The State of the Marine Environment

Regional Assessments

The Hague, July 2006

Foreword

Recognising the significance of the pressure of human development activities on the coastal and marine environment, 108 governments and the European Commission adopted the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA) in 1995. They made a commitment to deal with land-based impacts on the marine environment resulting from contaminants namely sewage, persistent organic pollutants (POPs), radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilisation, marine litter and the physical alteration and destruction of habitats.

The GPA calls for periodic reviews, taking into account assessments of the state of the marine environment. The UNEP/GPA Coordination Office commissioned a global State of the Environment report as a contribution to the Second Intergovernmental Review Meeting in Beijing in October 2006. This expert report provides a concise global overview of the developments over the last decade within the area of focus of the GPA.

The report relies on information that dates back farther than the adoption of the GPA, largely because of limited contemporary data. At the same time, there often exists a considerable time lag between the pressures imposed on the environment, the development of policies, the implementation of measures and the visible manifestation of their impact. Consequently, while the findings of the report may not be based on as current information as we would like, the resulting analysis is indicative of certain trends in the state of the marine environment as they relate to the GPA.

The State of the Marine Environment: A Regional Assessment informs and compliments the other studies the UNEP/GPA Coordination Office has produced for the Second Intergovernmental Review Meeting.

The report identifies that countries have made considerable progress in developing and implementing appropriate policy responses at national, regional and international levels. Nevertheless, progress over the last decade needs to be sustained and strengthened in response to the growing pressures, with special attention to implementation, enforcement and environmental governance.

The UNEP/GPA Coordination office and its partners are pleased to present this expert report and it is our hope that the findings presented here will further support global, regional and national efforts in implementing the Global Programme of Action. The scientific and logistical support of LOICZ as well as the scientific and financial support by UNEP/DEWA was much appreciated.

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Acronyms and abbreviations

AMCEN	African Ministerial Conference on the Environment
AMAP	Arctic Monitoring and Assessment Programme
AMCOW	African Ministerial Conference on Water
AMSP	Arctic Marine Strategic Plan
ASEAN	Association of South-East Asian Nations
ASOEN	ASEAN Senior Officials on the Environment
BAPCO	Bahrain Petroleum Company
BCLME	Benguela Current Large Marine Ecosystem
BOD	Biological Oxygen Demand
BPoA	Barbados Programme of Action for Sustainable Development of SIDS
BSC	Black Sea Commission
BSEP	Black Sea Environmental Programme
BSERP	Black Sea Ecosystem Recovery Project
BSSAP	Black Sea Strategic Action Plan
CAR/RCU	Caribbean Regional Coordinating Unit
CARICOM	Caribbean Community
CARIPOL	Caribbean Oil Pollution Programme
CEHI	Caribbean Environmental Health Institute
CEP	Caribbean Environment Programme
CLC	Convention on Civil Liability for Oil Pollution Damage
COD	Chemical Oxygen Demand
CSIR	Council for Scientific and Industrial Research
DEAT	Department of Environmental Affairs and Tourism (South Africa)
EBRD	European Bank for Reconstruction and Development
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EU	European Union
FAO	Food and Agriculture Organization
FUND	Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage
GCLME	Guinea Current Large Marine Ecosystem
GEF	Global Environment Facility
GIWA	Global International Waters Assessment
GoGLME	Gulf of Guinea Large Marine Ecosystem Project
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-based Activities
HABs	Harmful Algal Blooms
HDI	Human Development Index
IAEA	International Atomic Energy Agency
ICAM	Integrated Coastal Area Management
ICRP	International Commission on Radiological Protection
ICZM	Integrated Coastal Zone Management
IGR	Intergovernmental Review
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
ISPA	Instrument for Structural Policies for Pre-Accession
IUCN	The World Conservation Union
LBS	Land-Based Sources
LC	Lethal Concentration

LME	Large Marine Ecosystem
LOICZ	Land Ocean Interaction in the Coastal Zone
MARPOL	International Convention for the Prevention of Pollution from Ships
MDG	Millennium Development Goals
MPA	Marine Protected Area
MPC	Maximum Permissible Concentration
MPN	Most Probable Number
NEAP	National Environmental Action Plan
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organization
NOAA	National Oceanographic and Atmospheric Administration
NPA	National Programme of Action
OECS	Organization of Eastern Caribbean States
OHC	Oil Hydrocarbons
OPRC	Convention on Oil Pollution Preparedness, Response, and Co-operation
PADH	Physical alteration and destruction of habitats
PAH	Polycyclic Aromatic Hydrocarbons
PAME	Working Group on the Protection of the Arctic Marine Environment
PC	Personal computers
PEMSEA	Partnership in Environmental Management for the Seas of East Asia
PHC	Petroleum Hydrocarbons
POPs	Persistent Organic Pollutants
PTS	Persistent Toxic Substances
RAC	Regional Activity Centre
RMS	ROPME Member States
ROPME	Regional Organization for the Protection of the Marine Environment
Roshydromet	Russian Federal Service on Hydrometeorology and Monitoring of Environment
ROWA	Regional Office for West Asia
RPA	Regional Programme of Action
RSA	ROPME Sea Area
SAREC	Swedish Agency for Research Cooperation
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SIDS	Small Island Developing States
SoE	State of Environment
SPAW	Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region
SPDC	Shell Petroleum Development Company
TDA	Transboundary Diagnostic Analysis
TDS	Total Dissolved Solids
TOD	Total Oxygen Demand
UAE	United Arab Emirates
UNCED	UN Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US-EPA	United States Environmental Protection Agency
WACAF	West and Central Africa
WCR	Wider Caribbean Region

WEEE	Waste Electrical and Electronic Equipment
WESTPAC	Intergovernmental Oceanographic Commission Regional Secretariat for the Western Pacific
WHO	World Health Organization
WMO	World Maritime Organization
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WWF	Worldwide Fund for Nature

Metals and Chemicals

Al	Aluminium
As	Arsenic
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cs	Cesium
Cu	Copper
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
Fe	Iron
HCH	Hexachlorocyclohexane
Hg	Mercury
Mn	Manganese
NH_4	Ammonium
Ni	Nickel
NO_x	Nitrous Oxides
OC	Organochlorides
P	Phosphorus
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PBDE	Polybrominated Difenyl Ethers
PCB	Polychlorinated Biphenyl
PCDF	Polychlorinated Dibenzofurans
Po	Polonium
Pu	Plutonium
Se	Selenium
Sn	Tin
SO_2	Sulphur Dioxide
Sr	Strontium
TBT	Tributyltin
Tc	Technetium
U	Uranium
V	Vanadium
Zn	Zinc

Introduction

INTRODUCTION

Over the past decade, degradation of the coastal and marine environments continued globally, and in many places even intensified. The major threats to the health, productivity, and biodiversity of the marine environment result from human activities in both coastal and inland areas. In fact, nearly 50% of the world's coasts are threatened by development-related activities. Some 80% of the pollution load in the oceans originates from land-based sources, including municipal, industrial and agricultural run-off, as well as atmospheric deposition. In addition, coastal habitats are also being altered and destroyed. Increasing habitat alteration and destruction either by physical, chemical, or biological means constitutes the most widespread, frequently irreversible, human impact on the coastal zone.

Natural marine and coastal ecosystems represent tangible economic goods and provide valuable services, such as the treatment and assimilation of wastes, storm protection, production of food and raw materials, recreational amenities, genetic resources, and employment opportunities. According to the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection, the global value of the goods and services provided by marine and coastal ecosystems is roughly double the value of those provided by terrestrial ecosystems and is comparable with the level of global GDP. About one billion people currently live in coastal urban centers. The health, well-being and, in some cases, the very survival of coastal populations depend upon the health and productivity of coastal ecosystems such as coral reefs, mangrove forests, and estuaries. Land-based pollution and physical alteration and destruction of habitats undermine the sustainable use of oceans and coastal areas and their resources. In addition, exposure to pollution in the coastal and marine environments gives rise to human health concerns stemming from direct contact with polluted waters and the consumption of contaminated seafood.

Addressing the intense pressures exerted on coastal ecosystems by human activities require serious commitment and preventive action at local, national, regional, and global levels. Recognizing the growing and serious threat from land-based activities to both human health and well-being and the integrity of coastal and marine ecosystems and biodiversity, in 1995 the representatives of 108 governments and the European Commission adopted the Washington Declaration and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA). The GPA is mainly concerned with nine source categories: Sewage; Persistent Organic Pesticides (POPs); Radioactive substances; Heavy metals; Oils (Hydrocarbons); Nutrients; Sediment mobilization; Litter; and Physical Alteration and Destruction of Habitats (PADH).

In the Washington Declaration, the governments declared their intention to cooperate on a regional basis to coordinate GPA implementation efforts. Development of national and regional programmes of action is of primary importance. The United Nations Environment Programme (UNEP) Regional Seas Programme and other regional seas programmes and organizations provide an integrated framework for national action programmes. In adopting the GPA, governments expressed their commitment to protect and preserve the marine environment from the impacts of land-based activities and declared their intention to do so by, amongst others, according priority to the implementation of the GPA by providing for periodic intergovernmental reviews of the GPA, taking into account regular assessments of the state of the marine environment.

In this regard, the UNEP Coordination Office of the GPA has published a global state of environment (SoE) report on the GPA, as a contribution to the 2nd Inter-Governmental Review Meeting in Beijing, People's Republic of China, October 2006. The SoE report gives a global overview of the last decade's developments related to the nine GPA source categories. The report sheds light on trends and emerging issues with respect to the GPA source categories and illustrates the developments in several world regions during the last 10 years.

To support this Global Assessment, experts from several world regions were invited by the GPA Coordination Office to prepare an assessment of the state of the environment relevant to the GPA source categories for their respective regions:

1. West and Central Africa;
2. Southern Africa;
3. Eastern Africa;
4. Black Sea;
5. ROPME Sea Area;
6. South Asian Seas;
7. East Asian Seas;
8. Arctic Ocean; and
9. Caribbean Small Island Developing States (SIDS).

Regional experts used available data and information at the regional and national levels in preparing the assessments. Early versions of the papers were presented by the experts at a workshop convened by the GPA in Egmond aan Zee, the Netherlands, on 26 June, 2005, in association with the Land Ocean Interaction in the Coastal Zone (LOICZ) Inaugural Open Science Meeting. The workshop and the drafting of the regional papers provided references to the global SoE process and contributed to regional capacity in terms of assessment. The regional papers were reviewed and commented on by the Regional Seas Secretariats and UNEP regional Offices. The activities were supported by the UNEP Division of Early Warning and Assessment and co-funded by Netherlands Partnership Funds.

The papers report on the environmental state and trends where possible, with an indication of regional hotspots and emerging issues related to the GPA source categories in the respective regions. Also included is a discussion of the relevant institutional and legal framework and progress made in the past decade in protecting the coastal and marine environments from land-based activities, as well as suggestions for the way forward in addressing the GPA issues. In the final chapter the major trends, commonalities, and differences among the regions are highlighted. This chapter also presents the major outcomes of the June workshop and discusses some of the constraints to assessing and addressing the GPA issues in the various regions.

1 - West and Central Africa

INTRODUCTION

This regional overview covers the coastal and marine waters of the West and Central African (WACAF) countries, from the Atlantic Ocean to the Sahara Desert and from the shores of Lake Chad and Angola to Senegal (Figure 1.1). The countries making up this region are Angola, Benin, Burkina Faso, Cabinda, Cameroon, Central African Republic, Chad, Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo (UNEP/GPA 2005a). Although the island of Cape Verde is part of West Africa, its drainage basins as well as its human activities have limited large-scale impact on the marine environment as a result of its small land mass.

There is strong empirical evidence of serious localized degradation in the coastal environment of the Canary, Guinea, and Benguela Currents. However, up-to-date, relevant, and reliable data that can be used to assess the extent of degradation are not easily available or accessible on a national or regional scale. Demography, urbanization, industry, agricultural activities, and economic development exert significant anthropogenic pressures on the coastal zone. Pollution discharges from oil refineries and textile, leather, food, and brewery industries reduce water quality in the coastal zone. The region's main pollution problems are degraded water quality, the loss of critical habitats for migratory and non-migratory species, river effluents entering the ocean, offshore spills, marine debris, beach pollution, as well as industrial and solid waste.

Several regional assessments that examined environmental issues in the WACAF region have been carried out in the past decade. These include the Global International Waters Assessment (GIWA), which has ranked the severity of impacts of freshwater shortage, habitat and community modification and loss, pollution, unsustainable exploitation of living resources, and global change in transboundary water bodies across the globe. Another regional assessment, the ongoing Guinea Current Large Marine Ecosystem (GCLME) project funded by the Global Environment Facility (GEF), carried out a preliminary Transboundary Diagnostic Analysis (TDA) that identified the major perceived problems the countries face as:

- Decline in GCLME fish stocks and unsustainable harvesting of living resources;
- Uncertainty regarding ecosystem status and integrity (changes in community composition, vulnerable species, and biodiversity; introduction of alien species), as well as fisheries yields in a highly variable environment including the effects of global climate change;
- Deterioration in water quality (chronic and catastrophic) from land and sea-based activities, eutrophication, and harmful algal blooms (HABs); and
- Habitat destruction and alteration including, inter-alia, modification of seabed and coastal zone, degradation of coast-scapes, and coastline erosion.

The above issues are based on an initial analysis of the situation presented in a series of publications emanating from the GEF-funded Gulf of Guinea Large Marine Ecosystem Project (GoGLME) (Akrofi 2002, Bortei-Doku Aryeetey 2002, Cury and Roy 2002, Demarcq and Aman 2002; Hardman-Mountford and McGlade 2002; Ibe and Sherman 2002, McGlade and others 2002a, McGlade and others 2002b, Nauen 2002, Pauly 2002, Roy and others 2002, Scheren and Ibe 2002). Much similarity exists between these issues and those identified by the UNEP Regional Seas Programme Regional Coordinating Unit for the West and Central Africa Action Plan (http://www.unep.ch/regionalseas/regions/wacaf/wafhome.htm). The latter include the following, as well as major constraints and strategies and measures (UNEP/GPA 2005a):

Priority issues

- The decline of water quality due to land-based human activities, such as the introduction of sewage and wastewater from industrial, domestic, and agricultural runoff as well as coastal urbanization;
- Physical degradation and habitat modification; and
- Fishery resources depletion and loss of marine biodiversity.

Major constraints

These include the lack of:

- Detailed scientific data on coastal, marine, and freshwater environments;
- Quantitative and qualitative assessments of the major sources of land-based pollution in the region;
- Best available techniques;
- Effective environmental practices and product substitutes;
- Sufficient technical human resources, equipment, and financial means;
- Adequate legislation and regulatory measures;
- Good economic instruments and incentives; and
- Long-term planning and monitoring systems.

Strategies and measures

- Install adequate sewage and solid waste disposal systems and possible recycling;
- Locate industries in less vulnerable areas, preceded by an assessment of environmental impacts;
- Use of beneficial production technologies and improved port reception facilities;
- Implement and enforce legislation, where needed;
- Land-use planning and improved application of agro-chemicals, including whenever possible, nutrient recycling;
- Seek alternatives to Persistent Organic Pollutants (POPs), in view of their possible impacts;
- Establish integrated river basin and coastal area sustainable management;
- Establish coastal and marine resources surveillance, including appropriate aquacultural methods;
- Improve oil production and implement contingency plans, including MARPOL (the International Convention for the Prevention of Pollution from Ships).

According to UNEP (1999) the lack of detailed scientific data on coastal, marine, and freshwater environments in the WACAF region results in a considerable degree of uncertainty in assessing pollution loads. For example, where data on pollution concentrations are available, data on volumes of discharges are lacking. Where information on types of contaminants is available, no information on transport pathways exists. It is also clear that many of the key sources of pollution are very closely linked, e.g., sewage and nutrients. Knowledge on interaction and synergies between different land-based pollutants in the coastal and marine environments is insufficient. In the case of Cabinda, an enclave of Angola, apart from data on oil production and population, almost no relevant GPA data is available. There is an urgent need for a precise qualitative and quantitative assessment of the significant sources of land-based pollution in the region.

THE WEST AND CENTRAL AFRICAN REGION

Physiographic and ecological character

A detailed description of the regional morphology and river drainage basins, general oceanography, coastal morphology and processes, as well as ecosystem and species diversity is given in UNEP (1999). The following account is a summary from UNEP (1999), with slight modifications and additions.

The region has four narrow coastal sedimentary basins, with a few volcanic intrusions and outcrops of hard rock forming the major capes that have developed on the edges of the coastline: the Senegalese-Mauritanian Basin, the Côte d'Ivoire Basin, the Niger Basin (Delta) and the coastal basins from Gabon to Angola. These four major river systems drain into the coast from Senegal to Nigeria. The Niger and Volta Rivers, draining an area of over 1 million km^2 and 390,000 km^2, respectively, have been dammed for energy, irrigation, and flood control purposes, as have most of the region's rivers. As a consequence, significant alteration of their hydrology and sediment flow has occurred, creating inevitable downstream impacts and accelerating coastal erosion processes. On the coast the potential for sea-level rise and its impacts (e.g., shoreline retreat and erosion, increased frequency of submergence of coastal wetlands, and salt-water intrusion into estuaries and coastal aquifers) is great.

Five distinct and relatively persistent oceanic currents, which are essentially wind-driven, are found off the WACAF coast: Benguela Current, flowing along the southwest African coastal zone (Namibia, Angola); Guinea Current, flowing eastward and south-eastward, which carries warm waters along the coast of the Gulf of Guinea, near the Equator; Equatorial Countercurrent, of which the Guinea Current is a continuation; South Equatorial Current, which flows some distance from the coast, between 10°S and the Equator; and Canary Current, which flows south-westward along the coast in the northern part of the WACAF region and feeds both the Guinea Current and the North Equatorial Current. Due to the high precipitation and numerous rivers on the Central West African coast the waters are generally warm (above 24°C.) and of low salinity (less than 35%). The most important factor characterizing the open ocean waters not only off the Gambia, Mauritania, and Senegal but also off the coast of Ghana, Angola, and Namibia, is the quasi-permanent presence of upwellings, driven by the Canary Current in the north and the Benguela in the south. These cool and nutrient-rich upwellings, which are governed by the position of the Intertropical Convergence Zone and changes in wind patterns, have profound effects on nearshore productivity.

From north to south, the coastal morphology, follows a succession of: (a) sandy arid coastal plains bordered by eolian dunes (Angola, Mauritania, north coast of Senegal); (b) sandy marshy alluvial with estuaries and deltas with mangrove vegetation (southern Senegal, Guinea-Bissau, Guinea, Sierra Leone); (c) rocky scarps and sandy beaches, alternating with mangrove vegetation (Sierra Leone, Liberia, eastern Nigeria to Gabon); (d) low sandy coastal plains, which alternate with lagoons along the Gulf of Guinea (Benin, Côte d'Ivoire, Ghana, Togo, Congo Estuary up to the Angolan border); and (e) extensive marshy areas formed by the Niger Delta, with mangroves indented by fluvial channels that are subject to tidal influence. In addition, a number of islands and archipelagos can be found in the Atlantic Ocean off the coast of West Africa (Canary and the Cape Verde Islands; Bissagos archipelago) and in the eastern part of the Gulf of Guinea (São Tome and Principe, and Annabon in Equatorial Guinea) (Awosika and Ibe 1998).

A number of different types of coastal habitats exist in the WACAF region. Among them are (a) wetlands, with mangrove forests being the most dominant features (extending more than 25,000 km from Senegal to Angola); (b) coastal lagoons, which are found mainly in the Gulf of Guinea, from Côte d'Ivoire to Nigeria; (c) limited expanses of seagrass beds in some estuaries and deltas mouths (Cacheu, Casamance, Geba, Saloum); and (d) sandy beaches, particularly along Mauritania, northern Senegal, and Ghana.

A wide diversity of marine resource species characterizes the coastal waters. These include an estimated 239 fish species, some of which are well known pelagic species such as: *Sardinella aurita, S. maderensis, and Thunnus albacares;* demersal species such as *Arius* sp., *Pseudotolithus typus* and *P. senegalensis, Dentex* sp., *Octopus vulgaris, Cynoglossus* sp.; intertidal molluscs (e.g., *Anadara* sp., *Crassostrea* sp.); and reptiles (marine turtles, crocodiles). Large concentrations of migrant and resident seabirds, as well as waders are found seasonally in Gambia, Ghana, Guinea Bissau, Mauritania, and Senegal; these include *Larus genei and Sterna maxima albididorsalis*. Many species are present in internationally significant numbers (greater than 1% of the East Atlantic flyway). Marine mammals such as the West African manatee *(Trichechus senegalensis)* are also found in some lagoons.

Socio-economic background

Broadly speaking, the countries of the WACAF belong to the group of less and least developed countries, although some states that are rich in natural resources (e.g., Côte d'Ivoire, Gabon, Nigeria) are approaching the level of the newly industrialized economies. A notable fact is that most of the population lives in extreme, if not abject poverty, which is the main driver of degradation of the region's marine, coastal, and associated freshwater. All the WACAF countries are among those targeted by the Millennium Development Goals (MDG). According to the UN Human Development Index (HDI), the level of human development varies from medium (HDI of 0.72) in Cape Verde to low (HDI of 0.27) in Sierra Leone, which is the lowest among 177 countries (UNDP 2004). Characteristically, these countries have significant and increasing populations without access to safe water or improved sanitation (Figures 1.2 - 1.4).

Significant fractions of the population in the region are poor and live on under US$1 per day. Poverty results in rural-urban drift which causes urban populations to grow considerably faster (average projected increase of 8.5% for the period 2002 - 2015) than birth rates. The fact that a significant number of urban centres and commercial and industrial activities are located in the coastal zone exacerbates the problem of land-based pollution. It is estimated that between 40 - 60% of a population of over 235 million lives in the coastal zone; this is expected to rise to over 320 million by the year 2015. This translated to an annual production of over 25 million tonnes of human waste in 2002, which is expected to rise to over 34 million tonnes in 2015. Much of this sewage will be discharged untreated into the aquatic environment. The draft GCLME TDA noted that land-based sources and activities contribute about 70% of the coastal and marine pollution globally, while maritime transport and dumping at sea each contributes about 10%. The stresses resulting from interactive human developments, including economic and industrial development and consequent increases in harmful impacts on the region's environment and natural resources have great socio-economic and cultural implications, the most important of which are income reduction arising from the loss of fisheries stocks and of recreation and tourism amenities, as well as increased water treatment and coastal protection costs. This state of affairs presents the background to the discussion on land-based sources of pollution that affect the WACAF coastal waters.

MAIN LAND-BASED SOURCES OF POLLUTION

This paper presents an overview of the current state of the environment in relation to the GPA issues, with emphasis on new data available since the UNEP (1999) report. It also examines if the aforementioned constraints have been effectively dealt with by the proposed strategies and measures. Beyond the UNEP (1999) report, the most reliable transboundary information on the West African region became available through the GoGLME project. Data and information have been collated and presented in three key documents: Ibe and others (1998), Scheren and Ibe (2002), and Scheren and others (2002). In addition, efforts have been made to access additional relevant sources of information for the period 2000 - 2005. Other important sources of information are the studies carried out under the AfriBasins initiative of LOICZ (Arthurton and others 2002) and the GIWA Guinea Current assessment (UNEP 2004).

Sewage and nutrients

Sewage, according to Webster, is 'the contents of a sewer or drain; "refused liquids or matter carried off by sewers". Most of urban coastal WACAF lacks basic sewerage infrastructure, and in some cases even open drains are not present, so the term "sewage" is a misnomer for the situation in much of the region. In these circumstances where numerous diffuse sources exist, the terms "grey" and "black" water are preferred (grey water is wash water, i.e., all wastewater except toilet waste; black water is toilet wastewater). No recent precise data on the quantities of grey or black water being discharged into the WACAF seas were found in the literature. The annual total biological oxygen demand load (BOD) for the entire WACAF region presented in GCLME (2003) is estimated to be 288,961 tonnes from municipal sewage and 47,269 tonnes from industrial pollution, while the annual total suspended sediment load was estimated at around 410,929 tonnes from municipal sewage and 81,145 tonnes from industrial pollution. The rapid growth of urban populations is far beyond the capacity of relevant authorities and municipalities to provide adequate basic services such as water supply, sewerage, and wastewater treatment facilities.

Two examples that provide a rough indication of the magnitude of the production of grey water, as well as of its availability for farming purposes in some coastal cities are from Ghana and Nigeria. The total amount of grey and black wastewater produced annually in urban Ghana has been estimated at 280 million m^3 (Agodzo and others 2003). Since Ghana's industrial development and urban centres are concentrated along the coast, most of this wastewater, treated or untreated, is discharged into the ocean. In selected cities in West Africa, Cofie and others (2003) reported that a significant number of urban farmers use wastewater for crop irrigation (Table 1.1), which is a reflection of the availability of such water. Apart from elevated nutrient levels, the bacterial contaminant load of such water is also very high (Table 1.2). Studies in the Sakumo catchment between the cities of Accra and Tema (Yawson 2004) showed that such high bacterial loads makes the water unfit for contact with humans; a few of the sites have faecal coliform counts above 100,000/100 ml (Table 1.3). Table 1.4 indicates the volume of water used per capita per day and the low proportion of the wastewater that is treated in several coastal cities in the WACAF region.

Of all the GPA source categories, nutrients are the most difficult to quantify given the close linkage with other source categories, as well as their extremely dynamic spatial and temporal variability. There has been no comprehensive regional assessment of nutrients for the WACAF since UNEP (1999). However, it has been estimated that loss of nitrogen via hydrologic export to the Atlantic Ocean is about 1.5×10^9/kg; the loss from de-nitrification is estimated at 1.1×10^9/kg.

Primary productivity surveys have revealed an increasing occurrence of HABs, indicating intense eutrophication and therefore excessive nutrient loading from anthropogenic sources (Figure 1.5).

Persistent organic pollutants (POPs)

Although fewer pesticides are used in Africa than on the other continents, highly poisonous organic chemical products are applied under inappropriate conditions by women and men with no training or product information. Scheren and Ibe (2002) reported significant levels of organochlorine pollution in sediments and shellfish from the WACAF region (Table 1.5). The current prevalence of DDT in sediment and shellfish samples is due to the continued sale, despite many national bans, of this pesticide. Of the sites studied, Lekki Lagoon in Nigeria had the highest levels of most of the pollutants assessed.

Reports in the popular press in Ghana indicated that an analysis of samples of street food in Accra carried out in 1999-2000 revealed disturbing levels of contamination by pesticides. The organophosphate chlorpyrifos was detected in six out of eight samples of rice and beans. However, local analytical facilities and methododology could not determine if the chlorpyrifos residues exceeded the Codex Maximum Residue Levels of 0.2mg/kg. Chindah and others (2004) examined the toxicity of chlorpyrifos on *Tilapia guineensis* using 96-hour static bioassay. As expected, mortality was found to increase with exposure and with increase in concentration. The 96-hour mean lethal concentration (LC50) was 0.002 μg/l and mean lethal time was less than 24 hours at concentrations of 0.1 μg/l.

Current data on POPs based on the imports of pesticides by the WACAF region turned out to be very misleading due largely to false reporting of such imports. Work by the Pesticide Action Network, a United Kingdom-based non-governmental organization (NGO), suggested that the large quantity of illegal imports, the current in-country stockpiles of obsolete chemicals coupled with the large influx of fake and adulterated pesticides make it impossible to use official imports of chemicals as a reliable indicator of POPs use in the region.

Heavy metals

The most important sources of heavy metal pollution are industrial emissions and effluents. Heavy metals bio-accumulate and bio-magnify in the food chain, which causes serious concern in relation to human health. Scheren and Ibe (2002) investigated heavy metal concentrations in the coastal environment and biota in the region, and found concentrations below the level of detection in several localities (Table 1.6). This could be attributed to the limited industrial development in the WACAF region in general, with the exception of the oil-rich states.

Other sources of heavy metals include road sediments and mobilization from ore-rich mine tailings. For instance, all samples of road sediments in Lagos had high levels of heavy metals (Adekola and others 1999). Among all the heavy metals, iron (Fe) had the highest mean concentrations, which ranged from 729 mg/kg at Public Works Department, Oshodi, to 3,957 mg/kg on Oba Akran Avenue, Ikeja. Lead (Pb) was detected in only two locations in Lagos: 78 mg/kg at the Public Works Department, Oshodi, and 122 mg/kg at Ado-Odo Sango Otta. It is interesting to note that the cadmium (Cd) levels in Ilorin sediments were generally within the same range as those in the Lagos sediments.

Gnandi and Tobschall (1999) performed a number of laboratory experiments to assess desorption of trace metals from Cd-rich phosphorite deposits of Hahotoé-Kpogamé (Togo) using 1 part of sediment to 10 parts of artificial seawater. The results showed that elevated concentrations of the trace elements Cd (17 - 256 µg/l), nickel (Ni, 12 - 193 µg/l), and zinc (Zn, 21- 200 µg/l) were released into seawater by desorption. Thus, the direct disposal of potentially toxic metal-rich mine tailings into the sea may lead to regional coastal water pollution.

Oils (Hydrocarbons)

Accompanying the enormous economic benefits that could be derived from the oil industry are the constant threats of oil spills and the associated negative ecological and socio-economic impacts. Offshore mining and oil drilling activities are major sources of oil pollution, mainly because of leaking pipes, accidents, and ballast water and production-water discharges. Drilling also involves the use of chemical products laden with heavy metals such as vanadium (V) and Ni, which are known to affect marine plants and animals. Oil pollution damages coastal habitats and living resources such as commercial fish stocks, reducing catches and the incomes derived from them. The possibilities of oil spills and their impacts are real, even in non-oil producing countries; this is usually associated with oil distribution by ocean currents and along busy oil tanker routes. The potential for spills are thus widespread as they can occur at any stage in the exploration, extraction, refining, and distribution phase.

The entire Guinea Current and Benguela Current LMEs are particularly at risk from oil pollution (GCLME 2003). In Nigeria alone, a total of 2,676 separate oil pipeline spills were reported between 1976 and 1990. According to the Shell Petroleum Development Company (SPDC) of Nigeria, the volume of oil spilled between 1995 and 1999 as a result of operational accidents and corrosion ranged between 2,000 and 23,000 barrels. According to the Department of Petroleum Resources, between 1976 and 1996 a total of 4,835 incidents resulted in the spill of approximately 2,446,322 barrels of oil. In the period 1978 - 1980, the particularly high volumes were due to three major spills: GOCON Escravos spill in 1978 of 300,000 barrels; SPDC 1978 Forcados Terminal Tank Failure (about 580,000 barrels); and the Texaco Funiwa incidence of 1980 involving 400,000 barrels (Awosika and others 2002). From 1995 to the present, 349,020 km of seismic lines have been cut and 530 exploration wells drilled in Central Africa (Angola, Cameroon, Congo, Equatorial Guinea, Gabon). The impact of oil spills on marine fauna in the WACAF region is still not quantified for most species. Daka and Ekeweozor (2004) studied the acute toxic effects of a Nigerian crude oil (Egbogoro Liner II) on the mangrove oyster, Crassostrea gasar, in bioassays. The 96-hour LC50 value for the oysters ranged from 135 to 545 ppm.

Sediments

The FAO World River Sediment Yields Database (FAO 2005) provides information on the sediment yield of several WACAF rivers, which ranges from 3.1 - 483 tonnes/km^2/yr (Table 1.7). The role of impoundments in trapping sediments before they reach the sea has been demonstrated for the Volta River by Gordon and Amatekpor (1999) who also pointed out that sediment entrapment by dams cannot be the sole reason for coastal erosion. Given that land-use practices are not improving and desertification and deforestation are increasing, the relatively low sediment yield of 48 tonnes/km^2/yr of sediment for a highly impacted river basin such as the Volta (FAO 2005) must be a result of sediment entrapment.

The dynamics and magnitude of sediment entrapment by impoundments in the WACAF region is, however, yet another area where concrete data are lacking.

Morales (1979) noted that a major source of sediments, besides rivers, is the large-scale transportation and deposition of dust by desert winds. Large quantities of dust (13 million tonnes/season) are moved mainly from the Saharan and Sahelian zones and deposited at sea and on land all the way across the Atlantic Ocean. Recent satellite imagery from the European Space Agency illustrates this phenomenon (Figure 1.6). This material not only "fertilizes" the Latin American and Caribbean forest belt, but also provides trace nutrients including phosphorus (P) that promote the growth of oceanic plankton.

There is a strong link between sediments and physical alteration and destruction of habitats. Mangroves are a case in point as they influence the quality and quantity of sediments that are exported from the coast. Anthony (2004) examined the relationship between the circulation of fine suspensions in a mangrove-colonized estuarine complex and short-term mangrove substrate accretion and medium-term mangrove swamp geomorphic evolution in Sherbro Bay, Sierra Leone. The estuarine reaches of streams emptying into the bay have relatively high levels (0.8 - 40 g/l) of suspended silts and clays in association with the turbidity maxima (5-50 g/l) at the interface between freshwater input and saltwater intrusion. However, the surveyed mangrove swamp plots showed much lower levels of silts and clays (0.09-0.6 g/l) and low rates of accretion (1.1-3 mm/yr). The latter was mainly attributed to the short duration of tidal flooding due to the high substrate elevation within the tidal range, as well as to the low settling potential of the very fine-grained suspensions circulating in the swamps. The importance of this is that although mangroves are trapping the coarse sediments, the finer particles still reach the sea. Therefore, removal of mangroves will change the entire dynamics of sediment export to the sea, which will impact on adjacent habitats such as seagrass beds and coral reefs.

Coastal and marine litter

GIWA characterized the Gulf of Guinea as severely impacted by solid waste (UNEP 2004). Households and small industries generate the largest quantities of non-hazardous waste, which exceed industrial outputs by several orders of magnitude, as seen in Port Harcourt, Nigeria (Table 1.8). Solid waste collection in Port Harcourt is largely limited to private contractors who are not very efficient. The uncollected solid waste accumulates in the drainage systems, which when obstructed, amplify flooding, and expose residents to considerable health risks.

According to Scheren and others (2002), solid waste and marine debris for just the Gulf of Guinea region is estimated at 3.8 million tonnes/yr of mainly putrescible or non-hazardous waste. Plastics (fishing-related products, packing materials, and carrier bags) make up 62% of the waste per 500 m^2 of beach. The average number of items found on the beaches was 23/m^2. Derraik (2002) has drawn attention to an inconspicuous and previously overlooked form of plastic pollution: plastic scrubbers, which are small fragments of plastic (usually up to 0.5 mm in diameter) derived from hand cleaners, cosmetic preparations, and air blast cleaning media. In air blasting technology, polyethylene particles are used for stripping paint from metallic surfaces and cleaning engine parts, and can be recycled up to 10 times before being discarded, sometimes significantly contaminated by heavy metals. Derraik also noted that there are many possible impacts of these persistent particles on the environment, e.g., heavy metals or other contaminants that could be transferred to filter-feeding organisms and other invertebrates, ultimately reaching higher trophic levels.

Information extracted from Awosika (2002) illustrates the magnitude of the coastal and marine litter problem in the WACAF (Tables 1.9 and 1.10). The report that over 10 tonnes of litter/km were collected from beaches in Cameroon is very disturbing. However, this debris is not generated only in Cameroon but also by up-current countries from which it is transported through longshore drift to the Cameroon coast.

Physical alteration and destruction of habitats

Physical alteration and destruction of habitats along the WACAF coast is very common, especially in the vicinity of river mouths and lagoons. This is evident in shoreline erosion, removal of vegetation such as mangroves, changing hydrological patterns, and water abstraction and impoundment by the opening of channels to the sea or by physical structures such as ports and harbours. Arthurton and others (2002) used the Driver-Pressure-State-Impact-Response framework to illustrate the linkage between the dual drivers/pressures of deforestation and cultivation and their impact on the coast. The latter includes the degradation of wetland habitats, which results from reduced water retention in the catchment and greater severity of flooding (Finlayson and others 1998, Gordon 1998, 2000).

A recent estimate (Ade Sobande and Associates 1998) suggested that about 50% of Nigeria mangroves may have been lost as a result of oil industry operations. For instance, in State River, Nigeria, a total of 71.4 km^2 of mangroves, equivalent to 1% of the river's total mangrove area, have been converted by various oil exploration activities (Table 1.11). Using the factors derived from this table, it is estimated that oil exploration in Central Africa (Angola, Cameroon, Congo, Equatorial Guinea, Gabon) would have affected at least 350 km^2 of coastal habitats in the period 1995 to the present.

Dredging and unconfined creek bank spoil disposal is extensive in the Niger Delta (World Bank 1995, Human Rights Watch 1999), but little or no data and information are available on the extent of the problem or on the quantity of waste spoils disposed of. However, a major oil company generated approximately 20 million m^3 of waste spoils between 1990 and 1996 (Ade Sobande and Associates 1998). ERML (2002) reported that a major oil company generated about 5 million m^3 of sulphate-rich dredge spoils in creating a shipping channel approximately 15 km long and 100 m wide. It is expected that the amount of abandoned spoils is even higher, taking into account the activities of other oil companies, the nearly 50 years of such operations, and the observed high sedimentation/siltation rates that often necessitate frequent maintenance dredging.

