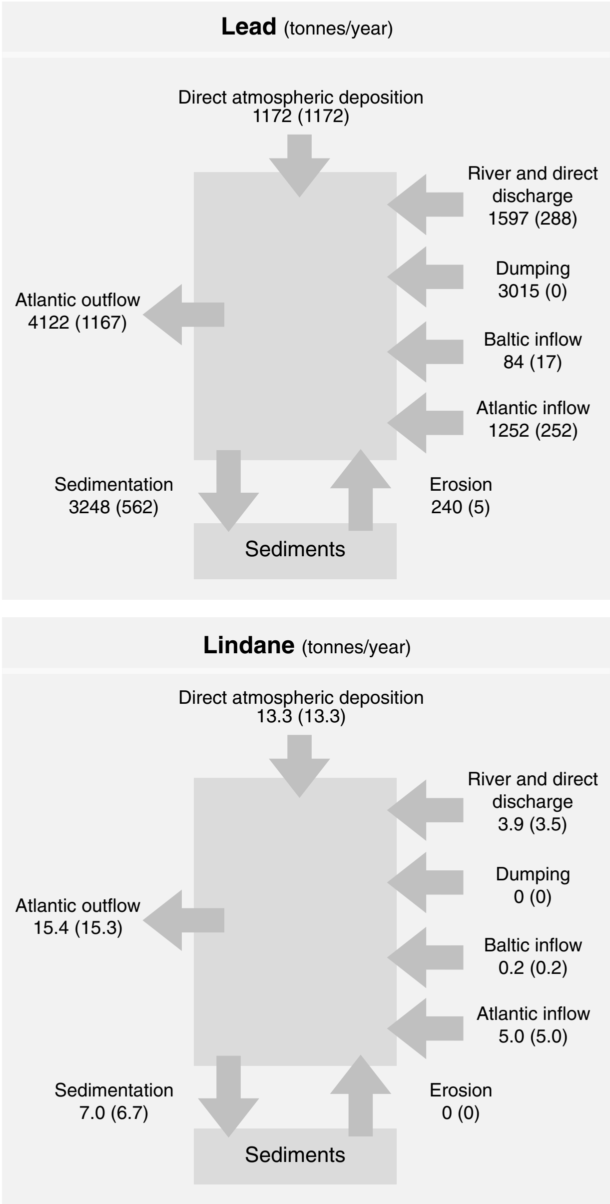
There has been growing concern about the input of a wide range of synthetic organic compounds to the coastal ocean. The atmospheric input of lindane (HCH) to the North Sea was compared with that from other sources (see Figure 2.6), and was found to dominate it: this is typical of many synthetic organic compounds.

There have also been many investigations of the **trace metal** input to the North Sea, the Baltic Sea and the Mediterranean Sea. One study of the North Sea considered not only the direct input to the surface waters, but also deposition on the watershed, with subsequent riverine input, Baltic Sea inflow, Atlantic Ocean inflow and outflow, and the exchange of metals with sediments. Figure 2.6 shows the results for lead. Atmospheric input is quite important in this larger context, being approximately equal to the inflow from the Atlantic Ocean, although still less than that entering the North Sea from dumping. It should be noted that approximately 20% of lead in the Atlantic inflow to the North Sea is also derived from the atmosphere.

For artificial **radionuclides**, atmospheric deposition (fallout) is still a significant pathway of input to land and the ocean although it is becoming smaller as the stratospheric reservoir of fission products from atmospheric weapons testing is reduced by radioactive decay. Atmospheric deposition is important to the supply of some natural radionuclides, such as Beryllium-7 and Lead-210, to the Earth's surface.

FIGURE 2.6

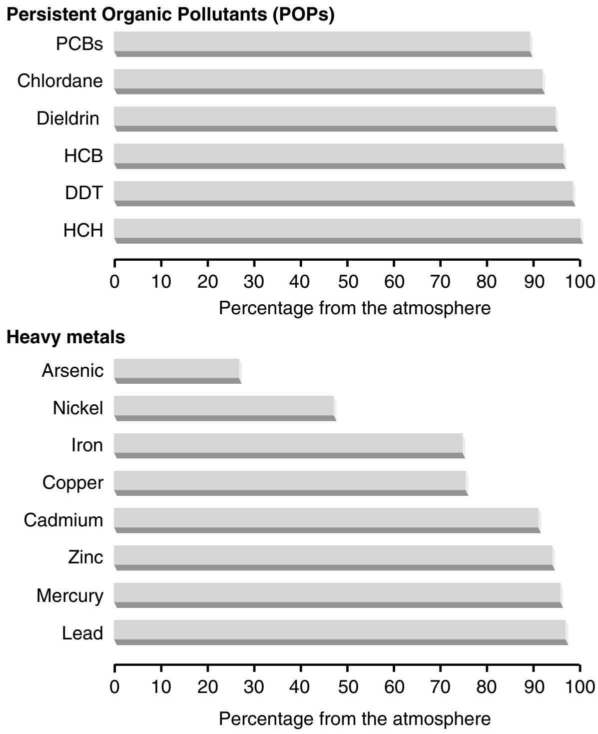
Input of lead and lindane to the North Sea



NB: Values in parentheses denote atmospheric contribution to the total input from that source.
Source: after van den Hout (1994).

FIGURE 2.7

Percentage input of heavy metals and synthetic organic compounds to the global ocean from the atmosphere



Source: after Duce *et al.*, 1991; Hg data from Mason *et al.*, 1994.

For many contaminants, a relatively small fraction of the material delivered to estuaries and the coastal zone by rivers makes its way through the near shore environment to open ocean regions. Thus, for the open ocean, atmospheric input for most contaminants is much more important than riverine input. For example, Figure 2.7 shows the proportions of the total input of several heavy metals and synthetic organic compounds that are derived from the atmosphere. While the values in Figure 2.7 have considerable uncertainty, the apparent dominance of atmospheric over riverine input for most of these substances is obvious.

2.4. CONTAMINANTS

This section deals with the classes of contaminants listed in the GPA/LBA. These are: sewage; persistent organic pollutants; heavy metals; oils (hydrocarbons); nutrients; sediment mobilization; and litter. Historically, specific contaminants, particularly chemicals, have been of foremost concern in terms of adverse effects on the marine environment. Such concerns are also reflected, but in a far more balanced context, in the GPA/LBA. In the sense that "a pollutant is a resource out of place" it should be noted that any substance - even a regular constituent of the environment - can cause pollution in abnormal concentrations arising from anthropogenic activities. There are some unique and surprising contaminants in some areas. One is salt (i.e., **seasalt**) which is discharged from seawater desalination plants at high enough volumes and concentrations in the Arabian/Persian Gulf and the Red Sea/Gulf of Aden significantly to alter the salinity of the nearshore zone, with attendant changes in community structure (Jeftic, 1998g; 1998h (Annex 2); GIPME, 1996). Similarly, although not usually given a great deal of attention by the public, **heat** discharges can also have significant effects, especially in small, poorly flushed, water bodies. Discharges from both power plants and desalination plants can alter temperatures and salinities in inshore areas of specific regions with potentially adverse effects. Mangrove mortality may be caused by a 3-5°C increase in ambient water temperature in the tropics and the diversity and mass of associated fauna may diminish by 90% (Jeftic, 1998g (Annex 2)).

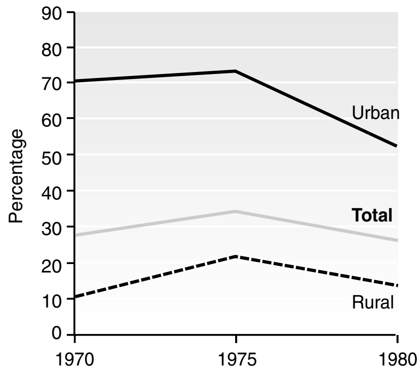
2.4.1 Sewage

Sewage discharges give rise to problems for bathing water and shellfish marketability, though invariably on local scales in the vicinity of untreated or incompletely treated discharges. Such compromises, however, are widespread and, therefore while not a truly "global" problem, the ubiquity of the adverse effects of sewage discharge make it a problem of global socio-economic dimensions. Net reductions in nutrient discharges to the marine environment depend on higher levels of sewage treatment because primary treatment alone does little to reduce nutrient releases. Such additional treatment does not always require reliance on conventional techniques that may be appropriate to urban sewage streams, but can be achieved through the use of natural coastal wetlands as treatment systems.

Historically, it was commonly believed that the introduction of organic carbon and nutrients to the marine environment in sewage was a good thing, resulting in increased biological production. The following statement was made by John Isaacs: "*The return of organic waste and plant nutrients resulting from the most natural of acts* (i.e., human defecation) *is most probably beneficial. The benefits of putting the same material on land is clear to any farmer but the advantages of the sea are not so easily appreciated. The sea is starved for basic plant nutrients and it is a mystery to me why anyone should be concerned with their introduction to coastal seas in any quantity we can generate in the foreseeable future*." Isaacs clearly did not foresee the growth and concentration of population in coastal areas that occurred in the latter half of the 20th Century with the resultant overloading of coastal waters - though his statement is still applicable to the open ocean. The sheer rate and ubiquity of nutrient discharge has overwhelmed the capacity of many inshore coastal areas to assimilate nutrients and oxygen demand without harm. This is not a problem for the open ocean because of its enormous capacity to assimilate oxygen demand and its oligotrophy. The use of long outfalls over narrow shelves, such as in California and the Pacific Islands, to deliver sewage to the offshore ocean is therefore still legitimate. However, the concept of waste disposal into the sea involving discharge and dispersion of the products of human activities, no matter how "natural" the products concerned, has come to be viewed as a bad thing. Goldberg has commented on this general topic on a number of occasions (e.g., Goldberg, 1993): society appears to be being swayed by previous evidence of bad management (hospital wastes on beaches, closed bathing beaches for reasons of microbial contamination) rather than a truly "ethical" debate about the use of the ocean for waste disposal. If well managed from the perspectives of eutrophication, oxygen demand and the protection of human health, there are no *a priori* reasons to regard sewage disposal in the ocean as invariably "bad practice" especially if human wastes are segregated from industrial wastes (*cf* Chapter 5).

FIGURE 2.8

Percentage of population in developing regions supplied with sewage treatment



Source: World Resources Institute (1998).

2.4.2 Persistent Toxic Substances and "Persistent Organic Pollutants"

Substances in this category are diverse. They include substances that are persistent in the sense of being long-lived and relatively slow to breakdown into other less persistent chemicals. They also include less persistent chemicals that, because of the amounts in widespread and continuing use, occur in significant equilibrium concentrations in the environment and are of concern due to possible adverse effects. There is currently a Global Environment Facility (GEF) funded evaluation of so-called "**persistent toxic substances**" (**PTS**) which includes attention to some less persistent substances that, because of their continuing use and dissemination, may give rise to chronic exposures over large temporal and spatial scales.

The so-called **Persistent Organic Pollutants** or "**POPs**" (see Box 2.1) that are the main focus of current international negotiations leading to a global agreement also reside in this category. They are characterixed by low solubility in water and high solubility in lipids. They are stable to photochemical, chemical and biological decomposition, and therefore accumulate in fatty tissues. Due to their volatility, several of these substances can undergo long-range atmospheric transport and deposition to the ocean. Most POPs of contemporary concern in the marine environment are synthetic compounds produced for the benefit of society, but their beneficial features must be weighed against their negative effects on human health and the environment.

Included in this group of 12 substances are polychlorinated dibenzo-*p*-dioxins (PCDD) (often simply referred to as "dioxins") and polychlorinated dibenzo-furans (PCDF) (often simply referred to as "furans"). These are discharged into water, largely from pulp mills using chlorine as a bleaching agent and certain types of treated wood feedstock, and give rise to predominantly local effects through, for example, the contamination of seafood. Larger scale concerns are associated with PCDD and PCDF releases to the atmosphere from waste combustion (Duarte-Davidson *et al.,* 1997; Kjeller *et al.,* 1991; Kjeller and Rappe, 1995). These compounds are, however, not purely artificial and are also produced in natural forest fires.

International controls on the production and use of a small number of POPs were introduced more than 20 years ago. Indeed the atmospheric concentrations of the controlled substances have decreased in remote areas of the northern hemisphere, showing that action can be effective. However, even where the use of some POPs has been discontinued, many developing countries lack the capacity to dispose of remaining stockpiles. Controls on POPs currently address only a small fraction of the potentially dangerous chemicals and there are persuasive arguments for broader international controls on the production and release of chemicals with physical-chemical properties known to be inimical to the environment. The increased use of these substances in areas of the world where regulations are not in place, or not enforced, represents a serious challenge - as do the threats posed by new substances coming into commercial use. Several major international efforts have been devoted to the integrated assessment of the primary inventories and pathways of certain POPs. These efforts have been useful, but obviously they are only a small part of what will be needed in both the near and the distant future.

2.4.3 Radioactivity and Radionuclides

A variety of practices and activities routinely introduce radioactivity into the marine environment. These include military activities, nuclear fuel cycle operations (mining, milling, conversion, fuel enrichment and fabrication, fuel reprocessing, waste storage, decommissioning) and the use of radioisotopes by research centers, hospitals and industry. Nuclear weapon tests carried out in the atmosphere (mainly before 1964) and fuel reprocessing plants are the main contributors to radioactive contamination of the marine environment by a wide range of man-made nuclides. Atmospheric nuclear weapon tests represent a source of global contamination, whereas releases from spent fuel reprocessing plants lead to contamination on local and regional scales.

Concerns about radionuclides in the marine environment from authorized releases continue to unduly preoccupy the public, though not scientists familiar with the topic. Previous and potential accidents in the nuclear industry are, however, a matter of universal and justified concern. Such accidents have resulted in major enhancements in the radioactive contamination of the environment, as demonstrated by releases from the fire at the fourth unit of the Chernobyl nuclear power plant in 1986.

Essentially all contemporary practices involving significant quantities of radionuclides are authorized in conformity with the International Basic Safety Standards for Protection against Ionizing Radiation and the Safety of Radiation Sources (IAEA, 1996) and - although accidental releases can occur - the impacts of such activities on human health and the environment at global and regional levels are generally of minor significance. Nevertheless, this is an emotive issue on which it is extremely difficult to change public opinion and the topic will continue to need addressing in environmental reviews at all levels.

There remains one outstanding limitation of the current system of regulation for radioactive substances and nuclear activities - its foundation on the protection of human health alone. It has long been hypothesized that protecting humanity also serves to protect the environment. However, at least one analysis (IAEA, 1988) has indicated that this hypothesis is flawed because situations can be conceived in which the exposure to organisms is short-range while that to humanity is by remote pathways. Accordingly, there are now pressures to broaden the basis of radiological protection to include consideration of the effects on the environment and its flora and fauna. While the IAEA and certain professional organizations are pursuing this subject, it is likely to be several years before the fruits of their labours show up in a revised and more comprehensive regulatory system.

2.4.4 Metallic Compounds

Contaminant metallic compounds justify concern predominantly on the local scale, and exceptionally (as noted in the next paragraph) on the regional one. This, however, seems yet to be widely appreciated. The preoccupation with basin-wide scale investigations of metals in the North Sea, for example, belies their limited hazards and their generally more localized threats. Greater tailoring of measurements of specific metals with those contained in emissions from local sources would appear warranted. Some reductions in the releases of metals in titanium dioxide wastes and from the pulp and paper industry - where the use of mercury cathode cells in chlor-alkali production has been substantially reduced - have been achieved, especially in Europe and North America.

The one instance in which such concerns extend to regional levels is in the Arctic where mercury and lead exposures to higher trophic organisms, including people, are thought to be close to a threshold for adverse effects (AMAP, 1998). Lead is less of a widespread problem than in the past because of measures to phase it out as an anti-knock compound in gasoline engine fuels. Cadmium is often included in the volatile inorganic group , but this is without much justification. It is not as volatile as mercury and lead and is more reactive in the atmosphere, as evidenced from studies of point source emissions of cadmium that show that it is largely precipitated over relatively short distances (10-100 km).

Other classical contaminants of concern at regional and local scales are diverse. **Tributyl tin** and its derivatives, dibutyl tin and monobutyl tin, gives justifiable reason for concern because of its low threshold for effects on bivalves (particularly oysters) and gastropods, and its widespread previous use. Again, control measures have been introduced to replace tributyl tin as an anti-fouling preparation on small vessels and mariculture structures. When released into water, organotins undergo pH-dependent dissociation (e.g., TBTOH to TBT+ + OH-). The undissociated moeties have log Kow of the order of 2.3-4.1 and can be bioaccumulated and adsorbed onto suspended matter (Fent, 1996). The dissociated form can also be adsorbed onto particles. Degradation takes place in the dissolved phase but persistence in sediments can be long (Fent, 1996). Thus concerns about the use of organotin preparations in the marine environment are related to its persistence and observed effects on marine organisms. Another organometallic compound of interest is methylcyclopentadienyl-manganese tricarbonyl (MMT), which can be used as a replacement for tetraethyllead anti-knock additive in gasoline.

2.4.5 Hydrocarbon Compounds

Releases of hydrocarbon compounds from routine operations, such as shipping and oil exploration and exploitation, are relatively well regulated (e.g., through the MARPOLS 73/78 Convention). Historically, the release of hydrocarbons from catastrophic spills or tanker accidents has been of most concern. Most of the environmental consequences of catastrophic spills are relatively short-lived, although they can cause disruptions of flora and fauna, including seabird populations. These populations may be slow to recover. Weathered oil from spills at sea can become adsorbed into beach strata for several decades. The development and installation of contingency plans and technology to counteract the effects of large oil spills reflects an awareness of the seriousness of such threats and has been a positive development, largely in response to previous tanker accidents. There are some ongoing concerns about seabird mortalities in coastal and offshore areas that may be related to illegal discharges of oil or chronic contamination from maritime sources. Future exploitation of marine oil and gas reserves will take place in many developing regions of the world. This raises concerns about abilities to provide adequate regulation and/or enforcement and to respond to oil spills in such regions.

It is interesting to note, in this context, that studies of the Persian/Arabian Gulf suggest that the chronic and acute releases of oil that have taken place as a result of leakage from shipping activity and, most recently, acts of war, have been accommodated by that system relatively rapidly. The potential for acute effects of oil spills is clearly one warranting stringent preventative and contingency measures to minimize damage, but the insidious introduction of low-levels of hydrocarbons from shipping, refining and runoff from parking lots is likely, overall, to be of greater biological significance. GESAMP is currently undertaking a review of the inputs of oil entering the marine environment from sea-based activities (GESAMP, 1999). The overall total average influx of oil to the sea from ship traffic and offshore activities is of the order of 850,000 tonnes per year. A further 350,000 tonnes per year is estimated to be derived from coastal refineries, storage and transhipment facilities, oil seeps and other unknown sources. Excluded from these estimates are releases from military activities and leisure craft and emissions to air of volatile organic carbons (VOCs). VOC emissions are potentially a major route of oil input to the oceans as they have been estimated to be 3,750,000 tonnes per year, principally from tankers. This latter estimate is, however, being re-evaluated taking account of the high proportion of methane in such releases.

An illustrative example of the relative contributions of oil from a variety of sources is provided in the Black Sea Assessment (Jeftic, 1998c (Annex2)). Of the total input of 111,000 tonnes, 53,000 tonnes (48%) enters via the Danube River. A further 30,000 tonnes is derived from domestic sources, 15,400 tonnes from industrial sources, and only 136 tonnes from accidental oil spills. To this must be added the unquantified inputs through the discharge of oily residues from ships, which is thought to be considerable. The point is that the land-based sources of oil input are likely to the most significant even in marine areas having heavy tanker traffic. This reinforces the view that marine sources, although probably significant in the case of this sea, are probably of negligible importance on oceanic scales. It is, of course, recognized that catastrophic spills such as those from the *Amoco Cadiz* and *Exxon Valdez* will cause severe, if transient, problems within regional areas, but they are of limited significance on spatial oceanic, and long-term time, scales .

2.4.6 Polycyclic Aromatic Hydrocarbons (PAHs)

The sources of PAHs are widespread and both natural (e.g., forest and bush fires) and anthropogenic. The coastal sediments in most industrialized areas, and all large ports, frequently contain concentrations well above regional background levels. Molecular spectra can indicate the most likely source(s) in given situations: parent unalkylated PAHs indicate combustion sources; alkylated PAHs indicate direct petroleum sources. There remain concerns about the incorporation of PAHs into seafoods. The Arctic, for example, has elevated levels of PAHs in seawater and marine sediments, particularly in the Beaufort Sea, relative to general background levels elsewhere. The capacity to exploit oil and gas reserves under the ocean floor at greater depths and further offshore is rapidly increasing. Undoubtedly, this will result in: increased trans-shipment of oil at coastal terminals; an increase in coastal refining capacity that, in turn, will increase the importance of the petrochemical sector as a source of land-based discharges of PAHs; and the construction of additional offshore field servicing facilities in diverse coastal areas. Increased shipment increases the risk of accidents at sea. The growth of the offshore oil exploitation industry will have physical effects on the coastal environment through construction work and is likely to increase the release of contaminants, especially petroleum derivatives, from land-based activities in this industrial sector. Concerns about polycyclic aromatic hydrocarbons (PAHs) stem largely from human health perspectives related to their occurrence in foodstuffs, including seafood. In this context, there remains a need for additional insight into the types of hydrocarbon compounds entering the marine environment from land-based activities.

2.4.7 Nutrients

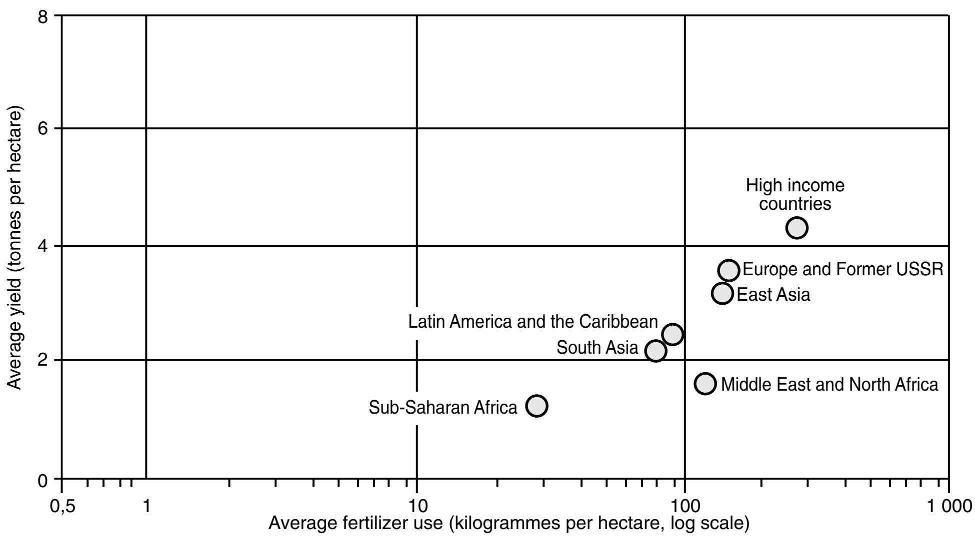
Although neither are "classical" contaminants, nutrients and particulate material are arguably the most important classes of contaminants at national and regional levels. Unquantified concerns remain about nutrients, although there is increasing evidence of changes in inshore phytoplankton communities, such as shifts from diatoms to flagellates (North Sea: Wollast, 1983; Lancelot *et al.*, 1987; Smayda, 1990) that may be attributable to declines in silicate inputs and concomitant increases in phosphorus and especially nitrogen inputs. Steps taken to control the use of phosphorus compounds in detergents for household and industrial use has undoubtedly had the effect of reducing phosphorus inputs to the marine environment in relation to the fluxes pertaining one or two decades ago (see Jeftic, 1998f (Annex 2)). Yet, there is every reason to believe that the amounts of nitrogenous compounds entering the marine environment have continued to increase as a consequence of intensified agriculture and industrial activities. Nutrient runoff, associated eutrophication and periodic anoxia are cited as major concerns in the Mediterranean LBA assessment (Jeftic, 1998e (Annex 2)). In other areas, such as the North Sea, there are *prima facie* reasons for concerns about departures from natural N:P:Si ratios in coastal areas and their effects on coastal water primary production communities (Lancelot *et al.*, 1987; Smayda, 1990). Clearly, the source of the nutrient imbalance is not attributable to human sewage discharges - which constitute a minor component of the supply - but to other practices, especially industry and agriculture, that have had significant effects on the balance among the nutrient supplies. This is reflected in the trend in the global use of fertilizers shown in Figure 2.1. This figure needs, however, to be considered in the context of Figure 2.9, which shows the relationship between crop yield and fertilizer use in various regions of the globe.

Experience in the Mediterranean, which is basically an oligotrophic sea, suggests that moderate levels of enrichment of originally nutrient-limited marine systems may favour production, and even suspension culture, of some bivalve species together with higher production of small pelagic fish of low economic value (Jeftic, 1998e (Annex 2)). However, they do so at the expense of more valuable bottom-dwelling fish and crustaceans. Increased nutrient loads in fresh water runoff to semi-enclosed seas may also accelerate phytoplankton growth to the point that it adversely affects aquatic vegetation by reducing light penetration, especially if it is accompanied by high suspended sediment discharges (UNEP, 1996a). In other oligotrophic areas, like the Red Sea, basin-wide effects are not likely to be significant, but eutrophication can still occur in inshore areas subjected to inputs from anthropogenic activities (Jeftic, 1998g (Annex 2)).

The serious deterioration that has occurred in the northern area of the Adriatic for over twenty years is attributable to nutrient input in amounts that exceed the basin's natural assimilation capacity. The River Po, carrying some

FIGURE 2.9

Fertilizer and cereal yields in developing countries and high-income countries, 1989



Source: FAO, Rome.

100,000 tonnes/yr of inorganic nitrogen and some 6,000 tonnes/yr of inorganic phosphorus, contributes most of the total nutrient load to the northern Adriatic basin. The total nitrogen and phosphorus discharges into the northern Adriatic from Italy alone amount to some 270,000 and 24,000 tonnes/yr, respectively (UNEP, 1996a). Another estimate of the total nitrogen input to the Adriatic Sea is 300,000 tonnes/yr, with half of this total being derived from atmospheric deposition (120,000 tonnes/year over the sea and 30,000 tonnes/yr through the watershed) (UNEP, 1996b; 1997).

Existing and potential trends in the delivery of nitrogen to the marine environment that raise more widespread concerns are discussed as an emerging issue in Chapter 3 .

2.4.8 Sediment Mobilization

The increasing mobilization of sediments from development activities is clearly an issue of primary concern at local and even regional levels (see, for example, Jeftic, 1998g (Annex 2)). In temperate areas, such increased introduction of sediment gives rise to benthic community blanketing with associated changes in community structure and an increased need to undertake dredging of navigation channels. In tropical areas, damage to coral reefs is a major concern. The rate of deforestation in developing areas, as depicted in Figure 2.3, is a major cause of increased sediment runoff.

Reduced sediment supply in runoff also poses an existing or potential problem. It gives rise to reductions in the natural inflow of chemicals, including nutrients, and to under-nourishment of beaches and fine shelf sediments. There are more than 36,000 large dams in the world, and countless small ones (McKinney and Schoch, 1998; Abramovitz, 1996): as a result, very few rivers run entirely free of man-made obstructions. It has been argued that hydrologic modification presents the most severe threat of major damage to the ecology of the Arctic. Even marine impoundments can present problems, or at least raise questions. The construction of a storm-surge barrier in St. Petersburg, Russia, has created a particularly intense debate about its effects on fisheries and human health (largely because of the discharge of untreated sewage into the harbour) (Jeftic, 1998a (Annex 2)). In the Mediterranean, particulate influxes from the Nile have been essentially eliminated by the construction of the Aswan High Dam, while particle discharges from many other rivers have been significantly reduced. Particle fluxes from the Ebro and Rhone, for example, have been reduced by 95% and 80% respectively (Jeftic, 1998e (Annex 2)). The reduction in suspended and bed load particle supply from the Nile has resulted in such demonstrably negative effects as groundwater salinization and erosion of the Nile delta. Positive effects of reduced sediment supply include reduced suspended sediment damage to coral reefs, although it is currently arguable whether the ***net*** effect is positive or negative in specific regional areas. Nevertheless, the entire issue of alterations to sediment loads in local and regional areas and their effects on flora and fauna is much more significant than is commonly appreciated. The most important point in this latter context is the need to understand the consequences of the alterations to natural or prevailing sediment fluxes, both reductions and augmentations, thereby providing an ability to assess the net benefits of alterations due to human interventions.

2.4.9 Litter

Litter has become more and more serious problems in recent times. It consists mostly of plastic waste discarded from centers of dense human population and fishing vessels. Another, more localized, source is tourism which is increasing worldwide particularly in tropical developing countries. Litter accumulates on beaches and in shallow water habitats The thousands of tons of plastics discharged into the marine environment constitute a considerable source of marine contaminants that affect marine wildlife, particularly turtles, mammals and birds, through entanglement and ingestion. Litter also has repercussions on coastal economic activities, particularly tourism.

A variety of land-based and marine activities result in the introduction of debris or litter into the marine environment. Generally speaking, urban debris is predominant in the vicinity of large cities while ship-generated litter is a major contributor on remote strand lines (Haynes, 1997). Since the 1970s, studies have addressed the problem of debris in the marine environment mainly in terms of quantitative measurements of abundance and the effects on marine fauna. Most of the data concern floating debris or litter along the coast. Plastics, notably polyethylene and polypropylene, account for the major part because of their poor degradability. Comparisons of the accumulation of marine debris among locations is, however, complicated by differences in the intensities and periods of study and the methods of classifying debris and beach substrate. Nevertheless, it is obvious that marine contamination by buoyant and neutrally-buoyant debris is ubiquitous. Even pristine environments located far from man-made sources, such as the Southern Ocean, are not free of marine debris.

The areas of most concern in relation to litter are shorelines where stranded material can pose risks to human health and cause the aesthetic deterioration of beaches and coastal waters, thus affecting tourism. Effects on marine organisms are, however, more widespread and extend to the pelagic ocean and other remote areas. High litter concentrations are found in the vicinity of shipping lanes, around fishing areas and in oceanic convergence zones (Pruter, 1987). Denser solid material can be found littering the seafloor. Large amounts of debris have been encountered on the continental shelf of the Bay of Biscay and around northwestern Mediterranean towns (Galgani *et al.,* 1995a,b). The presence of debris has also been recorded on the continental slope and the bathyal plain of the eastern and western Mediterranean basins (Galil *et al.*,1995; Galgani *et al.*, 1996). This further illustrates the ubiquity of litter and the associated risks of damage to marine ecosystems.

Social conditions have a major influence on the types of marine debris found on strand lines. Footwear is, for example, a comparatively large component in Indonesia (hundreds of thousands of flip-flops have been found on the shore of islands located more than 1000 km west of Jakarta; Willoughby *et al.*, 1997), while diverse plastic kitchen and laundry containers, and metal and aluminium cans, are increasing constituents of beach macro-litter in many countries.

Commonly, the issue of litter is considered in the context of problems associated with solid waste management including the effects of solid waste deposited in the ocean. Small island states can suffer difficulties both in disposing of solid wastes (because of limited landfill space) and in recycling (because of their limited scales of economy). Thus the discussion above, which focuses on litter derived from sea-based and coastal activities, does not encompass all the regional concerns about solid waste contamination of the marine environment expressed in Chapter 4 of this document.

2.5. PHYSICAL ALTERATION

This is the principal topic which, "coming to the fore" in recent years, has stimulated the adoption of more balanced perspectives of the causes and sources of damage to the marine environment. Sediment mobilization partly falls into this category because it results primarily from physical alterations of the coastal and hinterland environments by resource exploitation and socio-economic development activities. The nature and effects of physical alteration can be subdivided into two major categories: hinterland and coastal foreshore development.

The effects of hinterland development are predominantly manifest, as far as the marine environment is concerned, in changes to water and particulate fluxes, both in terms of scale and periodicity. Modification of river drainage basins by human activity has led to dramatic changes in the flow of the water, the suspended sediments and the nutrients that they bring to the sea. Most of the world's major river deltas are suffering receding coastlines as a result of decreased transport of sediments. There are secondary effects on the delivery of chemical constituents from diffuse sources, principally agriculture. Thus, the importance of hinterland development relates primarily to the rates of delivery to the marine environment of freshwater, nutrients, suspended particles and certain chemicals. Failure to adequately manage excavation works, forestry and agriculture, so that soils are retained on site, is responsible for severe degradation of water courses and some coastal environments. It should be noted that changes in the delivery rates of water and particles themselves have a direct impact on the delivery of both the conservative and the particle-reactive chemical constituents of runoff. This discussion will leave aside the issue of diffuse source delivery rates because it has already been addressed in previous sections of this document.

Physical alterations of the coastal foreshore include beach development and sustenance, tourist developments (construction of hotels, marinas, *etc*.), the dredging of navigational channels and the construction of industrial plants such as power stations, pulp mills, transshipment facilities, wharves and jetties, fish processing plants, shipbuilding plants, shore reception facilities, sewage treatment plants and a variety of outfalls. As they develop, many small island states - with limited land suitable for housing, industrial development and the installation of infrastructure - will necessarily have to resort to reclaming land from the sea. This necessitates physical alteration of the foreshore: the scales of potential effects beyond the altered area should be considered before development, and steps should be taken to minimize adverse impacts. All such developments have an impact on the coastal environment in terms of flow modification, of turbidity generation, of effects on biological communities in beach, littoral and sub-littoral environments - and, sometimes, of changing (augmenting or reducing) the influxes of other contaminants. It is interesting to note that in at least one regional area, the Red Sea/Gulf of Aden (Jeftic, 1998g (Annex 2)), it was concluded that physical alteration and destruction of habitats as a result of dredging and infilling operations associated with urban expansion, tourism and industrial developments constitute the main source of environmental degradation and, accordingly, were considered the region's highest priority.

Sand and gravel extraction from the seabed is registered as a specific concern in at least two of the regional GPA/LBA reviews. In some Northeast Atlantic states (e.g., Ireland) land-based sources of aggregates for construction are dwindling and, consequently, demand for marine-derived aggregates is growing rapidly. Sand and gravel extraction takes place in many different areas of the North Sea, but most intensively in its southern part. It is noted (Jeftic, 1998f (Annex 2)) that, during such recovery, four times as much material is put into suspension, increasing the area in which benthos are affected by the extraction process. Recovery of the benthic community can take ten years or more. In tropical areas, the adverse effects can extend to coral reefs and may be catastrophic for reef communities (Jeftic, 1998d (Annex 2)).

In certain sub-regions, such as the Irish Sea, concerns have also been expressed about the effects of physical alteration of the seabed by intensive trawling activities. There is a need for the physical effects of fishing activities - especially bottom disturbances by intensive trawling - to be considered more greatly in fisheries management.

Costs of Physical Alteration

The costs of physical alteration – representing the benefits to be obtained from effective control – comprise the use values provided by a particular ecosystem, such as waste assimilation, mitigation of storm surges and flood control, the loss of tourism, fisheries, fuelwood and option values. Non-use values may also be lost such as existence and bequest values. The magnitude of these costs vary greatly from one location to another.

For coral reefs in Indonesia, Cesar (1996) has estimated that the societal costs of a number of activities that result in reef damage to be up to 50 times the private benefits obtained (using 10% discount rate over a 25 year term). Intervention in this case would be reef management including, *inter alia*, restriction on access to reefs and the costs would be those of the implementation of the required management measures and the foregone individual benefits.

Countries, as a rule, give priority to economic "development" over environmental conservation: they pay little heed to lessons that may be learned from proper environmental impact assessment and cost-benefit analyses, especially when these incorporate long-term considerations instead of immediate or short-term gains. It is therefore foreseeable that increasing construction of urban settlements, industrial facilities, shipping ports, power plants and aquacultural facilities will lead to severe damage or total obliteration of natural habitats such as mangrove forests, coral reefs and seagrass beds - not to mention causing a general deterioration in water quality. With these consequences come losses of natural productivity of valuable sources of food and other useful products as well as such vital functions as coastal protection from storm waves.

2.6. AREAS OF CONCERN

Each of the following sub-sections discusses specific environmental resources or issues of concern, with emphasis on those relating to the consequences of land-based activities.

2.6.1 Coral Reefs

Coral reefs are shallow-water tropical and subtropical communities, with exceedingly complex interrelationships among species: they have arguably the highest species diversity of any marine community. Their productivity is driven by two main components: symbiotic algae (zooxanthellae) that live inside reef-building corals, and some other invertebrates and free-living algae, especially benthic seaweeds. The growth of the reef structure itself depends upon calcification by corals and coralline algae, and thus upon adequate light for photosynthesis: they are therefore sensitive to reductions in light penetration from increased turbidity. Reefs typically form in oligotrophic waters within a relatively narrow range of temperature and salinity, and tend to grow in temperatures near the upper limits of tolerance for the corals that build them. Thus, reef communities are sensitive to relatively small changes in temperature and salinity. Reef corals are also sensitive to many pollutants. Unstressed reefs grow fast enough to withstand erosion by wave action and boring organisms and keep pace with sea level rise, but relatively small changes in calcification can shift the balance from growth to decline.

The Economic Value of Coral Reefs

Coral reefs have supported human populations on tropical coasts of the world for hundreds, if not thousands, of years. At present the "sustainable" fisheries yield of coral reefs is estimated to be about 20-35 million tonnes per year. Human population growth in recent decades, however, has already far outstripped the capacity of coral reefs to produce harvestable biomass. Thus, a plea is made for coral reef conservation worldwide, bearing in mind the economic value of these ecosystems, not just in terms of fisheries production but also in terms of their various functions and the "services" they render to humanity (Birkeland, 1997; Crossland *et al*., 1991). Because of their relatively high biological diversity, coral reef communities harbour organisms that are a source of chemicals with potentially high commercial value, such as those used in drugs. Another less appreciated function of coral reefs is their action as natural breakwaters protecting coastlines from erosion and destruction by ocean waves and currents. Finally, reefs have been increasingly valued for their sheer intrinsic beauty that provides a basis for a booming tourist industry in many parts of the world. Recent estimates (e.g., McAllister, 1991; Spurgeon, 1992, 1998), including those made in court cases, indicate the value of a square metre of coral reef is probably in the range of hundreds to thousands of US dollars.

According to the most recent estimate (Bryant *et al*., 1998), reefs have been damaged in 93 of the 110 countries where they occur and some 27% of the world's reefs are at high risk of degradation. Globally, the greatest threats to coral reefs from human activities are sediment mobilization, eutrophication, over fishing and destructive fishing, aggregate extraction and direct physical destruction. Mass coral bleaching and the possibility of increasing frequencies of coral diseases have recently emerged as issues of concern and are discussed in Chapter 3.

Elevated sediment input damages reefs both by increasing turbidity and by directly smothering corals (Rogers, 1990). Coral recruitment may be reduced on sediment surfaces and sedimentation can alter coral community structure (Hodgson, 1994). Though reefs do sometimes develop in naturally turbid conditions, it is not known whether the vast majority of reefs, that have not done so, can adapt to elevated sediment loads (Brown, 1997).

Eutrophication is cited as a contributing factor in reef degradation in most parts of the world. The negative effects of eutrophication on coral reefs arise primarily from light attenuation due to increased phytoplankton biomass and the stimulation of benthic algal productivity to the competitive disadvantage of corals. There is no question that eutrophication has damaged reef systems in many parts of the world, especially in enclosed lagoon systems. The most commonly cited example is the degradation of reefs in Kaneohe Bay, Hawaii, resulting from sewage discharge (summarized by Hunter and Evans, 1994). There is evidence that eutrophication contributed to a "phase shift" from a coral-dominated to an algal-dominated community on Jamaican reefs (Lapointe *et al.,* 1997) although in this case hurricane damage and the removal of algal grazers by overfishing and disease were also major influences (Hughes, 1994).

Scientific understanding of the effects of anthropogenically elevated nutrient input on coral reef ecosystems is far from complete. There is a lack both of reliable baseline data and of understanding of coral reef processes. Even after a four-fold anthropogenic increase in nutrient input to the Great Barrier Reef - one of the best-studied reef systems in the world - the occurrence of ecologically significant eutrophication there remains a matter of scientific controversy (Brodie, 1995). Similarly, Szmant and Forrester (1996) were unable to find unequivocal evidence of elevated nutrient input to the Florida reef tract. ENCORE, a major experimental program to determine the effects of elevated nutrient levels on a reef, has produced equivocal results (e.g., papers in Lessios and MacIntyre, 1997). Increased benthic algal biomass is often interpreted as evidence of reef degradation by eutrophication, but algal biomass fluctuates naturally on decadal time scales (Done, 1997). There are many other uncertainties including the relative importance of nitrogen and phosphorus in nutrient limitation, possible effects of nutrient enrichment on the coral-zooxanthellae symbiosis and the possible effects of elevated phosphorus levels on calcification. Despite these uncertainties, there is a general consensus that eutrophication is among the most serious world-wide threats to coral reefs.

While not strictly a land-based activity, fishing pressure is one of the primary causes of reef degradation on a global scale and reduces the resilience of reef systems to land-derived stresses. Based on recent global assessments (papers in Ginsberg, 1994; Jameson *et al*., 1995; papers in Lessios and MacIntyre, 1997; Bryant *et al*. 1998, papers in Wilkinson, 1998) fishing pressure is particularly severe in east Africa, mainland India and Sri Lanka, southeast and east Asia, the south and eastern Pacific, and much of the Caribbean.

Fishing pressure leads to reef degradation in two main ways. First, overfishing may remove ecologically important components of the reef community, leading to sometimes profound alterations in community structure. The removal of fishes that graze on algae, for example, gives the algae a competitive advantage over corals and, as in Jamaica, can allow them to take over the reef. This problem is thought to be widespread in the Caribbean (CARICOMP, 1997). The removal of predatory fishes, which are thought to be important determinants of community structure, may also have effects. Outbreaks of a coral-eating snail in east Africa, for example, have been attributed to overfishing of predatory fish (McLanahan, 1997). In general, however, the ecological effects of overfishing are poorly understood and impossible to predict in any given situation. The second cause of reef degradation from fishing is the use of destructive fishing methods including poisons, explosives, and the physical destruction of the reef to extract fish or drive them into nets. Anchors, weights, and trampling also physically damage corals. These and other destructive fishing practices are used in most parts of the world that have reefs (Wilkinson, 1998).

Physical destruction of reefs also occurs by dredging and blasting for port and navigational improvements and maintenance, or through mining for construction material or lime. This large-scale physical destruction of reefs is thought to be especially serious in southern India, Sri Lanka, the Maldives, and parts of the south Pacific (Wilkinson, 1998).

2.6.2 Seagrass Beds

Seagrass beds are known to serve as shelter, nursery and feeding grounds for a variety of ecologically and economically important invertebrates and finfish. Their high productivity is driven by photosynthesis of the seagrasses themselves, of epiphytes attached to the seagrass blades and of macroalgae inhabiting the beds. Dredging to create or enlarge waterways near ports and harbours is major threat to the existence of these habitats. It involves removal of the plants and extensive damage to the habitat, and causes sediment resuspension resulting in increased turbidity in the water column. Increased turbidity can also result from increased sediment transport from land via runoff, or from eutrophication. It results in the reduction of the light that drives the photosynthesis essential for the maintenance of seagrass ecosystems. The presence of seagrasses in areas being developed for tourism and recreation is frequently regarded as objectionable, and they are deliberately removed from such areas by mechanical means.

2.6.3 Coastal Wetlands

Wetlands act as a sink for materials such as sediments, nutrients and organic carbon, and store other materials, such as water, on a temporary basis. The value of these storage functions is increasingly recognized as an important feature of watersheds: it contributes to flood control and geomorphological processes - such as the control of coastal erosion and the accumulation of organic carbon (Maltby, 1991; Immirizi *et al.*, 1992) - and the maintenance of genetic resources (James, 1991). The biogeochemical dynamics of wetlands also play a major role in filtering and cleansing water, such as the removal of toxic material from the water column (Richardson, 1985). These functions are considered of great potential economic value in providing tertiary treatment of sewage and reducing pollution from agricultural wastes (Maltby, 1991).

The movement of water, nutrients and organic materials between wetlands and other ecosystems is essential to the maintenance of the food chains, migration routes and environmental linkages that support the productivity and health of marine ecosystems and renewable resources. Coastal wetlands provide a number of buffer functions that help to protect life, property and the economy of local communities and some countries. Wetlands help to regulate the rates of surface water flow and groundwater recharge: this reduces flood peaks and regulates base water flows in rivers. Coastal wetlands also serve as a buffer to coastal storm surges and winds (Hamilton and Snedaker, 1984).

Wetlands are often used as landfill sites and for the dumping of domestic and other solid wastes. They have also suffered from coastal development, though there is now some indication that the value of coastal wetlands is being appreciated and more protection is being offered to them, at least in developed countries. When wetlands are destroyed, risks to the economic welfare of coastal communities increase dramatically. In effect, poor planning and management can turn a natural event, such as a coastal storm, into a human disaster (Wijkman and Timberlake, 1984).

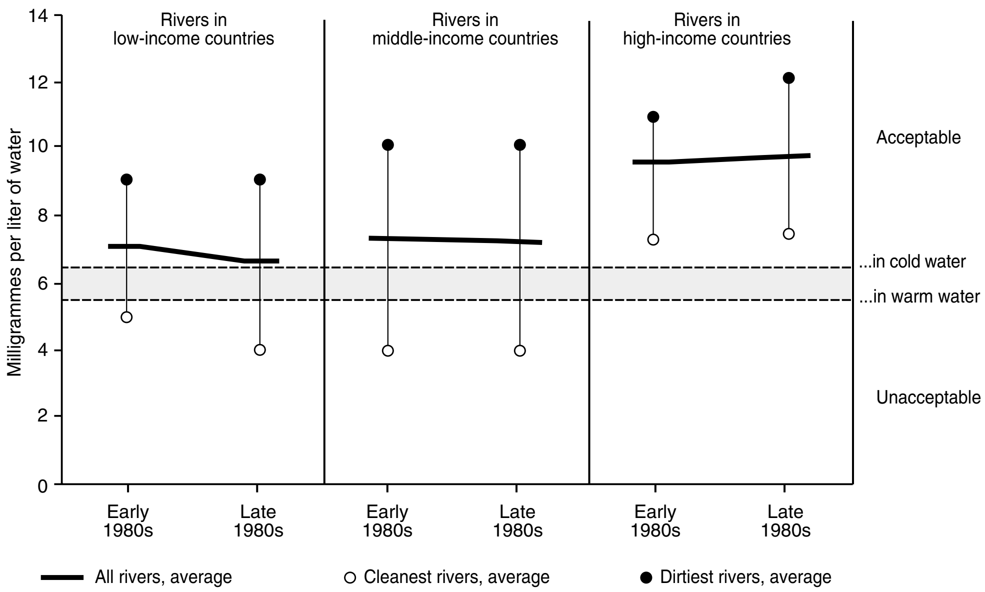
2.6.4 Mangroves

Mangrove forests function as shelter, feeding and/or breeding grounds for ecologically and economically important organisms such as various species of crustaceans, molluscs and finfish. They also serve to protect coastlines against erosion by the sea. In addition, it is believed that they act as large-scale filters, assimilating sediments, nutrients and other substances that would otherwise be washed into coastal waters.

In many parts of the tropical belt, huge amounts of mangrove cover (greater than 50%) have been lost during the 20th Century, mainly due to conversion to other uses (aquaculture, human settlements, the use of mangrove wood chips for the production of rayon) (Ong, 1982; 1995). A significant fraction of the human populations inhabiting the vicinity of intact mangrove forests still rely on these ecosystems for subsistence needs, such as food, wood for construction or for household use, plants with medicinal value, etc.

FIGURE 2.10

Dissolved oxygen in rivers: levels and trends across country income groups, 1980s



Source: USEPA, Washington, DC, USA.

2.6.5 Effects of Intensive Mariculture

Badly planned and managed mariculture can have serious effects on the marine environment. Intensive mariculture requires structures for rearing organisms either on the coast or in shallow waters, and this often involves converting such habitats as mangroves and lagoons. Such alteration of the structure and function of coastal habitats - often accompanied by modifications to water circulation and sediment movement - has frequently contributed to the loss or degradation of valuable coastal ecosystems. Mariculture also sometimes involves the propagation of non-indigenous organisms. If these are deliberately or accidentally released into surrounding coastal waters, they can disrupt populations of native species through competition or predation. Intensive feeding and the use of chemicals such as herbicides and antibiotics often lead to local pollution. One example is the accumulation of organic wastes in sediments, particularly beneath open-system structures such as sea cages and mussel rafts; the decomposition of these wastes consumes dissolved oxygen and places stress on sediment-dwelling organisms. However, when sound guidelines for the siting and management of farms are properly followed, the potential adverse effects of mariculture can largely be avoided.

2.6.6 Anoxia in Shallow Coastal Waters

As discharges of organic waste into enclosed and semi-enclosed shallow bodies of water increase, reducing conditions tend to develop in the sediments and water column, leading to oxygen deficiency. A dramatic result of this is the extensive mortality of organisms, especially when the anoxic sediment is resuspended due to disturbance by storms or by human activities such as dredging. Although not of direct relevance to marine waters, a harbinger of oxygen declines in coastal areas is indicated by trends in dissolved oxygen in the rivers of different country income groups shown in Figure 2.10 (World Bank, 1992).

The prevention of reduced oxygen levels in coastal waters can be achieved by ensuring that the rate of overall oxygen demand resulting from enhanced biological production and the introduction of oxygen-demanding wastes is less than the rate of supply of oxygen by advective and diffusive processes, taking account of seasonal variations. It has to be recognized, however, that there are areas - such as in fjords and the deep waters of certain regional basins like the Baltic and Black Seas - that are normally hypoxic (either seasonally or for longer periods) as a result of natural processes. It is common to have concerns about the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) of wastes in environmental management, but these are seldom accompanied by an understanding of the temporal periodicities of the demand and of the oxygen supply to the receiving area. Furthermore, the peculiarities of different methods of measuring oxygen demand introduce complications in the use of such routine measurements for oxygen balance calculations. The inadequacies of contemporary waste management are clearly illustrated by Figure 2.11 which shows the global distribution of seasonally oxygen-depleted areas worldwide.

2.6.7 Small Islands

Global warming resulting from emissions of greenhouse gases in industrialized countries may result in sea-level rise. The highest points on some low islands, such as the Maldives and the Marshall Islands, are only 2-3 metres

FIGURE 2.11

Areas with seasonal depletion of dissolved oxygen (●)

Source: Dian and Rosenberg. 1995. Oceanography and marine biology. An annual review 33, 245.

above sea level: even small increases of a few centimeters in sea level will have an effect on them. Changes in storm and wave patterns resulting from climate change could result in increased frequency of flooding on some islands. They could also upset the dynamic equilibrium of sandy shorelines, coral reefs and mangroves upon which many islands depend for their protection from waves and for their livelihood from marine resources and tourism. Even in the absence of climate change and sea level rise, small islands are highly vulnerable to such natural events as tropical storms. In some cases, the crops and/or marine ecosystems of entire islands have been destroyed by single storm events. Recovery can take years and substantially impede economic and social development.

Many islands are experiencing rapidly expanding populations and the establishment of industry and associated infrastructure. At the same time, many lack facilities for adequate sewage treatment or management and waste disposal, because of the comparatively high cost of building and maintaining such them. This results in increased pollution of the limited coastal areas upon which these small islands depend for their livelihood.

The Exclusive Economic Zones of small island states includes about 30 million km^2 of ocean space - about one-sixth of the Earth's surface. Given their limited national budgets and small populations, it is difficult for them to provide the financial and human resources to manage these extensive marine jurisdictions. This often results in overexploitation of fisheries by foreign fleets, in many cases through illegal practices.

Freshwater resources are limited in many small islands. Increases in population, industrial development and tourism can cause changes in use patterns resulting in the depletion of freshwater supplies. When the freshwater lenses of small islands are drawn down, there is an increased likelihood of saltwater intrusion into aquifers. Equally, increased infrastructural development can result in accelerated contamination of freshwater supplies with associated increased dangers to human health.

By definition, small island states have relatively limited land resources. Increases in urbanization and industrialization lead to deforestation and land erosion. This, in turn, can affect coastal ecosystems through the increased mobilization of soils and soil-associated contaminants.

Many small island states rely heavily on fossil fuels for energy production. In most cases, these have to be imported at considerable expense. In many cases, alternative energy sources (e.g., solar, wind, wave) require capital investments that are prohibitive for them Furthermore, the special energy needs of small island states do not easily attract industrial attention and investment because they represent a market of limited potential compared with those of larger countries.

Marine tourism is a major source of income for many small islands. However, increasing the numbers of tourists places greater demands on energy and water supplies, increases sewage and other waste disposal demands, competes for land and perturbs coastal ecosystems. Tourism can also have substantial deleterious effects on local communities and their culture.

Many small island states are the guardians of marine flora and fauna of global conservation value. It is in the interests of the global community that they are not threatened. However, the national budgets of many small island states are too limited to fund the biodiversity conservation programmes needed to manage and preserve these species.

2.7. ADDITIONAL ISSUES OF CONCERN

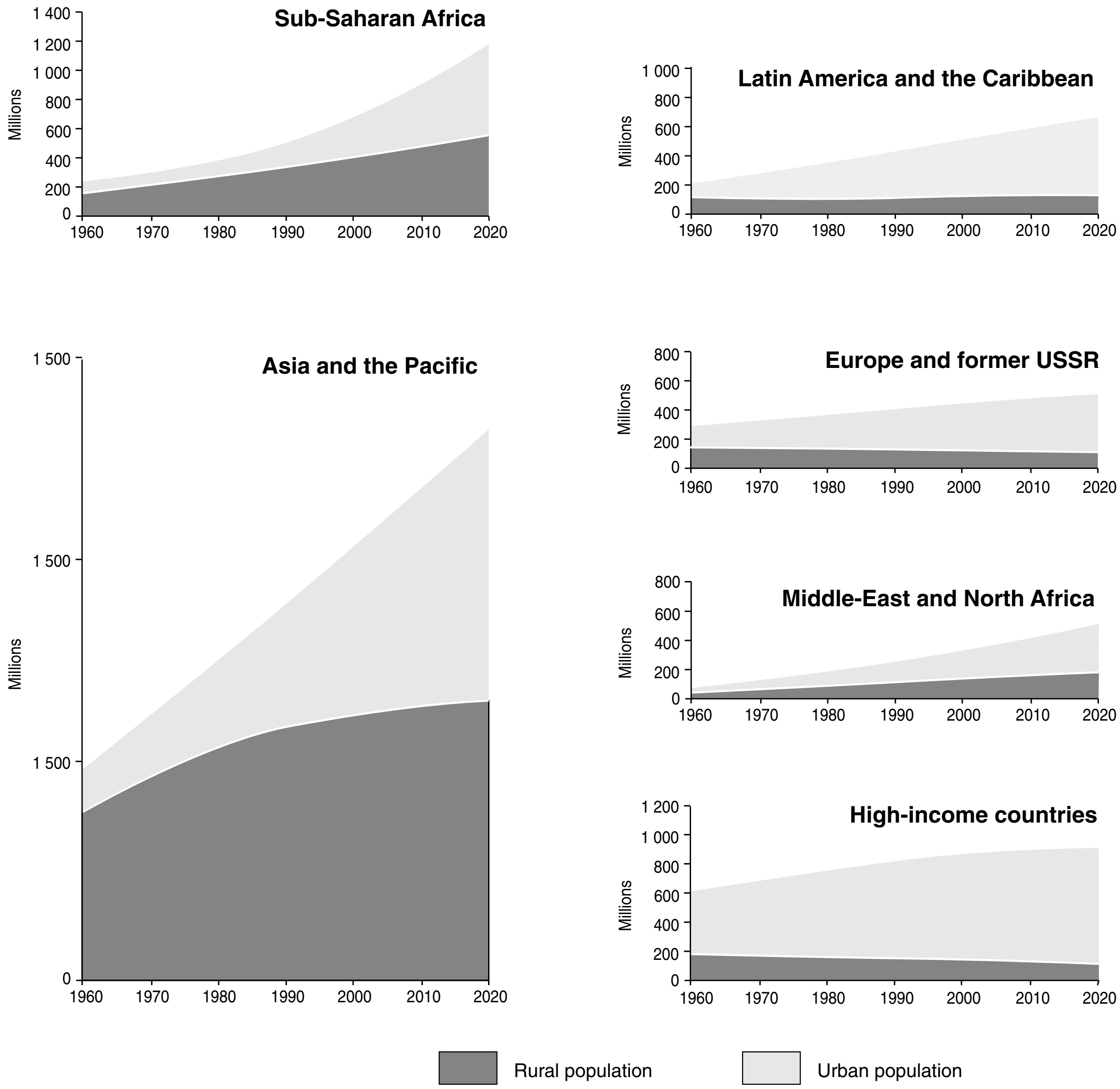
2.7.1 Expanding Coastal Populations and Tourism

Nearly two-thirds of the world's population lives along a coastline and there is a trend towards the increasing migration of people to the coasts. The population growth rates of the urban communities of Mombasa and Dar Es Salaam on the coast of east Africa, for example, are 5.7% and 7.8% respectively (Jeftic, 1998d (Annex 2)), much greater than the average rates of growth in their countries. Concerns have particularly been expressed about the growth of such coastal cities as Bangkok, Bombay, Buenos Aires, Cairo, Jakarta, Lagos, Los Angeles, New York, Shanghai, Manila and Tokyo into so-called "Megacities". This is a reflection of the respective trends in urban and rural populations in various regions of the world shown in Figure 2.12. Even less populated areas are seeing a growth in tourism with all the associated demand for infrastructure development. These increasing human pressures have triggered widespread resource degradation, and represent one of the greatest threats for marine coastal ecosystems. Deficiencies in infrastructure and waste treatment facilities have significant consequences, including the potential degradation of water supplies. Critical coastal resources, such as mangroves and coral reefs - among the most productive and biologically diverse ecosystems - are being plundered in the name of development. Fragile dune systems that provide stabilization of beach areas from erosion are also at risk from such activities. Half of the world's mangrove stands have already been destroyed by human development. Furthermore, human activities have damaged or destroyed coral reefs in at least 93 of the 110 countries in which they occur, primarily through increased sedimentation, eutrophication, overfishing and destructive fishing, mining, and tourism and recreational activities (Bryant *et al.*, 1998). Considering that almost 90% of global marine fisheries are located in the coastal zone, the gradual removal of coastal habitats is jeopardizing food security.

Tourism is popularly considered an "environmentally-friendly" alternative to more exploitive forms of liveli-

FIGURE 2.12

Rural and urban population in developing regions and high-income countries, 1960-2025



Source: World Bank, Washington, DC, USA.

hood dependent on coastal and marine resources. It has the advantage of providing a basis for countries to gain an increased appreciation of the perceived value of natural resources and, accordingly, the benefits of increased environmental protection. Unfortunately, the expansion of tourism also entails the construction of additional infrastructure along coastlines, with scant attention to increased requirements for waste treatment and disposal. The environmental impact of such construction is seldom considered. In addition, tourism results in changes in traditional values and ways of life: this needs to be considered in decisions regarding tourism potential and development.

2.7.2 Globalization of the Chemical Industry

The chemical industry is becoming increasingly globalized. There is a steady trend towards increasing chemical production capacity in developing countries and transition economies. Large quantities of chemicals are transferred at maritime, freshwater, road and rail transport nodes, with inherently increased risks of accidental spills and increasing diversification of operational discharges.

2.7.3 Toxic Algal Blooms

The existence of paralytic and diarrhetic shellfish poisons (PSP and DSP respectively) in shellfish is well established. In 1987, an amnesic shellfish poison (ASP) came to widespread attention as a result of adverse human health effects on consumers of cultured mussels from Prince Edward Island, Canada. The culprit in this case was domoic acid produced by marine algae. This increased the awareness of the possibility of natural neurological poisons occurring in seafood products, and of the likelihood that there may be other naturally-produced organic compounds posing risks to the health of seafood consumers. In the last decade, much greater attention has been given to harmful algal blooms (a more all-encompassing term commonly used to describe blooms having a range of adverse effects from purely aesthetic to the production of toxins), partly because of dangers to human health, but more directly because of effects on valued marine species such as cultured finfish. While the topic of such natural poisons is not of *prima facie* relevance to marine pollution from land-based sources, the contention that the frequency and ubiquity of unusual algal blooms is increasing has given rise to suspicions that there may be a connection with eutrophication. These suspicions relate to the increased influx of nitrogen compounds to the ocean resulting from anthropogenic activities, although a direct link with the frequency of unusual algal blooms has not been established.

The transfer of the cysts of potentially toxic dinoflagellates in ballast water from one marine coastal area to another is also of concern: it is discussed below under the topic of invasive species.

2.7.4 Relationship to Eutrophication

Ubiquitous or large-scale eutrophication remains an issue of concern particularly in the context of increased nuisance algal blooms in the coastal zone. The debate about whether there has been a global increase in the frequency and location of nuisance algal blooms continues (e.g., Smayda, 1990). Increasing agricultural production based on the enhanced use of fertilizers could reasonably have been expected to provide increased fluxes of nitrogen and phosphorus into coastal areas through runoff (Smayda, 1990). However, the declining use of phosphorus compounds in detergents would be expected to result in some decline in phosphorus inputs to the ocean. Some of the critical questions in this debate are: “Has there been a recent increase of the nitrogen-phosphorus ratio in runoff?” “Is phosphorus limitation of algal growth becoming more common than hitherto?” and “Does phosphorus limitation of growth, as opposed to the more common nitrogen limitation, give rise to metabolic responses in primary organisms that result in the production of toxins?”

2.7.5 Transfer of Non-Indigenous (Alien) Species

When an organism or plant that has its origins in one region becomes established in another - and significantly displaces a species or significantly changes the ecological balance of the region into which it was introduced - it is known as an *invasive species*. Invasive species can originate from domesticated or wild stock. The transfer from one area to another can be through normal physical and biological processes, through accidental introduction or by a deliberate act. The geographical range of some species in the Bay of Biscay, for example, is extending northwards: it is believed that this is a response to increased sea temperatures (i.e., a manifestation of climate change).