CONCLUSIONS

The first GPA Intergovernmental Review Meeting, which took place in November 2001, the Governments made committments to, among other things, mainstream GPA activities and capacity building (UNEP/GPA 2005b). It is unfortunate that this does not seem to have been effectively implemented in the WACAF region. From the foregoing, it is clear that none of the eight constraints previously mentioned has been adequately addressed. A major problem, as already stated, is the lack of detailed scientific data on the region's coastal, marine, and freshwater environments. This is related to the lack of quantitative and qualitative assessments of the significant sources of land-based pollution in the region, which in itself is a result of insufficient technical human resources, equipment, and financial means.

Though the best available techniques may not necessarily be the most expensive, sufficient capacity to apply them is not being developed. Until the magnitude of the problem has been understood and measured, by scientifically credible means, a comprehensive solution will not be forthcoming. The use of models has been proposed as one way to bridge the data gaps (e.g., Bormann and Diekkrüger 2004). Models, however, only function accurately when there is sufficient real data; the on-going GEF-funded GCLME project is a significant step towards the collection and analysis of data.

Environmental hotspots

Environmental hotspots can be considered as sites where threats are high or sites that are sensitive because of high biodiversity and/or relatively productive and/or pristine conditions. Though pollution is moderate in the WACAF region, threats are more serious in coastal hotspots associated with the larger coastal cities (UNEP 2004). A GEF medium-sized project (Development and protection of the coastal and marine environment in Sub-Saharan Africa) had, as one of its objectives, identification of hotspots in several of the countries in the WACAF region. In general, pollution hotspots related to the GPA issues include river mouths and estuaries that are heavily impacted by land-based pollution from urban and industrial areas, as well as by increased sediment loads. The study identified three areas in Ghana: Sakumo I wetlands (hotspot), Korle lagoon (hotspot), and the Lower Volta Mangroves (sensitive area). In Nigeria: three hotspots (Lagos Islands, Ogoni-Land/Bonny Area, and Eket Area) and three sensitive areas (Akassa/Brass/Santa Barbara Rivers, Barrier Island between Dodo and Nun Rivers, and Opobo area). In Côte d'Ivoire: two hotspots (Ebrié Lagoon and the eastern part of the littoral) and three sensitive areas (Aby and Grand-Lahou Lagoons and the maritime zone under national jurisdiction). In the hotspots the major issues are nutrients, sewage, and solid wastes. In oil-producing countries, operations related to oil exploration, extraction, storage, and transport give rise to oil pollution hotspots, such as the Niger Delta. Significant point sources of marine pollution have been detected around coastal petroleum mining and processing areas, where large quantities of oil, grease, and other hydrocarbon compounds are released into the coastal waters of the Niger Delta and off Angola, Cameroon, Congo, and Gabon (GCLME 2003).

Has the situation concerning the GPA issues improved or worsened during recent years?

In general, the situation concerning the GPA issues has worsened in recent years. Over the past decade, human population, urbanization, and industrialization have increased in the WACAF region. So too have the associated pressures on the environment, aggravated by the lack of adequate data and information and limited human, financial, and technological resources. This trend is best illustrated by the increase in the quantity of sewage entering the coastal environment from coastal urban centres, which have shown significant growth in recent decades. The increasing occurrence of HABs is indicative of intense eutrophication from anthropogenic activities. Other pollution indicators such as tar balls and the quantity of marine debris have also increased. In addition, habitat destruction has also increased, as a result of the intensification of development activities in coastal areas. The issues identified by UNEP (1999) continue to be a priority, as a consequence of the persistence of the constraints to effective environmental management in the region.

Has progress been made in protecting the marine environment during the last 10 years?

Progress in the protection of the marine environment from land-based activities is evident in past and ongoing efforts to obtain data and information through projects such as GIWA, the Afribasins initiative, the GoGLME project, and the on-going GCLME project. The latter is an ecosystem-based effort to assist countries adjacent to the GCLME to achieve environmental and resource sustainability. New environmental policies and legislation related to the protection of the marine environment have also been developed. However, slow implementation, enforcement, inadequate monitoring, and lack of data and information have impeded progress in protecting the marine environment from land-based sources of pollution. Several international NGOs such as the Worldwide Fund for Nature (WWF) and Wetlands International have programmes in the WACAF region aimed at conserving and protecting sensitive areas from degradation; these support activities of national governments who have established coastal Ramsar sites. The existing network of marine protected areas (MPA) from Mauritania to Guinea comprises nine national parks, 10 nature reserves, two large biosphere reserves, and a number of traditional sacred areas. Other countries have equally complex systems of protected areas.

The way forward

The way forward is for several management and policy interventions to be undertaken in order to mitigate the degradation of the coastal environment in the WACAF region. Over the past two decades the need for these kinds of interventions has been reiterated by reviews such as this. It is unfortunate that despite clear indications of the magnitude, growth, and negative impacts of coastal degradation, very little is being done to mitigate them apart from a few demonstration projects. The following should be considered in planning the way forward:

- Obligatory sustainable wise use practices to conserve coastal resources. More coastal and marine protected areas should be established not only to minimize human impacts but also to provide sites for research to better understand coastal processes;
- Ecosystem level research, which is necessary for fundamental understanding of the natural and human-induced processes operating in coastal environments, accompanied by comprehensive monitoring and research to identify impacts and to develop remedial actions for coastal zone improvement;
- Tighter regulations to control inflow of nutrient and chemical contaminants to coastal habitats coupled with enforcement of penalties imposed for illegal and unsustainable development that impacts these habitats;
- Education programmes on the social, economic, and ecological value of the region's coastal and marine habitats and their resources; and
- Improved dialog and interaction between scientists, policy-makers, and resource managers to ensure informed decisions regarding the management of coastal environments.

There are many examples of the congruence between the problems, challenges, and opportunities regarding the freshwater environment and those faced by the GPA, e.g., many of the concerns relating to sewage and/or wastewater are similar, as are many of the issues surrounding governance, financing, capacity building, and partnerships with the private sector. Therefore, cooperation between the freshwater community and the GPA is needed to achieve true integration of river basin and coastal area management. It is by working in such a manner that the tremendous potential for synergy generated by a cooperative effort can be realized.

The Environment Initiative of the New Partnership for African Development (NEPAD) and Bodies of the African Union such as the African Ministerial Conference on the Environment (AMCEN) and the African Ministerial Conference on Water (AMCOW) offer an opportunity for the last four of the eight constraints listed above to be addressed. The need for effective environmental practices and product substitutes, adequate legislation, and regulatory measures, as well as good economic instruments and incentives, cannot be addressed in isolation. Issues relating to fair trade, the World Trade Organization (WTO) General Agreement on Tariffs and Trade, and the negative impacts of globalization on developing economies also need to be addressed. All of the above require long-term planning and the use of monitoring and evaluation systems that can inform WACAF decision-makers if progress is being made towards meeting the development needs of their people and achieving the goals of the GPA.

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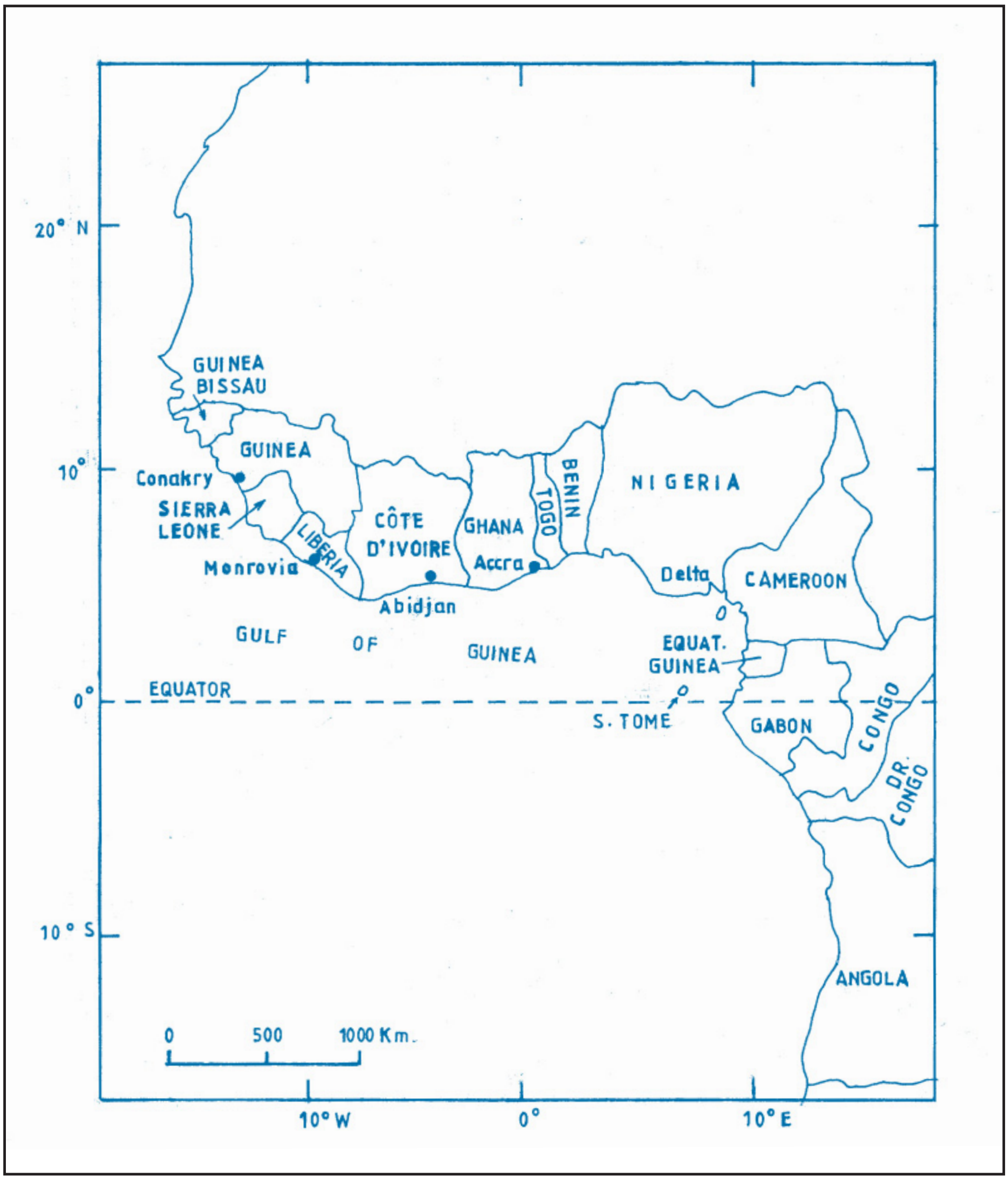
Figure 1.1

Coastal countries of West and Central Africa



(Source: GCLME 2003)

Figure 1.2

UNDP Human Development Index for selected WACAF countries

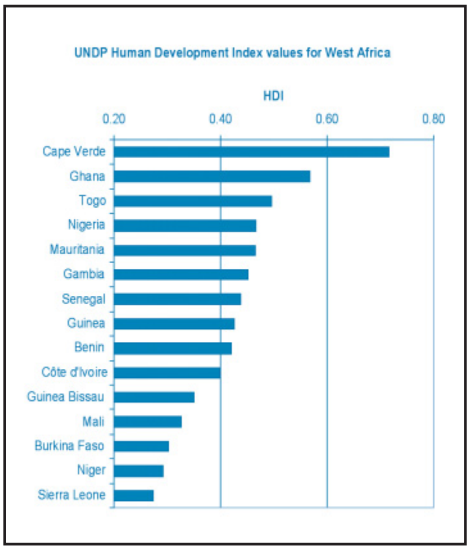


Figure 1.3

Urbanization in selected WACAF countries

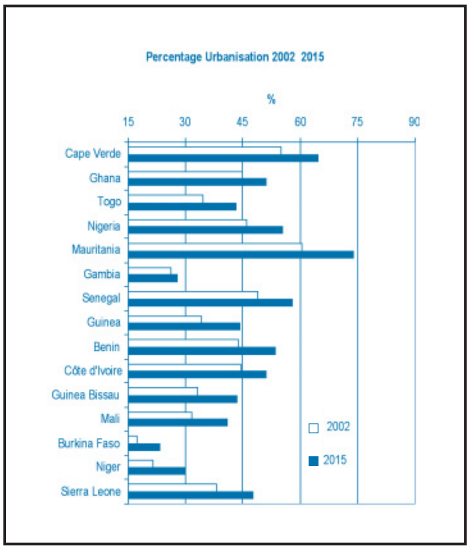
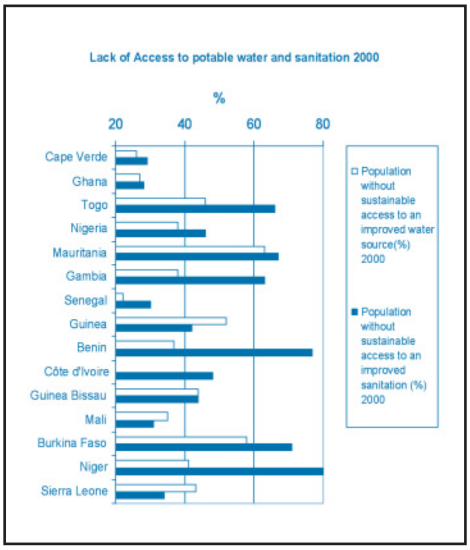


Figure 1.4

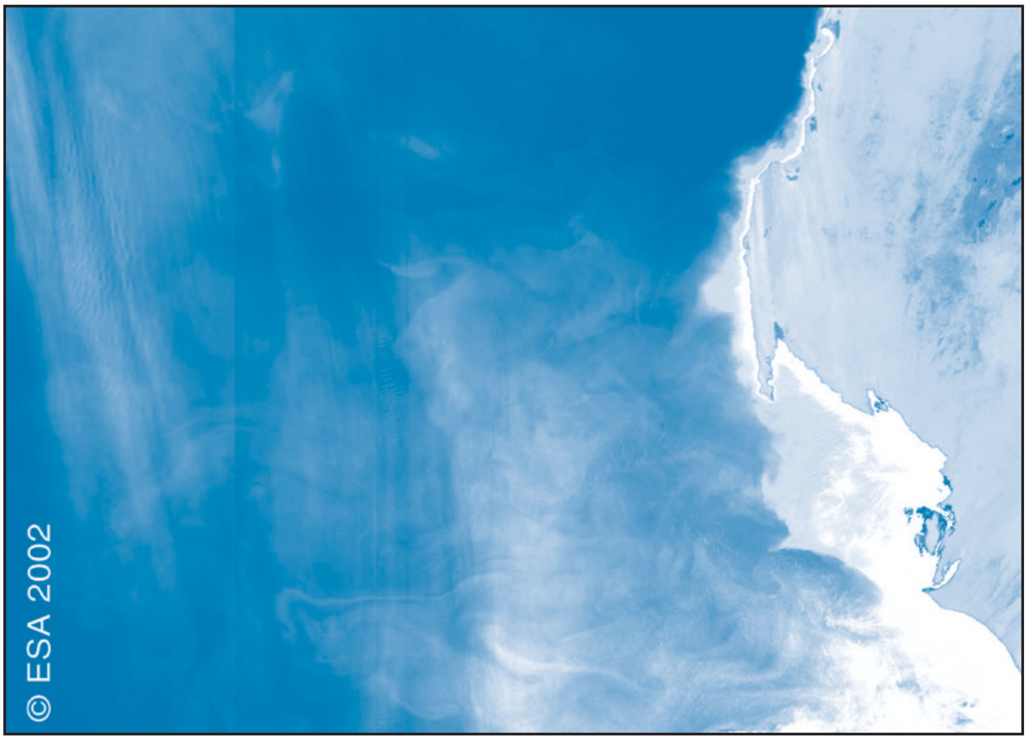
Potable Water and Sanitation in selected WACAF countries



(Source: UNDP 2004)

Figure 1.5

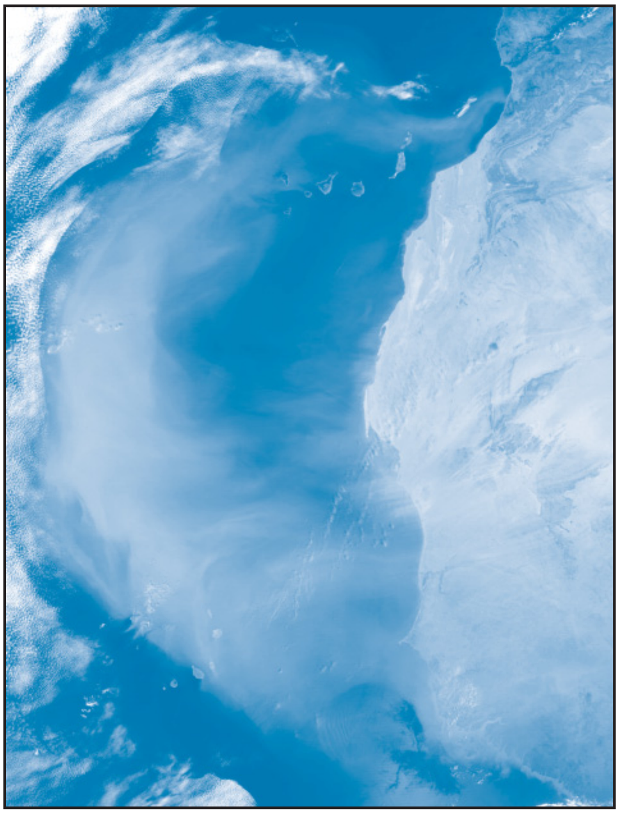
Algal blooms in the Atlantic Ocean caused by input of allochthonous nutrients



(Source: ESA 2002)

Figure 1.6

Aeolian transport of dust from the Sahara across the Atlantic Ocean



(Source: ESA 2002)

Table 1.1

Number of open space vegetable farmers in selected cities and their surroundings in West Africa

Cities	No. farmers
Lomé	1,500
Cotonou	570
Accra	1,000

(Source: Modified from Cofie and others 2003)

Table 1.2

Quality of irrigation water in several WACAF sites

Sampling Site	Distance from city centre (km)	Conductivity (μS/cm)	Nitrogen (NH_4 +NO_3) (μg/l)	Phosphorus PO_4-P (μg/l)	Faecal Coliform x 10^6 (MPN/100 ml)
Kaase	4	1,203	104.5	11.3	11.3
Asago	9	1,336	118.9	51.7	51.7
Adwaden	18	931	78.6	75.4	75.4
Ofoanase	32	849	78.1	47.7	47.7

(Source: Modified from Cofie and others 2003)

Table 1.3

Faecal coliform counts in the Sakumo Catchment

	Faecal Coliform (No./100ml)							
Month/Site	MAD	MOT 1	LAS	MAM	KAT	MOT 2	SAK 2	SAK 1
Nov-02		170	210	275	670	1,680	560	250
Dec-02	105	195	205	225	170	185	340	185
Jan-03	75	50	35	700	800	130	100	10
Feb-03	880	660	220	200	260	4,000	640	60
Mar-03	500,000	5,920	80	20	No data?-	112,000	0	0
May-03	96,000	1,050	4,300	350	950	152,000	50	150

(Source: Yawson 2004). [MAD - Madina; MOT 1 - Motoway Site 1; MOT 2 - Motoway Site 2; LAS - Lashibi; MAM - Mamahuma dam; KAT - Katamanso; SAK 1 - Sakumo site 1; SAK 2- Sakumo site 2)

Table 1.4

Water use and wastewater treatment in some WACAF coastal cities

City - Country	Per capita water used/day (litres)	% wastewater treated
Luanda- Angola	50	0
Porto Novo- Benin	22	No data
Douala- Cameroon	33	5
Yaounde- Cameroon	61	20
Abidjan- Cote d'Ivoire	111	58
Libreville- Gabon	100	0
Accra- Ghana	40	0
Conakry- Guinea	50	0
Lagos- Nigeria	80	No data
Lomé- Togo	35	No data

(Source: Modified from GCLME 2003)

Table 1.5

Typical levels of organochlorine compounds in coastal waters and coastal lagoon systems in the WACAF

Sample	Aldrin	Dieldrin	endrin	heptachlor	lindane	DDT	PCB
Sediment (ppb)							
Ebrié Lagoon, Abidjan	No data	No data	No data	No data	0.5-19	1-997	2-213
Lagos Lagoon, Lagos	19.3	28	12	28	No data	No data	No data
Lekki Lagoon, Nigeria	ND-347	190-8460	ND-129	190-8460	0.11-4.9	No data	No data
Shellfish (ppb)							
Ebrié Lagoon, Abidjan	19.9-132	13.5-168	6.1-74.0	13.5-168	12.5-93	No data	8.9-43.9
Ocean at Limbé, Cameroon	ND-12.0	No data	No data	No data	ND-5.3	ND-481	ND-716

(Source: Scheren and Ibe 2002). ND- not detected

Table 1.6

Typical levels of heavy metal pollution in some coastal lagoon systems in the Guinea Current LME

Sample	Cadmium	Chromium	Copper	Iron	Mercury	Manganese	Lead	Zinc
Sediment (μg/g dry weight)								
Lagos Lagoon, Nigeria	0.01-15.5	2.9-167	1.5-132	510-85 548	ND	98-2757	0.4-483	7.8-831
Ebrié Lagoon, Côte d'Ivoire	ND	20.7-465	3.0-76.3	1.3-67.0	0.05-0.49	24.0-534	4.0-88.8	5.5-398
Aby Lagoon, Côte d'Ivoire	ND	ND	ND	ND	0.0-16.5	ND	ND	ND
Unpolluted sediments	0.2-5	ND	ND	ND	0.01-0.08	ND	8-60	ND
Water (μg/l)								
Korle Lagoon, Ghana (median)	0.24	ND	0.31	ND	ND	ND	0.08	0.08
Lagos Lagoon, Nigeria (median)	0.002	ND	0.003	0.086	ND	0.021	0.009	ND?
Natural sea water levels	0.005	ND	0.003	ND	ND	ND	0.003	0.02
Shellfish (μg/g fresh weight)								
Lagos Lagoon, Legos (median)	0.18	ND	23.6	ND	ND	ND	5.1	240
Ebrié Lagoon, Côte d'Ivoire	0.35-0.95	ND	17.5-33.5	ND	0.07-0.19	ND	ND	608-2 155
WHO Guidelines	2	ND	30	ND	2	ND	2	1,000
						Mercury	**Arsenic**	**Selenium**
Fish (μg/g fresh weight)								
Aby Lagoon, Côte d'Ivoire						0.07-0.39	0.05-0.13	0.29-0.54
WHO Guidelines						50	ND	ND
Vegetable species (μg/g dry weight) e.g., Pistia stratiotes (Water lettuce)								
Aby Lagoon, Côte d'Ivoire						0.82	7.42	4.40

(Source: Scheren and Ibe 2002). ND- not detected

Table 1.7

Sediment yield of some WACAF rivers

River	Country	Sediment yield (tonnes/km²/yr)
Fafa	Central African Republic	3.1
Chari	Chad	3.9
Bangoran	Central African Republic	4.4
Gribingui	Central African Republic	5
Rima	Nigeria	7
Senegal	Senegal	8
Bahr Sar	Chad	8.4
Ouham	Central African Republic	9.4
Logone	Chad	14.9
Sanaga	Cameroon	20
S. Pedro	Ivory Coast	22
Tano	Ghana	22
Niger	Nigeria	33
Faleme	Mali	40
Volta	Ghana	48
Mbam	Cameroon	85
Tsanaga	Cameroon	210
Sokoto	Nigeria	212
Gagare	Nigeria	225
Zamfara	Nigeria	344
Bunsuru	Nigeria	438
	Nigeria	483

(Source: FAO 2005)

Table 1.8

Estimated total solid waste and sludge generation by industry and households in the Port Harcourt area (tonnes/yr)

	Medium and large-scale industries	Households and small industries
Putrescible waste	6,495	95,625
Non-hazardous waste	1,796	31,875
Hazardous waste	127	No data
Non-hazardous sludge	990	No data
Hazardous sludge	13,617	No data

(Source: Ashton-Jones and Oronto 1994)

Table 1.9

Debris from beaches in the WACAF region

Country	Debris collected (kg)	Length of beach cleaned (km)	Weight of debris (tonnes) per km
Cameroon	7,422	0.7	10.6
Côte d'Ivoire	2,275	0.9	2.5
Nigeria	1,419	1.6	0.9

(Source: Modified from Awosika 2002)

Table 1.10

Categories of debris collected during the 1995 beach clean-up at Victoria Beach, Lagos, Nigeria (Total weight of debris collected: 1,260.9 kg)

Categories of debris	Number of pieces	% composition of total
Plastics	6,768	31.86
Foamed plastics	2,161	10.17
Glass	1,462	6.88
Rubber	1,563	7.36
Metal	2,664	12.54
Paper	3,542	16.67
Wood	2,219	10.45
Cloth pieces	862	4.04
TOTAL	**21,241**	**99.99**

(Source: Awosika 2002)

Table 1.11

Oil industry activities by Shell Petroleum and mangrove conversion in State River, Nigeria

Activity	Area of mangrove converted (km^2)
Seismic Operations (56,400 km of seismic lines)	56.4
Drilling (349 drilling sites)	4.5
Production 700 km of flow lines 400 km of pipelines 22 flow stations 1 oil terminal	10.5
Total (=1% of mangroves in State River)	**71.4**

(Source: van Dessel and Omuku 1994)

2 - Southern Africa

INTRODUCTION

For the purposes of this assessment the Southern Africa region comprises Angola, Namibia, and South Africa (Figure 2.1). The Angolan coastline stretches over a distance of about 1,650 km from the border with the Democratic Republic of Congo in the north to the Kunene River in the south. Situated to the north of the Congo River is the province of Cabinda with a coastline of 150 km. The coastal zone ranges from desert in the southern more temperate zone to a typical tropical regime in the north. In the south the oceanic regime is dominated by the productive cold Benguela Current, while the north is mainly influenced by the warm Angola Current. Bays are generally shallow indentations in the otherwise straight coastline. The only deeply indented bay is at Namibe in the south. Most of these sheltered bays are protected by northward trending sand spits such as those at Luanda, Lobito, and Tombwa. There are about 22 estuaries that are permanently or seasonally open to the sea (Morant 1999, Sardinha 2000).

The coastline of Namibia extends over a distance of about 1,500 km from the Kunene River in the north to the Orange River in the south (Boyer and others 2000). The Namib Desert, the world's oldest arid region, lies along Namibia's entire coast. Except for the Kunene and Orange rivers, there are no other perennial systems along the Nambian coast, although there are about 9 ephemeral systems (Morant 1999).

The coastline of South Africa is about 3,000 km long, stretching from the Orange River on the west coast to Ponta do Ouro on the east coast. Two major circulation oceanic systems bound the South African coastline: the warm south-flowing Agulhas Current along the east and south coasts and the cold north-flowing Benguela Current along the west coast (Figure 2.2). The South African coastline is very rugged, with few sheltered embayments and is dominated by high wave conditions and strong winds for most of the year. Along this coastline some 250 estuaries represent much of the only sheltered marine habitats; as a result they are important for biodiversity protection, as well as the focus of coastal development.

MAJOR PRESSURES ON THE MARINE ENVIRONMENT

According to Sardinha (2000), the major pressures on the marine environment along the Angolan coast are:

- Informal settlements and associated sewage and solid waste pollution;
- Offshore oil and gas exploration where the discharge of drilling muds and cuttings, as well as of produced water (containing pollutants such as volatile organic compounds and poly-aromatic hydrocarbons) are a concern;
- Overexploitation of fisheries; and
- Physical modification of coastal habitats (e.g., through erosion).

As a consequence of the civil war, the majority of the population in Angola moved to the Atlantic coast where many reside in informal settlements surrounding the urban centres along the coast. Roughly 20% of the total population currently lives in the capital city of Luanda, although other coastal towns have growing populations. A shortage of potable water in these coastal centres is likely to be another consequence of the rapid pace of urbanization. Because of poor urban infrastructure, there is a very real danger that this rapidly expanding urban population will pose a serious pollution threat to the inshore marine environment.

With a predominantly semi-arid climate, the coastal regions of southern Angola, Namibia in its entirety, and the west coast of South Africa have a relatively limited agricultural potential. This implies that, in the absence of other income-generating opportunities, the population relies increasingly on the sea for its livelihoods or subsistence, particularly in Angola. On the east coast of South Africa the growing population also places increasing pressure on the inshore environment.

Pollution threats to the coastal and marine environments in Namibia are generally low and at present are mainly linked to development nodes along the coasts, in particular Walvis Bay and Lüderitz. Potential threats to these environments include:

- Biodegradable organic pollutants introduced by fish processing plants in Walvis Bay (16 factories) and Luderitz (7 factories) (Boyer and others 2000);
- Oil pollution associated with shipping traffic in and around the ports at Walvis Bay and Luderitz;
- Garbage (including plastics) and sewage disposal from ships anchored nearshore; and
- Accidental sewage spills (as far as could be established there are no piped sewage discharges into the marine environment).

Marine and coastal diamond mining between Lüderitz and the Orange River mouth is probably the main activity responsible for coastal habitat modification and destruction along the Namibian coast.

South Africa has an estimated population of 40 million people, about 30% of which lives within 60 km of the coast. The major issues threatening South Africa's coastal and marine environments were identified during a study conducted as part of a GEF project (Clark and others 2001).
These are, in order of importance:

- Reduction in the quantity and quality of available freshwater entering estuaries and the marine environment (mainly through river runoff);
- Overexploitation of marine living resources;
- Loss and modification, including physical alteration and destruction of habitats, primarily as a result of urban development; and
- Marine pollution.

In terms of marine pollution the major threats (or potential threats) relate to:

- Maritime transportation (e.g., accidental and deliberate oil spills and dumping of ship garbage);
- Contaminated stormwater runoff (e.g., from informal settlements and hard surfaces in urban areas);
- Inappropriate sewage (or municipal wastewater) discharges;
- Industrial discharges (including fish factories and other chemical industries);
- Dumping at sea, particularly dredge spoil; and
- Possible atmospheric sources.

In summary, the main land-based activities posing threats (or potential threats) to the marine environment in Southern Africa include:

- Disposal of **untreated sewage**, either through diffuse inputs from informal settlements or through effluents discharged from malfunctioning sewage treatment plants;
- **Coastal developments** (urbanization) and coastal mining activities, contributing to the modification and destruction of coastal habitats;
- **Water abstraction** (e.g., dams) resulting in a reduction in freshwater inflow to the marine environment (including estuaries). This, in turn, causes a reduction in the amount of sediment and nutrients that would naturally have reached the sea;

- **Inappropriate agricultural practices**, resulting in the deterioration in the quality of the river water entering the marine environment, e.g., by introducing toxic substances and excessive nutrients (from the inappropriate use of pesticides and fertilizers) and increased suspended solid loads as a result of soil erosion;
- **Contaminated stormwater runoff** from large urban areas along the coast, introducing toxic substances such as trace metals and oils (hydrocarbons) to the marine environment;
- **Industrial wastewater discharges** (mainly fish factories and oil refineries) introducing a range of pollutants to the marine environment, depending on the industry type; and
- **Fossil fuel fires** (large informal settlements) and traffic emissions (large urban areas) possibly introducing pollutants to the marine environment via the atmosphere.

As previously highlighted, **overexploitation of living marine resources, offshore oil and gas exploration**, and **activities associated with maritime transportation** pose an equally serious threat to the marine environment of Southern Africa, if not greater than those listed above. However, these are not considered to be land-based and are therefore not discussed further in this assessment.

DEVELOPMENT OF LEGAL AND INSTITUTIONAL FRAMEWORK

An informative historical perspective on policy responses to environmental issues on the African continent is provided in UNEP (2000). As far as could be established, current legislation in Angola specifically dealing with land-based sources of marine pollution is limited to that concerning oil and gas exploration in accordance with the Ministry of *Petroleum's Regulations on Operational Discharges Management*, issued under Article 23 of the Decree on Environmental Protection for the Petroleum Industry. Environmental aspects related to oil and gas exploration and production operations in Angola are regulated by the Ministry of Petroleum in collaboration with the National oil company, Sociedade de Combustiveis de Angola U.E.E (SONANGOL) (Morant 1999).

With the promulgation of the General Environmental Law in Angola, responsibility for the implementation of national environmental policy rests with the Ministry of Urban Planning and Environment and the Ministry of Fisheries. The Ministry of Petroleum, which administers the Decree on Environmental Protection for the Petroleum Industry, has also engaged with the International Maritime Organization (IMO) and the International Petroleum Industry Environmental Conservation Association for assistance in formulating a National Contingency Plan for the prevention and management of oil pollution in Angola (Sardinha 2000).

In Namibia, there is currently no legislation dealing specifically with the control of land-base sources of pollution. Existing legislation addressing waste management and pollution control is complicated and scattered in a variety of statutes and regulations, most of these being the old South African laws. There is also a lack of clarity as to which legislation applies and which ministry or institution is responsible for particular issues. However, in 1999, a Pollution Control and Waste Management Bill was drafted, designed to address these deficiencies and consolidate the legal framework, as well as to address the institutional fragmentation. Once this is implemented, it would make provision for the Integrated Pollution Control Licence as well as regulations for the storage, transport, management, and disposal of waste.

In terms of combating oil pollution - including that which may come from activities in the harbours at Walvis Bay and Lüderitz - Namibia formulated a National Oil Spill Contingency Plan that provides the framework for the national response to oil spills. This contingency plan is coordinated by the Government Action Control Group housed in the Directorate of Maritime Affairs in the Ministry of Works, Transport, and Communication.

In the past 10 years, South Africa's greatest effort in combating the impact of land-based activities on the marine environment has been in the development of sound environmental policies and legislation. For instance, in 1998, the National Water Act, which placed a strong emphasis on resource management, was promulgated. Protocols and policies that have since been promulgated under this Act relating to the management and control of impacts from land-based activities on the marine environment (including estuaries) include:

- *Methodology for the Determination of the Ecological Water Requirements for Estuaries* (RSA DWAF 2004a);
- *Operational Policy for the Disposal of Land-derived Wastewater to the Marine Environment of South Africa* (RSA DWAF 2004b). This operational policy outlines the Department of Water Affairs and Forestry (DWAF) new thinking in relation to discharges to the sea. In line with international trends and the national objective of efficient and effective management of South Africa's resources, priority is given to a receiving water quality management approach. The policy provides Basic Principles and Ground Rules as a framework within which disposal practices for land-derived water containing waste will be evaluated when marine disposal is a possible alternative for the disposal of wastewater. It also provides a management framework within which such disposal needs to be conducted (RSA DWAF 2004c); and
- *A Guide to Non-point Source Assessment* (Pegram and Görgens 2001) and *Managing the Water Quality Effects of Settlements* (RSA DWAF 1999). Of particular concern is contaminated runoff from informal settlements. To this end the DWAF, currently responsible for the management and control of pollution from land-based sources in South Africa (including stormwater runoff), has prepared these guidance documents.

The White Paper for Sustainable Coastal Development for South Africa (April 2000) also sets out a policy that aims to achieve sustainable coastal development through integrated coastal management. The policy is currently being defined in the National Environmental Management: Coastal Zone Management Bill to provide better control of coastal development without compromising economic development and job creation. South Africa also enforces Environmental Impact Assessment (EIA) Regulations (under the Environmental Conservation Act) whereby new coastal developments are required to undergo an EIA before authorization.

South Africa's Department of Environmental Affairs and Tourism (DEAT) has also proposed a National Environmental Management: Air Quality Bill that will introduce a comprehensive air quality management system for South Africa (www.info.gov.za/documents/bills/2003.htm). The new legislation will address the protection of the environment against air pollution as well as the cumulative impact of pollutants on the receiving environment, including the marine environment. DEAT is faced with the challenge of trying to leap from a 1960s control programme to a modern air quality management programme.

The DEAT Marine and Coastal Management also recently initiated a State of the Coast reporting programme for the marine and coastal environments of South Africa. The aim of this initiative is to compile the first State of the Coast Report for South Africa. The report will address numerous issues facing the marine and coastal environment and will use environmental indicators to track changes in a range of natural and anthropogenic components over time. More detail on this project can be found at http://dbn.csir.co.za/soc.

The Benguela Current Large Marine Ecosystem (BCLME) Programme (www.bclme.org) is currently playing a key role in institutional collaboration in Angola, Namibia, and South Africa. For example, one of its projects, Base-Line Assessment of Sources and Management of Land-Based Marine Pollution in the BCLME Region, is specifically aimed at assessing the current status, identifying gaps, and proposing a standardized framework for the management of land-based marine pollution sources in the region.

STATE OF THE MARINE ENVIRONMENT RELATED TO THE GPA ISSUES

Available and readily accessible information was reviewed to highlight trends over the past 10 years and emerging issues on the state of the marine environment in Southern Africa in relation to the nine source categories of the GPA: sewage, POPs, radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilization, litter, and PADH. The assessment focused on these categories in so far as key land-based activities were responsible for such trends and emerging issues (some of the pollutant categories can also be affected by activities at sea, e.g., offshore maritime transportation).

A category that currently is not included in the GPA but which constitutes a land-based impact that affects the marine environment (particularly estuaries) of Southern Africa, is the reduction in freshwater inflow. This was also assessed.

Sewage

No data on the volume of sewage disposed of in the marine environment (either directly or through river outflow) could be located for Angola. As has been reported, a large portion of the Angola’s population moved to the coast during and after the civil war (post-1974). As a result of poor urban infrastructure, untreated sewage is most likely discharged into the sea in increasing volumes. Using the estimated population increase of Angola as a proxy (Figure 2.3), the volume of untreated sewage entering the marine environment, particularly in the vicinity of Luanda and other larger coastal towns such as Benguela, Lobito, Namibe, and Cabinda would have increased markedly over the past 10 years.

In Namibia, pollution of the marine environment from land-derived sewage is not considered a major concern as the population densities along the coast are low and concentrated in a few development nodes (Henties Bay, Swakopmund/Walvis Bay, and Lüderitz). Being a water-scarce area, residual or grey water is usually re-used after treatment (e.g., for watering of gardens and golf courses). A portion of the treated sewage effluent from Swakopmund is disposed of in the sea (estimated at about 350,400 m^3/yr). Localized pollution incidents, however, do occur and are mainly linked to drain seepage and overflow from malfunctioning pump stations.

In South Africa disposal of sewage to the marine environment ranges from preliminary treated sewage discharged offshore, to secondarily treated effluent discharges to the surf zone and estuaries, to untreated sewage entering the marine environment from informal settlements through stormwater runoff. A summary of the estimated annual volumes is provided in Table 2.1. Data indicate that there has been no marked increase in the volume of sewage discharged to offshore areas, although over the past 10 years disposal to estuaries and the surf zone has almost doubled and tripled, respectively, reflecting the rapid population growth in coastal areas along the South African coast during this period.

The design of offshore sewage outfalls in South Africa since about 1985 has followed the receiving water quality objectives approach where effluent quantities and composition must be within limits that would meet site-specific Environmental Quality Objectives, as recommended in the *South African Water Quality Guidelines for Coastal Marine Waters* (RSA DWAF 1995). Long-term environmental monitoring programmes at these outfalls (as part of the licence agreements) have indicated no detrimental impact on the marine environment. Of greater concern is the rapid increase in discharges to less dynamic and sensitive areas such as the surf zone and estuaries, where effluents from malfunctioning or overloaded treatment facilities are adversely affecting the marine environment, albeit in a localized manner. However, the newly-adopted operational policy for the disposal of land-derived wastewater will, in future, also require better management and control of these systems.

Untreated sewage that enters the marine environment from informal settlements, although probably comprising a relatively small component of the total sewage load to the marine environment, remains a concern, particularly in the larger coastal cities such as Cape Town, Port Elizabeth, and Durban. Attempts are being made by local authorities to link as many dwellings as possible to sewage reticulation systems, but the demand continues to outgrow the supply.

Bathing beaches within the larger urban centres in South Africa (e.g., Cape Town and Durban) are regularly monitored by the local authorities. As is probably the case in many of the other urban centres in the region, contaminated stormwater runoff is considered the main cause for non-compliance with recommended water quality criteria. However, to protect the safety of bathers continuous efforts are being made to improve this situation, as demonstrated at beaches in False Bay, Cape Town (Table 2.2).

Persistent Organic Pollutants (POPs)

In Southern Africa river runoff from catchments where agriculture is the major land-use is probably the greatest source of land-derived POPs (mainly pesticides) to the marine environment. Agricultural activities in Angola are mainly related to small-scale subsistence farming. River runoff is therefore not considered to be a major source as pesticides are not used on a large scale. In Namibia, the Orange River, at its border with South African is considered the most important source of pesticides to the marine environment since its catchment drains excessive agricultural areas in South Africa (Vetter and others 1999).

No quantitative data could be located on pesticide loads entering the marine environment from rivers along the South African coast. The lack of data is partly as a result of the high cost involved in analysing such pollutants on a routine basis. Since agriculture is a major land-use activity in the country, river runoff is likely to contribute to POPs loads (in particular pesticides) entering the marine environment. In the subtropical and tropical regions of Africa, DDT has also been re-introduced to combat mosquitoes and needs to be highlighted as a potential source of POPs to the marine environment.

Being relatively insoluble in water, POPs enter the food chain and accumulate in fatty tissues of higher trophic levels (e.g., marine mammals). Pesticides have been detected in fatty tissues of seals and dolphins along the Namibian and South African coast (Vetter and others 1999), although, in general, levels were not considered to reflect serious pollution.
Radioactive substances

No data on the status or trends of radioactive pollutants entering the marine environment from land-based activities could be located for the Southern African region. However, at present it is not considered to be a major concern as there is currently only one nuclear power station, which is subjected to strict legislation (www.radwaste.co.za/regulation.htm), in the region situated near Cape Town (RSA DWAF 2004b).

Heavy metals and oils (hydrocarbons)

Land-based activities that introduce both heavy metals and oils (hydrocarbons) to the marine environment in Southern Africa are considered to be much the same and are therefore discussed simultaneously. Key land-based activities that are potential contributors to trace metal and oil (hydrocarbon) loads into the marine environment in the region include:

- Industrial wastewater (e.g., associated with harbour activities and oil refineries);
- Contaminated stormwater runoff from urban areas (Taljaard and others 2000); and
- Runoff from rivers used for maritime transportation.

Quantitative data on the status of the marine environment related to heavy metal and oil pollution could not be located for either Angola or Namibia. In Namibia such pollutants are introduced to the marine environment mainly through activities in the harbours at Walvis Bay and Lüderitz, but are not considered to be a major issue elsewhere along the coast. In Angola oil refineries and other oil production facilities are located at numerous places along the coast, mainly from Luanda northwards (UNEP 1999), and are likely sources of heavy metals and oils to the marine environment. The Congo River, along the northern border of Angola, is the only shipping route into the Democratic Republic of the Congo and is likely to contribute to the heavy metal and oil loads in the marine environment, but this is difficult to quantify at present.

The estimated volumes of industrial wastewater discharges likely to introduce heave metals and oils to the marine environment in South Africa are presented in Table 2.3. Oil refineries are located in Cape Town, Mossel Bay, and Durban, while chemical, textile, and wood pulp plants and aluminium smelters are mostly concentrated along the east coast (Durban and Richards Bay). The last quantitative assessment of stormwater runoff to the marine environment for South Africa was done in 1991 (CSIR 1991). Estimated stormwater volumes and associated trace metals and oil loads from some of South Africa's larger urban centres are given in Table 2.4. Taking into account the vast increase in coastal populations over the past 10 years, it is expected that the volume of stormwater runoff (as a result of the increase in hard surfaces) and associated trace metal and oil loads are likely to have increased since 1991.

In order to assess the actual long-term impacts of anthropogenic trace metal loads on the marine environment, DEAT has been conducting a mussel watch programme along South Africa's west coast (currently the long-term monitoring programme does not include oils-hydrocarbons). As monitoring sites are located along the shoreline, the mussel watch is probably a good indicator of land-based inputs of heavy metals. Results from different stations tend to show similar results, as illustrated in the example from a station near Cape Town (Figure 2.4). Results for Cd, Pb, Zn, and mercury (Hg) did reflect inter-annual variations, but as yet no clear long-term (increasing) trends seem to be apparent.

Nutrients

The major source of nutrients (inorganic nitrogen and phosphorous) to the marine environment in the Southern African region include:

- Sewage (including untreated sewage through diffuse stormwater runoff (particularly from informal settlement areas);
- River runoff from catchments where agriculture is the major land-use; and
- Industrial wastewater discharges, in particular fish processing industries.

As already discussed, in Angola the increase in the volume of untreated sewage and associated nutrients entering the marine environment, particularly in the vicinity of Luanda and other coastal towns would have increased markedly over the past 10 years, consistent with the estimated population increase. Agricultural activities in Angola consist mainly of small-scale subsistence farming. Since fertilizers are not used on a large scale, river runoff is not considered to be a major source of nutrients. A recent study by the World Commission on Water for the 21st Century revealed that among other international rivers, the Congo River, along the northern border of Angola, is still relatively unpolluted in terms of agricultural irrigation (nutrients), industrial waste, and sewage, as there are few industrial centres along its banks (Environmental News Service 1999).

Nutrient input to the marine environment through land-derived sewage and river runoff is not a major concern in Namibia. The only perennial rivers are the Orange and Kunene on the South African and Angolan borders respectively, and, being a water scarce country, sewage wastewater is largely re-used after treatment. However, areas like Walvis Bay and Lüderitz support numerous fish factories. Sixteen such factories at Walvis Bay and seven at Lüderitz discharge nutrient-rich effluents to the marine environment. Although no easily accessible data could be located on nutrient loads from these industries, the loads are largely dependent on annual fish landings and therefore vary from year to year.

Rough estimates of changes in nutrient loads entering the marine environment of South Africa over the past 10 years are presented in Table 2.5. Currently most of the routine sampling of nutrient levels in South African rivers is focused on inland surface water resources, which are often not representative of the levels that ultimately enter the marine environment due to marked changes in water quality between the sampling point (far upstream in the catchment) and the sea. Nutrient loads from smaller catchments probably also have their greatest impact on estuaries. These estuarine systems act as purifying systems where nutrients from the catchment are absorbed, resulting in cleaner water entering the sea. This nutrient removal function is manifested in excessive weed growth or phytoplankton blooms in estuaries, rather than in the adjacent marine environment. This is particularly evident during low flow periods (dry season) when the river water entering the estuaries can have high nutrients levels (e.g., due to agricultural irrigation return flows), as well as longer residence times within the estuaries.

Eutrophication of coastal waters (or signs thereof) is primarily linked to situations where nutrient-rich effluents are discharged directly to the sea. Such situations are limited mainly to the west coast where large volumes of fish factory effluents are discharged into sheltered bays, e.g., Saldanha Bay (Monteiro and others 1998).

Sediment mobilization

Land-based sources contributing (or potentially contributing) to the sediment load in the marine environment in Southern Africa include:

- River runoff (e.g., inappropriate agricultural practices, over-grazing and deforestation resulting in soil erosion); and
- Stormwater runoff (e.g., from informal settlements).

Changes in the sediment load to the marine environment from river runoff over the past 10 years have not been quantified for this region. Similarly, changes in inputs from stormwater runoff are also not properly quantified.

In Angola the sediment loads introduced through river runoff are not likely to have changed markedly over the past 10 years since agricultural and forestry activities in the interior were markedly reduced by the war. In addition, there are no new major dam developments on the Angolan rivers that could have altered sediment loads in the past decade.

Changes in the natural sediment loading to the marine environment over the past 10 years are not considered to be a major concern in Namibia. There are no westward flowing perennial rivers within the borders of the country and being mainly arid, sediment input through stormwater runoff is negligible.

Being a semi-arid country, many of the larger rivers in South Africa have been dammed, potentially reducing sediment loads to the marine environment, depending on the proximity of the dams to the coast. On the other hand, inappropriate agricultural practices in other catchments have contributed to increased sediment loading in the marine environment. Although changes in sediment loads have been estimated for some individual systems, these mainly relate to changes in inputs to estuaries (RSA DWAF 2003a, 2004e, 2004f). These studies have also provided estimates of change from the reference condition (prior to human interference) and do not reflect changes over the past 10 years. Such changes that have occurred in the past decade are considered to be incremental compared to changes in sediment loads over the past 30-50 years. However, the potential impacts of altering catchment-derived sediment loads to the marine environment have been highlighted in South Africa and a number of research initiatives are being planned to address this issue. This is particularly important along the South African east coast where river runoff is considered an important natural source of sediment and nutrients to the inshore marine environment, e.g., Thukela River (RSA DWAF 2004f).

Litter

In Southern Africa urban stormwater runoff is probably the single most important land-based source of litter in the marine environment. Although there are no quantitative data to support this, photographs taken at coastal cities, particularly those with large informal settlements where garbage removal services are lacking, clearly support this observation.

Taking into account the large increase in the population of coastal urban areas in Southern Africa in the past decade (Figure 2.3), it is expected that the litter introduced through urban stormwater runoff would also have increased markedly. To combat such pollution, the South African DEAT is currently embarking on a number of clean-up initiatives along the coast through its Coast Care Programme.

Stormwater runoff is not a major concern in Namibia, but the lack of effective services for collection of garbage from foreign fishing fleets anchored outside port boundaries (e.g., Walvis Bay) results in waste being dumped into the sea causing a serious litter problem on adjacent beaches.

Physical alteration and destruction of habitats

In Angola coastal erosion is considered to be a major concern in terms of the physical alteration and destruction of habitat (PADH). Although natural factors (e.g., storms) contribute to erosion, human activities (e.g., destruction of coastal vegetation, coastal structures erected in sensitive areas) are also a major contributing factor. In large urban areas such as Luanda, Benguela, and Lobito coastal erosion has resulted in considerable damage to infrastructure (UNEP 1999). No quantitative data are available on trends over the past 10 years, but using the increase in population as a proxy and given that most of the population is concentrated in the coastal areas, PADH is probably also increasing accordingly.

Along the Namibian coast destruction of coastal habitats is largely associated with diamond mining activities between Lüderitz and the Orange River mouth. No easily accessible information could be located on trends over the past 10 year. However, two projects under the BCLME Programme - *Data Gathering and Gap Analysis for Assessment of Cumulative Effects of Marine Diamond Mining Activities and Assessment of the Cumulative Effects of Sediment Discharges from On-shore and Near-shore Diamond Mining Activities*- are currently addressing this issue for the BCLME region (focusing on South Africa's west coast and Namibia).

Up until 20 years ago, South Africa differed from many coastal countries in that the centre of industrial activity was located in the interior of the country. Heavy industries developed around the gold mines, which are now becoming economically unviable. As a consequence, coastal areas are being targeted for industrialization, as reflected by the development of Richards Bay and Saldanha Bay and a new industrial node being developed at Coega near Port Elizabeth. Development pressures on the coast therefore have recently increased dramatically, and it is expected that this trend will continue.

Very little of the area above the high water mark along the South African coast has been unaffected by urban and industrial development. Furthermore, the 39% of the coast seen as undeveloped is fragmented and may not function effectively as ecological units (Clark and others 2001). Habitat loss above the high water mark is largely attributed to activities shown in Table 2.6.

Below the high water mark there has been considerably less habitat alteration as a result of development (e.g., ports and mining). Clark and others (2001) estimated that 10% of the total subtidal area of South Africa has been altered and attributed 50% of this to port and marina development, 40% to diamond and mineral sand mining, and 10% to various recreational facilities (e.g., tidal pools). Probably of greatest concern is the impact on intertidal estuarine habitats important for over-wintering Palaearctic migrant bird species.

Should these habitats be severely degraded or destroyed, a drastic reduction in the numbers and even extinction of these species could occur.

In the longer-term sea level rise could result in the elimination of many intertidal areas, particularly estuarine habitats as these become constricted between the rising water level and existing coastal developments.

Reduction in freshwater inflows

Within the Southern Africa region, major impacts of the reduction of freshwater inputs are currently a concern mainly in South Africa. This country is predominantly semi-arid, with an average rainfall of about 450 mm/yr, well below the world average of about 860 mm/yr, while the evaporation rate is comparatively high. As a result, South Africa's water resources are, in global terms, scarce and extremely limited with the combined flow of all the rivers amounting to approximately 49,000 million m^3/yr, less than half of that of the Zambezi River, the largest river close to South Africa (RSA DWAF 2004g).

South Africa depends mainly on surface water resources for its urban, industrial, and agricultural requirements. As a result, surface water resources are extensively exploited throughout most of the country. About 320 major dams with a total capacity of more than 32, 400 million m^3 already account for 66% of the total mean annual runoff (RSA DWAF 2004g). Freshwater runoff is further limited by smaller dams and water abstractions occurring directly from the rivers.

As a result of the high water demand in relation to supply, the freshwater inflow (including floods) reaching South Africa's estuaries and adjacent marine environment has been markedly reduced. This poses a major threat to the functioning of many estuarine systems and hence to the life-cycles of many fish and invertebrate species with an obligate estuarine phase in their life cycles. Lamberth and Turpie (2003) estimated that in 2002, the total value of estuarine and estuary-dependent fisheries was R1.251 thousand million (US$208.5 thousand million). Thus, loss of estuarine functions could have a severe economic impact on inshore fisheries.

Based on recent assessments (CSIR 1998, RSA DWAF 2002, 2003a, 2003b, 2003c, 2004e, 2004f, 2004h), the most important consequences of reduction in freshwater inflows, which in turn affect the ecological functioning and sustainability of these estuarine systems, include:

- Increase in the frequency of mouth closure of temporarily open/closed estuaries (e.g., cutting off important habitats for marine organisms that rely on estuaries for one or more of their life history stages);
- Increase in the extent of saline intrusion in permanently open systems (e.g., changing the salinity regime, which in turn alters the ecological characteristics of estuaries); and
- Increase of siltation in estuaries (due to a decrease in floods, which scour sediments).

Taking into account the increase in water demand over the past 10 years, it is likely that the ecological status of most of South Africa's estuaries have been modified, particularly the smaller systems that require a large proportion of their mean annual runoff to function properly.

A comparison between the health status of 27 South African estuaries assessed in the 1990s (Whitfield 1995, 2000) and more recently (Turpie 2004) showed a decline in the health of six of the 27 estuaries evaluated.

However, Turpie (2004) also concluded that many of South Africa's estuaries are still considered to be in a relatively good state:
• Excellent condition (28%)
• Good condition (31%)
• Fair condition (25%)
• Poor condition (15%)

The distribution of South Africa's estuaries, in terms of their health status, is illustrated in Figure 2.5. Although the deterioration in the health of estuaries in urban areas is probably more related to pollution and habitat destruction, the deterioration in health of the rural catchments is mainly the result of reduction in freshwater inflow.

CONCLUSION

Hotspots and trends over the past 10 years

In the Southern African region the vast increase in coastal populations over the past decade, particularly in Angola and South Africa (and to a lesser extent Namibia) is the key driver in terms of the contribution from land-based activities to the deterioration of the inshore marine environment. This is primarily manifested in a marked increase in:
• Sewage and associated nutrient loads;
• Physical alteration and destruction of habitats;
• Contaminated urban stormwater runoff; and
• Litter.

Hotspots in the region are mainly linked to large urban centres in:
• Angola - Luanda, Benguela, Lobito, Namibe and Cabinda;
• Namibia - Walvis Bay/Swakopmund; and
• South Africa - Saldanha Bay, Cape Town, Port Elizabeth, East London, Durban and Richards Bay.

The entire coastline of South Africa is increasingly coming under threat from PADH. Agricultural land is being re-zoned to accommodate large coastal developments such as golf estates particularly along the country's east coast (Kwazulu-Natal).

From the foregoing it is concluded that the situation concerning GPA issues in southern Africa probably worsened over the past 10 years.

Has progress been made in protecting the marine environment during the last 10 years?

Progress in the protection of the marine environment from land-based activities began mainly through recognition by the three countries of the urgent need to address this issue. This is manifested, e.g., in projects such as the *Base-Line Assessment of Sources and Management of Land-Based Marine Pollution in the BCLME Region*, undertaken as part of the BCLME Programme. In the case of South Africa this is further manifested in the array of new environmental policies and legislation with the goal of protecting the marine environment developed during this period.

The way forward

Over the next 10 years the protection of the marine environment from land-based activities, among other threats, will depend largely on the effectiveness with which the knowledge from recent research studies is applied and new legislation implemented in the three countries. In addition, the establishment of appropriate long-term monitoring programmes to detect trends related to the effects of land-based activities on the marine environment should be a key priority (and challenge) for Southern Africa and other developing regions over the next decade. A major concern in the region, as is the case in many developing countries, is the lack of appropriate data to quantify the effects of land-based activities on the marine environment. Developing countries usually have urgent socio-economic priorities such as combating poverty and improving health and education services, as a result of which issues related to the protection of the natural environment, are often not adequately addressed. Towards meeting this challenge a demonstration (GEF funded) project of the GPA coordination office - Addressing land-based activities in the Western Indian Ocean (WIO-LAB) - was initiated in 2005. The project represents a partnership between UNEP/GPA and the eight participating states: Kenya, Madagascar, Mauritius, Mozambique, Seychelles, South Africa, Tanzania, and Comoros.

The main objectives of the project are to:

- Improve the knowledge base and establish and demonstrate regional strategies for the reduction of stress on the marine and coastal ecosystem by improvin-g water and sediment quality;
- Strengthen the regional legal basis for preventing land-based sources of pollution, including the implementation of the GPA; and
- Develop regional capacity and strengthen institutions for sustainable, less polluting development, including the implementation of the Nairobi Convention and its action plan.

The Council for Scientific and Industrial Research (CSIR) in South Africa has been recently designated the Regional Activity Centre for the monitoring and assessment phase of this project, which aims to encourage a regional assessment of land-based sources of pollution in the marine and coastal environments (A.Naidoo, CSIR, pers. comm.).

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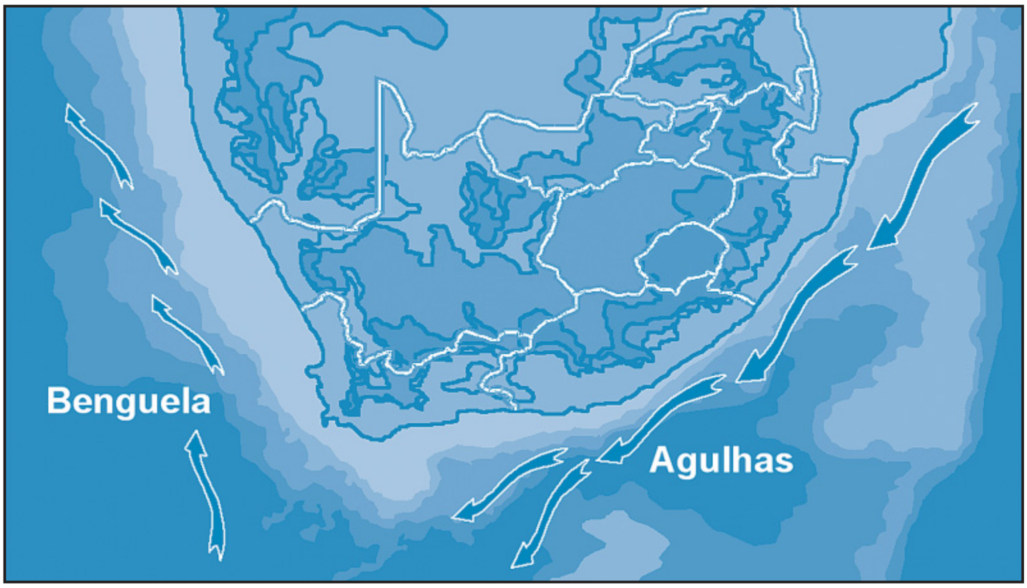
Figure 2.1

Countries included in the southern Africa region: Angola, Namibia, and South Africa

Figure 2.2

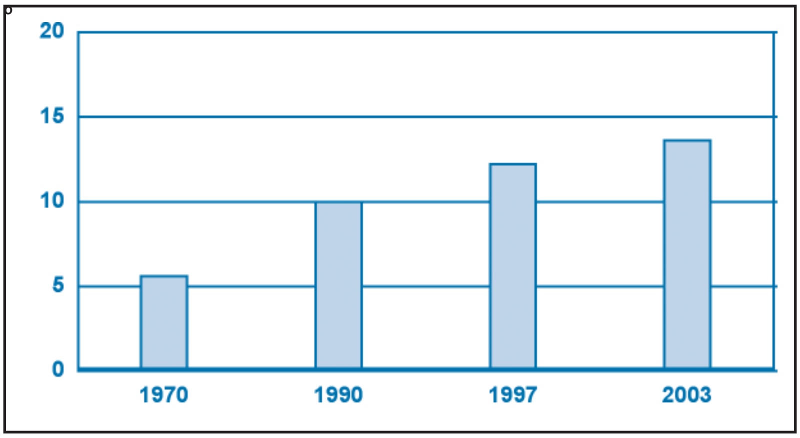
Southern Africa major coastal circulation systems



(Source: RSA DWAF 2004a)

Figure 2.3

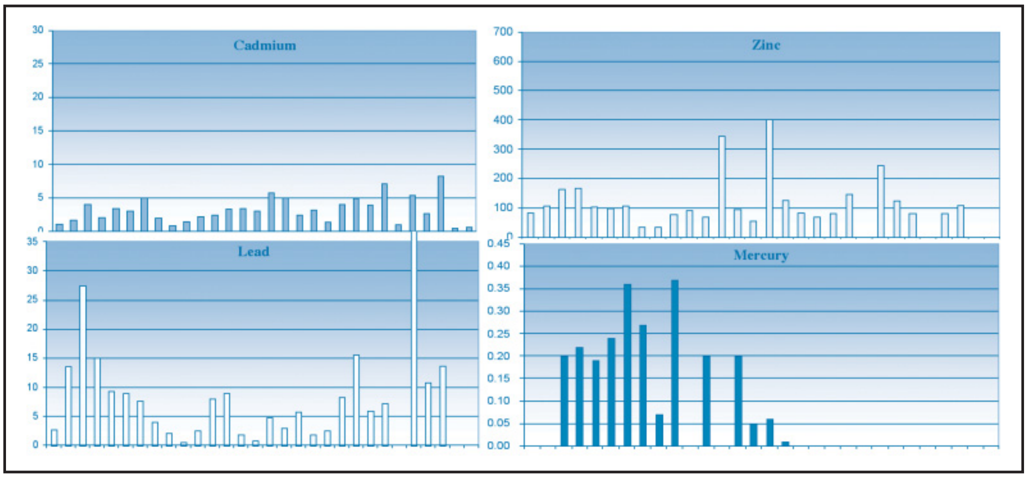
Estimated population of Angola from 1970 to 2003



(Source: RSA DWAF 2004a)

Figure 2.4

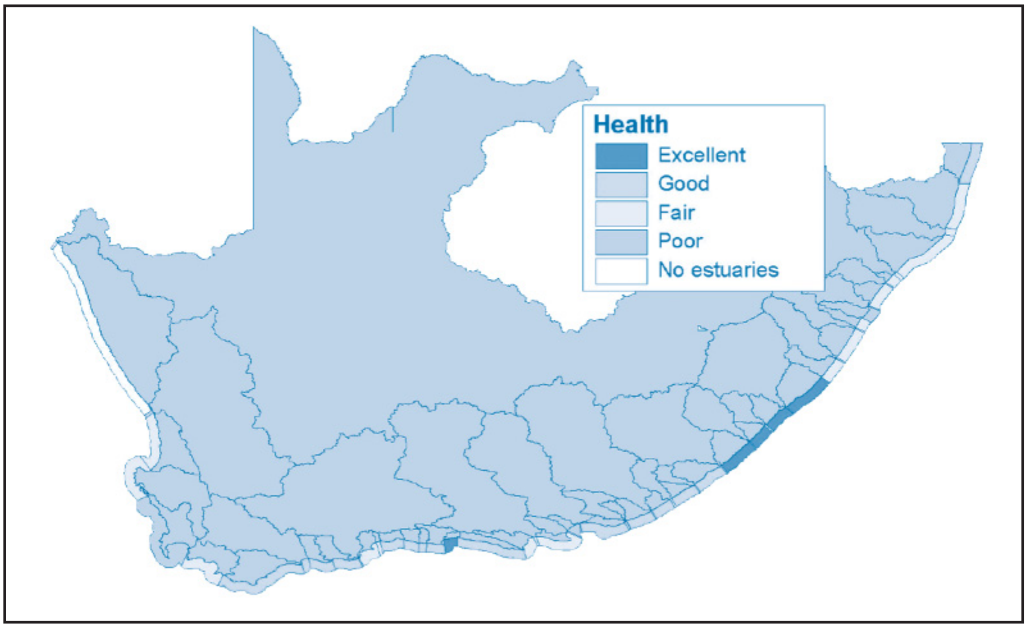
Trace metal concentrations in mussel tissues along the South African coast (Cape Town)



(Source: G Kieviets, Department of Environmental Affairs and Tourism, Marine and Coastal Management, South Africa)

Figure 2.5

The health status of South African estuaries



(Source: Turpie 2004)

Table 2.1

Estimated volumes of sewage effluent discharges to the marine environment in South Africa

Type	Estimated volume (million m³/yr)	
	1991	2004
Offshore marine outfalls (preliminary treatment)	110.6	122.5
Surf zone discharges (mainly secondary treated)	33.6	109.0
Estuarine discharges (mainly secondary treated)	21.4	55.5
Diffuse sources through stormwater runoff (untreated)	No data	No data

(Source: CSIR 1991, RSA DWAF 2004d)

Table 2.2

Compliance of beaches along the False Bay coast (Cape Town) with national and international quality guidelines for contact recreation

Year	No. of sites	% Beaches along the false bay coast that complied with microbiological targets			
			European Union		
		South Africa	Guideline	Mandatory	Australian
1995	46	74%	74%	91%	89%
1996	47	70%	70%	94%	94%
1997	47	79%	79%	89%	89%
1998	52	84%	84%	88%	90%
1999	50	90%	90%	98%	100%

(Source: Taljaard and others 2000)

Table 2.3

Estimated volumes of industrial waste-water discharges to the marine environment and associated pollutant categories in South Africa (no data found to estimate loads)

Industry type	Estimated volume (m³/day)	Pollutant category				
		Sediments (suspended solids)	Nutrients	Heavy Metals	Oil	Radio-active substances
Coastal mining	128 800	√				
Fishing industry	44 834	√	√			
Chemical/textile	15 460			√		
Oil refinery	8 254			√	√	
Wood pulp/aluminium smelter/ fertilizer	293 000	√	√	√		
Nuclear power stations (cooling water)	No data					√

(Source: RSA DWAF 2004d)

Table 2.4

Estimated volumes and pollutant loads from stormwater runoff from larger urban centres along the South Africa coast

Urban area	Estimated storm-water runoff (million m³/yr)	Estimated pollutant loads (tonnes/yr)			
		Suspended solids (Sediments)	Nutrients	Trace metals (mainly Iron)	Oils
Richards Bay	10.87	5.930	40	170	77
Durban	143.97	73.670	440	2.270	939
Port Elizabeth	37.93	19.420	114	601	247
CapeTown	64.34	32.490	190	1.010	413

(Source: CSIR 1991)

Table 2.5

Changes in estimated nutrient loads (mainly inorganic nitrogen and phosphate) entering the marine environment from land-based activities over the past 10 years

Type	Estimated nutrient load (tonnes/yr)	
	1991	2004
Sewage to offshore (preliminary treatment)	3.800	4.200*
Sewage to surf zone and estuaries (mainly secondary treatment)	650	1.950*
Stormwater runoff (main urban areas contribute 780 - see Table 2.4)	980	Probably higher, but no data
Industrial discharges (mainly fish processing industries on west coast)	2.900	No data
Rivers (using the following as examples):		
- Orange (west coast) (RSA DWAF 2003a)	No data	150
- Breede (south coast) (RSA DWAF 2004b)	No data	250
- Thukela (east coast) (RSA DWAF 2004c)	790 **	860

(Source: CSIR 1991, RSA DWAF 2004d)

** Calculated from volumes estimated for 1991 and 2004 (refer to Table 2.1) and estimated loads for 1991 (CSIR 1991).*
*** Reference Condition (i.e., prior to human interference).*

Table 2.6

Percentage contribution by various activities to coastal habitat loss

Sector	% Contribution to Coastal habitat loss
Urban and residential land use	56
Ports and harbours	16
Coastal mining	16
Industry	11
Tourism developments*	1

**Refers to areas that solely support tourism developments. Where such developments occur within existing urban and residential areas, it was difficult to separate them based on the data available and such developments were, therefore, included under urban and residential land use.*

3 - Eastern Africa

INTRODUCTION

The Eastern Africa Region

The Eastern Africa region (Figure 3.1) includes the riparian countries of Kenya, Mozambique, Somalia, and Tanzania (Table 3.1). The region has a coastline of about 6,845 km and a continental shelf area in the 0-200 m depth range of about 184,600 km^2 (Kelleher and Everret 1997, UNEP 1984, 1998, 2001, Motta 2001, Gove 1995, World Bank 2001). Covering about 318,966 km^2, the coastal land area is equivalent to 9.3% of the total land area of about 3,442,716 km^2. Several inland drainage basin systems with various major rivers that flow into the Indian Ocean characterize the region (Vanden Bossche and Bernacsek 1990, Hatziolos and others 1996, Hirji and others 1996, FAO 2001, UNEP 2001). These drainage basins are transboundary, extending inland into other countries.

The region is semi-arid to arid with rainfall patterns decreasing northwards from Mozambique (mean annual rainfall 530-1,140 mm) to Somalia (mean annual rainfall 250-375 mm) and increasing inland and at higher altitudes (AFRISCO 1994, IUCN 2003, FAO 2005). Reflecting the rainfall patterns, mean annual river discharge in the northern arid zone in Kenya and Somalia is lower, from 1.8 - 4.95 km^3, while that in the southern semi-arid zone in Tanzania and Mozambique is higher, from 2.9 - 106 km^3 (Vanden Bossche and Bernacsek 1990, Hatziolos and others 1996, Hirji and others 1996, FAO 2001, UNEP 2001). Thus, the southern zone is more estuarine than the northern zone in the Horn of Africa. As a consequence, both coastal forest cover and mangrove forest cover decrease northwards, ranging from 1,790 to 2 km^2 and 960 to 5 km^2 from south to north, respectively (Burges and others 1996, Ruwa 1996).

All four countries have proclaimed their respective Exclusive Economic Zones (EEZ) according to the United Nations Convention on the Law of the Sea (UNCLOS 1982). Some of the deep inlets along the region's coastline have provided good natural harbours, some which have been developed into major regional ports such as Maputo (Mozambique), Dar es Salaam (Tanzania), Mombasa (Kenya), and Mogadishu (Somalia). The region is also a major traffic route for oil tankers from the oil-producing Middle East countries. The major oceanic circulation (Figure 3.2), which flows toward the continent and along the coast, plays a major role not only in the physical environment of the coast and oceanic waters, but also affects maritime activities.

The coastal population is about 15.1 million, giving rise to a population density (Table 3.1) that is higher than that in the inland areas. High poverty levels (42-70%) are prevalent in the region where low life expectancy (43 - 48 years), high infant mortality (76 - 131/1,000 live births) and malnutrition (22 - 31%) are common (World Bank 2001). The inhabitants' survival is highly dependent on the exploitation of natural resources, which often leads to unsustainable resource exploitation and consequent negative social, economic, and environmental impacts.

Land-based sources of marine pollution and their impacts

Sewage, POPs, heavy metals, oil hydrocarbons, nutrients, sediments, and solid waste from land-based sources, as well as PADH are considered of greatest threat to coastal and marine ecosystems and to public health in the Eastern African region (UNEP/FAO 1999). In general, the sources and causes of land-based pollution are anthropogenic activities whose social and economic drivers are not controlled or adequately managed by the relevant policy bodies. The major activities are agriculture, pastoralism, maritime harbour activities, urbanization, mining, and industrialization. Each of these activities contributes in a crosscutting manner at different levels and in various ways to pollution of the coastal and marine environments. Approximately 80% of the region's population lives in rural areas where their main activity is subsistence agriculture and migratory pastoralism. Because of the aridity of the region and the high prevalence of drought, the agriculture and pastoral activities are concentrated in the water catchment areas and river drainage basins, which have significant potential for irrigation agriculture (FAO 2005). This has led to the degradation of these fragile habitats due to shifting slash and burn agricultural practices and overgrazing, which promote increased soil erosion.

The concentration of various economic activities and their job creation in urban areas encourage rural - urban migration. Major activities such as processing industries and harbours have been catalytic in urban growth in the region. However, within urban centres high population densities are characteristically found in slums, which have poor infrastructure and encourage environmental degradation. These urban centres and points of river discharge are regarded as pollution hotspots. In trying to critically ascertain the trends related to the GPA issues in the last 10 - 20 years, several published studies, including specific overviews such as in UNEP/FAO (1999) and Muhando and others (2004) were consulted. Since development of policies for pollution mitigation requires an appreciation of past scenarios and their socio-economic drivers, an attempt was also made to highlight the impacts of these drivers on future scenarios.

STATUS OF THE GPA ISSUES IN EASTERN AFRICA

Sewage

Sewage contains a mixture of various biological and chemical pollutants including microbiological organisms, nutrients, pesticides, and toxic wastes from being often mixed with industrial effluents. Urban centres are the major source of sewage in the coastal areas of Eastern Africa, with sewage production directly related to population increase (Table 3.2). There is a phenomenal growth of urban centres in the catchment areas and along the coastline. In general, less than 10% of the urban population is connected to a functioning sewerage system in which sewage is fully treated before the residual wastewater is re-cycled or released into the environment (Table 3.2). Sewage is mostly collected in soakage pits which, when full are emptied into tankers. The waste is subsequently discharged into rivers, coastal areas, and even in solid waste dump sites. As a result of inadequate or lack of sewage treatment facilities, significant quantities of waste often end up in the coastal and marine ecosystems. Over the last decade, environmental degradation from sewage has become worse, particularly in urban areas. The microbiological pollution levels in urban aquatic environments are several orders of magnitude higher than in rural aquatic environments (Tables 3.3 and 3.4).