Accidental and deliberate introductions of various species have accompanied the movement of people from their early history. Many species have been deliberately transported from their region of origin to become components of crops, domesticated livestock, horticulture and recreation in the regions to which they have been introduced. Most modern crops and livestock originated from fairly localized areas but are now spread throughout much of the globe.

Marine species have been transferred intentionally and unintentionally through many transportation vectors, including ships’ hulls and anchors, to new areas. They have also been transported with commercial products (e.g., as predators or disease agents), released from aquaculture, or sold for ornamental purposes. Continued concerns are being expressed about the effect of escapee fish from aquaculture facilities on wild stocks. The International Council for Exploration of the Sea has periodically examined this topic, most recently in 1997. It is clear that in recent years (mid 1980s to mid 1990s) significant numbers of mariculture salmon escapees have been caught in Norwegian fjords (10-21% of the catch), in coastal (34-54%) fisheries, and in certain areas of Scottish fisheries (up to 38%). The numbers of mariculture escapees in North America are also substantial: 17% of the rod catch of salmon in the East Machias River, Maine, was of farmed origin in 1990. The degree to which escaped salmon can significantly affect the composition, disease incidence and genetic character of wild stocks is of greatest concern. For these and other reasons ICES developed a Code of Practice on the Introductions and Transfers of Marine Organisms (ICES, 1984a,b; 1988).

Concerns about the introduction of alien species have focused primary attention on shipping as the most significant transport vector because of the volumes of ballast water transported and the intensity of shipping traffic. Ballast is placed in a ship to increase its draught, to alter its trim, or to otherwise regulate its stability, usually as a means of maintaining stress loads within acceptable levels.

The potentially adverse effects of introductions of species transported with ships’ ballast water to new locations have been demonstrated by the discovery in the 1980s of Ponto-Caspian zebra mussels in the Great Lakes and the North Pacific sea star *Asterias amurensis* in Australia. Introduced zebra mussels severely fouled water intakes in the Great Lakes, resulting in expensive measures to clear them and efforts to find methods of reducing such fouling. The range of zebra mussels in Europe continues to expand. One of the most damaging such transfers, of the ctenophore *Mnemiopsis leidyi* into the Black Sea, has been examined in detail by GESAMP (GESAMP, 1997a). Examples of harmful introductions that have cost many millions of US dollars in remedial action are set out in Table 2.2.

Table 2.2. Examples of introductions of alien species since the 1980s

Species	Origin	Location
Dinoflagellates *Gymnodinium catenatum*	Japan	Australia
Comb jellyfish (Ctenophora) *Mnemiopsis leidyi* American comb jellyfish	North America	Black and Azov Seas
Polychaete worms (Annelida) *Marenzilleria viridis* Spionid tubeworm	North America	Western and Northern Europe
Mussels and clams (Bivalvia) *Ensis americanus* American razor clam	North America	Western and Northern Europe
Musculista senhousia Japanese mussel	Japan	New Zealand
Dreissena polymorpha Zebra mussel	Black Sea	Eastern North America – Great Lakes
Crabs (Decapoda) *Charybdis helleri* Indo-Pacific swimming crab	Mediterranean	Colombia, Venezuela, Cuba, and United States
Seastars (Asteroidea) *Asterias amurensis* North Pacific seastar	Japan	Australia

Sources: Carlton and Geller, 1993; Carlton *et al*., 1995; Le Maitre, 1995

Shipping moves 80% of global commodities. Ships carry ballast water in a variety of tanks and holds. Ballast capacities range from a few tonnes in sailing and fishing boats to tens of thousands of tonnes in commercial cargo carriers, e.g., up to 140,000 tonnes in a very large crude carrier (VLCC). In general, ballast capacities are about 30% of the deadweight tonnage of a ship. Each year, about 10 billion tonnes of ballast water are transported by ships. Suspended material is also taken onboard within ballast water. It accumulates as sediments in tanks and holds and may contain biological material such as the cysts of dinoflagellates. It has been estimated that about 3,000 species of animals and plants are transported daily around the world. Although many non-indigenous species are benign after settling in new areas, others have threatened the existence of native species, overwhelmed commercial and recreational fish stocks, disturbed nutrient balances, and established new pathways for the spreading of pathogens.

Control technology is currently insufficient and haphazard. Increasing trade and development in the coastal zone, and enhanced commerce in marine living resources, will increase the possible pathways for introductions. In most cases there significant time elapses - sometimes decades - between the arrival of an invasive species in a new region, recognition of its presence and the determination of its effects. Typically, therefore, control programmes are formulated only after an invasive organism is already well established and has caused significant damage. In some cases the economic losses can run into billions of dollars before any attempt at control.

At the international level a number of agreements or guidelines can be used to address the management or control of introduced species. These include:

- The United Nations Convention on the Law of the Sea;
- The Global Convention on Biological Diversity;
- Global Programme of Action for the Protection of the Marine Environment from Land-based Activities;
- FAO Code of Conduct for Responsible Fisheries and related FAO Technical Guidelines for Responsible Fisheries, in particular on the Precautionary Approach to Capture Fisheries and Species Introductions, and on Aquaculture Development;
- ICES Code of Practice on the Introductions and Transfers of Marine Organisms; and
- IMO Guidelines for Preventing the Introduction of Unwanted Organisms and Pathogens from Ship's Ballast waters and Sediment Discharges

Commitments to address the issue of introduced species also exist in many other regional and global agreements on protected areas and species; but few specific measures have been articulated. The control and management of introductions has a number of institutional and regulatory pitfalls. Some deliberate introductions (e.g., in mariculture) can be beneficial, while some deliberate or accidental introductions can lead to fundamental changes in local ecology and degradation of the marine environment. This calls for a clear understanding of the pathways that introductions are likely to take and for the capability to recognize and assess the risk of ecological changes and the potential for subsequent, harmful impacts. The uncertainty associated with assessing these risks must be minimized; otherwise large sums of money could be allocated to control programmes that provide little return on the investment.

Since the early 1990s, a number of countries, including Australia, Canada, Chile, Israel, New Zealand and the United States, have recognised the threat of alien species transfer by ballast water and have adopted control measures. One option was a proposal for ships to exchange ballast water in the open ocean close to the port of destination. However, there appear to be significant engineering impediments to this: it can also increase the likelihood of accidents and loss of life at sea. Realising that unilateral action taken by individual countries in this field may disturb the global pattern of shipping, the International Maritime Organization in 1993 and 1997 adopted guidelines on ballast water control and management measures. In adopting these guidelines, IMO member States requested the Organization to develop legally binding provisions on ballast water control and management. These are being prepared in the form of a new free standing legal instrument to be adopted by a Diplomatic Conference in the biennium 2002-2003.

2.7.6 Energy and Turbidity Changes in Estuaries

Greater emphasis needs to be given to changes in energy budgets of coastal systems resulting from changes in watersheds (forest clearance, accelerated run-off, reduced base water flows in dry seasons, dam construction and water abstraction), changes in coastal systems (dredging and spoil disposal, removal of corals, etc.) and sea level rise. One role of coasts is to absorb energy. Alteration of estuaries and other natural energy management systems imposes social and economic costs and increases natural hazards. There is accordingly a need to obtain a rational balance between considerations of biological-chemical and geomorphological changes in land-ocean systems (Burbridge, 1997). Morphological changes may be far more significant to the maintenance of the functional integrity of coastal and marine ecosystems - and to the sustainable use of coastal and nearshore environments and resources - than is currently recognized.

2.7.7 Trends in Marine Transport

Waterborne commerce will continue to offer the least costly and most efficient mode of transport of large quantities of goods and bulk materials in international trade competitive shipping. Global trade and the economies of coastal nations are directly related to waterborne commerce, and to each nation's capability to maintain a navigation infrastructure to receive transport carriers. Many developing nations aspire to achieve this enhanced level of marine transport infrastructure in order to compete in global commerce, and countries striving to maintain a competitive import/export posture will increasingly rely on this mode of transport. Unfortunately from an environmental standpoint, most ports are not located in areas of natural deepwater, but are found in estuaries, river mouths and deltas, naturally shallow coastal areas, and areas of high siltation. Collectively, they represent some of the most environmentally diverse and productive estuarine, marine and wetland systems.

Navigation channels are the aquatic highways for waterborne commerce. Their maintenance by dredging can profoundly modify the coastal ecology including habitats, circulation patterns, organism migration patterns, sediment transport, pollutant distribution and loading, oxygen distribution, sediment erosion and accretion, suspended sediment profiles, salinity distributions and the distributions of sensitive biota. These modifications will, in turn, impact recreational and commercial fisheries, pleasure boating, aesthetics, cultural resources and subsurface aggregate recovery. The 21st century will see new classes of vessels with drafts far in excess of most of today's ships, reflecting the developing nature of shipping. They will require substantially deeper and wider navigation channels, anchorage sites, turning basins, and docking facilities than now exist. However, relatively few ports are likely to be chosen to handle these new vessels, and this will limit the scale of port and navigational channel modifications required.

The following general impact areas should be an integral part of an overall assessment of major port restructuring:

Water-related impacts, including a) dredging; b) dredged material disposal; c) construction of piers, breakwaters and other waterside structures; d) alteration of harbour/port ship traffic patterns; e) ship discharges, e.g., oily ballast, bilge water, sewage; f) spills; g) contamination by anti-fouling agents; and h) waterfront industry discharges, e.g., industrial, sewage, runoff.

Land-related impacts, including a) excavation for fill; b) wetland damage and filling; c) loss of uplands to expanding waterfront/industrial areas; d) noise from ports and harbour-side industry; e) dust and other airborne emissions; f) traffic burden projections; g) handling and disposal of shore generated solid wastes; h) runoff from raw material storage; i) waterfront drainage; and j) industrial liquid wastes not discharged to the harbour.

Air-related impacts, including a) ambient conditions; b) fugitive emissions; and c) gases, smoke, and fumes.

Hazardous materials/cargo impacts, including a) gases; b) liquids; and c) solids management.

Socio-cultural impacts: The coastal ecological impacts above must be balanced against short-term and long-term economic gains. The economic gains must then be contrasted with the loss of economic attributes, direct and indirect, and unacceptable stress on the broader coastal ecology. Environmental assessments prior to construction or further alteration of the coastal zone for navigation purposes must evaluate all of the short-term and long-term risks associated with navigation infrastructure developments and enhancement. The ultimate goal should be a globally competitive navigational infrastructure that in turn maintains a sustainable coastal ecology.

2.7.8 Deliberate and Accidental Disposals of Military and Commercial Materials at Sea

The dumping of material, including wastes, at sea is covered by the provisions of the London Convention 1972. The vast majority of such dumping occurs in coastal waters and this, in turn, is dominated by the disposal of dredge spoils. Only occasionally has there been deliberate dumping at sea of solid wastes such as oil exploitation platforms and low-level radioactive wastes, and these have been largely carried out pursuant to the provisions of the London Convention. There exists, however, an exception - the dumping at sea of low-level liquid and solid wastes and obsolete nuclear vessels by the previous Soviet Union. Such dumping activities - especially of reactor assemblies containing spent fuel and of entire submarines some containing fuelled reactors - have been of considerable concern. and led to an assessment by the International Atomic Energy Agency of the likely threats to human health and marine organisms (IAEA, 1998). Fortunately, this assessment indicates that such threats are not as great as might have been previously perceived. Nevertheless, although the Russian Federation has ceased the dumping at sea of such wastes, the difficulties being encountered in the decommissioning of military vessels, particularly nuclear submarines from the Russian Northern Fleet, suggest that such activities could still pose a threat to the marine environment. The difficulties of nuclear vessel decommissioning and nuclear waste management generally within the Russian Federation are, however, receiving priority attention through a number of bilateral, multilateral and international programmes.

The seas have long been an arena for warfare, especially for naval engagements. More recently, they been used for the deployment of ballistic missile submarines and various devices, such as acoustic arrays, to detect them. There has, however, long been a reticence to using the seas in a more aggressive way as indicated by the "*Treaty on the Prohibition of Nuclear Weapons and other Weapons of Mass Destruction on the Seabed and Ocean Floor and in the Subsoil Thereof (1971)*".

Aside from the debris from past conflicts, especially ships, that litters the ocean floor, the seas have long been used as dumping grounds for waste munitions: marine charts show commonly-used ammunition dumpsites. The sea has also been used as a disposal site for chemical weapons. Of the order of a million tonnes of munitions were dumped in the Irish Sea in post war years - including high explosives, incendiary devices, weapons containing arsenic (used in Lewisite), phosgene, mustard gas and uncertain amounts of nerve gases (Tabun/Sarin) recovered from Germany at the end of the Second World War. Some of these materials, most notably phosphorus flares, are now being washed up on coastlines where they clearly represent a hazard to the public. In addition, a recently constructed pipeline for natural gas passes through the perimeter of a previous munitions dumpsite in the northern Irish Sea. Underwater photography reveals munitions close to, or touching the pipe. Incidents involving fishermen in the Baltic encountering mustard gas residues in fishing nets are not uncommon (Wulf *et al.*, 1985; Perera and Thomas, 1987).

In more recent times, there have been a number of accidents involving nuclear-powered and nuclear-armed vessels. Five nuclear-propelled submarines have been lost since 1963 at various sites in the Atlantic Ocean. The depths of the sites of these accidents (>1500m) have not permitted the recovery of the reactors and the number of nuclear-armed weapons associated with these submarine hulls is not known accurately. A number of nuclear weapons, and materials used in the construction of nuclear weapons, have been lost at sea following the loss of military aircraft and rockets (see Table 2.3). Significant local plutonium contamination occurred Palomares, Spain, following the jettisoning of nuclear weapons from an aircraft in 1966 and at Thule, Greenland, when a B-52 bomber carrying 4 nuclear weapons crashed on sea-ice in 1968. A merchant vessel, the *Mont-Louis*, sank in coastal waters 20 km off Zeebrugge in 1984, but its load of uranium hexafluoride was recovered before any leakage to the environment occurred. More recently, in 1997, a container ship, the *Carla*, sank 70 nautical miles off the Azores with three sealed 137Cs sources on board; this material has not been recovered.

In addition to these marine accidents, five nuclear-powered spacecraft have been lost above the sea. Four of these contained radioisotope thermoelectric generators (RTGs) powered by 238Pu. One RTG (Transit 5BN-3) was vapourized during re-entry to the atmosphere causing worldwide low-level contamination and three impacted on the sea surface. Of these latter cases, one RTG was recovered (Nimbus B-1) without any release to the environment and two others (Apollo-13 and Mars-96) are still at the bottom of the sea. The fifth satellite (Cosmos 1402) containing an enriched uranium reactor re-entered the atmosphere due to a malfunction. It is likely that the reactor disintegrated into small fragments before falling to the bottom of the South Atlantic Ocean. It should, however, be noted that much radioactive debris was found after a similar Russian satellite, Cosmos 954, re-entered over northern Canada in 1978. A lighthouse RTG unit containing 90Sr was lost near the Sakhalin peninsula during shipment by helicopter. Finally, some hundreds of sealed radiation sources used in oil and gas prospecting have been lost when drill strings have become stuck in the borehole: usually in such cases the equipment is left in place and the hole cemented.

Table 2.3. Major accidents and losses at sea of nuclear materials

Date	Location	Incident	Con-firmed?	Releases detected/ Material recovered?
Feb 1950	Pacific Ocean off Puget Sound	B-36 aircraft with nuclear material	No*	?/?
Nov 1950	Over water outside the USA	Aircraft with nuclear material	No*	?/?
Mar 1953	Atlantic Ocean off Newfoundland	B-36 aircraft with nuclear material	No*	?/?
Mar 1956	Red Sea	B-47 aircraft with nuclear material	No*	?/?
Mar 1958	Atlantic Ocean off Georgia	B-47 aircraft with nuclear material	No*	?/?
Jun 1962	Pacific Ocean, Johnston Island	ICBM Thor with nuclear test device	Yes	?/No
Apr 1963	Atlantic Ocean 100 nm East of Cape Cod	US SSN-593 (*Thresher)* nuclear submarine with reactor	Yes	Yes/No
Apr 1964	West Indian Ocean North of Madagascar	Vapourization of a satellite SNAP-9A Pu-238 RTG	Yes	Yes/No
Dec 1965	Pacific Ocean 250 nm south of Kyushu, 70 nm east of Okinawa	US A4E Skyhawk with B43 fusion weapon rolls off USS *Ticonderoga*	Yes	?/No
Jan 1966	Mediterranean Sea 5 nm off Palomares, Spain	US B-52 bomber jettisoned 4 nuclear weapons (2 recovered)	Yes*	Yes
1967	Kola Bay off Severomorsk	Submarine reactor lost	No	?/Yes
Jan 1968	Baffin Bay, Thule Harbour, Greenland	US B-52 bomber crashed on sea-ice with 4 nuclear weapons aboard	Yes	Yes/Partial
Apr 1968	Pacific Ocean, 750 nm northwest of Oahu, Hawaii	Soviet Golf class diesel submarine K-129 sinks with two nuclear warheads	Yes	?/Yes
May 1968	Atlantic Ocean 400 nm southwest of the Azores	USS SNN-583 (Scorpion) sinks with one nuclear reactor and two nuclear armed Astor torpedoes	Yes*	Yes/No
May 1968	Pacific Ocean, Santa Barbara Channel	Spacecraft Nimbus B-1 with 2 SNAP-19 RTGs	Yes	No/Yes
Apr 1970	Bay of Biscay	Submarine K-8 with 2 reactors and nuclear warheads	Yes	?/No
Apr 1970	Atlantic Ocean, Tonga Trench	US Apollo-13 SNAP-27 RTG lost	Yes	?/No
Aug 1970	Atlantic Ocean, Bay of Biscay	USSR Submarine K-8 lost containing a nuclear reactor and nuclear weapon(s)	No	Not known
Sep 1974	Black Sea	Kashin-Class destroyer with nuclear war-heads	Yes	?/No
1978	Off Kolguyev Island SE Barents Sea	Lighter *Nikel* containing unenclosed solid low and interm level radwaste	Yes	?/No
Feb 1983	Atlantic Ocean, 1600 nm east of Brazil	USSR Cosmos 1402 re-entered containing enriched ^{235}U reactor	No	?/No
Jun 1983	NW Pacific off Kamchatka Penin.	Submarine with reactor core and 8 nuclear warheads	Yes	?/No
Aug1984	North Sea 20 km off Zeebruges	Containers of uranium hexafluoride lost from vessel *Mont Louis*	Yes	Yes/Yes
Aug 1985	Chazma Bay, Russian Pacific Coast	Submarine K-431 – criticality accident	Yes	Yes/Yes
Oct 1986	600 miles north east of Bermuda	Soviet Yankee class submarine K-219 sinks with two reactors and 16 SSN6 MIRV missiles plus probably two nuclear torpedoes	(Not # warheads)	?/No
Oct 1987	Sea of Okhotsk near Sakhalin Is.	RTG with ^{90}Sr source lost	Yes	?/No
Apr 1989	Atlantic Ocean, 100 nm southwest of Bear Island	USSR submarine Komsomolets K-278 containing nuclear reactor and 2 nuclear-tipped torpedoes sunk	Yes	Yes/No
Nov 1996	Pacific Ocean, west of Chile	Mars-96 interplanetary station containing 18 Pu-238 RTGs re-enters ocean	Yes	?/No

Source: IAEA (1999). This Table contains no entries for the loss of sealed sources at sea. For additional details see IAEA (1999).
* Indicates that confirmation is partial and may not apply to the number of nuclear devices involved.

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3

Emerging Problems and Perspectives

3.1. INTRODUCTION

Chapter 2 has identified and assessed problems affecting the marine environment related to land-based activities and sources of pollution. In most cases these problems have been identified for some time, and there has been significant research and/or activities devoted to understanding and reducing the impacts on the marine environment from these sources and activities. Chapter 3 addresses some of the most important issues which are expected to emerge, or are foreseen to be increasing problems in the marine and associated freshwater environments, related to land-based sources. In a discussion of emerging environmental issues in general, Munn *et al*. (1999) have defined an emerging issue as "an issue (positive or negative) which is not yet generally recognized, but which may have significant impact on human and/or ecosystem health in the 21st century." For this report on the marine environment, these issues have been identified from reports issued by national and international bodies, through the current scientific literature, and in extensive discussions by this working group. In some cases the issues are extensions of those identified in Chapter 2. One example is coral reefs: threats to them have been outlined in Chapter 2, but the emerging concerns about coral reef diseases and coral bleaching are discussed in this chapter. A number of issues are identified that have not been considered previously in this document, some of which are already growing in importance and scientific concern. In other areas, particularly those related to the impacts of climate and global change, the greatest impacts are yet to be felt. Indeed additional research to identify the detailed nature and extent of the potential impacts are required now so that adequate planning, mitigation activities and early warning, if necessary, can take place.

It is becoming increasingly apparent that atmosphere/ocean linkages are a very important part of the issue of the effects of land-based activities on the marine environment and associated freshwater systems. The atmosphere plays a vital role for life in the ocean, including: the winds that drive the major surface current systems and upwelling regions; the exchange of carbon dioxide which fuels primary production in the sea; and the transport of nutrients and harmful substances on a hemispheric to global scale before their delivery to the ocean. In a sense, the atmosphere can be considered as a fast response, short residence time component of the marine system. Historically we have seen that changes in the global atmosphere as a result of human activities have often been detected long before changes are observed in the ocean. Thus atmospheric change can often serve as an early warning system for the marine environment, particularly in open ocean regions. In this chapter we examine two such important areas, the impacts of climate change on the ocean and the increasing flux of nutrients from the atmosphere to the sea.

As indicated in the introduction to Chapter 2, estimating the economic costs of environmental damage as a result of the various environmental problems is extremely difficult. This is particularly true for these emerging issues, for their full impact on the environment is often far from clear, and the detailed ecological, social, legal and cultural considerations necessary to make realistic economic impact assessments have generally not yet been made. For this reason there is little information that can be presented on the economic impact of these emerging issues. Two exceptions, presented in this chapter, are the potential economic impact of coral bleaching and of diseases related to marine contamination

3.2. THE IMPACT OF MARINE ENVIRONMENTAL POLLUTION ON HUMAN HEALTH

Society generally views recreation at the seashore and ocean bathing as a positive experience for health. However, there has been some degree of historical awareness of the potential human health problems associated with bathing and harvesting shellfish - which are often eaten raw - in marine coastal waters contaminated by urban wastewater discharges. In the past these health risks have been perceived primarily as isolated local problems. The issue of marine biotoxin poisonings associated primarily with toxic algae blooms has also been of concern. However, the dramatic global impact of these human health problems has recently been underscored by a new study aimed at developing a preliminary quantitative estimate of the impact of these pathways of disease transmission (Shuval, 1999, see Annex 2). This has been underscored by other recent studies (e.g., Harvell *et al*., 1999).

Any comparison of health impacts from various sources must start with a sense of scale of the health problems. Which health impact is more important in human disease and social terms or in financial terms, and by how much? In Shuval's preliminary study, each of these negative health impacts has been evaluated in terms of the concept of Global Disease Burden - GDB. The GDB is measured in units of Disability-Adjusted Life Years - DALYs, a new concept recently developed by the World Health Organisation (WHO) and the World Bank (Murray and Lopez, 1996; World Development Report, 1993). This new approach calculates i) losses from premature death, defined as the difference between the actual age of death and life expectancy at that age in a low-mortality population, and ii) years of loss of healthy life resulting from disability. It is difficult to estimate the social and economic loss of one year of productive life resulting from premature death or disability (or one "DALY"). There are numerous approaches for making such economic estimates. For the purposes of this study, Shuval (1999), in consultation with the WHO, has estimated the money value of the economic loss of one productive year of life, or one DALY, as being US$4,000. This figure approximates the global mean annual GDP per capita, but it is not necessarily based on that figure (Costanza *et al*., 1998).

3.2.1 Infectious Diseases Related to Bathing/ Swimming in Marine Coastal Waters Contaminated by Wastewater Discharge

There is massive epidemiological evidence that enteric and respiratory diseases can be caused by bathing/swimming at marine coastal beaches contaminated with pathogenic micro-organisms, i.e., exposure to pollution from domestic wastewater sources (WHO, 1998; Kay *et al*., 1994; Pruss, 1998). The evidence from 22 highly credible epidemiological studies clearly supports the conclusion that the rate of infections and disease among bathers increases steadily with increasing concentrations of indicator micro-organisms of fecal pollution in a dose-response relationship (Pruss, 1998). These studies also support the conclusion that bathers face the risk of enteric and respiratory infection and disease even in lightly polluted coastal waters meeting current microbial standards of the EEC/European Union (EEC, 1976) and USEPA (1986). Based on an extensive and careful evaluation of the available credible epidemiological evidence, WHO (1998) estimated that bathing in what had previously been considered "acceptable" marine waters with a mean concentration of 50 faecal streptococci/100 ml will result in infection and illness in 5% of the adult bathers after a single marine bathing exposure. In Shuval's (1999) study slightly higher risk-of-disease rates were used for children (who are more susceptible than adults), for adults visiting beach resorts in countries with high endemic disease rates, and for a certain percentage of highly contaminated beaches.

Working from official reports from the World Tourism Organisation (WTO, 1999) and estimates from other sources, Shuval (1999) calculated that some 1-2 billion marine-exposure-days are spent at beach resorts each year by local residents and foreign tourists. From these global figures - and the WHO risk estimates for gastroenteritis and respiratory infections at various levels of beach pollution - a highly tentative estimate has been made that some 250 million clinical cases of mild gastroenteritis and upper respiratory disease are caused every year by bathing in contaminated seawater. Why has this situation gone unnoticed and unreported for so long? Epidemiological studies have revealed that minor cases of gastroenteritis are rarely seen by medical care professionals and even less frequently reported to health authorities. The ratio of actual clinical cases to reported cases of mild gastroenteritis can be 1000:1. Calculated in terms of DALYs the number of cases results in some 400 thousand DALY units. The economic impact or financial loss resulting from this amount of disease has been estimated at some US$1.6 billion/year.

3.2.2 Infectious Diseases Related to the Consumption of Seafood Harvested in Marine Coastal Waters Contaminated by Wastewater Discharge

Seafood - and particularly molluscs normally eaten uncooked - is a commonly implicated vehicle for the transmission of infectious diseases caused by enteric micro-organisms (including bacteria and viruses) that enter the marine environment through the disposal of urban/domestic wastewater. Pathogenic bacteria can remain viable in the sea for days to weeks, and viruses can survive in the marine environment or in the tissues of fish and seafood for months (Gerba, 1988). Filter-feeding shellfish - whose breeding areas are often placed near sources of nutrients, such as wastewater outfalls or polluted estuaries - are highly prone to concentrating high levels of pathogens.

A series of studies involving testing for and detecting viruses in shellfish in the United States found enteric viruses in 19% of 58 pooled samples taken from waters meeting current US bacteriological standards for shellfish growing and harvesting. A mean virus concentration in the shellfish meat of 10 PFU (plaque forming units) per 100 grams of shellfish meat was observed (Rose and Sobsey, 1993). One unpublished survey of enteric viruses in shellfish in a Paris market in 1978 indicated that 25% were contaminated with pathogenic enteroviruses. Infectious hepatitis A (HAV), a most serious and debilitating disease of the liver, is the gravest virus disease very frequently transmitted by shellfish.

Conventional depuration techniques are used to help clean shellfish harvested in contaminated waters. Shellfish are held in clean, disinfected water tanks for 36-48 hours of self cleansing. This is partially effective in removing bacterial contamination, but less effective for viruses, which are tightly adsorbed to the internal tissues of the molluscs (Cliver, 1997). Thus, eating raw or lightly steamed shellfish harvested from such contaminated - but considered acceptable - marine waters can cause infection and disease in a significant percent of the exposed population.

There is firm epidemiological evidence for numerous sporadic cases - not reported as part of epidemics - of the transmission of infectious hepatitis (IH) by eating raw or lightly steamed shellfish. In the study by Koff *et al*. (1967) it was reported that some 25% of all the cases of IH during a non-epidemic period in Boston were apparently associated with the ingestion of raw or lightly steamed shellfish. Similar figures were found in England (Scoging,1991).

Rose and Sobsey (1993) have written the seminal work on the development of the methodology for quantitative risk assessment associated with exposure to virus contamination in shellfish. They have estimated that the risk of infection for infectious hepatitis virus A for individuals who consume one raw shellfish serving of 60 grams harvested from approved waters in the United States is about 1 per 100, or 1%. The risk from highly polluted waters is greater.

Based on reports from the FAO, it has been estimated that some 8 million tons of molluscs, including clams, oysters, mussels and cockles, are harvested and marketed globally each year. Assuming that one kilogram of gross shellfish, including shells, is required for each shellfish meal or serving, Shuval (1999) has estimated that some 8 billion shellfish meals are consumed globally per year. Working with the assumption that some 88-90% come from clean safe waters and/or are not eaten raw, and using the risk of infection and disease drawn from the risk estimate study of Rose and Sobsey (1993), Shuval (1999) has estimated that each year there are about 2.5 million clinical cases of infectious hepatitus globally, with some 25,000 fatalities and 25,000 cases of long term disabilities from liver damage caused by eating contaminated shellfish. This level of disease results in some 1.8 million DALYs with an estimated economic impact of US$7.2 billion per year.

3.2.3 Diseases Associated with Contamination of Shellfish and other Seafood with Toxins from Toxic Algae Blooms

Marine biotoxins cause a large number of poisonings in humans annually, many with serious sequelae and causing frequent fatalities. Most of these poisonings are in the subtropical/tropical circumglobal belt region bounded by Florida, the Mediterranean and Japan in the north and the northern edge of Australia, the southern tip of Africa and Chile in the South. The human diseases most frequently associated with marine biotoxins are amnesic shellfish poisoning (ASP), paralytic shellfish poisoning (PSP), ciguatera poisoning, and the more recently identified neurotoxic shellfish poisoning (NSP) and diarrhoeic shellfish poisoning (DSP) (WHO, 1984). Most of these diseases are apparently associated with fish and seafood that feed on toxic marine algae and toxic algae blooms such as red tides. PSP in particular can lead to severe neurotoxic effects, paralysis and death. The death rate for PSP and some of the other marine biotoxin diseases appears to be in the range of 10%-20% or higher: serious long-term sequelae, such as neurotoxic effects and paralysis, are common.

There have been numerous local reports of outbreaks, and of high endemic incidence, of ciguatera poisoning in small communities and islands in the Pacific, such as Tahiti, Hawaii, Samoa and New Guinea, where the incidence has been estimated to be about 500 per 100,000 population. A similar incidence was reported in Dade County, Florida (Tu,1988). Higerd (1983) estimated that 10,000-50,000 individuals are afflicted worldwide each year by ciguatera poisoning alone. Tu (1988) estimates that the true rate of ciguatera poisonings for the South Pacific is likely to be 2,500 per 100,000. The case fatality rate is low (about 0.1%). It is estimated that the total population in the circumglobal belt where the disease is endemic is about 400 million people, 10% of whom live near seacoasts and frequently eat locally caught fish and seafood. If the incidence rate of ciguatera poisonings is 500/100,000, then the global incidence might be 200,000 cases a year. If the rate is 2500/100,000 as estimated by Tu, then the global incidence might be 1,000,000 a year. In the latter situation, a case fatality rate of 0.1% would result in 1,000 fatalities per year.

In Canada, which has one of the best marine biotoxin monitoring and control programs, there are an estimated 1000 cases per year of illness caused by seafood toxins, with 150 cases per year of PSP and 350 cases of ciguatera poisoning (Ewen Todd, Canada, personal communication, 27 July, 1999). If the incidence for Canada - of about 3.3 cases/100,000 for all marine biotoxin poisonings per year - is representative of the temperate zones globally, then it might be possible to extrapolate a minimum global incidence for the world population of some 6 billion persons at about 200,000 cases per year, with some tens of thousand fatalities and tens of thousand cases with serious life long sequelae. This would be a minimum since the rate for the tropical belt, where these diseases are highly endemic, would be expected to be much higher.

In light of the above very scanty data on global incidence of disease from marine biotoxins , Shuval (1999) was only able to make a very rough first approximation of the GDB. He estimated that marine biotoxins associated primarily with toxic algae blooms cause some 100,000 to 200,000 serious cases of poisoning a year globally, some 10,000 to 20,000 deaths and a similar number of cases with very serious neurological sequelae, such as paralysis. More accurate or reliable global information is not available at this time. Shuval's crude first estimate of the GDB and the DALYs based on the above was that it might be as high as one million DALYs per year, with an estimated global economic impact of some four billion US dollars.

3.2.4 Global Impact of these Human Health Effects

The total estimated impact of the illnesses associated with land based marine pollution may be about 3.2 million DALYs/year, with an estimated economic loss of some 13 billion dollars per year. The box presents these estimates, along with estimates for other known diseases of global public health importance for which DALYs have been calculated (Murray and Lopez, 1996). Note that the loss of life years and their associated economic loss is very significant, with the impact being similar to that from upper respiratory tract infections and intestinal nematodes. Shuval (1999) has pointed out that the estimates above are at best only rough first approximations which must be

Marine Contamination-Related Diseases

Comparison of estimated Disability-Adjusted Life Years -DALYs - per year and their economic impact for marine contamination-related diseases and a number of other diseases on a global scale. A mean value to US$4000 per DALY is used worldwide for the economic impact estimates. The potential impact of marine pollution-related diseases is quite apparent.

Disease	Estimated DALYs per year (millions)	Estimated Economic Impact (billion US$)
Diphtheria	0.36	1.4
Japanese Encephalitis	0.74	3.0
Dengue Fever	0.75	3.0
Trachoma	1.0	4.0
Upper Respiratory Tract Infections	1.3	5.2
Marine Contamination-Related Diseases	**3.2**	**13**
Bathing/Swimming-Wastewater Related	*0.4*	*1.6*
Seafood Consumption-Wastewater Related	*1.8*	*7.2*
Seafood Consumption-Toxic Algae Blooms	*1.0*	*4.0*
Intestinal Nematodes (ascaris, etc.)	5	20
Stomach Cancer	7.7	31
Trachea, Brachia and Lung Cancer	8.8	35
Diabetes	11	44
Malaria	31	124

taken with reservations and used with caution. They may serve as a basis for determining a rough order of magnitude of the global scope of the problem, which appears to be very much larger than previously estimated. The very provisional economic evaluation of this impact of marine pollution must be viewed with caution, since it is based on a very preliminary and unconventional economic approach. However, it might suggest that we are dealing with a global problem with major economic implications in the multi-billion dollar range every year.

3.3. THE EFFECTS OF CLIMATE AND RELATED GLOBAL CHANGE

The global mean surface temperature of the earth is projected to increase by about 2°C (between 1 and 3.5°C) by the year 2100 (IPCC, 1996). (Note that these are global averages, and considerable regional differences would be expected.) That average rate of warming would be greater than any seen in the last 10,000 years - but the actual annual to decadal changes would include considerable natural variability. In most regions and most seasons, night-time temperatures will rise more than day-time ones. Warming is projected to be greater over land than over the oceans, and the maximum warming is expected to occur at high northern latitudes, particularly in winter. Minimum warming is estimated to occur over the central North Atlantic and over the Southern Ocean near Antarctica. Regional winds may increase in intensity. Sea level rise would occur primarily as a result of thermal expansion of the ocean, as well as from the melting of glaciers and ice caps. Increased melting of sea ice is also possible. IPCC (1996) predicts a sea level rise of between 13 and 94 cm by 2100.

Climate change is an atmospheric phenomenon which affects land-based communities through changes in temperature, rainfall patterns, etc., thus leading to alterations in ecosystem structures. This could lead to the loss of more sensitive species and gains by organisms better suited to the new conditions. Though numerical models of climate and climate change clearly incorporate oceanic phenomena - particularly heat fluxes - and have been concerned with sea-level rise and winds over the ocean, relatively little attention has been paid to the impact of climate change on marine environmental quality. However, there are a number of potential environmental changes involving the health of the marine environment that will or may occur as a result of global warming. Several of these warrant future attention and are outlined below.

3.3.1 Frequency of Extreme Meteorological Events

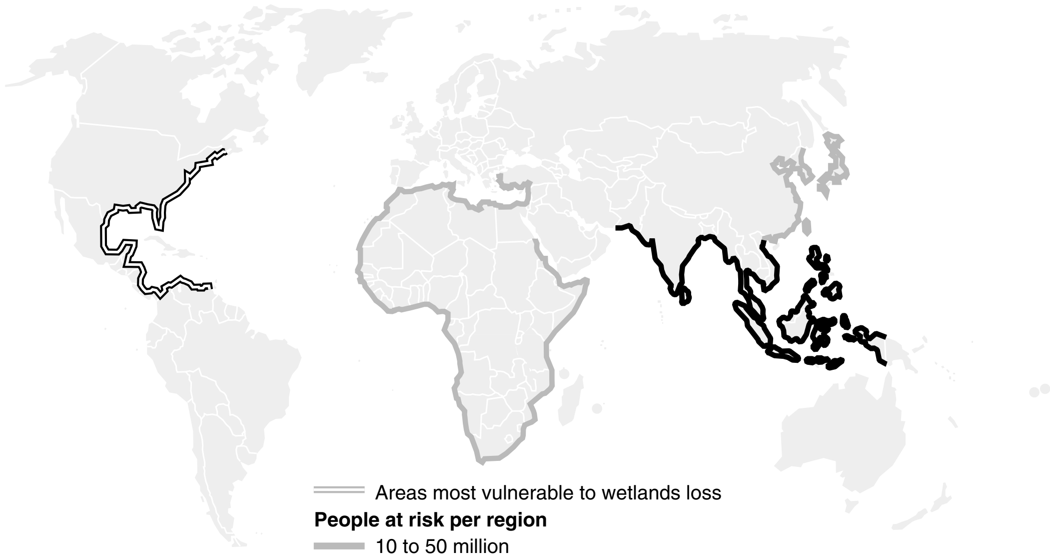
One potential consequence of the response of climate to anthropogenic forcing is projected to be a global increase in the number and magnitude of extreme events (droughts, floods, hurricanes, etc.). For example, the number of extreme precipitation events (heavy rainstorms and blizzards) has increased by 20% since 1990 (NOAA, 1997). The effects of the very strong El Niño event in 1997-1998 had a significant impact on both sides of the Pacific and elsewhere, including many deaths and much homelessness (see box). These events also have many consequences for marine communities . In particular, damage to nearshore coral reef and intertidal ecosystems may be devastating, with potentially significant secondary effects. Severe storms can destroy structures and contaminate water systems, and simultaneously create breeding sites for organisms carrying infectious diseases (see 3.3.3 below).

1997-1998 El Niño

The 1997-1998 El Niño resulted in the death of more than 21,000 people in 27 countries around the world, according to the World Meteorological Organization; in all, 117 million people were affected. Morbidity affected some 540,000 people, while 4.9 million were displaced and made homeless. Several economic estimates of the global loss during this El Niño have been made: these range from 14 billion US$ for structural losses, to more than 34 billion US$, which included socio-economic impacts. The form of the impact varied in different communities, with high material and structural losses incurred by developed economies, while loss of life dominated in less developed communities.

FIGURE 3.1

Areas and people at risk from a 44cm sea-level rise by the 2080s, assuming 1990s level of flood protection



Source: Nicholls, 1977.

3.3.2 Changes in Sea Level

Changes in sea level have clearly had a major influence on terrestrial and coastal systems over geological time scales. Predicted future sea level rises would be much more rapid than those observed previously (IPCC, 1996). Figure 3.1 shows the number and location of people at risk if there were a 44cm sea-level rise by the 2080s, assuming that the level of flood protection was the same as it is now.

Low lying coastal habitats, particularly those in densely settled deltas and small islands, are particularly vulnerable. They are of major significance to coastal marine ecosystems since they are frequently key places for the reproduction of marine organisms. Estuaries, mud flats, mangroves, coral reefs, and coastal wetlands in general - and densely settled deltas and small islands - besides being the most at risk from sea-level rise, are particularly important in this way and provide essential food supplies for terrestrial birds, reptiles, amphibians and mammals. Increased coastal erosion and changes in currents and waves will also have adverse effects on coastal ecosystems.

Since a large proportion of the world's population lives close to the coast, there is certainly risk of direct contamination (e.g., by sewage, toxic metals and toxic organic compounds) resulting from the inundation of portions of coastal towns, cities and associated industrial and power-generating plants. Many of the major cities of the world are coastal, and significant fractions of the area of some (e.g., cities in the Netherlands, Bangkok) are below current sea level. Many major industries - including oil refineries, power stations, chlor-alkali plants, sewage treatment plants, chemical manufacturing plants, and metal refineries - are sited along the coast because of their requirements for both cooling waters and access to shipping.

3.3.3 Other Risks to Human Health

In addition to the health effects related to marine environmental pollution discussed in section 3.2, many organisms and processes linked to the spread of infectious diseases are influenced by temperature, precipitation and humidity and thus would be affected by climate change (McMichael *et al.*, 1996; Harvell *et al.*, 1999). Over the past century, average sea surface temperature has increased approximately 0.7°C, and water temperature is an important factor in the growth of many marine algae. Red tides, which can cause paralytic shellfish and diarrhoeic shellfish poisoning, are blooms of toxic dinoflagellates, whose growth is favoured by warm water. Global warming is also expected to cause widespread shifts in the pattern of faecal-oral infections and foodborne diseases. It is expected that the wider geographic distribution (both by altitude and by latitude) of organisms that transmit diseases (i.e., vector organisms) would increase not only the potential for disease transmission, but also change the life-cycle dynamics (e.g., reproduction, survival and infectiousness) of vector organisms and infectious parasites (see Table 3.1).

Disturbances of ecological relationships due to climate change may disrupt the natural control mechanisms of vector organisms and their host organisms, as well as parasite populations. This could lead to changes in population dynamics and may result in an acceleration of pesticide resistance in vector organisms and drug resistance in infectious bacteria. Additionally, more frequent droughts and rising sea level might force human populations into areas where infectious organisms are located but currently have little impact on people.

Table 3.1. Vector-borne diseases and their possible distribution change with warming

Disease	Vector	Population at risk (millions)	Present distribution	Likelihood of altered distribution with warming
Malaria	mosquito	2,100	(sub)tropics	highly likely
Shistosomiasis	water snail	600	(sub)tropics	very likely
Filariasis	mosquito	900	Africa/Latin America	likely
Onchocerciasis (river blindness)	black fly	90	tropical Africa	likely
African trypanosomiasis (sleeping sickness)	tsetse fly	50	tropics	likely
Dengue fever	mosquito	unavailable	tropical South	very likely
Yellow fever	mosquito	unavailable	America & Africa	likely

From Watson *et al*. (1998)

Epstein *et al*. (1993) and Patz *et al*. (1996) have argued that the relationship between global warming, the occurrence of marine algal blooms and outbreaks of cholera warrants attention. However, Gray *et al*. (1996) have argued that at present the contention that global warming will increase the risks to human health as a result of increased incidence of *Vibrio cholerae* is speculative. Whether the frequency of marine algal blooms on a global scale is increasing still remains a matter of scientific debate. Furthermore, the causal association between global climate change, bloom frequency and associated risks to human health has not yet been firmly established. With regard to the ability of *Vibrio cholerae* to survive in water, long term survival has been shown in laboratory studies at salinities ranging from 1 to 30 parts per thousand, representing the spectrum from freshwater through estuaries to coastal seawater (Miller *et al*., 1984). Further, survival in fresh waters occurs in association with a variety of freshwater algae. *Vibrio cholerae* can attach to seaweed in laboratory studies. However, although it is accepted that *Vibrio cholerae* is a member of fresh water and estuarine microbiota, it remains uncertain whether coastal marine reservoirs of *Vibrio cholerae* play a major role in outbreaks of disease globally.

3.3.4 Impacts on Marine Life

There is considerable uncertainty about the specific impacts of climate change on marine life. As an example, the potential impact on the dynamics of marine fish populations or projections of the effects of such change on fisheries are discussed below. Sufficient warming could lead to disruption in the population of many fish species because:

- Fish tend to have complex life cycles in which the success of survival at certain stages in the development often appears to be dependent on specific environmental conditions, and
- In some cases, fish may be able to develop effective adaptive responses to changed environmental conditions, but in others they may not (Bakun, 1996).

As pointed out by Bakun, global warming is likely to have a relatively greater effect along the eastern boundaries of oceans, which tend to be drier than the western zones. In the Pacific Ocean, for example, a warming of the eastern equatorial zone relative to the west would tend to shift the tropical system to the "elevated El Niño" state experienced in the mid-1970s to mid-1980s. Such conditions would be disadvantageous, for example, to the Pacific albacore. On the other hand, they might be advantageous to northern ground fish stocks, as they were in the mid-1970s to mid-1980s. If warming has greater impacts on the less humid eastern sides of oceans, it is likely that the great upwelling systems in these regions will tend to intensify significantly. These conditions could exist at the same time as the speed of the circulation in both the atmosphere and the ocean in these regions is reduced. This reduction results from increased warming in the polar regions, leading to a slowing down of the global atmosphere/ocean "heat engine", which would change the flow of major oceanic current systems. However, increases in regional wind speeds might be expected to increase the prevalence of nutrient-rich ecosystems by increasing, for example, the rates of coastal upwelling and open ocean mixing. Thus, the dynamic effects of global climate change on various marine ecosystems will be quite complex and are likely to depend on the relative importance of these possible changes to ocean and atmospheric processes in each region.

Bakun (1996) indicates that another consequence of global warming that may affect fish productivity would be a seasonally earlier run-off of snow-melt in areas where much of the winter precipitation, in the form of snow in the mountains, currently contributes to river flow in the dry spring and summer months. Such changes in flow may make rivers unavailable to fish such as salmon, leading to a decline in population. Salmon may also be exposed to another threat through increased ultraviolet radiation: salmon fry nursery areas tend to be in very shallow, transparent waters, often at higher altitudes where less of the ultraviolet portion of the solar radiation is removed.

There are many other aspects of climate change with potential for major effects on marine ecosystems and fish resources. Interactions among species, notably within predator-prey systems, make it extremely difficult to model the likely consequences of any change in global climate. For example, the northern California Current anchovy spawns in a finely balanced habitat that is apparently subject to disruptions by such changes as run-off patterns, water temperature, etc. Major fish predators on the anchovy are salmon and albacore tuna. The reproductive success of the albacore depends on conditions existing many thousands of kilometers away, while those of the salmon are dependent primarily on continental conditions in the Rocky Mountains.

3.3.5 Rates of Production and/or Exchange of Climate-Influencing Gases

The oceans play a major role in the atmospheric budgets of carbon dioxide and dimethyl sulfide, the latter in part influenced by eutrophication processes. A key question is whether there is any feedback process in which oceanic gas exchange alters climate, and whether the altered climate then in turn alters oceanic gas exchange or other oceanic processes. For example, it has been suggested that primary producers might bloom earlier in a warmer climate, because a warmer ocean would provide a shallower, more stable, stratified surface water layer. Organisms that graze on these phytoplankton, on the other hand, might develop at the 'normal' time of year because their natural cycles are determined by the length of the day. This mismatch of the timing of predator and food development might significantly disrupt marine ecosystems and change the pattern, timing, and amount of the exchange of such climatically important gases as carbon dioxide and dimethyl sulfide. This could, furthermore, result in a greater proportion of organic carbon being recycled by bacteria and photo-oxidation, leading to a greater proportion of the photosynthetically fixed carbon being returned to the atmosphere as carbon dioxide.

The calcification of coral reefs is another potentially important marine issue related to increasing atmospheric carbon dioxide and its exchange with the ocean (Kleypas *et al*., 1999). Increased sequestering of atmospheric CO_2 in the ocean would result in a lowering of the oceanic carbonate (CO_3=) concentration. The calcification of coral reefs depends on the saturation of the carbonate mineral aragonite. Kleypas *et al*. (1999) suggest that by the middle of the 21st century increasing atmospheric CO_2 could result in a decrease in the aragonite saturation state in the surface ocean by 30% and biogenic aragonite precipitation by 14-30%. This could result in a significant decrease in the reef-building process. The authors point out that other calcifying marine ecosystems could also be affected by decreasing carbonate concentrations in the ocean.

3.3.6 Stratospheric Ozone and Ice Cover in Polar Regions

Changes in stratospheric ozone can lead to significant alterations in the wavelength and intensity of light reaching the earth's surface. High latitude ecosystems will be the most exposed to increased ultra-violet irradiation because of the lower concentration and greater variability of stratospheric ozone in polar regions. It is, however, possible that the effects of enhanced ultraviolet light on aquatic organisms has been overstated because of its very limited penetration into water. For example, in the clearest open ocean water, UV-B radiation is reduced to 86% of its surface level intensity at a depth of 1 meter and 22% at a depth of 10 meters. In moderately productive water, the respective percentages are 40% and 0.01%.

Animals which spend time out of the water and on ice (seals, penguins, polar bears, etc.) will be more vulnerable, both because of the increased UV-B radiation and because of the possibly of reduced ice cover as a result of climate change. Polar bears that hunt seals on the ice for their main source of food may be driven back onto land for longer periods, where their ability to find nourishment may be severely reduced. More important will be changes in the timing and possibly abundance of primary production through possible earlier removal of ice cover. It is also worth noting that the reduction in ice cover might have the effect of encouraging increased fishing activity in these waters.

3.4. THE EFFECTS OF OTHER CHANGES ON MARINE BIOLOGICAL SYSTEMS

3.4.1 Coral Diseases and Bleaching

While other threats to coral reefs have been known for some time (and are discussed in Chapter 2, increased incidences of coral reef diseases[1] and coral bleaching have been a more recent concern. Although diseases of reef-building corals have been known since the early 1970's, there are emerging concerns that their impacts on reef communities are increasing. New diseases, apparently unprecedented disease outbreaks which sometimes lead to mass mortalities, and the occurrence of coral diseases in locations where they were previously unknown all continue to be reported (e.g., Bruckner and Bruckner, 1997; Korrubel and Riegl, 1998; Littler and Littler, 1995, 1996; Richardson, 1992; Richardson *et al*., 1998; Kuta and

[1] "Disease" is defined as "Any impairment (interruption, cessation, proliferation, or other disorder) of vital body functions, systems, or organs." Thus, abnormal conditions caused by physiological stress, poor nutrition, genetic mutation, or other factors are considered diseases as well as those conditions caused by pathogens.

Richardson, 1996). A key question is whether diseases are actually having increased impacts on reef systems, or whether the apparent increase is an artifact of more intensive observation and reporting. As scientific observation of coral reefs has unquestionably increased in the past decade, an increased number of observations of coral disease would be expected even if the actual frequency of occurrence of disease were constant.

There are, however, reasons to believe that the frequency and severity of coral diseases are increasing, and that they are having significant negative impacts on reefs (ISRS, 1999). New observations of coral disease have been made even in areas with relatively good scientific baselines. A new disease variant dubbed "White Plague Type II", for example, was first observed in the Florida Keys in 1995 and has subsequently caused substantial coral mortality (Richardson *et al*., 1998). While it is unlikely that coral pathogens have arisen de novo (such as through mutations), it is quite possible that they have been transported beyond their natural ranges (Peters, 1997). For example, a fungus, *Aspergillus sydowii*, - which is believed to originate on land - has significantly infected sea fans throughout the Caribbean: it may have entered the marine environment through sediments from land runoff. Many reefs are being placed under increasing anthropogenic stress, which may both render corals more susceptible to pathogens and itself be a cause of some diseases. It has been speculated that there has been a global increase in the occurrence of coral diseases in response to increasing anthropogenic stress from sedimentation, eutrophication, and other forms of pollution (ISRS, 1999): evaluation of this impression requires better understanding of the causes of coral diseases. This would include determining whether all of the conditions described as "disease" actually represent abnormal physiological responses against the background of natural variability.

Coral bleaching is a generalized reaction to environmental perturbations of many kinds (Kushmaro *et al*., 1996, 1997) . Like coral disease, it is a natural disturbance to reef communities. If there is no extensive mortality, natural recovery can take place in a matter of months. However, if there is mass mortality, natural recovery may only occur on decadal time scales (Brown *et al*., 1996, 1997a, 1997b; Connell, 1997). As with coral disease, concerns have emerged about increases in coral bleaching due to land-based activities.

The possible effect of global warming on coral bleaching is another scientific concern. Corals on most reefs live near their upper limits of thermal tolerance, making them potentially vulnerable to sea-surface warming (Brown, 1997a). Significant increases in sea surface temperature over the last 50 years have been observed in some tropical areas. Corals have considerable ability to acclimatise to elevated water temperatures (Brown, 1997c), but it is not known whether they will be able to adapt to the projected rate of temperature increase. It is worth noting, therefore, that any anthropogenic component of global warming could negatively affect reefs by increasing the rate, as well as the magnitude, of ocean warming.

Until recently, the scientific consensus was that, although mass bleaching occurs in response to local episodes of high water temperature, available evidence did not support the occurrence of widespread coral bleaching in response to global warming (Wilkinson and Buddemeier, 1994). A new consensus is emerging, however, that global climate change may indeed threaten the long-term viability of coral reefs on a global basis. The most geographically widespread, and probably most severe, bleaching ever recorded occurred during the 1997-98 El Niño Southern Oscillation (ENSO) event, although not all of the bleaching can be attributed to ENSO-induced elevation of water temperatures (see ISRS, 1998; Anon., 1999; Wilkinson, 1998). Wilkinson *et al*. (1999) have recently reported the extensive coral bleaching and mortality that took place in 1998 in the Indian Ocean, where water temperatures were often 3 to 5 ^{o}C above normal in this ENSO year. Mortalities of up to 90% were observed in many shallow areas of Sri Lanka, Maldives, India, Kenya, Tanzania, and Seychelles, while mortalities of 50% were common in other parts of the Indian Ocean and in waters below 20 meters. As these authors point out, the socio-economic impacts of such losses are very significant, with potential reductions in fish stocks, negative impacts on tourism and future problems with coastal erosion.

While the economic loss resulting from reef damage is quite difficult to determine worldwide, Cesar (1996) has estimated that the societal costs of a number of activities which result in reef damage are up to 50 times the private benefits obtained from them (using a 10% discount rate over a 25 year term). Intervention in this case would be reef management - including, inter alia, restriction on access to reefs - and the costs would be those of implementing the required management measures and the lost individual benefits.

The 1997-98 ENSO event may fall within the bounds of natural variability rather than be an indication of anthropogenically induced climate change. The extremity of the associated bleaching event, however, is indicated by the bleaching-induced death of some coral colonies on the order of 1000 years old (Anon., 1999; Wilkinson, 1998). Since a possible consequence of global warming is an increased frequency of extreme climatic events such as the 1997-98 ENSO, this would presumably cause more frequent coral bleaching, altering the balance between disturbance and recovery. The problem will be exacerbated to the extent that anthropogenic stresses compromise the ability of reefs to recover from bleaching events. Contamination and other stresses interfere with natural recovery from bleaching and other natural disturbances, and could lead to reef degradation even in the absence of an increase in such disturbances.

3.4.2 Endocrine Disruption in the Ocean

There have long been concerns over sublethal effects of long-term, low level chemical exposure in the sea - particularly on critical biological processes such as reproduction, development and growth. These processes are all hormonally driven; for some marine animals (e.g., decapod crustaceans such as lobsters and crabs), they are quite well understood. The recent concerns about endocrine-disrupting chemicals, stimulated in large part by Colborn's book Our Stolen Future (1995), has led to significant new research on the hormonal effects of persistent (and some non-persistent) chemicals. Examples include chemicals expected to interfere with reproductive and growth hormones and/or a wide range of other hormones. As a consequence, many, if not most, persistent chemicals - from PCBs to certain metal compounds (e.g., TBT) - are now labelled as endocrine-disrupting chemicals (EDCs). This concern was mentioned in the report of a recent Marine Mammal Commission workshop, which discussed the effects of organochlorines on marine mammals, which stated: "The potential effects of contaminants may include (...) disruption of endocrine cycles and developmental processes causing reproductive failures or birth defects" (O'Shea *et al*., 1999).

It is not often acknowledged, however, that the evidence for most chemicals being EDCs is weak, and the evidence for other chemical effects occurring through hormonal modulation/interference (e.g., by DDT and its residues) has been present since World War II, especially through observations of wildlife such as birds. In fact, effects on reproduction and development in wildlife, known to involve the endocrine system, were the basis for Carson's concern about sublethal effects of trace chemicals in ecosystems, expressed in Silent Spring (1962).

In marine ecotoxicology, it has been known for many years that reproductive, developmental and growth processes - initiated and modulated by hormones - are also often susceptible to change at low concentrations of certain persistent chemicals. Laboratory studies have identified a number of comparatively common environmental contaminants as having disruptive properties (see Table 3.2).

Cause and effect relationships between environmental chemicals and specific diseases/abnormalities are very difficult to establish in the 'real world', where many other variables may come into play. There is much research currently in progress concerned both with the problem of identifying chemicals present in the environment that mimic or antagonize the actions of steroid hormones, and with establishing dose response relationships and Qualitative Structure-Activity Relationships (QSARs) in this field. At present, the clearest example of an endocrine-modulated sublethal effect occurring in the sea is the imposex phenomenon in marine snails (gastropods) caused by tributyl tin. It is a highly selective toxic response: no other known compound or class of compounds causes imposex. The cause-effect relationship has been demonstrated a number of times in the laboratory, as well as found very widely in organotin-contaminated sites in coastal waters.

Some examples of apparent effects of EDCs in the marine environment are given in Table 3.3 - but it must be noted that the evidence from the field of such effects, attributed or known to be reflective of effects on hormones or hormonal systems, is limited to estuarine waters (Lye *et al*., 1999). Thus, while we clearly need to have a major research effort underway on the chemicals most suspected of being EDCs, it has not yet been shown that many chemicals act in this manner under natural exposure conditions, and the "issue" itself is not new. One often cited example is that of increases in the abundance of hermaphrodite fish in waters downstream of effluent discharges from sewage treatment plants (Jobling *et al*., 1999; MAFF, 1994; Harries *et al*., 1995) and paper mills (Davis and Bortone, 1992). Increased vitellogenin production was detected at distances up to 15km downstream. It is not clear what specific chemical compounds are causing these changes and whether the changes are of significance at the population level.

Table 3.2. Chemicals with widespread distribution in the environment reported to have reproductive and endocrine-disrupting effects (from Colborn *et al*. (1993)

Herbicides	Fungicides	Insecticides	Nematocides	Metals	Industrial chemicals
2,4-D 2,4,5-T Alachlor Amitrole Atrazine Metribuzin Nitrofen Trifluralin	Benomyl HCB Mancozeb Maneb Metiram-complex TBT Zineb Ziram	a-HCH b-HCH Carbaryl Chlordanes Dicofol Dieldrin DDT+metabolites Endosulfan Heptachlor Methomyl Methoxychlor Mirex Parathion Synthetic pyrethroids Toxaphene	Aldicarb DBCP	Mercury Cadmium Lead	Dioxin (2,3,7,8-TCDD) PBBs PCBs PCP Alkylphenols Phthalates Styrenes

Table 3.3. Examples of adverse effects in the aquatic environment suggested as due to environmental EDCs (adapted from IEH, 1995 and Fairchild *et al.*,1999)

Animal (and sex)	Change recorded	Chemical/Effluent of concern
Marine gastropods	Masculinization (imposex)	Tributyl tin
Alligators, Fish	Disruption of embryonic development	DDE, dicofol
Fish	Induction of vitellogenin	Sewage effluent, oil
Fish (F)	Masculinization	Pulp mill effluent
Gulls	Feminization (super-normal clutches)	Organochlorines
Salmon	Reduced return to rivers for spawning	4-nonylphenol

The ecological implications of exposure to endocrine-disrupting compounds has not been adequately investigated. For example, though male fish exposed to estrogenic compounds show induced production of vitellogenin, the biological significance of elevated vitellogenin levels is speculative. The development of techniques to predict and more accurately assess the ecological relevance of exposure to endocrine-disrupting compounds is needed (Arcand-Hoy and Benson, 1998). The OECD has embarked on an activity to evaluate test methods for endocrine-disrupting chemicals and to assess the significance of observed effects (such as vitellogenin production).

At present, the issue is the "hypothesis/unproved" state of knowledge, and it is by no means clear whether or not there are serious issues that might impact marine systems. Knowledge of sources and processes responsible for the occurrence of endocrine-disrupting compounds in the marine environment is far from complete. WHO, through the International Programme on Chemical Safety (IPCS) is currently addressing scientific issues related to endocrine-disrupting chemicals. A global "State-of-the-Science" report, which summarizes current knowledge about human health and ecological effects of endocrine-disrupting chemicals, will be released in 2000-2001. In addition, a Global Endocrine Disruptors Research Inventory (GEDRI), which provides information on ongoing research, is available electronically.

A recent study in New Brunswick, Canada has strongly suggested that the spraying of a carbamate insecticide (aminocarb), in a formulation that included 4-nonylpheno, on the streams and rivers of many watersheds in the province may have contributed to low numbers of salmon returning to their spawning grounds in those waters in later years (Fairchild *et al*., 1999). Nonylphenol is known to affect the endocrine functions of animals: the young salmon were exposed during development in the stream beds and, possibly, while they made their way to the sea. It is very possible that other environmental chemicals could 'sneak up on us', causing unexpected population collapses of vulnerable species, as they have in the past. In this respect, particular attention should be given to sewage and sewage treatment processes that could by themselves be a primary source of natural or synthetic estrogenic compounds.

3.5. CHANGING PERSPECTIVES ON THE DELIVERY OF CONTAMINANTS TO THE OCEAN

3.5.1 Fixed Nitrogen Fluxes to Marine Systems

Coastal Waters

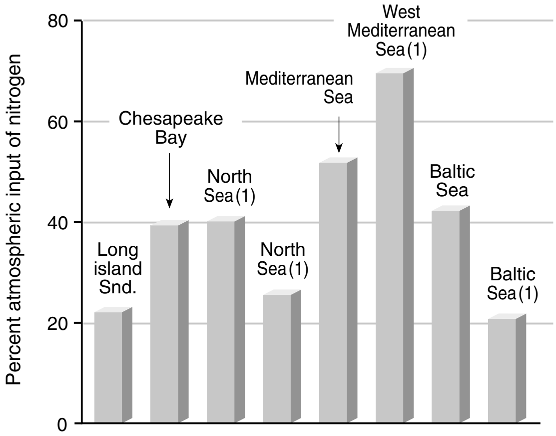
The atmospheric deposition of fixed nitrogen (e.g., as nitrate, ammonium, and some forms of organic nitrogen) has been receiving increasing attention in relation to coastal eutrophication. While significant attention has been paid to reducing and improving treatment of agricultural wastes and municipal and industrial wastes in relation to nitrogen input to coastal waters, there has been less concern about the emission of nitrogen species to the atmosphere. These types of emission have increased in a largely uncontrolled manner over the past several decades. At present, between 10% and over 70% of the fixed nitrogen input to many coastal regions is delivered by rain and fallout of nitrogen compounds, as shown in Figure 3.2, although regionally this has been evaluated primarily only in North America and Europe. It is now recognized that if the atmospheric input is to be ovulated accurately, not only the nitrogen falling directly on the water surface, but also that falling on watersheds and subsequently entering coastal waters via rivers and streams, must be considered.

Evidence in Europe and North America indicates that total atmospheric input of fixed nitrogen has increased by 50% to 200% during the past 50 years (Paerl, 1995). The burning of fuels by industry and vehicles is the primary source of this nitrogen. For example, there are huge emissions of nitrogen oxides from industrial fuel combustion in eastern and western Europe, while large European urban areas are major emitters of nitrogen oxides from burning gasoline and diesel fuel. Dairy and livestock farming in much of western Europe generates large quantities of ammonia. Similar sources exist in North America and other highly populated and heavily industrialised or agriculturally managed regions of the world. Nitrogen associated with organic matter has also recently been found to be a major component of rain in both the coastal zone and the open ocean, ranging from ~20% to 80% of the total nitrogen in rain (Cornell *et al*., 1995). Most of this organic nitrogen is apparently from human sources. Detailed studies of the importance of this nitrogen to marine biological production are just beginning (e.g., Seitzinger and Sanders, 1999).

One of the problems related to the ultimate control of

FIGURE 3.2

Fraction of the total input to a body of water that comes from the atmosphere



Source: Fisher *et al.* (1988); North Sea Conference (1987); Asman and Berkowicz (1994); Baart *et al.* (1995); Guardans and Soudine (1997); Martin *et al.* (1989); Erdman *et al.* (1994); HELCOM (1991 and 1993); Enell and Fejes (1995).

(1) indicates that the atmospheric fraction is from direct deposition to the water only.

atmospheric fixed nitrogen depositing on the ocean is that it often originates from diverse and distant sources. Much of the atmospheric nitrogen entering the coastal waters along the east coast of the United States, for example, comes from power plants and cities in the mid-western U.S., more than 1000 km from the coast. A similar situation occurs in the Baltic Sea, where much of the atmospheric nitrogen originates from Great Britain and from other areas of western and southern Europe. Management and political factors are obviously of considerable importance in this situation, because the primary causes of atmospheric anthropogenic nitrogen are central to energy generation, transportation, etc., and thus to society's economic and social activities. Transboundary issues can therefore become quite complex (see, for example, the UN/ECE 1979 convention on long-range transboundary air pollution, that addresses the control of emissions of nitrogen oxides and their transboundary fluxes.)

There is now widespread evidence that atmospheric fixed nitrogen compounds contribute to enrichment: in some areas they probably also contribute to coastal and estuarine eutrophication (Jaworski *et al*., 1997; Howarth *et al*., 1996). New scientific approaches are required to address this issue, including the use of stable isotopes of nitrogen to trace these processes, and the use of new satellite remote sensing capabilities such as SeaWiFS, which can "measure" biological productivity in the ocean (Zhang, 1994). Paerl (1995) and Paerl and Whitall (1999) point out that this increase in atmospheric fixed nitrogen input to coastal waters may also play a role in harmful phytoplankton blooms and in the increasing frequencies and persistence of anoxia/hypoxia in water - and in associated declines in, and losses of, fisheries and recreational resources. Atmospheric nitrogen input must be included among the nutrient sources that are assessed as part of better management of coastal waters quality.

Open Ocean

There is also growing concern about the increasing input of human-derived nitrogen species to the global open ocean. This issue is particularly important in parts of the open ocean where nitrogen is the nutrient that limits biological growth, such as in the nutrient-poor waters of the great central oceanic gyres in the Atlantic and the North and South Pacific Oceans and in the Southern Indian Ocean. Current estimates suggest that, at present, atmospheric nitrogen accounts for only a few percent of the total new nitrogen delivered to surface waters in these regions, with upwelling from deep waters being the primary source. It is recognized, however, that the atmospheric input to the ocean is highly episodic, often coming in large pulses extending over a few days: at such times atmospheric input plays a much more important role as a source for nitrogen in surface waters. A recent estimate of the current input of fixed nitrogen to the global ocean from rivers, from the atmosphere and from nitrogen fixation indicates that all three sources are important (Cornell *et al*., 1995). About half of the nitrogen input from rivers is derived from human activities, and the ratio may be even greater for atmospheric input. Paerl and Whitall (1999) estimate that 46-57% of the total man-mobilized nitrogen entering the North Atlantic Ocean is coming via the atmosphere. As mentioned above, the atmospheric organic nitrogen flux may be equal to - or perhaps significantly greater than - the inorganic (i.e., ammonium and nitrate) nitrogen flux in open ocean regions. The source of the organic nitrogen is not known, but a large fraction of it is likely to be anthropogenic as well. This form of atmospheric nitrogen input to the open ocean had not been considered in detail until very recently.

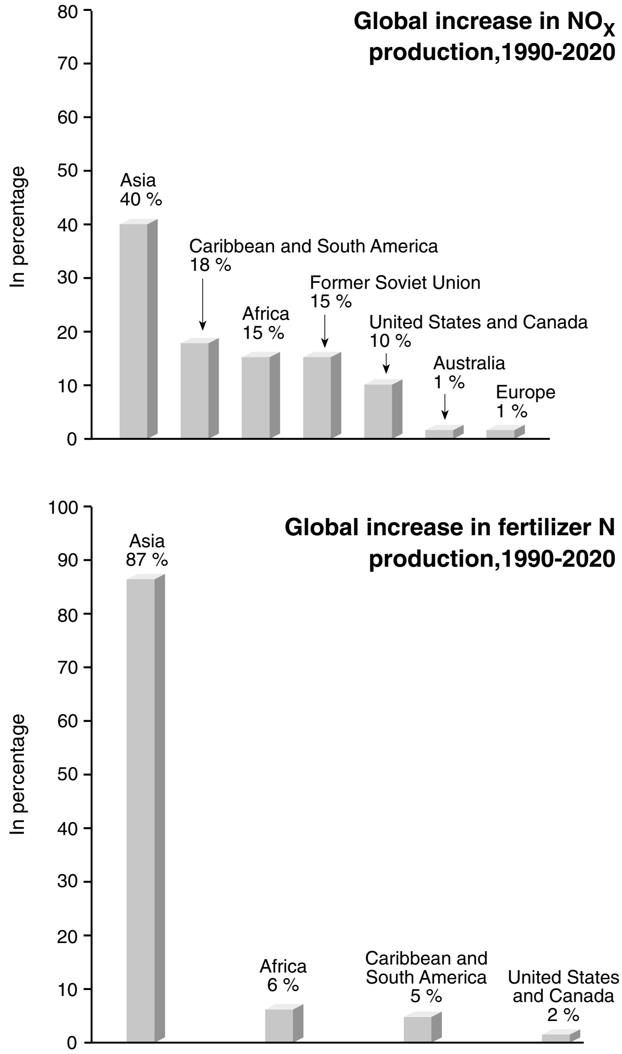
Particularly important is evidence suggesting both that the input of atmospheric fixed nitrogen to the open ocean will rise significantly in the future as a result of increasing human activities, and that the geographical locations of much of this input will probably change too. Galloway *et al*. (1994, 1995) have evaluated pre-industrial nitrogen fixation (formation of the so-called reactive nitrogen) on the continents; the near-current (1990) reactive nitrogen generated from human activities such as energy production (primarily as nitrogen oxides), fertilizer use and legume growth; the estimated reactive nitrogen that will be produced in 2020 as a result of human activities; and the current, and predicted future, geographic distribution of the deposition of reactive nitrogen to the continents and oceans. Figure 3.3 shows the estimated percentage increases in global fertilizer nitrogen production and the formation of reactive nitrogen as nitrogen oxides (NOx) from energy use between 1990 and 2020 in different regions (Galloway *et al*. (1995).

The most highly developed regions in the world are predicted to show relatively little increase in the formation of reactive nitrogen, with none contributing more than a few per cent to the overall global increase. However, other areas will contribute very significantly to increased human-derived reactive nitrogen formation in 2020. For example, it is predicted that Asia will account for ~40% of the global increase in energy-derived reactive nitrogen, while Africa will have a sixfold increase and will account for 15% of the total global growth. It is also predicted that production of reactive nitrogen from the use of fertilizers in Asia will account for ~87% of the global increase from this source! Both energy sources (nitrogen oxides, and ultimately nitrate) and fertilizer (ammonia, urea) result in the extensive release of reactive nitrogen to the atmosphere. Thus, these predictions indicate very significant potential increases in the atmospheric deposition of nutrient nitrogen species to the ocean downwind of such regions as Asia, Central and South America, Africa, and the former Soviet Union (see below). However, it should be pointed out that most of these regions have much lower per capita atmospheric emissions than the highly developed regions. Efforts must continue in the more developed nations to reduce their per capita emissions, and all parts of global society must develop effective industrial, vehicle combustion, and agricultural processes and practices that result in lower fixed nitrogen emissions.

The potential problem outlined above was highlighted by a computer modeling study undertaken by Galloway *et al*. (1994), who generated maps of the recent (1980) and expected (2020) annual deposition of reactive nitrogen compounds from the atmosphere to the global ocean. Figure 3.4 is a map of the projected ratio of the estimated deposition of oxidized forms of nitrogen in 2020 to the values for 1980. It appears that from 1.5 to 3 times, and in some limited areas up to 4 times, the present rate will occur over large areas to the east of Asia and across most of the North Pacific, to the east of most of South America and all across the South Atlantic, to the east of southern Africa almost to Australia, and to most of the Indian Ocean in the northern hemisphere. This increased nitrogen deposition will provide new sources of nutrient nitrogen to some regions of the ocean where biological production is currently limited by nitrogen, particularly the central gyres of the North Pacific and the South Atlantic and parts of the southern Indian Oceans. There is thus the possibility of important impacts on regional biological production and on the marine carbon cycle in these regions of the open ocean. The increased atmospheric reactive nitrogen transport would also be likely to result in enhanced ozone production in the troposphere over these regions, since NO (nitric oxide) is a critical species in the photochemical formation of tropospheric ozone.

FIGURE 3.3

Percentage of increased reactive nitrogen by fertilizer production and energy generation of NOx represented by different regions



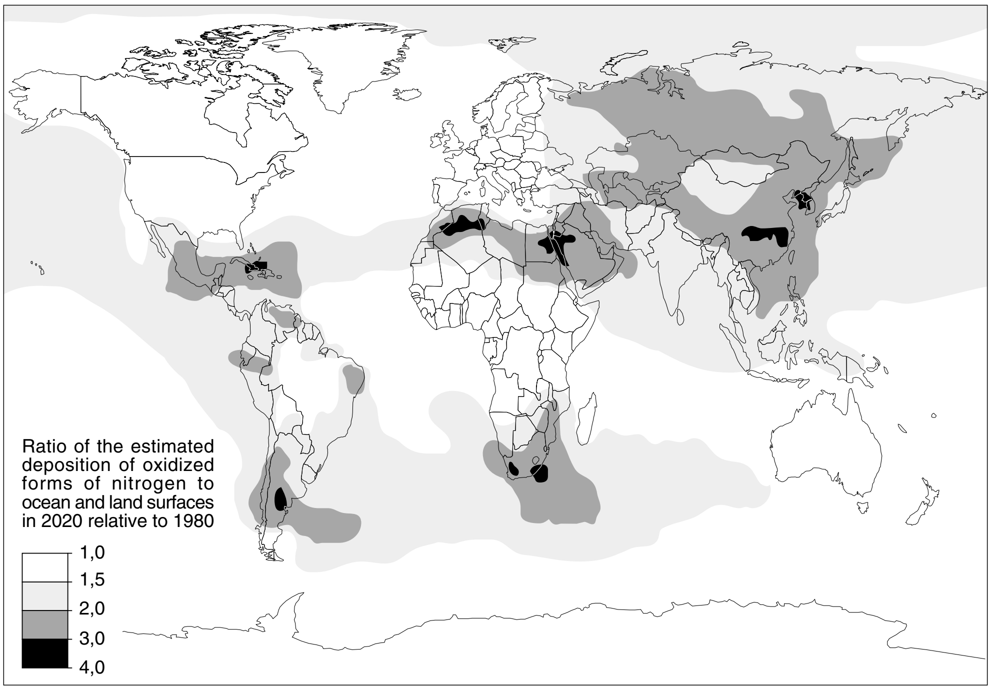
Source: Galloway *et al.* 1995.

3.5.2 Submarine Groundwater Discharge to Coastal Waters

Direct discharge of groundwater into the coastal ocean has been known for many years, but there has been a growing realization recently of the addition of significant quantities of both natural substances and contaminants to the coastal zone via this process. Groundwater enters the ocean through springs and seeps in many regions of the world. Submarine springs have been identified around the Pacific rim (e.g., Chile, Australia, Japan), at Pacific islands (Hawaii, Guam, Samoa), in Florida, in Yucatan, Mexico, in the Persian Gulf, and in many other areas. Slow but persistent seepage of groundwater takes place along most of the world's coastlines and may result in an equal, or greater input of material, as from springs (LOICZ, 1999). Voronov *et al.* (1996) point out that this is also an important issue for inland seas, such as the Gulf of Finland in the Baltic, and in the Mediterranean, where direct groundwater input has been observed off Spain, France, Italy, Greece, Syria, Lebanon, Israel, and Libya. Moore (1999) showed that this subterranean input not only occurs in the near-shore zone, but can take place in the inner, middle, and outer continental shelf, and even to some deep troughs. Moore

FIGURE 3.4

Increase in reactive nitrogen deposition, 1980-2020



Source: adapted from Galloway *et al.* (1994) and Watson (1997).

(1999) also stated that in many coastal regions (e.g., areas along some of the southeastern coast of the United States, the Bay of Bengal, and Sagami Bay, Japan) the input of freshwater from groundwater sources can be of the same magnitude as that from rivers. (It should also be recognized, however, that the reverse may be a significant problem in some regions - i.e., the intrusion of seawater into coastal aquifers as a result of the extraction of too much fresh water.)

Buddemeier (1996) has reviewed this entire issue, and indicates that there is growing evidence that the groundwater flux to the coastal ocean of many chemicals - both natural and anthropogenic - and, especially, nutrients may be much greater than is generally believed. The risk to coastal waters is also increasing because of the increasing contamination of groundwater. For example, Kalnejais *et al*. (1999) found that groundwater was one of the most significant sources of nitrogen found in the Swan Canning Estuary of Western Australia, and LaRoche *et al*. (1997) suggested a linkage between groundwater nitrate inputs and the initiation of brown tides on Long Island, New York, USA. Moore (1996) pointed out that estuarine processes can sequester many trace elements and nutrients entering coastal waters through such processes as flocculation, adsorption and intense biological activity; but groundwater inputs can short-circuit this estuarine "filter" and mix chemicals, including contaminants, directly into coastal and off-shore waters.

While the input flux of metals, nutrients and other contaminants into the coastal zone via groundwater is largely unknown in most regions, there is a growing realisation that the groundwater flux to the coastal ocean is an important biogeochemical and environmental factor. The physical and chemical processes involved in groundwater fluxes to the coastal marine environment are complex and highly variable in space and time (Buddemeier, 1996), and new methods are required to assess accurately this input. In areas where geological structures are particularly prone to seaward fluxes of groundwater, and where coastal waters are vulnerable to eutrophication, it would be prudent to apply high standards of nutrient management within the associated catchments.

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4

Regional[1] Perspectives

Chapters 2 and 3 have described the environmental impacts of LBAs upon marine and coastal areas from a global perspective. The purpose of this one is to present - and attempt to synthesise - regional perspectives on the threats LBAs pose. It is primarily intended to present a purely diagnostic summary and analysis of regional programmes, rather than to prescribe regional priorities and actions, although a few issues for possible regional consideration are pointed out. A detailed review of all regional programmes and conventions is beyond the scope of this report, and would be inappropriate to it. Regional efforts to protect the marine environment from sea-based activities have not been included. The discussion is based mainly on a summary of the Regional Programmes of Action (RPAs) prepared by UNEP's Coordination Office for the GPA/LBA (Annex 3), supplemented by examination of background documents (listed in Table 4.2). Additional background material was also examined in some cases in the preparation of a series of internal working documents (Annex 2). The comments of some regional secretariats on an earlier draft of the chapter have also been taken into account. No evaluation or endorsement of these documents is implied by their inclusion in the analysis presented in this chapter.

The chapter is divided into three sections. Section 4.1 provides brief background information about the history of regional efforts to control LBAs and of the preparation of the RPAs. Section 4.2 analyses the RPAs and available background documentation, and attempts to compare and synthesize regional priorities and approaches to the control of LBAs. As described in the section, the scope of the analysis is limited because the various regions have proceeded in somewhat different ways in prioritising issues and courses of action, and this makes it difficult to compare and contrast their approaches. Section 4.3 harmonises the regional and global perspectives as a basis for the discussion of strategies measures, and priorities for action in Chapters 5 and 6.

4.1. BACKGROUND

Existing regional efforts to protect the marine and coastal environment began around a quarter century ago. UNEP initiated its Regional Seas Programme in 1974. The Mediterranean Action Plan, the first of the UNEP Regional Seas action plans, was adopted in 1975, and its legal framework (Barcelona Convention) in 1976. At about the same time, regional seas agreements for marine environmental protection were adopted, independently of the UNEP Regional Seas Programme, for the Baltic Sea (Helsinki Convention, 1974) and North-East Atlantic (Oslo Convention, 1972 and Paris Convention, 1974. Most of the world's coastal regions now have regional sea programmes for the protection of the marine and coastal environment (see Annex 4).

The experience gained through regional seas programmes provided an indispensable basis for the development and adoption of the GPA/LBA. Since LBAs represent the major threat to most regional sea areas, the efforts of the programmes have often focussed on preventing, reducing, or ameliorating their negative impacts. Thus, regional efforts to control LBAs pre-date the GPA/LBA, and regions that have the most developed, and in most cases the longest-standing, programmes have developed them outside its framework. In the context of this chapter this applies specifically to the Mediterranean (MED), Black Sea, Arctic, Baltic (HELCOM), and North-East Atlantic (OSPAR) regional seas programmes.

Ten other regions have developed RPAs, with UNEP's assistance, specifically within the context of the GPA/LBA although their programmes to protect the marine environment pre-date it. These regions - Eastern Africa (EAF), West and Central Africa (WACAF), the East Asian Seas (EAS), the ROPME Sea Area (which encompasses the Persian Gulf, Gulf of Oman, and the southeast coast of Oman in the Arabian Sea), the Upper South-West Atlantic region (SWAT), the South-East Pacific region (SE/PCF), the South Asian Seas (SAS), the Red Sea and Gulf of Aden (PERSGA), the wider Caribbean region (WCR)[2], and the Pacific Islands (SPREP) - are referred to in this chapter as the "GPA programmes".

The distinction made here between those programmes that were developed specifically within the context of the GPA/LBA, and those that were not, should not be taken as implying anything about the relative merits of the programmes, or about the broader role of the GPA/LBA. It is used simply for convenience, as in explaining some of the variation in approach and presentation among regions (see 4.2.1 below). There are valuable lessons to be learned from all the regional seas programmes in developing RPAs to prevent or reduce degradation of the marine and coastal environment due to LBAs.

[1] The term "regional" is used throughout this chapter to refer to regions as defined for the purposes of cooperative international programmes, e.g., UNEP's Regional Seas Programme.

[2] The WCR has not yet developed an RPA, but it will be developed. The region has completed a regional assessment (UNEP, 1999a) and LBA Protocol (UNEP, 1999b)

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As explained in the text, five regional programmes considered in this chapter have developed independently of the GPA/LBA, although they are of great relevance to it. Another ten regions considered here have developed Regional Programmes of Action specifically within the context of the GPA/LBA process, but their efforts to reduce the impacts of LBAs on the marine environment also preceded the Washington agreement.

The South Pacific Regional Environment Programme (SPREP) provides a good example. With a few exceptions, SPREP's small island states are virtually entirely coastal. Their peoples are highly dependent upon marine and coastal resources, and in many SPREP countries these are the only natural resources available. Thus, essentially all activities in the region are tightly linked to the sea, and the environmental management of land-based activities has been a high priority for SPREP since its inception in 1982. Its past activities and accomplishments relating to land-based activities are too numerous to list in full here, but include:

- regional State of the Marine Environment assessments (1983, 1990);
- regional assessments/reviews of coastal protection (1984), pesticide use (1988), oil pollution threats and responses (1989, 1990), land-based pollutant sources (1993), and sediment transport (1994);
- State of the Environment assessments for 8 member countries and National Environmental Management Strategies for 12 member countries (1992-94);
- manuals, guidelines, and regional training programmes in: environmental impact assessment; protected area management; surveys and monitoring; and biodiversity conservation; and
- practical technical assistance and case studies at the national level in: watershed management; solid waste management; shoreline protection and erosion control; remote sensing; land-based pollution inventories; lagoon water quality; protected area management; resource surveys; and institutional strengthening and capacity building.

Thus, although the South Pacific is in a relatively early stage of developing its Regional Programme of Action in the context of the GPA/LBA, the region builds upon a body of past efforts. This is especially impressive considering the vast area occupied by the region and the severe resource constraints upon SPREP and its membership. From the region's point of view, the projects and activities that launched the region's participation in the GPA/LBA per se include:

- the Strategic Action Programme for International Waters of the Pacific Region;
- the Pacific Pollution Prevention Programme (PACPOL);
- the Nation Profiles to Assess the National Infrastructure for the Management of Chemicals project;
- the Management of Persistent Organic Pollutants in the Pacific project (regional assessment phase completed);
- the Hazardous Waste Management Strategies in Pacific Island Countries project; and
- the Pacific Regional Waste Awareness and Education Programme.

SPREP has been active and productive in its efforts to prevent the degradation of the marine and coastal environment, but is by no means unique. All of the regional programmes can point to a record of valuable accomplishments and contributions. From a regional perspective, therefore, the GPA/LBA marks not a new beginning but an important milestone in an ongoing journey.

4.2. ANALYSIS OF REGIONAL PROGRAMMES OF ACTION

The regional programmes for the 15 regions listed above were compiled and summarised by UNEP's Coordination Office for the GPA/LBA (Annex 3). The priorities, objectives, strategies, measures, and time frames specified in the documents are summarised in Table 4.1. Each region has expressed its priorities in somewhat different terms: only for Eastern Africa, the Mediterranean, and the Arctic are they expressed in terms that can be transparently related to the GPA/LBA contaminant classes and physical alteration. The Mediterranean Action Plan (MAP) lists physical alteration and all contaminant classes[3] except sediment mobilisation as priorities, but does not attempt to prioritise among them: instead, it identifies priority actions within each issue. OSPAR identifies four priority issues[4], three of which encompass more than one GPA/LBA contaminant class or physical alteration: like the Mediterranean, it does not rank the priority issues in order of importance (see Table 4.4). Seven regions (EAF, WACAF[5], EAS, SWAT, SE/PCF, WCR, SPREP) express their priorities for action in terms of source categories. Three regions (ROPME, SAS, PERSGA) express priorities in terms of institutional actions (e.g. surveys and assessments, formulation of regional plans and agreements) rather than sources of degradation. Priorities for the Arctic are stated both for institutional actions (e.g., regional identification and assessment of problems), and for contaminant classes and physical alteration. The Black Sea programme identifies priorities in terms of the physical nature of sources (e.g., rivers, point sources).

[3] The term "contaminant classes" refers herein to the 8 contaminant categories listed in the GPA/LBA (paragraph 21). The term "source categories" is used to refer to sources of contaminants or physical alteration, e.g. agriculture and industrial facilities.

[4] A fifth priority issue concerns offshore activities and is not considered herein.

[5] WACAF identifies a mixture of sources and contaminants/alteration as priorities.

Ten regions (EAF, WACAF, EAS, ROPME, SWAT, SE/PCF, SPREP, Black Sea, OSPAR, and HELCOM) explicitly identify objectives, strategies, and specific actions to address their identified priorities. The Mediterranean and Arctic regions do not explicitly state strategies as such, but these are implicit in their stated objectives and actions. The lack of identified objectives, strategies, and actions in the South Asian Seas and Red Sea/Gulf of Aden RPAs, as presented in Annex 3, reflect their relatively early stage of development ; indeed, the identification of objectives, strategies, and measures is an explicit current priority of both regions. Similarly, although Annex 3 does not list objectives, strategies, and actions for the Wider Caribbean in such terms, the regional LBA Protocol (UNEP, 1999b) embodies a range of objectives and strategies, and specifies a number of specific actions and targets for sewage and non-point agricultural sources.

Table 4.1. Identification of priorities, objectives, strategies, measures, and time frames related to the control of land-based activities in the regional programmes summarised in Annex 3

	Priority issues	Objectives	Strategies	Specific actions	Time frame (yr)
Eastern Africa (EAF)	Domestic sewage	Y	Y	Y	2-3
	Solid domestic waste	Y	Y	Y	3
	Agricultural run-off	Y	Y	Y	3
	Industrial waste	Y	Y	Y	2-3
	Habitat degradation/Ecosystems degradation	Y	Y	Y	1-15
West and Central Africa (WACAF)	Sewage	Y	Y	Y	3
	Agriculture	Y	Y	Y	2-5
	Industry and mining	Y	Y	Y	2-3
	Oil and hydrocarbons	Y	Y	Y	2-3
	Solid waste	Y	Y	Y	3
	Sediments	Y	Y	Y	3
	POPs	Y	Y	Y	3
	Physical modification of coasts / degradation of critical habitats	Y	Y	Y	5-10
	Heavy metals	Y	Y	Y	3-5
East Asian Seas (EAS)	Sewage	Y	Y	Y	1-2
	Agricultural run-off	Y	Y	Y	2-5
	Industrial waste	Y	Y	Y	2-5
	Habitat modification	Y	Y	Y	1-3
ROPME Sea Area (ROPME)	Update surveys of land-based activities	Y	Y	Y	1999
	Conduct a pilot study on POPs	Y	Y	Y	1999
	Preparation of a manual on the implementation of the LBA Protocol	Y	Y	Y	2000
	Develop a River Basin Management Programme	Y	Y	Y	2000
Upper South-West Atlantic (SWAT)	Urban waste water	Y	Y	Y	Short term
	Industrial waste	Y	Y	Y	Short/med. term
	Pollution and degradation from agriculture and forestry	Y	Y	Y	Short/med. term
	Degradation of marine and coastal ecosystem from urban and tourism development	Y	Y	Y	Short/med. term
	Solid waste	Y	Y	Y	Short term

	Priority issues	Objectives	Strategies	Specific actions	Time frame (yr)
South-East Pacific (SE/PCF)	Wastewater from urban origin	Y	Y	Y	Short/med. term
	Industrial and mining operations	Y	Y	Y	Short/med. term
	Ports, dredging and land-fills	Y	Y	Y	Short/med. term
	Aquaculture	Y	Y	Y	Short/med. term
	Recreational and tourism operations	Y	Y	Y	Short/med. term
	Agricultural run-off	Y	Y	Y	Short/med. term
	Critically degraded habitats and physical alterations	Y	Y	Y	Short/med. term
Medi-terranean[1] (MED)	Municipal sewage	Y	N[2]	Y	Up to 2025
	POPs and PAHs	Y	N[2]	Y	N
	Heavy metals and organometallic compounds	Y	N[2]	Y	Up to 2025
	Organohalogen compounds and used lubricating oils	Y	N[2]	Y	Up to 2010
	Nutrients and suspended solids – Industrial waste water and agriculture	Y	N[2]	Y	Up to 2025
	Urban solid waste	Y	N[2]	Y	Up to 2025
	Physical alterations and destruction of habitats	Y	N[2]	Y	N
South Asian Seas (SAS)	Development of strategy for the protection of the marine environment from LBA	N	N	N	N
	Development of a regional programme for monitoring of marine pollution	N	N	N	N
	Development of pilot activities to control degradation of marine environment from LBA	N	N	N	N
	Training of personnel involved in pilot activities	N	N	N	N
	Development of a regional programme to identify special problems of the largest coastal cities and of island States in areas of domestic sewage and solid waste	N	N	N	N
Red Sea and Gulf of Aden (PERSGA)	Development of a regional programme of action for LBAs	N	N	N	N
Wider Caribbean[4] (WCR)	Domestic sewage	Y[4]	Y[2,4]	Y[4]	0-20
	Agricultural non-point sources	Y[4]	Y[2,4]	Y[4]	5
	Chemical industries	N[4]	N[4]	N	N
	Extractive industries and mining	N[4]	N[4]	N	N
	Food processing operations	N[4]	N[4]	N	N
	Manufacture of liquor and soft drinks	N[4]	N[4]	N	N
	Oil refineries	N[4]	N[4]	N	N
	Pulp and paper factories	N[4]	N[4]	N	N
	Sugar factories and distilleries	N[4]	N[4]	N	N
	Intensive animal rearing operations	N[4]	N[4]	N	N
South Pacific (SPREP)	Sewage	Y	Y	Y	1-3 years
	Solid Waste	Y	Y	Y	1-3 years
	Agriculture runoff	Y	Y	Y	1-3 years
	Industrial Activities	Y	Y	Y	1-2 years
	Habitat modification	Y	Y	Y	1-5 years
	Cross-source	Y	Y	Y	1-5 years

	Priority issues	Objectives	Strategies	Specific actions	Time frame (yr)
Black Sea	Rivers	Y	N[3]	Y	N
	High priority point sources	Y	Y	Y	Up to 2006
	Regulation of point sources	Y	Y	Y	Up to 2006
Arctic	Prevention, reduction, control and elimination of pollution in the marine environment	Y	N[2]	Y	N
	Regional identification and assessment of problems	Y	N[2]	Y	N
	Regional establishment of priorities for action	Y	N[2]	Y	N
	Strengthening of regional and national capacity building	Y	N[2]	Y	N
	Harmonization of measures	Y	N[2]	Y	N
North-East Atlantic (OSPAR)[1]	Protection and conservation of ecosystems and biological diversity	Y	Y	Y	2003
	Hazardous substances	Y	Y	Y	2003
	Radioactive substances	Y	Y	Y	2003
	Eutrophication	Y	Y	Y	up to 2010
Baltic (HELCOM)[5]	Eutrophication (especially the contribution of agriculture)	Y	Y	Y	up to 2002
	Hazardous substances	Y	Y	Y	up to 2020
	Relevant issues from the land transport sector	Y	Y	Y	up to 2002
	Protection and conservation of marine and coastal biodiversity	Y	Y	Y	up to 2002
	Harmonization of HELCOM recommendations with EU directives	Y	Y	Y	up to 2002
	Implementation of the Action Programme	Y	Y	Y	ongoing

[1] The Mediterranean and Northeast Atlantic regions do not assign relative priorities among their priority issues (see text).
[2] Although strategies are not explicitly stated, they are inherent in the formulation of objectives and actions.
[3] The Black Sea RPA explicitly calls for the identification of strategies to address this issue.
[4] Although objectives, strategies, actions, and time frames are not listed in Annex B, the regional Protocol does specify general objectives and strategies, and some specific actions. For domestic sewage the Protocol specifies quantitative discharge standards and an agreed timetable. For non-point agricultural sources the Protocol specifies concrete actions and timetable.
[5] All entries were provided by the HELCOM secretariat; supporting documentation was not available. Unlike other regions the priority issues listed here are not related to Annex 3 (for which the information was also provided directly by the HELCOM secretariat).

Some regions (SWAT, ROPME, and SE/PCF) identify a general set of objectives - basically to prevent, reduce, or ameliorate degradation - and a strategy - to develop an RPA and identify programmatic areas. Other regions (EAF, WACAF, EAS, MED, SPREP, Black Sea, OSPAR, HELCOM) define objectives and strategies for each regional priority. All of the regions that identify specific actions, except the Arctic, link them with individual priorities.

4.2.1 Analysis of Regional Programmes of Action: Methodology

As noted above, the regions have adopted widely varying approaches in presenting priorities, objectives, strategies, and measures. In determining priorities, there are also many differences in ways the regions interpret the contaminant classes, physical alteration, and source categories. For example, different regions appear to use the term "POPs" to refer to the "dirty dozen "classes of chemicals listed in Box 2.1 (Chapter 2), to all persistent synthetic organic substances, to all pesticides, or to "hazardous" chemicals in general: SPREP also includes oil, some heavy metals, and medical wastes (UNEP, 2000a). Similarly, several regions quite logically treat sediment mobilisation and downstream sedimentation as a form of physical alteration. Such ambiguities exist not only in the RPAs, but in the language of the GPA/LBA itself. Sewage, for example, is considered as a contaminant in the GPA/LBA, but it can also be considered, as indeed happens in many regions, as a source (of pathogens, nutrients, etc.).

There is similar variation in the way that regions define their programmes. When identifying strategies, for example, some regions have defined specific ones for each objective and/or identified priority issue, while others have defined general strategies that apply to several, or all, objectives or issues. Other regions have defined a strategy in relation to the development of the RPA, rather than to the control of the effects of LBAs (i.e., the strategy is to identify programmatic areas for the RPA). Still other regions have identified strategies at a combination of these levels.

While no particular regional approach is necessarily better than another, this divergence makes it very difficult to compare the programmes of the different regions directly, or to arrive at a general synthesis of regional perspectives. As a result, the present attempt is not as detailed or complete as might be desired. The analysis is based primarily upon Annex 3 - but background documents related to the preparation of the regional action plans, shown in Table 4.2, were examined so as to understand the background and context of the RPAs and enhance their comparison.

As noted above, only a few regions prioritised on the basis of contaminant classes and physical alteration. This is useful, however, in identifying specific measures and priorities for action. For agricultural runoff, for example, measures to address pesticide contamination will be quite different from those to address sediment mobilisation. Therefore, an attempt was made to rank the severity of environmental threat associated with the GPA/LBA contaminant classes in the various regions. Where a stated priority could be directly associated with a contaminant or physical alteration, that issue was given a rank equal to its regional priority. For example, the second priority in the RPA for Eastern Africa was solid domestic waste, for which the background documentation clearly identified physical alteration as the primary concern; physical alteration was therefore assigned rank 2 for Eastern Africa. Identified pri-

Table 4.2. Background documents used in addition to Annex 3 in the analysis of the Regional Programmes of Action (RPAs)

Region	Document	Reference
Eastern Africa (EAF)	Workshop report Overview	UNEP, 1997a UNEP, 1998a
West and Central Africa (WACAF)	Workshop report Overview	UNEP, 1998b UNEP, 1999c
East Asian Seas (EAS)	Technical report Workshop report Overview Proposed RPA S. China Sea Trans-boundary diagnostic analysis Comments from regional coordination unit 17/1/00	Koe & Aziz, 1995 UNEP, 1997b UNEP, 2000b UNEP, 1999e UNEP, 1999f
ROPME Sea Area (ROPME)	Workshop report Overview	ROPME, 1997 UNEP, 1999d
Upper South-West Atlantic (SWAT)	Workshop Report	UNEP, 1998c
South-East Pacific (SE/PCF)	Overview	UNEP, 1999g
Mediterranean (MED)	Assessment of ICM initiatives Strategic action programme 10th meeting report	Hatziolos *et al.*, 1996 UNEP, 1998d UNEP, 1997c
South Asian Seas (SAS)	*Analysis based solely on Annex 3 -* *no background documents available*	
Red Sea & Gulf of Aden (PERSGA)	Regional assessment	UNEP, 1997d
Wider Caribbean (WCR)	Regional assessment Protocol Comments from Regional Coordinating Unit (31/1/00)	UNEP, 1999a UNEP, 1999b
Pacific Islands (SPREP)	Overview Comments from SPREP (21/1/00)	UNEP, 2000a
Black Sea	Transboundary diagnostic	UNDP, 1997
Arctic	Regional assessment State of the Environment	ACOPS, 1996 AMAP, 1997
North-East Atlantic (OSPAR)	North Sea QSR Strategy for hazardous substances Strategy for radioactive substances Strategy to combat eutrophication Strategy for ecosystems and biodiversity Action Plan 1998-2003 (Update 1999) Comments from OSPAR secretariat (14/1/00 & 25/1/00)	North Sea Task Force, 1993 OSPAR, 1998a OSPAR, 1998b OSPAR, 1998c OSPAR, 1998d OSPAR, 1999
Baltic Sea (HELCOM)	Comments from HELCOM secretariat (14/1/00) *No background documents available*	

orities often corresponded to more than one contaminant class; where the relative priority of these were not identified in the documents examined, the relevant contaminants were all assigned equal rank. Thus, more than one contaminant class was sometimes given the same rank. Again using the East African region as an example, the third identified priority is agricultural runoff, for which the contaminants of concern are identified as nutrients, POPs, and sediments. The relative importance of these three contaminants could not be determined from the available information, so they are all assigned rank 3. Since these three contaminants, if they could be prioritised, would account for ranks 3, 4 and 5, the contaminants associated with the next lower priority, industrial runoff, are assigned rank 6.

An important shortcoming of the analytical approach used in this chapter should be recognised. Although they very a great deal, the RPAs and supporting documents developed specifically within the context of the GPA/LBA have generally adopted its logical framework and organisational structure. The admittedly arbitrary analytical approach taken in this chapter also follows that of the GPA/LBA, and is therefore inherently more compatible with the approach of these regions than with the different approaches taken by the five regions that developed their programmes independently of it. As a result, many aspects of the latter regional seas programmes are "square pegs" in the "round holes" of the analysis, and thus tend to fall out of it. This chapter is therefore a poor reflection of many aspects of the generally more advanced programmes developed outside the GPA/LBA. Indeed, the necessary adoption in this report of a uniform approach to synthesising the regional programmes tends to obscure the unique aspects of all of the regions. More effective transfer of "lessons learned" from regional seas programmes would greatly benefit the implementation of the GPA/LBA (see Chapter 6)

Table 4.3. Summary of priorities for the seven regions that identified their priorities on the basis of source categories

	EAF	WACAF[6]	EAS	SWAT	SE/PCF	WCR[7]	SPREP
Sewage	1	1	1	1	1	1	1
Agricultural runoff	3	2	2	3[8]	6	2	3
Industrial facilities	4	3	3	2	2	3-9	4
Aquaculture					4		
Solid waste	2	4		5			2
Physical alteration/ habitat degradation	5	5	4		7		5
Urban and tourism development				4	5		
Ports, dredging, landfills					3		
Animal husbandry						10	

4.2.2 Regional Priorities: Sources and Contaminants

The top priority source categories for the seven regions that prioritised on this basis are shown in Table 4.3. Although there are some differences, the regions' priorities are generally consistent. Domestic sewage is the top priority for all 7 regions. Agricultural runoff and industrial facilities are each assigned either second or third priority by 5 of the 7 regions. The remaining two regions, Eastern Africa and the South Pacific consider solid waste as the 2nd highest priority. In East Africa this is because of concerns about physical habitat alteration due to landfills. In the South Pacific it achieves this ranking because of concerns about physical alteration, the release of nutrients and toxic substances from waste dumps, the limited space available on small islands for solid waste disposal, and the effects of litter on tourism and the environment. Habitat modification - or directly related sources such as urban and port development, reclamation and landfill, and dredging - are ranked 3-5 by all seven regions. The prioritisation of sources in the RPAs is generally consistent with the information in the background documents.

Annotated results of the interpretation of regional priorities for the eight GPA/LBA contaminant classes and physical alteration, according to the methodology described in 4.2.1 above, are shown in Table 4.4. Table 4.5 presents a more concise summary of the regional rankings. Again, there is general concordance among regions on the relative priorities of the issues, with sewage clearly taking the highest priority. Nutrients, sediment mobilisation, POPs, and to a lesser extent physical alteration and heavy metals are also widely perceived as high priorities

While there is general concordance on the prioritisation of issues, there are also clear specificities both regionally (e.g. the relatively high priority given to oil within the oil producing regions ROPME and WACAF) and nationally within regions (e.g., Mauritius, with its dominant sugar cane industry, places higher importance on contaminants from intensive agriculture than other countries in Eastern Africa). There are also regionally-specific concerns that the GPA/LBA does not encompass. The most widespread exam-

[6] In addition to listing source priorities West and Central Africa (WACAF) lists oils, sediments, POPs, and heavy metals as priorities.
[7] The order of listing of source categories for the Wider Caribbean (WCR) in Annex 3 is taken here to reflect priority order, although this may not be the case. WCR lists different industrial sectors in order 3-9.
[8] The Upper South-West Atlantic (SWAT) region combines forestry with agriculture as its 3rd priority.

ple concerns the discharge of organic wastes - specifically biological oxygen demand (BOD) and suspended solids (SS) - from sources other than sewage. Many regions identify this as a significant problem, but BOD and SS are not explicitly listed in the GPA/LBA. Another example is the importance of thermal and hypersaline effluents from power and desalination plants in the Red Sea/ Gulf of Aden region. Thus, while common priorities at global and regional levels form a basis for common action and resource sharing, regions and countries should not be obstructed in obtaining resources where their specific priorities differ from those at higher levels.

Table 4.4. Regional priority rankings of the GPA/LBA contaminant classes (including physical alteration), as interpreted from available background documentation. The Mediterranean Action Plan does not assign priorities on the basis of contaminants or activities and the South Asian Seas RPA specifies institutional priorities that cannot be associated with specific contaminant classes or physical alteration. These regions are therefore not listed in the table. See Table 4.2 for background documents examined and text section 2.1 for methodology

Region	Priority in Action Plan	Comments	Interpreted rank
East Africa (EAF)	Domestic sewage	Overview indicates that primary concern is groundwater contamination; nutrient input from sewage may be a problem, and assessment of eutrophication is one of the RPA objectives for sewage, but nutrients are not explicitly listed as a priority and are not included as 1st priority in Table 4.5	1. Sewage (Nutrients)
	Solid domestic waste	Although the RPA assigns this to the GPA/LBA category “litter”, the primary concern expressed in background documentation is physical damage to habitats from waste dumping	2. Physical alteration
	Agricultural runoff	RPA lists concerns as nutrients and POPs; overview indicates that sediments are the most serious problem, nutrients may be a problem, and there is little evidence of widespread POPs pollution	3. Nutrients, POPs, sediments,
	Industrial waste	RPA lists concerns as heavy metals, POPs, Nutrients, and BOD/COD; overview indicates that at present metals and POPs are not widespread concern,and industrial pollution generally is not serious but that management action should betaken to prevent future problems	6. Nutrients, POPs, heavy metals (BOD)
	Habitat degradation	Most causes listed in RPA relate to either Physical Alteration or Sediments	9. Physical alteration, Sediments
West and Central Africa (WACAF)	Domestic sewage	Pathogens, BOD, SS, and nutrients mentioned in background but relative priority is unclear	1. Sewage
	Agriculture	Nutrients and pesticides mentioned in background; only POPs specifically addressed in RPA	2. POPs
	Industry and mining	Contaminants of concern not clear; overview states that BOD/COD and suspended solids are primary industrial contaminants at present but heavy metals and POPs are expected to increase though present levels are low	3. Heavy metals, POPs (BOD, suspended solids)
	Oil and hydrocarbons		5. Oils
	Solid waste	Background refers specifically only to impacts of litter *per se*	6. Litter
	Sediments		7. Sediments
	POPs		8. POPs
	Physical modification		9. Physical alteration
East Asian Seas (EAS)	Sewage	Urban runoff is listed as a separate priority (4th) in background documents but in the RPA is combined with sewage for definition of objectives, strategies, and actions; the identified contaminants of concern for urban run-off are shown in parentheses but are not included in Table 4.5	1. Sewage (sediment, litter, oils, heavy metals, POPs, and nutrients)
	Agricultural runoff	Order of contaminant listing varies, this is from RPA section 6.2	2. Nutrients, sediments, POPs
	Industrial wastes	Contaminants listed are identified as “main pollutants” in RPA section 6.3, which also lists POPs, oils, heavy metals, and “hazardous wastes”	5. Nutrients (organic matter, suspended solids)
	Habitat modification		6. Physical alteration

Region	Priority in Action Plan	Comments	Interpreted rank
ROPME Sea Area	Oil and combustion products	The ROPME RPA lists priorities in programmatic terms (e.g., "Update surveys"), but provides a priority list of contaminants and physical alteration in its preface. These priorities are what is shown in the column to the left	1. Oils (hydrocarbons)
	Physical alteration, sediment mobilisation, and destruction of habitats		2. Physical alteration, sediment mobilisation
	Sewage and nutrients		4. Sewage, nutrients
	Litter	Background documentation identifies landfills as a source of oily sludges and physical alteration; litter *per se* does not appear to be the top priority	6. oils, physical alteration, litter
	Atmospheric deposition	Background documentation indicates that emissions of hydrocarbons and combustion products are the primary concern relating to atmospheric deposition	9. Oils (hydrocarbons)
	POPs		10. POPs
	Heavy metals		11. Heavy metals
	Radioactive substances		12. Radioactive substances
Upper SW Atlantic (SWAT)	Urban effluents, solid domestic waste	Workshop report identifies contaminants of concern; pathogens, suspended solids, and BOD are here grouped under the GPA/LBA contaminant category "sewage"	1. sewage, POPs, litter, heavy metals
	Industrial waste		5. POPs, oils, heavy metals, nutrients
	Agriculture and forestry		9. Nutrients, POPs, sediment mobilisation
	Urban and tourism development		12. Sediment mobilisation, physical alteration, sewage, litter
South-East Pacific (SE/PCF)	Wastewater from urban origin		1. Sewage, nutrients
	Industrial and mining operations	Organic pollution appears to be the primary concern, in some locations heavy metal contamination from mining operations is a problem	3. Nutrients, heavy metals (BOD, SS)
	Ports, dredging, & landfills		??? (physical alteration, sedimentation assumed, not ranked)
	Aquaculture		???
	Recreational and tourism operations		???
	Agricultural runoff		POPs
	Degraded habitats and physical alterations		physical alteration
Red Sea and Gulf of Aden (PERSGA)	Physical alteration	The column to the left reflects the order in which issues are listed in the assessment document, but sedimentation is listed as a consequence of physical alteration, and sediments as a consequence of sewage discharge. The primary industrial effluents of concern are warm water and brines from power and desalination plants	1. Physical alteration, sediment
	Sediments		3. Sewage, nutrients
	Sewage		5. warm water, brines
	Nutrients		
	Industrial effluents		

Region	Priority in Action Plan	Comments	Interpreted rank
Wider Caribbean (WCR)	Domestic sewage Agricultural non-point sources Chemical industries Extractive industries and mining Food processing Manufacture of liquor and soft drinks Oil refineries Pulp and paper factories Sugar factories and distilleries Intensive animal rearing operations	Contaminant classes and physical alteration could not be associated with the specific industrial sectors listed at left, or prioritised. Not included in the analysis	1. Sewage 2. Sediments, nutrients, POPs
South Pacific (SPREP)	Sewage	Related contaminants listed in overview are sewage, nutrients, and sediments. In the present report suspended solids are not considered under the GPA/LBA heading "sediment mobilisation", so sediments are not included here	1. Sewage, nutrients
	Solid waste	In addition to litter *per se*, the Overview explicitly links solid waste with the GPA/LBA classes POPs, nutrients and to a lesser extent heavy metals, and also clearly indicates that physical alteration (smothering) is associated with solid waste. SPREP uses the term "POPs" to refer to "all hazardous and potentially hazardous chemicals", including oils and some heavy metals. Oils and related substances account for the largest quantity of existing waste and the greatest number of contaminanted sites requiring remediation, followed by pesticides (Overview Table 10), but the relative contribution of different sources (domes-tic, agriculture, industrial) is not specified. Oils are included here with solid waste, but could be listed under agricultural and/or industrial activities	3. Litter, POPs, nutrients, physical alteration, oils (heavy metals)
	Agricultural activities	Overview lists associated GPA/LBA contaminants as sediments, nutrients, and "POPs"; the RPA (Table 3)v also links agricultural activities with solid waste and physical alteration	8. Sediments, nutrients, POPs, solid waste, physical alteration
	Industrial activities	Overview lists associated GPA/LBA contaminants as sediments, heavy metals, and "POPs"	13. sediments, heavy metals, POPs
	Physical alteration	The "Priorities for Action" section of the Overview explicitly links "physical alterations" only with the effects of sedimentation Examples of physical alteration else-where in the Overview, however, include mangrove clearing, coastal (including reef and beach) mining for sand and aggregate, hydrological alteration, destructive fishing practices, coastal development and erosion, smothering by solid waste, and filling of wetlands	16. physical altera-tion, sediment mobilisation
Black Sea	Not stated in Annex 3	Priorities at right reflect background documentation	1. Nutrients 2. Sewage, oils
Arctic	POPs, heavy metals	Both assigned high priority in RPA	1. POPs, heavy metals
	Physical degradation	Assigned medium high priority in RPA	3. Physical alteration
	Radionuclides, petroleum hydrocarbons	Both assigned medium priority in RPA	4. Radionuclides, oils

Region	Priority in Action Plan	Comments	Interpreted rank
North-East Atlantic (OSPAR)[1]	Protection and conservation of ecosystems and biological diversity	May include physical alteration or degradation from pollution and other sources; not included in analysis	
	Hazardous substances	POPs, heavy metals, and to some extent oil, but relative priorities of substances within the list are not assigned; Not included in analysis	
	Radioactive substances		Radionuclides
	Eutrophication		Nutrients, sewage
Baltic Sea (HELCOM)	Eutrophication (especially the contribution of agriculture)	Contaminants/alterations of concern, or their relative priorities not identified; not used in analysis	1. Nutrients
	Hazardous substances		
	Relevant issues from the land transport sector		
	Protection and conservation of marine and coastal biodiversity		
	Harmonization of HELCOM recommendations with EU directives	Unrelated to specific contaminant classes or physical alteration	
	Implementation of the Action Programme	Unrelated to specific contaminant classes or physical alteration	

[1] OSPAR does not rank its four priority issues, or the individual contaminants and physical alteration encompassed by the issues. Therefore, no interpreted rank priorities for the GPA/LBA contaminant classes and physical alteration could be assigned and OSPAR is not included in subsequent analyses based on priority rankings.

Table 4.5. Summary of regional rankings of GPA/LBA contaminant classes and physical alteration of Rank 5 and Above. The Mediterranean and North-East Atlantic regions are not included because they do rank their priority issued in order of importance; the South Asian Seas region is not included because its listed priorities are institutional actions that cannot be directly associated with contaminants or physical alteration

Rank	Sewage	POPs	Radio-nuclides	Heavy metals	Oils	Nutrients	Sediment	Litter (Solid waste)	Physical alteration
1	EAF WACAF EAS SWAT SE/PCF WCR SPREP	SWAT ARCTIC		SWAT ARCTIC	ROPME	SE/PCF BLACK SPREP BALTIC	PERSGA	SWAT	PERSGA
2	PERSGA BLACK	WACAF EAS WCR			BLACK	PERSGA EAS WCR	ROPME EAS WCR		EAF ROPME
3		EAF WACAF SPREP		WACAF SE/PCF	SPREP	EAF SE/PCF SPREP	EAF	SPREP	ARCTIC SPREP
4	ROPME		ARCTIC		ARCTIC	ROPME			
5		SWAT		SWAT	WACAF SWAT	SWAT			

4.2.3 Regional Programmes of Action: Objectives, Strategies, and Actions

Objectives. The majority of regional objectives are stated in very general terms (e.g., “reduce impact”, “improve knowledge”).Often the objective is simply to reduce or prevent degradation, either generally or from a given source. Some regions do identify somewhat more concrete objectives (e.g., “complete an assessment based on existing data”, “develop guidelines”), but these are still rather general. While such objectives are certainly desirable, their generality limits their utility in shaping the development of plans of action or in evaluating progress. For example, does a stated objective to reduce the effects of, say, sewage on the environment refer to a reduction from present levels or from what would occur in the absence of a RPA - and how will progress in meeting the objective be measured? Unless such issues are clarified, it will be difficult to assess the effectiveness of RPAs. For only two regions, the Mediterranean and Wider Caribbean, do the documents examined contain concrete, measurable targets or standards[9]. The Mediterranean region’s detailed, often quantitative, targets reflect the relatively long history of the Mediterranean Action Plan compared to most other regional efforts.

Strategies. As noted above, there is considerable variation among regions in the manner in which strategies are defined in the regional programmes. This precludes a synthesis of regional strategies; but the common themes can be identified ; improved environmental planning and management frameworks, improved awareness and education; improved information systems; development of regional guidelines, criteria, and standards; improved waste management systems; adoption and transfer of technologies; development of regional and international agreements; and the implementation of existing agreements, standards, and legislation. GESAMP considers these strategies to be generally appropriate, and would suggest particular emphasis on improved planning and management frameworks, improved awareness and education, and, perhaps most importantly, the enhanced implementation of existing mechanisms.

Actions. Given the variation in the way objectives and strategies are defined in the RPAs noted above, it is impossible to formulate a regional synthesis of specific actions. Actions identified in the RPAs range from the quite specific (e.g., “identify gaps in existing legislation”) to the very general (e.g., “regional actions to be devised”). The degree to which actions are logically matched to specific identified strategies and objectives also varies, but might be improved in a number of regions .

Initiating monitoring and assessment activities is among the most common actions in the RPAs. This is probably appropriate, given that many regions identify as a constraint a lack of reliable information about the sources and levels of contamination, about the extent and causes of habitat loss and, even more importantly, about the effects of these stresses on the environment and the relative importance of various sources of degradation. In at least one region (ROPME), the problem may not be so much a lack of raw data as one of data management (e.g., poor intercomparability, lack of analysis and interpretive data products, difficulty of access).

There is an impression that in many regions information availability is relatively higher for some trace contaminants (e.g., POPs, heavy metals) than for bulk contaminants that may have greater large-scale impacts (e.g. nutrients, sediments). This may reflect the high level of public concern about the trace contaminants and the results of various global and regional monitoring and assessment programmes. Many regions also have relatively good databases for discharge loading of BOD and SS, which are not explicitly addressed by the GPA/LBA, perhaps because relatively simple, standardised methodology (i.e., the WHO Rapid Assessment method, WHO, 1989) for estimating these loadings has been available for some time. Given this and the broad concern about organic loadings in coastal areas, it may be worth considering the explicit inclusion of BOD and SS in the GPA/LBA and regional programmes.

With regard to assessment, however, a problem inherent in most RPAs is that while the objectives, quite properly, are stated in terms of reducing environmental impacts, there is very little information about actual impacts in the background documents. The most common information presented in the background documents is loading data (i.e., discharges) on a gross weight basis (mt/yr), usually not scaled to length of coastline, volume of receiving waters, etc., or to potential effects in the environment (e.g., discharging 1 mt of toxaphene is likely to be worse than discharging 1 mt of BOD). Sources and contaminants are also sometimes assessed on the basis of consumption (e.g., pesticide sales), scale of activity (e.g., number and size of cities or industrial facilities), or, in relatively few cases, levels of contamination. Unfortunately, it appears that the assessment and monitoring initiatives in the RPAs of most regions, at least as they are presented in Annex 3, will do little to address this deficiency. The monitoring and assessment initiatives appear to be directed almost entirely at inputs (i.e., consumption, scale, discharge, and levels of environmental contamination), with little attention to the resultant environmental impacts. This is probably appropriate to a certain extent, given that there is considerable uncertainty about the environmental impacts of LBAs. Regions may, however, wish to consider placing more emphasis on determining the actual environmental impacts of contaminants and activities, for example through biological effects monitoring, in order to set priorities and evaluate whether source control is indeed appropriate and

[9] Annex 3 does not show targets or standards for the WCR, but these are specified for sewage and non-point agricultural sources in the regional Protocol. Other regions, especially the established programmes, have also set concrete targets but these were not stated in the documents used in the present analysis.

cost-effective in specific situations. Effects monitoring is also likely to improve understanding of the relationships between LBAs and their environmental impact, making it more possible to predict them.

It is important to note, however, that all the information desired by managers and policy-makers will probably never be available, and that it will be some years before assessment and monitoring programmes yield meaningful data, even if they are initiated immediately. In many cases, the information that is already available provides a sufficient basis for action. Thus, **while effective monitoring and assessment can certainly improve decision making in environmental management, action should not be postponed pending the results**. This is explicitly recognised in Principle 15 of the Rio Declaration.

Time Frames. Most regions that identify specific actions include time frames, either in absolute (number of years or dates) or relative (short, medium, long) terms. For the two regions that express time frames in relative terms (SWAT, SE/PCF) there is no indication of the number of years envisioned as representing the short, medium, and long terms.

The time frames adopted by the RPAs developed specifically within the context of the GPA/LBA, where they are specified, are, in general, relatively short compared to those adopted by the more advanced and long-standing regional programmes. Two important messages emerge from this discrepancy. The first is **urgency**. The need for urgent action was commonly expressed in the regional workshops, and the short time frames in the RPAs developed under the GPA/LBA reflect this. The second message is **the need for long-term commitment**. The regions with more experience presumably have a more realistic grasp of the inherent technical, financial, and political complexities of reducing the impacts of LBAs on the marine and coastal environment. The fact that regional programmes with as much as three decades' experience are framing their action plans on decadal time scales demonstrates that the GPA/LBA cannot expect quick fixes. Thus, the short time frames in the RPAs developed under the GPA/LBA are probably not realistic. It may be instructive in this regard to evaluate progress for activities whose time frame has already passed.

Cost of Regional Programmes. None of the RPAs developed specifically in the context of the GPA/LBA have developed costings for the recommended actions. This is to be expected given their early stage of development, but the development of cost estimates is obviously an early next step in developing, and implementing, the RPAs. Regions developing RPAs may findthe large scale of required investment identified by the more established programmes (see box) instructive in this regard. While it is argued elsewhere in this report (Chapter 5, section 5.3.7) that there are often opportunities for effective action that do **not** require large investments, it is also clear (and explicitly recognised by the GPA/LBA) that funds must be mobilized to implement the GPA/LBA. In many regions this will require international cooperation.

The high proportion of environmental expenditure that must be devoted to cleaning up hot spots in the Mediterranean (see box) is a characteristic shared by most, if not all, of the other established programmes. This provides another lesson to other regions: expenditure on planning and management measures to avoid creating hot spots will save money in the long term. The adage "an ounce of prevention is worth a pound of cure" certainly holds true, but again international cooperation will often be required to give developing countries the luxury of making long-term investments.

The Cost of a Regional Sea Programme: the Mediterranean Strategic Action Programme

The parties to the Convention for the Protection of the Mediterranean Sea Against Pollution (the Barcelona Convention) have estimated that planned activities to address environmental degradation of the Mediterranean Sea will require some US$9.973 billion during the period 1998 - 2008 (UNEP, 1998f). The largest component of this, US$6.453 billion, will address high-priority pollution sources, or "hot spots". A further US$2.8 billion is estimated for solid waste management and reduction of atmospheric emissions in coastal cities with populations over 100,000 (34 cities with a total population exceeding 18 million). Also required are US$461 million for the implementation of best available technology and best environmental practice, US$195 million for the protection of 54 sensitive areas, US$37 million for monitoring and enforcement, US$13 million for capacity building, US$11 million for the development of national plans, programmes and regulations, and US$3 million for information and public participation.

Even this level of investment represents a careful targeting of priorities. A first estimate by the World Bank of total investment requirements to promote environmentally sustainable development in the region in a "do everything" scenario is US$58-78 billion over the ten year period (UNEP, 1998f). This represents 1.3-1.8% of regional GDP, which is comparable to current expenditure on environmental protection in most OECD countries. The World Bank also estimates that environmental neglect in the region costs some US$11.5-14 billion annually - or US$115-140 billion over the ten years - in health impacts, lost productivity and tourism revenues alone (UNDP, 1998f). The cost of "doing nothing", then, far outweighs that of the Action Plan.

Prioritisation. The GPA/LBA recognises the importance of establishing priorities for action. As described above, regions have already identified their priorities in a variety of ways, (i.e., on the basis of source categories, contaminant classes, or institutional actions). No particular way is inherently superior. Indeed, effective, integrated management probably requires the assessment of priorities in each of these ways as a matrix of the most important contaminants, the most important sources of contaminants, and the actions to deal with priority sources and contaminants that yield the highest net benefit. It is probably no coincidence that the MAP, arguably the most advanced of the regional programmes described in Annex 3, does not prioritise on the basis of contaminant categories and physical alteration. Given the realistically long time frames for action identified in the MAP, it is probably not justifiable to focus only on a few issues to the exclusion of others. Even if sewage is recognised as the highest priority, for example, it would be a mistake to take no action to address lower-priority contaminants (say, heavy metals or POPs), during the several decades, at least, that it will take to adequately control the negative impacts of sewage. Other regions also recognise this; one example is OSPAR which, like the Mediterranean, identifies a set of priority issues but does not rank them. The SPREP Overview (UNEP, 2000a) states that the relative prioritisation of pollution and the physical alteration of habitats is regarded as inappropriate because of the interlinkages of threats and the need for an integrated approach to their management. The present report stresses that the guiding principle should be to assign the highest priority to those actions that produce the greatest overall net benefit. Prioritisation at levels above that of specific actions should be used as a tool to this end, rather than as an end in itself.