Persistent organic pollutants (POPs)

Several regional reviews on POPs in Eastern Africa have been published over the past two decades, e.g., UNEP (1982, 1987, 1989), Bryceson and others (1990), and UNEP/FAO (1999). These reviews, however, are not adequate for determining trends because of their generally qualitative nature. According to UNEP/FAO (1999) pollution from POPs is negligible in the region, while evidence that they cause pollution in localized areas such as the Rufiji Delta and Mafia Island complex is circumstantial.

Quantitative studies such as that by Mwevura and others (2001) reported POPs residues (pp-DDE, pp-DDT, dieldrin, and γ-HCH) during both the rainy and dry seasons in the coastal waters of Dar es Salaam, focusing on Msimbazi and Kizinga Rivers and the coastal habitats into which they discharge. Both the POPs residues and their frequency of detection were higher during the rainy than during the dry season (Table 3.5). The high frequency of detection coincided with the period when POPs are intensely used and subsequently leached into the rivers during the rainy season. 100% of the rainy season samples and 37.5% of the dry season samples had pp-DDE levels ranging from 0.05-0.45 μg/l and 0.08-0.2 μg/l, respectively. In 81% of the rainy season samples and 25% of the dry season samples pp-DDT was detected at levels ranging from 0.1 - 0.3μg/l and 0.1 - 0.4 μg/l, respectively. Dieldrin and γ-FCH were detected only in the rainy season at levels ranging from 0.2 - 2.5 μg/l and non-detectable to 0.2μg/l, respectively. Mwevura and others (2001) concluded that the observed levels of POPs had no acute effects on aquatic biota but that the levels of total DDT and dieldrin during the rainy season could result in chronic effects (Table 3.6).

Heavy metals

Recent studies on heavy metals since the last overview of UNEP/FAO (1999) are those of Kamau (2001), Munga (2002), and Mwashote (2003). Other significant studies include that of Everaatts and Nieuwenhuize (1995). Nevertheless, studies on heavy metals in the region are still scarce, and in a 1999 workshop on marine science development in Tanzania and Eastern Africa the only paper on heavy metals focused on their toxicity to algae (Kangwe and others 2001). There have been some studies in the Tana and Athi/Sabaki River Basins at various time intervals in the last two decades (Table 3.7).

According to UNEP/FAO (1999) the major sources of heavy metals are manufacturing industries and maritime harbour activities, with increased localized Pb, Zn, and Cu contamination, especially in urban creeks and harbours. On the other hand, Munga (2002) found that urban and rural environments with no harbours in the Ungwana and Malindi Bays also exhibited similar high concentrations, especially of Pb and Zn (Table 3.7). The Cd levels in the Ungwana and Malindi Bays are within the range for the Mombasa creeks. Comparisons of the levels of Pb, Zn, and Cu from Williams and others (1996) cited in UNEP/FAO (1999) with studies after 1999 showed that no significant changes have occurred since the period covered by the UNEP/FAO (1999) review.

Oil (hydrocarbons)

UNEP (1982) clearly stated the concern about and the sources of oil (hydrocarbons) in the region, and noted the lack of data and specialized equipped laboratories to undertake scientific analyses on these compounds. This report described oil pollution in terms of the occurrence of oil spills, the quantity of spilled oil, and the occurrence and estimation of tar ball pollution on beaches. However, tar-ball pollution monitoring has since stopped, having been briefly undertaken in Kenya until the early 1980s. In subsequent environmental reports (UNEP 1987, 1989, 1990), there were still no quantitative studies on oils despite the need expressed in UNEP (1982). The region is still a very important transit route for oil tankers, which carry 20,000 to 100,000 tonnes of crude oil annually from the Middle East to Europe and America, and any accident could be disastrous (Linden and Lundin 1996). These tankers are believed to be the source of tar balls on the region's beaches because they discharge ballast water in the coastal waters. This requires monitoring of oils in the marine and coastal waters.

The harbour areas continue to experience minor oil spills but with significant impact on coastal wetland habitats, as reported for Mombasa Harbour where the latest oil spill occurred in April 2005 (Table 3.8).

Nutrients

Nutrient pollution in the coastal and marine environments of Eastern Africa arises mainly from nitrogen and phosphorous compounds, of which the major sources are sewage from urban centres, agricultural fertilizers, leachates from terrigenous sediments, and solid waste carried to the ocean by rivers and stormwater runoff. Another less obvious but significant source of nutrients is seepage of groundwater into the sea, carrying leachates from sewage and solid waste storage pits that are commonly used in the region.

Significant studies of nutrients in the region's coastal and marine waters have been undertaken in the last one and a half decades. Such efforts have concentrated on establishing the natural geographical distribution patterns especially across estuaries into the ocean and in relation to the seasons and oceanic circulation, in particular tidal circulation. Attempts have also been made to relate nutrient distribution and magnitude to anthropogenic sources or causes. Studies have been conducted at different time scales in various estuarine creek environments in urban areas, e.g., where rivers discharge in urban creeks (Tables 3.9, 3.10, and 3.11); rural creek environments (Tables 3.12 and 3.13); urban lagoonal waters outside creeks (Tables 3.10, 3.14, and 3.15); and lagoonal waters in rural areas (Tables 3.16 and 3.17). The observed patterns are as follows:

I During the dry season there is no clear gradient observed in the urban estuary of Tudor Creek, Mombasa, with the nutrient levels being similar upstream to the creek mouth, except for silicates. The Tudor Creek Estuary is fed by seasonal rivers and has almost oceanic conditions during the dry season. On the contrary, in the estuaries of perennial large rivers, e.g., Athi-Sabaki, a nutrient gradient exists, increasing upstream (Table 3.11). It is noted further that the nutrient levels are in magnitude higher than those of Tudor creek levels in Mombasa although the latter is a larger urban areas than Malindi where the Athi-Sabaki estuary is located (Table 3.9). This confirms the over-riding importance of river discharge compared to the input of sewage as a source of nutrients to the marine environment;

II Within localized sites during the rainy season there is a clear decreasing gradient in nutrient levels from upstream to the mouth of the creek (Tables 3.9 and 3.11), which again clearly demonstrates the significance of river discharge as a source of nutrients;

III In general, nutrient levels are significantly higher in the water column during the rainy season in all creek waters (Tables 3.9, 3.11, 3.12, 3.13, and 3.16) except in the lagoonal waters. These showed a positive correlation with increased river discharge into the ocean except in the open lagoonal waters where the nutrient levels were higher during the dry season (Table 3.15);

IV Generally, the nutrient levels in the water column are higher in both the rainy and dry seasons during low tide when the degree of mixing is lower than at high tide (Table 3.16). This implies that sewage should be released at high tide for greater mixing and subsequent increased dilution. The region has a high mean tidal amplitude of about 3 m, generating strong tidal and thus greater mixing;

V Generally, the nutrient levels show a decreasing gradient in an oceanward direction in open lagoons or bays (Table 3.17);

VI There is no geographical trend in nutrient levels in a northerly or southerly direction (Table 3.18). The absence of a clear indication that nutrient levels are higher in urban than in rural areas could be attributed to the high mixing and transport by coastal currents and the low residence time of seawater in the creeks. This has been the major factor encouraging disposal of sewage from urban areas in the region's estuarine and ocean environments;

VII Long term records such as those of Kazungu and others (1989) and Osore and others (1999) for the Mtwapa and Tudor Creeks in Mombasa show insignificant differences in the nutrient levels over the 10-year period. As expected, the nutrient levels in the open coral reef lagoons are significantly lower than those in the creek waters. It must be noted, however, that there is no regular monitoring programme or documentation to determine recent trends.

Sediment mobilization

Rapid input of sediments into the rivers is a significant problem in all the drainage basins as a result of increased anthropogenic activities, especially agriculture and human habitation. These activities are responsible for increased deforestation, which currently ranges from 0.2 - 1.0% annually (World Bank 2001). The water catchment areas and river drainage basins support almost the entire agricultural and livestock production in the region (FAO 1995, 2005). This has led to increased exposure of the land and hence increased soil erosion by both wind during the dry season and water during the rainy season. Soil erosion is further undermining the soil fertility, leading to the use of considerable quantities of fertilizers and increased production costs.

Large amounts of sediments are carried by the rivers and deposited in the sea. For example, the Tana and Athi-Sabaki Rivers in Kenya respectively deposit 4.9 million tonnes and 9.2 - 14.3 million tonnes of sediments annually into the ocean (Kitheka and Ongwenyi 2002). It has been observed that the sediment discharge into the Indian Ocean from the least dammed Athi-Sabaki River has increased considerably from about 50,000 tonnes/yr in the 1950s to 8.4 million tonnes/yr in 1992 (GoK/JICA 1992). More recent studies in the Athi-Sabaki have indicated further increased sediment discharges ranging from 9.2 - 14.3 million tonnes annually (Kitheka and Ongwenyi 2002). This explains the increased beach accretion in Malindi Bay, where the beach has prograded to over 100 - 200 m seaward in the last 10 years (Kairu 1997). It should be noted that in the 1960s, the Malindi Beach was experiencing rapid erosion and a defence wall was built and reinforced in the 1970s. However, in the late 1970s shore accretion began to occur, indicating a switch from an erosional to a depositional environment (Kairu 1997).

In the period 1967 - 1981, five major dams with a total capacity of 1,752 million m^3 and a total area of 1,405 km^2 (Vanden Bossche and Bernacsek 1990) have been constructed along the Tana River, with plans to construct five more. Before the building of the first dam in 1967, it was estimated that the Tana discharged 10 million tonnes of sediments annually (Ongwenyi 1985). At present, it is estimated that the river discharges about 4.9 million tonnes annually, which indicates a reduction in sediment discharge by about 50% in the last 40 years (Kitheka 2002). This reduction in sediment replenishment in the Ungwana Bay into which the Tana discharges is thought to be the cause of extensive coastal erosion in the southern part of the bay.

In Mozambique, as a result of rapid sediment deposition, the ports of Maputo and Beira have to be dredged annually to remove about 1.2 million m^3 and 2.5 million m^3 of sediments, respectively (Motta 2001). In the Zambezi Delta, sediment discharges from the Zambezi River have contributed to shore accretion of 1 m annually in the last 40 years (Kairu and Nyandwi 2000).

Litter

Solid waste disposal is a significant problem for all the urban areas in the region. A wide variety of solid waste is rapidly generated from the increased diversity of economic activities. For example, Mombasa City with a population of about 665,000 generates about 220,000 tonnes of solid waste annually (MCM 2001). Being a port city, it additionally receives about 500 tonnes of solid waste annually from ships that call at the port (EAMEMC 2001). Only 60% of the total solid waste generated in Mombasa is collected; the rest accumulates to rot in the neighborhoods, especially in slum areas (Ruwa and Mwaguni 2002). In the last 20 years, the annual per capita production of solid waste in Mombasa has increased by 1.6 times from 0.20 to 0.32 tonnes (Table 3.19). A similar trend is observed for the larger city of Dar es Salaam in Tanzania, with an increase in per capita production of solid waste by 7.5 times in the same period. This waste cannot be disposed of or re-cycled as fast as it is produced, leading to the accumulation of garbage in the urban areas and posing a great human health and environmental hazard; this will worsen if not addressed soon.

Physical alteration and destruction of habitats

Coastal habitats of Eastern Africa include wetlands (including rivers), estuaries, mangrove forests, seagrass beds, coral reefs, rocky shores, sandy beaches, and sand dunes. Physical alteration and destruction of these habitats are related to various anthropogenic activities that include human habitation, farming, fishing, tourism, mining, maritime shipping activities, and exploitation of forests for timber and fuel wood. In addition, global climate change, which is a crosscutting concern also attributed to anthropogenic activities, leads to abnormal rainfall patterns, droughts, floods, and sea level changes. These in turn result in various physical and ecological changes in coastal and marine environments.

Evidence of progress in the protection of the marine environment in the region includes the creation of MPAs in all the four countries except Somalia (IUCN 2004). Kenya has the longest history in the region in the creation of MPAs, with 82.5% of its 1,631.3 km^2 of MPAs created 25 years ago and an average of 2.51 km^2 of protected area/km of coastline (IUCN 2004). Most of the MPAs in Tanzania and Mozambique were created in the last 15 years. In Tanzania, 99.9% of the total 3,775.05 km^2 of MPAs was created between 1991 and 2000, with an average of 2.65 km^2 of MPA/km of coastline. Similarly, 83.8% of Mozambique's total 8,950 km^2 of MPAs was created between 1991 and 2000, with an average of 3.23 km^2 of MPA/km of coastline; this is the highest among the four East African countries. The MPAs cover all the critical habitats, i.e., mangrove forests, seagrass beds, and coral reefs.

Various global programmes, especially the Intergovernmental Panel on Climatic Change, LMEs, GIWA, LOICZ, the WWF Eco-regions, among others, have addressed the issue of PADH as guided by their objectives and goals. The GPA land-based pollution categories directly or indirectly cause physical alteration of habitats. A recent study on PADH in Eastern Africa (Muhando and others 2004) discussed the issue in relation to land-based sectoral activities, rather than the GPA categories. PADH may be addressed using: (i) ecosystem approaches, which address, e.g., loss of biodiversity, loss of biomass, loss of habitat disruption of food chains, and explosion of opportunistic species; (ii) toxicological approaches, especially for chemicals such as heavy metals, POPs, and oil hydrocarbons whose effects are more than PADH; and (iii) policy approaches, which address policy failures that lead to the aggravation of the socio-economic drivers of PADH.

The report by Muhando and others (2004) is descriptive because of the lack of data to quantify the impacts of sector activities on coastal habitats. However, linking the sector approach of Muhando and others (2004) with the GPA categories allows an assessment of the extent of PADH in the region, as follows:

I Tourism

Coastal tourism is the dominant form of tourism in the region, with a concentration of hotel infrastructure along the coast on sandy beachfronts. This has led to the destruction of marine vegetation on sandy beaches and excessive beach combing for shells and corals for souvenirs. There is also increased physical damage to corals and seagrasses by boat anchors and trampling by divers. The difference in the condition of habitats in protected and unprotected areas is appreciated from the fact that biodiversity and biomass are higher in protected areas (MacClanahan and others 1996, 2000).

Despite fast tourism growth, the region lacks studies on tourist carrying capacities for beach hotel development. For example, the Kisauni Division in Mombasa, with an area of 126 km^2, a coastline of 30 km and a population density of 1,500 persons/km^2, supports about 70% of the hotels in Mombasa, which are all situated along the coast. In the 20- year period from 1978 to 1998, the land use for tourist facilities increased by about 72% from 0.3 to 1.05 k . Currently, the tourism industry has a chain of 30 beach hotels and restaurants with bed capacity of about 7,000 and employing about 12,500 people. The public beach in the area is visited by 3,000 - 5,000 people weekly, especially during public holidays. Although the division has an MPA of about 210 km^2 adjacent to the hotel area, intensive human activity has led to the removal of marine and littoral vegetation. This, in addition to sea level rise, has aggravated shoreline erosion to the extent that the beach hotels are threatened (Kairu and Nyandwi 2000).

II Fishing

Destructive fishing methods include the use of beach seines, which uproot seagrasses, as well as dynamiting, which also destroys coral reefs. These methods are more commonly used in Tanzania, where the density of beach seines in Tanzania is about 0.4/km of the 1,425 km coastline (Jiddawi and Stanley 1999), whereas in Kenya the density is about 0.1 /km of the 650 km coastline. Dynamiting in Kenya is almost non-existent except at the border with Tanzania, having been introduced by Tanzanian fishers. The ecological impacts of these destructive fishing methods have been documented by MacClanahan and others (1996, 2000). However, data on the rate of "desertification" due to removal of seagrass and destruction to rubble of coral reefs by beach seining and dynamiting are lacking.

III Ports and harbours

Dredging of the ports of Maputo, Beira, and Mombasa yields considerable amounts of sediments that cause increased turbidity not only in the creeks but also in coral, mangrove, and seagrass habitats. This results in smothering and death of corals, mangrove forests, and seagrass. Sediments generated during dredging of Lamu Port in Kenya were deposited within the adjacent mangrove forest, killing about 1 km^2 of mangroves (NES 1985, Muhando and others

2000). The area has not recovered because of shoreline elevation above the intertidal zone by the sediments, which makes it inaccessible for re-colonization by mangroves.

Other significant causes of habitat destruction, including of mangroves, are oil discharges and spills. The major sources of oil hydrocarbons in the region's coastal environments are accidental oil spills in the harbour areas, ballast water from oil tankers, and effluents from oil refineries. Accidental oil spills heavily impact the mangrove habitats in the creeks, with subsequent death of portions of forest. Once mangroves die, the area remains bare and re-colonization does not occur for a long time. For example, a 1988 oil spill of 5,000 tonnes in Mombasa Harbour killed 0.1 km^2 of mangroves and polluted an intertidal area of about 0.5 km^2. The substrate remained bare for about 14 years until recently when a new fringe of mangrove started growing, although further inland than before the spill occurred (Ruwa and others 2004). Soluble hydrocarbons in the water column are also harmful to seagrass and corals, but there are no records of their death due to oil hydrocarbons. Toxicity studies are recommended to establish appropriate environmental standards to facilitate habitat restoration and management in the region.

IV Mining

Considerable commercial mining of sand for building purposes occurs in the rivers discharging into the Indian Ocean. Although the actual quantity of sand harvested annually is unknown, it is considerable since urban construction in the drainage basins depends heavily on this sand. Besides the trapping of sand in the dams, sand mining activities contribute to the reduction of sediments for beach replenishment, therefore contributing to increased beach erosion and physical alteration of sandy beaches in the region (Muhando and others 2004). This negatively impacts sandy beach-dependant fauna, such as endangered marine turtles.

V Forestry

The high rate of deforestation in the region has led to an annual forest loss rate of 0.2-1% (World Bank 2001). This exposes the soil in this semi-arid drought prone region to severe erosion and desertification. During the rainy season large quantities of sediments are washed into the rivers and discharged into the ocean (Ongwenyi 1985, Kairu and Nyandwi 2000, Kitheka and Ongwenyi 2002). Loss of mangrove forests has exacerbated coastal erosion in the region. Destruction of non-mangrove coastal vegetation has also contributed to sand dune instability, leading to increased soil erosion and loss of the groundwater reservoirs provided by the dunes.

A considerable amount of information on the issue of sediments and PADH in East Africa exists. This is most probably due to the high economic importance of coastal tourism in the region, which has resulted in heavy investment in infrastructure along the beaches. A high level of concern has developed over the increased beach erosion that is threatening most of the coastal infrastructure. Various studies have been commissioned, especially jointly by the Intergovernmental Oceanographic Commission (IOC), United Nations Education Scientific and Cultural Organization (UNESCO), UNEP, World Maritime Organization (WMO), and Swedish Agency for Research Cooperation (SAREC) to implement an integrated approach to addressing the impacts of coastal erosion and sea level rise, as well as to develop guidelines for monitoring shoreline changes in the Western Indian Ocean region (Kairu and Nyandwi 2000).

In the Tana River Basin the impact of reduced sediment deposits from the river is unknown. However, it has been postulated that this may be contributing to increased beach erosion in the Ngomeni area just south of the mouth of Tana River and north of Athi/Sabaki River. Unlike the Tana, Athi/Sabaki River has enhanced sediment discharge, which has been attributed to the low development of mangrove forests (less than 0.2 km^2) despite it being a perennial flowing river with a large estuary (Ruwa and Polk 1986). Excessive sediment deposits have also negatively impacted the corals in Malindi Marine Park where only the sediment-tolerant corals have survived (Obura and others 2000). In 1970 the average annual rate of deposition of sediments along Malindi beaches was estimated to be about 5 million tonnes (Delft Hydraulic Laboratory). More recent studies have shown an increase to 9.2 - 14.3 million tonnes/yr.

Malindi Bay is showing rapid beach accretion, with terrestrial vegetation increasing on the landward side of the shores. In Mombasa and south of Mombasa excessive beach erosion requires the construction of seawalls to protect infrastructure (Kairu and Nyandwi 2000). However, it is claimed that the seawalls have aggravated shoreline erosion where excessive mangroves have been cut. During the El Niño rains in 1998 and 2002 several hundreds of square kilometres of mangrove forest were reportedly destroyed in all the countries of the region by excessive sediments deposited by rivers. Although the impact of this has yet to be documented, most of these areas cannot be restored because of their increased elevation above the intertidal zone.

VI Agriculture

Agriculture is the most significant economic activity in the region, both as a foreign exchange earner and the mainstay of peasant farmers and rural inhabitants who form 80% of the total population. Commercial farming is an important activity in all the river drainage basins. As previously mentioned, this sector contributes heavily to land degradation especially in river basins and water catchment areas, resulting in increased soil erosion. In addition, agricultural activities, especially commercial farms, also contribute pesticide residues and fertilizers, which leach into the rivers and ultimately reach the coastal areas. The various types of pesticides used can kill both marine plants and animals, and are already used to control crabs that destroy rice seedlings in the Rufiji Delta, Tanzania (Kulindwa and others 2001). Nevertheless, there are no known records in the region of death of mangroves, seagrass, and corals due to POPs. As with the case of heavy metals, toxicology studies on mangroves, seagrass, and corals are lacking in the region. The agriculture sector also contributes fertilizer residues to coastal areas, resulting in increased algal growth that can be detrimental to corals and seagrasses. This is discussed further in the following section.

VII Coastal urbanization and industrialization

Coastal urbanization is not only an issue of human habitation but also a process linked with economic and industrial growth. As previously mentioned, coastal urbanization and the associated industrial sector are growing rapidly in the region. Urbanization not only leads to destruction of both coastal mangrove and non-mangrove forests, but also of seagrasses and coral reefs as a result of land reclamation. Furthermore, wastes especially sewage and solid waste, are dumped on the shores and in mangrove forests, destroying these habitats and contributing to the degradation of adjacent seagrass beds and coral reefs. Compounding this problem are excessive leachates from the solid waste and industrial effluents in sewage. Dumping of solid waste on open beaches and along mangrove shores is very common. On the islands of Lamu in Kenya, this age-old practice, which still continues, is claimed to combat shoreline erosion (NES 1985). Some of the solid waste also drifts on ocean currents into the open sea.

Urbanization, as well as agriculture, animal husbandry, and port activities contribute nutrients to coastal habitats. Seepage of sewage effluents from soakage pits into the sea has been linked with the destruction of benthic habitats through the stimulation of the growth of opportunistic flora, which replaces the original vegetation. For example, Uku (1995, 2005) demonstrated the abundant growth of epiphytic algae on seagrasses and the dominance of the green algae (Ulva and Enteromorpha sp.) in areas adjacent to heavy tourism infrastructure development. The epiphytic cover reached up to 69% in the more developed areas (Uku 2005). Elevated nutrient levels can also promote the growth of algae, which can form dense mats on corals and subsequently kill them. Furthermore, such algal growth can retard re-colonization by corals where they have died from other causes such as bleaching.

Coral bleaching due to climate change is currently a major problem on all the region's coral reefs (McClanahan and others 2000). Mangroves, seagrasses, and corals are negatively impacted by heavy metals, which they can absorb from the substrate and/or the water column. Data on toxicological effects of heavy metals on mangroves, seagrasses, and corals in the region are lacking and there are no records of their death caused by heavy metals. Although the levels detected so far are not alarming, toxicological studies are highly recommended because of the industrial growth in the region. Currently, the heavy metal standards are related to food for humans, rather than to habitat health. Although the threats from urban and industrial growth are increasing, there is no monitoring of the impacts on coastal habitats.

CONCLUSIONS

In Eastern Africa the state of the environment in relation to the GPA issues, including the progress made in protecting the marine environment during the last 10 years can be summarized as follows:

Hotspots

The environmental hotspots in the region are areas characterized by intense impacts of the GPA pollution categories. These hotspots are found in urban areas and points of river discharge into the ocean. As previously described, urban areas and the harbours located within them are point sources of most of the GPA categories of pollution, i.e., sewage, solid wastes, nutrients, heavy metals, and hydrocarbons. It is noted that the major cities of Mogadishu, Mombasa, Dar es Salaam, and Maputo are hundreds to thousands of kilometres apart, creating distinct hotspots. However, due to the rapid urbanization in the region, the satellite towns and suburban areas will grow and join with the main cities, thereby creating larger contiguous urban zones along the coastline in the future. In such a case, the issue will no longer be one of hotspots. Other hotspots are points of river discharge into the ocean, where the main issues are sediments, POPs, and nutrients. The major river discharge hotspot areas are Tana and Sabaki Rivers in Kenya, Rufiji in Tanzania, Ruvuma on the border of Tanzania and Mozambique, and Zambezi in Mozambique.

Has the situation concerning the GPA issues improved or worsened during recent years?

In summary, sewage, solid waste, and sediments have shown significantly increased levels in the aquatic environment causing higher impacts than the other GPA categories. The environmental degradation due to sewage, solid waste, and sediments has worsened over the past 10 years and will continue to worsen. PADH has increased and will continue to increase in future due to increased economic activities.

Has progress been made in protecting the marine environment during the last 10 years?

There has been good progress in the region in conservation efforts, especially the creation of MPAs. The major threat to MPAs in the region is water quality degradation especially from sewage, solid waste, and sediments where the MPAs are close to hotspots. These issues also retard efforts to rehabilitate habitats in the region.

The way forward

Since environmental protection requires relevant knowledge as well as enforcement of appropriate environmental standards, there is a need in the region for the following:

Monitoring programmes: A major challenge in addressing land-based pollution in the region is the unavailability of both short and longterm scientific data collected using agreed protocols. Scientific data available on the GPA issues in the region is scanty and gathered using various protocols, making comparisons difficult.

Capacity Building: There is need to develop appropriate regional human capacity and facilities for efficient and timely collection and analysis of samples and data and information on the GPA issues. This would improve the quality of the data required for accurate monitoring of the status of the environment in relation to the GPA issues.

Proactive management approach: In the Eastern Africa region the future pollution scenario is expected to worsen such that it will no longer be a hotspot issue confined to urban areas but more widespread as the socio-economic drivers of pollution increase, expand in geographical scope, or become more diversified. Pro-active approaches are required to control and manage waste by implementing the multilateral environmental agreements signed by the countries (UNEP/SIDA 1996), as well as ensuring that environment and social impact assessments and audits are conducted for the various activities so that they comply with the desired environmental standards. Best practices of integrated coastal area and river basin management that promotes sustainability and conflict resolution, some of which are already in existence, should be supported.

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Figure 3.1

The Eastern Africa Region

River drainage systems connecting with the Indian Ocean in the Eastern Africa region.

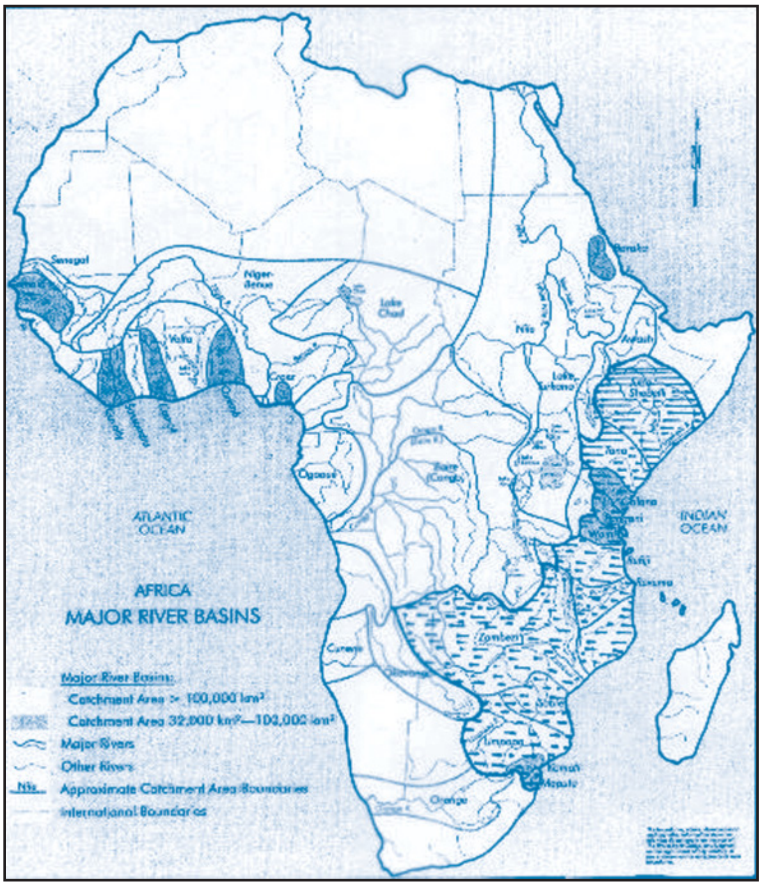

Figure 3.2

Ocean current system in Eastern Africa

Ocean current systems in the shaded Eastern Africa region.

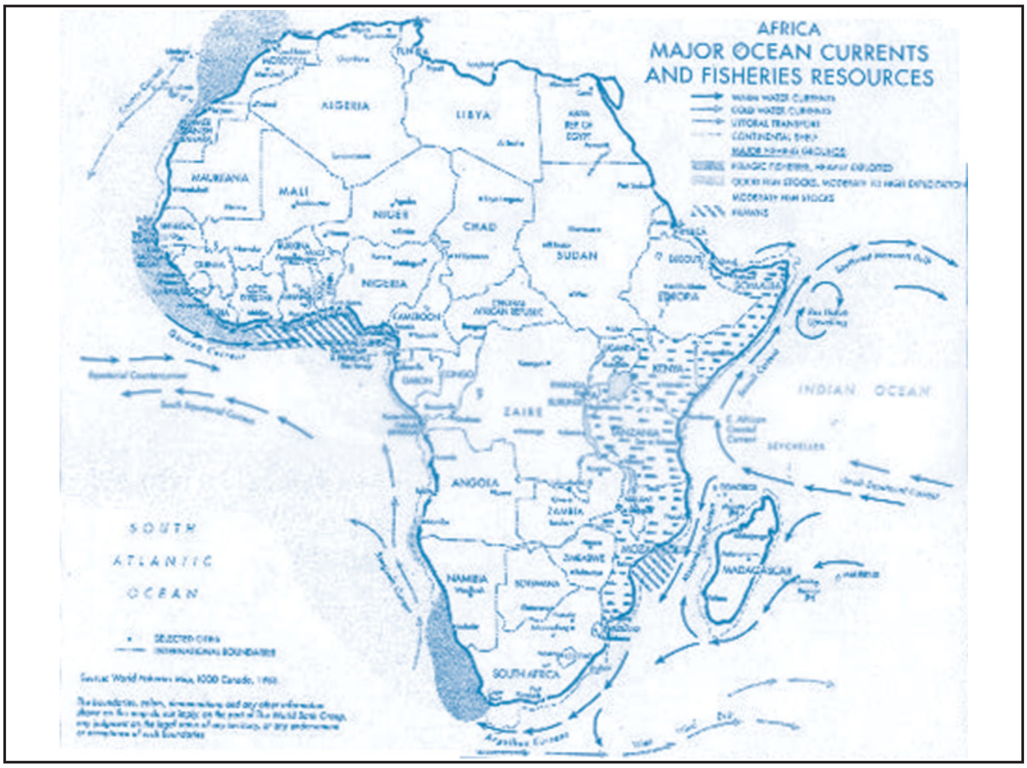

Table 3.1

Country profiles of the Eastern African countries

Country	Area (km²)	Coastal land area (km²)	Length of coastline (km)	Continental shelf area 0-200 m depth (km²)	Population (million)	Population growth rate (%)	Coastal population (million)	Coastal population density (people/km²)	Coastal population density (people/km²)
Somalia	637,657	80,315	2,000	60,700	9.4	3.1	1.0 (1980)	12.45	14.74
Kenya	582,650	32,447	650	14,400	29	2.4	2.5 (1999)	77.05	49.77
Tanzania	883,749	57,225	1,425	41,200	33	2.8	6.7 (2000)	117.08	37.34
Mozambique	784,100	148,979	2,770	68,00	17.3	2.3	8.7 (1999)	58.40	22.06

(Source: Gove 1995, Kelleher and Everrett 1997, UNEP 1984, 1998, 2001, Motta 2001, World Bank 2001)

Table 3.2

Estimated annual discharge of domestic sewage and BOD5 by the urban population connected to sewerage systems on the coasts of the Eastern African countries. The BOD5 calculations are based on the estimated 20 kl/capita/yr given by UNEP (1982)

Country	Year	Coastal Population	Coastal urban population	% coastal urban population	% coastal urban population connected to sewerage system	Urban population connected to sewerage system	BOD5(tonnes/yr) for the urban population connected to sewerage system
Somalia	1980	1,000,000	565,000	56.5	10	55,600	1,112
Kenya	1980	1,340,000	460,000	33.6	15	69,000	1,380
	1989	1,829,191	661,753	36.2	20	132,350	2,647
	1999	2,487,265	1,008,092	40.5	20	201,618	4,032
Tanzania	1980	3,147,344	890,000	28.3	13	115,700	2,314
	1988	4,818,545	1,735,558	36.0	15	260,334	5,207
	2000	6, 738,143	3,099,735	38.6	15	390,138	7,803
Mozambique	1980	5,458,500	1,220,000	22	13	158,000	3,172
	1999	8,650,000	3,546,500	41	15	531,975	10,640

(Source: UNEP 1982, 1984, 1990, 1998, and 2001, Gove 1995, Linden and Lundin 1996, SID 2004)

Table 3.3

Average faecal coliform counts and E. coli in the urban creek and open sea lagoons in the marine park

Locality	Coliform count (no./100ml)	E. coli count (no./100ml)
Tudor creek	1,703	12.8
Kilindini creek	1,525	690
Mtwapa creek	1,400	55
Bamburi Marine Park	69.5	18.5
Borehole waters	362	22

(Source: Mwaguni 2002)

Table 3.4

Average faecal coliform counts and E. coli in rural coastal waters adjacent to the Tana and Sabaki Rivers, Kenya

Locality	Faecal coliforms (no./100ml)	E. coli (no./100ml)
Tana: Ungwana Bay		
Kipini	19	4
Sadani	13	4
Tana	10	3
Kilifi	12	2
Sabaki: Ngomeni		
Mambrui	16	3

(Source: Mwaguni 2002)

Table 3.5

Pesticide levels in 32 water samples in the rainy and dry seasons in coastal areas of Dar es Salaam

Season	Type of pesticide	Percentage of samples with pesticide	Mean concentration (µg/1)	Concentration range (µg/1)
Dry season	p,p'-DDT	25%	0.20	ND - 0.4
	p,p'-DDE	37.5%	0.12	ND - 0.2
	Total DDT	37.5%	0.27	ND - 0.5
Rainy season	p,p'-DDT	81%	0.20	ND - 0.3
	p,p'-DDE	100%	0.23	0.05 - 0.45
	Total DDT	100%	0.40	0.05 - 0.8
	Dieldrin	100%	0.65	0.2 - 2.5
	γ-HCH	6%	0.20	ND - 0.20

(Source: Mwevura and others 2001)
ND - not detected as levels fall below detection capacity of measurement equipment

Table 3.6

Comparison of pesticide residue levels with water quality criteria and guidelines for the protection of aquatic life by MacDonald (1994) quoted in Mwevura and others (2001)

	Average concentration (µg/l)						
	Pesticide	**Total DDT**		**Dieldrin**		**√-HCH**	
	Season	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**
Present Study	Msimbazi River	0.3	0.5	ND	0.8	ND	ND
	Marine waters	ND	0.1	ND	0.3	ND	ND
	Kizinga River	ND	0.4	ND	0.8	ND	0.0.7
USA	Acute	1.1		2.5		2	
	Chronic	0.001		0.001		0.08	

(Source: Mwevura and others 2001)
ND - not detected as levels fall below detection capacity of measurement equipment

Table 3.7

Concentration of heavy metals in substrates of various creeks and bays in the Tana and Athi Galana River Basins

Heavy metal	Makupa Creek, Mombasa (Oteko 1987)	Coastal marine substrate, Kenya (Everaarts and Nieuwenhuize 1995)	Inshore substrate, Mombasa (Williams and others 1996)	Makupa and Kilindini Creeks, Mombasa (Kamau 2001)	Ungwana and Malindi Bays (Munga and others 2002)	Makupa creek, (Tudor creek) (Mwashote 2003)
Cadmium (Cd)	0.2	0.0.1 - 0.34	No data	10 - 13	4.0 -14.8	0.25 - 0.5 (0.25 - 1.0)
Lead (Pb)	No data	0.5 - 15.8	1.0 - 427	No data	63.8 - 111.7	13.9 - 26.9 (5.9 - 14.3)
Manganese (Mn)	No data	90 - 2,545	No data	No data	No data	No data
Iron (Fe)	No data	10 - 32	No data	20 - 27.7	10 - 81.3	No data
Zinc (Zn)	311	2 - 117	3.0 - 283	200 - 1,429	69.9 - 294.4	No data
Copper (Cu)	84	3 - 42	1.0 - 1,177	5.5 - 114	26.4 - 24.1	No data