4.2.4 Analysis of Regional Programmes of Action for Individual GPA/LBA Contaminants and Physical Alteration

Sewage

Sewage, as noted above, is the highest-priority issue in most regions. Generally, the response in the RPAs is (i) to assess and monitor the problem; and (ii) to invest in sewage treatment infrastructure. The Mediterranean Action Plan is the only programme that explicitly addresses the need to construct sewerage infrastructure (i.e., piped collection systems) before treatment can be provided, although the household connection rate to sewerage is low in most regions. The generally short time frames for action proposed for addressing sewage are probably not realistic given the need to finance, design, and construct first sewerage systems and then sewage treatment infrastructure. Only EAF, EAS, and SE/PCF specifically point in their RPAs to “intermediate”, “appropriate”, or “alternative” disposal/treatment solutions - and in the case of SE/PCF this is not necessarily specifically with respect to sewage. Regions may wish to consider further alternative, low-cost solutions to the control of sewage pollution that both can be implemented in the short term and are appropriate for their particular situations.

Human health risks associated with sewage pollution were identified as a significant concern in seven regions (EAF, WACAF, EAS, SWAT, SE/PCF, MED, SPREP), but RPA responses were largely limited to assessing of the problem and to sewage treatment. A few regions identify the need for improved water quality standards either explicitly in the RPA or in background documents. No RPA specifies public health responses such as public education[10], drinking water treatment, or immunisation. Although the human health risks of sewage pollution are widely recognised, the actions identified in RPAs generally concentrate on environmental rather than human health impacts.

The discussion of sewage is complicated by an imprecise definition and overlaps with other contaminants inherent in the GPA/LBA. The GPA/LBA (paragraphs 94 and 95) clearly uses “sewage” to refer specifically to domestic wastewater, and this is the approach followed by GESAMP in the present report. At the regional level, however there is inconsistency, both within and among regions, in whether or nor urban stormwater and industrial wastes are included under “sewage”. Stormwater seems often to be included when sewage is listed as a priority, although most RPAs do not specify objectives or actions to address this source of contamination. Related to this problem is the fact that several regions (EAF, WACAF, EAS, WCR, SPREP) identify organic wastes - i.e., BOD, nutrients, and suspended solids - as the contaminants presently of chief concern in industrial waste; the only category in the GPA/LBA which would embrace these is “sewage”. Many regions apparently use BOD and suspended solids as key indicators of coastal pollution load and, as noted above, have relatively good databases for these contaminants. The explicit inclusion of BOD and suspended solids in the GPA/LBA may be worth considering.

Sewage is clearly recognised by many regions as an important source of nutrients, but the relative importance of domestic sewage, agricultural runoff, urban runoff, industrial wastes, and atmospheric inputs has not been assessed in many regions. Regions that have identified eutrophication as a problem may wish to consider an assessment of the relative importance of sewage, agricultural runoff, and other activities as sources of nutrients.

POPs

POPs are listed as a relatively high priority in a number of regions but the documents examined do not indicate that they are a serious, widespread problem at present. It

[10] The SPREP RPA does refer to “improved national environmental education/community awareness” in relation to human health effects of sewage.

is interesting that, although a number of regions report that their environmental levels of POPs contamination are low "relative to other regions", only one , the Arctic, reports levels that are high regionally (i.e., rather than at localised sites). Where environmental effects of POPs contamination are discussed, it is in general terms based on known effects in published literature: there are few specific indications of adverse effects of POPs contamination from within the regions. The major exception to this is again the Arctic, where the human health impacts of elevated levels of some POPs have been assessed; though worrisome, these are thought to be less than the probable impacts of a change in diet away from traditional foods or of reduced breast feeding (AMAP, 1998).

The high priority given to POPs in the RPAs may reflect the widespread international attention they have received, concern over an increasing trend in POPs contamination as a result of intensification of agriculture, industrialisation, and urbanisation, or a recognition that the global nature of POPs contamination may require action by regions even if they are themselves relatively unaffected. There are also scientific uncertainties about the environmental concentrations, fates, and effects of many POPs.

As in the case of sewage, some confusion is introduced by varying usage of the term "POPs". It does not appear that any region has used "POPs" only in the restricted sense that it is used in the GPA/LBA (i.e., the "dirty dozen" listed in Box 2.1). As noted in Chapter 2, it is eminently sensible to consider a broader range of persistent toxic substances (PTSs). Some regions (e.g., SWAT, SPREP), however, have used the term "POPs" in a much broader sense to include a range of "hazardous" substances that may be neither organic nor persistent. Indeed, the SPREP regional overview (UNEP, 2000) states that the SPREP region has:

> "*utilised the term more broadly to include all hazardous and potentially hazardous chemicals such as pesticides, polychlorinated biphenyls (PCBs), industrial chemicals, medical wastes, laboratory chemicals, oil, bitumen, timber treatment chemicals, and fertilisers. This is appropriate as the use of many of these hazardous substances, while growing, is relatively small compared to other regions of the world. The limited resources of region require that the management of these substances be integrated and coordinated with other waste management activities. Thus, other categories of contaminants identified under the GPA are discussed in the context of POPs. For example the GPA category of oils (hydrocarbons and polyaromatic hydrocarbons) is included in the discussion of POPs, as are metals commonly found in pesticides such as arsenic.*"

It is not clear, however, in what way using the term in such a general sense contributes to integrated, coordinated waste management.

Radioactive Substances

Only the Arctic, Baltic, and North-East Atlantic regions identify radioactive substances as a high priority In the Arctic and Baltic they rank as the fourth highest: the North-East Atlantic, as noted above, does not rank its priority issues in order of importance. Concern about radioactive substances arises in the Arctic largely from the ocean disposal of radioactive wastes by the former Soviet Union, and in the Baltic from the consequences of the Chernobyl accident. The most important inputs of radioactive substances to the North-East Atlantic are from nuclear reprocessing plants and the Chernobyl accident, with the latter being mostly secondary inputs from the Baltic; scientific evidence is that, at present, these pose low risks to human health and the environment.

Heavy Metals

The only regions for which heavy metals are unequivocally high priorities are the Arctic and North-East Atlantic. For the Arctic, this is largely because of intensive and poorly regulated mining and smelting activities. Inputs of metals to the North-East Atlantic warrant particular concern in poorly flushed inshore regions, but the justification for serious larger-scale effects has not been convincingly demonstrated.

The no. 1 priority rank shown for heavy metals in the Upper South-West Atlantic region in Table 4.5 is probably misleading. The stated top priority for the South-East Atlantic is "urban liquid effluents", and heavy metals are one entry on a list of contaminants in such effluents. There is evidence of at least localised heavy metal (primarily mercury and cadmium) contamination in Southeastern Pacific, but the documents examined do not include a regional synthesis adequate to determine whether heavy metals are a problem on a regional as well as local scale. The background documents indicate that levels of heavy metal contamination in West and Central Africa are presently low, but the region has identified heavy metals as a priority because a trend of increasing industrialisation is expected to increase the threats they pose in the region. As is the case for POPs, many of the regional background documents discuss the effects of heavy metal contamination in general terms, describing known effects from laboratory studies or other regions, with little specific evidence of known adverse effects within the region itself.

Oils

The high priorities given to oil in ROPME, the Black Sea, Arctic, West and Central Africa, and the Upper South-West Atlantic are probably appropriate given the importance of oil production and transport in these regions. It is worth noting that in the ROPME Sea Area the effects of oil contamination are almost entirely on beaches, and that the effects in offshore waters are minor because this region's ecosystems have a high assimilative capacity for oil.

Nutrients

The background documents for most regions identify elevated nutrient inputs as a problem and many regions (EAF, WACAF, EAS, ROPME, SE/PCF, WCR, SPREP, Black Sea) give indications that eutrophication is increasing. The background documents examined for the Baltic, Mediterranean, and North-East Atlantic were programmatic in nature and did not discuss the basis for action; but eutrophication is known to be a problem in these areas. Relatively few of the programmes developed under the auspices of the GPA/LBA, however, go on to explicitly assign a high priority to nutrients in their RPAs[11]. Most do include nutrients (sometimes implicitly, as "organic pollution") as among the contaminants of most concern in both sewage and industrial discharges. Nutrient inputs from agriculture are also often identified as a problem in the background documents, although the objectives, strategies, and actions in RPAs themselves tend to focus on pesticides, rather than nutrients, in agricultural runoff. The RPAs for many regions, therefore, do not appear to place a level of emphasis on nutrients that is warranted by the information in background documents.

Atmospheric inputs of nitrogen, which can be significant (see Fig. 3.2) are not explicitly considered in any of the regional plans. The background documentation for West and Central Africa, the East Asian Seas, and ROPME does indicate that atmospheric pollution is an increasing concern in these regions, but does not indicate the contaminants of concern. The emphasis with regard to atmospheric emissions appears to be on air pollution rather than on inputs to the marine environment.

Sediment Mobilisation

The background documentation generally justifies a higher priority for sediment mobilisation that is explicitly identified in the RPAs. As is the case for nutrients, sediment mobilisation is often recognised in overviews and workshop reports as a problem associated with agricultural runoff, but the RPAs generally focus on POPs. Sediment mobilisation is discussed in some regions as an important source of nutrient input. Other regions consider it as a cause or consequence of physical alteration. This is entirely correct, but tends to reduce the priority explicitly assigned to altered sediment fluxes in the RPAs. In other words, altered sediment fluxes are likely to be of greater relative importance in many regions than is indicated in Tables 4.4 and 4.5 (e.g., in the South Pacific, see section 4.3 below).

Some regions consider the release of suspended solids in industrial waste and sewage in terms of sediment mobilisation.

[11] It should be noted, however, that both the Mediterranean and North-East Atlantic regions, which are not included in Table 6.5, identify nutrients/eutrophication as a priority issue.

Table 4.6. Environmental issues other than litter *per se* associated with solid waste

Region	Issues
Eastern Africa	Physical alteration of habitats from waste dumps
East Asian Seas	Leaching of contaminants
ROPME	Groundwater contamination, oil sludges, physical alteration
Upper South-West Atlantic	Pathogens and vectors, SS, nutrients
South Pacific	Physical alteration ("smothering of wetlands and reef flats"), leaching of nutrients and toxic substances, human health (pathogens, physical injury).

Litter

There is an apparent disparity between the relatively high priority assigned to solid waste/litter in many regions, as shown in Table 4.3 and the generally low priority assigned to litter in Table 4.5 (and by GESAMP). In many cases, however, regional concerns about solid waste arise wholly or in part not from litter *per se* (i.e., floating solids in the marine environment) but from other sources of degradation arising from the improper disposal of solid waste (Table 4.6). Indeed, the high ranking of litter in the Upper South-West Atlantic region (Table 4.5) arises from the inclusion of litter on the list of contaminants in "liquid urban effluents": it was not explicitly identified as a high regional priority. Though some regions (WACAF, EAS, SPREP) *do* identify litter *per se* as a problem associated with inadequate solid waste management, only West and Central Africa list it as the only problem.

Physical Alteration

The physical alteration of habitats appears in Table 4.5 to have relatively low priority at regional level, but this probably does not reflect the true situation. To some extent, it is an artifact of the method used to interpret regional priorities in terms of GPA/LBA contaminant classes and physical alteration. For example, the South-East Pacific region identified ports, dredging, and landfills - where physical alteration is presumably a major concern - as its third highest priority in terms of source categories (Table 4.3); but because this was not explicitly stated in the background documentation, physical alteration was not assigned a rank in Tables 4.4 or 4.5. There are also inconsistencies in some cases between the background documents and the resultant RPAs with regard to the relative importance of physical alteration. As one, but by no means the only, example, physical alteration, particularly shoreline alteration, was the third highest priority in the West and Central Africa regional overview - and was a prominent concern in most individual country reports (UNEP, 1999c) - but it is considered only as the eighth priority in the RPA. Finally, the importance of physical alteration may have been obscured in some regions because it is not explicitly considered under other categories such as solid waste, urban and coastal development, and agriculture, although it is inherent in them.

Related to physical alteration is the overexploitation of resources, which is not explicitly considered by the GPA/LBA. Examples include: the overextraction of groundwater and resultant saline intrusion (EAF, WACAF, SPREP); overharvesting of mangroves and other coastal forests (WACAF); and erosion and loss of agricultural soils (WACAF).

4.3. SYNTHESIS OF GLOBAL AND REGIONAL PERSPECTIVES

As noted in 4.2.2, there is general concordance among regions on the relative prioritisation of source categories and contaminant classes/physical alteration. Sewage is clearly the highest overall priority. Also noted above (section 4.2.4) is the fact that Table 4.5 probably does not accurately reflect the real priorities of some regions because of methodological artifacts. Table 4.4 indicates a number of instances where contaminant categories or physical alteration were not assigned a rank because this could not be determined on the basis of the background documents examined. This does not mean, of course, that such issues are not important. Table 4.5 also represents a purely mechanistic analysis of the available information. This mechanistic approach has the advantage of being based entirely on information provided by the regions themselves, but it introduces artifacts. The South Pacific region, for example, clearly regards sediment mobilisation as a serious concern, stating "*Sedimentation of reefs and coastal areas is considered* [a] *very serious problem for Pacific Island countries.*" (UNEP, 2000) and identifying a variety of sediment-related problems in its overview document. A variety of issues, however, are associated with the South Pacific's two highest priorities, sewage and solid waste, and these issues all receive an equal rank: because of the method used, this results in a much lower rank assigned to sedimentation and other issues associated with agriculture than is justified (see Table 4.4). Similar distortions occur for other regions.

Table 4.7 presents an interpretive synthesis of regional priorities that attempts to avoid these artifacts. It reflects scientific judgements and interpretations of the information in the background documents with regard to the relative importance of contaminant classes and physical alteration, where these are not clearly identified by the regions. Table 4.7 - being more subjective than Tables 4.4 and 4.5 - may not accurately reflect regional priorities either. Every attempt has been made, however, to base Table 4.7 as objectively as possible upon information presented in the regional documents and to avoid imposing external bias.

Table 4.7. An interpretation of regional priorities. Interpreted priorities are not listed for the Mediterranean, South Asian Seas, Wider Caribbean, North-East Atlantic, or Baltic Sea regions because they do not prioritise contaminant classes or physical alteration, or because the priorities could not be interpreted (see text and Table 4.4)

Region	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5
Eastern Africa	Sewage	Physical alteration	Nutrients	POPs	Sediments
West and Central Africa	Sewage	Physical alteration	Nutrients	POPs	Oil
East Asia	Sewage	Nutrients	Sediments	Physical alteration	POPs
ROPME Sea Area	Oil	Physical alteration	Sediments	Sewage	Nutrients
Upper SW Atlantic	Sewage	POPs	Heavy metals	Nutrients	Sediments
SE Pacific	Sewage	Nutrients	Heavy metals	POPs	Physical alteration
Red Sea/Gulf of Aden	Physical alteration	Sewage	Nutrients	Sediments	
South Pacific	Sewage	Sediments	Physical alteration	Nutrients	Oil/POPs
Black Sea	Nutrients	Sewage	Radionuclides	Oil	Sediments
Arctic	Heavy metals	POPs	Physical alteration	Radionuclides	Oil

It is useful to compare regional views about the priority of issues with the global perspective developed by GESAMP. On the basis of an analysis of the relative priorities of contaminant classes and physical alteration, presented in Chapter 6, GESAMP has concluded that the issues associated with land-based activities which have the highest priority on a global scale, in order (with the first two sharing joint priority) are as follows.

- effects of sewage on human health;
- alteration and destruction of habitats and ecosystems;
- widespread and increased eutrophication;
- changes in sediment flows due to hydrological changes.

The interpreted regional priorities shown in Table 4.7 are generally consistent with GESAMP's prioritisation, but the regions tend to place relatively higher emphasis than GESAMP on heavy metals and POPs, and relatively less on physical alteration. For the Arctic, this emphasis is clearly justified by available information. For other regions, the information examined does not support the relatively high priority given to POPs and heavy metals. Most regions report low levels of contamination, although for some regions there is evidence of localised problems. Some regions have given these contaminants a high priority because of expected increases in industrialisation, urbanisation, and use of agrochemicals; Eastern Africa and West and Central Africa explicitly identify these expected trends. Regions may also recognise a responsibility to address contaminants that undergo long-range transport even if the contaminant does not have serious local effects, although none of the RPAs or background documents states this. There is a possibility, however, that there is also a bias to elevate their priority because of their high public and international profile. As noted previously, the regional reports generally discuss the negative impacts of POPs and heavy metals in general terms, with reference to the broader literature, rather than on the basis of actual observations of problems within a region. There also appears to be a trend that these contaminants are given somewhat higher priority in the final RPAs than in the regional background overviews/assessments. Determination of the relative importance of trace contaminants as opposed to the major ecosystem changes such as physical alteration, anthropogenic eutrophication, and altered sediment fluxes may require further consideration at the regional level. The regional assessments and RPAs examined in this chapter have understandably concentrated on the identification of priorities. Accordingly, attention to strategies and measures has not been as detailed as might have been expected for more mature regional organisations (although it is to be noted that some of these latter regions have similar limitations with respect to the logical development of strategies and measures). The following chapters of this report, on strategies and measures (Chapter 5) and conclusions and priorities for action (Chapter 6) therefore provide a somewhat more detailed discussion of these elements than might otherwise have been appropriate. While they deal with all the activities, sources, contaminants and physical alteration specified in the GPA/LBA, the issues identified by GESAMP as of highest global priority (i.e., sewage, physical alteration, nutrients, and altered sediment flux) warrant the most detailed attention if the most expeditious action to protect the marine environment is to be achieved through the implementation of the GPA/LBA.

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5
Strategies and Measures

The preceding chapters have described the nature, causes, and consequences of degradation of the marine and coastal environment resulting from land-based human activities, from both a global (Chapters 2 and 3) and regional (Chapter 4) perspective. The GPA/LBA explicitly assigns primary responsibility for dealing with these problems to governments, especially those of coastal states, but also stresses the parallel role of international co-operation at both the regional and global levels. It is designed to assist states in identifying and taking actions to prevent, reduce, control and/or eliminate such degradation, and to promote environmental recovery where degradation has already occurred. It outlines the concepts, and the institutional and co-operative arrangements, that underlie effective strategies - and surveys technical measures to address particular sources of degradation and to evaluate progress.

The GPA/LBA recommends priority identification as an essential first step in a hierarchy of actions to develop a programme tailored to national and/or regional requirements. It clearly implies that - unless an assessment of priorities shows otherwise - initial actions should be focused on the protection of human health, the conservation of habitats, and the alleviation of poverty. It recommends a sequence of actions for each major source of degradation, to initiate measures and build capacities, and assigns responsibility for them.

This chapter describes general organisational frameworks and legislative policy measures of potential value in achieving the goals of the GPA/LBA. It also examines specific management and technical measures - and requirements and incentives to induce their implementation - for each contaminant class and for the physical alteration of habitats. The chapter is divided into six sections. Sections 5.1 and 5.2 describe the general policy principles that underlie effective environmental management, and summarise strategies for the control of the effects of LBAs on the marine and coastal environment. Section 5.3 provides an overview of measures to prevent, reduce, or ameliorate degradation of the marine environment - and of requirements and incentives for their implementation. Section 5.4 briefly examines specific technical measures available to reduce the impacts of each of the GPA/LBA contaminant classes and physical alteration, and assesses the costs and benefits of their implementation. Section 5.5 considers needs for additional information and technical research and development, while Section 5.6 describes the institutional and policy requirements for implementing the GPA/LBA.

5.1. A POLICY FRAMEWORK FOR MANAGEMENT

The policy setting for the GPA/LBA varies from one country to another, but there are certain principles and conditions that are common to all. Among the most important of these are:

- management should be cross-sectoral;
- policies should be directed to the rational and equitable use of natural resources;
- policies will not succeed without clear and manifest government commitment accompanied by public commitment;
- policies should be based on adequate information and analysis, and on effective communication among policy makers, experts, and the public;
- the amelioration of poverty is a precondition to sound resource use in many countries; and
- in many countries, international cooperation is critical to the adoption of sound environmental management policies.

5.1.1 Holistic Management

In seeking the marine and coastal environment's optimum long-term contribution to social welfare, societies must ultimately depend on trade-offs between different activities and uses of resources, some of which occur far from the coast. It is not possible to arrive at the optimal set of trade-offs within an institutional framework where decisions are made at the sectoral level. A more holistic approach is required. A consensus has therefore developed - particularly in tandem with the emphasis on sustainable development during the 1990s - that "a narrow sectoral approach is likely to be inadequate" (FAO, 1996) and that "careful planning and management of all sectoral activities simultaneously will result in greater overall benefits than pursuing sectoral development plans independently of one another" (Pernetta and Elder, 1993). This focus has been reflected in many initiatives in both developed and developing countries to initiate holistic approaches to management.

The French Approach to Managing Water Resources

The integrated management of water resources in France, which is organised on the basis of major river basins, has been evolving for more than three decades. Although it is tailored to French conditions, the "French Water School" ("école française [de gestion] de l'eau) - as the model has come to be known - has a number of features that are generally applicable.

The French approach recognises that water has no political or administrative boundaries. **Management is organised on the basis of natural physiographic units: river basins. It also cuts across sectoral considerations and involves stakeholders**. Local communities, large regional developers, industrialists, farmers, water suppliers, fishermen, fish farmers, and conservation organisations act as partners with the government in setting policy that seeks to optimise benefits from the resources while maintaining ecosystem integrity.

Critical to implementing the approach is that **national legislation provides a sound institutional, regulatory, financial, and technical framework** for multi-sectoral management at the scale of catchments. Master plans consistent with national legislation are formulated at the river basin level and implemented at the local level. Thus, **planning and implementation are devolved to the lowest appropriate level**. At all three levels (national, river basin, local) there are **institutionalised arrangements for stakeholder dialogue** that involve representatives from other management levels, providing **vertical integration** between levels. All planning processes are supported by a national technical information system that provides for effective **data access and exchange**.

Critical to the long-term effectiveness of any management system are arrangements for **sustainable financing**. In the French system, the Water Agencies are funded on the basis of the **user-pays/polluter-pays principle** and are financially autonomous.

5.1.2 Rational, Equitable, and Sustainable Use of Natural Resources

Many international legal texts incorporate the principle that the use and management of resources should be rational and equitable. The "rational" use of resources means that they are managed to generate optimum benefits: "equitable" is generally taken to mean that those benefits are allocated fairly. The concept is generally accepted that human activities should not damage the environment in a way that seriously threatens the viability of ecosystems or renewable resources (i.e., so that the environment cannot *sustain* the activities).

Under normal market conditions, resource use is neither rational - viewed from the perspective of overall benefit to society - nor equitable, because the market does not reflect the costs of private actions that are borne elsewhere either publicly or privately, such as the environmental costs of wetland drainage or of environmentally harmful effluent discharged into a river. This market failure arises from a discrepancy between private and societal interests. This discrepancy can be corrected through a range of measures, including regulatory and economic instruments and the creation of private or public property rights (see section 5.5.3).

5.1.3 Government and Community Commitment

The rational and equitable allocation of natural resources requires a high measure of commitment by governments, the private sector, and communities. Governments may need to modify institutional frameworks, establish new institutions, and reduce the authority of others. Difficult decisions may have to be made on the allocation of resources. These concern not only natural resources - where there are likely to be private interests that will lose benefits they previously derived - but also public human and financial resources that may have to be channeled away from some areas and redirected into others. At the local level, communities may have to agree, for example, that established uses of natural resources are unsustainable, and that resources should be reallocated, or that public investment should be financed to the benefit of the community as a whole (perhaps through realistic levels of charges).

The absence of firm commitment is the underlying reason for policy failure in the rational and equitable allocation of natural resources. Inadequacies in addressing market failure due to externalities (see 5.1.2), policy paralysis resulting from inadequate information, and policy inconsistency - where sectoral decisions conflict with the environmental goals of government - may all be attributed, to a greater or lesser extent, to a lack of commitment at central or local levels. Where there <u>is</u> commitment, financial resources are sometimes a constraint. More frequently, perhaps, a low level of economic development prevents effective intervention.

5.1.4 Poverty Alleviation

Poverty is a root cause of environmental degradation in much of the world. The poorest people, and poorest countries, do not have the luxury of taking a long-term view and are forced to take whatever actions are necessary to meet immediate needs, even when they know these to be detrimental in the long-term. In addition, poor people often inflict disproportionately high damage because, with limited alternatives, they are often forced to place pressure on the environment. This includes, for example, gardening on marginal land, fishing depleted stocks, cutting mangroves and other coastal forests for fuel and building materials, and living in unplanned peri-urban settlements without water and sanitary services. Preventing resource degradation from such pressures - driven by increasing population and poverty - is thus part and parcel of sustainable development. As incomes rise, the incidence of polluted drinking water falls and the rate of population increase declines. There is a strong argument, therefore, that improving the long-term welfare of the poor should be a priority for government actions. Moreover, levels of awareness of environmental threats, and of willingness to participate in mitigation, also increase as incomes rise.

Pressure on natural resources can often only be resolved by creating alternative employment opportunities. This sometimes requires large investments in physical infrastructure and education; but much may also be achieved through reform of agricultural policies in many situations.

5.1.5 Regional and International Cooperation

Countries that reduce local environmental impacts by using air or water to carry contaminants away - by building tall stacks, for example, or discharging contaminants into a river - may simply transfer impacts to neighboring countries. States may also tolerate practices that are detrimental in another jurisdiction: one state, for example, may tolerate LBAs that accelerate coastal erosion without considering possible effects - such as those of siltation on coral reefs - in a neighbouring country.

Such situations are likely to create conflict. Regional cooperation, though not a panacea, can not only reduce conflict but also enhance the efficient use of human and financial resources through such means as:

- agreements to reduce the export of environmental impacts and to tackle problems in shared seas collectively;
- the exchange of information and experience both about transboundary environmental impacts and at a more general level, for example on changes in the status of coastal ecosystems;
- cooperative programmes for research, environmental monitoring, assessment, training, information management, and technical assistance;
- coordination of the management of coastal areas and associated catchments; and
- cooperation and networking to address common needs.

Such cooperation allows countries to pool resources to undertake complex activities that would otherwise be beyond the capability of any one of them, and recognises their inter-dependence with regard to environmental threats. Examples include regional programmes in the Mediterranean, North, Black, Baltic, and South China Seas. A less sophisticated level of technical cooperation between developing countries, both within and between regions, can also work relatively well.

To support such international cooperation - and, indeed, unilateral efforts by developing countries - donors may need to reconsider their priorities and policies. Many donors are reluctant to provide assistance that they perceive as supporting the recurrent budgets of recipients. Instead they usually confine it to projects that emphasise short-term capital investment and narrowly targeted training. The critical need in many countries, however, is long-term support in building the administrative and technical capacity to formulate and, in particular, to implement sound and coordinated environmental policies.

Case History: International Cooperation in the South China Sea

The South China Sea is an interesting example of the benefits of international cooperation, because of the looming threat of military confrontation over the Spratly Islands, which several countries - including China, Vietnam, Malaysia and the Philippines - claim to lie in their territorial waters. Scientists in these countries have taken strong initiatives to promote the peaceful use of the Sea and its resources so as to shift the trend towards mutual benefit in the region, rather than towards potentially destructive competition for resources. These initiatives are exemplified by joint scientific cruises organised by the Philippines and Vietnam. There has also been an increasing exchange of scientists and students among these countries, taking advantage of the relative strengths in marine science and environmental management training of the different institutions around the Sea's basin. Negotiations are currently under way at senior government levels - such as the respective departments or ministries of foreign affairs - to institutionalise such forms of collaboration in order to make them a permanent feature of regional cooperation.

The capacity to manage natural resources rationally and equitably depends upon adequate GNP and institutional capacity - barriers for many developing countries. Global environmental concerns and international trade are increasingly being governed by international conventions, whose application may be counter to the short-term interests of many smaller countries. Similarly, international institutions often call for economic policy reforms that are not always appropriate for the countries concerned, and constrain their ability to formulate and implement effective natural resources management policies. There is a need for the concerns of these countries to be taken into account to a greater extent.

5.2. STRATEGIES TO CONTROL DEGRADATION OF THE MARINE ENVIRONMENT FROM LAND-BASED ACTIVITIES

5.2.1 Common Strategic Elements

The optimum strategy for reducing the impacts of LBAs on the marine and coastal environment will be different in each country; but there are certain common elements. The “umbrellas” within which key elements may be grouped are:

- incorporation of environmental considerations into all projects, policies, and programmes;
- promotion of efficient resource use;
- avoidance of policy failure; and
- maintenance of future options.

Incorporation of Environmental Considerations into all Projects, Policies, and Programmes

Elements falling into this group include:

- carefully evaluating the likely environmental consequences of all projects, policies and programmes;
- adjusting programmes to ensure that the overall net damage is minimised; and
- giving priority to programmes and policies that generate long-term net economic benefits.

Promotion of Efficient Resource Use

Policies that promote technical economic efficiency without infringing equity (fairness) or environmental considerations will promote the welfare of present and future generations. Elements would include:

- allocating property or use rights;
- avoiding subsidies that encourage environmentally damaging practices;
- adopting measures to internalise environmental costs, including the broad interpretation of the polluter pays principle where appropriate ;
- promoting technical efficiency, which reduces industrial costs and pollution; and
- giving due consideration to the degree to which activities or interventions are irreversible.

Avoidance of Policy Failure

The role of government, in the context of the mitigation of the effects of land-based activities on the marine environment, is (i) to provide the legal, institutional and policy framework conducive to sustainable development and resource use and (ii) to correct market failure. Various elements might be included here but among the more important are:

- enhancing the institutional capacity to manage natural resources, with particular attention to capacities for information development and economic analysis;
- taking a holistic approach to the management of the uses of natural resources;
- adopting devolved management, with a twin-track policy process that involves all stakeholders;
- providing education on environmental matters;
- ensuring better communication between experts, policy makers, and the public;
- selecting policy instruments according to the policy problem being approached, giving particular attention to measures that use market mechanisms; and
- adopting policies that ameliorate poverty.

Maintenance of Future Options

This “umbrella” element is concerned with preventing irreversible actions that might diminish the options of future generations. It would include:

- adopting a precautionary approach when the ecological impact of a proposed action is uncertain; and
- ensuring that unavoidable environmental damage is offset by compensatory action elsewhere.

5.2.2 Factors that Influence the Setting of Priorities at the Regional and National Levels

Each region - and each country within a region - has a unique set of prevailing circumstances which will determine its priorities. As noted in Chapter 4, differences in the industrial base and population characteristics influence regional priorities for contaminant categories. Priorities for action depend in part upon the status of regional agreements and institutions, shared social and cultural characteristics, and other regional characteristics.

Similar factors influence priorities at the national level: one example would be whether the land-based activities that are causing adverse environmental effects are primarily rural or urban in origin. In heavily urbanised countries, industrial pollution of rivers and the sea will often have a high priority. In more rural economies land, water, and forest management may well be among the priorities. Most developing countries, however, lie between these poles. Typically, these countries combine largely rural economies with relatively large urban areas - frequently on or near coasts - and, often, with areas used for coastal tourism. Small island developing states almost always have to contend with rural and urban environmental issues within a small area; among other things, this places physical constraints on key environmental services, such as solid waste disposal. As at the regional level, the nature of existing institutions and legislation must be taken into account in setting priorities, as well as social and cultural characteristics.

5.2.3 Setting Priorities, Objectives, and Targets

The following considerations should underlie the selection of priorities:

- priority issues are those at the source of the problem to be addressed, (e.g., poverty, wasteful technologies, human behaviour, etc.);
- short-term priorities should be identified as those where:
  - analysis of existing information indicates that significant improvements can be achieved in the short term by applying or redirecting existing human and financial resources; and/or
  - where action has a high chance of success;
- longer-term priorities should be those that:
  - require additional financial and human resources not available in the short term; or
  - address problems likely to be intractable in the short term.

At the national and sub-national levels, the objectives of strategies and policies should be clearly written, unambiguous, specific to the issue being addressed, and realistic in terms of the time allowed to achieve the objective and the technical, human and financial resources available.

Objectives and targets are the keystones of programme monitoring and should be determined in such a way that they are susceptible to it. They should, therefore, be specific and well defined, and, where possible, quantified as targets, (e.g., standards for water, sediment, seafood, and protection of habitat, to facilitate the programme monitoring process (see 5.6.9)).

5.2.4 Criteria for the Selection of Measures

The selection of measures, and of the policy instruments to induce their implementation, obviously depends upon the environmental and socioeconomic conditions, goals, and priorities at national and regional levels. There are some fairly straightforward criteria to guide the selection of measures, including:

- **environmental objectives**, which should clearly dictate, in large parts which measures are appropriate;
- **cost effectiveness**, which for a given measure should not be evaluated in isolation but with respect to overall objectives and priorities. A relatively cheap and effective treatment technology to remove a contaminant, for example, may not be cost-effective in the broader context if the contaminant is not of significant concern, especially if using the technology diverts resources from higher priorities;
- **legal implications** of a measure with respect to national law and binding international agreements;
- **flexibility** to respond to changes in technology, resource base, or markets quickly and simply;
- **predictability**;
- **reversibility**;
- **equity**, especially with regard to any distributive aspects of a measure intra- and inter-generationally;
- **capacity to implement and sustain the measure**;
- **acceptability** to those affected, which can best be achieved through consultation and participation; and
- **the fiscal and economic impacts** of the measure.

5.3. OVERVIEW OF MEASURES, AND OF REQUIREMENTS AND INCENTIVES TO INDUCE THEIR IMPLEMENTATION

The sustainable development of coastal and marine areas requires the application of a suite of measures tailored to local, national, and regional circumstances. The suitability of a given measure usually depends less upon its inherent technical merits than upon benefits and costs relative to other measures, the priority of the issue that it addresses, and - perhaps most importantly - the prospects for implementing it effectively. Implementation, in turn, depends upon applying a range of appropriate policy instruments, including regulatory and economic instruments, the promotion of voluntary action by industry, and public and private investment.

Many specific tools and measures are available to address individual contaminants, activities and sources; these are summarised in Section 5.4 and Table 5.4 below. This section - much of which is summarised in Tables 5.1 and 5.2 - provides an overview of four categories of technical measure (source reduction, stress reduction, impact reduction, and mitigation), three types of policy instruments (regulatory instruments, economic instruments, and the promotion of voluntary initiatives), and appropriate conditions and tools for their implementation. Discussion of the organisational arrangements and broader policy and legal frameworks for implementation is deferred until Section 5.6.

Table 5.4. Available measures for prevention of degradation of the marine environment by land-based activities by contaminant and source. The gray columns correspond to the "intervention points" in Figure 5.1

Contaminant or alteration	Major anthropogenic sources	General planning and management approaches/ frameworks	MEASURES TO: *Prevent or reduce contaminant production or a harmful practice* (Source reduction)	*Modify contaminants or practices or reduce contaminant discharge or extent of the practice* (Stress reduction)	*Prevent or reduce degradation of affected areas* (Impact reduction)	*Mitigate or reverse degradation that is unavoidable or has already occurred* (Mitigation)	Suitable requirements and incentives
Sewage	**Diffuse sources** (latrines, septic tanks, etc.)	Social policy; urban planning; waste management	Water conservation, construct sewerage infrastructure (converts diffuse sewage sources to point sources)	Improved design and construction (e.g. of septics); innovative technologies (e.g. composting toilets)	Good public health/ environmental engineering practice; use of natural or constructed interceptors/ assimilators (e.g. wetlands, mangroves)	Natural regeneration after earlier measures have reduced contaminant loads	Public investment; public education; subsidies for appropriate technologies
Sewage	**Point sources** Sewage Outfalls Animal husbandry Industry (food processing, pharmaceuticals)	Social policy, urban planning; waste management De-intensification; land-use planning Not applicable (?)	Water conservation Best practice	Treatment; waste extraction and reuse; effluent/ sludge recycling; land disposal; waste stream separation	Appropriate construction and siting of outfalls; appropriate timing of discharge (e.g. tidal phases); use of natural or constructed interceptors/ assimilators (e.g. wetlands, mangroves)	Natural regeneration after earlier measures have reduced contaminant loads	Regulation; effluent taxes/ charges; user charges; subsidies for infrastructure;
POPs (PCBs, hexachloro-benzene)	Industries: PCBs: electrical, hydraulics, printing Hexacholor-benzene: widespread use		Bans; Product substitution	Treatment, incineration, recycling; ban landfill disposal; containment technologies (e.g. geotextiles)	Discharge, environmental quality, and product residue standards; Appropriate siting;	Removal of contaminanted sediments; bioremediation; natural attenuation	Regulation; user charges; deposit-refund systems; sub-sidies for clean technology; subsidies for BEP/BAT; removal of subsidies for outdated technology; liability insurance
POPs (Pesticides)	Agriculture	Integrated pest management, BEP, BAT	Bans; product substitution Ban landfill disposal	Reduced use; targeted application		Bioremidiation (may be possible in near future)	Residue standards in agricultural and aquacultural products
POPs (Chlorinated dioxins, furans)	Incinerators, industrial facilities (pulp mills)	Improved waste management; Best management practice	High temperatures during incineration; pulp mill feedstock segregation; substitutes for chlorine in pulp bleaching	Stack scrubbers	Discharge, environmental quality, and product residue standards; Appropriate siting;	Removal of contaminanted sediments; bioremediation; natural attenuation	Regulation; subsidies for clean technology, BEP, and BAT; removal of subsidies for outdated technology

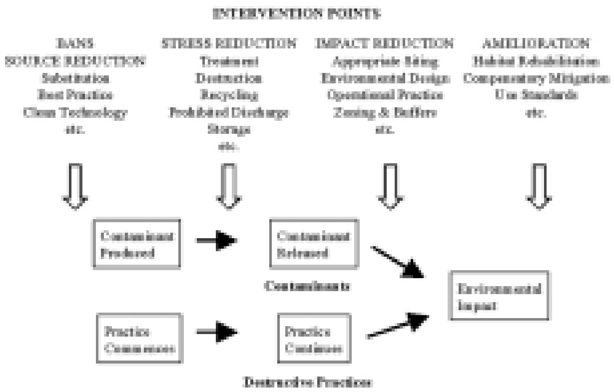
Contaminant or alteration	**Major anthropogenic sources**	**General planning and management approaches/ frameworks**	**MEASURES TO:** *Prevent or reduce contaminant production or a harmful practice* **(Source reduction)**	*Modify contaminants or practices or reduce contaminant discharge or extent of the practice* **(Stress reduction)**	*Prevent or reduce degradation of affected areas* **(Impact reduction)**	*Mitigate or reverse degradation that is unavoidable or has already occurred* **(Mitigation)**	**Suitable requirements and incentives**
Artificial radionuclides	Nuclear cycle installations (especially spent fuel reprocessing plants), hospitals, research facilities	Radiological protection, regulation	Ban nuclear power generation, spent fuel reprocessing, medical and research use of radionuclides; cleaner technologies	Reduce medical and research use of radionuclides, waste treatment, stack scrubbers	Release limits; land storage; deep-sea disposal of solid radioactive wastes; restricted access	Sediment removal, capping, natural burial	Regulation; subsidies for clean technology
	Accidents	Risk management	Ban nuclear power generation, nuclear weapons		Restricted access		
Natural radionuclides	Mining activities, fossil fuel combustion	Risk management	Ban mining, fossil fuel combustion				
Heavy metals	Industrial facilities: smelting, mining, metal plating, shipyards, solid municipal waste	Health protection Seafood safety Clean technology	Collection and recycling or proper disposal of relevant consumer products (e.g., batteries)	Waste separation and treatment; stack scrubbers; product substitution; landfill containment	Appropriate siting of discharges; Restrictions on fisheries or fish consumption; assimilation by wetlands & mangroves;	Sediment removal, capping, natural burial, landfill remediation	Regulation, effluent charges/taxes, subsidies for clean technology; removal of subsidies for outdated technology; product charges; deposit-refund schemes; liability insurance
Oils	Industrial facilities (refineries, production, storage and distribution facilities, port facilities)	Best practice, implement MARPOL (port waste reception)	Ban relevant industries; cleaner technologies;	Product substitution (gas, nuclear power); mandatory booming of ships in harbour; oil waste interception and treatment; fuel bunds; improved operational practice	Discharge and environmental quality standards; appropriate siting	Bioremediation; physical removal;	Regulation, effluent charges/taxes, subsidies for clean technology; removal of subsidies for outdated technology
	Urban runoff	Urban planning	Ban terrestrial oil dumping	Stormwater interception and treatment; used oil disposal facilities; oil recycling; reduced use for dust control	Not applicable	Physical removal	Deposit refund schemes (for used lubrication oil); user/ product charges; public education; public investment
	Accidents	Risk management; regulation	Not applicable	Safety measures; maintenance	Not applicable	Bioremediation; physical removal; dispersants; natural attenuation	Regulation;

			MEASURES TO:				
Contaminant or alteration	**Major anthropogenic sources**	**General planning and management approaches/ frameworks**	***Prevent or reduce contaminant production or a harmful practice* (Source reduction)**	***Modify contaminants or practices or reduce contaminant discharge or extent of the practice* (Stress reduction)**	***Prevent or reduce degradation of affected areas* (Impact reduction)**	***Mitigate or reverse degradation that is unavoidable or has already occurred* (Mitigation)**	**Suitable requirements and incentives**
Nutrients	Sewage	Social policy, urban planning; waste management	Water conservation	As for sewage above	As for sewage above	As for sewage above	As for sewage above
	Runoff from agriculture, cities, aquaculture, forestry, construction sites, recreational/tourist facilities	Best practice	Improved land management to reduce run-off	Interceptors; buffer zones; closed-system aquaculture; reduced fertiliser use; improved road design and construction	Appropriate siting and timing of activities	Capping sediments; alum addition	Regulation; taxes/charges on fertiliser; subsidies for BEP/BAT; removal of subsidies on fertiliser
	Atmospheric emissions - transportation, power plants, industrial facilities; incinerators; agriculture	Best practice; urban planning	Cleaner technologies; reduced vehicle use; energy conservation	Catalytic converters; stack scrubbers; improved transport systems	Not applicable	Not applicable	Regulation; TDPs,
Altered sediment flux - large engineering works (Sediment mobilisation)	Channelisation; flood control (levees), coastal protection (sea walls); diversions	Place watershed management within an ICM regime; EIA; good engineering practice	Reject project proposal	Design improvements (e.g., catchments, salinity controls, non-reflective sea walls); bank stabilization; post-construction engineering modifications (e.g., open/modify closures)	Natural or constructed interceptors/assimilators (e.g. vegetation buffers and wetlands); constructed offshore berms; dredging (sediment removal)	Habitat creation and restoration	Regulation; subsidies for BEP/BAT; soft loans for erosion control investments
(Sediment impoverishment)	Dams; channelisation; flood control (levees); coastal protection (groynes); coastal enclosures			sediment bypasses; diversions; enhanced flow through; deliberate flooding	sediment replenishment; enhanced erosion; artificial sediment sources; dredge and reinject;		
Altered sediment flux (general land use) (Sediment mobilisation)	Agriculture; forestry; construction	Place land use and watershed management within an ICM regime; BEP	Ban destabilising activities in sensitive areas (e.g. steep slopes)	Modify tillage, road building, other practices in agriculture and forestry; construction methods that reduce erosion; timing of activities (e.g. earthworks, ploughing) to avoid heavy rainfall	Natural or constructed interceptors/ assimilators (e.g. vegetation buffers and wetlands)		Regulation; subsidies for BEP/BAT; soft loans for erosion control investments
Litter	Domestic and industrial waste	Solid waste management	Ban harmful products, ban dumping/ littering	Reduce packaging; reduce use of disposable products; recycling; incineration; collection and proper landfill disposal	Regular clean up; degradable materials; "wildlife-friendly" packaging	Wildlife rehabilitation	Regulation; public education; deposit-refund systems;
Physical alteration	Construction, landfill, deforestation, agriculture, mariculture, recreation, port development, navigation, non-aquatic transportation, discharges (e.g. tailings), dumping	ICM	National legislation; permitting; enforcement; protected areas; regional agreements	Compensation or mitigation of habitat losses	Habitat restoration and creation		Regulation; public education; soft loans for erosion control investments; compensatory incentives

5.3.1 General Overview

Measures to reduce the anthropogenic degradation of coastal and marine environments can address environmental problems at different stages in the sequence that leads up to it (Figure 5.1). Conceptually, it is preferable to address environmental risks earlier rather than later in this sequence: prevention is better than cure. In practice, however, this is not necessarily the case, either because of technical constraints (e.g., it may not be possible to avoid producing a harmful by-product) or cost-benefit considerations (e.g., it may be cheaper to remove a contaminant by treatment than to avoid producing it), or because degradation has already occurred. The discussion in this chapter, building upon the logic of the GPA/LBA, classifies environmental management measures into four groups.

Figure 5.1. Points of intervention in the sequence that leads to environmental degradation



Measures to prevent or reduce contaminant generation or harmful practices (Source reduction). Some sources of degradation can simply be banned. Bans on atmospheric nuclear weapons tests, on lead in vehicle fuel, and on the production and use of DDT, PCB's, and some other POPs, have led to measurable improvements in environmental conditions. Bans may be justified for extremely harmful contaminants or activities and, when effectively implemented, have the advantage of entirely eliminating the environmental risk associated with them. In most situations, however, total bans are either technically unfeasible or unacceptable to society. Bans create an enforcement burden, which can sometimes be reduced by education and training or by the development of less harmful alternatives. They may also have counterproductive consequences - such as the creation of black markets or forcing the adoption of more harmful alternatives - and do little to address legacies of the past, such as the stockpiles of banned pesticides that exist in many countries.

A more generally applicable approach is to apply measures to reduce, rather than eliminate, sources of degradation - for example by employing cleaner technologies and/or better production practices. The terms "Best Environmental Practice (BEP)" and "Best Available Technology (BAT)" embody this concept. The prospects for implementing BEP and BAT are best where there are direct economic benefits. In agriculture, for example, BEP can significantly reduce inputs of pesticides, fertiliser, and water, and reduce soil loss. Similarly, clean industrial production technologies are often the most modern and economically efficient ones. In some industries, market demand for environmentally friendly products also creates economic incentives. The primary barriers to implementing BEP and BAT in these situations are lack of investment capital, subsidies and other policies that favour the retention of old plant and practices (e.g., HELCOM, 1996), and the failure to disseminate information about them.

It must be noted that these terms are sometimes taken to imply that state-of-the art practices and technologies are universally desirable. In many situations such solutions are, in fact, not appropriate because, for example, they depend upon implementation capacity that does not exist, require investment out of proportion to the problem being addressed, or are socially unacceptable. They may also offer relatively little incremental improvement over less advanced, but more appropriate ,technologies and practices. Any evaluation of what constitutes "best" technology or practice for a given situation should include careful consideration of local needs and capacities over the long term.

Acknowledging that the most technically advanced solutions may not be appropriate to all situations, some countries have adopted the concept of requiring the best "practicable" technology or practice to reduce the environmental impacts of LBAs. Unfortunately, "practicability" is often interpreted largely in terms of the effects of implementing environmental protection measures upon an enterprise's profitability. Measures are not required when they have large negative impacts upon profitability, regardless of the environmental costs imposed by the enterprise. Thus, environmental costs are not internalised. Where practicability is determined relative to the profitability of enterprises, economically marginal activities may be exempted even from relatively low-cost requirements.

Measures to modify or reduce contaminants or other forms of degradation after generation (Stress reduction). Once a contaminant has been generated, there are often alternatives to discharging it to the environment - or measures to render it less harmful. Treatment technologies exist for many contaminants; others can be destroyed by incineration or other means. Waste streams vary markedly between domestic and industrial wastes, and among industries. In general, separating waste streams and treating waste on-site, wherever possible, will improve treatment efficiency, reduce overall costs, and foster the internalisation of environmental costs and the application of the "polluter pays" principle. With or without treatment, wastes can often be recovered and re-used. Again, the pros-

Industrial Ecology

A relatively new discipline, “industrial ecology” involves the analysis of interactions of industrial production and consumption systems with each other and the environment. Although the term is sometimes used very broadly to encompass all aspects of sustainable development, industrial ecology more commonly focuses on flows of materials and energy, seeking to increase the efficiency of these flows and reduce their environmental impact. The concept is most powerful when it results in industrial practices that generate direct commercial as well as environmental benefits.

A central concept in industrial ecology is that of “closing the loop”, that is, making a transformation from a linear production system where products are used once and discarded to a closed-loop system where products, materials, and even energy are used repeatedly, even indefinitely. Although the idea of recycling certainly isn’t new, there is a growing corporate awareness of opportunities to profit from using materials rather than wasting them. A Texas steel company, for example, has adopted the philosophy that “waste is a sacrificed financial opportunity” and generated nearly US$10 million in cost savings and additional revenue from improvements in the recovery, reuse, and sale of materials from the waste stream (Quinn, 1995).

It is much easier to reuse and recycle when products, processes, and practices are explicitly designed with eventual recycling in mind. Spurred by legislation that requires them to take back their products when their life cycle is complete, for example, German auto builders use materials and construction methods, that make it easier to eventually recycle the cars. Xerox Corporation has achieved a competitive as well as environmental advantage from its “Asset Recycle Management (ARM)” program to optimise the recovery of used business machines and parts for remanufacture and resale, again in part by design features, for example the types of plastic used, that make reconditioning and remanufacturing easier and cheaper.

In what is often called “industrial symbiosis”, industries use the waste products of other industries as raw material. The waste recipients can reduce raw material costs, while the waste generators reduce disposal costs and even generate revenue by selling the waste. A well-known example is an industrial symbiosis project at Kalundborg, Denmark.

One tool of industrial ecology is Life Cycle Assessment (LCA), which evaluates the environmental impacts of products or activities at every stage including the extraction of raw materials, production, distribution, use, re-use, and final disposal. LCA has been criticised for its complexity and, often, lack of clearly defined boundaries (Johnston, 1997). Properly applied, however, it has promise for identifying opportunities to reduce environmental impact, and often improve profitability, by more efficient practices, product and process substitution, and other means.

pects for this are best where there are direct economic benefits, such as reducing raw materials costs. An important caveat is that stress reduction measures should not simply transfer environmental risks from the sea to land.

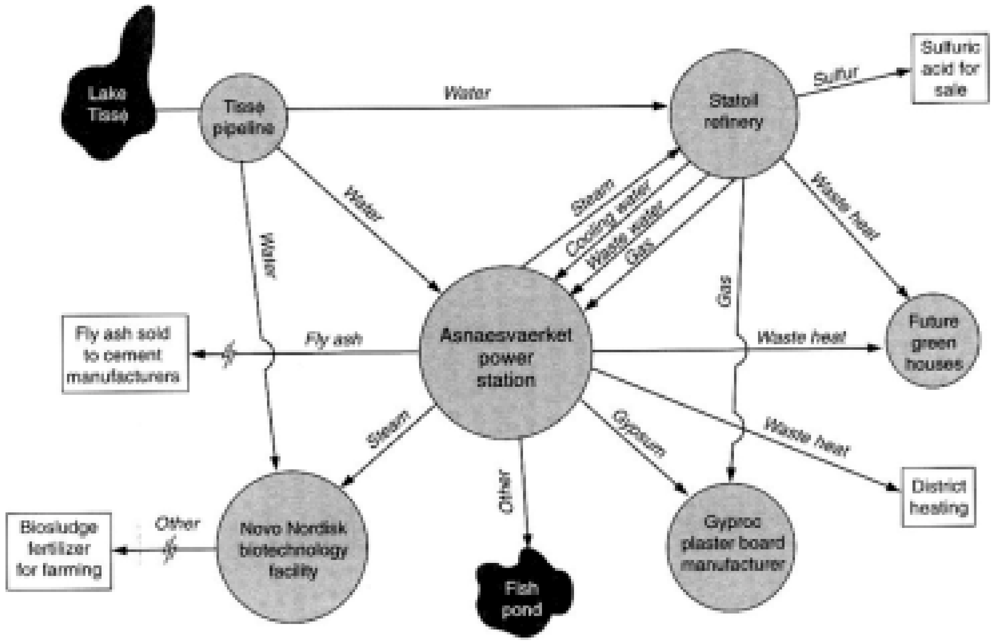
In some cases the discharge of contaminants has been prohibited, forcing their containment and storage. This is expensive and unsustainable, but may be a necessary interim measure while a sustainable solution is sought. Discharge prohibitions may have other negative consequences; banning ocean disposal of some substances, for example, might actually increase environmental and human health risks by forcing their disposal on land.

Measures to prevent or reduce the degradation of affected areas (Impact reduction). Human use of the marine environment - including for the disposal of wastes - is legitimate (GESAMP, 1991), and will continue in any case. There are, however, measures that can be employed to reduce its impacts. Locating LBAs and waste discharges at sites that minimise environmental impact is extremely effective. This applies to hinterland watersheds as well as to coastal areas. Unfortunately, poor siting of LBAs is a common cause of environmental degradation and resultant use conflicts. EIA is useful in assessing site suitability for large-scale development projects. Broader-scale, integrated land-use and coastal management planning is generally more useful in managing the siting of dispersed small-scale activities. One prominent example is zoning schemes which, by identifying the suitability of sites for particular uses protect critical areas, and designate buffer zones (e.g., wetlands and forest) to control the spread of impacts.

Good environmental design can further reduce environmental impacts. Examples include: setback limits for construction; diffusers and other outfall design elements to maximise diffusion and dispersion; the use of trails and boardwalks to control visitor impacts; and containment technologies (e.g. to prevent sediment flows from construction sites or leaching from landfills). Operational practices - such as limits on visitor numbers or the timing of activities to avoid sensitive periods (e.g. wet seasons, spawning or migration events) - may also be effective.

Measures to mitigate the degradation of affected areas (Mitigation). Sometimes environmental degradation has already occurred, cannot be prevented (e.g. because of accidents), or is deemed acceptable in view of overriding

Figure 5.2. The industrial symbiosis at Kalundborg, Denmark. Arrows indicate flows of material and energy between industries (re-drawn from Grann, 1997)



economic or other benefits of development. In such cases it may be possible to reverse or otherwise ameliorate the degradation. Natural systems can often regenerate, given nothing more than the termination of the source of degradation, but regenerative capacity varies among biological communities. The recovery times of bottom communities disturbed by dredging, for example, can differ from months to a decade (Newell *et al.*, 1998). Regeneration also depends upon the environmental health of the broader ecosystem and the nature, severity, and spatial scale of the degradation.

Where natural regeneration is inadequate, active interventions - such as hydrological modification, the provision of artificial substrate, or transplantation - may be required. Attempts at rehabilitating habitat have met with varying success. Replanting mangroves and reconstructing coastal wetlands have been reasonably successful in some instances, for example, while efforts to restore seagrass beds have only met with very limited success.

Furthermore, while rehabilitating habitat rehabilitation can achieve specific environmental goals - such as controlling erosion - it is unlikely to restore all ecosystem function and diversity. Rehabilitation is also expensive - often much more so than preventative measures - and technically difficult. Remedial action may itself have adverse consequences: the removal of contaminated sediments and certain oil spill cleanup measures, are prime examples of this. Measures to prevent degradation, therefore are generally preferable to habitat rehabilitation, and the alternative of taking no action (i.e., of relying upon natural recovery) should always be evaluated before undertaking them.

The Impact and Cost of an Accident

Eleven million gallons of oil were spilled in March 1989 when the *Exxon Valdez*,a large supertanker, ran aground off Alaska's coast. Although only the 53rd largest oil spill at the time, it spread out to cover 1,300 miles of shoreline, killed about 250,000 birds and 2,800 sea otters, reduced fish and shellfish stocks, and wiped out a considerable part of the intertidal and subtidal flora and fauna. Eleven years later, the spill's ecological and economic effects are still very much in sight, although some of the effected species and habitats have partially recovered. Exxon spent more than US$2.1 billion in cleanup costs, but only 14 per cent of the spilled oil was recovered. It is paying US$1 billion in civil and criminal fines, and has been ordered to pay a further US$5 billion in punitive damages to local fishermen, native hunters and others.

Remedial action may be required to support other components of an overall strategy. International bans on some persistent organics, for example, have failed to produce the desired reductions in the levels of these substances in the North Sea (North Sea Task Force, 1993), principally due to continuing inputs of these substances from such secondary sources as land disposal sites and the atmosphere. Remediation at these sites may therefore be necessary to achieve the bans' objectives.

Management measures sometimes aim to reduce the negative consequences of degradation rather than to prevent or reduce the degradation *per se*. Water quality standards for bathing or seafood harvesting, and safety standards for seafood contamination, for example, are designed primarily to reduce the risks of pollution to human health rather than to prevent it from occurring, although the effects of enforcing the standards (e.g. by closing bathing beaches) may provide an impetus for pollution reduction.

The measures available to protect the marine environment from degradation due to LBAs have some technical shortcomings. The primary reason that they are not effectively implemented, however, is that markets fail to send price signals that reflect the real economic costs of downstream degradation. Intervention, primarily by governments, is therefore required to induce implementation. Three broad categories of intervention are most important:

- **regulatory instruments** involving the direct limitation or control of activities to coerce enterprises and the public into implementing environmental protection measures.
- **economic instruments** that correct the failure of markets to send adequate price signals by creating financial incentives to implement protective measures. Economic instruments are intended to use market forces to bring private costs more into line with the costs of environmental degradation borne by society.
- **instruments to foster voluntary action** by enterprises and the public can be highly effective and reduce the burden of environmental management on governments.

These and other measures are discussed in more detail below. Regulatory instruments have been the traditional approach to environmental protection in all countries; most, if not all, countries have promulgated environmental regulations. The problems described in Chapters 2 and 3 indicate that regulatory approaches have not been entirely successful in protecting the marine environment from LBAs. Only in the case of bans and prohibitions are regulatory instruments the sole option (Table 5.1). Given the need to use scarce human and financial resources to the greatest advantage, especially in developing countries, innovative and less regulatory approaches to environmental management must be developed and, more importantly, implemented.

Table 5.1 Applicability of Instruments for Implementation to Different Classes of Environmental Protection Measures (Y = yes)

Class of measure	Regulatory instruments	Economic instruments	Voluntary action
Bans and prohibitions	Y		
Source reduction	Y	Y	Y
Stress reduction	Y	Y	Y
Impact reduction	Y	Y	Y
Amelioration	Y	Y	Y

5.3.2 Regulatory Policy Instruments

The Range of Regulatory Policy Instruments

The range of regulatory instruments available to address the causes of marine degradation includes:

- restrictions on inputs (e.g., maximum allowable levels of lead or sulphur in fuels);
- planning regulations (e.g., EIA requirements);
- zoning by use, including the establishment of protected areas;
- emission or effluent standards;
- environmental quality standards, such as water quality standards;
- licensing requirements for waste discharge;
- restrictions on the extent or timing of certain activities (e.g., harvest limits, closed seasons);
- design, construction, and operational standards (e.g., set-back limits., requirements for pollution abatement equipment or spill response capability); and
- risk-based regulatory approaches.

Many of these are so-called "Command-and-Control (CAC)" regulations, setting rigid standards or specifying the environmental management procedures and equipment to be used, and compelling compliance by threatening sanctions. In other cases (e.g. for radiological protection) regulations are risk-based and probabilistic in nature - requiring estimation of hazards and exposures, and documenting uncertainties - and can be used for comparative assessments of management alternatives.

Strengths and Weaknesses of Regulatory Instruments

Regulatory instruments have been widely preferred by environmental management agencies, by the enterprises they manage, and by interested third parties, because of their familiarity and perceived certainty compared to economic instruments and voluntary action (Barbier, 1992)[1]. They are also conceptually compatible with the prevailing legal frameworks in most countries. Some types of well-drafted regulations (e.g., simple zoning regulations, closed seasons) are relatively easy to disseminate to the target sector.

Regulatory controls, however, have several weaknesses, including:

- enforcement costs for inspections, administration, technical support, and legal action are often high;
- they are difficult to implement and enforce where there are many resource users or polluters and/or where these are dispersed. This is typical of, though not confined to, rural economies of countries with scarce financial and administrative resources;

[1] Barbier (1992) referring to Bohm and Russell (1985), Opschoor and Voss (1989) and Pearce (1990), provides a brief summary of the preferences of policy makers and polluters and resource users for regulatory controls over economic instruments.

- conversely, governments may find it difficult to enforce environmental regulations if they rely upon a few industries or even individual projects for revenue, foreign exchange, and other economic activity: this, too, is not uncommon in developing countries;
- they are inflexible; and
- they are often economically inefficient.

Activities perceived to present low environmental risk due to their nature (e.g., agriculture, food processing) or scale (e.g. cottage industries) are often exempted from regulations so as to reduce the administrative and enforcement burden, and for political and other reasons. Such exemptions generally mean that significant pollution sources go unrecognised and unregulated; they are seldom justified from an environmental management perspective. Regulatory legislation should be inclusive, albeit with appropriate flexibility.

The inflexibility of regulations, particularly CAC regulations relating to emission or effluent standards in the manufacturing and extractive industries, often results in economic inefficiency. A study at an oil refinery in the United States revealed, for example, that compliance with regulations cost US$51 million while alternative approaches could achieve a similar reduction in pollution for only US$11 million (after Richards and Frosch, 1997).

Compliance with uniform standards may entail higher costs at older plants than at newer ones, thus reducing the overall net environmental benefit per unit of investment and creating pressure for less stringent standards. Newer plants may be able improve on the standards at relatively low cost, but have no incentive to do so. One solution is to introduce variable standards that are more restrictive for new plants; but this can create a disincentive to modernise. Firms may actually have incentives *not* to improve on standards in order to dissuade the regulator from tightening them.

5.3.3 Economic Policy Instruments

Economic policy instruments aim to modify private costs and benefits so that unaccounted social costs (and benefits) of environmental degradation are internalised (i.e., borne by those responsible (Barbier, 1992)). The common characteristic is that, unlike regulatory controls, they do not directly control or restrict activities. Instead, they create financial incentives to modify or reduce activities that result in environmental degradation. Their effectiveness thus depends on incentives that are sufficient to modify behaviour - or to generate revenue, when that is the prime policy objective.

A number of factors have been important driving forces for the adoption of economic, instead of regulatory, policy instruments in different countries. They include:

- the high administrative - and especially enforcement - costs of regulatory controls;
- poor ongoing compliance with regulatory measures;
- the disincentives to do better than standards or to introduce new control technologies that are associated with regulatory instruments;
- opportunities to raise revenue via charges, taxation, etc. - sometimes but not always in order to subsidise the costs of environmental management.

The Range of Economic Policy Instruments

Table 5.2 shows a range of economic policy instruments, their potential benefits and disadvantages, and brief lessons from experience. Only a few comments are offered here to supplement the information presented there.

Direct instruments, such as effluent charges and tradeable discharge permits (TDPs), are targeted at specific individuals and groups. They can be economically advantageous but, like regulatory instruments, impose a high monitoring and enforcement burden and often require considerable institutional capacity to design and apply them. Effluent charges have three main effects:

- by increasing the private cost of stressing the environment, they create an incentive to continually reduce such stress - unlike fixed regulatory standards. This incentive, of course, depends on the level of the charge relative to the cost of improved environmental protection;
- they may internalise the environmental costs of environmental degradation, again depending on the scale of the charges; and
- they raise revenue.

Effluent charges are often set too low to alter behaviour dramatically. They have been most useful in raising revenue, which can be invested in environmental management. In some countries, however, charges **have** been high enough to provide incentives for pollution abatement and for innovation in control technology (Smith, 1994).

Creating markets in TDPs is the most sophisticated use of economic instruments. In theory, TDPs focus investment on pollution control where it will achieve the greatest unit discharge reduction, while still meeting a targeted level of discharge. The concept of TDPs has captured much attention, notably because of its large economic advantage compared to standard-setting instruments: permit trading under the US Clean Air Acts saved industry over US$4 billion up to 1985 (Hester and Hahn, 1987). Experience with them, however, is limited to very few developed countries, primarily in controlling sulphur dioxide emissions. There are impediments to establishing effective TDP markets for water quality management (see box).

TDPs and Water Pollution: Barriers to Creating Effective Markets

Reasons for the difficulty of establishing a well-functioning TDP in water pollution rights have been reviewed by Smith (1994), quoting Tietenberg (1990) and Klaasen (1994). The primary obstacles revolve around the fact that the pollution is not well mixed in most water quality problems. As a result, different polluters have different impacts on individual receptors. This leads to three significant differences, which have to be overcome prior to the establishment of a successful market:

- differential impacts are a major hindrance to making trades, because it can be difficult to determine whether or not any individual trade will comply with ambient water standards;
- because of this, the regulator must approve each trade, to satisfy itself that this complies with its standards, thus increasing transaction costs: and
- differential impacts necessitate the grouping of polluters that have similar impacts on receptors into sub-markets; this increases the likelihood that there will be too few potential traders and trades in any sub-market to make it competitive.

Indirect economic instruments - commencing in Table 5.2 with taxes - do not target specific individuals or groups, and can generally be implemented through existing administrative mechanisms. They are therefore particularly useful when research, monitoring, analysis, and/or enforcement capabilities are weak and/or there are a large number of polluters or resource users (e.g., agricultural run-off, wastes from small industrial enterprises, and solid waste from households). The instruments that can be most effective in such situations include taxes and, particularly, deposit refund systems.

Charges are a "stick" to penalise environmentally harmful activities, whereas subsidies offer a "carrot", a financial inducement to improve. Subsidies usually take the form of financial assistance for investment in environmental protection. Smith (1994) suggests, however, that enforced deadlines are more effective than subsidies in achieving rapid compliance, and that subsidies may encourage excessive capital investment, for example in sewage treatment. In general, experience indicates that any short term benefits achieved by subsidies are more than offset by the disadvantages - especially the difficulty, common to all subsidies, of bringing them to an end. Where they may, however, be effective is in reducing sources of degradation where it is difficult to enforce regulatory controls: subsidising BEP to encourage farmers to reduce nutrient loadings provides one example of this (Smith, 1994).

Other policy tools, in addition to those shown in Table 5.2, can be broadly considered to be economic instruments. One example is *removing* subsidies that distort the private costs of resource use and pollution, as opposed to giving subsidies for desirable behaviour (Panayotou, 1990; Pearce, 1990). Institutional reforms such as the improvement or establishment of property right regimes, legal titling, and contract enforcement also assist or even establish markets for environmental goods and services (Panayotou, 1990, quoted in Barbier, 1992).

There are usually also economic aspects to regulatory enforcement, such as, most commonly , fines for non-compliance. Performance bonds or liability systems are another example, but are used in only a few countries. Australia, Finland, Norway, Sweden, the UK and the US all have variations of these two instruments.

Table 5.2. Summary of economic policy instruments to induce implementation of measures to prevent or reduce the adverse effects of LBAs on the marine environment

Category/type	Description	Potential benefits	Potential disadvantages	Lessons from experience
DIRECT INSTRUMENTS Effluent charges	Charges on discharges based on quantity and/or quality over an allowable maximum for each enterprise.	• Create incentives for municipalities, firms and individuals to find improved ways of reducing pollution • Provide revenue for (i) environmental protection or (ii) general public expenditure • Shift burden of financing water quality programmes from the taxpayer to the polluter	• Effectiveness depends on sufficiently high charge rates • Require research and a high level of political will • Require close monitoring and high administrative competence • Effectiveness may be limited by ability of polluters to pay, especially in countries with critical need for economic development	• Often set too low (often cheaper for polluters to pay the charge than invest in controls) • Administrative systems may fail to collect the charges • Where administrated effectively, charges can (i) raise revenue; (ii) result in improved water quality; (iii) provide some incentive for innovation in control methodology

Category/type	Description	Potential benefits	Potential disadvantages	Lessons from experience
DIRECT INSTRUMENTS Effluent charges (continued)			• When the number of discharges increases because of industrial or population growth, the allowable discharge and/or charge must be made more stringent to maintain a given total pollution load. This creates regulatory uncertainty • Often economically inefficient: do not allow for variation in costs/ benefits of controls among polluters • Provide no incentives to exceed standards, therefore impede technical development of controls	• Political acceptability can be promoted by transparently recycling revenue into projects that clearly improve water quality • In developed countries, may encourage over investment in water treatment plants
Compensatory incentives	Financial inducements for individuals or firms who disproportionately bear the risks or costs of environmental improvement or who possess valuable environmental assets, e.g., compensatory financing of "environmentally friendly" technology transfer to developing countries, debt-for-nature swaps	• May increase access and adoption of pollution control technology in some developing countries • May result in conservation of critical marine habitat that might otherwise be lost	Limited applicability	So far, used little if at all in mitigating the effects of LBAs
Emissions and effluent trading (Tradeable or Transferable Discharge Permits, or TDPs)	The regulator sets a total allowable pollution load, and allots a share of this to firms (or municipalities), and/or sources within firms, in the form of permits. Firms able to reduce discharges below this level can sell or trade their unused allowance to other firms, which can then exceed their initial limit by that amount. Alternatively, the unused allowance can be applied to other sources within the firm. New entrants must purchase discharge rights on the open market	• Theoretically relatively simple. Once permits have been issued, interactions are between individual firms • Flexibility enhances economic efficiency, e.g.: - Firms will invest the least expensive of TDPs or environmental controls; overall goals set by management will thus be met at least overall cost - TDPs allow the development of leasing markets in which firms can acquire permits in the short term until, for example, investment in pollution control can be coordinated with plant investment • Total load remains fixed, so there is no need to revise discharge standards in response to economic growth: reduces regulatory uncertainty	• Significant technical, financial and legal issues must be resolved before trades can occur • Therefore, high administrative costs for regulators and operators • When initial TDPs are free (the usual system) the cost of subsequently buying TDPs may render investment in otherwise more efficient new production capacity uneconomical • Firms may not wish to sell TDPs, preferring to retain the flexibility of being able to use them at a later date	• Developed for atmospheric sulphur dioxide emissions; very limited application to water quality management. Confined almost entirely to the USA • Most programmes target only one pollutant; the Tar-Pamlico Program targets two (phosphorus and nitrogen) • Very few programmes have resulted in significant trading between firms; they have primarily been used to trade off sources within firms (see boxed text); the low level of market activity prevents realisation of much potential economic benefit; but • Evidence indicates that operators achieve lower unit costs than under a regulatory system • Evidence suggests that TDPs have not achieved significantly greater reductions than regulatory systems • Evidence for widespread applicability to water quality management is unconvincing

Category/type	Description	Potential benefits	Potential disadvantages	Lessons from experience
Compensatory mitigation	Requires developers to compensate for any loss of habitat or habitat functionality that results from their activities by protecting, restoring, or constructing similar habitat.	• Reduces net loss of habitat or habitat function • Allows flexibility in allocating sites for development or conservation • Helps create markets for ecosystem services	• Mitigated and damaged habitats usually at different locations, so geographic and ecological patterns are altered • Created or restored habitat rarely duplicates values of natural habitat • May be difficult to maintain compensatory habitat in undeveloped state over the long term	So far used mainly for USA's "no net loss of wetlands" policy; has slowed wetland loss but not achieved the policy goal.
Liability insurance	Legal liability for environmental damage or clean-up is transferred from potential polluters to insurers. Lower premiums provide incentive for improved industrial practice.	• Administratively simple. Interactions are between firms and insurance companies • Very economically efficient: directly associates costs with environmental risk (as perceived by insurers	Requires active monitoring and the imposition of significant financial penalties on polluters.	???
INDIRECT INSTRUMENTS Taxes	Indirect taxation (e.g., on fuel products, energy, pesticides, fertilisers).	• Simple to apply through existing tax collection system • May quickly influence consumer choice in favour of "environmentally friendly" products	May have unintended or counterproductive effects if demand is relatively price-inelastic.	Often a limited range of products is suitable.
Product charges	Charges on products that generate pollution during manufacture or consumption or for which a disposal system has been established. Can be based on some product characteristic (OECD, 1989), (e.g. Dutch Manure Surplus Charge based on phosphate content above what farmers are allowed to put on their land) or on the product or process itself (e.g., an Australian charge on new tyres that funds used tyre disposal).	• Create incentives for continuing improvement; • Raise revenues for (i) environmental expenditure or (ii) general public expenditure; • Shift burden of financing water quality programmes from the taxpayer to the polluter. • Relatively low administrative and enforcement costs, except in certain applications		• Experience in many countries is that charges on intermediate or finished goods are harder to use than charges on production processes or post-consumption wastes, although several countries do apply charges to some finished goods such as batteries, fertilisers, pesticides, and plastic bags • However, an input tax is likely to achieve greater improvement than a production levy that has little relationship to the environmental problem
Tax differentiation	A variation of product charges. The imposition of positive or negative charges to create price advantages for "environmentally friendly" products. Usually, the sole purpose is this incentive impact and it is aimed to be budget-neutral, unlike product charges which often have a revenue-raising goal	• Simple to apply through existing tax collection system • Can quickly influence consumer choice in favour of "environmentally friendly" products		Often a limited range of products is suitable.
Deposit refund systems	A refundable surcharge on a potentially polluting product creates a market for return of the used or residual product.	• Economically highly efficient, rewarding environmentally sound behaviour and imposing costs for unsound behaviour • Administratively efficient: once the deposit is paid further involvement by authorities is limited mostly to providing the refund mechanism	None	Widely effective in encouraging improved waste disposal (e.g., reduced littering, safe disposal of batteries).

Category/type	Description	Potential benefits	Potential disadvantages	Lessons from experience
User charges	Charges for use of natural resources (e.g., water extraction, beach access), waste treatment or disposal (e.g. incineration or landfill), etc. Tariffs may be uniform or vary with level of use.	• Relatively simple and quick to apply • Raise revenue for (i) environmental expenditure or (ii) general public expenditure	• Effectiveness depends on sufficiently high charge rates • Require administrative and judicial systems for revenue collection and enforcement • Usually are fixed charges, which do not provide an incentive for continual improvement	• Often set too low to modify behaviour • Can be significant revenue raisers
Subsidies	Grants (e.g., subsidisation of best agricultural management practices to reduce nutrient loadings from non-point sources), soft loans (e.g., for construction of treatment plants), tax allowances (e.g., for energy conservation), and price supports (e.g., for recycled paper)	May hasten investment in environmental protection because: (a) subsidies lower compliance cost. (b) those eligible may accelerate investment if it is uncertain how long the subsidy programme will be in place; or (c) the desired investments or actions will not take place without the subsidy.	• Often politically unpopular to pay polluters not to pollute (contrary to the polluter pays principle) • May promote economically inefficient and environmentally unsound development	Can promote “environmentally friendly” investment or management practices. Experience in a number of developing countries in particular points to the need for good judgement regarding the level of technology to be subsidised.

Strengths and Weaknesses of Economic Instruments

There is a consensus in the literature that *well designed and effectively implemented* economic instruments are often more cost-effective in meeting environmental goals than regulatory alternatives. First, they devolve decision-making to entities that typically have much better information for determining the appropriate individual response to a change in economic conditions. For example, studies have shown that the costs of direct regulatory control of air pollution are two to 20 times higher than economic instruments (Barbier, 1992, quoting Tietenberg, 1990). Secondly, economic instruments can reduce administrative costs, though they vary greatly in this respect. As noted above, indirect instruments that can be implemented through existing mechanisms greatly reduce the administrative burden. Economic instruments also allow greater flexibility than regulation.

Economic instruments do, however, have shortcomings, many of which have been noted above or in Table 5.2. Pervasive problems are that there is often inadequate political will to set punitive instruments (charges and taxes) high enough to dramatically influence behaviour, while subsidies and other incentives may encourage inappropriate investment unless carefully designed. Governments often perceive economic instruments as inflationary or detrimental to economic development. The extent to which this is true depends very largely on their design and, notably, on the extent to which they are successful in modifying behaviour. Governments should also recognise that when instruments relate charges or taxes to environmental damage, they are simply internalising costs already imposed upon the economy. Admittedly, there may be a short-term, visible impact of some inflation or job losses.

Case Study: Experience with Economic Instruments in Latin America and the Caribbean

The use of economic instruments is increasingly high on the environmental agendas of developing countries. They are widely regarded as having lower compliance costs than direct regulatory approaches, and can raise much-needed revenue for government coffers.

A recent review of their use in eleven countries in Latin America and the Caribbean (Motta *et al*, 1997) found that:

- they are used in all eleven countries, and a wide range of mechanisms have been developed for applying them;
- historically, their role has primarily been to raise revenue. Other benefits, such as reduced environmental impact or improved cost-effectiveness, have generally not been attained;
- there is a need to channel the revenues into institutional capacity building; and
- a low level of stakeholder awareness and participation is a real constraint to implementation.

Thus, the experience in the region is that the clear potential of market-based schemes for environmental protection has not been recognised. The primary constraint is a lack of the institutional capacity to design and implement effective economic instruments. These instruments, therefore, are no substitute for capable institutions. Gradual and flexible reforms are the ones most likely to be consistent with ongoing institutional development.

It is difficult to apply effluent charges and other direct instruments in hot spots where there is a mix of contaminants, or in places where there are geographical or seasonal variations, or other factors affecting the critical loading (Barbier, 1992). While it is theoretically possible to apply different charge schemes for each particular environment and/or contaminant, the administrative costs are usually very high. In these conditions, the cost advantages of economic over regulatory instruments may be minimal, or even negative.

With both economic and regulatory instruments there is uncertainty about the cost of achieving a specified level of protection, and about whether it exceeds the cost of degradation. Economic instruments have additional uncertainty about the response of individuals and enterprises to specific incentives, and therefore about the level of environmental protection that will be achieved. This is one reason for management agencies' general preference for regulatory controls.

5.3.4 Compliance and Enforcement

Compliance and enforcement are the weakest links in the environmental protection chain. Most countries have enacted environmental legislation, but it is often inadequately implemented and enforced. In both developed and developing countries, enforcement is hampered by tight budgets, violations that are difficult to detect, cumbersome inspection procedures, poorly written regulations, complex mechanisms for punishing violations, high staff turnover among inspectors, and political influence. In many developing countries, the additional problems of underpaid and inadequately trained inspectors, remote or widely dispersed polluters and resource users, and/or weak government authority, further weaken enforcement and create fertile grounds for corruption (which is, of course, by no means restricted to developing countries). Moreover compliance often declines, even when it is initially high, because ongoing monitoring and enforcement are ineffective and control equipment or environmental practices are not maintained (Goodstein, 1995). In all countries, then, increasing the cost-effectiveness of enforcement, and reducing reliance upon it as much as possible, are critical considerations in designing strategies for environmental protection.

The more sophisticated and targeted both regulatory and economic instruments are, the greater is the burden of enforcement. Regulations based on environmental effects (e.g., standards for the quality of receiving waters or biological effects) may address management objectives more directly; but standards for control equipment, or effluent quality, facilitate monitoring, the identification of violators, and successful prosecution. Indirect instruments are easier to enforce than direct ones, which specifically target individuals or groups who act in ways that threaten the environment. Fines or charges for excessive contaminant discharge, for example, require specialised monitoring and prosecution capacity, while taxes on potentially harmful products (e.g., pesticides) are compatible with the routine work of most tax departments. The down side of indirect instruments, of course, is that all parties are affected, not just those who contribute to degradation.

Compliance with environmental protection requirements depends upon three factors:

- **realistic requirements:** inevitably, compliance with onerous or senseless requirements is low. A high level of stakeholder participation in the design of standards - and in operational, reporting, and other requirements - will enhance compliance. The time to be nice is when setting standards;
- **effective monitoring:** there must be a high probability that violations will be detected. Frequent inspections, for example, increased compliance with health and safety regulations in the pulp and paper industry (Magat and Viscusi, 1990). Management agencies must thus have adequate capacity for research, monitoring, and administration - including the capacity to modify instruments in response to changing conditions; and
- **effective enforcement:** there must be a high probability of meaningful punishment for violations. This requires a strong legal framework[2], including specification of the chain of authority, jurisdictions, and the legal standing of affected parties. There will also be a range of requirements specific to the instrument and issue being addressed. In addition, enforcement agencies must have adequate capacity for successful prosecution, including the ability to collect environmental data of sufficient quality to hold up in court. Fines, charges, and other punishments must have enough sting - relative to the incentives to violate - to be an effective deterrent. This is commonly not the case.

These factors suggest that enforcement that is wholly dependent on policing is unlikely to be effective in many countries. A number of options are available to management authorities:

- for industrial polluters, require firms to install specific abatement technology. As noted above, this has the disadvantages of uncertain continuing compliance and of providing no incentive for innovation;
- self-reporting can be effective in certain situations. In the USA, self-reporting by private firms subject to the Clean Water Act has achieved reported compliance rates of 75%-82%; and
- enhance voluntary action and cooperation, as described in the following section.

[2] An advantage of indirect economic instruments is that these are often already in place, although supplementary legislation or adjustments to existing institutional arrangements may be needed.

Governments may also introduce measures designed to increase public commitment to environmental matters: this enhances compliance in appropriate circumstances. Examples of such measures include: requirements upon government agencies for public participation in environmental matters; promotion and support for environmental groups in participating in environmental monitoring; and increased access to the courts - which in many countries is poor - to enable citizens to bring civil suits related to environmental protection. So far, this latter approach has been largely limited to the USA.

5.3.5 Appropriate Conditions for the Adoption of Regulatory and Economic

An overriding condition for any intervention is that its benefits should outweigh the costs, not just in direct financial terms but in ethical, social, and other less tangible ones too. Cost-benefit analysis is the appropriate tool for making this assessment, but experience has shown that difficulty in valuing the environmental benefits of intervention is a critical limitation (World Bank, 1992; Hahn, 1995). Other tools for assessing environmental benefits - environmental impact assessment (EIA), for example - are needed to support cost-benefit analysis.

Appropriate Conditions

Regulatory and direct economic instruments both have certain prerequisites if they are to be effective, including:

- the existence of appropriate institutional and legal arrangements;
- the availability to management agencies of adequate information for the formulation of instruments and standards;
- the availability of financing for investment in improved environmental management;
- the ability of management agencies to modify instruments appropriately in response to changing conditions; and
- the ability of violators to pay charges or fines that are set at high enough levels to influence behaviour - or raise revenue where that is the management objective.

Case Study: Cost-Benefit Analysis of Reducing the Nutrient Load to the Baltic Sea

Turner *et al*. (1999) estimated the national costs of measures to reduce inputs to the Baltic Sea by 50%, including changes in agricultural practice, improved sewage treatment, and wetland creation. Benefits were estimated by the valuation of a single environmental service, beach recreation and amenity, because data on other environmental costs of nutrient input are inadequate. Estimates based on slightly different assumptions indicate total net benefits ranging from 457 million SEK/yr (Markowska and Zylicz, 1999; Söderqvist, 2000) to 38,240 million SEK/yr (Turner *et al*., 1995) , but there is little doubt that a cost-effective nutrient abatement programme would generate significant positive net economic benefits overall.

Cost and benefits of economically optimal nutrient load reductions (millions of SEK/yr)

Country	Reduction	Costs	Benefits	Net benefits
Sweden	42%	5,300	11,591	6,291
Finland	52%	2,838	6,046	3,208
Denmark	51%	2,962	6,929	3,967
Germany	39%	4,010	4,687	677
Poland	63%	9,600	5,899	-3,701
Russia	44%	586	1,769	1,183
Estonia	55%	1,529	212	-1,317
Latvia	56%	1,799	291	-1,508
Lithuania	55%	2,446	468	-1,978
Total	**50%**	**31,070**	**37,892**	**6,822**

Importantly, the analyses agree that a strategy of uniform reduction for all countries would be neither environmentally nor economically optimal. The most effective approach would be to concentrate abatement measures on the southern sub-drainage basins, because the northern basins already possess quite effective nutrient traps.

Countries would not benefit equally from such a strategy. Specifically, the market economies generally benefit the most, while most transitional economies would suffer net economic losses. This suggests that side payments may be necessary in order to achieve overall cost effectiveness.The study also found that the economically best strategy is the simultaneous reduction of nitrogen and phosphorous, rather than applying measures to reduce these nutrients individually. Because the marginal costs of sewage treatment increase markedly with higher levels of treatment, the most cost-effective strategy to reduce nutrient inputs from sewage was to target areas that presently lack treatment facilities of adequate standard, rather than making further improvements to facilities that already provide a relatively high level of treatment.

Particularly favourable conditions for the use of regulatory approaches include:

- when used in conjunction with participatory measures to control land and water use, through zoning regulations. This consideration is particularly relevant in coastal areas where demand for land for competing uses is often very high;
- when complemented by educational and participatory approaches, to mitigate non-point sources of pollution and resource degradation; and
- where there are relatively few entities - which are highly visible and located in a relatively small area - to be managed, and where the management measures are relatively uniform, thus facilitating monitoring and enforcement (World Bank, 1992).

The above conditions enhance the prospects that regulatory approaches will be effective, but they do not rule out the use of economic instruments. There are, however, conditions that specifically militate for the use of regulatory rather than economic instruments, including:

- where there are unknown “threshold” effects of increased environmental impact;
- where there is an unacceptable level of uncertainty about the likely influence of economic incentives upon behaviour;
- where economic incentives give entities little cost advantage either because existing environmental regulation is relatively lax or, conversely, where it is very stringent;
- where there are pollution “mixes”;
- where bans are required; and
- where economic instruments increase management costs.

A precondition for the effectiveness of all economic instruments is that polluters and resource users should be sensitive to price changes. This in turn requires that (i) those targeted have competitive or other pressures to reduce costs (e.g., regulatory oversight of monopolies or an informed electorate in municipalities) and (ii) that the economic instruments produce a state of affairs where acting in an environmentally appropriate manner costs less that acting otherwise. Further conditions favouring the use of economic instruments include:

- manageable levels of resistance to their use within government and the managed sector and within the management agency itself;
- significant cost savings over regulatory instruments; and
- the opportunity to reduce the complexity of the management regime.

Selection of Regulatory and Economic Instruments

Although there is broad recognition that economic instruments are more effective in certain situations than regulatory ones, most countries continue to rely on regulation. Many, if not most, of these countries recognise that their capacity for effective regulation is weak. Even so, they prefer to retain significant elements of their current institutional framework, whatever its failings, rather than undertake revolutionary change in their environmental management approach. The task in these countries, therefore, is to identify incremental steps to enable them to move from their existing frameworks - which typically rely excessively upon ineffective and/or expensive regulatory instruments - to more effective systems, with a better balance between regulatory and economic instruments.

Because of this - and because different environmental policy instruments are likely to be most appropriate under conditions of uncertainty - the best policy “mix” of regulatory and economic instruments will vary from country to country (Barbier, 1992). These “mixes”, for example, might involve using indirect economic and regulatory instruments or, at a more sophisticated level, using an economic instrument to improve economic effectiveness while using a standard to ensure that the desired environmental outcome is achieved. Countries in the early stages of introducing economic instruments are probably well advised in most cases to focus initially on indirect ones, which have lower human and financial resource requirements than direct ones.

5.3.6 Voluntary Action by Industry

There is an increasing acknowledgment that traditional regulatory instruments, even when supplemented with economic ones, sometimes fail to provide the most economically efficient management regime. In response, industries are increasingly developing their own environmental management initiatives, primarily but not exclusively in the industrialised countries. These include: industry-wide programmes; programmes developed on an individual project basis; and programmes that seek to improve the design of products or production processes (for recent reviews see Richards, 1997; NRC, 1997; World Bank, 1999).

At least in the United States, such initiatives are generally not aimed directly at environmental protection or even technical compliance with regulations, but at cost savings (NRC, 1977). Having intimate knowledge of their own particular facilities and industrial processes, companies can often design measures that are more efficient and cost-effective than those mandated by regulators, thereby reducing compliance costs. Furthermore, some measures for environmental protection - such as more efficient use of energy and raw materials - also reduce production and waste disposal costs, and the public image of industries is often enhanced by voluntary environmental initiatives.

The International Organization for Standardisation (ISO) certification, ISO14001, sets a standard for environmental management that can be applied by most organizations worldwide. Adoption of the standard almost always requires a firm or other organization to implement additional comprehensive environmental management measures, even if they already have many in place. In addition to giving firms relief from regulation, this enables customers to assess better whether a product or service has been produced in an environmentally friendly way (Kuhre, 1995). Desirable aspects of voluntary action by industry include:

- the potential to address some environmental problems more efficiently;
- the ability to use industry knowledge to develop industry-specific, cost-effective solutions;
- greater flexibility in meeting environmental objectives;
- the ability to establish environmental approaches that are consistent with companies' business goals (NRC, 1997); and
- direct economic benefits to industry, for example through reduced energy, materials, and waste disposal costs.

Actions by regulators (other than those referred to above) to encourage environmentally responsible action - which may exceed compliance requirements - can include the following:

- establishment of an information clearing house, e.g., the US Pollution Prevention Act, 1990, and the US Green Lights program (through which the US Environment Protection Agency provides technical assistance concerning energy efficient lighting) and Toxics Release Inventories;
- demonstration projects to stimulate innovative technologies; and
- the use of standards as a reference point to induce voluntary action. For example, a water supplier in the UK, who must meet standards for herbicides and pesticides in drinking water, pays farmers to switch to organic agriculture in order to reduce water contamination (The Times, 1999).

Another way to achieve environmentally responsible action, which may exceed compliance requirements, is through demand pressure for environmental responsibility by manufacturers and suppliers (e.g., the German "Blue Angel" eco-label for goods meeting the strictest environmental criteria).

Despite the potential advantages of voluntary initiatives by industry, it has been often been difficult to measure their environmental benefits rigorously (NRC, 1997). Where there has been rigorous assessment, the record of environmental benefits has been uneven. There is a need to improve the independent and objective assessment of industry-initiated environmental action (NRC, 1997).

5.3.7 Public and Private Sector Investment

Public investment covers a wide spectrum of possible activities, from environmental monitoring and research, through public awareness building and participation, to "hard" investment in, for example, sewage treatment and solid waste disposal. With governments everywhere seeking balanced budgets - and many poorer countries burdened with international debt - environmental investment is usually less than is required for sustainable development.

For many developing countries and countries in transition, the scale of degradation - or high costs in financial and human resources - are likely to cause many efforts to move directly to developed-country standards to fail. In these countries, the most practical approach might be to adopt somewhat less stringent – but still environmentally meaningful standards that are realistically achievable and enforceable, with the intention of tightening them, as necessary, as management capacity grows.

Priority areas for large-scale public investment in many parts of the world include: sewage disposal facilities (piped sewerage, sewage treatment plants, and outfalls); and facilities and management systems for municipal and industrial solid waste. In many instances, however, high levels of investment - particularly in relatively sophisticated technology that requires expert and costly maintenance - is neither desirable nor necessary. More appropriate is small- to medium-scale investment in such areas as:

- national pollution control programmes;
- promotion of improved pesticides and fertilisers;
- restoration and protection of critical habitats; and
- adoption of intermediate technological approaches, where appropriate, to water supply, sewage, and solid waste (World Bank, 1992).

Experience shows there is a need to improve the quality of public investment. Such improvements include: project preparation that takes into account all the investment options available within the context of achieving a sustainable project; the adoption of thorough environmental impact analysis for all capital investment projects; and, at the institutional level, the adoption by governments of the principle that the responsibility for any environmental damage resulting from public investment lies with the sponsoring agency.

Public investment need not necessarily be borne entirely by central or local government. There is an abundance of evidence available (World Bank, 1992) that people in developing countries are willing to pay for household water and sewage systems. Moreover, private investment in water supply, sewage and solid waste disposal companies may often be a way to accelerate investment in these public services and to improve performance (World Bank, 1992).

While the private sector can play a significant role in the financing and operation of "hard" facilities - such as those for waste treatment and disposal - public investment is vital in administrative areas such as the coordination of sectoral agencies, environmental monitoring and assessment, research, natural resources management, public awareness and participation, and compliance and enforcement. Public-sector investment is also necessary to ensure that government agencies have natural scientists, social scientists, and economists with the skills needed to allocate resources for optimal benefit to society. Unfortunately, the budgeting processes of most countries treat this capacity building as recurrent expenditure rather than investment, which typically results in it being drastically under-funded.

5. 4. SPECIFIC TECHNICAL AND MANAGEMENT MEASURES

There is an immense array of specific measures - technologies, engineering solutions, practices, and so on - that can be applied to environmental protection issues. No measure is appropriate in every circumstance, or even most of them, and few if any issues require more than a fraction of those available. The preceding two sections of this chapter outline some general considerations for devising policies and strategies for the control of LBAs. In the end, however, the effectiveness of any environmental protection effort, whether at the global level or the level of a single process within an industrial plant, depends upon the selection - and most importantly, the implementation - of a subset of measures that are not only technically effective and economical but can be readily implemented and sustained in the prevailing economic, institutional, social, and cultural conditions. A number of general tools are available to guide decisions about the need for intervention and the selection of measures. The most important of these are briefly described in Table 5.3.

Unfortunately, selecting measures based on both technical merit and prospects for successful implementation in a given socioeconomic setting is not a well-developed science. While there certainly have been success stories, more progress is needed in distilling the lessons from these successes so as to transplant them elsewhere.

Table 5.4 shows a range of measures available to prevent, reduce, or ameliorate the impacts of the GPA/LBA contaminant classes. The table is intended to summarise those that are available, and not to prescribe those that are appropriate. Few, if any, of the alternatives are universally appropriate; indeed, some alternatives, such as bans, may be unacceptable in most cases. Thus, for example, preventing oil pollution by banning petroleum production, processing, and/or distribution will be feasible only in a few instances, such as the prohibition of petroleum exploration and development within the Great Barrier Reef Marine Park in Australia.

The following sections are not intended to reiterate information presented in Table 5.4, or to provide detailed analysis of the technical, social, and economic merits of alternative measures, but to provide an overview of some key considerations with regard to each contaminant class. The emphasis is on sewage, nutrients, sediment mobilisation, and physical alteration - which have already been identified as having the greatest impact on the marine environment on a global scale.

5.4.1 Sewage

Sewage is not a single contaminant but, as noted in Chapter 2, a complex mixture containing pathogens, nutrients, suspended solids (SS), oxygen demanding substances, and many other contaminants - each with different environmental effects, and different responses to disposal and treatment. It is therefore essential, in devising a sewage management strategy, to begin by identifying the environmental problems to be addressed and the contaminants that cause them. Expensive nutrient removal technology, for example, is irrelevant if the problem is microbiological contamination.

Treatment plants are the most commonly propounded measure to address environmental degradation from sewage. Such treatment can indeed be highly effective, but should not be seen as a universal solution. In many situations, particularly in the developing world, there are simpler, less capital-intensive, and more financially and technically sustainable alternatives that may provide better environmental outcomes, both with respect to sewage pollution and by allowing investment to be diverted to address other environmental problems. There is still a need, however, for continuing development of innovative and appropriate solutions.

Table 5.3. Relevant Management Tools

Management tool	Summary description	Selected references
Cost-benefit analysis (CBA)	CBA has a role in providing an input into the decision making process relating to proposed changes, such as drainage of wetland, alteration of freshwater flows, etc. It can also be a useful tool in the appraisal of policy instruments. A prime requirement is the incorporation of environmental values (see below). The use of the discount principle is a potential weakness of the tool that can be met to a certain extent by the incorporation of environmental considerations into the planning process. Although CBA has weaknesses, it remains the key tool to measure societal net benefits between uses of natural resources or between policy instruments and help in the prioritisation of management options	Pearce *et al*., 1988; Sassone & Schaffer, 1978; Sugden & Williams, 1978; Turner, 1988

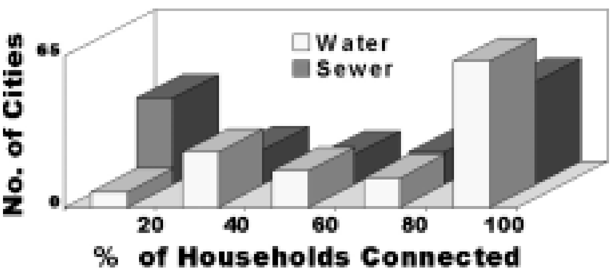
Management tool	**Summary description**	**Selected references**
Economic valuation of natural resources	There are a number of CBA techniques available to establish the trade-offs and measure societal net benefits. However, the overriding consideration in all of them is that of placing values on the benefits to society which normally do not carry a market price or are under priced. In many instances, the most important of these non-market values are those of the ecological functions of an ecosystem. Experience around the world has shown that very often the direct use values of an ecosystem, e.g., market values of fish, forest products or tourism, together with the ecological function values of the threatened system, greatly outweigh the economic benefits of development. However, the use of valuation techniques is constrained by the relatively large financial and human resources required for the collection and analysis of the ecological, economic and sociological information needed for valuation. These resources are often beyond the capability of many developing countries to marshal on a regular or continuing basis. There are a number of valuation techniques, each of which has been developed to meet certain requirements	Barbier, 1994; Barbier & Strand, 1998; Heal, 2000; Ludwig, 2000; Norse & Saigal, 1993; Pearce & Turner, 1990; Tietenberg, 1994; Winpenny, 1991
Multi-criteria analysis (MCA)	In MCA criteria considered to be important in the appraisal of selected options are compared and may be weighted. MCA does not consider efficiency and does not require the monetarisation of values or effects. It is therefore significantly less demanding of information than CBA and thus may be a more attractive tool than CBA in many developing countries. MCA also may be argued to perform better than CBA in accounting satisfactorily for sustainability objectives. However, MCA suffers methodologically from the subjectivity implied in the selection of criteria and the weightings that are attached to them	Resource Assessment Commission, 1992; Petry, 1990; Van Pelt, 1993
Institutional analysis (IA)	IA provides a systematic way of obtaining an understanding of the nature, strengths and weaknesses of institutions within the context in which they are operating or which it is proposed they may operate in the future. It is, therefore, a key element in moving away from sectoral-based management of natural resources to an holistic approach that is likely to require modifications in the roles of different institutions	De Graaf, 1997
Rapid appraisal	Rapid Rural Appraisal (RRA) and Participatory Rapid Rural Appraisal (PRRA) are ways of gathering local knowledge, identifying and assessing local attitudes and preferences. Identifying problems and using the people concerned to identify possible solutions. In PRRA advantage is taken of the process to exchange knowledge and develop and interaction with local people. The process requires a team, some members of which at least, have previous experience of using the technique and a good theoretical background to it. RRA and PRRA are essential prerequisites to developing a coastal management strategy and plans in the preparation of a coastal profile for the area to be managed	Pretty, 1997; Townsley, 1993
Remote sensing and geographic information systems (GIS)	Remote sensing covers all techniques related to the analysis of and use of data from satellites. These data integrate surface and earth observations over time and can provide good information on a wide range of characteristics. When used effectively the system enables data to be converted quickly into information for use in decision-making. GIS are computer-assisted systems that can input, retrieve, analyse and display geographically referenced information for decision making. Remote sensing and GIS can have an important role in planning. However, they require considerable skills if they are to be used effectively	Lantieri, 1998; Populus & Lantieri, 1991
Environmental impact assessment (EIA) and cumulative environmental impact assessment (CEIA)	EIA may be described as a process for the assessment of how a project or plan may affect, negatively or positively, various indicators that provide a measure of environmental impact. The responsibility for carrying out EIAs depends on the national legislative requirements of countries and varies considerably from country to country. The value of EIA is critically dependent on the level of professional skill and objectivity with which it is carried out. EIA may be meaningless if the regulator does not have the legal power or there is the political will to reject development consent or impose enforceable conditions, the process is inherently flawed. Another weakness of EIA is that is confined to large project or plans while the effect of numerous small actions that may have a cumulatively larger impact than many large projects are not assessed CEIA is a process that takes account of individual small impacts that have an incremental impact. It aims to allow regulators to decide whether an incremental change is acceptable and, through this facility, to increase their capability to control or influence small scale activities that would not be considered under the conventional EIA process. A weakness of CEIA is that it does not yet have a generally accepted methodology. Other reasons for its so far relatively slow adoption are the costs and, frequently the reluctance of managers to give a high priority to cumulative impacts. It is important to note that by its very nature CEIA cannot be applied at the level of individual projects	UNEP, 1990; GESAMP, 1986; Sorensen & West, 1992; Vestal *et al*. 1995
Risk assessment	Risk assessment is a probability-based process whose integral components are a hazard evaluation coupled with an exposure evaluation. It results in a characterization of the risk posed to an environmental target by a chemical, biological, or physical stressor. Simply stated, hazard without exposure or *vice versa* results in no risk. Risk assessments may be conducted as generic or site-specific. A generic risk assessment may be based on a laboratory hazard evaluation of the stressor coupled with predicted exposures. A site-specific risk assessment relies on field observations of an existing situation. In both cases, the exposure evaluation must identify the environmental compartments at risk (e.g. sediment, water column, habitat). Risk assessment may include a range of exposure scenarios, especially for comparative risk assessments. In many circumstances, a site-specific risk assessment may be more appropriate, based on knowledge of likely exposure. However, where exposures may be variable, it may be simpler to conduct a generic risk assessment. Risk assessments can range from a very conservative “ back-of-the –envelope” exercise to very complex, highly documented effort	CLS, 1993; Stern, 1996; Suter, 1993

Management tool	Summary description	Selected references
Dispute resolution	The limited availability of water and coastal resources means that there is always a risk of conflict over their use. Disputes can be resolved through litigation or through alternative dispute resolution (ADR) techniques. These are: direct negotiation, conciliation, facilitation, arbitration and negotiated rule making. The selection of the most appropriate is dependent on local conditions. ADR techniques are especially appropriate in coastal and catchment areas where issues are complex with usually considerable scope for compromise	Acland, 1995; Ahmed, 1996; Bacow & Wheeler, 1984; Rolley & Brown, 1996

Diffuse Sources

Sewage treatment is an option only if there is a reticulated sewerage system to collect the sewage and deliver it to the treatment facility. In fact, this is more the exception than the rule. In many developing countries - and indeed some developed ones - only a minority of the population is served by reticulated sewerage systems, even in urban areas (Fig. 5.2): the number of people without adequate sanitation is not expected to decrease before 2030 even with accelerated investment (World Bank, 1992). Constructing municipal sewerage requires substantial capital investment, which is often not available. Even when capital is available, it may not make economic sense to invest in treatment facilities prior to completion of the reticulation network (e.g., in the Philippines, Koe and Aziz 1995). Rapid urbanisation in many coastal areas, often in the form of unplanned squatter settlements, adds to the difficulty of providing sewerage and treatment infrastructure. In such circumstances, providing water supply usually has a higher priority than sewage collection and treatment. Neighborhoods are often provided with a municipal water supply before they receive sewerage to dispose of the increased volume of wastewater that results (Fig. 5.2).

Figure 5.2. Connection rates to water and sewer services in cities for which information is listed in WRI/UNEP/UNDP/WB (1998)



As a result, non-point sources such as septic fields, and pit or overwater latrines, are a significant source of sewage contamination in many areas. In many countries significant reductions in sewage contamination could be achieved by converting pit or overwater latrines to septic tanks, by better design and construction of existing septic tanks, or by better provisions for septic sludge disposal. The failure of on-site systems because of poor ongoing operation and maintenance (e.g., not emptying tanks or pits) is a common reason given for needing sewerage (Reed, 1996). Septic tanks can also be linked to stepped digestion tanks that produce effluent suitable for irrigating home gardens. There are also simple technologies, such as composting toilets and biogas generation, that are suitable for application in individual households or to small groups of them.

Depending on circumstances, measures concerning such on-site systems can have significant advantages over centralised reticulation and treatment systems. They are less expensive than conventional sewerage systems, especially at relatively low population density (Fig. 5.3) and can be implemented in smaller increments and with shorter lead times. They can also be implemented at the community or even individual level, while ongoing operation and maintenance are often less financially and technically demanding. Furthermore, equipment can often be manufactured locally.

Even when reticulated sewerage and sewage treatment is the best long-term approach to sewage management, on-site systems may be useful interim measures, and may enhance the system in the long term. In “settled sewerage”, for example, septic tanks are used to pre-treat wastewater before it is discharged to a central system, reducing the load on it.

On-site systems do have disadvantages, however. Soils have a finite capacity to absorb septic effluents. This varies widely with soil characteristics, and in some places soils are unsuitable for septic tanks. Septic tanks are also relatively poor at disinfection. They can lead to microbial contamination of ground water - a negative impact, especially where wells are an important source of drinking water. Sewage contamination of wells, for example, has been identified as the highest regional priority in Eastern Africa (UNEP, 1998; see Chapter 4).

Another useful measure in managing the impacts of diffuse sources of sewage is to take advantage of the capacity of artificial or natural wetlands to assimilate and retain wastes and remove pathogens. Again, however, the it is not unlimited; when it is exceeded, the wetland can be degraded. Such assimilative capacities are poorly known, particularly in the context of long-term variability.

For this reason, and because natural coastal wetlands are both ecologically very important and widely threatened, using existing wetlands for sewage treatment should be approached with considerable caution. The construction of artificial wetlands, on the other hand, increases the extent of coastal wetland habitat, often generating cross-benefits, but requires considerable areas of land. The use of wetlands for sewage treatment may also be incompatible with other uses, such as food production and recreation.

Point Sources: Wastewater Outfalls, Animal Husbandry, and Industry

The costs and technical capacity required to construct, operate, and maintain sewage treatment systems increase with progressively higher levels of treatment: but contaminant removal efficiency does not, except for nutrients (Fig. 5.4). The increased cost of tertiary treatment is therefore justified only when nutrient input is a significant environmental concern and sewage is important relative to other nutrient sources. Tertiary treatment is particularly likely to be required when a series of cities discharge effluents down the course of a river, producing a cumulative increase in nutrient levels. Where, however, effluent is discharged into particularly sensitive areas such as tropical lagoons, even relatively advanced tertiary treatment may not reduce nitrogen concentrations to a level that removes the threat of eutrophication.

Where waters are used for bathing or producing seafood, protecting human health is often a primary objective. Disinfection can reduce the numbers of bacterial indicator organisms by more than 99%, depending upon the nature of the effluent (Tchobanoglous and Burton, 1991). There are so many microbes in untreated sewage, however, that large numbers may remain even after very high

Figure 5.3. Costs of conventional sewerage, shallow sewerage (i.e., low cost systems dependent upon gravity flow), and on-site systems (septic tanks) at different

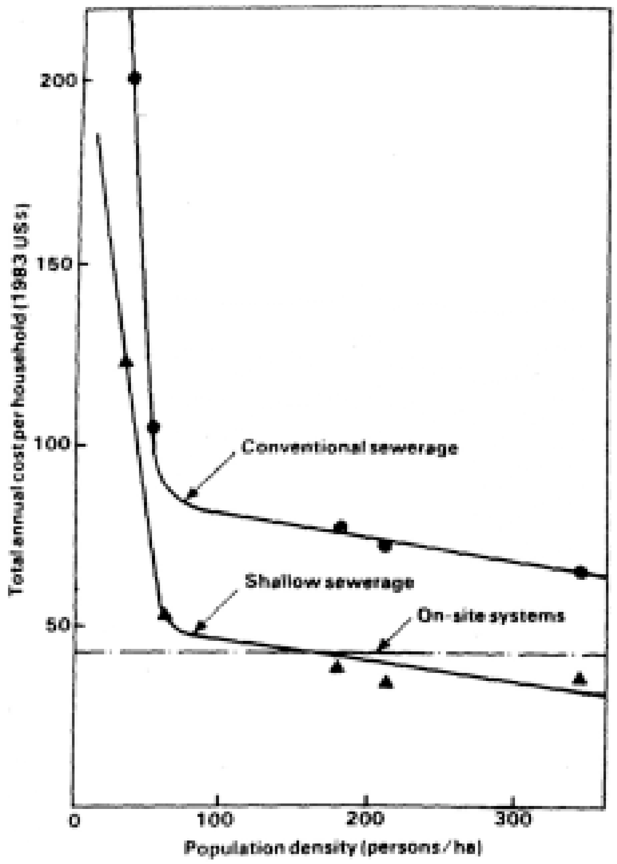
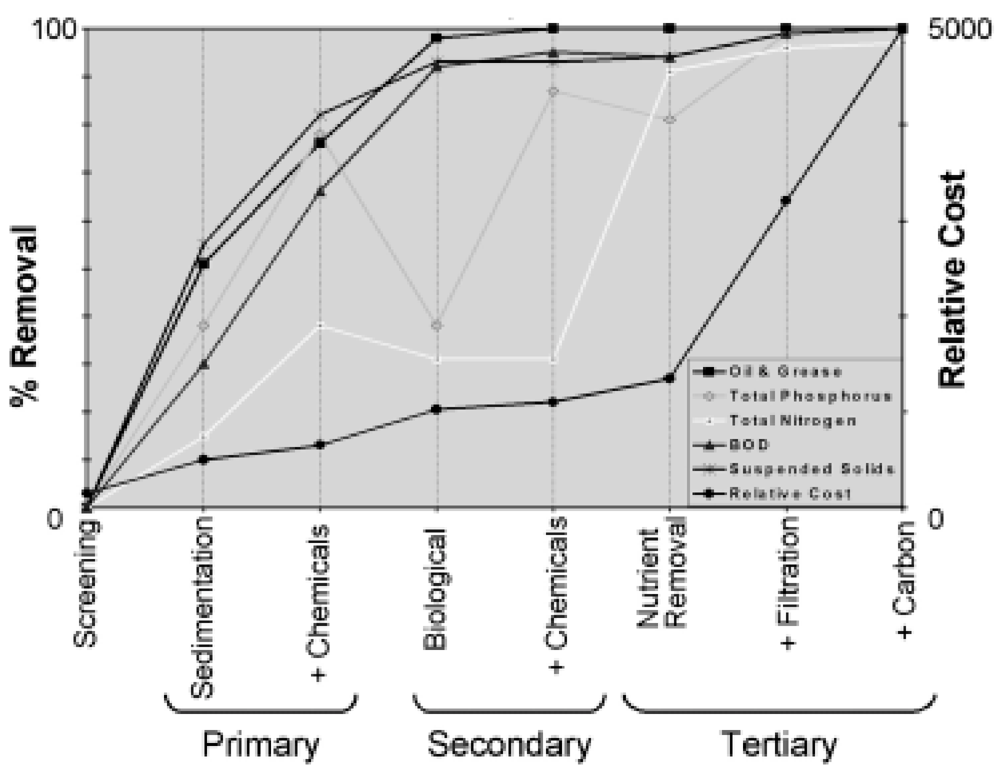


Figure 5.4. Typical removal efficiencies and relative costs of progressively higher levels of sewage treatment. This figure is for illustrative purposes only; the actual efficiency and cost of any particular treatment system will depend upon a large number of factors. Based on data from NRC (1993)



percentage reductions. Furthermore, standard indicator organisms such as coliform bacteria are not necessarily reliable indices of pathogen levels (Ashbolt, 1995; NRC, 1993). It is therefore good practice to locate sewage outfalls well away from bathing beaches, shellfish beds, and similarly sensitive areas, even if the sewage is disinfected before discharge. It is also important to consider the possible harmful effects of disinfection methods, such as chlorination, that can leave harmful residues.

Placing effluent discharges appropriately is often effective in reducing the environmental impacts of a given level of treatment - or in reducing the cost of treatment necessary to achieve acceptably low impacts. Deep ocean outfalls are a viable option for many, if not most, coastal cities. Offshore outfalls often distance the discharge from bathing and recreational waters and fishing grounds and, depending upon local water circulation, maximise dispersion and dilution. They require much less ongoing technical support and expense than advanced treatment plants, and have a lower frequency of failure. This is a particularly important consideration for developing countries with low capacities to maintain treatment plant performance. Convard (1993), for example, reported treatment facilities in Pacific Island nations that discharge effluent of no better quality than raw sewage. Given that tertiary treatment may not adequately safeguard against eutrophication, even when plants are performing to specifications, plant failure can be expected to have severe negative effects. In such cases, an ocean outfall is likely to provide a better, more certain, and more cost-effective environmental outcome than the construction of a treatment plant.

Figure 5.4 is purely indicative, and the performance of any particular sewage treatment system will depend upon a number of factors. One is the characteristics of the raw waste stream, and, in particular, whether or not it includes industrial waste. Figure 5.4 is based on domestic waste streams with no industrial component. Domestic sewage treatment systems typically fail adequately to remove POPs, radionuclides, and some other trace contaminants, but the levels of these are usually low if there is no industrial component in the waste stream. Some industrial wastes, such as some POPs, may actually interfere with domestic waste treatment, for example by poisoning biological digestion. When raw sewage is discharged with industrial waste, lipophilic chemicals in the latter adsorb to the organic matter: the two are subsequently transported together and inextricably linked. It is therefore usually preferable to treat industrial and domestic liquid waste streams separately.

In practice, the effective level of sewage treatment is usually determined on the basis of socioeconomic conditions rather than through objective analysis of environmental protection needs. As noted above, high costs prevent much of the world's population from being serviced by any form of sewerage system. Sometimes there are also distortions in the allocation of investment in sewage treatment. Some small island developing states, for example, are denied access to concessionary financing for treatment facilities because of relatively high per capita incomes.

Costs and Benefits of Sewage Management: Case Histories

A case study of the island of Rhodes (Constantinides, 1993) estimated that the cost of planned projects for protecting the marine environment - primarily for sewage treatment and disposal - amounted to US$61 million. The benefits were estimated to be US$152 million, almost two and a half times greater than the cost. Similarly, a study of Izmir Bay, Turkey (Balkas and Juhasz 1993) - which was concerned primarily with sewage, but also, to some extent, with industrial pollution - estimated the discounted cost of controls between 1988 and 2025 to be US$1.3 billion, while the discounted benefits were in the range of US$4.77 - 10.2 billion (not including multiplier effects). Thus, benefits in this case would exceed costs by a factor of 3.6 - 7.8. (The range reflects different assumptions about the future of the tourism industry.)

Investment in sewage treatment and disposal clearly shows considerable benefits. Its feasibility depends on a variety of factors; among the most critical of them, in many situations, is the willingness of responsible authorities to adopt appropriate technical and financing solutions - coupled with external techical and financial assistance in the poorest countries.

Conversely, there may be excessive investment in treatment infrastructure. A simple offshore outfall may be perceived locally as "second-class" technology. Engineering and construction firms aggressively market advanced treatment systems. International donors often have a pre-disposition for capital-intensive infrastructure projects and developed-world solutions, but have budgetary constraints that prevent long-term investment to build the capacity needed to sustain treatment plant performance. Some donors require that treatment plants be constructed for all development projects, usually with a level of technology appropriate for the donor - but not necessarily the recipient - country. These pressures should be resisted in favour of a realistic assessment of environmental risks and of the sustainability of treatment performance. Where large infrastructure projects are undertaken, there should be adequate provisions for capacity building and sustainable financing to support long-term performance.

There are opportunities for financing sewage treatment systems sustainably. The most common approach is to charge residents a fee for sewerage. The World Bank (1994) concluded that "*there is substantial evidence that urban families are willing to pay substantial amounts for the removal of excreta and wastewater from their neighborhoods*". It must be remembered, however, that the urban poor are often simply unable to pay for sewerage services. Reed (1996) points out that willingness to pay (usually determined by questionnaire) tends to reflect the importance that people attach to having such services, rather than their realistic assessment of cost or of their ability to pay. He advises that decisions about cost recovery be made on the basis of ability, rather than willingness, to pay, with a maximum fee of 2% of family income as an accepted standard.

Another option for sustainable financing is to market the water, nutrients, and organic matter contained in sewage, which are valuable resources in most countries. They can be recovered and used for irrigation, industrial process water, fertiliser, and soil conditioner, while organic matter can be processed into methane to generate electricity. Where markets exist for these products, they may create an economic incentive to invest in treatment. Concerns about public acceptance and health, however, sometimes restrict this option.

Although the GPA/LBA includes only domestic wastewater under the category of "sewage", several regions identify as a priority organic wastes *(*i.e., BOD, SS, and nutrients) from such activities as animal husbandry and food processing and manufacture, as described in Chapter 4. Such wastes, though generally more concentrated than domestic sewage, require similar management approaches to it, and are therefore considered here.

It may be feasible to discharge industrial organic wastes into domestic treatment systems, if these have adequate capacity for the load. It will generally be appropriate in such cases to levy user charges, sufficient to cover the cost of treatment, on the enterprises generating the waste and/or require on-site pre-treatment of the wastes prior to discharge into the municipal system. Wherever possible, complete on-site treatment should be encouraged. This forces the internalisation of environmental protection costs, and may have technical advantages. The high concentration, for example, may facilitate waste recovery and re-use, while the often less complex mix of substances in the waste stream - and relatively constant (or at least predictable) volume of flow- may lead to savings in unit costs. The latter advantage, however, may be offset by the declining unit cost of treatment with increasing flow volume.

In the case of feed lots and other intensive animal husbandry operations, it is often necessary to install facilities, such as drains and pits, to intercept wastes in runoff and deliver them to treatment facilities. Retaining or constructing wetlands may also be effective, particularly where the husbandry enterprises are small and lack the resources to invest in interceptors. Carpenter *et al.* (1998) note that discharge standards for animal wastes are generally less stringent than those for human sewage.

International industry has long possessed the capacity to operate and maintain sophisticated systems to treat organic waste. In developing countries the construction of industrial facilities may create opportunities to harness this capacity for the benefit of local communities, for example by discharging domestic waste into industrial treatment systems.

Industrial waste streams that are incompatible with domestic sewage treatment plants, are inadequately treated by them, or exceed their capacity, require specialised treatment tailored to the nature of the waste stream, the receiving environment, and the environmental objectives. "End-of-pipe" solutions may be effective in reducing the quantity and/or harmfulness of industrial waste discharge, but have limitations. Satisfactory treatment alternatives are not available for all contaminants and sources. Treatment processes usually involve significant capital, operation, and maintenance costs with little direct economic return to the industry. For this reason they may not be implemented or, if they are, they may not be properly operated and maintained in the absence of effective regulatory and enforcement regimes. Reduced industrial competitiveness, or the perception of it, may render industrial waste treatment measures socio-economically unacceptable, particularly in developing countries. Some treatment technologies require technical capacity that is not available in many countries. "End-of-pipe" solutions are also usually the last stage prior to discharge to the environment, creating a risk of accidental discharge of partially treated or untreated waste in the event of equipment or process failure. For these reasons, final treatment of industrial wastes is often most effective in preventing environmental degradation when it constitutes just one component of a broader approach to BEP, rather than the primary or only measure employed. In some cases this principle has been formalised. The Baltic JCP, for example, stipulates that the upgrading or completion of industrial wastewater treatment plants should only be supported if there are complementary pre-treatment programmes (HELCOM, 1996).

5.4.2 Persistent Organic Pollutants

General approaches to controlling environmental degradation from POPs are bans on production or on certain uses, substitution with less harmful products, the implementation of BEP and BAT, and various forms of treatment and safe disposal. Rehabilitation may be called for where severe contamination has already occurred, but it should be approached with caution because of the risk of net environmental harm as a result, for example, of remobilisation of the contaminants or of collateral damage from physical disruption or sedimentation. Technologies to accelerate the degradation of contaminants through the use of microorganisms have promise, but are not yet in widespread use.

In 1998 thirty six countries of the Northern Hemisphere adopted an agreement aimed at reducing atmospheric emissions of some POPs, under the convention on Long Range Transboundary Air Pollution: they also adopted criteria for the later inclusion of other substances in the agreement. In 1997 the UNEP Governing Council established an intergovernmental negotiating committee to develop a binding global agreement with regard to the initial list of twelve POPs (see Box 2.1 (Chapter 2)), and criteria for the future inclusion of other substances: it is expected that an agreement will be reached by late 2000 or early 2001.

As noted in Chapter 2, many chemicals not on the POPs list are at least potentially of environmental and human health concern. These include not only PTSs but also less persistent chemicals that occur in significant concentrations in the environment as a result of chronic inputs. PAHs are one notable example. For the most part, these chemicals can be categorised in the same way as POPs (i.e., into industrial chemicals, pesticides, and unintended by-products), but the measures appropriate for managing them will vary with their nature and their sources. PAHs, for example, are primarily unintended by-products but require different control measures than dioxins and furans because their sources are much more ubiquitous.

Costs and Benefits of Reducing POPs Emissions

The World Bank (1992) has estimated that industrial pollution, and therefore presumably industrial POPs emissions, would be significantly reduced if spending on pollution control were to approach two to three per cent of investment costs. Although the development costs of, for example, integrated pest management, can be substantial, agricultural measures to reduce POPs can have high ratios of benefits to costs. The World Bank (1992) has reported a ratio of nearly 150 to 1 in cassava production in Africa, for example.

At the technical level there is little difficulty in achieving a significant reduction in the quantity of POPs entering marine waters. The costs of doing so, however, can be relatively large at the level of individual enterprises, making effective government policy and compliance the determining factor.

It should also be noted that, in the relatively near future, improved information on chronic sublethal effects - such as endocrine disruption - may necessitate a re-evaluation of requirements for managing POPs and other toxic organic chemicals.

PCB's, Hexachlorobenzene

Acceptable alternatives are generally available for these chemicals, and bans and restrictions on their manufacture and use have been adopted in most developed countries. This has resulted in reduced disposal rates: but it has not necessarily reduced environmental contaminant levels because of the persistence of these chemicals and due to continuing inputs from such secondary sources as landfills (e.g., in the North Sea, see 3.1 above). The chemicals are still in widespread use in much of the developing world, where post-production measures such as disposal through incineration or containment in safe disposal sites are not widely available.

Pesticides

The eight pesticides on the initial list of 12 POPs (see Box 2.1) are, unlike the other POPs on the list, deliberately released to the environment, largely in agriculture and forestry. The acceptability of substitutes varies with industry, region, and the ability to pay for more expensive alternatives. Bans have been variously applied, with varying effectiveness: substantial illicit trade in certain pesticides, for example, occurs in many regions. Bans and substitution must be considered against the benefits derived from pesticides, for example in food production and disease control, especially in developing countries. In some countries, pesticide bans have created problems regarding the safe storage and disposal of existing stockpiles, pointing to the need for careful planning. The development of more environmentally benign alternative pesticides, stimulated largely by regulation, promises to reduce dependence on the most harmful ones and has already delivered significant benefits. Standards for pesticide residues in agricultural products serve to protect human health, and provide an economic incentive to reduce pesticide use. This can apply across agricultural sectors. In Australia, for example, the rejection of export lots of wool and beef because of high pesticide residues has stimulated dialogue between graziers and the cotton industry, and improved practices by the latter. The best approach to reducing pesticide contamination of the marine environment lies not in any particular measure but in integrated BEP that reduces the use of dangerous pesticides, targets their use more efficiently, and reduces dangerous practices. These considerations apply broadly to all pesticides, as well as to those included on the POPs list.

Chlorinated Dioxins and Furans

These are unintended by-products rather than commercially produced chemicals, and so production and use controls are not appropriate. Control measures focus on improved practice, and on post-production interception and treatment measures. Both these approaches need substantial technical and financial inputs, which will in turn require international assistance in developing countries. Subsidies and other distortions that favour the continued operation of "dirty", outdated industrial facilities should be phased out. This may also require international assistance, for example to reduce the economic impact of plant closures.

5.4.3 Radionuclides

Artificial radionuclides are derived from a relatively few sources (Table 5.4). The regulatory framework applied to these sources is based on protecting human health and minimising releases to the extent achievable and consistent with economic and social constraints (the ALARA or “as low as reasonably achievable” concept). The regulatory framework does not consider environmental effects, but, based on current knowledge, environmental considerations impose more stringent requirements in the vast majority of authorisations.

Other sources of artificial radionuclides have either been considered in the authorisation process for existing and previous activities, or result from unregulated ones, such as nuclear weapons explosions and nuclear accidents. In these cases, the international system of radiological protection requires that measures to reduce human exposures be considered when they exceed certain limits.