(All metal concentrations in $\mu g g^{-1}$ except for iron which is in mgg-1)

Table 3.8

Records of oil spills in Mombasa Harbour area

Year	Oil spilled (tonnes)
1972	1,500
1973	2,100
1988	5,000
2005	150

(Source: National Oil Response Committee NOSRC 1995, pers. comm. 2005)

Table 3.9

Nutrient levels in urban Tudor Mangrove Creek, Mombasa, Kenya, rainy and dry seasons

Locality	NO3- + NO2- (µM-N)	PO_4^{3-} (µM-P)	Si (µM-Si)
Upper River Month at end of creek			
Rainy season	28.50	2.04	180.50
Dry season	0	0.92	50.51
Mid-creek			
Rainy season	5.52	0.64	65.50
Dry season	1.19	0.92	13.01
Creek mouth adjoining the ocean			
Rainy season	2.80	0.36	40.00
Dry season	0.44	0.69	7.46

(Source: Kazungu and others 1989)

Table 3.10

Nutrient levels in Mombasa City Lagoon Park and urban Mtwapa Creek, Kenya

Locality	NH4+ (µM-N)	NO3- + NO4- (µM-N)	PO_4^{3-} (µM-P)
Mombasa Lagoon Park			
1995/96	0.65	1.06	0.32
1996/97	1.61	2.32	0.28
Mtwapa creek			
1995/96	2.51	4.14	0.58
1996/97	2.19	5.57	0.82

(Source: Osore and others 1999)

Table 3.11

Nutrient levels in Athi-Sabaki Mangrove Estuary Malindi, Kenya, rainy and dry seasons

Locality	NO3- + NO2- (µM-N)		PO_4^{3-} (µM-P)		Si (µM-Si)	
	Rainy	Dry	Rainy	Dry	Rainy	Dry
Upstream	83	87	10.2	7.2	410	340
Midstream	51	75	5.8	6.1	270	180
River mouth	9	10	2.4	4.3	100	30

(Source: Ohowa 1996)

Table 3.12

Nutrient levels in Mkurumuji and Kidogoweni Rivers discharging into Kenyan rural Gazi Mangrove Bay in the rainy and dry seasons

Locality	Flow rate (m^3s^{-1})	NH4+ (µM-N)	NO3- (µM-N)	PO_4^{3-} (µM-P)
Mkurumuji				
Rainy season	4.79	2.11	6.47	2.47
Dry season	0.23	0.54	0.52	0.82
Kidogoweni				
Rainy season	2.73	1.90	3.48	1.44
Dry season	0.02	0.62	0.26	0.72

(Source: Ohowa and others 1997)

Table 3.13

Nutrient levels in the Kenyan rural Mida Mangrove Creek waters and groundwater in the rainy and dry seasons

Locality	NH4+ (µM-N)	NO2- + NO3- (µM-N)	PO_4^{3-} (µM-P)	SiO_3 (µM-Si)
Creek water				
Rainy season	0.39	2.64	0.44	15.94
Dry season	0.22	1.52	0.34	6.35
Ground water				
Rainy season	11.05	642.87	4.88	470.25
Dry season	8.00	1,124.00	3.41	149.80

(Source: Kitheka and others 1999)

Table 3.14

Nutrient levels in coral reef lagoonal waters in urban Zanzibar, Tanzania

Locality	NH4+ (µM-N)	NO3- + NO2- (µM-N2)	PO_4^{3-} (µM-P)
Stone town Chumbe Island	26	1.3 - 7	3.75 - 15.17
(Off Zanzibar Island)	ND	0.25	0.2

(Source: Mohamed and others 1993)
ND- not detected as levels fall below detection capacity of measurement equipment

Table 3.15

Nutrient levels in the water column in coral reef lagoonal waters at Chapwani and Bawe in urban Zanzibar during June 1997- July 1997

Period	NH4+ (µM-N)		NO3- + NO2- (µM-N)		PO_4^{3-} (µM-P)	
	Chapwani	Bawe	Chapwani	Bawe	Chapwani	Bawe
Nov-Dec - Short rains	0.53	0.61	0.22	0.19	No data	
Mar-Jun - Long rains	0.62	0.56	0.17	0.17		
Jan - Feb/Jul - Oct.						
Dry season	0.61	0.60	0.23	0.22	2.59	2.67
Spring tides	0.47	0.44	0.23	0.23	2.59	2.14
Neap tides	0.74	0.76	0.23	0.21	2.58	3.25

(Source: Mohamed and Mgaya 2001)

Table 3.16

Nutrient levels in Kenyan rural Gazi Mangrove Bay water in the rainy and dry seasons during high tide (HT) and low tide (LT)

Locality	NH_4^+ (μM-N)	NO_3^- + NO_2^- (μM-N)	PO_4^{3-} (μM-P)
Gazi Bay			
Rainy season HT	0.16	0.68	0.46
LT	0.47	1.33	1.87
Dry Season HT	0.21	0.36	0.48
LT	0.23	0.36	0.43

(Source: Ohowa and others 1997)

Table 3.17

Oceanward distribution of nutrients at rural Ungwana Mangrove Bay, Kenya

Nutrient	Distance from coastline (nautical miles)			
	1.5	3	4	5
NH_4^+ (μM-N)	6.2	5.5	5.0	3.9
NO_3^- + NO_2^- (μM-N)	1.4	1.5	1.5	1.0
PO_4^{3-} (μM-P)	1.1	1.0	0.6	0.7

(Source: Mwangi 2002)

Table 3.18

Nutrient levels in various localities in a north-south direction from Ungwana Mangrove Bay in Kenya to Zanzibar in Tanzania

Locality	NH_4^+ (μM-N)	NO_3^- + NO_2^- (μM-N)	PO_4^{3-} (μM-P)
Tana River, Ungwana Bay			
Perennial river and rural setting	6.20	1.40	1.10
Athi-Sabaki River, Malindi Bay			
Perennial river and urban setting	No data	9.5	3.4
Mida Creek			
No surface river flow and rural setting	0.31	2.08	0.39
Mtwapa Creek			
Seasonal river and urban setting	2.35	4.86	0.70
Tudor Creek, Mombasa			
Seasonal river and urban setting	No data	6.4	0.93
Mombasa open coral reef lagoon			
Urban setting	1.13	1.69	0.3
Gazi Creek			
Seasonal river and rural setting	0.78	1.68	1.09
Zanzibar open coral reef lagoon			
Urban setting	0.60	0.21	2.64

(Source: Kazungu and others 1989, Ohowa and others 1997, Kitheka and others 1999, Osore and others 1999, Mwangi 2002).

Table 3.19

Solid waste production including per capita production/yr in Mombasa and Dar es Salaam

Country	City	Year	Population	Total annual solid waste production (tonnes)	Solid waste production/capita/yr (tonnes)	Coastal urban population	Estimated annual total solid waste production (tonnes) in the coastal urban areas based on per capita/yr production
Kenya	Mombasa	1980	440,000	88,258	0.20	460,000	92,000
Tanzania	Dar-es-salaam	1999	665,018	216,000	0.32	1,008,092	322,589
		1980	760,000	15,200	0.02	890,000	17,800
		2000	2,430,500	364,575	0.15	3,099,735	464,960

(Source: UNEP 1982, 2001, Nguta and Mwaguni 1995, Linden and Lundin 1996, Ruwa and Mwaguni 2002, SID 2004)

4 - Black Sea

INTRODUCTION

For the purposes of this assessment, the geographic coverage of the Black Sea follows the definition of the Convention on the Protection of the Black Sea against Pollution (Bucharest Convention). The Black Sea, located approximately between 41o - 46o N latitude and 28o - 41.5o E longitude, is surrounded by Bulgaria, Georgia, Romania, Russia, Turkey, and Ukraine (Figure 4.1). It is an elongated and semi-enclosed basin connected in the north to the shallow Sea of Azov by the Kerch Strait and in the southwest with the Aegean Basin of the Mediterranean Sea through the Sea of Marmara and the Bosphorus and Dardanelles Straits.

The Black Sea surface area of 423,000 km^2 is approximately one-fifth of that of the Mediterranean Sea. The total volume of the Black Sea is 547,000 km^3 and maximum depth about 2,200 m. Narrow shelves and very strong topographic variations are found around its periphery. The northwestern shelf is the only major shelf area, occupying about 20% of the Black Sea total area; it receives discharges from three of Europe's largest rivers: Danube, Dniepr, and Dniester (Figure 4.2).

BIOPHYSICAL CHARACTERISTICS

The Black Sea has always had a positive water balance (Unluata and others 1990, Ozsoy and Unluata 1997), with the freshwater excess of 300 km^3/yr balanced by the net outflow through the Bosphorus. Below a permanent halocline at depths of 100 -150 m, the intermediate and deep water masses possess almost uniform characteristics vertically, defined by T~9°C, S~22, st~17.0 kg/m^3 (Murray and others 1991). Below approximately 1,700 m the deepest part of the water column covering the entire abyssal plain of the sea consists of a vertically and horizontally homogeneous water mass formed over several thousand years by convective mixing.

A strong density stratification that effectively inhibits vertical mixing results in permanent anoxia within almost 90% of the Black Sea volume (below 200 m), making this the largest anoxic basin of the global ocean. The lower anoxic layer, with high hydrogen sulfide content, is a 'dead' zone, with the sea's marine life being confined to the upper layer. The Black Sea is considered a Class I, highly productive ecosystem (>300g C/m^2/yr) based on SeaWiFS global primary production estimates (NOAA 2003). High primary production is associated with fluvial discharge (Balkas and others 1990) and natural winter production (Sur and others 1994, Nezlin 2000).

During the 1970s and 1980s, agriculture in the Black Sea Basin dramatically increased in intensity. Higher inorganic fertilizer application rates and growing livestock numbers brought with them increased export of nutrients (nitrogen and phosphorus) and organic waste to the Black Sea and the rivers feeding into it. This resulted in large areas of oxygen depletion, which spread from 1974 to 1983, as shown in the upper part of Figure 4.3. From the early 1970s through the 1980s, tens of thousands of square kilometres of the western Black Sea were under hypoxic conditions. As a consequence, large-scale ecological changes occurred, including a significant decrease in the area occupied by the red seaweed, *Phyllophora*, and increased dominance of phytoplankton as primary producers in shallow shelf waters. This process also resulted in the widespread death of benthic invertebrates which, allied with over-fishing and the introduction of invasive species such as the ctenophore *(Mnemiopsis leydi)*, led to the collapse or severe damage of some parts of the ecosystem. In recent times, however, oxygen saturation levels have increased considerably; the dramatic autumnal recovery in oxygen status during the mid-1990s and early 2000s is illustrated in the lower part of Figure 4.3.

The recovery of oxygen conditions in the western Black Sea is undoubtedly associated with the significant decrease in commercial fertilizer use in the eastern Danube countries and of many industrial and agriculture point sources at the beginning of the 1990s, as well as improvements in municipal wastewater treatment in the upper reaches of the Danube Basin. Hypoxic events have only rarely occurred on the northwestern shelf in recent years; for instance, an unexpected hypoxia event occurred during late summer of 2001. Nevertheless, the northwestern shelf does appear to be in the early stages of recovery. Results of the first complete benthic invertebrate sampling exercise in nearly 15 years are now available (Sinegub 2004, Todorova and others 2004). The signs are very positive, although the system is still highly vulnerable to human-induced eutrophication.

LEGAL AND INSTITUTIONAL FRAMEWORK AND REGIONAL AND INTERNATIONAL COOPERATION

In 1992 the Bucharest Convention was signed by the six coastal states and entered into force in 1994. Responsible for the achievements of the Convention is the Commission for the Protection of the Black Sea (BSC), which is assisted by the Permanent Secretariat. Three Protocols are an integral part of the Convention: a) Protocol on the Protection of the Black Sea Marine Environment Against Pollution from Land-based Sources (in process of revision since 2004); b) Protocol on Cooperation in Combating Pollution of the Black Sea Marine Environment by Oil and Other Harmful Substances in Emergency Situations; and c) Protocol on the Protection of the Black Sea Marine Environment Against Pollution by Dumping. A fourth protocol, the Black Sea Biodiversity and Landscape Conservation Protocol, was signed in Sofia in 2003, and is currently undergoing ratification.

Following the signing of the Bucharest Convention, but before its entry into force, the Ministries of the Environment of the six Black Sea countries approved the Odessa Declaration (1993), which is based mainly upon Agenda 21, in order to set goals, priorities, and timetable for environmental actions. In June 1993 a three-year Black Sea Environmental Programme (BSEP) was launched with US$9.3 million from GEF and collateral financing from the EU and other countries. Under the BSEP a series of background studies have been completed and a Transboundary Diagnostic Analysis (TDA) was finalized in June 1996. On the basis of this comprehensive report senior government officials negotiated the Black Sea Strategic Action Plan (BSSAP), signed in October 1996 during the Ministerial Conference in Istanbul. In 1997-1999 National Strategic Action Plans (NSAP) were developed and implemented.

Several other initiatives and programmes are underway to protect the Black Sea environment from land-based activities. For instance, during the last five years the EU policy underwent significant development and a Framework for Community Actions in the Field of Water Policy was approved in October 2000. At the national level, the EU accession countries Bulgaria and Romania are working on both the transposition and implementation of the EU Water Framework Directive and other related directives. In June 2002 the Ministries of the Environment of the six Black Sea countries adopted the Sofia Declaration by which they commit themselves to further improve the Black Sea and the state of its marine and coastal ecosystems. Commencing in 2002 and linked under the Danube/Black Sea Strategic Partnership together with the Danube Regional Project (UNDP) and the Black Sea Nutrient Reduction Facility (World Bank), a Strategic Partnership, a US$97 million support framework is providing investments and capacity building to the 17 riparian countries of the Danube/Black Sea Basin, to improve water quality and reduce nutrient loading.

BLACK SEA HOTSPOTS

Forty-six hotspots have been identified along the Black Sea coast (Figure 4.4). These are associated with treatment plants for municipal and urban (29), industrial (10), domestic (2), and port (4) wastewater, as well as one ballast wastewater treatment plant. The main pollutants coming from the above sources are: inorganic N and P, oil, heavy metals such as Cu, Cd, and Pb, in addition to COD, BOD, and POPs.

CURRENT STATUS RELEVANT TO THE GPA SOURCE CATEGORIES

Sewage

As seen in Table 4.1, numerous urban settlements exist in the coastal zones of the Black Sea countries. In the majority of these countries the construction of wastewater treatment facilities is not sufficient for eliminating pollution from the major sources. Furthermore, the existing sewer systems, built in 1960 -1970s, also need upgrading. In general, a large percentage of the households in rural areas is not connected to a sewerage system, as demonstrated in Russia and Romania (Figure 4.5). Nevertheless, there has been a steady reduction in the percentage of both rural and urban households not connected to a sewerage system in Russia. The number of urban households that are not connected to a sewerage system is lower in Romania.

Nutrients

Urban wastewater discharges are an important source of nutrients in the Black Sea. Other major sources of nutrients in the Black Sea are industrial wastewaters and river discharge. In fact, the latter is the most significant contributor to eutrophication in the Black Sea (Tables 4.2 and 4.3). Based on available scientific assessments and findings of the Black Sea TDA (1996), the overall yearly input of nutrients to the Black Sea from human activities and river discharges amounts to 647,000 tonnes of N and 50,500 tonnes of P (Tables 4.2 and 4.3) (Black Sea Pollution Assessment 1998).

Urban and industrial wastewater

Inputs of insufficiently treated wastewaters from the Russian Federation show a notable reduction from nearly 84,000 m^3 in 1995 to 9,500 m^3 in 2003 (Figure 4.6). In contrast, in Ukraine the input of insufficiently treated water began rising again in 1999 following a decline from 90.2 million m^3 in 1997 to 34.5 million m^3 in 1998 (Figure 4.7). The volume of insufficiently treated wastewater in the Romanian Black Sea coast was significantly reduced from slightly over 200 million m^3 in 1999 to less than 50 million m^3 in 2003. In this country direct industrial and untreated municipal discharges into coastal waters have also been reduced and the municipal wastewater treatment plants are being upgraded with funds from the European Bank for Reconstruction and Development (EBRD), Instrument for Structural Policies for Pre-Accession, and local authorities.

An assessment is difficult for Bulgaria, Georgia, and Turkey mainly due to the limited available data. While no progress is seen in Georgia, considerable progress has been made in Turkey where 50% of the total volume of discharged wastewaters is currently treated. Some progress has also been made in Bulgaria with a slight decrease in the volume of insufficiently and untreated wastewater in 2002 and 2003 (Figure 4.8). (Note: These data have not been validated.)

River input

Danube River

The total water discharged from the Danube River is significantly greater than that of the other rivers in the Black Sea region. An analysis of the trophic status of the Black Sea coastal waters demonstrates the influence of the Danube River: rocky shores close to the Danube Delta have a higher trophic status than those further away (Appendix 4A). The adoption of good quality assurance procedures by the Danube Trans-National Monitoring Network has resulted in three years of nutrient loading data (Table 4.4).

Although this is too short a period to undertake a trend analysis of river loads, a large body of evidence suggests that nutrient loads to the Black Sea via the Danube River have fallen substantially over the last 10-15 years. For example, a number of statistically significant trends (improvements in water quality, notably nutrients) have been detected in this river over the last 10-15 years, with up to 30% annual reductions between1996 and 1998 in the concentrations of some nutrients (e.g., ammonium). At the Constanta site in Romania, P and Si showed a general decline over the past three decades while nitrate concentrations increased in recent years (Figure 4.9).

Recent improvements in the Black Sea water nutrient concentrations are much less dramatic when average results are considered. In fact, in contrast to the Danube, some Black Sea trends show up to 3-5% increases in nutrient concentrations. It is likely that a longer lag period is required before the benefits of reduced riverine nutrient loads to the northwestern shelf are reflected within the sea itself, a conclusion that is supported by the recently published nutrient budget for the northwestern shelf (Mee 2005, Mee and others 2005 based on Friedrich and others 2002).

The Danube River is still a significant source of other contaminants - both organic (some PCBs and chlorinated pesticides) and inorganic (heavy metals). Large capital investments in sewage treatment within the Danube River Basin have improved the situation with regard to nutrients and major organic pollution. However, improvements in heavy metals loads and diffuse sources of pollution are much more difficult to assess, particularly as the current assessment does not involve source apportionment modelling. For this, inputs from other rivers, direct (local) discharges to the marine environment, atmospheric deposition, and the historical contribution to surface sediment contamination need to be fully evaluated. It is noteworthy that sediment concentrations are not significantly elevated offshore of the Danube's mouth and comparable concentrations of many of the pollutants associated with this river have been recorded at sites that are much less heavily influenced by it. This implies that pollutant export from coastal regions (much smaller areas than that of the Danube Basin) is proportionally greater (per unit area) than from the land drained by the Danube.

Since the 3-year period for which data on nutrient loads are available is too short a timescale over which to undertake a trend analysis, no such analysis is presented. Thus, even though there appears to have been an increase in ammonium, nitrate, and inorganic nitrogen, as well as a decrease in ortho-phosphate over this period, there is little basis for assuming that these changes represent significant trends. Clearly, the Danube has had a major historical impact on the northwestern shelf, but the sea appears to be recovering as a functional ecosystem, as indicated by dissolved oxygen and macrozoobenthos data.

Dnieper, Dniester, and other rivers

Nutrient inputs from the Dnieper, Dniester, and Southern Bug Rivers into the Black Sea are considerably lower than that of the Danube (Figures 4.10 and 4.11). The nutrient loads from these rivers appear to have generally decreased since 1999, although input of P from the Dnieper has increased. The nutrient loads discharged by Rioni River (Georgia), as well as by Sochi River (Russian Federation) are significantly lower than those originating from Danube, Dnieper, and Dnister. For instance, in 2002 nutrient input from the Rioni River was below 400 tonnes while in 2004 that from Russia was less than 0.1 tonne. Although the impact of these rivers on the Black Sea as a whole is lower, it is not negligible.

Persistent organic pollutants and heavy metals

Pollution of sediments with organic and inorganic contaminants is discussed in detail in Appendix 4B. Overall, results indicate the impact of the Danube on the coastal sediments of the northwestern shelf, particularly with regard to heavy metals, albeit that any increases in sediment contamination levels are relatively small in view of the catchment area of the Danube in relation to that of the coastal land that drains directly into the northwestern shelf.

The levels of contamination at individual sites reflect export of contaminants from land as a result of their production/use in coastal areas, direct discharges to the marine environment, illegal waste dumping at sea, and atmospheric deposition as well as river inputs. While surface sediment samples were used for the vast majority of the analyses, there was also the risk of a historical 'shadow' reflecting sediment contamination. This was primarily due to bioturbation - mixing of marine sediments by burrowing animals - so that older, deeper and possibly more contaminated sediments (reflecting levels occurring before the Danube clean-up programme of the 1990s and early 2000s) may have become incorporated into surface sediments.

The highest concentrations of a number of chlorinated pesticides (dieldrin, lindane, opp DDD, opp DDT, pp'DDD, pp'DDT, DDMU, op'DDE, pp'DDE and βHCHa) were found in Ukrainian sediments, with concentrations diminishing in a southerly direction. For two of these contaminants (dieldrin and op'DDE), however, increased concentrations were recorded in Bulgarian sediments. Elevated levels of HCB, δHCH, lindane, heptachlor, aldrin, and endosulfan were also detected in Bulgarian sites. For three pesticides (cis- and trans-chlordane and a-HCH), maximum levels were associated with the Sulina branch of the Danube, although for a-HCH, comparable levels were detected at a number of other sites. The massive level of DDT contamination recorded at one Ukrainian site is considered much more likely to reflect illegal discharges/dumping than land run-off.

PCB concentrations were highest at more northerly sites of the northwestern shelf. Maximum concentrations of 10 PCBs (aroclor 1260, PCBs 149, 153, 170, 174, 177, 180, 183, 187, and 194) were associated with Danube River input via the Sulina Channel. Maximum concentrations of another 12 PCBs (aroclor 1254, PCBs 44, 49, 52, 87, 101, 105, 110, 118, 128, 138, and 201) were recorded in Ukrainian sediments, which could also reflect inputs from the Dneister and Dnipro Rivers. Concentrations of all PCBs except one (PCB 201) were low in northern Bulgarian sediments, but for most PCBs greater contamination was detected in southern Bulgarian sediments.

For eight metals, highest sediment concentrations are associated with inputs from the Sulina Branch of the Danube Delta, although elevated levels of contamination of some metals (Co, Ni, Cu, and Al) were also noted in samples from off the coast of southern Bulgaria.
A sampling site off the coast of Ukraine also had elevated levels of As. However, as suggested for organic contaminants, the Ukrainian result is also likely to reflect greater inputs from the Dnipro and Dneister Rivers.

Radioactive substances

The current levels and trends of radionuclide pollution do not present a threat to human health and biota in the Black Sea region, although, in general, the background values in the Black Sea are twice as high as those in the Mediterranean. Since the Chernobyl accident, the radioactivity level has been gradually decreasing and is currently near previous levels. The preliminary results of the IAEA project "Marine Environmental Assessment of the Black Sea Region" show that radioactivity levels have no significance in terms of human health and environmental safety. However, the reliable data accumulated as a result of this monitoring programme will have great importance for the further assessment of the Black Sea marine environment and emergency response programmes.
Oil (Hydrocarbons)

Based on available scientific assessments and the findings of the TDA (1996), the overall yearly input of oil to the Black Sea from the coastal countries amounts to about 57,400 tonnes (Table 4.5). In addition, inputs from accidental oil spills and the Danube River bring the total to 110,840 tonnes/yr. Currently, overall decreasing trends are reported for oil-related pollution in sediments and marine waters of all Black Sea coastal states (Figures 4.12 and 4.13) (Black Sea Commission 2002).

Despite these decreasing trends, oil pollution of the Black Sea environment is a concern especially because of the increasing risk of accidental spills that may result from the expected two-fold increase in transit by oil tankers. The freight flow of oil from the Middle Asia and Azerbaijan via Georgia is expected to gradually increase. Over 20 million tonnes of oil and petroleum products are expected to be transported via these terminals in Georgia to the west through the Black Sea. It should also be noted that an increase in oil transportation from Georgia would proportionally enhance the uncontrolled flow of isolated ballast into the central part of the sea, thus increasing the threat of the introduction of exotic species and pathogenic organisms to the Black Sea ecosystem, and possibly additional pollution. The volume of such ballast water in Georgian ports is currently estimated at 5 million tonnes/yr.

Several accidents involving spills of hydrocarbons have occurred in the Black Sea. For instance, 16 accidents were recorded in Constanta Port in 2000 - 2002 and involved 0.42 tonne bilge water, 0.55 tonne diesel oil, 0.1 tonne crude oil, and 0.3 tonne mineral oil. The affected area, however, was limited. During 2000 - 2003, five pollution accidents were reported on the Bulgarian coast; only one involved 0.17 tonne of hydrocarbons and the affected area was limited. In 1996 - 2002 seven out of five pollution accidents reported in the Russian Federation Black and Azov Seas involved hydrocarbons (Figure 4.13).

In 2003 Bulgaria, Romania, and Turkey signed the Black Sea Contingency Plan to the Protocol on Cooperation in Combating Pollution of the Black Sea by Oil and Other Harmful Substances in Emergency Situations: Volume I, Response to Oil Spills. The negotiations in Georgia, Russian Federation and Ukraine are continuing and are expected to be finalized in 2005-2006.

The status of National Contingency Plans by countries is as follows:

Bulgaria:
The Bulgarian National Oil Spill Contingency Plan (CP) was revised in terms of the communications. The respective flowchart displaying communications among different institutions, as well as the Annex 19 “Telephone Directory” were revised. All of the revisions were also made in the Black Sea CP at the time of its adoption by the Bulgarian parliament.

Georgia:
The Georgian National Oil Spill Contingency Plan was prepared and is awaiting the approval by Parliament. Delay with approval is explained by political changes in Georgia. Parts of National Contingency Plans on oil spills are being implemented by the Maritime Transport Administration and port regulation. Also being implemented are all Georgian ports oil spills combating plans, even though the national plan has not received final approval by the Government of Georgia.

Romania:
The National Contingency Plan has been prepared and is being implemented. Communication will be improved following the experience of the exercise on combating oil spills.

Russian Federation:
The Federal Contingency Plan and Regional Contingency Plan for the Black Sea on the level of Krasnodar Kraij and Rostov Oblast were prepared and updated in line with requirements of IMO. Its approval by the Government of the Russian Federation is expected.

Turkey:
The National Contingency Plan was submitted to the National Assembly for approval and will be further developed for practical implementation.

Ukraine:
The Black Sea Contingency Plan was submitted to the Parliament of Ukraine. The National Black Sea Contingency Plan will be developed after its approval. At the practical level each port has its own contingency plan and all necessary equipment for handling oil spills.

The increasing amount of oil cargo (information on the amount of oil transported through the Black Sea is being validated) and harmful substances transported in the Black Sea (subject of a regional study) calls for the implementation of precautionary principles and readiness to abate accidental pollution.

Litter

The littering of beaches and ultimately marine waters is illegal in all Black Sea coastal states. Nevertheless, due to a poorly developed tourist infrastructure and the illegal disposal from marine transport and households, the problem still exists. The scope of the problem and the impact of litter on marine life have never been assessed although this is required under the Bucharest Convention.

Physical alteration and destruction of habitats

The designation of protected areas is one of the most powerful tools used for conservation of biodiversity and landscapes. Protected areas are reported by all Black Sea coastal states but require further consultations (Black Sea Commission 2005). In the Black Sea coastal States 177 protected areas of different types were reported (Table 4.6), from biosphere reserves to historical nature monuments, and including 13 MPAs. In Ukraine seven MPAs include adjacent terrestrial parts. The Black Sea wetlands occupy a significant part of the region's protected territories; most of these are RAMSAR sites because of their importance for migratory waterfowl.

ASSESSMENT OF THE SITUATION

Has the situation concerning the GPA issues improved or worsened during recent years?

The key ecosystems of the northwestern shelf of the Black Sea have started to recover, although their current condition is still below that of the 1960s. There have been substantial improvements in sewage treatment facilities, particularly in the Danube River Basin. As a result, riverine nutrient loads to the sea from sewage inputs have been reduced considerably since 1990. This status, however, is still far from the strategic target to restore the condition of the Black Sea environment back to that of the 1960s. The Black Sea is still a 'Sea in Trouble'. Eutrophication was identified in the Black Sea TDA as one of the major threats to the Black Sea environment and still remains a priority problem. With any additional pressure, the status can revert to previous conditions, endangering the ecosystem. Pollution, although localized, affects biological communities and algae blooms are still heavy in some localities. Fish stocks of commercially valuable species, such as sturgeons and turbots, still suffer from illegal fishing, pollution, and destruction of their habitats. Nevertheless, progress was made in the last decade, but further improvement at the national level in relation to the GPA issues is needed.

In order to assess the situation relevant to the GPA in each of the Black Sea countries a questionnaire - "Situation in a Black Sea Country Relevant to the GPA" - was completed by the National Focal Points for the LBS Advisory Group of the BSC and its Secretariat. This survey showed that a wide array of measures to protect the Black Sea environment has been taken at the national and international levels.

Black Sea countries adopted the BSSAP and several countries have national programmes that are either NSAPs or closely relevant to the implementation of the BSSAP. The current situation regarding NSAPs in the Black Sea countries is as follows: Turkey adopted its NSAP (1999); Romania has a NSAP (1998-2005) according to the National Report of Romania for the IGR Meeting in Montreal (1998); in 2001 Ukraine passed the Law on the State Programme on Protection and Restoration of the Azov Sea and the Black Sea, which covers the Bucharest Convention, the Odessa Declaration and the BSSAP; the Russian Federation has a National Environmental Action Plan (NEAP), with its sub-programme on Integrated Coastal Zone Management of the Black Sea and the Sea of Azov (2002-2006). The NSAP of Georgia for Rehabilitation and Protection of the Black Sea has been elaborated, but it is still not adopted. Although Bulgaria does not have an NSAP, all its elements are contained in other normative documents.

National efforts to reduce eutrophication are supported by international cooperation through a number of GEF and EU projects initiated in the Black Sea Convention area, as well as by the World Bank and EBRD investment programmes.

Wastewater treatment investments is also addressed through the Danube Black Sea Task Force (DABLAS), an EC mechanism to support regional priorities, evaluate financial feasibility of projects, and identify funding sources (e.g., co-funding, guarantees).

Although solid waste management problems are not addressed at the regional level, national policies in Black Sea countries are aimed at waste minimization, reuse, recycling, and the recovery of landfills. In addition, the major legislative and regulatory tools for waste management are adequately developed in the Black Sea countries.

Framework legislation, regulations and licensing systems, and applying the "polluter pays" principle were in existence in all Black Sea countries long before the adoption of the BSSAP and its relevant principles. However, these measures are not sufficiently enforced because of existing economic problems such as the low paying capacities of polluters and insufficient institutional strength of the environmental authorities to address problems. Bulgaria, Romania, and Turkey are transposing the EU directives and approaches in their accession to the EU. In March 2004, the State Programme of adaptation of legislation of Ukraine to EU was approved by the Law; the first phase of the Programme implementation, scheduled for 2004 - 2007, has as priority sectors the protection of the environment, as well as the protection of the human, plants, and animals health .

National monitoring programmes are conducted by Bulgaria, Romania, Ukraine, and the Russian Federation within their territorial waters, although often irregular and with a limited number of parameters because of economic reasons. As EU accession countries, Bulgaria and Romania developed a monitoring system according to the EU Water Framework Directive provisions. In addition, improvements in national data reporting since the establishment of the Black Sea Commission Permanent Secretariat have also occurred. Major improvements in monitoring the environmental status of the Black Sea are planned during 2005-2006 as a result of the activities of the Black Sea Commission supported by the UNDP/GEF BSERP.

The way forward

The recovery of the Black Sea will take a long time and will require implementation of all measures in the BSSAP as well as those in future provisions. The gaps in scientific knowledge and information on many processes and phenomena, which are needed for policy and decision-making, should be addressed. Among the priorities of the governments of the Black Sea coastal states should be the sustainable development of society and the wellbeing of the coastal populations. It is widely recognized that only concerted actions at the national level and effective cooperation with all concerned sectors (municipal, agricultural, industrial, etc.), all countries in the Black Sea basin, and international partners will lead to sustainable results. The national and international efforts of the Black Sea coastal states should be directed at two targets:

- Intermediate target: prevent the increase of pressures from human activities; and
- Strategic target: restore environmental conditions in the Black Sea similar to those of the 1960s.

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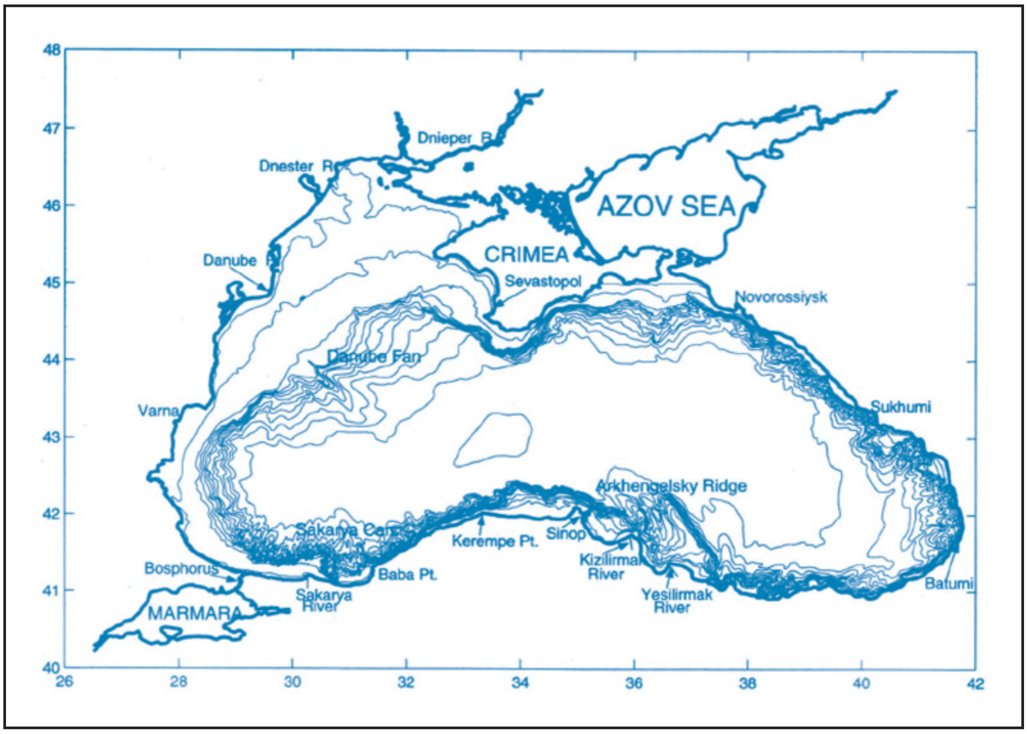
Figure 4.1

The Black Sea Basin

Figure 4.2

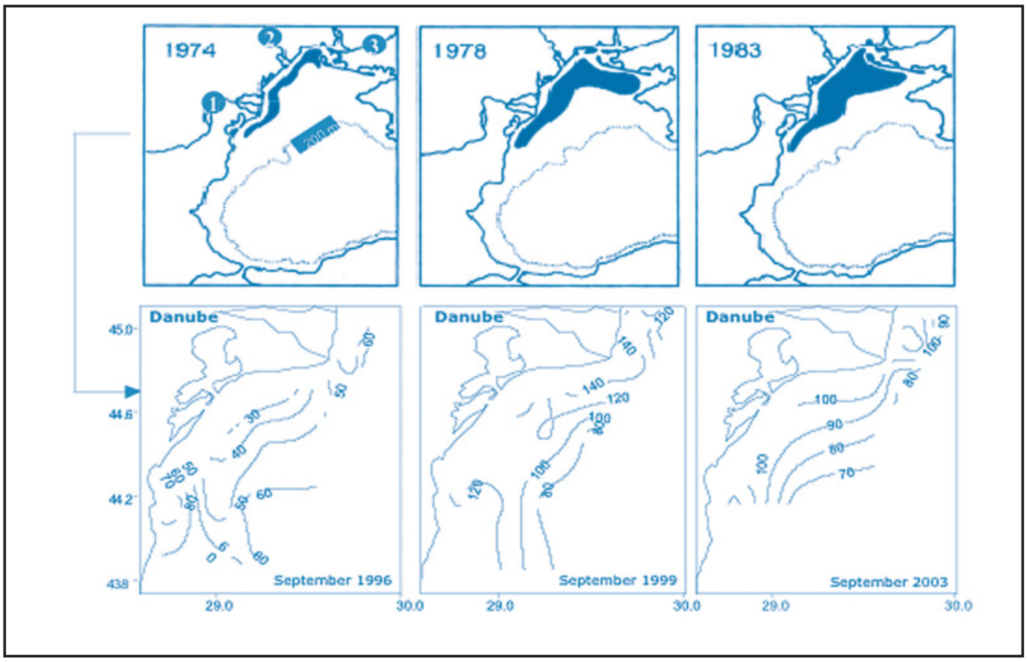
The Black Sea: geographic setting, main rivers, and bathymetric features



(Source: Besiktepe and others 2001)

Figure 4.3

Area of oxygen depletion (1974, 1978, 1983) and percentage oxygen saturation levels (1996, 1999, 2003) in the northwestern shelf of the Black Sea



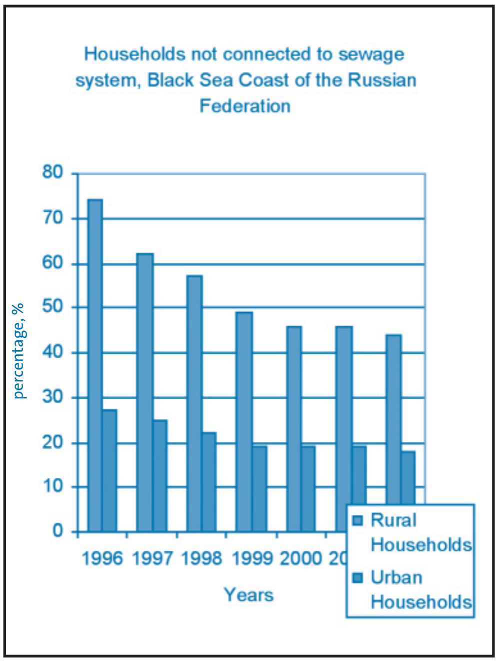
(Source: Zaitsev & Mamaev 1997, Kroiss 2003, daNUbs 2005) (ICPDR -Danube Basin Analysis WFD Roof Report 2004)

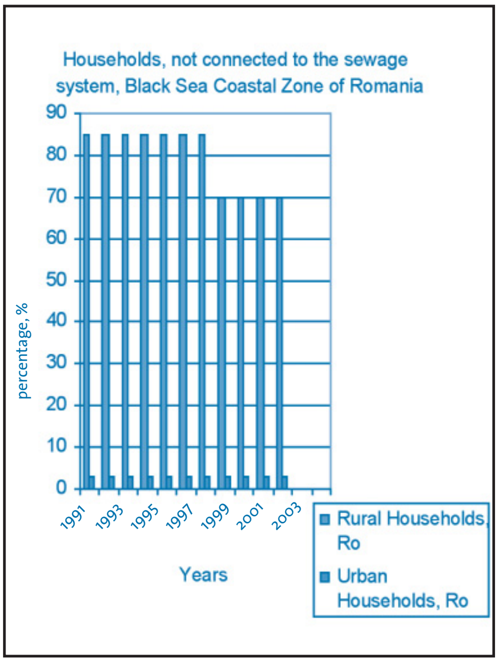
Figure 4.4

Black Sea coastal hotspots (black dots)

Figure 4.5

Percentage of households in the coastal zones of Russia and Romania not connected to a sewerage system





(Source: Russia - E. Antonidze reporting to BSC 2004; Romania - C. Coman, reporting to BSC 2004)

(Note: These data are not yet validated; they were reported to the BSC and are presented in the Annual Report 2003 - 2004 (see www.blacksea-commission.org). Starting in 1998/1999 in Romania, the number of rural households not connected to the sewerage system decreased by about 15% as a result of investment programmes. This most probably applies to the rural areas located in the vicinity of urban centres, where the sewerage system is connected to the urban wastewater treatment plant.)

Figure 4.6

Discharge of wastewater, Russian Federation

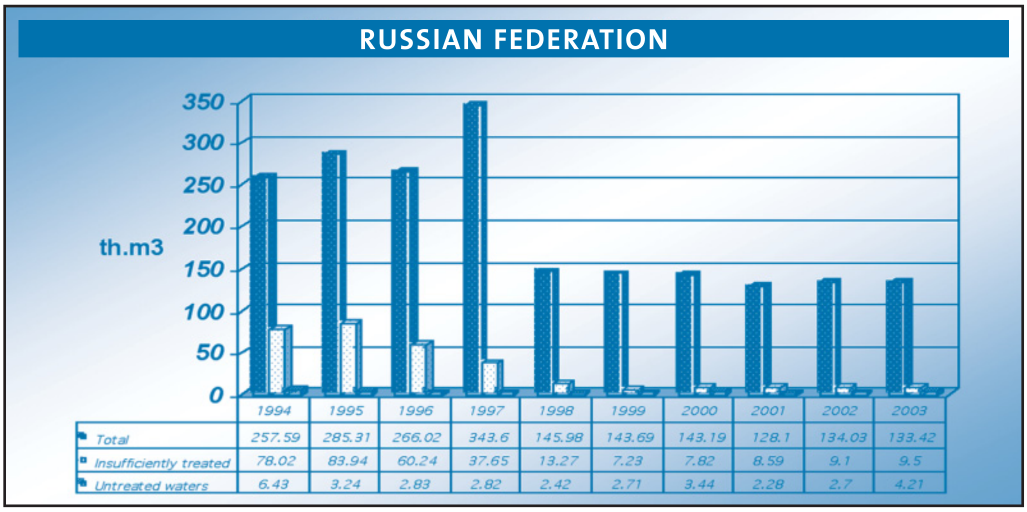


Figure 4.7

Discharge of wastewater, Ukraine

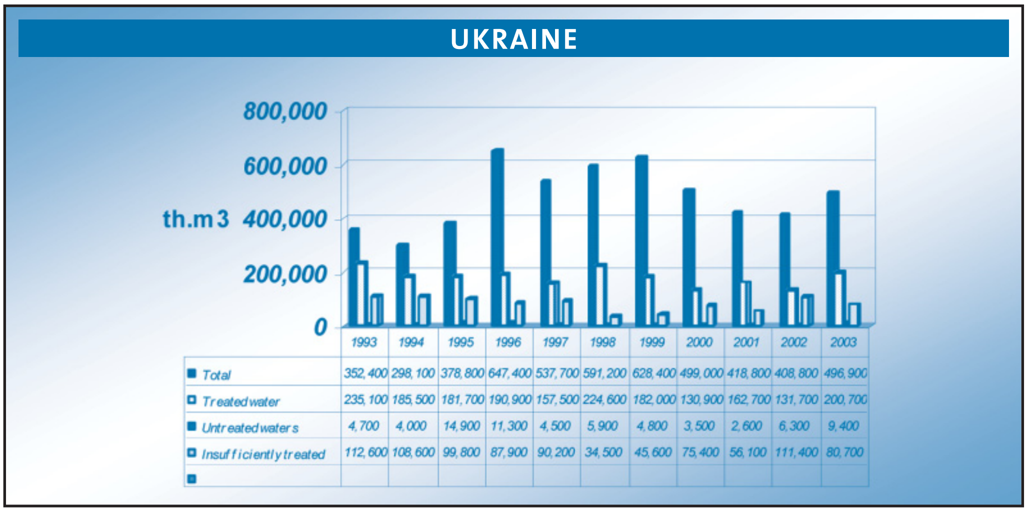


Figure 4.8

Discharge of wastewater, Bulgaria

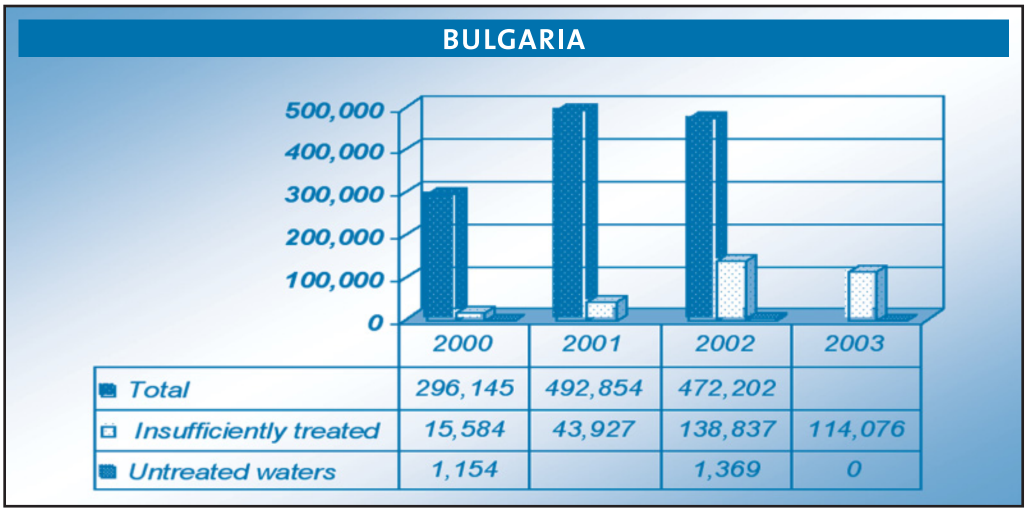


Figure 4.9

Trends in Black Sea nutrient concentrations at Constanta monitoring station, Romania (1974-2004)

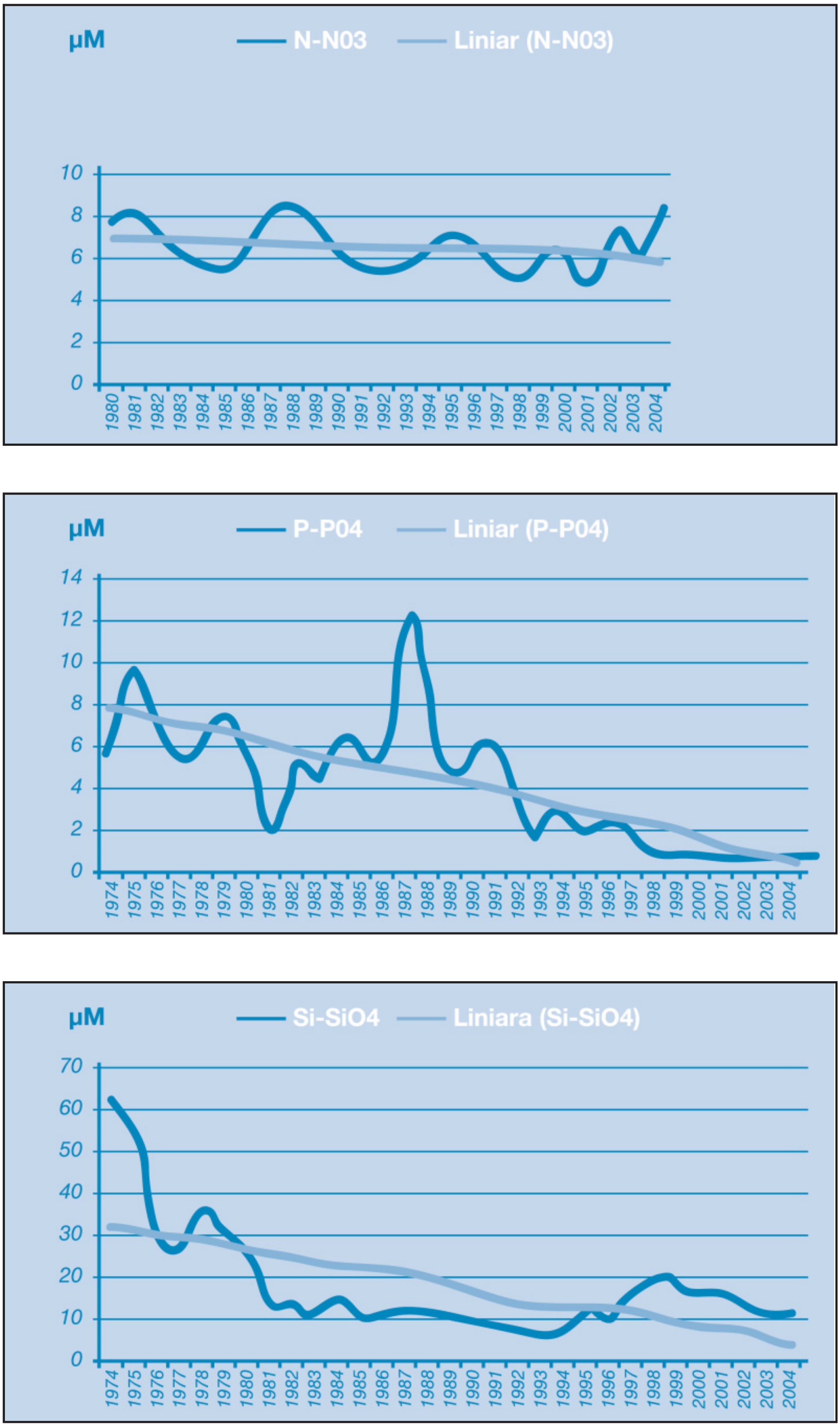


Figure 4.10

Riverine inputs of total N - Ukraine

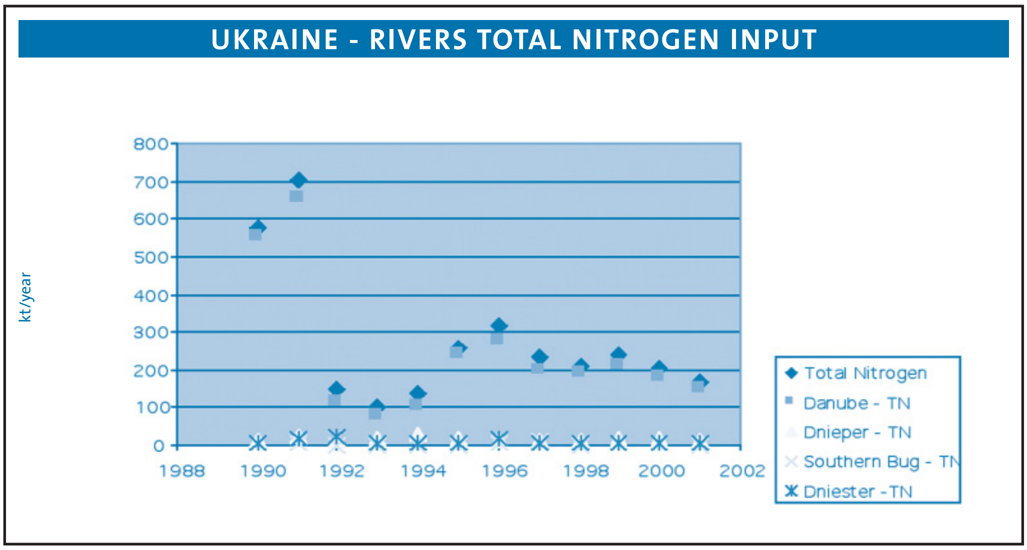


Figure 4.11

Riverine inputs of total P - Ukraine

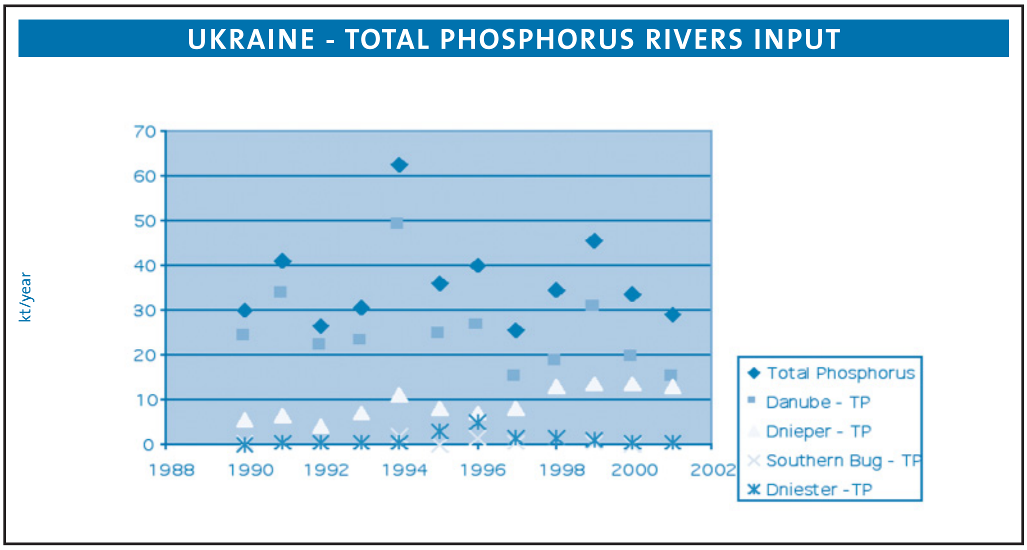


Figure 4.12

Concentrations of petroleum hydrocarbons in bottom sediments in the Black Sea, 1999)

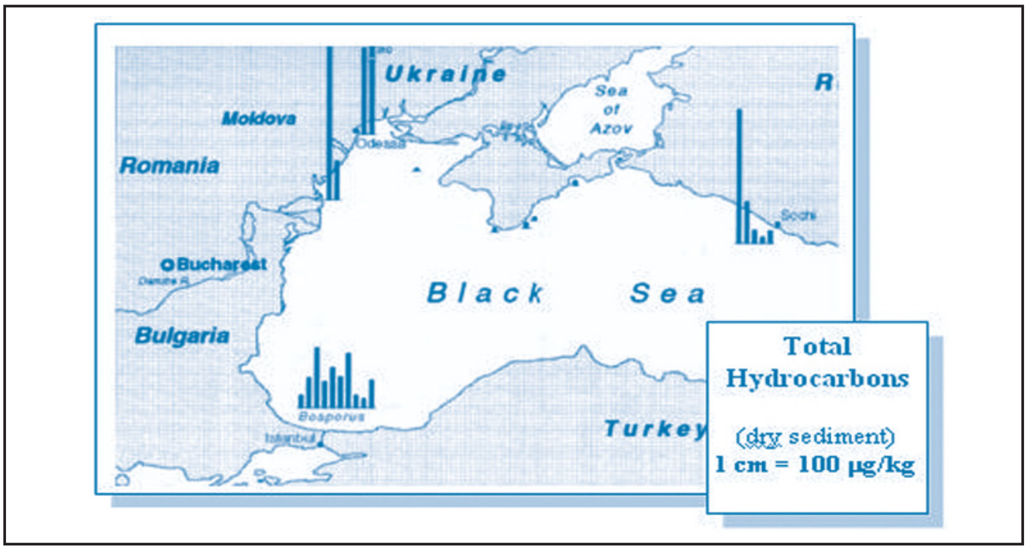
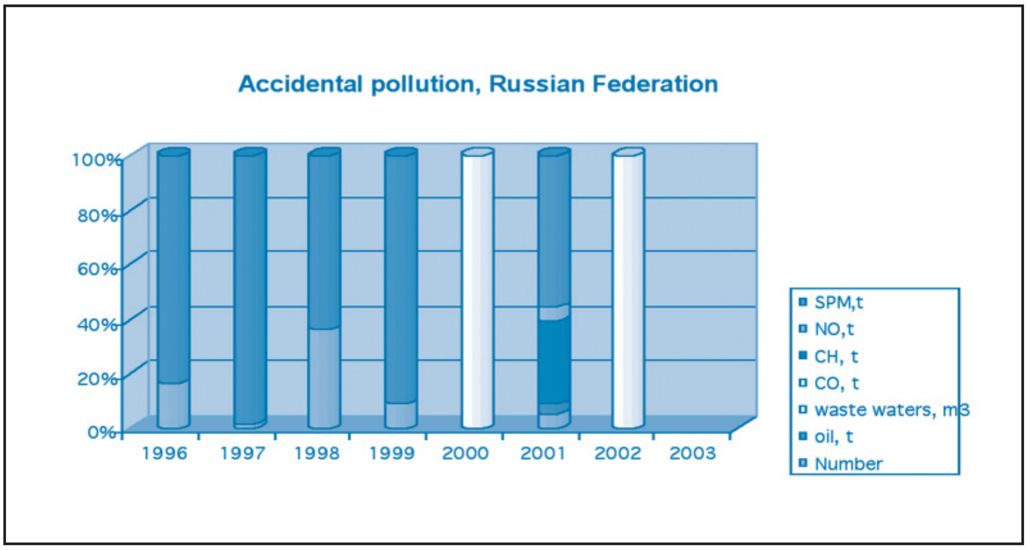


Figure 4.13

Accidental pollution in Russia by type of contaminants



Appendix 4A Black Sea trophic status

The trophic status of the Black Sea coastal waters has been assessed along seven transects, based on the rocky shore macroalgae morpho-functional indices methodology. The results of this assessment are shown in Figure 4B.1 and demonstrate the higher trophic status of rocky shores close to the Danube delta than those further away. Coastal waters at Sevastopol and Istanbul (regarded as being at the outer edge of influence of the Danube in this assessment) are define as mesotrophic (“clean enough”) according to this methodology, while Odessa, Constanta, and Varna are all described as eutrophic (moderately polluted). However, the results from Batumi, where the macroalgal community is also described as eutrophic, illustrate how this methodology is more affected by local influences (e.g., relatively small local discharges) than those based further offshore (e.g., zoobenthos assessments) when investigating the impact of the Danube.

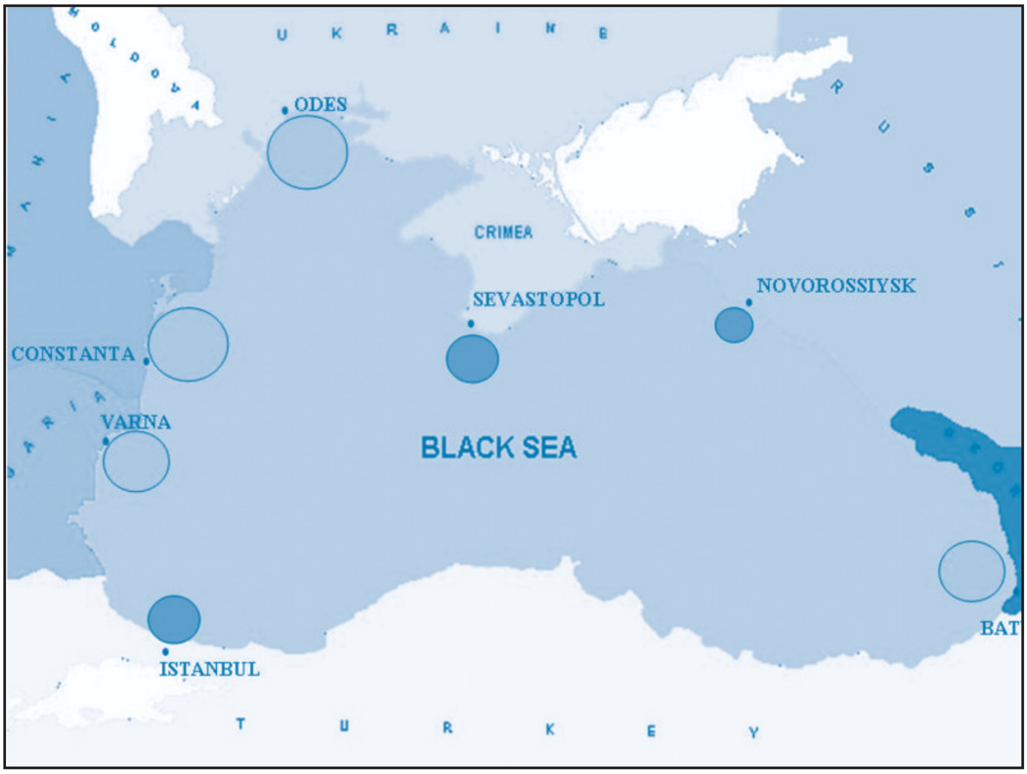


Figure 4A.1 Trophic status of Black Sea coastal waters as determined by macro-algal morphological indices (Minicheva 2004)

Mesotrophic	Novorossiysk	
	Sevastopol, Istanbul	
Eutrophic	Varna, Batumi	
	Odessa, Constanta	

Appendix 4B

Sediment contamination with organic and inorganic pollutants in the Black Sea

Sediment core samples were collected at 7 stations chosen randomly out of 55 stations sampled in the Black Sea (Figure 4C.1). The cores were sliced in 0-1, 1-2, 2-4, 4-6, 9-11, 14-16, 19-21, 24-26, 29-31, 34-36, 39-41, and 44-46 cm layers. Sixty-five core samples were analysed for chlorinated pesticides, PCBs, and trace elements by the Marine Environmental Studies Laboratory of the IAEA. Only the data for the surface layer (0-1 cm) of sediments are presented in this assessment, and correspond to recent developments in the system dynamics.

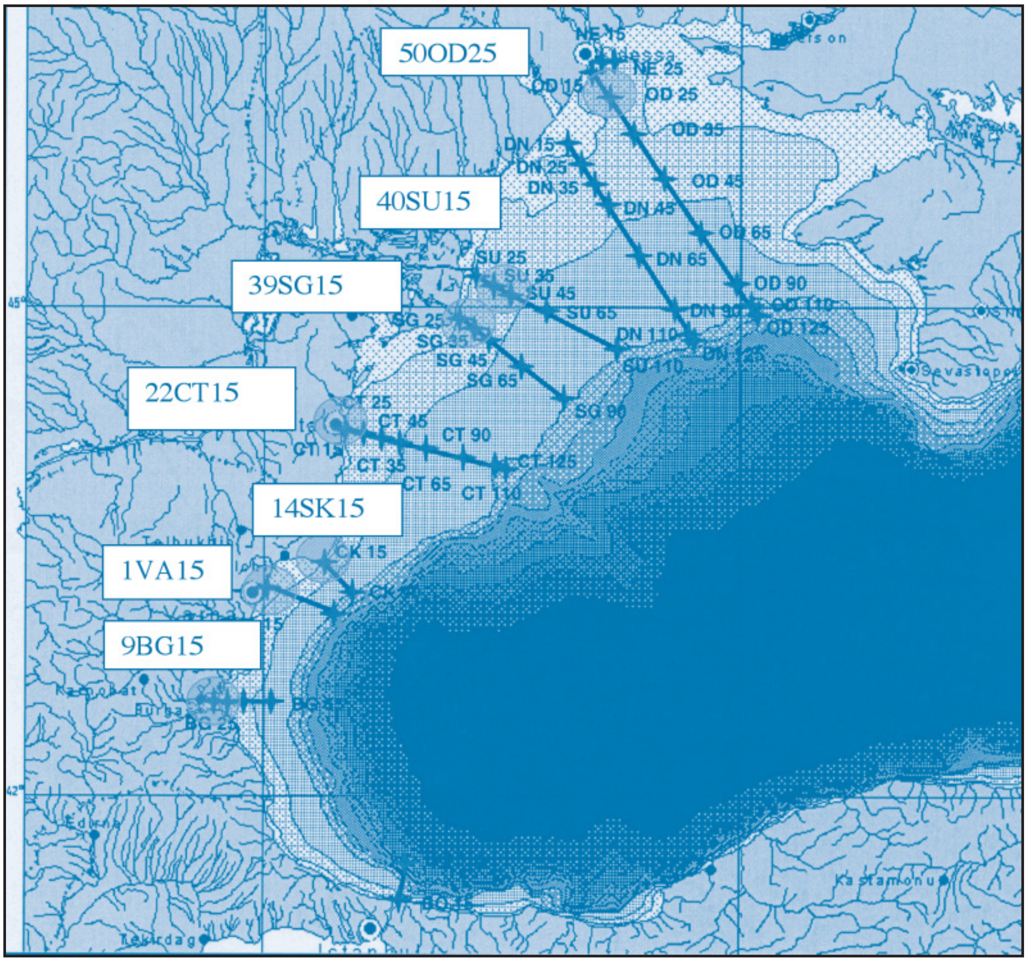


Figure 4B.1

Sites on the northwestern shelf of the Black Sea for pollutant screening

Chlorinated pesticides

The following pesticides were analysed: HCB, αHCH, βHCH, Lindane, δHCH, pp'-DDE, pp' DDD, pp' DDT, DDMU, op DDE, op DDD, op DDT, Cis chlordane, Trans chlordane, Trans nonachlor, Heptachlor, Aldrin, Dieldrin, Endrin, αEndosulfan, βEndosulfan, and Endosulfan sulfate. Graphical presentation of a profile Ukraine-Romania-Bulgaria is shown in Figure 4B.2.

Figure 4B.2

Chlorinated pesticides profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

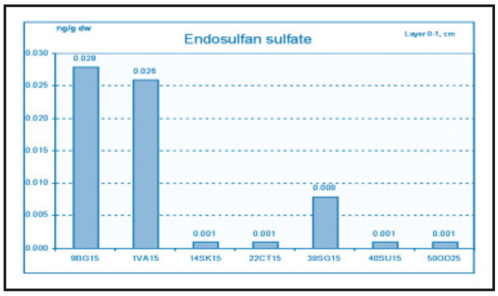
Figure 4B.2

Chlorinated pesticides profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

Figure 4B.2

Chlorinated pesticides profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

As shown on this page, heptachlor was found at concentrations above the limit of detection only at the Bulgarian site 1VA15.



The highest concentrations of a number of pesticides (dieldrin, lindane, opp DDD, opp DDT, pp'DDD, pp'DDT, DDMU, op'DDE, pp'DDE and βHCHa) were found at the Ukrainian station 50OD25, with the levels decreasing in a southerly direction. For dieldrin and op'DDE, however, there was an increase at one of the Bulgarian locations (1VA15 or 9BG15). For three pesticides (cis- and trans-chlordane and a-HCH), maximum levels were associated with the Sulina branch of the Danube, although for a-HCH, comparable levels were detected at a number of other sites. Concentrations of other pesticides were low at all stations on the northwestern shelf of the Black Sea, except at one or both Bulgarian stations. Elevated levels of HCB, δHCH, lindane, heptachlor, aldrin, and endosulfan pesticides were detected at Bulgarian sites. Endrin was not recorded at concentrations greater than the limit of detection at any site.

Differences in the levels of pesticide contamination at individual sites reflect both current and historical levels of pesticide usage, as well as differences in crops grown/pesticides used in different areas surrounding the northwestern shelf. The level of DDT contamination at site 50OD25 is so great that it is considered much more likely to reflect illegal discharges/dumping than land run-off.

PCBs

The following PCBs were analysed: Aroclor 1254, Aroclor 1260, and 20 PCB congeners. Graphical presentation of a profile UA-RO-BG is shown in Figure 4C.3.

Figure 4B.3

PCBs in sediment samples of the Black Sea. Profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

Figure 4B.3

PCBs in sediment samples of the Black Sea. Profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

Figure 4B.3

PCBs in sediment samples of the Black Sea. Profile (Ua-Ro-Bg). Benthic BSERP Cruise (Oct 2003)

PCB concentrations were highest at more northerly sites in the northwestern shelf. For 12 PCBs (aroclor 1254, PCBs 44, 49, 52, 87, 101, 105, 110, 118, 128, 138, and 201) maximum concentrations were recorded at the Ukrainian station 50OD25' while maximum concentrations of another 10 PCBs (aroclor 1260, PCBs 149, 153, 170, 174, 177, 180, 183, 187, and 194) were recorded at station 40SU15. Results from the Ukrainian site reflect inputs from land run-off, as well as inputs from the Dneister and Dnipro rivers. However, concentrations of the latter group of PCB congeners most obviously reflect inputs via the Sulina branch of the Danube Delta.

Sediment concentrations of all PCBs except one (PCB 201) were lowest at the northernmost Bulgarian site (14SK15), but for most PCBs greater contamination was detected in southern Bulgarian sediments

Heavy metals

Six surface sediment samples were analysed for nine metals: Cd (µg/g), Pb (µg/g), Co (µg/g), Ni (µg/g), Cu (µg/g), Zn (µg/g), Al (µg/g), As (µg/g), and Hg (µg/g). Concentration profiles from south to north (from left to right: Bulgarian -Romanian-Ukrainian coastal sediments; see Figure 4C.1) are shown in Figure 4C.4.

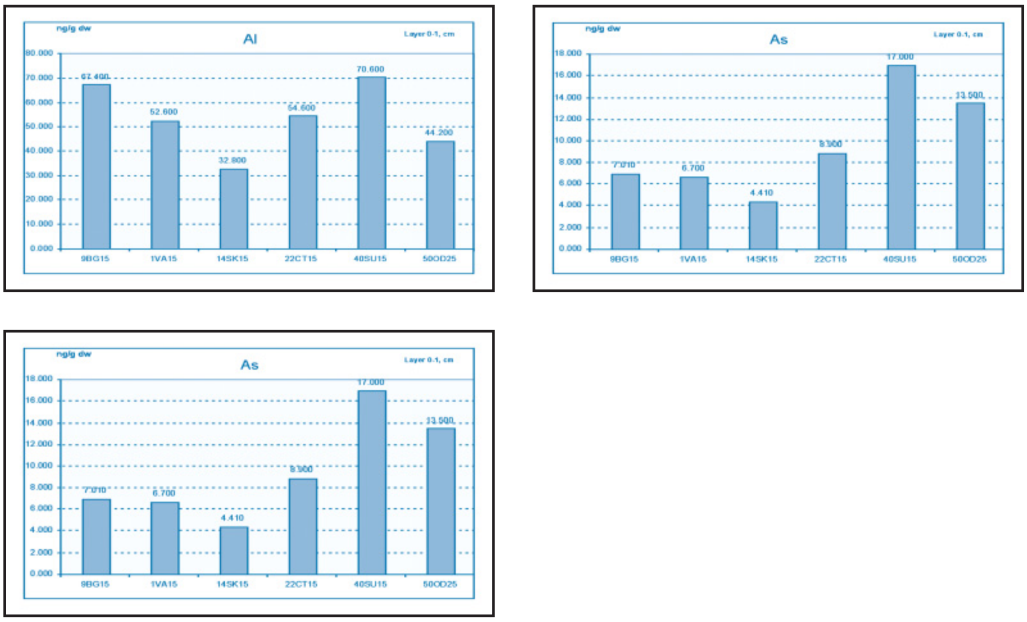
Figure 4B.4

Trace elements in Black Sea sediment samples. Profile (Ua-Ro-Bg). Benthic Cruise (Oct 2003)

Six surface sediment samples were analysed for nine metals: Cd (µg/g), Pb (µg/g), Co (µg/g), Ni (µg/g), Cu (µg/g), Zn (µg/g), Al (µg/g), As (µg/g), and Hg (µg/g). Concentration profiles from south to north (from left to right: Bulgarian -Romanian-Ukrainian coastal sediments; see Figure 4C.1) are shown in Figure 4C.4.

Figure 4B.4

Trace elements in Black Sea sediment samples. Profile (Ua-Ro-Bg). Benthic Cruise (Oct 2003)



For all the metals except Co, highest concentrations were recoded at Station 40SU15 and are associated with inputs from the Sulina branch of the Danube Delta. Elevated levels of contamination of some metals (Co, Ni, Cu, and Al) were also noted in samples from off the coast of southern Bulgaria. The Ukrainian sampling site had elevated levels of As. However, as stated for organic contaminants, the latter results are also likely to reflect the greater influence of inputs from the Dnipro and Dneister Rivers.

Table 4.1

Urban Settlements in the coastal zones of Black Sea countries

	BG	RO	RU	TR	UA
Total number of urban settlements (cities, towns)	17	16	9	14	12.8
Number of cities over 100,000 inhabitants	2	1	2	12	690
Number of cities over 1,000,000 inhabitants	0	0	0	1	55
Total number of rural settlements (villages), less than 10,000 inhabitants	206	322	409	No data	18.5 22

(BG:Bulgaria; RO: Romania; RU: Russia; TR: Turkey; UA: Ukraine)

Table 4.2

Estimated input of total nitrogen into the Black Sea

Country	Inputs (thousand tonnes/yr)			
	Domestic	Industrial	Riverine	total
Bulgaria	2.5	71.0	19.2	92.7
Georgia	1.6	0.0	0.0	1.6
Romania	0.9	44.4	132.0	177.3
Russian Federation	0.4	0.0	62.3	62.7
Turkey	5.4	0.6	32.0	38.0
Ukraine	9.5	31.0	36.3	78.6
Other countries	No data	No data	No data	198.3
Total	**20.3**	**146.9**	**281.8**	**647.3**

Table 4.3

Estimated input of total phosphorus into the Black Sea

Country	Inputs (thousand tonnes/yr)			
	Domestic	Industrial	Riverine	total
Bulgaria	0.7	0.0	1.9	2.6
Georgia	0.4	0.0	0.0	0.4
Romania	0.3	0.3	11.6	11.6
Russian Federation	0.5	0.0	6.1	6.6
Turkey	2.2	0.1	3.6	5.9
Ukraine	2.6	1.7	5.7	9.9
Other countries	No data	No data	No data	13.6
Total	**6.7**	**2.0**	**28.2**	**50.5**

Table 4.4

Annual loads of pollutants/contaminants from the Danube River into the Black Sea (2000-2002)

Load (tonnes/yr)	2000	2001	2002	Mean (2000-2002)
Suspended solids	5,100,000	3,700,000	5,100,000	4,633,333
NH_4-N	62,100	67,592	71,584	67,092
NO_3-N	252,540	355,852	413,980	340,791
NO_2-N	9,315	8,350	11,212	9,626
Inorganic N	299,000	437,000	493,000	409,667
PO_4-P	6,100	5,200	5,000	5,433
Total P	10,900	13,100	No data	12,000
BOD_5	395,000	303,000	343,000	347,000

(Source: ICPDR reporting to the BSC, 2003)

Table 4.5

Input of oil (tonnes/yr) to the Black Sea from various sources

Sources	Bulgaria	Georgia	Romania	Russia	Turkey	Ukraine	Total
Domestic	5,649.00	No data	3,144.10	No data?	7.30	21,215.90	30,016.30
Industrial	2.72	78.00	4,052.50	52.78	752.86	10,441.00	15,379.86
Land-Based	No data	No data	No data	4,200.00	No data	5,169.20	9,369.20
Rivers	1,000.00	No data	No data	165.70	No data	1,473.00	2,638.70
Total	6,651.72	78.00	7,196.60	4,418.48	760.16	38,299.10	57,404.06

Total from the Black Sea Coastal Countries	57,404 t/yr
Accidental Oil Spills*	136 t/yr
From the Danube River	53,300 t/yr
TOTAL IN THE BLACK SEA	110,840 t/y

*Average for the last years. Information on illegal discharges from shipping not included.