There are also secondary sources in the environment - either intrinsically considered in the regulatory procedure for existing sources or as the result of previously unregulated practices - such as nuclear weapons explosions in the atmosphere. Again there is a requirement to consider intervention when human exposures from these sources exceed certain limits.

5.4.4 Heavy metals

Most heavy metals have effects only on local scales - or at most on sub-regional ones, so control measures are required only where needed to achieve local environmental goals. For lead and mercury, which have long-range effects, emission reduction is probably warranted even in the absence of local impacts. The banning of source industries is generally inappropriate.

In 1998 thirty-six countries of the Northern Hemisphere adopted under the convention on Long Range Transboundary Air Pollution an agreement aimed at reducing atmospheric emissions of heavy metals: this covered lead, cadmium and mercury in its first phase.

The use of tributyl tin (TBT) in antifouling paints for aquaculture facilities, oil platforms, wharves, and small vessels, has been phased out in many countries. It remains in use for large vessels, but the release rates to the environment have been substantially reduced by improvements in the paints. Despite considerable effort to find replacements for TBT preparations, the existing alternatives are either much more expensive or less effective, imposing high vessel maintenance costs. It is debatable whether further reductions in TBT use on large vessels are called for, at least until more suitable alternatives are available. Phasing out TBT use on small vessels, however, is warranted in countries that have not already done this.

5.4.5 Oils

The most appropriate control measures are collecting waste oil to reduce deliberate dumping, and intercepting waste oil that **has** been released before it reaches the marine environment. Both ultimately require alternative ways of disposing of it, such as recycling or incineration, which may themselves have environmental implications. Markets for waste oil and other economic incentives could reduce dumping.

Point Sources: Industrial and Port Facilities

Oil contamination of the marine environment from port and industrial facilities could be greatly reduced by applying existing best practice and technology, from effective EIA and by enforcing environmental management provisions. More widespread implementation of MARPOL measures to improve port waste reception facilities, probably requiring regional and international cooperation and assistance, would reduce not only oil discharges from ports but probably also illegal operational discharges from ships.One problem, however, is the provision of appropriate disposal options for oil received at port facilities.

Non-point Sources: Urban Runoff, Land Transport

Leaks and dumping of used lubricating oil from vehicles and other machinery are major sources of oil in urban runoff. Other sources include ruptures of storage tanks (e.g., at petrol stations), and, in some places, the use of used lubricating oil for dust control. Removing oil from storm drainage is not technically difficult where there is storm sewerage. Constructing storm sewerage, however, requires large capital investment, and may not be feasible in low-lying areas that experience regular flooding, such as Bangkok and Bangladesh. In some places, it may be possible to construct interceptors in strategic locations, such as natural drainage channels, without needing to invest in storm sewerage.

Providing readily available waste oil reception facilities in urban areas can greatly reduce dumping of used motor oil, especially when combined with effectively enforced prohibitions on it, as already exist in some countries. Public education and economic incentives, such as a market for used oil, reduce the reliance on enforcement. Other measures to reduce oil in urban runoff include maintenance standards for vehicles and petroleum facilities, and discontinuing the practice of applying used oil to roads for dust control. Deposit-refund schemes for used motor oil, or surcharges on the purchase of new oil (with the proceeds used to fund disposal facilities), may have potential; but they do not appear to have been widely tried.

Accidents

Tanker and offshore wellhead accidents are the largest source of oil spills, but these also occur from ports, pipelines, refineries, and other land-based facilities. Two parallel control approaches are required: risk reduction and spill response. Considerable technical improvements have been made in both areas. Continued improvement in the state of the art is certainly desirable, but greater gains can probably be made from implementing existing technologies and practices more widely, especially in developing countries.

5.4.6 Nutrients

Although point sources are of great concern in some localities, anthropogenic flows of nutrients to the marine environment are dominated by non-point sources on global and regional scales (see Chapter 2). These cannot be addressed by simple end-of-pipe technological solutions and urgently require broad-scale changes in industrial practice, and in land and energy use. While continuing improvements in BEP would be welcomed, great gains could be achieved by applying existing BEP and BAT more widley, and especially by the transferring them effectively and rapidly transfer developing countries - a measure that will require international technical and financial assistance.

Costs and Benefits of Reducing Nutrient Emissions

The costs and benefits of measures to address nutrient runoff from agriculture have not been adequately assessed, but it is reasonable to assume that their benefits would be substantially higher than their costs. Regarding atmospheric emissions, there are three broad, mutually reinforcing policies available: improving fuel pricing to reflect the environmental costs of its use; reducing urban congestion (e.g., through better urban planning and mass transport); and promoting clean fuel and engine technologies. The costs of the first two policies are relatively low. The global phasing-in of cleaner fuels and engine technologies which reduce - but do not eliminate - nitrogen oxide emissions from vehicles, as well as further technological improvements, has been estimated by the World Bank (1992) to cost 0.5% of global GDP by 2010. The World Bank (1992) has also calculated that phasing in reforms to rectify price inefficiencies and problems of accountability up to 2030 would make electricity production more efficient and reduce pollution, while raising incomes and human welfare. Introducing more environmentally friendly technologies and practices would produce additional pollution reductions. The Bank argues that the resultant savings in investment (e.g., in new power plants) - not to mention the benefits of pollution reduction itself - would far exceed the costs.

The two technical approaches to reducing industrial emissions, other than from power plants, are end-of-pipe controls and improvements in the industrial process. End-of-pipe controls can be expensive, but the industrial sectors of developing countries are advancing rapidly and each new investment offers the opportunity to incorporate cost-effective pollution abatement. The World Bank (1992) has noted that developing countries should therefore be able to reduce emissions from large industrial plants at a lower cost than industrial countries, which are more dependent on fitting end-of-pipe controls to old plants. This will require developing countries to adopt appropriate policies to induce a proper combination of waste reduction and end-of-pipe controls.

Point Sources: Sewage and Industrial Waste

Control measures for nutrients entering the marine environment from sewage and organic industrial wastes are discussed in 5.3.1 above. Except on local scales, point sources of nutrients are of secondary importance relative to non-point sources, and it can be argued that investment in control measures would in general be better directed toward the more difficult problem of non-point nutrient releases. Treatment and outfall construction will , however, often be necessary to reduce local problems resulting from excessive nutrient discharge. Furthermore, there is a case that the "polluter-pays" principle requires that point sources internalise the costs of their nutrient releases by paying for control measures even if they are not the most importance source of nutrients.

Non-Point Sources: Runoff and Groundwater

Altered patterns of fertiliser use and application, cropping, tillage, and other agricultural practices would significantly reduce nutrient contamination of coastal areas. Vitousek *et al*. (1997) describe an example from a sugar cane plantation where the subterranean delivery of fertiliser in dissolved form, together with timing application to coincide with crop growth, cut nitrogen fertiliser use by a third (improving profitability) and reduced runoff of nitrogen nutrients by a factor of ten. Applying existing best practice - and continued improvements in it - would have similar benefits in other industries; the specific measures that are appropriate vary widely among industries and from place to place.

Urban runoff is another significant non-point source of nutrients to coastal waters. The measures most likely to be effective include regular street sweeping, and others that reduce the concentration of nutrients in runoff, and stormwater management to slow the flow of runoff and promote ground penetration. Given reticulated storm sewerage, it is theoretically feasible to provide tertiary treatment, but not only would the costs be unacceptably high even in developed countries, but the large variations in flow rates would create considerable technical difficulties. Re-use of stormwater, for example for municipal irrigation, might reduce nutrient inputs, but would require both storm sewerage and infrastructure for water storage and delivery.

Improved environmental practice in agriculture and other industries can greatly reduce human-induced nutrient flow into marine areas, but probably never eliminate it. Wetlands, including mangroves, play a key natural role in intercepting and immobilising dissolved nutrients in runoff and groundwater. A global strategy to reduce eutrophication and other problems associated with excessive nutrient inputs should place a priority on protecting and rehabilitating natural wetlands. The construction of artificial wetlands can also be an effective tool. Better drainage management is associated with this: it would, for example, reduce channelisation and slow the flow of run-off to the marine environment, thereby allowing more time for natural assimilation and denitrification. A complicating factor is that wetlands typically convert dissolved nutrients into particulate organic form, which is exported to other systems: management and regulatory schemes should take this net export of particulate organic nutrients into account.

It is important to note that the same control measures will often be effective in addressing nutrient mobilisation, sediment mobilisation, and the physical alteration of habitats, because of the strong inter-relationships among them. In particular, measures that reduce sediment mobilisation (Section 5.4.7) will also address nutrient inputs. Reducing the alteration of physical habitats both cuts destabilisation of soils at the habitat site and preserves the function of wetlands and other habitats in immobilising nutrient and sediment flows from upstream.

Non-Point Sources: Atmospheric Emissions

Controlling atmospheric emissions of nitrogen poses a considerable challenge. Technological fixes - such as catalytic converters and more efficient vehicle engines, end-of-pipe interception and/or treatment (e.g., stack scrubbers), and cleaner industrial technologies - can achieve significant reductions. It is unclear that many such measures are feasible in developing countries; certainly, international cooperation will be required. Improved practice in fertiliser use and manure storage and handling to reduce emissions from agriculture are feasible in many countries, and reasonably readily transferable to many others.

It is doubtful, however, that the available measures can reduce atmospheric nitrogen inputs to the ocean to a level where they are no longer a serious concern. What are probably required are significant societal changes in transport and energy use patterns, and/or major technological breakthroughs to control vehicle and industrial emissions.

5.4.7 Altered Sediment Fluxes

As noted in Chapter 2, marine and coastal environmental problems can arise from both increased mobilisation and downstream accretion of sediments and from impeding natural sediment flows and resultant impoverishment of sediment-dependant habitats downstream. The activities leading to these impacts may be broadly grouped into two main categories: large scale industrial and engineering works (e.g., hydroelectric and coastal protection schemes), which can lead to either accretion or impoverishment downstream, and broad-scale land uses such as agriculture, forestry, and other forms of land clearing and destabilisation.

Engineering and Industrial Works

The large-scale engineering works considered here are specifically designed to alter natural hydrology or beach processes, and therefore, by definition, natural sediment fluxes. There are a variety of engineered solutions that can address problems of altered sediment flux (Table 5.4). Depending upon the sensitivity and value of downstream habitats, and the technical difficulty and effectiveness of control measures, these may require a high level of investment relative to the overall cost of a project, and even render some projects economically non-viable. Provided that the economic feasibility of projects is assessed on the basis of overall net benefit, this should not be regarded as an impediment to progress, but as an internalisation of environmental costs. In practice, there are often political as well as economic motivations for large-scale engineering projects, but political decisions that overrule net benefit considerations will be economically counterproductive.

Engineered solutions to problems of altered sediment flux caused by dams, channelisation, and other large-scale hydrological modifications can either be built into the original design or retrofitted after construction if environmental problems occur. It is generally better to assess possible downstream environmental effects from the outset, and incorporate measures to address them in the initial design, rather than to retrofit. First, this is often cheaper and more effective; second, retrofitting usually involves additional construction, which creates its own impacts; and third, and perhaps most importantly, considering the possible environmental costs of a project from its inception allows a realistic assessment of its true net benefit. It is far better to shelve a project that will ultimately not be cost-effective than to proceed with it and discover that the problems it creates, or the cost of rectifying them, outweigh its benefits. Careful EIA is the best tool for assessing the impact of large engineering works on sediment fluxes.

Sediment Mobilisation

Channelisation of waterways for navigation, flood control, and other purposes often enhances the delivery of sediments to coastal waters, by diverting water from natural interceptors such as wetlands and mangroves, and by increasing the speed of the currents. The design of sea walls and other coastal protection works rarely gives adequate consideration to the dissipation of wave energy, longshore currents and other beach processes, often resulting in shoreline erosion and offshore transport of beach material.

Constructed solutions to such problems are often costly, but many design improvements (e.g., sloping, rough-surfaced sea walls as opposed to smooth, vertical ones) are quite inexpensive and only require that sediment processes be taken in to account in the design. In addressing coastal erosion, the best option by far in many, if not most cases, is to invest in coastal planning and accept some opportunity costs of wise coastal development (e.g., to refrain from developing the immediate foreshore even though potential revenues are forgone), rather than to invest in coastal protection works, which are often expensive and only marginally effective.

Instead of, or in addition to, engineering solutions, the use of interception fields, such as buffers of vegetation along watercourses, mangroves and other wetlands, can often reduce the delivery of sediments to sensitive habitats. This may entail the targeted preservation of natural habitats or the construction of artificial ones. This approach also has the advantages of addressing sewage, nutrients, and physical alteration, and of providing valuable habitat.

Many of the world's approximately 38,000 dams are aging, and there are increasing pressures to remove dams to restore the natural condition of watercourses. Dam removal should be done with great care, however, so as to avoid suddenly mobilising great quantities of sediment, which can cause great damage to downstream environments.

Sediment Impoverishment

The effects of sediment retention behind dams can largely be predicted through EIA. Along the coast, groynes built to retain beach sands are marginally effective on their up-current side, but invariably divert most of the material that naturally moves along the shore to deeper water offshore, impoverishing the shoreline downstream.

Engineering works can be constructed to restore natural sediment flow through or around dams, groynes, and other obstacles. In the absence of such diversions, sediments may be dredged from their site of deposition and re-injected into the river or longshore flow downstream of the obstacle. This usually involves considerable ongoing expense. Dredging may also create secondary environmental impacts, including disturbance to benthic communities, re-suspension of sediments and elevated turbidity. Given the expense of such measures, groynes built to retain beach sand rarely generate a net benefit, although they may be advantageous to individual private interests such as resorts or beachfront homeowners. For dams, barrages, and similar river obstructions, periodic intentional flooding is another way to restore natural sediment flux; in some situations this has the added advantage of mimicking the episodic nature of natural events.

An alternative to restoring natural fluxes is to provide artificial sediment sources. Examples are deliberately enhanced erosion or injecting sediment from distant sources (e.g., beach replenishment). Beneficial placement of dredged material to enhance or construct habitat can rectify sediment impoverishment and restore degraded areas.

Cost and Benefits of Controlling Erosion in Agriculture and Forestry

It has been widely demonstrated that farmer-controlled soil conservation measures can be developed and implemented at reasonable cost in agriculture - and that they generate significant benefits. In East Asia, for example, decreases in erosion of 40-90% were associated with increased yields of up to 188%. The benefits of agricultural improvements in reducing sedimentation in rivers and the marine environment are unquantified.

Studies in the Philippines (Hodgson and Dixon, 1988) and Indonesia (Cesar *et al*, 1996) have demonstrated that the costs of environmental damage to coral reefs from logging-induced sedimentation greatly exceed the economic benefits of logging. Cesar *et al.* (1996) also showed that the economic benefits of improved logging practices - in terms of reduced environmental costs - outweighed the private costs to loggers by 3:1.

Effective control of erosion - and of the consequent mobilisation of sediments - from agriculture and forestry is technically feasible, at moderate cost, and can produce considerable net benefits. Its implementation, however, largely depends firstly on political will (including resolving conflicts between private and public interests) and, secondly on governments being able to mobilise the necessary financial and human resources, something that requires international assistance for poorer countries.

General Land Use Patterns Including Agriculture and Forestry

Improved practices are the primary measure available to control sediment mobilisation from land use. Terracing, low tillage, modified cropping, reduced agricultural intensity and many other practices help to reduce the loss of agricultural soils. This avoids the costs both of soil loss and of downstream sedimentation. Practices - particularly improved road construction and restrictions on logging steep slopes - have also been developed to reduce erosion from forestry area. Barriers to erosion from construction sites can produce similar benefits, as can timing construction to avoid periods of heavy rainfall.

Natural vegetation and wetlands are very effective in stabilising soils and trapping sediments transported in runoff. Measures that capitalise on this include the revegetation of degraded watersheds, and the protection, rehabilitation, and/or construction of wetlands or natural buffers of vegetation along watercourses.

5.4.8 Litter

There are two overarching solutions to problems of litter in the marine environment. The first is improved municipal and industrial solid waste management, which requires public and private investment. The second is to induce changes in individual behaviour through enforcement, improved education and awareness, and such economic incentives as deposit-refund schemes. Remediation (cleanup) is not generally feasible for the marine environment as a whole, but is both feasible and relatively inexpensive on beaches and shorelines. The economic benefits are often disproportionately high relative to the impacts on environmental health due to the negative effects of litter on beach amenity and tourism.

5.4.9 Physical Alteration of Habitats

Continuing habitat destruction results from such a wide range of LBAs that halting it, perhaps more than any other cause of environmental degradation, requires the application of a broad mix of tools and measures within a framework of ICM. Creating protected areas, using zoning to designate areas where particular activities are appropriate, and public education about the value, sensitivities, and appropriate uses of key habitats are broad-based measures that are widely applicable to at least some extent. More targeted measures include: bans or moratoria on destructive practices (e.g., on cutting mangroves or draining wetlands); requirements for compensatory mitigation; setback limits; and construction codes that specifically address coastal environmental concerns. One example of the latter might be that roads through wetland or lagoon areas should have culverts or bridges to allow unimpeded tidal circulation: there are many others depending on specific circumstances.

All of the tools listed in Table 5.3 are useful in controlling the physical destruction of habitats, particularly EIA (including more sophisticated forms such as cumulative EIA), GIS, and the economic valuation of habitats. Full economic valuation is still a technically demanding exercise that can strain the capacities of many countries - and, indeed, those of many regional and local authorities even in developed countries. There is, however, a critical first step that does not require much technical skill or money and would go a long way towards in reducing habitat destruction. This is simply the explicit consideration, even in qualitative terms, of the value of marine and coastal environments - and of the costs of altering them - when making decisions about the uses of coastal areas and resources.

The full participation of local communities in managing coastal habitats is essential. This provides the basis for identifying and prioritising the values and uses of habitats and for resolving use conflicts. In many situations it allows for flexibility and creative solutions to management needs, and results in better on-the-ground management, especially where management and enforcement capacity is inadequate. Effective community-based management, of course, depends upon good public awareness and understanding of environmental processes and problems, and needs to be supported by governments in the context of a twin-track (i.e., “bottom up” and “top down”) approach (see section 6.2).

The benefits of intervening to protect or restore habitat are often unambiguous and significant. Nevertheless, problems are often encountered in placing economic values on ecological benefits. Much discussion, for example, has been devoted to how to select a discount rate that will properly account for transfers between generations. It is also usually not known what proportion of a given habitat must be protected or restored to achieve the associated benefits - how much mangrove, for example, is needed to provide a sufficient breeding and nursery area for fish stocks. These problems, and the tools for dealing with them, are briefly discussed in Annex 1. In some instances, however, the problems are, at present, intractable. For example, the restoration of wetlands in the southern Mississippi basin would call for enormous civil engineering costs and compensatory payments that make it difficult to demonstrate positive tradeoffs against often intangible ecological benefits.

Among the most important requirement in many developing countries is to alleviate poverty and provide employment alternatives to allow people to reduce subsistence and artisanal pressure on coastal habitats and resources. This applies not only to coastal areas: better employment opportunities and services in the hinterland would do much to alleviate migration pressure on coasts.

5.5. INFORMATION NEEDS

Effective environmental management depends on the availability of relevant and reliable information. Information has at least three critical roles here, all of which relate to reducing uncertainty:

- **assessment of the present situation**, including: the present state of the environment; the causes and costs of degradation and relative priorities for addressing it; the identification of gaps in knowledge and the priorities for filling them; human activities and social conditions; and societal goals and capacities;

- **prediction and policy formulation**, including: trend forecasting; risk assessment and early warning; the comparison of likely costs and benefits of alternative actions; the establishment of objectives and targets; and the development of criteria and standards for public and environmental health; and

- **performance evaluation**: periodic environmental assessments; evaluation of the implementation and effectiveness of policies and measures; and reformulation of policies and programmes.

5.5.1 General Considerations

The scope of information required for effective environmental management of LBAs embraces both the environment and human uses and values. It includes: current land and other resource use patterns and dynamics; demographics; investment; types, location and levels of economic activity which affect the coastal area; status and changes in public health; environmental characteristics (physical, chemical and biological, including natural processes and variability); economic values of natural resources under threat; and social characteristics (income, housing, availability of clean water and sanitation, causes of concern to people in the coastal area, etc.).

Managers should make the use of existing information their first priority. Frequently, adequate information to provide a basis for action either exists or can be made available relatively quickly and easily. Managers should identify information relevant to the requirements of the planning and implementation processes in, for example, government agencies and certain non-governmental organisations (NGOs), such as producers' organisations. Then they should make the appropriate organisational changes to ensure that this information is channeled to the appropriate points. Sound professional relationships should be developed between information users and providers to ensure that the latter are aware of the value of the information they supply and to improve the quality of the data and interpretive products.

Information provided by local people is an essential element of the planning process in coastal areas. Coastal profiles (see Table 5.3) can be assembled with little difficulty to complement scientific information. They enable planners to benefit from the knowledge of local people.

In most developing countries, there is a lack of adequate information. Even in developed countries, policy makers and managers will never have all the information they need or desire. This should not be a reason for inaction, or policy paralysis. Useful action can often be taken even when the available information is limited.

5.5.2 Monitoring

Strategic and technical considerations related to monitoring have been described in a number of publications (e.g., GESAMP 1980, 1991, 1996; NRC, 1990). The intention here is not provide a detailed discussion of monitoring, but rather to stress the components of marine environmental monitoring strategies that are essential to achieve useful and cost-effective results.

Perhaps the most important consideration for a monitoring programme is the necessity to state clear, specific, and realistic objectives. There is ample experience from national and international monitoring programmes that the failure to do so often results in the expensive collection of data that is of little management value. The objectives should not only specify what is required of the monitoring programme itself, but be closely tied to the broader environmental objectives of society. The design of monitoring programmes, therefore, must not simply involve, but be driven by, managers rather than scientists. The proper role of scientists in an environmental monitoring programme is to ensure that the programme is scientifically sound. Research undertaken by a monitoring or broader management programme should focus almost exclusively on reducing key management uncertainties. Monitoring and management programmes do offer opportunities for basic research that improves understanding of the natural system. Such opportunities should be seized, but basic research should, in general, be funded by mechanisms outside of the management programme.

International Cooperation in Monitoring

International and regional cooperation can be particularly beneficial in developing monitoring capabilities, and data quality assurance programmes. Most regional agreements on protecting the marine environment (e.g., UNEP's Regional Seas Programme) provide for scientific cooperation between signatory states to facilitate common approaches and assist the development of methodologies and indigenous expertise in research and monitoring. Transferring experience between laboratories with common programmes and objectives - and the opportunity to compare methodologies and analytical results - can improve the efficiency of monitoring and reduce the uncertainties associated with analytical measurements.

At the technical level, the objectives must specify the geographic areas, issues and, in quantitative terms, minimum levels of environmental change that are of interest to management - and therefore the scope and detection limits required of the programme. This determination should not be made simply with regard to detecting environmental degradation, but provide early enough warning of impending degradation to allow preventative action. There is a trade-off between cost and the ability to detect small changes, so the specification of objectives and programme design are often an iterative process.

Monitoring must also be designed to provide a basis for action, for example to identify sources that require management intervention or to support enforcement. Monitoring should, in fact, be "reactive", meaning that the course of action to be taken in the event of a threshold level of environmental change should be predefined. This not only improves the targeting of programme design to management needs, but ensures that the debate about appropriate actions in the face of environmental change precedes the observation of that change, and therefore that action is timely (Connor and Sommaripa, 1997).

Collecting data without regard to their eventual use is a common failing of monitoring programmes . It is critically important to produce interpretive products that serve the needs of different clients, including policy makers, managers, and the general public. Full use should be made of information technology, which is increasingly cheap and efficient (see Table 5.3). In this regard, it is worth investing, at least modestly, in information delivery (e.g., to employ a Director of Information linked to the data processing function).

An important function of monitoring programmes is to measure the effectiveness of environmental management, as well as trends in the environment. This should include assessment of the impacts of management intervention upon environmental outcomes, as well as routine institutional evaluation.

Monitoring programmes can only be effective if provided with the financial, human, and technical resources required to meet the objectives. Given the critical importance of trend analysis, this implies long-term resource commitments. Conversely, monitoring designs must be realistic in light of available resources and the likelihood of funding variations. Monitoring should be built into the routine workload and budget of the responsible agency (Andersen, 1997). It is also generally preferable to use the simplest available measurements consistent with achieving the stated objectives. Wherever possible, support should be given to low-cost, community-managed monitoring systems (GESAMP, 1996).

5.5.3 Specific Needs for Information and Technical Development

There will always be gaps in the information available for environmental management, and technical deficiencies in the available tools. Managers should identify these, in consultation with the appropriate technical staff (e.g., engineers, economists, natural scientists, sociologists, etc.), and build research and development to address them into strategies and plans. Many of these needs will be specific to a given regional, national, or local situation, but there are others that apply more generally. Some of the most important of these are identified in the sections below.

The present report highlights the overarching need for better methodologies for integrated assessments. Improved methods are needed consistently and transparently to assess and prioritise issues related to the effects of LBAs upon the marine and coastal environment; to consider scenarios resulting from different courses of action; and to identify the most important uncertainties in available information. Such methods would be particularly valuable in improving regional assessments and developing regional action plans. They could be developed in cooperation with other frameworks (e.g., GIWA, IGBP, IPCC, LRTAP) or based upon work carried out in them.

Biological, Chemical, and Physical Information Needs

High-priority needs for better biological, chemical, and physical information include:

- patterns of variability in hydrography and climate;
- inventories, mapping, and trends in the status of major habitat types;
- relationships between environmental and human health;
- basic baseline data, in most regions;
- sources, transport pathways, and fates in the environment of certain contaminants;
- relationships between anthropogenic stresses and environmental responses. Better predictive models to evaluate the environmental risks of LBAs is needed;
- understanding of dose-response relationships, in particular the effects of chronic, low-level exposures to contaminants;
- effects of elevated nitrogen input on the open ocean;
- relationships between elevated nutrient input and altered nutrient ratios and algal blooms; and
- ecosystem dynamics, function, and linkages to support economic valuation.

Technological Research and Development Needs

High-priority areas for technological research and development include:

- clean technologies, particularly ones suitable to the conditions prevailing in developing countries, and their rapid and effective transfer;
- monitoring methods and technologies that are more cost-effective, require less technical capacity, and provide for improved quality control;
- more consistency in selecting parameters and analytical procedures in assessment and in monitoring programmes;
- environmentally friendly substitutes for materials, products and processes, and for activities that have adverse environmental effects;
- Surveillance, enforcement, and the dissemination of information;
- improvement and dissemination of best environmental practice regimes for various industries;
- techniques for predicting and managing the cumulative impacts of small-scale development;
- techniques and technologies to reduce key uncertainties in measuring key parameters related to the effects of nitrogen input to the open ocean;
- development and dissemination of more appropriate methods of sewage treatment, especially small-scale, on-site systems; and
- more efficient and reliable indicators of the state of the environment, including trends.

Economic and Social Information Requirements

The initiation of sound environmental strategies and policies should be based on an understanding of the benefits provided by marine and coastal ecosystems. It is not always possible to place monetary values on environmental benefits. It may be possible to identify and quantify (although often with great difficulty and tenuously), the "use values" which represent the commercial and amenity benefits of, for example, a marine ecosystem[3]: but the "non-use values"[4], which represent more intangible benefits, are very difficult to identify in economic terms. Nevertheless, governments should have an understanding of the total value of an ecosystem when evaluating interventions.

High-priority needs for economic and social information include:

- uses of the marine environment and marine resources and how they are changing;
- economic values of coastal ecosystems;
- links between environmental indicators and sustainable development;
- economic valuation of the benefits and costs of environmental protection/degradation;
- analysis of the effects of economic and development policy on the environment.

5.6. POLICY AND ORGANISATIONAL REQUIREMENTS

5.6.1 Coordinated Management

In rural areas, some progress can be made in controlling environmental degradation even without coordination of all the concerned sectors and institutions. In urban areas, progress without coordination is much more difficult, because organisations usually have much more jurisdictional and sectoral overlap. In this situation, divided but overlapping responsibilities often result in inadequate programme implementation, even where environmental concerns are taken into account. For example, investment in controlling industrial pollution may not be integrated with investment in wastewater treatment, or treatment plants may be constructed without the necessary interceptor and trunk line sewers (World Bank, 1992).

In many countries, policy decisions are taken without regard for their downstream environmental costs, which may be in neighbouring jurisdictions. Coordination is needed to bring about the holistic management required to minimise these costs (see 5.1.1). Strategies and policies should be formulated though the coordination of all stakeholders (e.g., line agencies, local government institutions, NGOs, and community groups). Horizontal and vertical cooperation between institutions, with clear lines of authority established within each institution, is vital. This coordinated approach has to involve institutions, municipalities, industry and agriculture organisations, etc. in catchment areas. The coordinated policy formulation process should include implementation procedures, schedules, and provisions for cost sharing (see, for example, Pernetta and Elder, 1993; Scialabba, 1998; Sorensen and McCreary, 1990; UNEP, 1995, 1996).

Many countries are not moving towards a coordinated approach to natural resources management. This reflects a lack of commitment at high government levels, often resulting from a lack of understanding of the national benefits provided by marine and coastal ecosystems (see 5.1.3).

Governments should consider undertaking an institutional analysis that reviews the roles of all government agencies with regard to the environment, their relationships with non-governmental bodies, and the financial and human resources at the agencies' disposal. Such an analysis should be carried out in the context of understanding by government of the significant economic benefits, both priced and non-priced, generated by the country's habitats and natural resources and of the immediate costs of environmental degradation, including, for example, those related to public health. Environment ministries are sometimes the most appropriate institutions to act as the lead agencies in coordination, but are too weak to effectively fulfill this role in many countries .

5.6.2 Twin track Management

Overall goals, strategies, policies, and policy instruments will usually be established centrally, but implementation is better when it is decentralised. Catchment and coastal area assessment, analysis, and management are often best done at the local level. Similarly, intersectoral groups in urban areas are best equipped to provide strong mechanisms for the management of air and water pollution based on local knowledge . Lessons learned at the local level, and proposals based on these - for example for new legislation - should be fed into the strategy and policy formulation processes.

5.6.3 Public Participation

Participatory approaches offer many advantages including:

- they give planners a better understanding of local values, knowledge, and experience;

[3] For example, the commercial benefits of a reef system may be commercial fishery and the amenity benefit may be its value as a storm barrier.
[4] Non-use values are existence values and bequest values. Existence values is the present intrinsic value to a society of a particular resource, excluding and direct economic benefits it may produce. The importance of a resource to a culture of a society is an example of an existence value and it is, clearly, very difficult to establish a monetary value for it. A bequest value is the value that a society puts on its desire to preserve the intrinsic characteristics of a resource for future generations.

- they win community backing for management objectives and community help with local implementation;
- they can help to resolve conflicts over resource; and
- they can increase peoples' willingness to pay for environmental management.

Local community participation in the management of coastal areas through integrating conservation and development activities builds on the principle that local communities must be involved in devising and implementing ways to protect the environment. Typical approaches in obtaining participation through consultation include: the creation of consultative committees; public meetings; informal consultations with stakeholders; the publication of discussion papers; and the use of public media to inform and provide a forum for discussion and promotion of the active role of local NGOs. Such processes often result in more comprehensive, efficient and successful management than would occur otherwise. Techniques such as rapid rural appraisal, and particularly participatory rapid rural appraisal (see Table 5.3) help generate participation in the early stages of area planning.

Community groups can play an important part in the enforcement of environmental legislation. The success of such approaches depends on readily available information, in non-technical terms, to help the public - and particularly community groups - to monitor their environment and seek redress if necessary. Public disclosure of standards can help focus the attention of management on pollution and on the opportunities for controlling it, and can supplement official monitoring with public and community oversight (World Bank, 1992).

Natural resources are often best managed by local people, often through traditional institutions and practices. Community management is not necessarily a lower cost alternative to conventional enforcement. It is time consuming, and resource users need continuing support. Where community management is not appropriate, participatory approaches that involve local people in decision making are very much more effective than reliance on conventional enforcement alone.

5.6.4 Education

Education can play a powerful role in environmental protection. Children taught about the value of their environment not only carry this learning into their adult lives but relay the lessons to their parents. Informal education programmes about environmental concerns brought to rural communities through film shows, plays and, poster exhibitions, for example, have proved to be effective in many parts of the world. Educating women and girls can be particularly effective, leading to reduced infant mortality and to lower rates of population increase, which in turn often reduce pressure on natural resources.

5.6.5 Institutional Capacity

Few developing countries have the organisational, policy and legal frameworks, or the human and financial resources, to manage their coastal areas effectively. Consequently, the implementation of national measures and global and regional agreements is slowed, causing countries to carry rising environmental costs. The overriding need in most countries is for a higher level of skills, particularly in environmental planning and management and in environmental law and economics; many are relatively well equipped with natural scientists.

5.6.6 Environmental Legislation

The identification of appropriate, practical legal mechanisms to give effect to such principles as sustainable development is a major challenge facing those drafting of legislation (Scialabba, 1998). In general, environmental legislation for coastal and catchment areas provides for a number of legal mechanisms, including:

- recognition of customary rights, provision of public and private property rights, and revision of property rights when the management regime obstructs the attainment of desired environmental objectives;
- establishment of an institutional framework (e.g. enabling legislation for agencies);
- establishment of regulations, criteria, standards, and implementation guidance, with associated provisions for enforcement;
- establishment of protected areas;
- zoning, set back lines and administrative controls on development;
- restrictions on certain agricultural and forestry practices that result in soil erosion or excessive depletion of standing forest; and
- EIA requirements.

The usefulness of legislation is entirely dependent on the level of compliance with it. When governments lack the ability to elicit compliance - be it through enforcement, stakeholder participation, education, or other means - environmental legislation will not only be ineffective but often counter-productive, since it will fall into disrepute. Governments should therefore include a realistic assessment of the prospects for compliance in the process of drafting legislation.

A number of concepts to support good environmental management are frequently implemented through national legislation. They include the precautionary approach, the need for preventive action, amelioration, and the polluter-pays principle.

5.6.7 Regulatory Autonomy and the Provision of Services

Experience in a number of countries has shown the value, in terms of improved efficiency and a higher level of environmental protection, of having separate, autonomous agencies to undertake the regulation of government agencies that provide public services (World Bank, 1992). Such separation removes conflicts of interest and helps industrial plants, public utilities and municipalities to focus on well-defined objectives.

5.6.8 Institutional Frameworks at the International and Regional Levels

A number of international agreements contain general provisions for the protection and preservation of the marine environment Among the more important are: Part XII of the United Nations Convention on the Law of the Sea - UNCLOS; the London Convention of 1972; the Ramsar Convention on Wetlands of International Importance; and the United Nations Convention on Biological Diversity. Many, such as the Ramsar Convention and the London Convention, have had significant success. Unfortunately, the primary and stringent obligations in UNCLOS have not been translated into more specific LBA objectives and initiatives in most regions. As with all international law, responsibility for implementation and enforcement rests primarily at the national level.

The GPA/LBA does not have the status of an internationally legally binding agreement. Although the institutional framework of the programme appears to be rational and cost-effective, its implementation is proceeding slowly. This is partly because of financial constraints and inadequate support from UN agencies that were expected to play a major role in implementing it from within their available resources. It thus appears that the governing bodies of these agencies have not been persuaded to diverthuman and financial resources to the GPA/LBA in any meaningful way . Another factor contributing to slow implementation is that governments, which bear most of the responsibility for implementing the GPA/LBA, have not taken advantage of it in shaping national and regional responses. Contributing to this is the fact that citizens have not held their governments to account for their inaction, perhaps due, at least in part, to their lack of awareness of the GPA/ LBA.

The situation is not so bleak at the regional level. In a number of regions, legally binding intergovernmental agreements and programmes for the control of LBA (albeit mostly unrealistic ones) have been adopted that take into account regional priorities and capabilities. The adoption of the GPA/LBA has provided a new impetus and a global framework for these regional programmes. However, their implementation is again slow, because of weaknesses at national levels where it is to be carried out.

5.6.9 The Policy Process

Strategies, plans, policies and projects should all be part of an iterative process comprising information collection and analysis; formulation; and implementation accompanied by monitoring and review, or evaluation. The results of on-going monitoring and evaluation should be used to modify programmes, as necessary ,and to use the lessons learned in designing other programmes. The process of iteration based on evaluation makes the programme cycle a learning process.

Experience in single sector renewable resources management and in cross-sectoral management, points to the value of policy makers accepting relatively modest initial objectives, and accepting that progress might be relatively slow in the early years of coordinated coastal management, as experience is gained. With subsequent iterations of the programme cycle, the experience and additional skills of managers, administrators, scientists and economists will enable policy makers to set more ambitious objectives, and to expect improvements in institutional performance in achieving them.

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6

Conclusions and Priorities for Action

6.1. CONCLUSIONS

Land-based activities are the major sources of problems and threats facing the oceans, especially coastal areas, except for the effects of fishing and the threats posed by global climate change.

In the past decade, there have been some notable successes in curbing the negative impacts of land-based activities on the marine and coastal environment. Unfortunately, from a global perspective, the degradation of the oceans and coastal areas has continued, and in many places even intensified. Degradation is much more severe in the coastal areas than in the open ocean.

The most serious problems associated with land-based activities are:

- alteration and destruction of habitats and ecosystems;
- effects of sewage on human health;
- widespread and increased eutrophication;
- changes in sediment flows due to hydrological changes.

These problems are not new; that this is so reflects a failure adequately to address both the long-term trends of environmental decline and acute, short-term threats. The root causes of these problems lie in widespread poverty, often associated with the pressure of population on natural resources, and poorly planned economic development. A major contributory factor is the lack of determination of governments and their publics to adopt and implement effective long-term solutions in the face of the necessity to meet short-term needs.

A critically important consideration in formulating strategies and policies to deal with the problems presented by the negative effects of land-based activities on the marine environment is that individual causes and effects cannot be dealt with in isolation because of their intricately interlinked nature. These linkages include:

- the ecological interdependence of the marine and terrestrial environments, which are linked by complex atmospheric, geological, chemical and biological interactions;
- the social and economic interdependence of human activities on particular ecological linkages;and
- the transboundary nature of coastal and marine environmental problems, necessitating international cooperation in setting common objectives and in implementing compatible policies and programmes.

The priority action areas for the control of land-based activities to improve the quality of the marine environment are:

- to recognise and deal with market failure;
- with respect to pollution, to focus management effort on sewage, nutrients (especially nitrogen) and sediment mobilisation;
- to prevent habitat destruction and loss of biodiversity by the enforcement of legal, administrative and economic measures appropriate to local circumstances;
- to establish protected areas for habitats and for sites of exceptional scenic beauty or cultural value; and
- to integrate the management of coastal areas and associated watersheds.

6.2. RATIONALE FOR ACTION

6.2.1 The Value of Marine and Coastal Ecosystems and Renewable Resources

As well as the market priced values, such as fish, forest products and tourism (direct use functions) that marine ecosystems provide - primarily to the maritime countries in whose exclusive economic zones they occur - they also supply enormous benefits to the international community as a whole through their ecological functions (or indirect use functions), such as nutrient recycling, storm protection and water supply. This fact has been reflected in a number of international instruments concerned wholly or partly with the protection of marine ecosystems and renewable resources from the effects of land-based activities. These include, notably: Chapter 17, Programme Area A of Agenda 21 (United Nations, 1992), endorsed at The United Nations Conference on Environment and Development, Rio de Janeiro, 1992; and the GPA/LBA, adopted three years later at an inter-governmental conference in Washington, DC; as well as more limited agreements, such as on the dumping of radioactive and other wastes and agreed procedures for handling other wastes.

It is difficult to put a monetary value on the worth of the services provided by marine natural ecosystems and natural capital stocks in the form of ecological life support systems and renewable resources. Recent research (Costanza *et al*, 1997, 1998) has valued marine ecological life support systems and renewable resources, including coastal wetlands, at about US$ 23 trillion a year (1994) - almost the same as the global annual gross national product of about US$ 25 trillion (1994). This amount includes the market value of goods and the value put upon the ecological functions of ecosystems, but not values which are even more difficult to assess in monetary terms - such as bequest values (the perceived value of passing the ecosystem or resource on to future generations) or existence values (the value placed on an ecosystem or resource because it exists). The coastal environment is very important within this figure, contributing almost two thirds of the total value.

There are many conceptual and practical problems in assessing the value of these services but, whatever the true figures, the research quoted above illustrates in monetary terms the magnitude of the ecological linkages that, together, constitute the marine ecosystems, human activities and human welfare. Unless controlled, human activity damages marine ecosystems. In doing so, it imposes economic costs through the reduction of the "natural capital" that the ecosystems and renewable resources supply. It is clear that the health of the oceans - in which the coastal areas play a critical role - is vital for the world's economic wellbeing

The effects of land-based activities threaten all marine services, but particularly those provided in the coastal environment. Estimates of the extent of the damage are not available, but empirical evidence suggests that economic losses are mounting year by year together with unknown losses of biodiversity. These economic and biodiversity losses affect almost all countries directly or indirectly, not only those where they occur.

Death and disease resulting from the impact of contamination of the marine environment affect many millions of people annually. As well as the human suffering involved, the economic costs are considerable, amounting to an estimated US$12-24 billion annually.

6.2.2 Cooperation Between Countries to Deal With the Problem

The primary responsibility for controlling land-based activities so as to minimise threats to marine and coastal systems lies with the countries concerned. In two respects, however, countries are unable to deal with the problem unilaterally. Firstly nations have to cooperate at the global level to enhance the capacity and capability of developing countries to deal with the threats from their activities. Secondly, they must co-operate at the regional and sub-regional levels where land-based activities have transboundary effects, as contaminants are carried by the atmosphere, rivers and by the sea.

At the global level, the international community has agreed to international instruments, but these have been implemented only to a limited degree. In general, they have proved to be inadequate to deal with increasing threats generated by the growing demand for scarce resources. Most importantly, many developing countries that have demonstrated the political will to take effective action lack the necessary institutional, managerial, financial and technical capabilities. Having regard to the global implications of the economic costs of marine systems degradation, cooperation between industrialised countries and these developing countries to reduce such costs is not altruism but in the economic interest of the cooperating countries.

In perhaps most cases, the land-based activities causing environmental damage are located within the country where their impact is most severely experienced. However, the effects are frequently also carried across national boundaries. Individual States have a duty not to cause harm to others; but their capability to act effectively is often reinforced when countries cooperate at the regional and sub-regional levels. Such cooperation can minimise the transboundary effects of land-based activities on the marine and coastal environment , and can enable countries to develop cost-effective ways of dealing with problems common to all. It frequently requires technical and financial resources that the participating countries are not able fully to provide themselves: industrialised countries have a role in this regard.

6.3. ROOT CAUSES OF ENVIRONMENTAL DAMAGE

The damage caused by the frequently negative effects of land-based activities on the marine and coastal environment stems from two sources. These are poverty - often associated with excessive population pressure on natural resources - and the negative effects of economic and social change. Consumption patterns in the industrialised countries contribute to pressure on natural resources. At the secondary level, institutional failure allows these factors to have a powerful effect, most importantly when governments are unwilling or unable to correct the market failure that occurs when markets do not fully reflect the value of the resources. A major part of the reason why governments fail to act is their reluctance to adopt the necessary measures that yield benefits in the long-term when pressed to meet short-term needs or to channel financial and human resources from other areas of government responsibility, such as defence.

The connection between poverty and resources degradation is well documented and there is strong and growing evidence of the links between poverty reduction and environmental goals (World Bank, 1992). There is, therefore, a strong case to be made for poverty reduction programmes, such as education, agrarian reform and the creation of employment opportunities. Apart from their moral justification and direct economic benefits, such programmes are an essential basis for environmental improvements in many developing countries.

Economic and social change in coastal areas usually results in increasing pressure of demand for scarce natural resources both in them and in associated watersheds. In the absence of a sound environmental policy, land-based activities generate negative externalities, represented by the degradation of marine and coastal resources as markets fail fully to reflect their value.

The failure of governance associated with such market failure allows the root causes to have a devastating effect on natural resources and ecosystems.Allocating resources through the establishment of property and use rights is central to overcoming this failure. Two other features of good governance in this regard are, first, the true indication, through environmental valuation, of environmental goods and services and, second, the internalisation of environmental costs. Failure to follow these prescriptions inevitably results in natural resource loss and ecosystem degradation. Governments are often at fault, but the informed and effective involvement of stakeholders and the public in policy making processes - and in holding governments accountable for their actions, or lack of them - is essential. Together, they can ensure the enactment of appropriate policy and legislation frameworks. The effectiveness of such frameworks depends, in turn, on the adoption by governments of the priority actions described below.

Governments are responsible for formulating and implementating policies. Difficult decisions have to be made on allocating, not only the natural resources but also the human and financial ones available to governments. These decisions may affect both private interests and governmental institutions as financial and human resources are redirected from them to others. Government determination to make the necessary reforms is the essential prerequisite of successful environmental policy.

6.4. GESAMP PERSPECTIVES ON THE GPA/LBA

GESAMP'S perspectives concern both the over simplification of the classification of chemicals and the ignoring of distinctions between wastes (mixtures) and contaminants (substances) that characterise the GPA/LBA. It also has some differences with regard to its identification and treatment of priorities.

Examples of the oversimplification of the classification of chemicals, shared with other international environmental programmes, are the terms "Persistent Organic Polluters (POPs)" and "endocrine disrupters" that have no basis either in chemistry or toxicology. A clear case of the lack of distinction between wastes and contaminants is the inclusion in the GPA/LBA of sewage in the list of marine contaminants; these lists typically contain nutrients, metals and other substances that are significant components of sewage. Such lack of precision is unnecessary and can lead to anomalies, and occasionally ambiguity, in measures and recommendations designed to prevent pollution by hazardous materials.

A number of the actions proposed in this report are within the GPA/LBA. However, it has not been possible to support to the same degree two priorities it identifies. These are: (i) the establishment of a clearing house mechanism which would identify information needs and sources of information; and (ii) the mobilisation of funds for major investments. GESAMP would also place more emphasis on institutional capacity building to enhance good governance than appears to be the case in the GPA/LBA.

With regard to the proposed clearing house mechanism, it is strongly agreed that policy makers, environmental managers and their advisers need better access to information. In particular, they need better technical information and assistance to evaluate local conditions and the likely impacts of specific developments and to identify and evaluate management options. GESAMP, however, would not assign a similar level of importance to the clearing-house mechanism as does the GPA/LBA. It further considers that a brokerage mechanism to facilitate direct contacts between those needing financial and technical assistance and those in a position to offer such assistance may be of greater value in promoting the implementation of the GPA/LBA than the mere provision of information. In any event, local action to protect the marine environment should not be delayed pending the development of the clearing-house.

In relation to the mobilisation of funds, the GPA/LBA recognises that the scale of financing required will vary with the circumstances. Nevertheless, there appears to be an implicit emphasis on large-scale investment that takes attention away from the fact that relatively small-scale investment opportunities constitute much of the financing required by developing countries. For example, the GPA/LBA's recommended approach for sewage focuses on the provision of capital intensive reticulation and treatment systems, with little attention being given to innovative, low-cost approaches. While there are many requirements for large capital investments, an important consideration in making them is the capability of the country where investment is taking place to maintain the infrastructure provided. Capital investment requiring skilled and costly maintenance is often not the most cost effective use of funds, and alternative, low cost and innovatory options often better suit the countries' needs. In other cases, opportunities for private sector investment and management should be stimulated and encouraged. Most financing needs are at the level of technical cooperation and the relatively low levels of capital funding designed to help countries help themselves.

As noted above, failures of governance associated with market failure are the most important causes of natural resource loss and ecosystem degradation. This conclusion leads to the institutional, legislative and policy actions identified by GESAMP as priorities that differ in a number of respects to those within the GPA/LBA. Notably, institutional capacities need to be enhanced so that governments have the capability, for example, to undertake actions - within the context of an understanding of the economic value of natural resources (although the difficulties in doing so are fully acknowledged) - to establish the net long term economic benefits of intervention, and to design and implement the full range of policy instruments to prevent or mitigate market failure. Such institutional capacity building would appear to be different from that described in the GPA/LBA, which focuses on the need for developing countries to acquire technical skills (an aim that GESAMP also supports). GESAMP would also give greater emphasis to the need for institutional change in countries to provide for an holistic approach to resources management through promoting organisational arrangements that enhance a cross-sectoral approach to the management of land-based activities. Other areas of GESAMP's emphasis include: the need for institutional capacities and legislation to provide for the creation of property and use rights; the decentralisation of management, including its devolution to autonomous agencies, the private sector and communities; promotion of the most appropriate technology as an alternative to high cost, conventional technology; and stakeholder and public involvement in decision-making.

6.5. PRIORITIES

6.5.1 Prioritisation for Action of Physical Alteration and Contaminants

GESAMP agrees that the key objectives of the national and regional programmes for protecting the marine environment from land-based activities, as embodied within the GPA/LBA, should be identifying priorities and establishing targets. In this context, a global assessment cannot be an adequate substitute for informed judgments at the local level. Nevertheless, this Chapter identifies priorities from a global perspective with regard to the contaminants and sources discussed in the GPA/LBA, and provides guidance on the more important actions consistent with them. These priorities are generally in accord with those identified at the regional level (Chapter 4), although not wholly so. Marine activities, such as fishing, are not considered here.

Tables 6.1 and 6.2, respectively, illustrate two complementary approaches to helping determine the level of priority that may be assigned at the global level to the source categories considered in the GPA/LBA. These evaluations are based on the use of the Delphi Technique by a group of natural and social scientists, expert in issues relating to the marine environment, followed by intensive discussions with other scientists. The evaluations, therefore, reflect informed scientific judgement, embodying a high degree of subjective judgment about the contaminants in the marine environment, and their movement through it.

Keys for the symbols used in each table are shown below it. Some care has to be taken in reading the tables. In Table 6.1 it is assumed that each vertical category has the same weight, and the plusses in each vertical category may be summed to give the order of ranking of each source/contaminant: physical alteration is placed higher than sewage, although both have the same number of plusses, on a subjective judgment of the priority to be assigned to each. In Table 6.2, because of the different weighting that applies to each vertical column, the relative importance of each source/contaminant is not a simple sum of the entries but has to be expressed in qualitative terms.

Table 6.1, the impact matrix, evaluates each source category with respect to its impact according to the GPA/LBA criteria of food security, public health and safety, coastal and marine resources and ecosystem health. It is evident within the table that the greatest benefits, in terms of the criteria applied, would result from the effective management of sewage and physical alteration, with managing nutrients and sediment mobilisation also of high priority.

Table 6.2, the global priority matrix, first shows our judgment of the adequacy of the science to deal with each source category. Shown secondly in the table is the geographic scale - global, regional and local - of the impact of each source category on the marine environment. For example, POPs and mercury are global-scale issues as a result of the long-distance atmospheric transport that distributes them over at least hemispheric scales. In contrast, the introduction of sewage and sediment mobilisation are usually local problems, with their impacts generally restricted to spatial scales of tens of kilometers from their individual sources and within a single national jurisdiction. Regional impacts are intermediate between global and local, describing impacts over regional marine areas, usually within number of national jurisdictions. Our as-

Table 6.1. Impact matrix

Source/ category	Food security	Public health	Coastal and marine resources	Ecosystem health	Overall impact
Physical alteration	++	++	+++	+++	+++
Sewage	++	+++	++	+++	+++
Nutrients	++	++	++	+++	+++
Sediment mobilisation	+	+	+++	++	++
POPs	+	+	+	++	+
Hydrocarbons (oil)	++	+	+	+	+
Heavy metals	+	+	+	n	+
Litter	n	+	+	n	+
Radio-nuclides	+	+	n	n	n

Key: +++ = high; ++ = moderate; n = negligible impact

Table 6.2. Global priority matrix

Source/ category	Adequacy of science	Geographic scale of impact	Ubiquity of source	Adversity of impact	Ability to be managed	Benefit/cost ratio of interventions	Priority ranking
Physical alteration	Moderate	Regional	+++	+++	++	+++	High
Sewage	Good	Local	+++	+++	+++	+++	
Nutrients	Low	Regional	+++	+++	+	?	Medium
Sediment mobilisation	Moderate	Regional	+++	++	++	++/+++	
Litter	Good	Regional	+++	+	++	+++	Low
POPs	Low	Global	++	+	+	++	
Mercury, lead	Moderate	Global	++	+	++	++	
Other heavy metals	Moderate	Local	++	+	++	++	
Hydrocarbons (oil)	Moderate	Local	++	+	++	++	
Radionuclides	Good	Regional	+	+	+++	+	

Key: Adversity of impact; ability to be managed; benefit cost ratio: +++ = high; ++ = moderate; + = low
Ubiquity: +++ = found everywhere; ++ = found frequently; + = found sparsely

sessment of the geographic scales of impact is followed by our assessments of: the adversity of the impact of each source category on the marine environment; the ubiquity of sources; our ability to effectively manage each of them; and the order of magnitude of the benefit-cost ratios of management intervention. An overall priority ranking has been made on the basis of this evaluation. It shows physical alteration of the marine environment and sewage as having the highest priority when these criteria are considered. Sediment mobilisation and nutrients also deserve priority consideration.

An evaluation of these two approaches to identifying priorities at the global level indicates that the highest priority should be given to physical alteration, sewage, nutrients and sediment mobilisation.

6.5.2 Priority Actions at the Technical and Management Levels

Physical Alteration

One of the most serious threats to coastal ecosystems is not environmental degradation due to pollution but rather the direct physical destruction, or radical alteration, of habitats. While the direct effects are local, physical habitat alteration has been identified as a priority issue in most regions and is therefore a global problem. Furthermore, coastal habitat alteration may have impacts well beyond the geographic boundary of the affected habitat because, typically, the habitats are important breeding and nursery grounds, and play important roles in fluxes of water, nutrients, and sediments.

The most widespread forms of physical habitat alteration are: the destruction of wetlands by draining, landfill, or modification of water flows (e.g. through canalisation or impoundment); accelerated beach and foreshore erosion because of inappropriate infrastructure development and sediment impoverishment; and the deforestation of mangroves and other coastal forests. Other common forms of physical alteration include: beach, coral reef, and seabed mining; damage from boat anchors, propellers, and wakes; damage from divers and walkers; and the dredging and blasting of harbours and navigation channels. As physical alteration may occur in discrete events (e.g., the reclamation of an estuary for urban development) or as the cumulative effect of small-scale activities (e.g., reef damage from scuba divers), different threats will often require different management measures. However, such measures should be designed and implemented within a coordinated approach to the management of coastal areas and associated river basins, including measures, for example, to reduce rural poverty, to provide education, and to build popular support and local participation into policies. These broader, non-technical actions are referred to again below.

Priority actions:

- **identify and map critical and sensitive coastal habitats, including those already lost or severely impacted;**
- **increase the number, size, and effectiveness of protected areas;**
- **impose moratoria on further destruction of wetlands, mangroves, and other critical habitats**. Moratoria - and requirements for compensatory habitat rehabilitation - will generally only be effective in dealing with large-scale developments, not with cumulative effects of small-scale activities;
- **apply ICM to coastal planning and development;**
- **assess the economic value of coastal habitats when making development decisions affecting them**. In many instances, habitats have higher economic value than the developments for which they are sacrificed, resulting in a net economic loss when a development proceeds;
- **impose setback limits, zoning restrictions, and similar shoreline protection measures** in the overall context of these ICM regimes; and
- **expand research to support the economic valuation of coastal habitats**, including ecological linkages among habitats and marine resources, predictive models of ecological responses to stresses, and patterns and economic value of human use of coastal resources.

Sewage

The effects of individual sewage discharges are usually localised, but sewage is a major source of marine contamination in all regions, and is therefore a global issue. The chief concerns are: human health impacts from exposure to pathogens, via seafood contamination or contact with contaminated water; resultant losses in fisheries and tourism revenues; and the environmental impacts of nutrients, BOD, suspended solids and other components of the sewage. Pathogenic microorganisms in sewage-contaminated marine and estuarine waters cause a massive transmission of infectious diseases to bathers and to consumers of raw or undercooked shellfish. The global economic impact of such illness has been estimated at over US$10 billion annually.

Available measures to reduce these impacts include: appropriate siting of discharges; conventional treatment; and the development and application of alternative technologies such as composting and biogas generation. Conventional treatment technologies are well-developed, but should not be regarded as a universal panacea. They require large capital investment in collection and treatment infrastructure, often necessitate high ongoing operational costs and technical capacity, and in certain settings (e.g. low-lying areas subject to frequent flooding) have significant technical limitations. It should not be assumed that higher levels of sewage treatment are always desirable. For some sewage-related issues (e.g. suspended solids and litter), minimal treatment is often adequate and higher levels provide only marginal improvement. The effective removal of nutrients is expensive and only justified when sewage inputs of nutrients are of concern; in low-nutrient waters vulnerable to eutrophication (e.g. tropical lagoons), even advanced tertiary treatment may not achieve adequate reductions of nutrient discharges. The appropriate siting of effluent discharges to enhance dilution and dispersion, minimise environmental impact, and/or reduce human exposures to sewage-borne pathogens is often less expensive, more effective, and more operationally sustainable than advanced treatment. It is, in any case, essential regardless of the level of treatment.

Priority actions:

- **develop and apply more appropriate technologies and practices**. In many regions the provision of conventional collection and treatment infrastructure cannot keep pace with urban growth, and may not be appropriate to local circumstances. Less centralised and less capital-intensive technologies (e.g., improved septic systems, composting toilets, small-scale biogas and treatment plants, use of artificial or natural wetlands) may offer more appropriate solutions, and improved opportunies to re-use valuable components of sewage (e.g. water and nutrients);
- **immediately improve the implementation of existing measures**. Relatively simple and inexpensive measures such as better design and installation of septic systems, better maintenance and operation of existing treatment plants, and improved siting of municipal sewage outfalls could yield significant gains in many, if not all, regions;
- **link capital investment in infrastructure to sustainable financing for ongoing maintenance and operational costs**. Large expenditures on collection and treatment works achieve little if there is not adequate financial and technical capacity for operations and maintenance. In particular, new sewerage projects in developing countries should include long-term provisions for operations and maintenance, including local capacity building; and
- **prioritise issues, set objectives, and assess all alternative solutions** objectively and with regard to environmental goals and the nature and uses of receiving water. Pathogens, nutrients, organic materials and other components of sewage pose different environmental risks, requiring different measures to address them that depend upon the nature and uses of the receiving waters. Siting of discharges is often more important to environmental outcomes than the level of treatment. For example, disposing raw sewage in well-flushed deep oceanic waters through a long outfall may have less environmental impact, lower costs, and less risk of failure than discharging tertiary-treated effluent into an enclosed nearshore basin.

Nutrients

Land-based activities are the dominant source of nutrients, especially fixed nitrogen, in the ocean. As is the case with sewage, nutrient inputs are often very localised, but in aggregate they form a major source of marine contamination in all regions and are therefore a global issue. There are three main sources of anthropogenic nutrient input:

- fertiliser in agricultural runoff and, to a lesser extent, aquaculture facilities;
- releases to the atmosphere from fossil fuel combustion and, to a lesser extent, from agricultural fertiliser and manure. These nutrients are subsequently deposited in watersheds and the ocean, often after long-distance atmospheric transport; and
- sewage and industrial discharges. Though these are relatively minor globally they may be dominant nutrient sources in local areas, especially basins with restricted water circulation.

Growing evidence indicates that the effects of nutrient input from land-based activities include: general stimulation of the growth of phytoplankton and benthic algae; large-scale oxygen depletion from the decomposition of organic matter produced by phytoplankton growth; changes in phytoplankton community structure resulting from altered nutrient ratios, often favouring toxic or otherwise undesirable species; increased frequency in algal blooms, and perhaps a disproportionate increase in harmful algal blooms (HABs); and the degradation of coral reefs, seagrass beds, and other habitats from algal overgrowth and reduced light penetration. The overall effects on fisheries are not clear because of the many factors that may account for fish mortality. However, nutrient inputs in some areas (e.g., parts of the Mediterranean and North Sea) have led to increases in fisheries production. In other areas, where there are high concentrations of nutrients and a low level of flushing of the affected area, there have been significant reductions in catches. The impacts of point-source discharges can be managed by siting discharges appropriately and, in some cases, by treatment, but managing the dominant, non-point sources requires far-reaching changes in policy and practice.

Priority actions:

- **identify and correct policy failures**. Examples include: inappropriate agricultural subsidies or transportation policy; subsidized energy and fuel consumption; and inadequate institutional arrangements, particularly including the absence of independent regulators;
- **disseminate and implement existing best-practice regimes in agriculture and aquaculture**. Practices have already been developed that reduce non-point nutrient inputs to rivers and coastal waters. Examples include improved methods of fertiliser application; improved fertilisers; the use of artificial or natural wetlands to intercept and assimilate nutrient runoff; improved storage of fertiliser and manure; and improved land and aquaculture management;
- **improve upon existing best practice in agriculture and aquaculture**. Further reductions can almost certainly be achieved through refinements to the best-practice regimes that already exist and the development of new ones;
- **reduce nitrogen emissions from vehicles**. This will require action on a number of fronts, including more widespread implementation of existing technology (e.g. catalytic converters, cleaner engines), the development of new technologies, and changes in transportation systems (e.g., improved mass transit, electric vehicles); and
- **improve control of emissions from industrial facilities and fossil-fuel power plants**, including the application of the best appropriate technology. While vehicles are a larger global source of atmospheric nitrogen emissions, point-source industrial facilities may be more amenable to control and yield higher marginal reductions per unit investment in the short term.

Sediment Mobilisation

Land-based activities can both increase and reduce sediment fluxes to coastal areas. Increased fluxes result largely from soil erosion due to deforestation, agricultural activity and construction in watersheds, as well as from port development. Long-term damage, lasting perhaps many decades, can result from poorly managed mining operations. Increased sediment flux degrades reefs, seagrass beds, wetlands, and other coastal habitats through siltation and reduced water clarity - and therefore light penetration. It may also alter benthic community composition. Reduced fluxes from dams, and other forms of water diversion, impoverish supplies of sediment to deltas and beaches. In some regions this has caused problems resulting from shoreline erosion and saltwater intrusion. Land-use practice and engineering works are the primary management tools for addressing the issue of altered sediment fluxes.