Table 4.6

Protected areas in the Black Sea countries

Sources	BG	GE	RO	RU	TR	UA
Number of protected areas	42	2	3	113	5	7
Number of MPAs	2	None	1	1	None	9
Total area of wetlands (hectares)	8,328		580,000	173,000	28,485	131,000

5 - ROPME Sea Area

INTRODUCTION

The Regional Organization for the Protection of the Marine Environment (ROPME) Sea Area (RSA) includes the Arabian (or Persian) Gulf and is the area surrounded by its eight Member States (Figure 5.1): Bahrain, Islamic Republic of Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates (UAE). Plenipotentiaries of the ROPME Member States (RMS) coined the term 'ROPME Sea Area' to achieve unanimity in denoting the area covered by the 1978 Kuwait Regional Convention for Cooperation on the Protection of the Marine Environment from Pollution (Kuwait Convention). According to Article II of this convention, the RSA is defined as extending between the following geographic latitudes and longitudes respectively: 16°39'N, 53°3'30"E; 16°00'N, 53°25'E; 17°00'N, 56°30'E; 20°30'N, 60°00'E; 25°04'N, 61°25'E. The gulf is a shallow semi-enclosed sea with an average depth of 35 m and a maximum depth of over 100 m. The surface area is 260,000 km^2, with the width ranging from between 200 - 300 km to over 1,000 km in Shatt Alarab in northwest Iraq. Separating the gulf from the Gulf of Oman and the Indian Ocean is the Strait of Hormuz, where the narrowest point is 56 km wide.

The RSA coastal waters are very vulnerable to pollution as a consequence of their heavy use, close proximity to various sources of pollution, shallowness of the water bodies, as well as low water circulation. Rising industrialization, as well as high population growth rates and rapid urbanization (with over 40% of the population living in the coastal areas) are placing considerable pressures on the region's coastal and marine environments. Over 20 major industrial complexes have either been completed or are currently under construction. Almost all development projects have been established on the coast, taking advantage of the easy access to the sea for transportation, availability of water for cooling and other uses, and for releasing effluents. As a consequence, the region's coastal and marine areas are experiencing increasing acute ecological and environmental problems, including loss and degradation of productive habitats. The impacts of municipal sewage and industrial effluents, particularly those of petroleum refineries and the petrochemical industry, are significant. In addition, power plants cause thermal pollution and desalination plants contribute halogenated organic compounds, brine, and thermal loads to the sea. Dredging and land reclamation are also permanent features in many coastal areas, with significant damaging impacts on the environment. Other land-based activities include agriculture and groundwater extraction, which result in increased sediment run-off and salt water intrusion, respectively.

Recognizing the urgent need to protect the marine environment from land-based activities, the RMS adopted the Kuwait Convention and its Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources. The protocol, which was signed in February 1990 and entered into force in January 1993, was prepared in fulfilment of Article III, paragraph (b), and Article VI of the Kuwait Convention and draws mainly from the Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land-based Sources (1985) and the relevant Articles of UNCLOS.

ROPME has developed guidelines on Integrated Coastal Area Management (ICAM) to harmonize development activities in the coastal zone in cooperation and full support of UNEP. Following the review of the first draft by regional experts in mid-1999, the guidelines were issued at the end of 2000. The purpose of these guidelines is to:

- Provide, within the context of the conditions prevailing in the RSA, general guidelines for national policy-makers, managers, and professionals involved in the development and implementation of ICAM programmes, plans, and projects aimed at achieving sustainable development of coastal and marine areas; and
- Assist in development of national guidelines for integrated coastal area management and development, and thus contribute to the implementation of principles and recommendations adopted by the 1992 UN Conference on Environment and Development (UNCED).

Previous assessment and analysis of priority issues in the RSA carried out by ROPME/UNEP experts indicated the following order of priority:

1. Oils (hydrocarbons) and combustion products;
2. Physical alteration and destruction of habitats; sediment mobilization;
3. Sewage and nutrients;
4. Litter;
5. Atmospheric deposition;
6. POPs;
7. Heavy metals; and
8. Radioactive substances.

LAND-BASED SOURCES OF POLLUTION AND IMPACTS ON THE ENVIRONMENT OF THE RSA

Oils (hydrocarbons) and combustion products

The RSA is considered an area with one of the highest oil pollution, including combustion products such as Polyaromatic Hydrocarbons (PAHs), risks in the world. This is mainly due to the concentration of offshore petroleum installations, tanker loading terminals, and the large volume and density of marine transportation of oil. In 2003 RMS, with the exception of Oman, produced about 27% of the world's oil while holding 57% (715 thousand million barrels) of the world's crude oil reserves. The ROPME region also has immense reserves (2,462 trillion cubic feet of natural gas), accounting for 45% of total proven world gas reserves. In 2000 RMS oil production capacity was about 21.7 million barrels per day (bbl/d) (EIA 2004). At the end of 2003 RMS maintained an oil production capacity of about 22.9 million bbl/d, which is expected to reach about 26 million bbl/d by 2010 and 35 million bbl/d by 2020 (EIA 2004). The net oil exports in 2003 were 17.2 million bbl/d distributed among the RMS as shown in Figure 5.2. About 90% (15-15.5 million bbl/d) of this oil is exported through the Strait of Hormuz and represents 40% of the global oil trade. The oil is exported from 29 major oil ports and terminals scattered around the region (Figure 5.3).

According to the Oil Spill Intelligence Report (SOMER 2003) six out of 20 worldwide cases of oil spills greater than 10 million gallons have occurred in the ROPME region. Oil pollution incidents at a smaller scale, such as submarine pipeline ruptures and well blowouts, are more frequent. Roughly 2 million barrels of oil are spilled into the region’s waters every year from the routine discharge of dirty ballast water and tanker slops, as well as from the 800 offshore oil and gas platforms (Hinrichsen 1996).

Between 1998 and 2002 a total of 25 oil spill incidents took place in the RSA, with the amount of oil spilled estimated at about 10,000 - 1.8 million US gallons (SOMER 2003). The impacts of oil pollution could now be observed both in sediment and biota, as well as on extended areas of beaches and along the region's coastline in the form of tar balls. The adverse environmental impact of oil pollution on mangroves, coral reefs, and fisheries is well documented (Price and others 1993, Vogt 1996).

There is an urgent need to establish waste oil reception facilities and to protect the marine environment from operational discharges of oil from tankers, commercial ships, and ports. The RMS, supported by ROPME, are coordinating with the IMO towards the ratification of the MARPOL Convention and to declare the RSA as a 'Special Area' in accordance with MARPOL 73/78, as well as meeting the requirements for adequate oil reception facilities in the region. ROPME, as well as the IMO, are also concerned about the potential for introducing alien species through ballast water discharges; a pilot study has been initiated in the region to assess this issue.

It should be noted that unless RMS take the necessary steps to declare the RSA a 'Special Sea Area', oil pollution from transportation, offshore operations, and land-based activities will continue. As indicated by the conclusions of the feasibility study on port reception facilities, meeting the requirements of MARPOL 73/78 need not be costly or technically complex. With the ratification of MARPOL 73/78 and the adoption and implementation of other relevant global agreements such as the Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC), Convention on Civil Liability for Oil Pollution Damage (CLC), and Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND), the region will move towards protecting its marine environment from oil and other forms of marine pollution. This must be accompanied by enforcement of national legislation, as well as penalizing and claiming compensation from violators (Al-Majed and Abdulraheem 2001).

Monitoring of beach tar balls is required within the marine monitoring programme. This was considered in the Manual of Oceanographic Observation and Pollutants Analysis Method (1983, 1989, 1999 editions). However, with the exception of Oman, some RMS, which started reporting on the density of tar balls in early 1980s, discontinued this part of the programme by the late 1990s. The Marine National Monitoring Programme of Oman reported a significant decrease in the average density of beach tar balls from over 400 g/m in the 1980s to less than 100g/m in 2002 (SOMER 2003).

Assessment of marine oil and hydrocarbons on different parts of the RSA, including intertidal and offshore areas, was undertaken by regional and non-regional scientists during the last two decades. The results and reports are published in national, regional, and international journals. At the national level, Kuwait, Qatar, Bahrain, and Oman conducted their national offshore marine monitoring programme considering the levels of total petroleum hydrocarbons (PHCs) in sediments and seawater, using Kuwait heavy crude oil as a standard. Sediment from a station next to the oil terminal in the Fahaheel area, southern Kuwait, showed an average of more than 250 mg/kg PHCs during the period 1986 - 2002 (Figure 5.4). Seawater samples showed an average of 0.002 - 0.040 µg/l PHCs (Figure 5.5); the concentrations were higher in the southern stations, which could be attributed to oil shipping activities in this area (Butayban 2005).

At the regional level, ROPME had an agreement with the International Atomic Energy Agency to conduct a Contaminant Screening Programme in the ROPME region during 1994 - 2001. The programme covered the oil and non-oil contaminants in seawater, sediments, and biota from 35 locations along the ROPME coastline. The results of this programme indicated high levels of total aliphatics in Minafa Bay and Ras Algar (Saudi Arabia), which were heavily impacted by an oil spill in 1991. The same was found along the Kuwaiti coast near Ras Azzor, with a maximum concentration of 300 mg/kg PHCs. High levels of PAHs were also reported in the Doha area (inside Kuwait Bay), which could be attributed to the presence of two desalination plants, in addition to the slow current and shallow depths of the water.

Total PHCs between 73 - 100 mg/kg were reported on the east coast of Oman, which indicated oil contamination in this area. Qatar showed lower concentrations of PHCs varying between 39 - 73 mg/kg. High concentrations of PHCs between 690 - 1600 mg/kg were reported in samples collected off the Bahrain Petroleum Company (BAPCO) refinery in Bahrain. This was attributed to an oily sludge discharge from the refinery. Coastal seawater samples collected within the same programme from UAE, Qatar, and Oman showed values of PHCs ranging from 0.01 - 0.07 µg/l while samples from Kuwait and Suadi Arabia showed less than 0.2 µg/l (SOMER 2003). Biota samples were also analysed. PHCs varied from 0.18 - 11 mg/kg dry weight of fish muscle and were slightly higher (2.2 -38 mg/kg dry weight) in fish liver.

At the regional and international levels ROPME conducted several open sea cruises to assess pollution from land- and sea-based activities. These included the Mt. Mitchell cruise (1992) in cooperation with agencies such as the National Oceanographic and Atmospheric Administration (NOAA) and the three UmitaKa-Maro cruises (January 1993, December 1993, and January 1994) in cooperation with Tokyo University. Two other regional cruises (ALQUDS) were conducted in summer 2000 and summer 2001 in cooperation with Iran. The findings of these cruises are presented in most of ROPME recent publications such as SOMER (1999, 2000, 2003).

Physical alteration, sediment mobilization, and destruction of habitats

Physical damage to marine and coastal habitats is of major concern in the region. Massive development projects in the coastal areas of most Gulf Cooperation Countries (notably Dubai and Bahrain) have resulted in the reclamation of tens of square kilometres at a time. The rapid growth of tourism and shipping presents the potential for increased PADH in the region. Tourism development represents the main driver of land reclamation, followed by harbour and industrial plant development. Direct PADH takes many forms:

- Replacement of entire habitats by large housing and hotel developments, harbours, shipping channels, and other infrastructure, as well as sand and gravel mines;
- Building of dams, which block spawning migrations, drown habitats, alter chemical and thermal conditions, and reduce freshwater flow to the estuaries, thus allowing salt water intrusion into the rivers;
- Drainage, canalization, and flood control can also affect water and sediment flows, affecting coastal geomorphology;
- Pollution and solid waste disposal (from domestic agricultural, industrial, and mining sources), and overuse of groundwater aquifers (for domestic, agricultural, and industrial purposes);
- Removal of natural materials (such as vegetation, gravel, mangroves, coral rock, and stones) for fuel, timber, and construction purposes;
- Dredging and dumping of dredge spoils; and
- Erosion and siltation.

The northern and eastern parts of the RSA are characterized by muddy sediments, which are introduced by the Tigris, Euphrates, Karun, Hileh, and Monds Rivers (Figure 5.6). During high water periods, silt is carried far beyond the river mouths by the anti-clockwise currents in the northern RSA, which could result in the destruction of the habitats where the most productive shrimp grounds are found (Figure 5.7). The western and southern parts are characterized by sandy sediments in addition to some coral and rocky sediments in the north of Bahrain and part of the eastern coast of Saudi Arabia. The waters are shallow with slow currents and a limited tidal range. Dredging and land-filling in this area could result in the destruction of the coastal habitats.

Coastal erosion is evident in several parts of the RSA. Some erosion is a natural process and part of the continuing shoreline change. Dam construction and alteration of river courses may also result in erosion of beaches in the affected areas, as in the case of Iraq.
About 45 - 50% of the total population of the RSA lives in the coastal areas (SOMER 2000). Coastal developments in the RMS increased in the last few years. Land reclamation for residential developments, ports, bridges, causeways, and other structures is very obvious. Constructing new causeways and coastal reclamation probably represent two of the most serious impacts on the ROPME environment. In some countries, about 40% of the coastline has now been developed (Price and Robinson 1993).

Dredging spoils could be a major source of pollution in critical habitats and areas with sensitive faunal communities, as shown in northern Kuwait Bay (Butayban and Preston 2004). In this bay methyl mercury was found as a result of dumping of sediments dredged from the south coast next to Shuwaikh Port and an old chlorine production plant (Figures 5.8 and 5.9). A new project will be started in Khiran close to the proposed nature reserve of Khawr al-Muffateh in the southern part of Kuwait. This area comprises a rich expanse of mudflats around the creek, which supports large numbers of migratory waterfowl during winter. Similar important wetlands occur around Kuwait Bay and opposite Bubyan Island, where military roads are being built across undisturbed marshes, leading to erosion and disruption of resident and migratory bird communities (WCMC 1991a, 1991b). A new port will be constructed in Bubyan Island, which will lead to some environmental changes in that area. Kuwait has also recently started construction of a new port at Um-almaradim Island, which is surrounded by coral reefs. The environmental impact studies have shown that the existing corals will be under threat and about 40% may be destroyed before the completion of the project. The construction of three major ports in Oman (Sohar, Shinas, and Kasab) on an area of 0.6 km^2 led to the removal of 2.2 million m^3 of dredged material (MTC-Oman 2002).

Large areas of the coastal zone in the Gulf countries (notably in Bahrain and Dubai) have been reclaimed in recent years. In addition, dredging is carried out to maintain navigation channels, and as a result large amounts of silt flow directly onto coral reefs, with devastating impacts. For example, surveys have shown an almost total loss of live hard corals on Fasht Al Ahdom, with coral cover declining from between 30 - 40% to 0% between 1997 and 1999. In 1999, divers reported small coral colonies (1 - 3 cm diameter), but these were too few to be detected by Reef Check surveys (GCPMR 2003). Nearshore reefs were severely damaged by coral bleaching in 1996 and 1998, while offshore reefs were less affected. Major coral bleaching also occurred in late 2000 in the northern Gulf.

Overfishing of fish and shellfish is a major concern in some parts of the region. Degradation of coral reefs from fishing practices, recreation, and tourism is becoming widespread. In spite of the efforts by most countries to control trawling (e.g., Kuwait, Qatar, Saudi Arabia, and UAE), trawling for shrimp and fish is still practised.

This causes physical damage to bottom habitats, including coral reefs, and has negative impacts on fish stocks. Moreover, destruction of habitats by physical alteration of river courses, drainage of marshes, and dredging of coastal areas have contributed significantly to the loss of nursery grounds of fish, feeding grounds of migratory birds as well as indigenous reptiles, mammals, and other ecologically and economically important habitats such as mangroves, seagrass beds, oyster banks, coral reefs, and tidal flats.

River basin management using an integrated ecosystem approach should be considered on a regional basis. This implies that management should consider linkages between the river basins and coastal areas. For example, rivers are not only to be shared by riparian states but also coastal habitats must receive sufficient freshwater to sustain them and the fisheries they support, as well as to prevent excessive seawater intrusion into the estuaries. The loss of the Mesopotamia Marshes in southern Iraq is a notable example of the devastation that could be caused by mismanagement of river systems. The loss of indigenous species of freshwater fish and birds, the destruction of spawning and nursery grounds of Shatt Alarab, in addition to the loss of human heritage that extends over 6,000 years, is a major environmental disaster in recent times.

Sewage

The concern about sewage arises from the great quantity of nutrients and the variety of other chemicals, heavy metals, pesticides, as well as other toxins and bacteria it contains. The sewage reaching the RSA come from two main sources: direct discharge through domestic sewage outfalls and indirect discharge through river outflow.

Domestic sewage outfalls

The total amount of treated and untreated sewage discharged in the region varies between 750 -950 million m^3/yr, 90% of which is related to total dissolved solids (TDS). Sewage treatment plants exist in all the RMS, with the level of treatment varying among the countries from secondary to tertiary. At the end of 2004 a Reverse Osmosis sewage treatment plant with a maximum capacity of 400,000 m^3/day began operation. However, the existing treatment plants are not sufficient to handle the current load due to the rapid population growth in the region. The RMS (e.g., Kuwait, Oman) have issued their own regulations or adopted international regulations and standards for the disposal of wastewater into the sea, and their implementation should be strengthened. As a result of the increased demand and limited resources of freshwater, the RMS have adopted and implemented policies for utilizing the treated wastewater for industrial and agricultural use.

In Bahrain an average of 130,000 m^3/day (47.45 million m^3/yr) of untreated sewage were discharged into the sea until 1998 (LBA-Bahrain 1999). In Iran about 152 million m^3/day (56,575 million m^3/yr) of sewage are discharged to Karun and Dez Rivers, with a maximum TDS load of 448,492 tonnes/yr representing 46.3% of the total load. In addition, 190,898 m^3/day were discharged from Abadan, Khorramshahr, Bander-e-Emam, Bander-e-Mashshahr and Hendijan until 1998 (SOMER 2000).

In Kuwait, with the exception of emergency untreated waste discharged during maintenance, about 70% of the tertiary treated water is discharged daily to the sea. In this country the water treatment capacity reached 375,000 m^3/day in early 1990s. About 250 wastewater treatment plants, including six major plants with a capacity ranging from 8,000 - 15,000 m^3/day, are in operation in Oman.

These plants generate about 29 million m^3/yr of treated water, most of which is utilized for irrigation, aquifer recharging, and industrial purposes while about 0.25 million m^3/yr are discharged to the sea (LBA-Oman 1999). There has been a three-fold increase to one million m^3/yr in the quantity of wastewater discharged to the sea during the period 1999 - 2001. Of this, about 0.40 million m^3/yr is discharged from the Darsait sewage treatment plant (SOMER 2003). Currently, there is an attempt by the government to halt the discharge of wastewater to the sea (LBA-Oman 2002).

In Qatar domestic wastewater amounts to 350,000 m^3/day, most of which is used for irrigation following tertiary treatment. In Saudi Arabia most of the domestic sewage generated receives secondary treatment. Thirty sewage treatment plants with a total capacity of 1.424 million m^3/day are in existence, treating both domestic and industrial effluents. About 0.6 million m^3/day are discharged to the sea, with the highest load (12,801 tonnes/yr) reported for Chemical Oxygen Demand/Total Oxygen Demand (COD/TOD), which represents 45.3% of the total contaminant load (SOMER 2000). In UAE, a treatment facility with a capacity of about 460,000 m^3/day is in operation. The sewage receives tertiary treatment following which 60% of the wastewater is used for irrigation while 40% is discharged to the sea (LBA-UAE 1999).

Within the contaminant screening programme tests were conducted for chemical sewage indicators in sediment samples collected from Kuwait and Saudi Arabia during 1998, where no previous data were available. Results indicated high concentration of sterol compounds (more than 1,000 ng/g of coprostanol) in samples collected from Kuwait Bay (Doha and Shuwaikh) while in Saudi Arabia the concentration was 10 ng/g (SOMER 2000). The former could be attributed to the muddy sediments and the shallow water with low tidal circulation in Kuwait Bay. Similar findings for Kuwait Bay were reported by Al-Omaran (1998). In Oman at AlSawadi the level was (160 ng/g coprostanol), which indicated a sewage source. Qatar samples reached a maximum of 170 ng/g at Ras Al Nouf area (SOMER 2003).

Rivers input

The discharge of untreated wastewater into the rivers constitutes another major impact on the region's coastal environment. The rivers are located on the northern and eastern parts of the RSA with an average annual flow of 3,250 m^3/s (Reynolds 1993). The main flow representing 45% of the total flow is through Shatt Alarab (a combination of Tigris, Euphrates, and Karun Rivers), followed by 43% from Mond River (Figure 5.10). The waste discharged into the RSA amounted to 22 km^3/yr, 34 km^3/yr, and 5 km^3/yr from the Karun, Mond, and Hilleh Rivers, respectively (MNR-I.R.Iran 2003). The contaminants and their respective concentrations were BOD5 (4.0 µg/l), nutrients (about 5 µg/l), and iron (1.2 µg/l).

In Iraq 11 waste treatment plants with a total capacity of 650,000 m^3/day are located near the rivers. Contaminants reach the RSA through Shatt Alarab. Hydrocarbon contamination due to sediment transport near Shatt Alarab during August 2003 (Figure 5.11-1) was indicated in the northern part of the RSA by ROPME satellite receiving station. Other images also showed algal plumes, which resulted from the increase in nutrient levels (Figures 5.11-2 and 5.11-3).

Another source of liquid discharge to the RSA is industrial wastewater, especially from power and desalination plants. Although RSA contains a vast number of oil industrial plants, wastewater in most of these is controlled, with several treatment plants located adjacent to the industrial areas. Of major concern are the power and desalination plants, which discharge wastewater directly to the sea. The total daily production of desalination plants in the RMS, with the exception of Iran, is 23,889,228 m^3 (GWI 2000), of which 49% is produced in Saudi Arabia, followed by 23% in UAE and

13% in Kuwait (Figure 5.12). The process for producing distilled water from wastewater is technique-dependent. For example, Reverse Osmosis has the lowest energy consumption of about 6 kWh of electricity/m^3 of water, while Multi-stage Flash Distillation and Multiple Effect Distillation require heat at 70-130°C and 25-200 kWh/m^3 (UIC 2004).

The effect of brine on the marine environment is evident in the increase in salinity in areas close to the desalination plants. This impact is expected since it is known that the production of 1 unit of distilled water requires 4 units of seawater, in which a 25% increase in salinity will take place. This problem is very obvious close to desalination plants in shallow areas where saturation has occurred over time. In Kuwait a significant difference in salinity was observed between samples collected 0.8 - 1.6 km from the coastline and close to desalination plants and samples from other locations (Figure 5.13). Corrosive materials can also be found in brine, contamination of sediments by which was also reported (Butayban 2005).

Power plants have no lesser impact on the marine environment. Total power plant production vary among the RMS (Figure 5.14), ranging from 1.1 GW/h in Bahrain to 36 GW/h in Iraq (GSNL 2003). The pollution load associated with the production of one unit (MW) of electricity consists of varied concentrations of BOD5, COD, chromium (Cr), Cu, Fe, Ni, Zn, oil, phosphates, TDS, and suspended solids. Among the contaminants discharged by power plants, suspended solids and total suspended solids have the highest concentrations (Figure 5.15). These discharges degrade water quality in coastal areas, which could affect marine life.

Nutrients

The RSA is very limited in nutrients, although high productivity has been observed adjacent to river mouths in the northern and eastern parts (WCMC 1991a, 1991b). Domestic and industrial sewage outfalls contribute to the nutrient budget in the marine environment. The most toxic nutrients are ammonia and nitrite. The monitoring of nutrients was undertaken in some RMS within their marine monitoring programme and the data presented in their respective state of the marine environment reports or annual reports. In Kuwait territorial waters, ammonia, nitrites, phosphates, and silicates showed very low levels over the period 1986 - 2004. The effect of point sources of pollution was evident in the high ammonia level at a station 1.6 km from the outfall of the Industrial Petroleum Company, which produces urea (Figure 5.16). Although the average ammonia level falls within Kuwait's national standard, particular attention should be directed toward this issue in order to prevent any future pollution of the marine environment (Butyban 2005).

Other attempts at measuring nutrients in the open sea were carried out during the last five research cruises organized by ROPME. The results are presented in SOMER (1999, 2000, 2003). Results indicated very low levels of nutrients in the open sea and slightly increased levels in the stations nearer the coast.

In 2003 ROPME established its satellite receiving station, which could be used to detect coastal activities and their effects on the marine environment. A recent image (May 2005) from the station indicated plankton growth in the northern and eastern parts of the RSA (Figure 5.17). Another image showed high biological activity in the form of algae patches near Halul Island in Qatar (Figure 5.18), which could be attributed to wastewater discharge in this area. Greenish patches of phytoplankton in the coastal waters of Oman were seen near Ras Alhad, Masira Island in early May 2005.

The analysis and interpretation of these data with other existing data, as well as other measures undertaken in individual RMS will help in evaluating the status of the marine environment on a more regular basis. This information will help decision-makers to develop and adopt appropriate policies and strategies to protect the marine environment from land-based activities.

Litter

Litter from various sources poses an increasing problem in the RSA. Litter comes from oil platforms, fishing vessels (including small fishing boats), coastal tourism facilities (resorts, hotels, and public beaches), and coastal urban centres. Ships are another source of litter; it has been estimated that 1.2 - 2.6 kg/person/day of plastic waste is generated on ships, much of which is thrown overboard (Anbar 1996). Solid waste (building demolition materials) is often used for land-filling, which damages habitats and creates ugly and unsafe conditions on the coast.

Efforts to clean beaches and remove litter are carried out by voluntary initiatives. At the national level some RMS (Bahrain, Kuwait, Qatar, and UAE) conducted 'Campaigns for Beach Cleaning' as one of the public awareness programmes aiming to protect the marine environment. An advanced and noticeable effort was also undertaken by the Kuwait Dive Team, which is supported by various governmental and non-governmental bodies. For example, in 1999 the team shifted the 100-tonne dhow from Doha Harbour to Dhow Harbour in Salmiya. In addition, up until 2003, more than 18 fishing nets measuring more than 3,000 m^2 and weighing more than 3 tonnes were removed from the reefs of Kuwait. The team was also involved in implementing measures to protect marine life; in 2003 it placed 84 buoys around the Kuwaiti coast to protect the coral reefs. Concrete blocks were also used to establish artificial reefs. In the 2004 "Clean-Up the World Campaign" organized by the Dubai Municipality more than 2836 tonnes of waste, 10 tonnes of which came from the Dubai creek bed, were collected.

Atmospheric deposition

Industrial installations including oil refineries, oil storage centres, oil platforms, and petrochemical, fertilizer, power, and desalination plants, as well as motor vehicles are the main sources of atmospheric pollution in the RSA. Dust storms are also contributing to the atmospheric deposition load. The effect of atmospheric pollution on the RSA marine environment is dependent on several factors. For example, the location of industrial plants in relation to metrological conditions (mainly wind direction) and the quantity and type of oil used in industries can determine the degree of risk to the marine environment. Oil industries are characterized by emissions of hydrocarbons, nitrous oxides (NOx), carbon monoxide, and sulphur dioxide (SO_2) in addition to the particulates. The levels of these pollutants depend on the process used and type of oil produced.

The total capacity of major oil refineries in Bahrain, Kuwait, Oman, Qatar, and UAE is 1.7 million bbl/d (GSNL 2003). In Saudi Arabia oil refineries contribute 58% of SO_2 emissions while power plants account for 18%. Oil refineries are the major contributor to the volatile organic carbon load, representing 98% of the total load. About 2.0 tonnes/yr of V are emitted by the power plants. Cement plants represent the major source of particulate emissions (78%), followed by power plants with 13%. NOx accounted for 34% of the total emissions in Saudi Arabia, with the petrochemical industries contributing 32% (LBA- Saudi Arabia 1999). In Oman the levels of emitted pollutants were within the permissible limits of the US Environmental Protection Agency and the World Health

Organization (US-EPA/WHO). Levels of hydrocarbons varied between 2.1 - 3.3 μg/m^3; the US-EPA allowable limit is up to 160 μg/m^3. Emission loads in Iran come from various domestic and commercial sources (SOMER 2003).

Carbon emissions related to energy production varied between 5.6 million tonnes in UAE to 90.1 million tonnes in Iran (GSNL 2003), with a total of 177.5 million tonnes in the region. The percentage contribution among the RMS is shown in Figure 5.19.

Vehicular traffic showed a notable increase in the last decade, with the pollution load depending mainly on the fuel type and quantity used. The principle pollutants from this source are particulates, PAHs, and Pb, although there has been an increase in the consumption of unleaded gasoline. Mercury was also found in air as a result of traffic. Over a 24-hour period in Kuwait the concentration of mercury varied between 2.0 - 6.5 ng/m^3, with the highest levels reported during the rush hours (Al-Majed 2000).

Another source of atmospheric pollution in the RSA is dust storms, which come from almost all directions and which affect the marine environment. Wind direction and speed are major variables for estimating the contaminant load of dust storms. During the last two decades the RSA was affected by wars, e.g., the Gulf and Iraq Wars, in which a large quantity of oil was burned. The resulting soot, heavily contaminated with all types of combustion products (PHCs, PAHs, etc.), as well as SO2 passed over the marine areas. About 20,000 tonnes of SO2 were emitted during the Kuwait oil fires for almost seven months, which was almost comparable with the daily total emitted SO2 from electricity generation in the RSA (Husain and Memon 2002). Recent satellite images processed by ROPME have revealed some of these trends (ROPME 2005).

The Asian Brown Cloud resulting from the numerous industrial developments in Asian cities also passes across the RSA. However, so far no data are available to reflect the impact of this polluted cloud on the RSA. Air monitoring stations should be established in different Asian countries to monitor the air quality of this phenomenon.
Air monitoring programmes in several RMS (e.g., Kuwait) started in the 1980s with fixed and mobile monitoring stations. The levels of the major pollutants are available directly online through the Environment Public Authority website (http://www.epa.org.kw). In Iran information on air quality is provided to the public on fixed monitors in Tehran City. On a regional level the ROPME secretariat can monitor the air direction of dust storms and other similar cases without specifying the quantity or quality of the pollution.

Heavy metals

Heavy metal pollution in the ROPME marine environment arises from a combination of various sources: industrial releases, power and desalination plants, treated and untreated sewage discharges, atmospheric deposition, and dust fallout. As a result of electricity generation in the RSA about 10 tonnes/yr of Zn, 45 tonnes/yr of Ni, 6 tonnes/yr of Cr, 5 tonnes/yr of Cu, and 527 tonnes/yr of Fe are released to the RSA (Figure 5.20).

The levels of trace metals and compounds such as Cd, Cr, Cu, Ni, Zn, V, Pb, arsenic (As), mercury (Hg), Tributyltin (TBT), etc., are monitored by most of the RMS as part of their national monitoring programmes. Measurements were also taken in seawater, sediments, and biota during the regional research cruises started in the early 1990s.

Trace metals measurements in nearshore sediment of the ROPME region were included within the ROPME/IAEA contaminant screening programme. All results are presented in the three editions of the regional state of the marine environment reports (SOMER 1999, 2000, 2003). High levels of trace metals were found in samples collected close to industrial areas and in harbours. Tin and organotin compounds were reported in UAE at Jebal Ali port complex, at Umsaid in Qatar, and off BAPCO and Askar in Bahrain. In Oman these compounds were found only on the west coast of Masirah Island. TBT was found at levels ranging from 0.82 - 20 ng/g of fish muscles, 0.82-8.5 ng/g of fish tissue, and 0.8 - 480 ng/g of bivalve samples.

High Cd concentrations were detected in fish samples from the southern coast of Oman. This was attributed to food chain bioaccumulation of this metal brought into the productive surface water by the natural upwelling process occurring in the region (SOMER 2003). Mercury levels were high in muscles of bottom-feeding and carnivorous fish species, although in most of the samples they were below the WHO threshold (0.5 mg/kg wet weight). The levels of particulate and gaseous Hg in air were measured over Kuwait Bay. The concentration of total Hg (T-Hgv) is strongly influenced by wind direction. About 40% of the T-Hgv values over Kuwait Bay were higher than the global range (1-3 ng/m^3) while T-Hgp concentrations were within the global range. It has been hypothesized that local sewage treatment plants make a significant input of T-Hgv to the atmosphere over Kuwait Bay (Al-Majed 2000).

In the last open sea cruises (2000-2001) trace metals concentrations were measured in sediment samples, using the NOAA Sediment Quality Guidelines as a standard. Results ranged from 0.1-0.7 mg/kg Cd, 4 - 15 mg/kg Cu, 4 - 11mg/kg Pb, 0.01 - 0.7 mg/kg Hg, and 40 - 105 mg/kg V, and were consistent with NOAA guidelines. Zn ranged from 40 - 100 mg/kg with the exception of 2,200 mg/kg reported at the station off northeast Iran. In comparison with NOAA guidelines, Cr and Ni were found at extremely high levels ranging from 90 - 185 mg/kg and 60 - 100 mg/kg, respectively. These results were related to the sediment mineralogy in the region. In general, relatively high levels of As and Cu, and an enormous level of Zn (2,200 mg/kg) were reported for stations in the northeastern RSA, reflecting the river input to the marine environment. In northeastern Saudi Arabia relatively high levels of Cd, Cu, and Ag were reported, which could be attributed to the industrial activities in that particular area (SOMER 2003). In addition, relatively high levels of As, Cd, Pb, Hg, V, and Cr were reported for the southeastern station; this could be due to the movement of water though the Strait of Hormuz.

Persistent organic pollutants (POPs)

POPs are organic compounds of natural or anthropogenic origin that resist photolytic, chemical, and biological degradation. This increases their persistence and toxicity in the marine environment and their effects on human health. POPs include many persistent chlorinated and polychlorinated pesticides such as dieldrin, DDT, toxaphene, chlordane; several industrial compounds such as Polychlorinated Biphenyls (PCBs) and chloroparaffins; and some degradation, industrial, and combustion by-products such as PAHs, polychlorinated dibenzofurans (PCDFs), and hexachlorobenzene.

Among the chlorinated pesticides, DDT was found in concentrations exceeding 1 ng/g, compared to other chlorinated pesticides, in bivalve samples collected from the RSA during the last two decades. Data from the last five years reflected a similar trend. However, this should not be generalized and taken as conclusive unless a comprehensive study can confirm this finding under high quality control procedures, since few scattered samples were analyzed since the early 1980s. It is worth noting that the RMS have never included these measurements in their marine monitoring programmes. In addition, in most RMS the use of chlorinated pesticides are prohibited or limited under special circumstances (e.g., combating mosquitoes). They have been replaced by organophosphorus pesticides, which are less toxic since they are hydrolyzed and converted to non-toxic compounds in the aquatic environment.

Chlorinated pesticides assessment was included in ROPME monitoring programmes, and detailed results can be found in SOMER (1999, 2000, 2003). During the regional open sea cruises (2000 and 2001) a relatively high concentration of DDT (0.7 ng/g) was found in sediment samples collected adjacent to the Mond River off the eastern part of the RSA, while that of Hexachlorocyclohexane (HCH) was 0.8 ng/g in samples collected from the same area. Similar levels were found for PCBs in that area as well as in the Strait of Hormuz. These results indicate the transport of pollution by this river.

PAHs have been measured by many researchers in the region and the data are reflected in a wide range of national and international journals. Individual member states also carry out assessments of these compounds in different media. For sediment collected from Oman the ROPME/IAEA project showed results that varied between 0.1 ng/g acynaphthylene to 8 ng/g pyrene with the total PAHs less than 100 ng/g. In general, PAH levels in the RSA are far below the NOAA Sediment Quality Guidelines.