Priority actions:

- **disseminate and implement existing best-practice regimes in agriculture and forestry**. These may include improved land-management, road-building, and harvesting practices;
- **give higher priority to protecting the physical integrity of coastlines and watersheds**. This means using techniques and adhering to practices to control sediment mobilisation in watersheds and coastal areas; and
- **include the environmental and social costs and benefits of altered sediment fluxes in economic assessments of project viability and engineering alternatives**. At the very least, predicted downstream effects of alterations in sediment flux resulting from large projects should be characterised qualitatively and not only in terms of physiographic and ecological changes. Ultimately, quantitative economic estimates should be attached to these predictions, and the costs internalised in assessing the economic viability of projects.

Persistent Organic Pollutants

Persistent organic pollutants (POPs) have initially been defined as 12 classes of organic chemicals that decompose very slowly in the environment and accumulate in organisms. They can be transported long distances via the atmosphere. They have a range of adverse biological effects and, in some regions, may pose human health risks from ingestion in seafood. The environmental and human health effects of long-term sub-lethal exposures to POPs, individually or in combination, are poorly understood. Three groups of POPs have been implicated: industrial chemicals (PCBs, hexachlorobenzene); pesticides; and by-products from waste incineration and pulp mills (chlorinated dioxins and furans). Control measures vary among these groups, but include: bans on production, use, or discharge; improved practice (e.g. better incineration practice can reduce dioxin production, while integrated pest management can reduce dependence on pesticides); substitution with less harmful alternative chemicals; and treatment, incineration, recycling, and related measures. Such measures have been effective in reducing atmospheric concentrations of certain POPs. There are, however, many other persistent organic substances that are not presently subject to adequate regulatory controls. Furthermore, the potential effects of the chronic release of many hazardous but less persistent organic compounds are generally not known. Endocrine (hormone) disrupting substances, which include both POPs and other substances, are emerging as a particular concern.

Priority actions:

- **implement best appropriate practice in industries that are major sources of POPs**. For example, process and operational improvements can reduce emissions of chlorinated dioxins and furans from incinerators and pulp mills, and the adoption of integrated pest control and improved training of farmers in pesticide use can reduce pesticides in agricultural runoff;
- **enact and implement regional and international agreements to harmonise regulatory regimes and regulate trade in POPs;**
- **expand research on chronic sub-lethal effects of POPs and other potentially harmful substances on environmental and human health;** and
- **improve enforcement of existing regulations on production and use of POPs.**

Litter

Solid waste, or litter, is concentrated near urban areas, on beaches near villages and in shipping lanes, but is found throughout the oceans. Plastics are the largest component, followed, in urban areas, by steel and aluminium cans. Litter causes mortality to marine organisms, notably sea turtles, marine mammals, and sea birds. The extent of this mortality is unknown, but there is no evidence that it has major effects at the population level. Litter also has negative aesthetic impacts, thereby affecting recreation and tourism, and can be a navigational hazard. Better solid waste management is the overarching solution to problems of marine litter.

Priority actions:

- **improve urban and rural waste management, and (where appropriate) recycling**. This is a particularly difficult problem in small islands where particular actions, such as degradable bulk packaging may be appropriate;
- **develop more degradable packaging materials;**
- **improve public education;** and
- **improve port facilities for solid waste reception and disposal.**

Oils (hydrocarbons)

Although illegal discharges of oil from ships continue to be significant, land-based sources now dominate inputs of hydrocarbons to the marine environment in most regions. The major land-based sources include urban runoff, refineries, municipal waste, and crank case oils. A special category of hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) are produced by the combustion of fossil fuels and transported in the atmosphere, as well as being natural constituents of petroleum; crank case oils are a particularly important source of PAHs. The ecological effects of land-based inputs, which are generally chronic and long-term, are poorly known. Tainting of seafood can have drastic economic impacts, and there are concerns about the human health impacts of some PAHs. In some areas natural systems probably have a high capacity to assimilate petroleum products.

Priority actions:

- **place increased emphasis on reducing chronic hydrocarbon discharges from land-based activities;**
- **enhance collection and proper disposal (including re-use) of used lubricating oils;**
- **improve the interception and removal of oils from domestic storm water**, as appropriate in the context of costs, capacity, and other environmental priorities; and
- **strengthen the risk assessment and management aspects of EIA, as well as accident response**, for refineries, pipelines, terminals, and other land-based infrastructure in the oil industry.

Radioactive Substances

The level of public concern about radionuclides in the marine environment is not generally supported by objective risk assessment. The most important sources of radionuclides to the ocean are past atmospheric weapons tests, which are decreasing in importance, and discharges from nuclear fuel reprocessing plants, which lead to contamination on local or regional scales. Existing controls on routine discharges are generally adequate. The risk of nuclear accidents remains a matter of concern. Assessments of risk associated with radionuclide contamination of the marine environment have dealt almost exclusively with human health risks.

Priority actions:

- **reassess the comparative risks associated with the disposal of radio active wastes into the marine and land environments;** and
- **incorporate environmental considerations into the current system of radiological protection.**

Heavy Metals

The two metals of most concern at a global level are mercury and lead because they are highly toxic, at least in certain forms, and because they are relatively volatile and therefore transported over large distances in the atmosphere. Levels of lead in ocean surface waters are declining in the north Atlantic due to the removal of lead from vehicle fuel. In the Arctic, however, lead and mercury levels are of environmental and human health concern. Tributyl tin and its derivatives, used in anti-fouling paints, are widely distributed and have proved to be more persistent in the environment than expected. They are known to have endocrine disrupting properties in some marine organisms. In some countries, the use of tributyl tin (TBT) has been prohibited in antifouling paints used in mariculture and in smaller vessels (e.g., less than 25 metres),but its use continues in other countries and for certain categories of ships. Measures to phase out the use of TBT on all vessels from the year 2003 may be introduced in response to decisions taken at the IMO. Marine contamination with other heavy metals is largely at the local scale near major sources, primarily downstream from mining operations, metal processing, electroplating, industrial facilities, and waste dumps.

Priority actions:

- **reduce discharges from the metal processing and electro-plating industries by treating effluent, eliminating discharge of untreated effluents to domestic sewer systems, and implementing and improving upon best-practice industrial processes;**
- **develop less expensive alternatives to TBT as an antifoulant;**
- **continue phasing out the use of mercury in chlor-alkali production for the pulp and paper industry;**
- **ensure the adequate containment and/or treatment of leachates from landfills;**
- **provide adequate treatment and/or containment for mine tailings;** and
- **continue phasing out lead from fuel.**

6.5.3 Institutional, Policy and Legislative Priorities

Technical measures to mitigate the effects of land-based activities on the marine and coastal environment require appropriate institutional, policy and legislative support if they are to function effectively. From the preceding chapters, particularly Chapter 5, a number of institutional, policy and legislative priorities can be identified at the national, regional and global levels if the technical measures are to be implemented effectively.

National Level Priorities

There is no doubt that massive improvements can be made in economic efficiency, output, equity, and public and long-term economic prospects in countries as a result of the rational and equitable use of coastal and marine natural resources. This requires governments to either allocate the resources directly or to influence their allocation. The most important single factor is the priority given by governments and their citizens to a strong political commitment to resolving environmental problems. Institutional and policy priorities for achieving a rational process of resource allocation vary from one country to another, but most nations share the following ones in dealing with the effects of land-based activities upon the marine environment.

Institutional Capacities

In most developing countries institutional capacities are too weak to effectively manage natural resources (specifically, the users of natural resources) so as to protect the marine and coastal environment.

Priority actions:

- **increase funding when benefits can be established;**
- **focus on training or re-training of staff**, particularly of environmental economists, sociologists and environmental lawyers; and
- **involve the private sector and NGOs to the maximum extent** to assist in providing accountable and efficient services.

Institutional Arrangements

In most developing and many industrialised countries institutional arrangements are inadequate for dealing with the complexity of protecting the coastal and marine environment.

Priority actions:

- **continue to work towards moving away from sectoral management of coastal and associated river catchment areas to a more holistic approach**, thereby recognising the interdependence of freshwater (including groundwater) and coastal and marine systems and the cross-sectoral effects of land-based activities;
- **provide national institutions with the authority and human and financial resources needed to carry out their tasks;**
- **work towards the optimum level of devolving policy implementation** to local government, autonomous agencies (including regulatory agencies), private industry, communities and individuals;
- **work towards a twin-track management approach which is genuinely top-down and bottom-up in its application** and makes full use of the participation of stakeholders in decision making about resources management which affects them;

- **facilitate the establishment of community groups and other associations concerned with the state of the marine environment** to take an active role in environmental protection; and
- **provide for fair resolution of conflict between competing resource users.**

Legislation, its Enforcement and Voluntary Action

Legislation in many countries is focussed on providing for the legal basis of institutions concerned in the management of natural resources and for the control measures they take to protect the environment. In all countries, enforcement is the weak link in the policy process: this is particularly acutely so in many developing countries where the large numbers of those affected by legislation and weak enforcement capabilities contribute to environmental degradation. Often poor coordination between agencies is another factor contributing to poor enforcement.

Priority actions:

- **design policy instruments which have a large measure of self-policing** through the participation in their design and implementation of those affected by them;
- **enhance implementation through improved coordination of agencies;**
- **introduce legislation only after considering the extent to which it can be successfully implemented;**
- **rewrite legislation to enable the private sector to participate with confidence in the design and supply of utility services;** and
- **provide the legal framework for voluntary action by industry and agriculture to mitigate resource degradation.**

The Rational and Equitable Allocation of Property or Use Rights

The rational and equitable allocation of property or use rights is the key element in policies to correct market failure.

Priority actions:

- **use price mechanisms where appropriate to bring the scarcity of resources and the internalisation of environmental costs to bear on decision making;**
- **where economic instruments are not appropriate, use regulatory instruments, such as zoning, or organizational instruments, such as the establishment of community managed areas;**
- **promote the creation of individual and common property rights;**
- **maintain or re-establish customary rights.**

Strengthening Environmental Considerations in all Areas of Government

Environmental considerations should be incorporated into policy formulation in all sectors where there are direct or indirect implications for coastal and marine resources from proposed actions.

Priority action:

- **ensure that all government departments carry out risk assessments, appraisals of long term benefits and costs of proposed actions, EIA where appropriate, and apply the precautionary approach when there is doubt about the environmental impact of an action.**

Policy Consistency and Stability

Policy inconsistency is a major cause of resources degradation in many, if not most, countries. Policy instability results in uncertainty that often encourages accelerated degradation of resources. An organisationally coordinated approach to natural resources management offers an effective way of avoiding policy inconsistency. However, the importance of the issue means that explicit attention to it should not be delayed until organisational coordination is achieved.

Priority action:

- **adopt legislation or practices that require government agencies to conform to procedures that reduce the risk of policy inconsistency and avoid uncertainty.**

Adoption of Low-cost/High-gain Measures

Particularly where relatively small financial resources are available, countries have to secure the optimum benefits available.

Priority action:

- **focus on measures that yield the maximum benefits for the investment being made**, accepting that: (i) it is not always appropriate to seek immediately developed country standards of water quality and (ii) in appropriate situations it is preferable to adopt relatively low cost, low technology solutions to deal with, for example, sewage.

Provision of Information

Providing information is an important role of government. Firstly, it improves resources management decision making. Secondly it can enhance peoples' ability to participate at different levels in resources management by enabling them to (i) discriminate between real and perceived threats to the marine environment and (ii) to participate more meaningfully in decision making about the use of resources, particularly when they are fully aware of the value of the value of ecosystems.

Priority actions:

- **ensure policy makers are aware of the kinds of and orders of magnitude of economic benefits provided by marine and coastal ecosystems within the country's boundaries;**
- **focus on problems mutually identified by managers and scientists as priorities and provide resources to deal with them;**
- **increase the provision of public information about the environment both generally and in relation to specific issues.**

National Support for Regional Cooperation

Cooperation at the regional level enables countries to make the best use of scarce human and financial resources, most notably in research and training, and helps to minimise the risk of potential intra-regional conflict arising from the potential export of environmental impacts. Implementing regional agreements at the national level is often slow because of weakness there.

Priority action:

- **give a high priority to regional cooperation**

Regional Level Priorities

Some regions, both UNEP Regional Seas regions and others, are at a relatively early stage of development. Other regions, such as the Baltic, Mediterranean, North-east Atlantic and the South Pacific have more experience and have gone much further in the development of regional strategies and compatible measures for the protection of the ocean and coastal environment than regions in which consultative processes have a shorter history. There are valuable lessons to be learned, both positive and negative, from the experience of these more experienced regions in developing strategies for implementation within realistic timeframes and in formulating and implementing measures.

Priority action:

- **identify and implement more effective means to transfer relevant experience from more experienced regions, such as the Baltic, Mediterranean, North-East Atlantic and the South Pacific, to those regions at an early stage of development of GPA/LBA measures.**

To date, most of the flow of information regarding the design and use of policy instruments follows a "North-South track". There is an opportunity to share resources management experience among developing countries that often have similar institutional constraints. This type of exchange is likely to be most valuable at the regional level.

Priority action:

- **enhance information sharing on policy formulation within regions.**

Global Level Priorities

The degradation of marine and coastal resources resulting from the adverse effects of land-based activities occurs primarily but not wholly in the coastal areas of the states where the activities are taking place or in those of their geographical neighbours. These resources have values that are not reflected in the market not only for the coastal states but also for the international community. The wide interest in the need to protect these resources has led to a series of international agreements that have had varying success in achieving their objectives, largely because governments have either determined not to comply fully with their provisions or because they lack the means to do so. The latter constraint is primarily the result of inadequate institutional and technical capacities and relatively weak governance.

Priority action:

- **review international agreements, such as the GPA/LBA, to include provisions for financial and technical assistance with implementation, with the emphasis on helping countries to help themselves through assisting them to strengthen their institutional capabilities.**

Measures to control the negative effects of land-based activities on the marine environment are largely ultimately dependent for their success on macro factors such as political stability, sound economic development and successful poverty amelioration strategies, such as provision of education, agrarian reform, etc. These factors are frequently the focus of cooperation between international institutions and developed countries. The value of this cooperation in mitigating the adverse effects of land-based activities would be further enhanced if special attention were given to the environmental dimensions of programmes and projects provided through international cooperation.

Priority action:

- **incorporate a focus on environmental considerations when appropriate in cooperation between countries and between international institutions and countries.**

The enhancement of the capabilities of national institutions is critical for the protection of the marine environment. This requires action at the multilateral and bilateral levels.

Priority action:

- **increase the level of support provided by the international community to developing countries to enhance their capabilities to protect the marine environment.**

6.6. REFERENCES

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Glossary[1]

algal bloom: A rapid increase in the abundance of phytoplankton or benthic algae in a given area.

alien species (also called introduced, exotic, or non-indigenous species): A species that has been transported by human activity, intentionally or accidentally, into a region where it does not occur naturally.

amnesic shellfish poisoning (ASP). A disease with severe neurological effects caused by eating shellfish contaminated with the marine biotoxin domoic acid. The signature symptom is chronic short-term memory loss (see also **biotoxins**).

anadromous: A form of life cycle in some fishes (e.g., salmon) in which maturity is attained in the ocean, and the adults ascend streams and rivers to spawn in fresh water. (see also **catadromous**)

anoxia: The absence of oxygen.

anthropogenic: Originating from human activities.

aquaculture: The cultivation of aquatic organisms.

aquifer: A permeable geological formation through which groundwater can flow and from which groundwater can be readily extracted. (see also **groundwater**)

aragonite: A crystalline form of calcium carbonate.

background (level or concentration): Ubiquitous and generally very low concentration of a contaminant in a defined marine area, resulting from historical inputs via multiple pathways, especially through the atmosphere.

ballast water: Water carried by a vessel to improve its stability.

benefit-cost analysis (cost-benefit analysis): A technique to compare the relative economic efficiency of projects or policies. A comparison is made between the gross benefits of a project or policy and the opportunity costs (the highest value a productive resource such as labour, capital or a natural resource could return if placed in its best alternative use) of the action.

benthic organism: Bottom dwelling organism.

benthos: Collective synonym for benthic organisms, but frequently also applied to the floor or deepest part of a sea or ocean.

billion: 1,000,000,000.

biodegradation: The breakdown of a substance by biological activity.

biogenic: Produced by organisms.

biogeochemical cycle: The flow of a substance among different places, environmental compartments (e.g., atmosphere, water column, organisms), and chemical forms as a result of geological, chemical, and biological processes.

biological diversity (also called biodiversity): The diversity of life, often divided into three levels: genetic (diversity within species), species (diversity among species), and ecosystem (diversity among ecosystems).

biomass: The mass of living matter per unit of habitat (e.g., volume of water or area of bottom). Synonyms: standing crop, standing stock.

biotoxins: Naturally occurring toxic compounds produced by certain organisms.

catadromous: A form of life cycle in some fishes (e.g., freshwater eels) in which maturity is attained in the fresh water, and the adults descend streams and rivers to spawn in the ocean. (see also anadromous)

coastal area: An entity of land and water affected by the biological and physical processes of both the sea and land and defined broadly for the purpose of managing the use of natural resources.

conservation: The management of a natural resource for the protection, maintenance, rehabilitation, restoration, and/or enhancement of populations and ecosystems.

contamination (marine): An anthropogenic increase in the concentration of a substance in the marine environment. In this report the term “contamination” makes no inference about the existence of any adverse effects.

coral: Colonial animals in the phylum Cnidaria; in this report the term is used to refer to those that build reefs. “Coral” is also often used to refer to the hard, calcareous coral skeleton.

coral reefs: Extensive limestone structures built largely by corals. They occur in shallow tropical and provide habitat for a large variety of other marine life forms.

coral bleaching: A phenomenon in which corals under stress (e.g., by elevated water temperature) expel their mutualistic algae (zooxanthellae) in large numbers, or the concentration of algal photosynthetic pigments decreases. As a result, the corals’ white skeletons show through their tissue and they appear bleached.

cost-benefit analysis: see **benefit-cost analysis**

DALY (disability-adjusted life year): A method of calculating the global or world-wide health impact of a disease or the global disease burden (GDB) in terms of the reported or estimated cases of premature death, disability and days of infirmity due to illness from a specific disease or condition. (see also **global disease burden**)

DDT (dichlorodiphenyltrichloroethane): A potent, slowly degradable insecticide still widely used in many parts of the world.

[1] Sources used for the preparation of the glossary: suggestions and inputs from the members of the Working Group and various publications (e.g.: Norse, E.A. (1993) Global Marine Biological Diversity. Island Press, Washington D.C.; Allaby, M. (1977) A Dictionary of the Environment. The Macmillan Press Ltd., London; Baker, B.B. *et al.* (editors) (1966) Glossary of Oceanographic Terms. US Naval Oceanographic Office. Washington D.C.; Young, M.D. (1992) Sustainable Investment and Resource Use, UNESCO, Paris and The parthenon Publishing Group, Carnforth, UK; Scialabba, N. (ed.) (1998) FAO Guidelines: Integrated Coastal Areat Management in Agriculture, Forestry and Fisheries. FAO, Rome)

depuration: The process by which pathogens are removed from contaminated live seafood (shellfish in particular) by holding it in clean water for a period of time.

detritus: The particulate, organic remains and waste of organisms. It constitutes a major food source in marine ecosystems.

diarrhetic shellfish poisoning: see **gastroenteritis**.

diffuse sources of pollution (also called non-point sources): Multiple, not easily identifiable sources of pollution (e.g., agriculture, urban areas).

dimethyl sulphide (DMS): An organic compound containing sulphur that is produced in the ocean by certain phytoplankton species and is a precursor for some cloud condensation nuclei in the atmosphere.

dinoflagellates: A group of marine phytoplankton, some of which produce biotoxins.

disability-adjusted life year: see **DALY**

dumping: Any deliberate disposal at sea of wastes or other matter, or any deliberate disposal of vessels or other man-made structures.[2]

ecology: The branch of science studying the interactions among living things and their environment.

economic costs: Reductions of economic value. (see also **economic value**)

economic externalities: A benefit or a cost not included in the market price of the goods and services being produced, i.e., costs not borne by those who create them and benefits not paid for by those who receive them.

economic value: The sum of the following: direct use values (the net value of any income that can be earned from a resource, e.g., timber, fish, tourism); ecological function values (e.g., flood control, waste assimilation, storm protection); option values (e.g., sources of future drugs, genes for plant breeding); existence values (e.g., satisfaction that the resource exists); bequest values (e.g., inter-generational equity). As far as possible, the economic value is expressed in monetary terms (see **environmental valuation**).

ecosystem: A community or several communities of organisms together with their physical environment. A conceptual view of interaction within and independence among species and communities emphasising the nature of the flow of material and energy among these parts and the feedback loops from one part to another.

ecotoxicology: The science of poisons and toxic substances occurring in the environment and their effects.

El Niño: A warm current that usually appears around Christmas off the coast of Ecuador and Peru. In this report the term is used to refer to episodic (3-5 year) events when the current is particularly intense and dominates the local population of organisms (the abundance of fish in particular). Such events lead to wider regional or global ocean-atmospheric perturbations whose manifestations range from increased sea surface temperatures in the tropical East Pacific to aberrant rainfall patterns. (see also **ENSO**)

endemic disease: An infectious disease that is present in the community at all times but normally at low frequency.

[2] as defined by the London Dumping Convention

endemic species: Species native to and restricted to specific geographic areas.

endocrine disruptors: Substances that interfere with processes controlled by animal hormones (e.g., growth, sexual maturity).

ENSO (El Niño/Southern Oscillation): A cyclical, large-scale changes in atmospheric and ocean patterns in which, among other things, warm surface water in the Pacific moves further to the east than normal. (see also **El Niño**)

enteroviruses: Viruses that cause disease, mainly in the intestinal tract of mammals. (see also **pathogens**)

environmental impact assessment (EIA): A process by which the consequences of planned development projects are evaluated as an integral part of planning the project. The analysis of biological, physical, social and economic factors to determine the environmental and social consequences of a proposed development action. The goal of the EIA is to provide policy makers with the best available information in order to minimise economic costs and maximise benefits associated with a proposed development.

environmental valuation: Procedures for valuing changes in environmental goods and services, whether or not they are traded in markets, by measuring the changes in the consumer or producer surpluses associated with these environmental goods.

epidemiology: The study of the factors that influence the frequency and distribution of diseases.

estrogen: A hormone that produces sexual changes or cycles in mammals.

estuary: The region where a river meets the marine environment. It is characterised by variable salinity and often by high biological productivity.

eutrophication: Increased primary production caused by the anthropogenic enrichment of a water body with nutrients. In the context of the present report the term is used only when the increased production results in negative impacts such as harmful algal blooms, oxygen deficiency, or the overgrowth of corals by seaweeds. (see also **primary production** and **nutrients**)

gastroenteritis: A pathological disturbance of the gastrointestinal tract (i.e., the stomach and intestines), often caused by pathogens and biotoxins found in certain shellfish. (see also **pathogens** and **biotoxins**)

global disease burden (GDB): A term used by the World Health Organisation to numerically estimate the relative world-wide or global health impact of diseases. The estimate is made in terms of DALYs. (see also **DALY**)

greenhouse gases: Gases that trap heat radiating from the Earth's surface, thereby warming the lower atmosphere.

gross domestic product (GDP): A measure of the value added to an economy as a result of human activity. It includes activities carried out in the country by foreign owned companies and individuals and excludes the value of output of goods and services by firms outside the country owned by residents and the remittance of funds to the country from these entities. The measure is "gross" in that it does not include the depreciation of man-made capital nor the depletion or degradation of renewable natural resources.

gross national product (GNP): A measure of the value added to an economy as a result of human activity. It includes the value of output of goods and services by firms outside the country owned by residents and the remittance of funds to the country from these entities but excludes the value of output of goods and services by foreign-owned firms in the country. Like the measure of GDP, it does not include the depreciation of man-made capital nor the depletion or degradation of renewable natural resources.

groundwater: Water that occupies pores and crevices in rock and soil, below the surface of the Earth. The upper limit of the groundwater is the water table, whose level varies according to the quantity of water entering and extracted from the groundwater. (see also **aquifers**)

habitat: The physical space where an organism, population or species lives. Habitats are usually categorised by particular physical or biological characteristics (e.g., coral reefs, mangrove forests).

hermaphrodite: An organism that has both male and female reproductive organs.

hypoxic waters: Waters with a low concentration of oxygen.

hydrology: The study of the processes affecting the movement of freshwater, including underground waters. Also often used to refer to the processes and movements themselves.

imposex: A pseudo-hermaphroditic condition in female gastropods (snails) caused by TBT and manifested by the development of a false penis.

institutional integration (as related to integrated coastal management): The process of bringing together separate functions of government at different levels together with other stakeholders to provide a unified approach to interventions in the managed area.

integrated coastal management (ICM): The management of sectoral components (e.g., fisheries, forestry, agriculture, tourism, urban development) as part of a functional whole (a holistic approach to management). In ICM the focus is on the users of natural resources, not on the stock *per se* of these resources. Frequently used synonyms for ICM are integrated coastal area management (ICAM) and integrated coastal zone management (ICZM).

intertidal zone (often called littoral zone): The part of the shoreline that is submerged at high tide and exposed at low tide.

littoral: see **intertidal zone**.

mangrove forest (or mangal): A community of salt-tolerant trees and shrubs, with many other associated organisms, that grows on some tropical and sub-tropical coasts in a zone roughly coinciding with the intertidal zone.

mariculture: The cultivation of marine organisms.

market failure: The concept that markets do not reflect the societal costs of all economic activity and, in particular, the economic costs imposed on third parties.

natural resources: May be classified as non-renewable (e.g., coal, oil) and renewable. The latter may be further classified as unconditionally renewable (e.g., solar, tidal or wind energy) and conditionally renewable (e.g., fish, forest products). Conditionally renewable resources will last indefinitely if not over-exploited because that part of the resource that is used can be replaced through natural processes.

nematodes: A group of worms, some of which may cause intestinal and other diseases.

net economic benefit: The economic value of a measure (or measures) less (i) the value of any benefits foregone as a result of the measure(s) and (ii) the cost of measure(s).

neurotoxic shellfish poisoning (NSP): A disease of neurological system caused by ingestion of biotoxins found in certain shellfish. (see also **biotoxins**)

non-governmental organisation (NGO): An organisation, usually non-profit, that is not part of the central, local, or municipal government.

non-point sources of pollution (also called diffuse sources): Multiple, not easily identifiable sources of pollution (e.g., agriculture, urban areas).

nutrients (in the context of the present report): Substances that are essential for the growth of marine organisms that perform primary production (algae, bacteria, and plants). Excess nutrients, especially nitrogen and phosphorous, can be major pollutants.

oceanic gyre: A very large, more or less circular, pattern of water circulation in an open ocean basin.

oligotrophic: Waters with low primary productivity because of limited supplies of nutrients.

organochlorines: Organic compounds that contain chlorine atoms (e.g., PCBs).

ozone: A colourless form of oxygen gas with three oxygen atoms in each molecule Stratospheric ozone, which screens out harmful ultraviolet radiation, is generally found between 10 and 50 km above the Earth. Tropospheric ozone is found in lower atmosphere (generally below 10 km above the Earth). Ozone is also commonly found in smog.

paralytic shellfish poisoning (PSP): A disease with severe neurological effects, including paralysis and death, caused by eating shellfish that contain the marine biotoxin saxitoxin. (see **biotoxins**)

pathogens: Organisms that cause (e.g., certain bacteria and viruses).

PCBs (polychlorinated biphenyls): Highly toxic and durable synthetic organic compounds that accumulate in tissues of organisms.

pelagic organisms: Free-swimming or floating organisms in the water column of the open sea or above the continental shelf.

photo-oxidation: Loss of hydrogen or electron from a chemical compound as a result of interaction with light.

piscivorous fish: Fishes that eat other fishes.

plankton: Organisms, mostly small, that drift or swim too slowly to oppose ocean currents. Plankton that perform photosynthesis are called phytoplankton, those that do not are called zooplankton.

plaque forming unit (PFU): A unit used in the measurement of the concentration of viruses in an environmental sample.

policy failure: The situation when a policy or policies are inconsistent and militate against the success of other policies (e.g., subsidies on agricultural fertilisers and environmental protection policies).

policy process: An iterative activity consisting of: the determination (usually by government or a government agency) of goals; the development of a strategy for achieving these goals that consists of objectives and policies; and the formulation and implementation of plans (usually at the sectoral level) in which objectives are related to measures, human and financial resources, and the time frame to provide the basis for action.

polluter-pays principle: The principle, adopted by the OECD countries in 1972, requires that the polluter should bear the costs that pollution damage or pollution control impose upon society.

POPs (persistent organic pollutants): A diverse group of chemicals that persist in the environment, bioaccumulate through the food web, and pose a risk of causing adverse effects to human health and the environment. A group of twelve POPs (the "dirty dozen") have been initially selected for international action by the International Programme on Chemical Safety (IPCS).

pollution (marine): "Pollution means the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to maritime activities including fishing, impairment of quality for use of sea water and reduction of amenities."[3]

precautionary approach: The essence of the approach is expressed in Principle 15 of the Rio Declaration that states that "Where there are threats of serious or irreversible damage, lack of scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." The approach is concerned with avoiding risk that has not been assessed, i.e., uncertainty.

primary production: The process in which organisms synthesise organic matter from inorganic materials, or the organic matter itself.

protected area: A geographically defined area that is designed and managed to achieve specified environmental objectives.

PTSs (persistent toxic substances): Substances to which organisms, including humans, have environmental exposures that are of concern because of their potential adverse effects. Thus, in addition to the 12 classes of POPs listed for initial international action, the term encompasses not only all POPs in the generic sense but also less persistent substances to which organisms are chronically exposed over large temporal and spatial scales because of their continuous release by human activities (see also **POPs**)

red tide: Discolouration of surface waters from blooms of phytoplankton. Strictly refers to blooms that produce a reddish-brown colour but often used for blooms of other colours. (see also **algal bloom**)

seagrass beds: Benthic communities, usually on shallow, sandy or muddy bottoms, dominated by grasslike marine plants.

siltation: The settling of fine mineral particles to the sea bottom.

[3] GESAMP's definition of marine pollution

stakeholders: Individuals, groups of individuals and non-governmental and government entities that have either a direct or indirect interest or claim which will, or may, be affected by a particular decision or policy.

standing stock: see **biomass**

stratosphere: The layer of the atmosphere 15-50 km above the Earth's surface in which ozone prevents most ultraviolet radiation from reaching the Earth's surface.

submarine groundwater: Underground fresh water that has flowed beneath the sea floor.

sustainable development (in the context of the present report): "There are many dimensions to sustainability. First it requires the elimination of poverty and deprivation. Second, it requires the conservation and enhancement of the resource base which alone can ensure that the elimination of poverty is permanent. Third, it requires a broadening of the concept of development so that it covers not only economic growth but also social and cultural development. Fourth and most important, it requires the unification of economics and ecology in decision making at all levels."[4] The essence of sustainable development is to ensure that society meets its present needs without compromising the ability of future generations to meet their own needs; this implicitly requires that development should not compromise the ecological integrity of the environment.

TBT (tributyl tin): A very toxic organic compound containing tin. It is used in antifouling paints on vessels and fixed marine structures.

thalassogenic diseases: Diseases caused by polluted or contaminated sea water or edible marine products.

trillion: 1,000,000,000,000

trophic levels: Successive stages of nourishment as represented by the links of the food chain. According to a grossly simplified scheme the primary producers (i.e., phytoplankton) constitute the first trophic level, herbivorous zooplankton the second trophic level, and carnivorous organisms the third trophic level.

twin-track (in the context of the present report): A management process in which the setting of objectives and implementation of policies and plans is devolved to the optimum degree. There is a flow of information to policy-makers from the bottom used to revise strategies, policies and plans and in the design of policy instruments and legislation.

upwelling: The slow upward transport of cold, nutrient-rich water masses to the surface from depth. Coastal upwelling is usually induced by surface winds.

valuation: The attachment of monetary value to an object through a consideration of both internalised and externalised costs.

vector organisms: Organisms that transmit certain diseases.

Vibrio cholerae: Pathogenic microorganism causing cholera.

vitellogenin: A variety of primary lipoproteins produced by egg-laying vertebrates, including fish.

[4] Quote from Gro Harlem Brundtland's Sir Peter Scott Lecture in Bristol, 8 October 1986

Abbreviations and Acronyms

ACOPS: Advisory Committee on Protection of the Sea
ADR: alternative dispute resolution
ALARA: as low as reasonably achievable
ARM: asset recycle management
BAP: best available practice
BAT: best available technology
BOD: biological oxygen demand
CAC: command-and-control (regulation)
CBA: cost-benefit analysis
CEIA: cumulative environmental impact assessment
COBSEA: Coordinating Body on the Seas of East Asia
COD: chemical oxygen demand
CPPS: Permanent Commission of the South Pacific
DALY: disability-adjusted life year
DDT: dichlorodiphenyltrichloroethane
DSP: diarrhoeic shellfish poisoning
EAF: Eastern African Region
EAS: East Asian Seas Region
ECE: Economic Commission for Europe
EDCs: endocrine disrupting chemicals
EEC: European Economic Community
EIA: environmental impact assessment
ENSO: El Nino / Southern Oscillation
EU: European Union
FAO: Food and Agriculture Organisation of the United Nations
GESAMP: Joint Group of Experts on the Scientific Assessment of Marine Environmental Protection
GBD: global burden of disease
GDP: gross domestic product
GEF: Global Environment Facility
GIS: geographic information system
GIWA: Global International Waters Assessment
GNP: gross national product
GPA/LBA: Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
HELCOM: Baltic Marine Environment Protection Commission
IA: institutional analysis
IAEA: International Atomic Energy Agency
ICAM: integrated coastal area management
ICES: International Council for the Exploration of the Sea
ICM: integrated coastal management
ICZM: integrated coastal zone management
IMO: International Maritime Organisation
IOC: Intergovernmental Oceanographic Commission of UNESCO
IPCC: Intergovernmental Panel on Climate Change
ISO: International Organisation for Standardisation
IUCN: World Conservation Union
LBAs: land based activities
LCA: least-cost analysis
LCA: life cycle assessment
LIFDCs: low-income food deficient countries
MAP: Mediterranean Action Plan
MARPOL: International Convention for the Prevention of Pollution from Ships
MCA: multi-criteria analysis
MEA: Working Group on Marine Environmental Assessments of GESAMP
MED: Mediterranean Region
NGO: non-governmental organisation
NSP: neurotoxic shellfish poisoning
OECD: Organisation for Economic Cooperation and Development
OSPAR: Oslo and Paris Commission
PAHs: polycyclic aromatic hydrocarbons
PCBs: polychlorinated biphenyls
PERSGA: Red Sea and Gulf of Aden Environment Programme
PFU: plaque forming units
POPs: persistent organic pollutants
PRRA: participatory rapid rural appraisal
PSP: paralytic shellfish poisoning
PSTs: persistent toxic substances
QSARs: qualitative structure-activity relationships
ROPME: Regional Organisation for the Protection of the Marine Environment (in the region covered by the Kuwait Convention)
RPAs: regional programmes of action (of GPA/LBA)
RRA: rapid rural appraisal
SAS: South Asian Seas Region
SE/PCF: South-East Pacific Region
SPREP: South Pacific Regional Environment Programme
SPM: suspended particulate matter
SS: suspended solids
SWAT: South-West Atlantic Region
TBT: tributyl tin
TDPs: tradeable discharge permits
UN: United Nations
UNCED: United Nations Conference on Environment and Development
UNCLOS: United Nations Convention on the Law of the Sea
UNEP: United Nations Environment Programme
UNESCO: United Nations Educational, Scientific and Cultural Organisation
UV: ultraviolet
VOCs: volatile organic compounds
WACAF: West and Central African Region
WCR: Wider Caribbean Region
WHO: World Health Organisation
WMO: World Meteorological Organisation
WORLD BANK: International Bank for Reconstruction and Development
WTO: World Tourism Organisation

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Annex 1

Economic Valuation[1] of Coastal and Marine Systems and Net Benefit Analysis

The key requirement upon policy-makers in ensuring that land-based activities have the minimal adverse effect on the marine environment is to fully incorporate environmental considerations into policy making in all sectors. In turn, this imperative requires that institutional mechanisms are in place that ensure that the likely environmental consequences of **all** projects, policies and programmes are taken into account within the decision-making processes and, specifically:

- programmes which have adverse environmental consequences are adjusted to ensure that the overall net damage is as close to zero as possible; and
- priority is given to programmes and policies that generate net environmental benefits.

Fundamental to this process is the institutional capacity to make good and consistent choices between the conservation of natural resources and development. Institutional capacity, in this context, means that government has the capacity to understand the trade-offs and policy issues involved in the conservation of coastal and marine systems. To have this capacity calls for: first, the ability to make sound assessments of the values to society of ecosystems threatened by development; and, second, the ability to apply the appropriate methodology for evaluating the different policy or management options.

Three techniques are available to help policy makers make these choices. These are cost-benefit analysis (CBA), least-cost analysis (LCA) (also termed cost-effectiveness analysis) and multi-criteria analysis (MCA), which may also be termed cost-utility (and feasibility) analysis.

CBA is the most commonly used technique in determining priorities and the setting out of options in policy and project appraisal. Its objective is to compare costs and benefits of impacts of different options, in terms of their monetary values. Benefits here are those ecological goods and services which have an impact on people's welfare and which policies are designed to recover or maintain. Correspondingly, costs are usually primarily the foregone welfare associated with a reduction in the flow of non-ecological goods and services resulting from measures to protect the environment. The other source of costs here is the administrative costs of the design and implementation of measures which protect the environment. Cost and benefit streams are discounted to arrive at present values. The most important attribute of CBA is that, subject to the limitations referred to below, there is a strong body of opinion that it is the best available technique to help policy makers establish priorities and orient investment decisions. Moreover, beneficiaries and losers can be identified so as to address resulting issues of equity promtly.

Perhaps most discussion relating to the validity of CBA in environmental management decision-making has been devoted to how to select a discount rate that will properly account for transfers between generations. However, in recent years there has been a growing consensus (see, for example, Pearce *et al.*, 1989) that the adoption of an artificial discount rate introduces more problems than it resolves. Instead of attempting arbitrarily to fix a seemingly appropriate rate, it is argued that it is better to use current rates but take steps to ensure that environmental concerns are fully taken into account.

While this solution recognises the impracticability of attempting to fix an appropriate discount rate, it focuses attention on the other major problem with CBA. This is that the placing of monetary values on ecological system functions is very difficult and leads, perhaps more often than not, to the under-valuation of the ecological services provided by an ecosystem.

There are a number of problems in placing values on ecological benefits. A common and fundamental problem is that our knowledge of ecological linkages is often limited. For example, it is usually not known what proportion of a given mangrove area is necessary to create the habitat for the fish stocks which benefit from it. Another type of problem that occurs is that it is often difficult to take fully into account the interconnectedness between coastal and marine ecosystems. For example, if a fishery has free and open access, it will be more heavily exploited in the long run and its similarly value will fall in the long run, all other things being equal. Consequently, any economic losses associated with the destruction of the habitat supporting this fishery are likely to be lower than those which would be shown in a "snapshot" of the current value of that fishery. There are many ways in which this interconnectedness

[1] The benefits provided by marine ecosystems have been briefly reviewed in Chapter 2 (section 2.2.iv). The total economic value of an ecosystem may consist of two groups of elements, termed use values and non-use values. Use values are made up of three elements. These are: (i) direct use, or consumptive, values, which are the consumptive outputs of an ecosystem, e.g., fish, wood, recreation, tourism, etc.; (ii) ecological function values, which are the benefits such as flood control and nutrient recycling which a system may provide; and (iii) option values, which are the benefits which a system may provide in the future, such as future drugs. Non-use values have two elements. These are (i) existence values which relate to the value people put upon the fact that the ecosystem is there; and (ii) bequest values which relate to the satisfaction of people in passing a resource on to future generations (after Barbier, 1991).

occurs and of the approaches that have been made to deal with them (Barbier and Swallow 1999). A third type of problem is the valuing of biodiversity where values may be incompletely accounted for in markets or completely overlooked by market decision-makers. Not directly related to the problems associated with putting values on ecological functions is a fourth type of problem, that of valuing in monetary terms non-use values, such as existence or bequest values.

A key tool in dealing with the interconnectedness between marine and coastal systems is bioeconomic modelling. There is now a considerable body of experience in its application to the types of problems which occur in the valuation of coastal ecosystems (Bell, 1980 and 1987; Lynne *et al*. 1981; Kahn and Kemp, 1985; Ellis and Fisher, 1987; Farber and Costanza, 1987; Strand and Bockstael, 1990; Swallow, 1990, 1994, 1996; Feeman, 1991; Parks and Bonifaz, 1994; Ruitenbeek, 1994; Knowler, Strand and Barbier, 1997; Satirathai, 1997; Nowlis and Roberts 1997; Pezzey *et al.*, 1998 and Holland and Brazee 1998; Barbier and Swallow, 1999, cite Barbier and Strand, 1988).

Among other applications of bioeconomic modelling, where it has been used successfully, is to show the impact of the loss of a keystone species (cf. Costanza *et al.*, 1995 and review and citations in Gudmundsson and Sutinen, 1988).

Bioeconomic modelling is now well past the research stage and can significantly improve the quality of advice provided to decision-makers. However, it has so far been rarely used in the formulation of policy advice. Three factors work toward limiting its use: first, it is enormously demanding of information and few fisheries, especially in developing countries have been sufficiently well studied to provide the information required - although there are a number, especially high value single fisheries where appropriate data exists -; second, dealing with multi-species fisheries, common in tropical areas, presents severe difficulties; and, third, there are still relatively few economists, especially in developing countries, trained and experienced in its use.

These limiting factors point to the need to focus on those areas where increased information for use in bioeconomic modelling (e.g., the impact of fishing mortality on fish stocks) is likely to show dividends in terms of better decision making. The potential of bioeconomic modelling is also a further illustration of the need to enhance administrative capacities in many countries so that they have, for example, economists who are trained and experienced in bioeconomic modelling applications.

For the other problems referred to here, leaving to one side the valuation of existence and bequest values, the methods associated with contingent valuation may provide the best available approach. This technique involves surveys of respondents in which they are asked their willingness to pay, for example, for the conservation of a certain marine system. Over the last twenty years or so, there has been increasing attention given to contingent valuation of natural resources (Barbier and Swallow cite, Azjen and Peterson, 1988; Anderson and Bishop 1986; and Carson, and Navarro, 1988; Mitchell and Carson, 1989). A recent modification of the contingent valuation technique, termed “contingent choice” or sometimes “choice experiments”, has shown itself to be a promising approach to the valuation of a broad spectrum of biodiversity (Opaluch *et al.*, 1993; Swallow, 1997 and Adamowicz *et al.*, 1998, quoted in Barbier and Swallow, 1999).

Contingent valuation techniques can be very effective but there are limitations to their use, including several types of bias that can influence the results. It is important, therefore, that surveys are carefully designed to minimise the chance of bias, while experience has shown also that the inclusion of attitudinal questions in surveys and careful definition of the natural resource being valued have added to the usefulness of the techniques (Wilks, 1990). Nevertheless, contingent valuations have to be treated with care.

Contingent valuation techniques may be also applicable to expressing existence and bequest values in monetary terms (see Brookshire, *et al.*, 1983), although the limitations on the technique in these applications may be more severe than in attributing monetary values to natural resources. In particular, existence and bequest values are frequently of an ethical nature and cannot be expressed in monetary terms.

The foregoing shows that in most instances the valuation of ecosystem benefits continues to be more of an art than a science; it is rare that the valuation of a system can be reduced to figures in which the analyst has full confidence. Far more likely are situations where certain benefits will be, by their nature, not quantifiable, or where the valuation will be rough and ready because of the lack of, or weakness of, information. Even so, the valuation of a few benefits of a given policy may be enough to show that these undervalued benefits are already exceeding costs. This result in itself is not sufficient to provide an assurance that society is making the best use of its economic resources. Nevertheless, it does enable policy makers to guarantee that economic efficiency will not be diminished due to the environmental investment associated with the conservation of a natural resource (Serroa da Motta, 1997). In view of society’s concerns, especially in poorer countries, that environmental investment may be detrimental to economic development, such a guarantee is of great importance. Perhaps equally importantly, CBA is a tool to identify and clarify the value (political) decisions which have to be taken in the valuation process and can help policy makers to rank policies in terms of their likely impact on economic efficiency and equity.

CBA may often be usefully complemented, or even replaced, by least-cost analysis (LCA) or multi-criteria analysis (MCA). LCA is perhaps, other than CBA, the most frequently used technique in the appraisal of interventions that threaten natural resources. It enables policy makers to consider the various options available to meet a predefined priority and compares their discounted costs (and thus, like CBA, is dependent on the selection of a discount rate) and relative effectiveness in meeting these objectives. Critically, the prime condition for the use of LCA is the awareness of policy makers of all the economic and ecological values of a natural system. For example, when considering whether to drain a wetland for economic development, policy makers should be aware of the range of economic and ecological values of that wetland and decide which of them to incorporate into the LCA analysis. Very often, this process presents enormous data and technical problems but it does serve to focus attention on the number ,and likely magnitude, of the economic and ecological values and enables policy makers to compare these with the non-ecological benefits likely to flow from economic development of the wetland area. Note, however, that LCA does not rank options to help policy makers to set priorities.

MCA begins with specifying the options to be considered, and the economic and ecological criteria that are considered to be important in their evaluation. Examples of criteria are: irreplaceability and level of biodiversity; option, existence and bequest values; and ecological and economic values. Weighting of criteria may be made to vary the relative importance of criteria in the analysis.

There are a number of advantages of MCA compared with CBA or LCA. First, it does not depend upon the monetarisation of effects nor focus exclusively on the measurement of efficiency. These attributes are particularly advantageous in situations where ecological values are an important consideration, where economic activities are directly dependent on natural resources but databases are weak and where distribution concerns are strong. Furthermore, the avoidance of the use of a discount rate may be argued to enable MCA to perform better than CBA in accounting satisfactorily for sustainability objectives.

While these advantages of MCA over the two more established techniques make its use attractive in many situations, it suffers also from two key disadvantages. The main methodological shortcoming is the setting up of generally acceptable scales for determining the relative importance of each criterion, that is, the weights. The second is the determination of the level of benefits associated with each criterion or, in other words, if valuation of benefits is being avoided, how analysts can measure each benefit. Stakeholders' participation in the decision-making process and an institutionally holistic approach by government to the issue being addressed are the only ways to minimise these constraints (Serroa da Motta. 1997). Like CBA, therefore, MCA serves to identify and clarify the value questions that are essentially political in nature.

CBA, with its limitations, remains the key tool in helping policy-makers decide upon the allocation of resources. In certain situations, LCA may be the most appropriate tool to be used while in others CBA may be complemented by MCA. In many situations, the techniques considered here will provide unambiguous evidence to policy makers of where net benefits lie. Very often, however, the difficulties of quantifying benefits and of other factors, such as institutional capacity, government commitment and social acceptance means that the role of these techniques can only be to guide governments and regulators in determining priorities.

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FURTHER READING

Ecosystems, Volume 3, issue 1-3, contains a number of articles on various apects of environmental valuation.

Annex 2

Unpublished Internal Documents of the MEA Working Group

Jeftic, L. (1998a). Analysis and evaluation of two documents relevant to the Arctic region (ACOPS, 1996. Identification and Assessment of Land-Based Sources which lead to the Degradation of the Arctic Marine Environment. ACOPS, London, 1996, 92 pp; AMAP, 1997. Arctic Pollution Issues: A State of the Arctic Environment Report. Arctic Monitoring and Assessment Programme. AMAP, Oslo, 1997, 188 pp) 15 + 3 pp

Jeftic, L. (1998b). Analysis and evaluation of eight documents relevant to the Baltic Sea region (HELCOM, 1995. Radioactivity in the Baltic Sea 1984-1991. Balt. Sea Environ. Proc. No. 61, Helsinki Commission, Hamburg, 1995, 182 pp; HELCOM, 1996a. The State of the Baltic Sea Marine Environment. Helsinki Commission, Uddevalla, 1996, 20 pp; HELCOM, 1996b. Protection of the Baltic Sea – results and experiences, Helsinki Commission, Uddevalla, 1996, 32 pp; HELCOM, 1996c. Fourth Activity Inventory, The Baltic Sea Joint comprehensive Environmental Action Programme. Helsinki Commission, 1996, 160 pp; HELCOM, 1996d. Coastal and Marine Protected Areas in the Baltic Sea Region. Balt. Sea Environ. Proc. No. 63, Helsinki Commission, Uddevalla, 1996, 104 pp; HELCOM, 1996e. Third Periodic Assessment of the State of the Marine Environment of the Baltic Sea, 1989-1993; Executive Summary. Balt. Sea Environ. Proc. No. 64 A, Helsinki Commission, Helsinki, 1996, 25 pp; HELCOM, 1996f. Third Periodic Assessment of the State of the Marine Environment of the Baltic Sea, 1989-1993; Background document. Balt. Sea Environ. Proc. No. 64 B, Helsinki Commission, Helsinki, 1997, 252 pp; HELCOM, 1997. Overview on Activities 1996. Balt. Sea Environ. Proc. No. 65, Helsinki Commission, Helsinki, 1997, 22 pp) 16 + 4 pp

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Jeftic, L. (1998d). Analysis and evaluation of a document relevant to the Eastern African region (UNEP, 1997. Overview of Land-based Sources and Activities Affecting the Marine, Coastal and Associated Freshwater Environment in the Eastern African Region. UNEP, FAO, Institute of Marine Sciences, University of Dar Es Salaam, and Swedish International Development Agency, Nairobi, 1997, 28 pp) 8 + 2 pp

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Jeftic, L. (1998g). Analysis and evaluation of a document relevant to the Red Sea and Gulf of Aden region (UNEP, 1997. Assessment of Land-based Sources and Activities Affecting the Marine Environment in the Red Sea and Gulf of Aden. UNEP and PERSGA, Nairobi, 1997, 88 pp) 9 + 2 pp

Jeftic, L. (1998h). Analysis and evaluation of a document relevant to the Persian/Arabian Gulf and Gulf of Oman – ROPME Sea area (UNEP, 1998. Overview on land-based sources and activities affecting the marine environment in the ROPME sea area, UNEP, Nairobi, 1998, 128 pp) 9 + 1 pp

Jeftic, L. (1998i). Analysis and evaluation of a document relevant to the South-East Pacific region (UNEP, 1998. Regional Diagnostic on Land-based Activities Affecting the Marine, Coastal and Associated Freshwater Environment of the South-East Pacific. UNEP, Nairobi, 1997, 97 pp) 7 + 2 pp

Jeftic, L. (1999). Analysis and evaluation of a document relevant to the West and Central African region (UNEP, 1998. Overview on land-based sources and activities affecting the marine coastal and associated freshwater environment in the WACAF region (Western and Central Africa), UNEP, Nairobi, 1998, 85 pp) 13 + 1 pp

Shuval, H. (1999). The impact of microbial pollution in the marine environment on human health. A preliminary quantitative estimate of global disease burden (GDB). 24 pp

Annex 3

Summary of Regional Programmes of Action on Land-based Activities

BACKGROUND NOTES

This summary was prepared based on:

(i) Development of the regional programmes supported by UNEP:

1. Eastern Africa – Extract from the Regional Programme of Action
2. West and Central Africa – Extract from the Regional Programme of Action
3. East Asian Seas – Extract from the Regional Programme of Action
4. ROPME Sea Area/Kuwait Action Plan – Prepared from the Regional Programme of Action with projects elaborated for implementation of land-based activities
5. Upper South-West Atlantic – Prepared from draft Regional Programme of Action
6. South-East Pacific – Prepared from draft Regional Programme of Action
7. South Pacific - Extract from Regional Programme of Action
8. Mediterranean – Taken from UNEP: Strategic Action Programme to Address Pollution from Land-based Activities. MAP Technical Reports Series No. 119, UNEP, Athens, 1998. The Strategic Action Programme was adopted by the Tenth Ordinary Meeting of the Contracting Parties (November 1997)

The Regional Programmes of Action 1-7 were all endorsed by Government-designated experts. Those for the East Asian Seas, South Pacific and Mediterranean have been adopted by the Governments of the respective regions. They were distributed as Information Document No. 8 at the Second Global Meeting of Regional Seas Conventions and Action Plans (The Hague, 5-8 July 1999) organised by UNEP. Of these, only the EAS regional programme of action was modified according to version 2 of the regional programme provided by the EAS/RCU.

North-West Pacific – Not available in the present compilation – At the last two intergovernmental meetings (early and late 2000) land-based activities were recognised among the priorities for the workplan, which is to be jointly developed with the GPA Coordination Office.

(ii) On-going work for the preparation of the regional programmes supported by UNEP and first drafts available for:

9. South Asian Seas
10. Red Sea and Gulf of Aden

Other regions which, to date, have no regional programmes of action on land land-based activities as such:

11. Wider Caribbean – Regional Programme of Action to be developed

(iii) Regional programmes or strategies on-going or developed for land-based activities:

12. Black Sea – Prepared from a working paper provided by Coordinator of the BSEP
13. Arctic – Prepared from a working paper provided by Chairman of PAME
14. North-East Atlantic – Prepared from a working paper (and additional information) prepared by OSPAR and information from their Web site
15. Baltic – Not available in the present compilation-

1. Summary of the Regional Programme of Action for the Eastern Africa (EAF)

Problem	Source of pollution	GPA source category	Objectives	Strategies	Specific action	Action to be taken by	Time frame (years)	Programme support
Regional National	**1. Domestic sewage**	Sewage	Reduce sewage impact on the environment Assessment of eutrophication and its implications for coastal waters and habitats around urban centres	Effective, low cost treatment Scale of approach • urban • peri-urban Environmental planning Monitoring programmes	• Construction of sewage treatment facilities in urban areas • Intermediate technologies and innovative solutions • Training of personnel-particularly in maintenance • Scientific investigation to access nutrient concentration and their effects on coastal ecology	Government agencies Government and NGOs Scientific institutions in each country	2 2 3	World Bank GEF EU Sida COI DFID
Regional	**2. Solid domestic waste**	Litter	Reduce litter impact on the environment	Improvement of domestic waste collection and disposal systems	• Construction of appropriate disposal sites • Management of dumping sites • Training of personnel • Recycle of some waste • Mass communication	Urban authorities and consultants Academic institutions/ NGOs	3	World Bank GEF EU Sida COI DFID National governments
Regional	**3. Agricultural run-off**	Nutrients, POPs	Reduce the effects of nutrients and POPs in the environment	To reduce the concentration of nutrient and POPs in agricultural run-off Set regional standards Education	• Enforcement of best practices for the application of agrochemical • Convene workshop to set guideline concentrations • Control the application of pesticide in coastal agricultural areas • Public awareness	Agricultural agencies or relevant ministries Coordinating regional body Agricultural agencies or relevant ministries NGOs	3 3 3	UNEP FAO WHO National governments IAEA
National	**4. Industrial waste**	Heavy metals, POPS, nutrients, BOD/ COD	Minimise pesticide concentration in potable water supplies To reduce the impact of industrial waste on the environment	To develop and implement national standard for the discharge of waste water Improvement of facilities and practices to reduce industrial waste discharges	• Monitoring to assess concentrations on the marine environment • Set guidelines concentrations at the national level based on monitoring • Incentives for cleaner production • Planning of allocating industries in appropriate locations	Government agencies Government and research institutions Government and research institutions Governments	2 3 3 3	National governments UNEP FAO WHO IAEA UNDP UNESCO UNIDO EU

Source of pollution	Cause	Objective	Strategy	Specific action	Action to be taken by	Time frame (years)	Programme support
5. Habitat degradation/ Ecosystems degradation *(Note that table headings differ for "Habitat/ Ecosystems degradation" as per originals)*	Siltation from land-use, agriculture/deforestation and construction activities	Restoration of degraded habitats	Proper land use planning Reforestation	Identify priority area to be protected, methods of enhancing soil stabilisation and rain water drainage	National level	3-5	FAO
	Mineral exploitation/ sand and heavy metal extraction use	Control and management of areas of use/ potential use for sand/heavy metal mineral extraction	Proper management programme for mineral and sand heavy metal extraction	• Discourage use of beach/lime sand • Regulations/legislation on sand extraction on coastal zone • Monitoring • Land use plan regarding mineral extraction /legislation	Ministries responsible	on-going	OAU/ UNCHS (Habitat)
	Dredging	Control impacts/ improve activity management	Proper legislation. Monitoring and good practices	• Monitor the activity • Improve legislation and establish codes of good practice	Ministries responsible	on-going	IOC IOC/UNEP/ World Bank
	Erosion	Reduce erosion impacts and restore eroded areas	Proper land use planning, improve legislation, monitoring and good practices	• Identify areas sensitive to erosion/order • Identify gaps in the existing legislation and propose improvement or enforcement • Protect areas sensitive to erosion • Restore eroded areas	Ministries concerned	2	IOC/UNEP
	Aquaculture development	Minimise the impact of aquaculture development to the coastal habitat Ensure sustainability of the activity	Proper coastal planning and management EIA to be undertaken on major projects	• Formulate and implement National/Regional guidelines for aquaculture development • Identify sensitive areas prone to aquaculture	National/Regional levels Ministries concerned	2 1-2	FAO/government, IOFC FAO
	Destructive fishing methods (dynamite trawling, poisoning, spearing)	Combat destructive fishing method	Proper fishing management Control and surveillance	• Make available appropriate fishing gears at affordable process and research of proper fishery techniques • Enforcement of regulations and laws • Monitoring and increase public awareness	National level, Ministries concerned, Local communities	3-5	FAO/WB/ Sida NORAD CIDA
	Land reclamation	Controlling land reclamation activities	Land management and planning	Regulations and/or land tax policy	National level (Ministries responsible for Housing, Local communities/ NGOs)	15	UNCHS (Habitat)
	Tourist activities in special areas	Control tourist activities	Establishment of protected areas Public awareness	• Control the accessibility to sensitive areas by tourists • Regulations and / or access price policy	National level Ministry of environment NGOs	5	IUCN/ UNEP/ IOC-UNESCO
	Coral reef and sand extraction	Protect and restore	Discourage extraction of coral reefs and beach sand as source of building materials	• Find other source of building materials • Find sources of lime		10	Government institutions
	Saline intrusion	Protect and reduce the impact of saline intrusion	Improve water resource management Discourage abstraction of underground water	• Diversify sources of drinking water • Harvest rain water • Research and monitoring	Ministries concerned, private sector, NGOs and local communities	long term 2	FAO/ Habitat/ UNEP/WB
	Residential and hotel development along the beaches	Protect coastal zone	Proper land use planning and Tourism Development Strategy	• Identify sensitive areas for protection • Establish tourism development sites • Establish code of good practices/ guidelines for construction • Development of legislation	Ministries responsible for tourism, environment and urban development, Local communities	3-5	IUCN / NGOs / UNEP/ WWF/ Sida
	Mangrove clearing (aquaculture, saltpan, construction)	Control the impact and replanting of mangroves in the cleared areas	Proper management of mangrove and implementation of plans Continuous monitoring	• Identify areas to be protected • Promote alternative energy source and poles for building • Planting mangroves in cleared areas • Public awareness	National level, Ministries concerned, Local communities	5-10	WB/ NORAD/ GEF/Sida

2. Summary of the Regional Programme of Action for West and Central Africa (WACAF)

Translated by the GPA Coordination Office from the original in French

Source of pollution	Objective	Strategy	Specific action	Action to be taken by	Time frame (years)	Programme support
1. Sewage	Reduce impacts of wastewater on aquatic ecosystems and public health	Regional agreement on criteria and quality standards for wastewater and implementation of an Action Plan	• Collect qualitative and quantitative data on sewage • Prepare detailed regional report on sewage • Apply and reinforce appropriate regulations and laws • Improve and/or build sewage treatment facilities in WACAF countries • Regional evaluation workshop, followed by an expert meeting.	Govts., Univs., and NGOs;	2	International organisations, financial institutions and specialised agencies
2. Agriculture	Reduce amounts of agro-chemicals and control their use and impacts on the environment	Implementation of relevant conventions on POPs Develop programmes for the control of pesticides and their impacts at national and regional levels Evaluate the environmental impacts of agro-chemicals	• Collect data on the use of agro-chemicals; review and compile existing legislation • Review documentation and inventories of existing legislation • Consult Ministries, structures and commissions concerned • Institutional arrangements, based on FAO's recommendations for use, control, importation and commerce of pesticides • Develop a monitoring programme for pesticides • Review available data and existing capacities; produce a report and a database • Measure pesticide residues • Improve existing laboratories and analytical capacities • Effective implementation of regulations and reinforce national legislation as needed	National Focal Points, Govts., specialised laboratories Research centres NGOs	2-5 and on-going	World Bank, GEF, EU, Sida, others, and Govts.
3. Industry and mining	Reduce or eliminate the impacts of industrial waste and mining on the coastal, marine and aquatic environments of the region	Implementation of relevant conventions Develop programmes to measure impacts of waste at national and regional levels Evaluation of impacts of industrial waste and mining on the environment Implement adequate measures to control pollution from industrial waste and mining	• Inventory of main industries in coastal and drainage basins with collection of information • Measure contaminants, progressive contrail and implementation • Determine status of regulations at the national level and adoption of measures at the regional level, revising them as needed • Apply the polluter pay principle • Adopt clean technologies • Adopt reuse and recycling principles • Develop institutional capacities and laboratories for control of residues	Govts, NGOs and private sector	2-3 on-going	UNEP, IAEA and others
4. Oil and hydrocarbons	Control and/or reduce oil and hydrocarbons and their environmental impact	Evaluation of impacts Implementation of national contingency plans and of MARPOL provisions	• Inventory of data and information on oil production and hydrocarbons • Document available quantitative and qualitative data • Inventory of industries producing Hydrocarbons • Monitoring of residues in air, land and water • Effective of international agreements at nat. and subregional levels • Draft legislation and adequate regulations and incentives (polluters pay principle)	Govts, Technical Ministries, Industry and private sector	2-3 on-going	UNEP, IMO, and others
5. Solid waste	Reduce or eliminate the impacts of solid waste on the coastal, marine and aquatic environments of the region	Develop a regional framework for management of wastes	• Evaluate status of problems and impacts through a regional study • Evaluate in each country collection and treatment capabilities for solid waste and adopt adequate measures • Develop awareness programme at community level • Take adequate measures and legislation to reduce pollution from solid waste	Govts, NGOs and private sector, municipalities, local communities	3	Development Banks and international donors

Source of pollution	Objective	Strategy	Specific action	Action to be taken by	Time frame (years)	Programme support
6. Sediments	Reduce, control and prevent degradation from erosion	Develop regional directives on activities influencing sedimentation and erosion Restore and rehabilitate habitats degraded by erosion	• Regional study on erosion • Advocate EIA for development projects • Education campaign on negative impacts of traditional fisheries	Govts, NGOs and local community (fishers), Universities	3	International organisations
7. POPs	Reduce or eliminate the impacts of POPs on the environment and on population health	Develop guidance and programmes of action for the use of POPs Implement international agreements	• Evaluate status of use and develop information system • Control cycle of distribution and importation • Establish a monitoring system • Carry out analysis with reference laboratories • Improve methods of control and establish strict measures (customs, airport) • Circulate list of prohibited substances and execute awareness campaigns	Govts, Industries, Private sector and specialised NGOs, Users, States, Research Centres	3	International organisations, Intergovernmental Forum for Chemical Substances (IFCS)
8. Physical modification of coasts/ degradation of critical habitats	Minimise physical alterations to habitats Rehabilitation of degraded coastal and marine ecosystems	Integrated Management of Resources Economic incentives and use of alternative resources	• Identify problem extent and causes • Public information • Protection of critical areas • Conservation and restoration measures • Harmonise existing legislation • Abide by EIA studies in development projects	Technical Inst., NGOs, Private sector, Communities	5-10	Govts., international organisations and donors
9. Heavy metals	Reduce or eliminate anthropogenic emissions Ensure the health of populations	Encourage the adoption of appropriate technologies	• Identify types and sources of heavy metals and evaluate impacts • Establish guidelines for acceptable levels of heavy metals in the environment • Provide necessary guidance and equipment for follow-up • Establish laws in accordance with established standards	Technical Inst., Govts, Industries, International structures for follow-up	3-5	GESAMP, international organisations

3. Summary of the Regional Programme of Action for the East Asian Seas (EAS)

Source of pollution	Target	Action and ancillary action	Action to be taken by	Time frame (years)
Sewage	A regional agreement on waste water recycle management. Criteria and standards for sewage and urban run off release into waterways. A regional action plan.	**Action S1:** Establish a data and information network to link with GPA Clearing House, based on the existing monitoring network in the region; **Action S2:** Establish the infrastructure for enhancing the exchange of scientific information on sewage discharge and its impacts to the marine environment, marine habitats and human health; **Action S3:** Reduce the discharge of sewage using a treatment systems for the key sources, with potential technical transfer to other sewage sources; **Action S4:** Negotiate and establish a regional agreement on sewage discharge to protect marine environments in the region.	EAS/RCU, participating countries, and consultant if necessary	2 3 5 3
Agriculture run-off	To reduce the nutrient inputs from agriculture and aquaculture practices and to introduce sustainable use of seeds, fertiliser and pesticides. To reduce the suspended solids released from agricultural lands.	**Action A1:** Establish a data and information network to assess the quantities and types of fertilisers used and the quantity of solid and liquid manure produced by farm animals and aquaculture; **Action A2:** Promote rational use of fertilisers and reduce the losses of nutrients by misuse of inorganic fertilisers and manure; **Action A3:** establish sediment load targets with regard to the sensitivity of the receiving environment; develop integrated catchment plans to achieve the targets and implement these plans followed by a timely review of their impact; **Action A4:** Develop, promote and implement integrated pesticide management plans.	Participating countries, EAS/RCU, international organisations Participating countries, EAS/RCU. Participating countries, EAS/RCU. Participating countries, EAS/RCU.	2 4 5 5
Industry and mining	To reduce inputs of industrial waste. To determine the capacity of marine habitats to absorb industrial waste.	**Action In1:** Establish a data and information network on the: (i) sensitivity waters to outfall pollutants; and (ii) technologies available to control the levels of pollutants to acceptable levels; **Action In2:** Undertake a feasibility study for the introduction of cleaner production in the region; **Action In3:** Upgrade the capability of participating countries in controlling industrial wastes	Participating countries, EAS/RCU, international organisations, and consultant if necessary	2 2 3
Habitat modification	To reduce environment impacts from modification of habitats in the region	To provide guidelines for port development, land reclamation, forestry, logging and aquaculture to limit habitat destruction and marine pollution effects	Participating countries, EAS/RCU, international organisations and consultant if necessary	1 2 3
PILOT PROJECTS **Pilot Project 1: To be identified - Urban discharges**	i) To formulate and adopt regional guidelines for sewage treatment and disposal and environmental quality criteria and standards; ii) To establish on environmentally suitable and economically feasible system of collection and disposal of urban solid waste; iii) To assist the development of national plans and programmes for reduction of the pollution discharge from main cities in the demonstration sites.	i) To set up a criteria for selection of a city in the region to be the site of pilot project. It is suggested that this city should be: • A coastal city near marine habitats that can be used to indicate effects of urban activities • Population over 1,000,000 • With certain level of industry development during last 3 decades • Some environment monitoring data available for the project; and • Reasonable infrastructure on environmental protection ii) To identify sources of pollution and decide on the monitoring scheme; These pollutants are mainly: • Municipal sewage • Solid wastes • Heavy metals • POPs iii) To monitor the pollutants from identified sources, and to study the impacts to the marine and coastal environments; (iv) To establish a management plan to reduce the pollution discharge.	Participating countries, EAS/RCU, international organisations, and consultant if necessary	5

Source of pollution	Target	Action and ancillary action	Action to be taken by	Time frame (years)
PILOT PROJECTS **Pilot Project 2: Agricul-ture dis-charge and sediment run-off**	(i) To formulate and adopt regional guidelines for assess-ment of agriculture input of pollutants, and the relevant environmental quality criteria and standards; (ii) To establish an environ-mentally suitable and eco-nomically feasible methods for the sustainable use of fertiliser and pesticides in the demonstration site; and (iii) To assist the develop-ment of national plans and programmes for reduction of the agriculture discharge to the marine environment in the demonstration sites.	**Project Activities:** (1) Confirm that fertiliser and/or pesticides are affect-ing the marine environment. To formulate and adopt regional guidelines for assessment of agriculture input of pollutants, and the relevant environmental quality criteria and standards; (2) Work towards obtaining fertiliser/pesticide scenarios which combine high agricultural outputs and low pol-lution levels. To assist the development of national plans and programmes for reduction of agriculture discharge to the marine environment at demonstration sites. (3) Determine the effects of decreased level of discharge of a river on salinity intrusion, sediment load and coastal erosion or accretion. (4) Assess impacts of mining activities to the coastal marine environment. (5) Communicate, educate and train all members of the community in being more environmentally aware and caring for marine ecosystems.	Participating countries, EAS/ RCU, international organisations, and consultant if necessary	5

4. Summary of the Regional Programme of Action for the ROPME Sea Area

OBJECTIVES: Overall goal to prevent, reduce, control and/or eliminate processes causing the degradation of the marine and coastal environment in ROPME Sea Area.

STRATEGY: Four Programme areas were devised based on key issues already identified in the ROPME Sea Area and in support of the 1990 Protocol for the Protection of the Marine Environment Against Pollution from Land-Based Sources.

Programme areas	Status	Specific action	Time frame
1. Update surveys of land-based activities	Completed for Bahrain, I.R. Iran, Oman, Qatar, Saudi Arabia and UAE.	• Regional report to be compiled.	1999
2. Conduct a pilot study on Persistent Organic Pollutants (POPs)	Completed for Bahrain, I.R. Iran, Oman, Qatar, Saudi Arabia.	• Regional actions to be devised.	1999
3. Preparation of a manual on the imple-mentation of the LBA Protocol		• Outline in simple language the legal, institutional and technical aspects of the LBA Protocol and its requirements for those involved: • e.g. developers, private sector, Govts. and authorities	1999-2000
4. Develop a river basin management programme		• Prepare profiles and management plans for main rivers/ systems in the ROPME Sea Area • Develop regional co-operation in river basin management with the participation of non-contracting States (e.g. Syria and Turkey)	1999-2000

5. Summary of the Regional Programme of Action for the Upper South-West Atlantic (SWAT)

OBJECTIVES: Overall goal to prevent, reduce, control and/or eliminate processes causing the degradation of the marine, coastal and associated freshwater environments in the Upper Southwest Atlantic, originating from land-based activities. Four specific objectives have been devised.

STRATEGY: Six programmatic areas were devised and 14 strategic elements have been outlined in support of the imple-mentation of the Regional Programme of Action

ACTORS IN IMPLEMENTATION: Priority areas and actions identified were primarily geared towards Governments as key players in the implementation of the Regional Programme of Action at the national level.

Programme areas	Specific action	Time frame
1. & 5. Urban wastewater and solid waste	• Identify and quantify heavily contaminated areas • Identify and quantify sources of pollution • Prepare a register of pollution sources	short term short term short term
2. Industrial waste	• Identify main pollutants for control • Inventory of main sources of industrial waste	short term short-medium term
3. Pollution and degradation from agriculture and forestry	• Inventory of pollution and degradation from agriculture and forestry sources • Regional and National workshops for exchange and harmonisation of information	short term short-medium term
4. Degradation of marine and coastal ecosystems from urban and tourism development	• Inventory of impacted ecosystems • Regional and National Workshops for exchange and harmonisation of information	short term short-medium term

6. Summary of the Regional Programme of Action for the South-East Pacific Region (SE/PCF)

OBJECTIVES: Overall goal to protect the coastal and marine environment of the South-East Pacific from pollution caused by land-based activities through cooperative actions among countries of the region. Nine specific objectives were also devised.

GENERAL STRATEGY: A draft Regional Programme was developed (Programa Regional para la Protección del Pacífico Sudeste frente a las actividades realizadas en Tierra -PROSET) tackling main pollutant source categories and key priority areas identified for action. A preliminary identification was carried out of activities required at the national level.

Programme areas	Status	Specific action	Time frame
1. Wastewater from urban origin **2. Industrial and mining operations** **3. Ports, dredging & land-fills** **4. Aquaculture** **5. Recreational and tourism operations** **6. Agricultural run-off** **7. Critically degraded habitats and physical alterations**	Environmental Assessment and Management Capacity building Transfer of Technologies Standard methodologies Financial and Institutional aspects	• Integration of national marine environmental assessments • Strengthen and develop agreements and regional cooperation framework regarding principles, standards and practices for marine pollution control from land-based activities • Advocate appropriate and alternative treatment technologies, reducing or prevent pollution loads through adoption of clean technologies • Strengthen participation and public awareness of key stakeholders (local community, NGOs and private sector) • Development of environmental management plans for relevant industries • Capacity building and training on best management practices particularly for waste management • Support rehabilitation of identified critical areas and habitats and consideration of special management measures	Short to medium term

7. South Pacific

Priority areas identified for the protection of the marine environment from land-based activities:

• Summary to be prepared following endorsement of the Regional Programme of Action in early 2000.

8. Summary of the Regional Programme of Action for the Mediterranean (MED)

	Mediterranean[1]
Sewage	Priority (Municipal sewage)
POPs	Priority (POPs and PAHs)
Radioactive substances	Priority
Heavy metals	Priority (Heavy metals and organometallic compounds)
Oils	Priority (Organohalogen compounds and used lubricating oil)
Nutrients	Priority (Nutrients and suspended solids - Industrial waste water and agriculture)
Sediment mobilisation	Not covered in the Strategic Action Programme
Litter	Priority (Urban solid waste)
Physical alterations and destruction of habitats	Priority

[1] UNEP: Strategic Action Programme to Address Pollution from Land-based Activities. MAP Technical Reports Series No. 119, UNEP, Athens, 1998: "Taking account the GPA/LBA and the LBA Protocol, the following categories of substances have been selected as priorities. The selected categories of substances cover urban environment (municipal sewage; urban solid waste; and air pollution) and industrial development (substances that are toxic, persistent and liable to bioaccumulate; other heavy metals; organohalogen compounds; radioactive substances; nutrients and suspended solids; and hazardous waste)". The Strategic Action Programme was adopted by the Tenth Ordinary Meeting of the Contracting Parties (November 1997).

	Targets	Activities at the Regional level	Activities at the National level
Sewage (Municipal sewage)	• By 2025, to dispose all municipal waste water in conformity with the provision of the LBS Protocol • By 2005, to dispose sewage from cities and urban agglomerations exceeding 100,000 inhabitants and areas of concern in conformity with the provisions of the Protocol	• By 2000, to update and adopt the 1986 guidelines for sewage treatment and disposal and, as appropriate, environmental quality criteria and standards • To develop programmes for sharing and exchanging technical information and advice regarding environmentally sound sewage treatment and facilities • To promote research programmes to identify and validate sewage treatment technologies	• To update and adopt, over a period of two years, national regulation concerning sewage discharges into the sea and rivers which take into account the LBS Protocol and especially its Annex II and whenever appropriate, the common measures already adopted by the Parties • By 2005, to develop National Plans and Programmes to the environmentally sound Management of Sewage, and to this end to ensure: • By 2005, that the coastal cities and urban agglomerations of more than 100,000 inhabitants are connected to a sewer system and dispose all waste water in conformity with a national regulation system • To locate coastal outfalls so as to obtain or maintain agreed environmental quality criteria and to avoid exposing shell fisheries, water intakes, and bathing areas to pathogens and to avoid the exposure of sensitive environments (such as lagoons, seagrass beds, etc.) to excess nutrient or suspended solid loads • To promote the primary, secondary and , where appropriate and feasible, tertiary treatment of municipal sewage discharged to rivers, estuaries and the sea • To promote and control the good operation and proper maintenance of existing facilities

	Targets	Activities at the Regional level	Activities at the National level
Sewage *continued*			• To promote the reuse of the treated effluents for the conservation of water resources. To this end, infrastructural measures, treatment at source and the segregation of industrial effluents, shall be encouraged, as well as: • The beneficial reuses of sewage effluents and sludge by the appropriate design of treatment plant and processes and controls of the quality of influent waste waters in accordance with national regulations • The environmental sound treatment when domestic and compatible industrial effluents are treated together • To promote the separate collection or rain waters and municipal waste water and ensure treatment of first rain waters considered particularly polluting • To identify the availability and sustainability of productive uses of sewage sludge, such as land-spreading, composting, etc. • To prohibit the discharge of sludge into water in the Protocol Area
POPs (POPs and PAHs)	• By 2010, to phase out inputs of the 9 pesticides and PCBs and reduce to the fullest possible extent inputs of unwanted contaminants: hexachlorobenzene, dioxins and furans • By 2005, to reduce 50% inputs of the priority 12 POPs • By 2005, to collect and dispose all PCB waste in a safe and environmentally sound manner • By 2025, to phase out to the fullest possible extent inputs of PAHs • By 2010, to reduce by 25% inputs of PAHs	• To provide Contracting Parties with technical information and advice on the nine pesticides and PCB substitutes and make appropriate recommendations • To develop programmes for sharing and exchanging technical information and advice regarding the environmentally sound disposal of the existing quantities of the nine pesticides and PCBs. These Programmes should consider their progressive elimination, including the decontamination of equipment and containers • To prepare guidelines for the application of BEP, and if possible BAT, by the point sources of dioxins and furans • To prepare guidelines for the application of BEP and BAT by the point and diffuse sources of PAHs • By 2010, to formulate and adopt, as appropriate, emission values for point source discharges and emissions of PAHs	• To make, over a period of two years, and inventory of quantities and uses of the nine pesticides and PCBs, as well as of the industries which manufacture or condition them • By 2000, to phase out the use of the nine pesticides, except those uses which involve the safeguarding of human life when the latter is in danger or when a risk/benefit analysis is very conclusive, according to WHO recommendations • By 2000, to prohibit the manufacture, trade and new use of PCBs and by 2010 all existing uses of PCBs • To prepare pilot programmes aimed at the safe disposal of the PCBs; these programmes should consider their progressive elimination, including the decontamination of equipment and containers • By year 2000, to organise the collection and environmentally sound disposal of the existing quantities of the nine pesticides • To reduce the emission of HCB, dioxins and furans as much as possible and, in order to do so, to promote the implementation of environmental audits and apply BEP, and if possible BAT, to the processes which generate these compounds, such as waste-incineration or recovery of metals, mainly copper wire and electric motors • To promote the implementation of environmental audits in the industrial installations that are sources of PAHs mentioned in the previous paragraph and located in selected hot-spots • To reduce the emission of PAHs as much as possible and, in order to do so to apply BEP and if possible BAT to the processes which generate these compounds
Radioactive substances	• To eliminate to the fullest possible extent inputs of radioactive substances	• To transmit to the Parties reports and other information received in accordance with the Convention and the Protocol	• To promote policies and practical measures including the setting of targets and timetables to minimise the generation of radioactive waste and provide for their safe processing, storage, conditioning, transportation and disposal • To adopt measures, including BAT and BEP, for the reduction and/or elimination of discharges, emissions and losses of radioactive substances to the Mediterranean Sea • To submit reports on: the authorizations granted, data resulting from monitoring, quantities of pollutants discharged from their territories and the action plans, programmes and measures implemented
Heavy metals (Heavy metals and organo-metallic compounds)	• By 2025, to phase out to the fullest possible extent discharges and emissions and losses of heavy metals (mercury, medium, lead) • By 2005, to reduce by 50% discharge, emissions and losses of heavy metals (mercury, cadmium, lead)	• To prepare guidelines for the application of BAT and BEP in the industrial installations that are sources of heavy metals (mercury, cadmium and lead) • By 2010, to formulate and adopt, as appropriate, environmental quality criteria and standards for point source discharges and emissions of heavy metals (mercury, cadmium and lead)	• To reduce discharges and emissions of heavy metals as much as possible and in order to do so, to promote the implementation of environmental audits and apply BEP and, if possible, BAT in the industrial installation that are sources of heavy metals giving priority to installations located in the selected hot-spots • To prepare National Programmes on the reduction and control of pollution by heavy metals • To adopt at the national level and apply the common measures for preventing mercury pollution adopted by the Parties in 1987 (releases into the sea, max. conc. 0.050 mg/l)

	Targets	Activities at the Regional level	Activities at the National level
Heavy metals *continued*	• By 2000, to reduce by 25% discharges, emissions and losses of heavy metals (mercury, cadmium, lead) • To eliminate to the fullest possible extent pollution of the Mediterranean Sea caused by discharges, emissions and losses of zinc, copper and chrome • By 2010, to reduce discharges, emissions and losses of zinc, copper and chrome • By 2010, to phase out to the fullest possible extent discharges, emissions and losses of organomercuric compounds and reduce to the fullest possible extent those of organolead and organotin compounds • By 2010, to reduce by 50% discharges, emissions and losses of organometallic compounds • To phase out by 2005 the use of organomercuric compounds	• To prepare guidelines for the application of BAT and of BEP in industrial installations which are sources of zinc, copper and chrome • By 2010, to formulate and adopt, as appropriate EQ criteria and standards for point source discharges and emissions of zinc, copper and chrome • To prepare guidelines for BAT and BEP in industrial installations that are sources of organometallic compounds • By 2010, to formulate and adopt, as appropriate, environmental quality criteria and standards for point source discharges and emissions of organometallic compounds	• To adopt and apply for the industries of the alkaline chloride electrolysis sector, as well as the previous standard, the maximum value of 0.5 grams of mercury in the water per tonne of chlorine production capacity installed (brine recirculation), 5 grams of mercury in the water per tonne (lost brine technology) and, if possible, 2 g of mercury from total releases into water, air and products) • To adopt at the national level and apply the anti-pollution common measures for cadmium and cadmium compounds adopted by the Parties in 1989 (releases into the sea, max. conc. 0.2 mg/l) • To prepare environmental voluntary agreements to which authorities, producers and users are committed on the basis of a reduction plan • To reduce discharges and emissions of zinc, copper and chrome as much as possible and, in order to do so, to promote the implementation of environmental audits and apply BEP and, if possible, BAT in industrial installations which are sources of zinc, copper and chrome, giving priority to installations located in the selected hot spots • To adopt at the national level and apply the common measures to control pollution caused by zinc, copper and their compounds adopted by the Parties in 1996 (releases into the sea, max. conc. 1.0 mg/l for zinc and 0.5 mg/l for copper) • To reduce discharges and emissions of organometallic compounds as much as possible and, in order to do so, to promote the implementation of environmental audits and apply BEP and, if possible, BAT in industrial installations that are sources of organometallic compounds • To promote the use of lead-free petrol • To make an inventory of the uses and quantities of organomercuric used • To adopt at the national level and apply the anti-pollution common measures for the organotin compounds adopted by the Contracting Parties in 1989 • To phase out the use of organotin compounds as anti-fouling agents in cooling systems
Oils (Hydro-carbons) (**Organo-halogen compounds** and used lubricating oil)	• To eliminate to the fullest possible extent pollution of the Mediterranean Sea caused by discharges, emissions and losses of organohalogen compounds • By 2010, to reduce discharges, emissions and losses into the Mediterranean Sea of organohalogen compounds	• To prepare guidelines for the application of BAT and of BEP in industrial installations which are sources of organohalogen compounds • By 2010, to formulate and adopt, as appropriate, environmental quality criteria and standards for point source discharges and emissions of organohalogen compounds	• To reduce discharges and emissions of organohalogen compounds as much as possible and, in order to do so, to promote the implementation of environmental audits and apply BEP and, if possible, BAT in the industrial installations which are sources of organohalogen com-pounds, giving priority to installations located in the selected hot-spots • To prepare National Programmes on the reduction and control of pollution by organohalogen compounds • To adopt at the national level and apply the anti-pollution common measures adopted by the Parties • To regulate releases of organochlorines by the paper and paper pulp industries by limiting discharges measured as AOX (adsorbable organic halogen) to 1 kg per tonne of pulp produced and by reducing it further through the promotion of alternative bleaching to molecular chlore and the use of BAT and BEP • To make an inventory of the uses and quantities of chlorinated paraffins and to reduce the use of short-chain chlorinated paraffins • To make an inventory of the uses and quantities of pesticides • To reduce and control the manufacture and use of PDBEs and PBBs • To reduce and control the manufacture and use of certain pesticides such as lindane, 2,4-D and 2,5-T herbicides, and tri-, tetra- and penta- chlorophenols, used in the treatment of wood • To participate in the programmes and activities of international organizations, especially FAO on the sustainable use of pesticides and to promote integrated pest management • To participate in the OECD/FAO Pesticide Risk Reduction Project • To prepare environmental voluntary agreements to which authorities, producers and users are committed on the basis of a reduction plan

	Targets	Activities at the Regional level	Activities at the National level
Oils (Hydro-carbons) *continued* (Organo-halogen compounds and **used lubricating oil**)	• By 2005, to collect and dispose 50% of used lubricating oil in a safe and environmentally sound manner	• To formulate and adopt a standard on the maximum amount of PCB an oil may contain before it is considered to be contaminated (i.e. 50 mg/kg) • By 2000, to make an inventory of the quantities of the three categories of luboil	• To prepare and adopt national pilot programmes for the collection, recycling and disposal of used luboils • To prepare and adopt national pilot programmes for the collection, recycling and disposal of used luboils • To prepare and adopt national pilot programmes for the collection, recycling and disposal of used luboils from the public services sector (air, road and railway transport, energy transport and distribution) and from military establishments • To adopt at the national level and apply the common anti-pollution measures for luboils adopted by the Contracting Parties in 1989
Nutrients (Nutrients and suspended solids) Industrial waste water and agriculture)	• By 2025, to dispose all waste water from industrial installations which are sources of BOD, nutrients and suspended solids, in conformity with the provisions of the LBS Protocol • Over a period of 10 years, to reduce by 50% inputs of BOD, nutrients and suspended solids from industrial installation sources of these substances • To reduce nutrient inputs, form agriculture and aquaculture practices into areas where these inputs are likely to cause pollution	• To prepare guidelines for the application of BAT and BEP in industrial installations which are sources of BOD, nutrients and suspended solids • By 2010, to formulate and adopt, as appropriate, EQ criteria and standards for point source discharges of BOD, nutrients and suspended solids • By 2010, to formulate and adopt guidelines for waste waters treatment and waste disposal from industries which are sources of BOD, nutrients and suspended solids • To participate in the programmes and activities of international organizations, especially FAO, on sustainable agricultural and rural development in the Mediterranean • To participate in the FAO programme on the sustainable use of fertilizers and to encourage the preparation of national and regional strategies based on the controlled, appropriate and rational use of seeds, fertilizers and pesticides • To prepare guidelines for the application of BEP (including good agricultural practices) for the rational use of fertilizers and the reduction of losses of nutrients from agriculture	• To reduce discharges of pollutants as much as possible and, in order to do so, to promote the implementation of environmental audits and apply BEP and, if possible, BAT in the industrial installations which are sources of BOD, giving priority to installations located in hot-spots • To develop National Programmes for the environmentally sound management of waste water and solid waste from industrial installations which are sources of BOD, and to this end to ensure: • By 2005, that at least industrial installations which are sources of BOD, nutrients and suspended solids, located in areas of concern, dispose all waste water in conformity with national regulation system • To locate coastal outfalls so as to obtain or maintain agreed environmental quality criteria and to avoid the exposure of sensitive environments (such as lagoons, seagrass beds, etc.) to excess nutrient or suspended solid loads • To promote primary, secondary and, where appropriate and feasible tertiary treatment of BOD waste water discharged into rivers, estuaries and the sea • To promote sound operation and proper maintenance of facilities • The reduction and beneficial use of waste water or other solutions appropriate to specific sites, such as no-water and low-water solutions • The identification of the availability and sustainability of productive uses of waste water sludge, and other waste, such as land-spreading, composting, energy uses, animal feed, etc. • To prepare environmental voluntary agreements to which authorities, producers and users are committed on the basis of a reduction plan • To assess the quantities and types of fertilizers used • To assess the quantity of solid and liquid manure produced by farm animals • To promote the rational use of fertilizer and reduce the losses of nutrients by misuse of inorganic fertilizer and manure • To promote ecological agriculture and ecological aquaculture • To promote rules of good agricultural practices • To participate in the programmes and activities of international organizations, especially FAO, on sustainable agricultural and rural development in the Mediterranean • To promote the implementation of the Convention on Desertification
Sediment mobilization	***Not covered in the Strategic Action Programme***		
Litter (Urban soild waste)	• By 2025 at latest, to base urban solid waste management on reduction at source, separate collection, recycling, composting and environmentally sound disposal • By 2005 at latest, to base urban solid waste management on reduction at source, separate collection, recycling, composting and environmentally sound disposal in all cities and urban agglomerations exceeding 100,000 inhabitants and areas of concern	• By 2000, to formulate and adopt guidelines for environmentally suitable and economically feasible systems of collection including separate collection, and disposal or urban solid waste • By 2005, to develop programmes for the reduction and recycling of urban solid waste	• By 2000, to develop national plans and programmes for the reduction at source and environmentally sound management of urban solid waste • By 2005, to establish environmentally suitable and economically feasible systems of collection and disposal or urban solid waste in cities and urban agglomerations of more than 100,000 inhabitants • To promote the reduction and recycling of urban solid waste

	Targets	Activities at the Regional level	Activities at the National level
Physical alterations and destruction of habitats	• To safeguard the ecosystem function, maintain the integrity and biological diversity of species and habitats • Where practicable, to restore marine and coastal habitats that has been adversely affected by anthropogenic activities	• To formulate guidelines for the preservation of habitats and normal ecosystem functions in coastal areas, particularly in the context of ICZM • To develop programmes for ICZM	• To support programmes for ICZM • To undertake studies on the potential effects on the environment or EIA according to the importance of the physical alterations and the destruction of habitats related to management projects • To establish a system of previous authorization by competent national authorities for works which cause physical alteration of the natural state of the coastline or the destruction of coastal habitats

9. South Asian Seas (SAS)

Priority areas identified for the protection of the marineenvironment from land-based activities:

- Development of strategy, including a Programme of Action for the protection of the marine environment of the South Asian Seas from Land-based Activities;
- Development of a regional programme for monitoring of marine pollution in the coastal waters of the South Asian Seas and the regular exchange of relevant data and information;
- Development of pilot activities in the countries of South Asian Seas to control the degradation of the marine coastal environment from land-based activities
- Training of personnel involved in these pilot projects to control the degradation of the marine and coastal environment from land-based activities, including the preparation of a training-manual; and
- Development of a regional programme to identify special problems of the largest coastal cities and of the island States in areas of (a) disposal of domestic sewage effluents and (b) collection and disposal of solid waste.
- *The preparation of (a) National Programmes of Action, (b) Regional Overview and (c) Regional Programme of Action on Land-based Activities under preparation, coordinated by SACEP (Secretariat of the SAS Action Plan) with the support of the GPA Coordination Office and will include two additional land-locked countries (Nepal and Buthan).*

Source: Matrices of the Status of Implementation of Regional Seas Conventions and Action Plans, UNEP(DEC)/RS.Inf 13, Second Meeting of Regional Seas Conventions and Action Plans, The Hague, The Netherlands, 5-8 July 1999.

10. Red Sea and Gulf of Aden (RED)

Priority areas identified for the protection of the marine environment from land-based activities:

- Development of a regional programme of action for land-based activities.
- *The Regional Programme of Action on Land-based Activities is under preparation, coordinated by PERSGA (Red Sea and Gulf of Aden Environment Programme), taking into account efforts of the Strategic Action Programme under GEF, and with the support of the GPA Coordination Office*

Source: Discussions of GPA Coordination Office with PERSGA Secretariat held during Second Meeting of Regional Seas Conventions and Action Plans, The Hague, The Netherlands, 5-8 July 1999

11. Wider Caribbean (CAR)

Priority areas identified for the protection of the marine environment from land-based activities:

Source Categories and Activities:

Domestic Sewage, Agricultural Non-Point Sources, Chemical Industries, Extractive Industries and Mining, Food Processing Operations, Manufacture of Liquor and Soft Drinks, Oil Refineries, Pulp and Paper Factories, Sugar Factories and Distilleries, Intensive Animal Rearing Operations.

Associated Contaminants of Concern

The contaminants mentioned below have been identified on the basis of their hazardous or otherwise harmful characteristics. This list shall serve as a guide when formulating effluent and emission limitations and management practices for the sources and activities in Annex I of the Protocol on LBA (see more below).

1. Primary Contaminants of Concern

a. Organohalogen compounds and substances which could result in the formation of these compounds in the marine environment; b.Organophosphorus compounds and substances which could result in the formation of these compounds in the marine environment; c.Organotin compounds and substances which could result in the formation of these compounds in the marine environment; d.Heavy Metals and their compounds, e. Crude Petroleum and hydrocarbons; f. Used Lubricating Oils, g. Polycyclic aromatic hydrocarbons; h.Biocides and their derivatives, i. Pathogenic micro-organisms, possible result of eutrophication; j. Cyanides and fluorides; k.Detergents and other non-biodegradable surface tension substances; l..Nitrogen and phosphorous compounds; m. Persistent synthetic and other materials including garbage, that float, flow or remain in suspension, or settle to the bottom and affect marine life and hamper the uses of the sea; n. Compounds with hormone-like effects; o. Radioactive substances, including their waste, p. Sediments and q. Any other substance or group of substances with one or more of the characteristics outlined in Section 2 of Annex I.

The above information is as per priority sources identified in the Draft protocol on LBA being negotiated under the Cartagena Convention by the Regional Coordinating Unit for the Caribbean Environment Programme (see Annex I to the Draft Protocol)

- *The preparation of a Regional Programme on LBA will likely follow directives from the Plenipotentiary Meeting for the Adoption of the Protocol on Land-based Activities (Aruba, 27 September-6 October 1999), where the Protocol was negotiated, adopted and open for signature*

Source: Discussions of GPA Coordination Office with CEP Secretariat held during Second Meeting of Regional Seas Conventions and Action Plans, The Hague, The Netherlands, 5-8 July 1999

12. Black Sea Environment Programme (BLACK)

Priority areas identified for the protection of the marine environment from land-based activities:

Rivers:

Development of Black Sea Basin Wide Strategy, to address the eutrophication problem in the Black Sea. The objective of the strategy should be to negotiate a progressive stepwise reduction of nutrient loads, until water quality objectives are met for the Black Sea, including the reduction of input of other pollutants into the Black Sea, in particular oil. Given that the Danube is the largest single source of nutrient inputs into the Black Sea, it is imperative that strategies for the reduction of nutrients be adopted for this river. The provisions in the Danube Strategic Action Plan (maintenance of 1995 levels) clearly are insufficient for addressing the eutrophication problem in the Black Sea.

High priority point-sources:

Completed: A list of high priority sites (hot-spots) for reducing discharges of pollutants

On-going: National Strategic Action Plans (NSAPs) were developed and are at the stage of approval by Governments *[as of July 1999]* which will include strategies and timetables for substantial reduction of inputs of pollutants from hot-spots by 2006, in accordance with agreed water quality objectives.

Planned: National reports on the progress made in addressing the identified hot-spots will be presented to the Istanbul Commission and widely disseminated in 2000 and 2006. This report should include an assessment of the progress made on the strategy for each site. If the progress made is found to be insufficient to meet the agreed water quality objectives, further steps to reduce inputs will be decided upon at the Ministerial meetings.

Regulation of point sources:

Planned: (1) **Comprehensive national studies on the discharge of insufficiently treated sewage** will be prepared by each Black Sea state by January 2000. The Istanbul Commission, through its Advisory group on the Control of Pollution from Land-Based sources will coordinate this activity. These studies will analyse the national and regional benefits to public health, the environment and recreation as well as the economic costs of installing sewage treatment plants to serve as a basis for taking decisions and implementing measures on insufficiently treated sewage from large urban areas by 2006. (2) **Implementation of the Protocol on Land-Based Sources to the Bucharest Convention and the elimination of discharges of POPs of global significance**. The following actions shall be taken:

- Water quality objectives shall be harmonised on the basis of use of water. The Istanbul Commission upon the recommendations of its Advisory Group on pollution Monitoring and Assessment will adopt such harmonised water quality objectives and where necessary standards by mid-1998. These objectives should be subjected to a comprehensive review every five years.
- Each Black Sea state shall endeavour to adopt and implement, in accordance with its own legal system, by 1999, the laws and mechanisms required for regulating discharges from point sources. The basis for regulating discharges will be a licensing system, through which the harmonised water quality objectives can be applied.
- Each Black Sea state will also endeavour to adopt and implement, in accordance with its own legal system, efficient enforcement mechanisms by 1999.
- Each Black Sea state will consider the introduction of policies in which polluters are made to pay for compliance. The application of environmentally friendly production processes or other innovative process which reduce inputs of pollutants may also be encouraged through economic incentives.

Source: Paper on the “Black Sea” received from the Coordinator of the Black Sea Environment Programme at the Second Meeting of Regional Seas Conventions and Action Plans, The Hague, The Netherlands, 5-8 July 1999.

13. Summary of the Regional Programme of Action for the Arctic (Arctic Council Regional Programme for the Protection of the Arctic Environment from Land-based Activities)

Objectives	Specific action	Action by whom	Time frame
Take action individually and jointly which will lead to prevention, reduction, control and elimination of pollution in the marine environment; Regional identification and assessment of problems; Regional establishment of priorities for action; Strengthen regional and national capacity building; and Harmonize, as appropriate, and adjust measures to fit the particular.	• Clearing House Development • Revise Mining Guideline Proposal • Establish Correspondence Group on Shipping • Finalize Russian NPA Arctic • Support for Russian NPA-Arctic and Partnership Conference • Review Operating Guidelines • Co-sponsor IUCN Marine Workshop in November • Report to CSD	All countries Canada Norway Russia All countries All countries PAME/CAFF/ IUCN Canada	1999

	• Define Coastal Area
	• Respond to Marine Workshop Recommendations
	• Preparatory Meeting on Partnership Conference
	• Identify Lead for Analysis of International Agreements and Arrangements
	• Complete Shipping Analysis
	• Consider Indicators for Offshore Oil and Gas Guideline Effectiveness
	• Progress Reports to Ministers on:
	  • RPA, Russian NPA-Arctic, Partnership Conference
	  • shipping analysis
	  • meeting goals and objectives of offshore guidelines
	• Status of agreements and additional instruments
			2000

	• Hold Partnership Conference • Collate Shipping Proposals • Collate proposed amendments to PAME Offshore Oil and Gas Guidelines • Respond to additional RPA Proposals • Complete update on marine pollution sources		2001

	• Complete Analysis of International Agreements and Arrangements. Provide recommendations on:
	  • adequacy of international agreements and arrangements
	  • possible new shipping measures
	  • possible amendments to offshore oil and gas guidelines
	  • possible new measures for land-based activities
			2002

Priorities of Regional Programme of Action:

Source categories	Priorities for action
POPs	High
Radionuclides	Medium
Heavy metals	High
Petroleum hydrocarbons	Medium
Sewage	Low
Nutrients	Low
Sediment	Low
Litter	Low
Physical degradation	Medium-High

Source: Paper on the “Arctic Regional Programme” received from the Chairman of PAME following the Second Meeting of Regional Seas Conventions and Action Plans, The Hague, The Netherlands, 5-8 July 1999.

14. Summary of the Regional Programme of Action for the North-East Atlantic (OSPAR)

Source of pollution	Objectives	Strategy	Specific action	Action by whom	Time frame
Human activities producing the hazardous substances as defined in Annex I of the OSPAR Strategy with regard to Hazardous Subtances	To prevent pollution of the maritime area by continuously reducing discharges, emissions and losses of hazardous substances (as defined in Annex I of the Convention), with the ultimate aim of achieving concentrations in the marine environment near background levels for naturally occurring substances and close to zero for man-made synthetic substances	To identify the sources of hazardous substances and their pathways to the marine environment and establish whether these represent either a widespread problem or a problem restricted to regional or local environments. To select substances to be given priority attention, including those which give reasonable grounds for concern that they are endocrine disruptors. To develop programmes and measures to monitor and control the emissions, discharges and losses of hazardous substances which reach, or could reach, the marine environment. To take effective action when there are reasonable grounds for concern that hazardous substances which reach, could reach, or are introduced to the marine environment, may bring about hazards to human health, harm living marine ecosystems, damage amenities or interfere with other legitimate uses of the sea, even where is no conclusive evidence of a causal relationship between the inputs and the effects.	Activities for 1998-1999, include: Development of dynamic selection and prioritization mechanism for hazardous substances; preparation of comprehensive background documents on harzardous substances; Review PARCOM Decision 96/3 on Harmonised Mandatory Control System for the Use and Reduction of the Discharge of Offshore Chemicals; reports containing effects of dredging and contaminant inputs from dredged materials. • **Selection and prioritisation of hazardous substances:** a. *give priority to the finalisation,* by OSPAR 2000, of the dynamic selection and prioritisation mechanism for hazardous substances (including endocrine disruptors), and will apply this mechanism to substances and groups of substances of concern, including those substances and groups of substances as set out in the 1998 OSPAR List of Candidate Substances at Annex 3 to the OSPAR Strategy with regard to Hazardous Substances; b. *give priority to the development* of programmes and measures for the substances on the OSPAR list of chemicals for priority action (cf. Annex 2) until the development of the selection and prioritisation mechanism is completed. This Annex will be updated from time to time on the basis of the results of the application of this mechanism. • **Substitution of hazardous substances:** a. develop procedures for identifying less hazardous or preferably non-hazardous substitutes for hazardous substances used both on land and offshore. Priority will be given to identifying relevant substitutes for the hazardous substances on the OSPAR list of chemicals for priority action. • **Development of programmes and measures to combat pollution** a. *prepare background documents, including descriptions of Best Available Techniques (BAT) and/or Best Environmental Practices (BEP),* as a basis for the development of programmes and measures for: i. the substances and groups of substances listed in the attached Annex 2; ii. the sectors listed in the attached Annex 3; b. *adopt appropriate programmes and measures (including BAT/BEP)* for these sectors, sources and substances with a view to continuously reducing discharges, emissions and losses of hazardous substances; c. *give special attention to:* i. the development and adoption of programmes and measures for reducing uses of the substances and/or the generation of hazardous substances on the OSPAR list of chemicals for priority action; ii. to the need of developing other programmes of work (e.g. as regards diffuse sources of hazardous substances); d. *review OSPAR BAT/BEP measures* in accordance with the agreed timetable (cf. reference number 1999-7) and taking into account, *inter alia*, the progress achieved in the development of BAT Reference Documents under Council Directive 96/61/EC concerning integrated pollution prevention and control.	Working group on Point Sources (POINT); working group on Diffuse Sources (DIFF); working group on Concentrations Trends Effects of Substances in the Marine Environment (SIME); working group on Inputs to the Marine Environment (INPUT); and others	The reduction by the year 2000, of discharges, emissions and looses of hazardous substances which could reach the marine environment, to levels that are not harmful to humans or nature, with the aim to eliminate them. Move towards the target of the cessation of discharges, emissions and losses of hazardous substances by the year 2020

Source of pollution	Objectives	Strategy	Specific action	Action by whom	Time frame
			• Monitoring a. *establish inputs of hazardous substances to the marine environment* for: i. atmospheric inputs, including an inventory of emissions to air and the monitoring of atmospheric pollutants; ii. riverine inputs and land-based discharges directly into the marine environment differentiating, where possible, anthropogenic inputs; iii. discharges and emissions from particular sectors (including offshore installations) or activities (including the dumping of materials); iv. inputs of selected substances (e.g. via pilot studies for a detailed overview) b. *monitor hazardous substances in relevant compartments of the marine environment* (Coordinated Environmental Monitoring Programme) and, in particular: i. develop and implement programmes and models to provide suitable monitoring data (e.g. surveys) concerning hazardous substances and their effects in the maritime area (3); ii. Develop and apply screening methods for hazardous substances not normally monitored particularly those prioritised by the Dynamic Selection and Prioritisation Mechanism for Hazardous substances (DYNAMEC); iii. give priority to the development of suitable monitoring and testing techniques for endocrine disruptors; iv. conduct, on the basis of an intercomparison exercise, a concerted survey of the maritime area to gauge the spatial extent of any adverse effects arising from exposure to endocrine disruptors. **• Assessment** a. *assess whether there are reasonable grounds for concern with regard to specific hazardous substances* (in particular when there is a lack of relevant risk assessment or monitoring data), and will, to the extent possible, initiate immediate programmes to help characterise the risks connected to such substances; b. *compile and consider the development and use of tools and criteria* (including guidance for their use) such as: i. background/reference values; ii. ecotoxicological assessment criteria; iii. EQOs and EcoQOs where applicable; iv. statistical techniques and mathematical models for assessing inputs to the maritime area and for evaluating the environmental conditions in sea areas		
Human activities impacting on marine specie and habitats	To protect and conserve the ecosystems and biological diversity of the maritime area which are, or could be, affected as a result of human activities, and to restore, where practicable, marine areas which have been adversely affected	To assess which species (or populations of species) and habitats need to be protected and those human activities that are likely to have an actual or potential adverse effect on these species and habitats or on ecological processes. To draw up programmes and measures (including guidance for the selection and establishment of a system of specific areas and sites which need to be protected) with a view to controlling the human activities having an adverse impact, and to restore, where practicable, marine areas which have been adversely affected, giving priority to those marine species, habitats or ecological processes that appear to be under immediate threat or subject to rapid decline	For 1998-2003 • Develop and compile criteria and guidance for the selection of species and habitats and apply this for: i. the compilation of lists of e.g. threatened or declining species and of threatened habitats; and ii. and for the selection of species and habitats which need to be protected; • Carry out an assessment of the actual or potential impact of the human activities listed in Annex 1 [to this strategy]; • Carry out an assessment of marine areas which have been adversely affected; • Collect and evaluate information concerning existing protection programmes for marine species and habitats which are already protected; • Draw up programmes and measures including, as appropriate: i. a system of specific areas or sites which need to be protected and plans to manage such areas or sites; ii. control of specific human activities that have an actual or potential adverse impact on species and habitats; iii. protection of marine species, habitats or ecological processes that appear to be under immediate threat or subject to rapid decline; and iv. restoration, where practicable, of marine areas which have been identified as being adversely affected; • Develop and implement a biological component of the Joint Assessment and Monitoring Programme aimed at assessing the status of the biological diversity of the maritime area.	The working group on Impacts on the Marine Environment (IMPACT) will implement the activities.	Rapid adoption of programmes and measures once Annex V to the Convention enter into force

Source of pollution	Objectives	Strategy	Specific action	Action by whom	Time frame
Human activities that result in elevated concentrations of nutrients in the marine environment	To combat eutrophication in the OSPAR maritime area, in order to achieve a healthy environment where eutrophication does not occur	To identify areas where actions need to be taken through an agreed "Common Procedure" which will be used to characterise each part of the maritime area as a problem area, potential problem area, or a non-problem area with regard to euthophication. To identify and quantify the various sources of nutrients and establish the direct and indirect links between these sources and any eutrophication problems. To take an integrated target-oriented and source-oriented approach in the development of further measures to prevent and eliminate eutrophication in the OSPAR maritime area.	• **Assessment of the eutrophication status [priorities]** a. *carry out an evaluation of the situation in the maritime area* that would be expected following the implementation of agreed measures; b. *compile information on agreed methodologies and monitoring* in support of the classification of areas; c. *develop them where they do not already exist*. • **Development and implementation of measures to combat eutrophication** a. further develop and adopt harmonised quantification and reporting procedures for nutrients, including relevant sources, basic figures, calculation methods and emission factors; b. review the implementation of, and reporting on PARCOM Recommendation 88/2 on the Reduction in Inputs of Nutrients to the Paris Convention Area; c. review the implementation of national action plans in the context of PARCOM Recommendation 89/4 on a Coordinated Programme for the Reduction of Nutrients; d. review the implementation of, and reporting on, any national or international measures as adopted by individual Contracting Parties for the reduction of nutrients in discharges/ emissions from industry, sewage treatment plants, agriculture and other diffuse sources. evaluate the experience gained and the results achieved with the OSPAR Strategy to Combat Eutrophication (e.g. in the light of the ongoing activities to fulfil the 50% reduction target) e. assess the need for the setting of further reduction targets; f. develop further relevant source-reduction measures needed to complement or update existing measures, inter alia by developing BEP for the sectors listed in Annex 3; and g. consider the updating of PARCOM Recommendations 88/2, 89/4 and PARCOM Recommendation 92/7 on the Reduction of Nutrient Inputs from Agriculture into Areas where these Inputs are Likely, Directly or Indirectly, to Cause Pollution	Working group on Nutrients and Eutrophication (NEUT) with shared responsibilities with other working groups.	By 2000 to have evaluated the situation expected in the maritime area following the implementation of agreed measures, and to have identified non-problem areas with regard to eutrophication. By 2002 to have identified the eutrophication status of all parts of the maritime area and to have agreed on any additional programmes and measures reuqired to achieve by the year 2010 a healthy marine environment where eutrophication does not occur
Radioactive substances			Activities for 1998-1999 include assessment of information on reduction of emissions from parties ;summary of national reports; revised guidelines on BAT; report on EIA for discharges. a. *identify and take the action required by the year 2000* as a result of § 4.1a of OSPAR's Strategy with regard to Radioactive Substances; b. *identify and assess the need for action and prioritise by the year 2003* radioactive substances and/or human activities which give rise for concern about their impact on the marine environment. c. *undertake to develop environmental quality criteria for the protection of the marine environment from adverse effects of radioactive substances* and report on progress by the year 2003; d. *develop programmes and measures, thereby ensuring the application of BAT/BEP*, for nuclear sectors and for non-nuclear sectors with discharges, emissions or losses of radioactive substances (cf. Annex 3), including, where appropriate, clean technology; e. *examine in the year 2000 the results of a review and assessment of the reprocessing and non-reprocessing options for spent fuel management* (carried out by the Nuclear Energy Agency), and prepare proposals for actions to be initiated / taken in the framework of OSPAR.	RAD and SIME will implement the activities outlined	OSPAR Action Plan 1998-2003

Source of pollution	Objectives	Strategy	Specific action	Action by whom	Time frame
		Overall evaluation and review of progress **Note: activities for 1998-1999, include:** Five regional Quality Status Reports (QSRs): Arctic Waters, Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast and Wider Atlantic to be finalised in 1999. Revised "Standard implementation Reporting and Assessment Procedure" to be adopted in 1999.	**• Monitoring and tools for assessment** a. *further develop and adopt a set of quantified assessment criteria* and means for interrelating them for use in the characterisation of problem areas, potential problem areas and non-problem areas with regard to eutrophication; b. *initiate the following actions in the period up to the year 2000:* i. develop the appropriate scientific basis and an agreed methodology to derive ecological quality objectives; ii. develop procedures for the use of information from monitoring, research and modelling and for the use of assessment criteria of the Common Procedure; and c. *adopt and apply ecological quality objectives* taking into account the review of the OSPAR Strategy to Combat Eutrophication and of the quinquennial reports on progress achieved. **• Assessment and Monitoring** Continue to work in accordance with the Joint Assessment and Monitoring Programme (JAMP). In the period 1998-2000, finalise the five regional Quality Status Reports (QSRs) and the convention-wide QSR 2000 in the year 2000. The findings of the QSR 2000 will betaken into account in the quinquennial review of the OSPAR strategies **• Compliance and effectiveness assessment** a. assess reports of Contracting Parties on the implementation of programmes and measures adopted under the Convention; b. assess the effectiveness of these programmes and measures with a view to improving the protection of the marine environment.	OSPAR's subsidiary bodies will execute the activities in accordance with their terms of reference, and present the relevant results to the Commission	

Annex 4

Regional Seas Programmes

ACTION PLANS OF UNEP'S REGIONAL SEAS PROGRAMME

The UNEP Regional Seas Programme was initiated in 1974 as a global programme implemented through regional components. Its general objective is the sustainable management of resources through integrated management of the coastal and marine environments, focusing not only on the mitigation or elimination of the consequences, but also on the causes of environmental degradation. The Programme at present comprises 12 regions with over 140 coastal States and Territories participating.

The fulcrum for each regional programme is an Action Plan, designed to link assessment of the quality of the marine environment and the causes of its deterioration with response actions for the management and development of the marine and coastal environment. The regional action plans promote the parallel development of regional legal agreements. Overall implementation of each action plan and activities is coordinated by a Regional Coordinating Unit (RCU) to ensure integrated and well-arranged execution, from within the region, of projects under the action plan.

Mediterranean (MAP)

Action Plan for the Protection of the Mediterranean Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (20 participant States). Action plan adopted in 1976, rev 1995. Legislative authority: Barcelona Convention for the Protection of the Mediterranean Sea against Pollution (adopted in 1976, entered into force in 1978, amendments 1995); operated under the authority of UNEP's Executive Director on the basis of decisions of UNEP Governing Council and the meetings of Contracting Parties to the Barcelona Convention. Secretariat: Coordinating Unit for the Mediterranean Action Plan (Athens, Greece)

Caribbean (CAR)

Action Plan for the Caribbean Environment Programme (28 States and the Caribbean territories of France, the Netherlands and the United Kingdom). Action plan adopted in 1981. Legislative authority: Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (adopted in 1983, entered into force in 1986); operated under the authority of UNEP's Executive Director on the basis of decisions of UNEP Governing Council and the meetings of Contracting Parties to the Cartagena Convention. Secretariat: Regional Coordinating Unit for the Caribbean Environment Programme (Kingston, Jamaica)

West and Central Africa (WACAF)

Action Plan for the Protection and Development of the Marine and Coastal Areas of the West and Central African Region (21 States). Action plan adopted in 1981. Legislative authority: Abidjan Convention for Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (adopted in 1981, entered into force in 1984); operated under the authority of UNEP's Executive Director on the basis of decisions of UNEP Governing Council and the meetings of Contracting Parties to the Abidjan Convention. Secretariat: Regional Coordinating Unit for the West and Central African Region (Abidjan, Côte d'Ivoire)

Eastern Africa (EAF)

Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (9 States). Action plan adopted in 1985. Legislative authority: Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region (adopted in 1985, entered into force in 1996); operated under the authority of UNEP's Executive Director on the basis of decisions of UNEP Governing Council and the meetings of Contracting Parties to the Nairobi Convention. Secretariat: Regional Coordinating Unit for the East African Action Plan (St. Anne Island, Seychelles)

East Asian Seas (EAS)

Action Plan for the Protection and Development of the Marine and Coastal Areas of the East Asian Seas Region (10 States). Action plan adopted in 1981, rev in 1994). Legislative authority: A Convention does not exist (the action plan is implemented under the authority of UNEP's Executive Director of the basis of decisions of UNEP Governing Council and the Intergovernmental meetings of the Coordination Body on the Seas of East Asia-COBSEA) Secretariat: Regional Coordinating Unit for the East Asian Action Plan (Bangkok, Thailand)

Northwest Pacific (NOWPAP)

Action Plan for the Protection, Management and Development of the Marine and Coastal Environment of the Northwest Pacific Region (5 States). Action plan adopted in 1994. Legislative authority: A Convention does not exist (the action plan is implemented under the authority of UNEP's Executive Director of the basis of decisions of UNEP Governing Council and the intergovernmental meetings of the countries participating in the action plan).

Secretariat (on an interim basis): Division of Environmental Conventions, UNEP (Nairobi, Kenya).

Upper South-West Atlantic (SWAT)

UNEP is facilitating a tripartite cooperation between Argentina, Brazil and Uruguay, but a regional programme does not exists.

Northeast Pacific (NEP)

A regional programme is under negotiation with the auspices of UNEP.

ACTION PLANS IN THE FRAMEWORK OF AND ASSOCIATED WITH UNEP'S REGIONAL SEAS PROGRAMME

ROPME Sea Area/Kuwait Action Plan Region (KAP)

Action Plan for the Protection of the Marine Environment and the Coastal Areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. Action plan adopted in 1978. Legislative authority: Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (adopted in 1978, entered into force in 1979). Action plan implemented under the authority of the Executive Secretary of the Regional Organization for the Protection of the Marine Environment (ROPME) on the basis of decisions of the ROPME Council consisting of representatives of the Contracting Parties to the Kuwait Convention. Secretariat: ROPME (Safat, State of Kuwait)

South-East Pacific (SE/PCF)

Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific (adopted in 1981, rev in 1986) (5 States). Legislative authority: Lima Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific (adopted in 1981, entered into force in 1986). Action plan implemented under the authority of the Secretary General of the Permanent Commission for the South Pacific (Comision Permanente del Pacifico Sur-CPPS) on the basis of decisions of the meetings of the Contracting Parties to the Lima Convention. Secretariat: CPPS, the Secretariat of the CPPS is located in one of the member States on a rotational basis every four years, and is currently in Quito, Ecuador

Red Sea and Gulf of Aden (RED)

Action Plan for the Conservation of the Marine Environment and Coastal Areas of the Red Sea and Gulf of Aden (adopted in 1982, rev in 1985) (7 States). Legislative authority: Jeddah Regional Convention for the Conservation of the Red Sea and Gulf of Aden Environment (adopted in 1982, entered into force in 1985). Action plan implemented under the authority of the Director General of the Arab League Educational, Cultural and Scientific Organization (ALECSO) on the basis of decisions of the ALECSO General Conference and the meetings of the Contracting Parties to the Jeddah Convention. Secretariat: Red Sea and Gulf of Aden Environment Programme (PERSGA) (Jeddah, Saudi Arabia).

South Pacific (SPREP)

Action Plan for Managing the Environment of the South Pacific Region (adopted in 1982, rev in 1991 and 1996) (19 States and the South Pacific Territories and Dependencies of France, New Zealand, United Kingdom and the United States of America). Legislative authority: Noumea Convention for the Protection of Natural Resources and Environment of the South Pacific Region (adopted in 1986, entered into force in 1990); operated under the authority of the Contracting Parties to the Noumea Convention. Secretariat: South Pacific Environment (SPREP) (Apia, Western Samoa)

Black Sea (BLACK)

Black Sea Environmental Programme (BSEP)(adopted in 1993) (6 States). Legislative authority: Bucharest Convention on the Protection of the Black Sea Against Pollution (adopted in 1992, entered into force in 1994); operated under the authority of the Administrator of United Nations Development Programme (UNDP), acting on behalf of the implementing agencies of the Global Environment Facility (UNEP, UNDP and the World Bank), on the basis of the Odessa Declaration on the Protection of the Black Sea (1993) within the general framework of the Bucharest Convention. Secretariat: BSEP Coordinating Unit (Istanbul, Turkey)

South Asian Seas (SAS)

Action Plan for the Protection and Management of the South Asian Seas Region (adopted in 1995) (5 States). Legislative authority: A Convention does not exist; action plan operated under the authority of the Director of the South Asia Cooperative Environment Programme (SACEP) on the basis of decisions of plenipotentiary meetings representing the participant countries. Secretariat: SACEP (Colombo, Sri Lanka)

OTHER REGIONAL SEAS PROGRAMMES

Baltic

Programme of the Baltic Marine Environmental Commission. Baltic Sea Joint Comprehensive Environmental Action Programme (adopted in 1992) (9 States). Legislative authority: Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (adopted in 1974, entered into force in 1980, rev 1982, signed in 1992 and entered into force in 1995); operated under the authority of the Executive Secretary of the Baltic Marine Environmental Protection Commission (HELCOM) based on unanimous decisions, recommendations and ministerial declarations of the Contracting Parties to the Helsinki Convention. Secretariat: HELCOM (Helsinki, Finland)

North-East Atlantic

Programme of the Oslo and Paris Commission for the Prevention of Marine Pollution (adopted in 1992, reviewed and updated on an annual basis) (13 States). Legislative authority: The “Oslo” Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircraft (adopted in 1972, entered into force in 1974; administered by the Oslo Commission)) and the “Paris” Convention for the Prevention of Marine Pollution from Land-based Sources (adopted in 1974, entered into force in 1978; administered by the Paris Commission). The Oslo and Paris Conventions and Commissions ceased to exist on 25 March 1998 with the entry into force of the OSPAR Convention, which is administered by the OSPAR Commission. Secretariat: OSPAR Secretariat (London, United Kingdom)

Regional Seas: Status of Programmes of Action and legal frameworks on land-based activities[1]

Regional Seas	Legal framework	Status of Regional Programme of Action	Adoption/ time frame
Mediterranean Action Plan	Barcelona Convention: Protocol for the Protection of the Mediterranean Sea against pollution from Land-based Sources and Activities (1980, **1983**, amended 1996)	The MED POL Regional Programme now in Phase III - Under implementation	Adopted in November 1997 (Meeting of the Contracting Parties, Tunis)
Caribbean Environment Programme	Cartagena Convention: Protocol Concerning Marine Pollution from Land-based Sources and Activities (adopted in 1999)	To be developed following the adoption of the LBA protocol (1999)	
South-East Pacific Action Plan	Lima Convention: Protocol for the Protection of the South-East Pacific against Pollution from Land-based Sources (1983,**1986**)	Second draft Regional Programme discussed at the Ninth Intergovernmental Meeting (Quito, February 2000)	
East Asian Seas		Submitted to the Fourteenth COBSEA meeting (Bangkok, November 1999)	Adopted in 2000
Red Sea and Gulf of Aden	No specific Protocol on LBA under the Jeddah Convention (initiative in progress for its development)	First draft Regional Programme available (March 2000)	
South Pacific	No specific Protocol on LBA under the Noumea Convention	Regional Programme developed	Adopted by governments (December 1999)
Black Sea	Bucharest Convention 1992: • Protocol on Protection of the Black Sea Marine Environment against Pollution from Land-based Sources (1992,**1994**) • Protocol on Protection of the Black Sea Marine Environment against Pollution from Dumping (1992,**1994**)	Regional Programme under discussion by governments	
South Asian Seas		National/Regional Programmes under development	
Kuwait Action Plan	Kuwait Convention: Protocol for the Protection of the Marine Environment against Pollution from Land-based Sources (1990, **1993**)	Regional Programme under implementation	
West and Central Africa Action Plan	No specific Protocol on LBA under the Abidjan Convention	Regional Programme discussed at the Fifth Conference of the Parties (Accra, March 2000)	
East Africa Action Plan	No specific Protocol on LBA under the Nairobi Convention	Regional Programme discussed at the Second Meeting of Contracting Parties (Mauritius, November 1999)	
North West Pacific		Regional Monitoring Programme (NOWPAP/3 Phase II)	Adopted by the Fourth Intergovernmental Meeting (Beijing, 6-7 April 1999)
Upper South-West Atlantic (no formal secretariat, cooperation facilitated by UNEP headquarters)		Regional Programme developed National Programme under development by Brazil	
Northeast Pacific (creation of this Regional Seas was called for by UNEP Governing Council decision 20/20 of 5 February 1999)			
Baltic	Helsinki Conventions on the Protection of the Marine Environment of the Baltic Sea Area (1974) and (1992) (**1999**)	No Regional Programme developed. LBA are addressed by separate programmes under the Helsinki Convention	
North-East Atlantic	Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention)	No Regional Programme developed. LBA are addressed by decisions and workplan under the OSPAR Convention	
Arctic		Regional Programme developed (Regional Programme of Action for the Protection of the Arctic Marine Environment from Land-based Activities)	Adopted by the Arctic Council Ministers (Iqaluit Declaration, 18 September 1998)

[1] In this table, years in brackets indicate the year when the corresponding legal instrument was adopted and the years in bold indicate the year when legal instruments entered into force.

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