Radioactive substances

Radioactive substances have entered or are entering the ROPME marine and coastal environments, directly or indirectly, as a result of a variety of human activities, which include energy production, reprocessing of spent fuel, military operations, nuclear testing, and medical applications. Other activities, such as the transport of radioactive material, also pose risks of releases of such materials, which are hazardous to human health and to the environment.

Very limited data on radioactive substances are available for the ROPME region. During 1994 IAEA conducted an analysis for Cesium (Cs), Plutonium (Pu) and Polonium (Po) in sediments collected from Bahrain, Kuwait, and UAE. In Kuwait ^{137}Cs varied between less than 1.2 Bq/kg in the northern part of Kuwait Bay to 15 Bq/kg at Shuwaikh port, while it was undetected in UAE. In Bahrain values of less than 1.2 and 5.0 were reported for Jasra and Fast Aljirm stations, respectively. Pu and Po were analysed only in Kuwait samples. Shuwaikh samples reflected a high level of ^{210}Po (38 Bq/kg) compared to Shuaiba station (12.3 Bq/kg) on the southern coast of Kuwait. In Bubyan samples the level was about 25 Bq/kg, which could be a reflection of the specific sedimentary regime in this area, with sediments mainly transported from Shatt Alarab (SOMER 2000). Uranium (U) was also included in the contaminant-screening programme. Sediment samples collected from Kuwait and Saudi Arabia showed a maximum of 3 mg/kg and a minimum of 0.4 mg/kg (SOMER 2000). No measurements were taken for the other RMS.

STRATEGIES AND PRIORITY ACTIONS FOR SUSTAINABLE DEVELOPMENT

The RMS should expedite the implementation of ROPME's Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources and the associated Regional Programme of Action (RPA). The RPA components include surveys of land-based activities, a pilot study on POPs, and development of a river basin management plan for Shatt Alarab and other rivers in the RSA. Such efforts will require cooperation with countries outside the RSA, diplomatic skills, and the ability to draw the support and cooperation of the international and regional organizations concerned.

Dredging and reclamation activities are an almost permanent feature in many coastal areas in the RSA. As a remedial measure, strict government restrictions on dredging and reclamation should be imposed, and legislation prohibiting these activities should be strictly. Environmental Impact Assessments should be required for such operations and formal permission obtained prior to the initiation of any small or large-scale project requiring dredging or filling, particularly those adjacent to environmentally sensitive areas. Furthermore, authorized dredging operations should follow clear operational standards. The impacts of such projects on the adjacent marine and coastal ecosystems should be carefully assessed and monitored.

Projects involving land-filling and alteration of the coastal morphology of a given state need to be evaluated from a regional perspective through ROPME in order to avoid major ecological changes in the RSA. The recommendations for building reception facilities for ballast water as well as for sewage and litter should be implemented. In addition, ROPME could consider producing a protocol only for sewage by which countries become obligated to prevent the release of raw or treated sewage into the marine environment, as well as to build sewage treatment plants and to recycle the water for irrigation.

SETTING MANAGEMENT OBJECTIVES FOR PRIORITY PROBLEMS

Physical alteration, oil pollution, and sewage remain the most significant causes of degradation of the marine environment in the region. Sewage releases into the marine environment does not only mean introducing undesired nutrients and microbial and chemical contaminants but also wasting a valuable water resource that is often produced through the expensive and energy-intensive desalination process. Physical habitat alteration, when done without careful consideration of the dynamics of currents and sediment transport, could lead to disaster. The continued input of oil and other hydrocarbons into the marine environment affects not only marine life, but may also impact the quality of the water produced by desalination.

As previously mentioned, ROPME has developed ICAM guidelines to harmonize development activities in the coastal zone. Member states are also taking appropriate measures to develop ICAM plans, as well as to prevent and abate pollution from land-based activities. ICAM may be adopted at national levels but with a regional perspective in order to provide an overall framework for coastal area management. This should be complemented by more specific plans for urban and industrial areas, industrial ports and free zones, as well as appropriate plans for management of tourist centres and ecologically sensitive areas including coastal and marine reserves and MPAs. Complementary to ICAM is EIA, another planning tool that can be applied to major development projects and other human activities, which would help to significantly reduce environmental degradation, particularly from land-based activities.

CONCLUSION

Hotspots

The RSA is highly vulnerable to pollution because of the intensity of use for various activities, its close proximity to numerous sources of pollution, as well as its shallow and semi-enclosed nature and low water circulation. As a result, the entire RSA could be considered a potential environmental hotspot. Specific hotspots created by land-based activities are related mainly to industries (particularly the oil industry), desalination plants, and power plants. The risk from oil pollution in the RSA is among the highest in the world, and oil terminals and harbours throughout the region are potential hotspots. The major issues in these hotspots are oil hydrocarbons and heavy metals. Significant levels of marine pollution have been detected around coastal petroleum refining and shipping localities from which oil, grease, and other hydrocarbon compounds are released into coastal waters. Other pollution hotspots are found at the mouths of some rivers (e.g., Tigris, Euphrates, Karun, Hileh, and Monds Rivers) and domestic and industrial sewage outfalls, where the major concerns are sewage, nutrients, sediments, and heavy metals (e.g., Doha and Shuwaikh in Kuwait Bay, Ras AlNouf in Qatar, and Alsawadi in Oman).

Has the situation concerning the GPA issues improved or worsened in recent years?

As a result of growing industrialization accompanied by a high population growth rate and rapid urbanization, the region's coastal areas are experiencing increasing acute environmental problems related to land-based pollution and the degradation of coastal and marine habitats. The concentration of urban areas and industrial activities in the coastal zone aggravates the environmental problems experienced in the RSA. Increasing coastal reclamation, construction, and dredging continue to degrade productive coastal and marine habitats. In addition, during the last two decades some parts of the RSA were affected by the grave environmental consequences of the Gulf and Iraq Wars. As a result of major efforts by the RMS to protect their coastal and marine environments, the situation regarding the GPA issues has generally improved in some RMS due to implementation of rules and guidelines for pollution discharge to the sea.

Has progress been made in protecting the marine environment during the last 10 years?

Progress in the protection of the RSA from land-based activities is reflected in various achievements especially in terms of data collection, assessment and monitoring, development and implementation of appropriate policies and legislation, and adoption of regional and international agreements and action plans. A notable achievement is the adoption by the RMS of the Kuwait Convention and its Protocol for the Protection of the Marine Environment against Pollution from Land-Based Sources. The latter was signed in February 1990 and entered into force in January 1993. ROPME has developed ICAM guidelines and the RMS have had varying degrees of success in developing ICAM plans and in preventing and abating pollution of the coastal and marine environments from land-based activities.

The way forward

According to the Council Ministries (CM/12) Meeting of ROPME the Council took the decision (Decision CM/12/9) to:

1. Implement a regional programme of action for the protection of the marine environment from the land-based activities;
2. Request the UNEP Regional Office for West Asia (ROWA) to review the RPA on Land-based Activities (LBA) in order to ascertain its consistency with the GPA framework;
3. Allocate about US$450,000 to carry out the following:
    a. Updating the surveys of LBA including POPs and preparing a regional report on LBA in cooperation with UNEP/ROWA;
    b. Developing of technical guidelines for management of LBA in cooperation with UNEP/ROWA;
    c. Cooperating with UNEP/GPA and UNEP/ROWA on their strategic plan on municipal wastewater;
    d. Convening a training seminar on the LBA protocol for legal experts of the member states;
    e. Organizing of annual seminars on the implementation of the LBA protocol; and
    f. Establishing a digital data-base system.
4. Cooperation with UNEP/ROWA and partners on the GIWA project activities and on developing and implementing of river basin management programmes.

These decisions need political commitment from the RMS to be effectively implemented. With the support of UNEP, the GPA, and UNDP (which is mostly funded by the RMS themselves in the region) the RMS should organize a ministerial conference at which such commitments are made, and budgets, timetables, and deliverables clearly stated. Efforts to have the RSA designated as a 'Special Area' should also be strengthened and continued.

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Figure 5.1.

The ROPME Sea Area and Member States

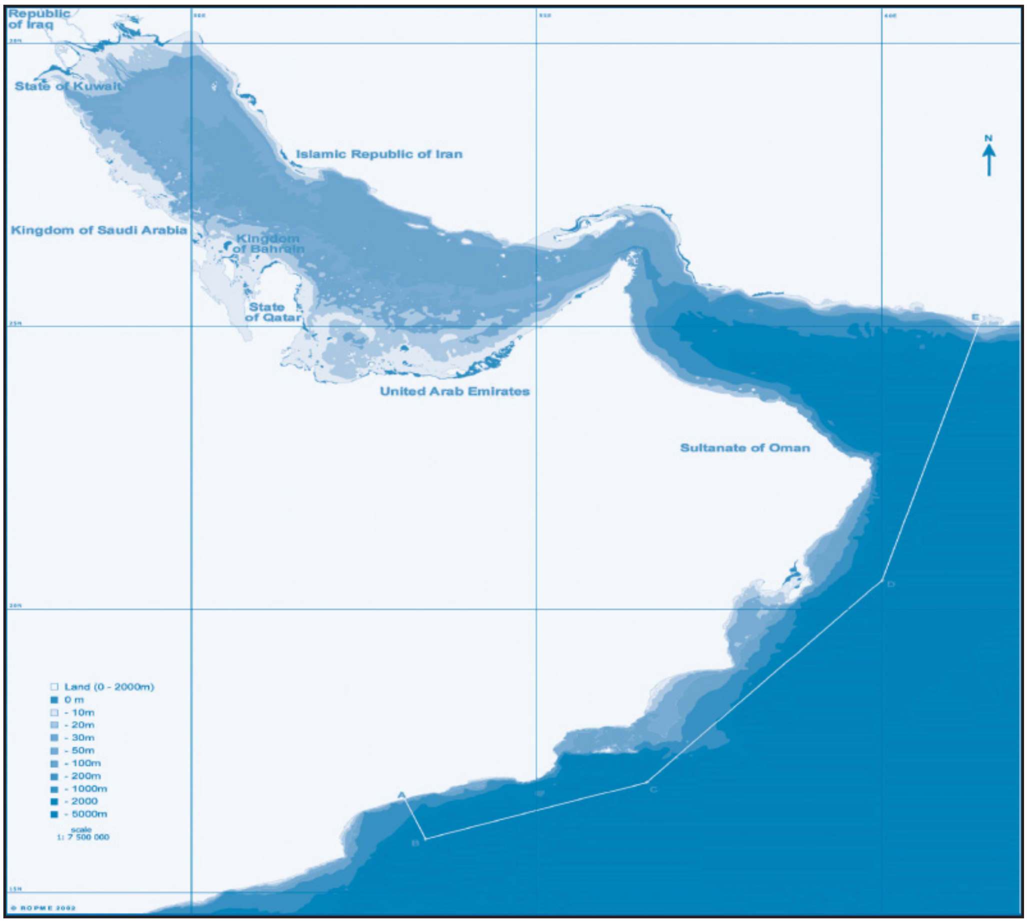


Figure 5.2

Percentage of oil exports in the RSA (2003)

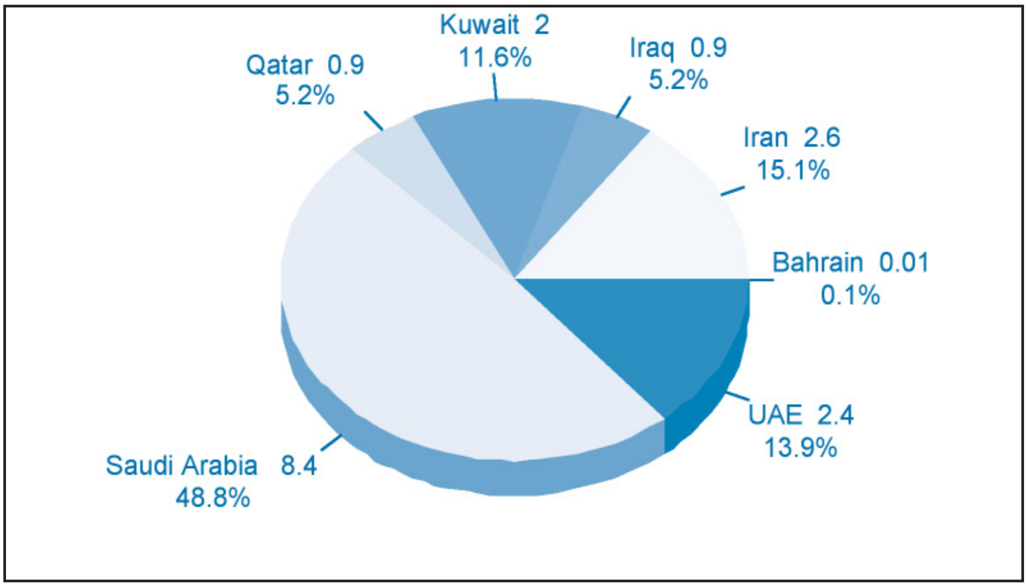


Figure 5.3

Distribution of oil ports in the RSA

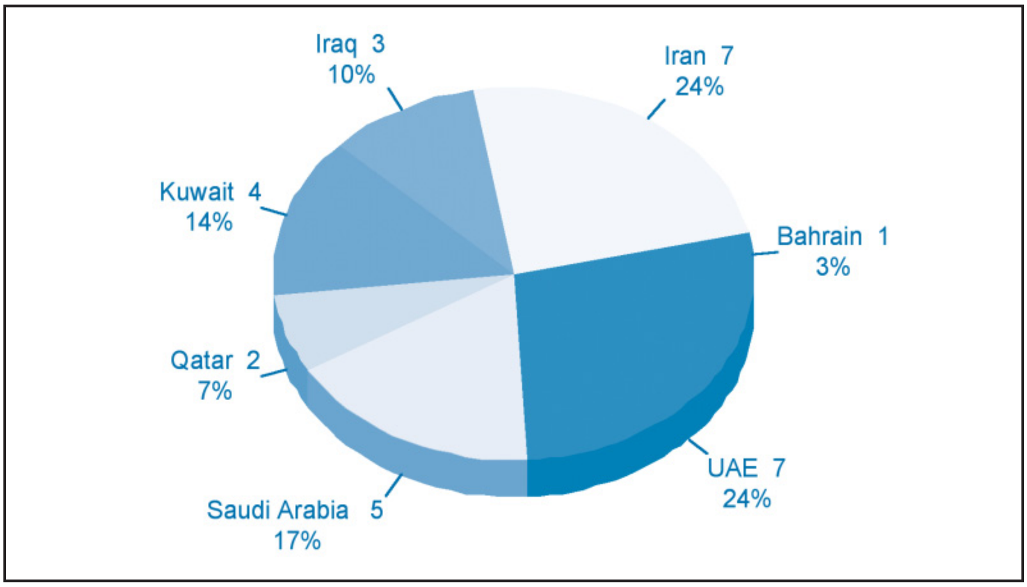


Figure 5.4

Annual mean PHC in sediments, Kuwait (1986-2002)

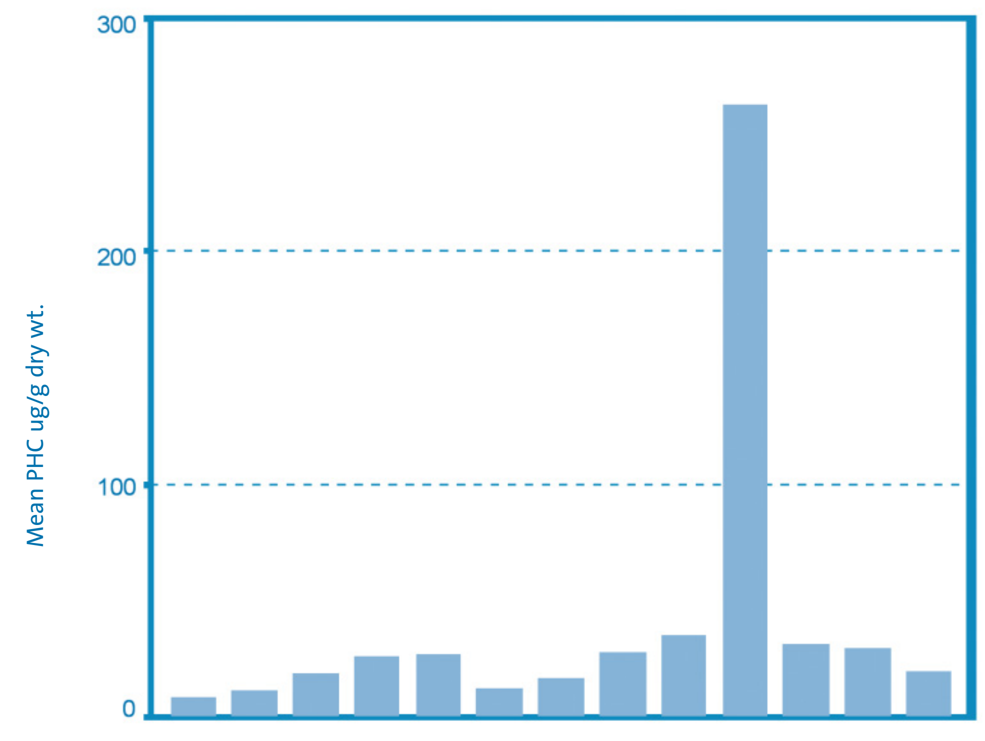
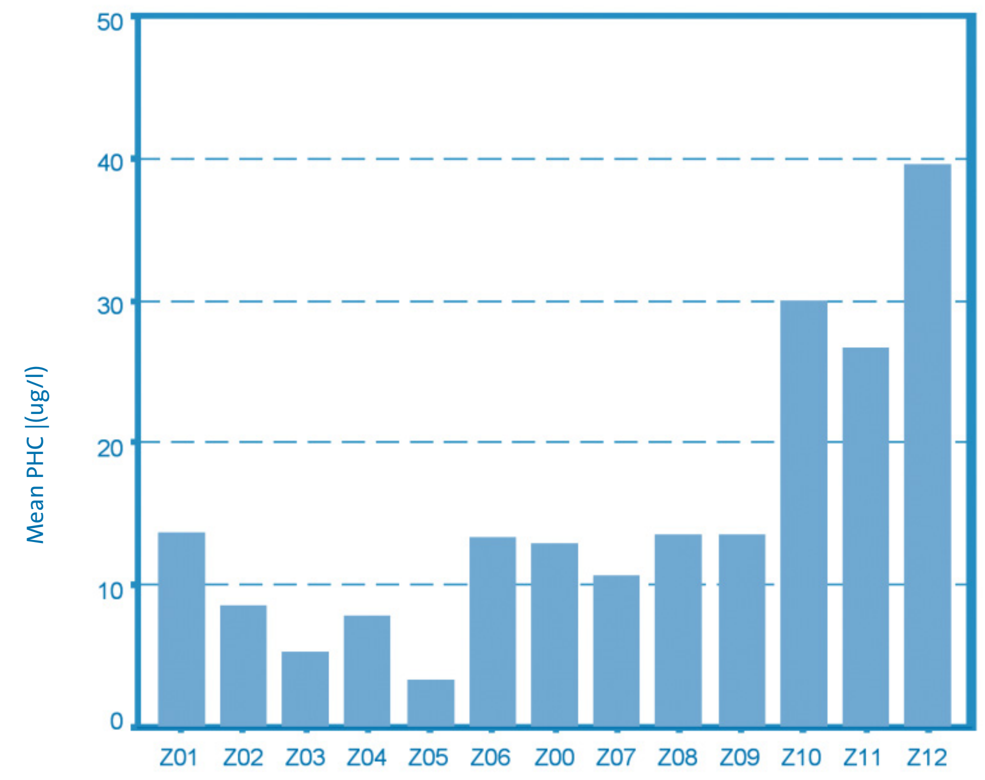


Figure 5.5

Annual mean PHC in seawater, Kuwait (1985-2004)



Note: Z9 - Z10 stations are located south Kuwait

Figure 5.6

Sediment types in the RSA

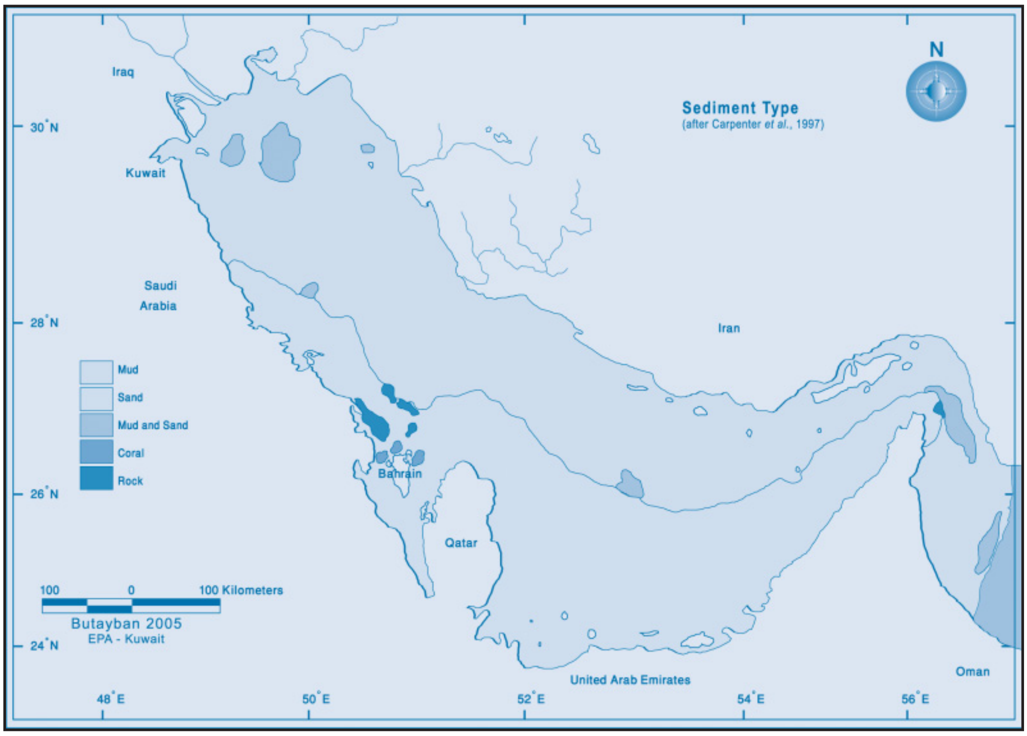


Figure 5.7

Productive trawling grounds in the RSA

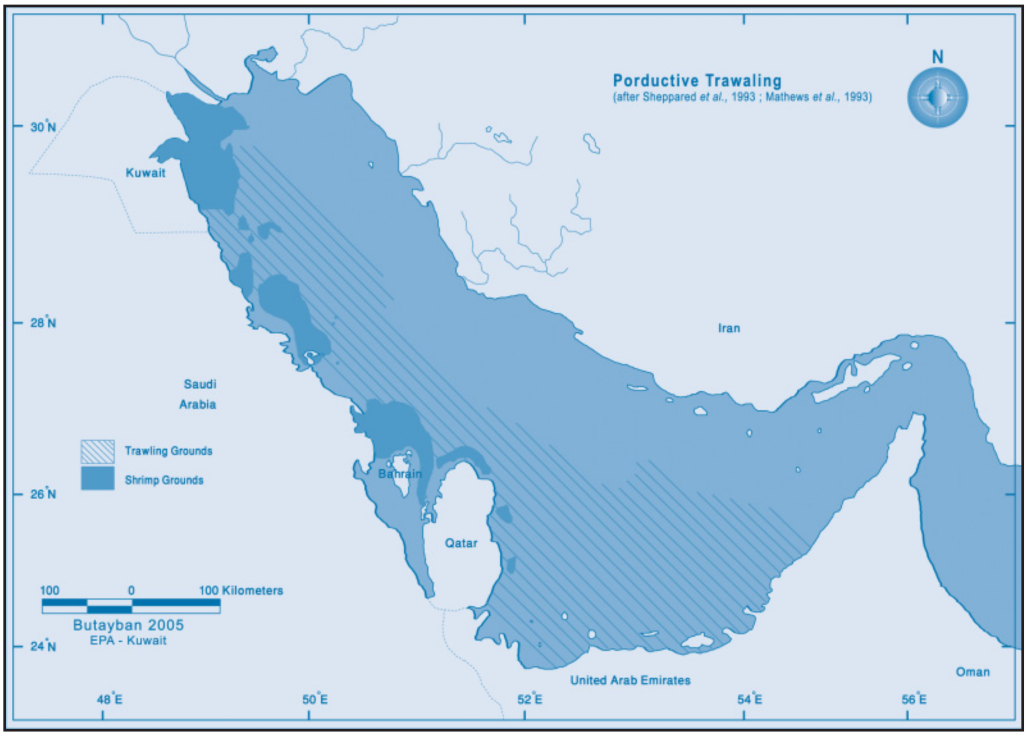


Figure 5.8

Distribution of total mercury in the upper layer of (0-15 cm) sediment samples, Kuwait Bay (1996-1998)

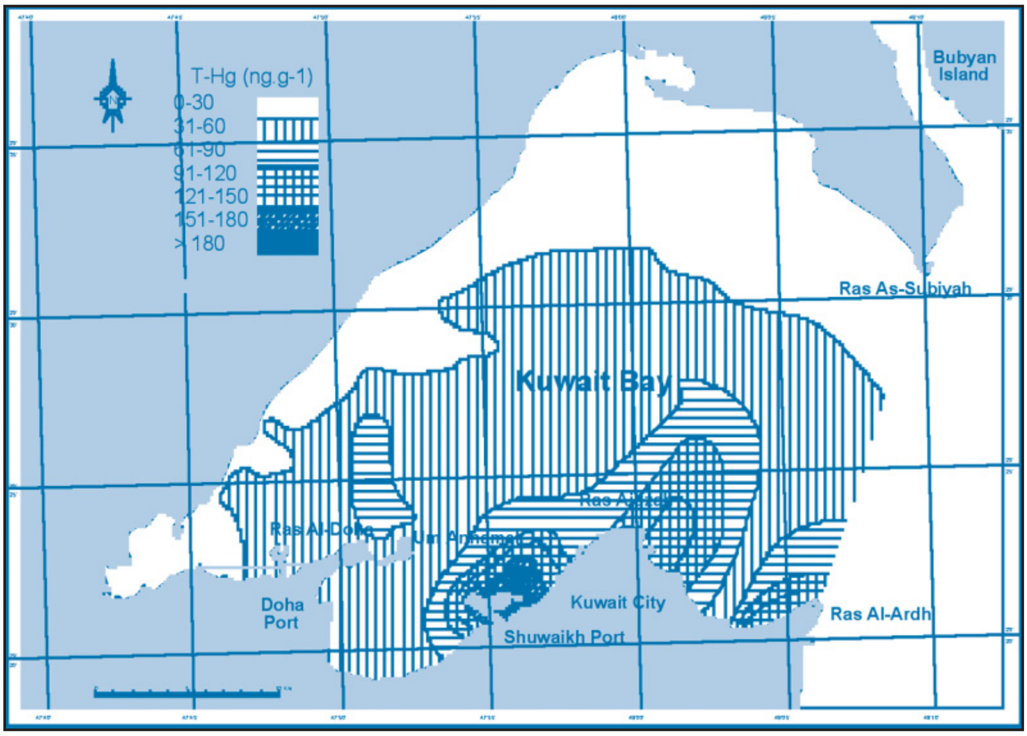


Figure 5.9

Distribution of methyl mercury in the upper layer of (0-15 cm) sediment samples, Kuwait Bay (1996-1998)

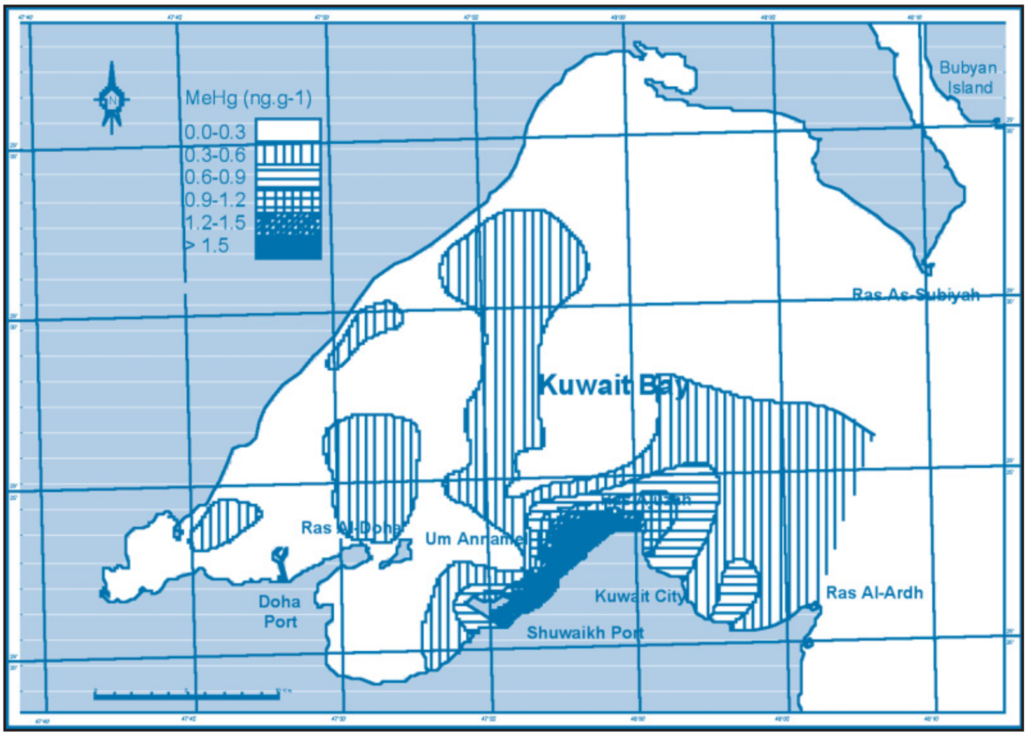


Figure 5.10

Annual average river flow (m^3/s) in the RSA

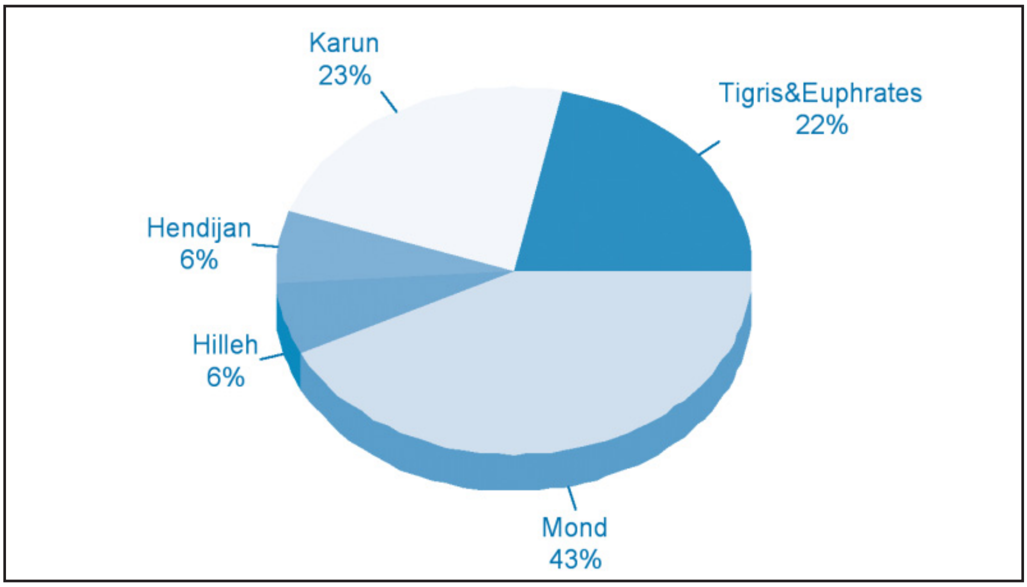


Figure 5.11-1

The contrast shows the muddy intertidal /low tide, turbidity and hydrocarbons /oil contamination of sediments (ROPME Satellite Receiving Station)

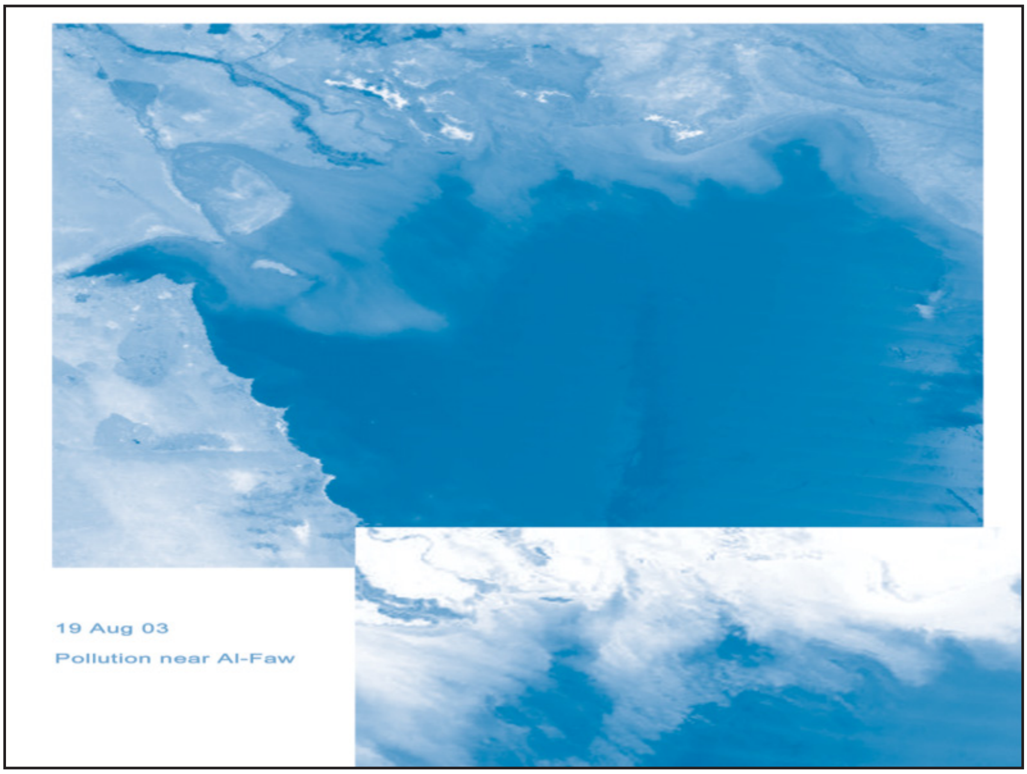


Figure 5.11-2

Increasing biological activity along the RSA coastline (8 May 2005)

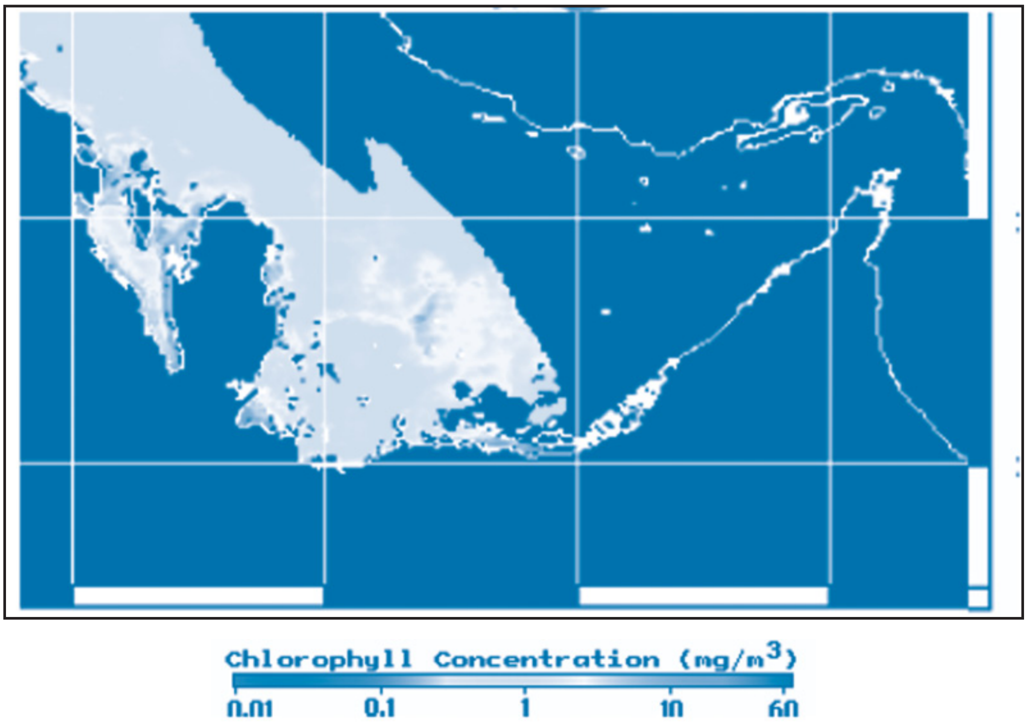


Figure 5.11-3

Growth of plankton in the northern RSA (May 2005)

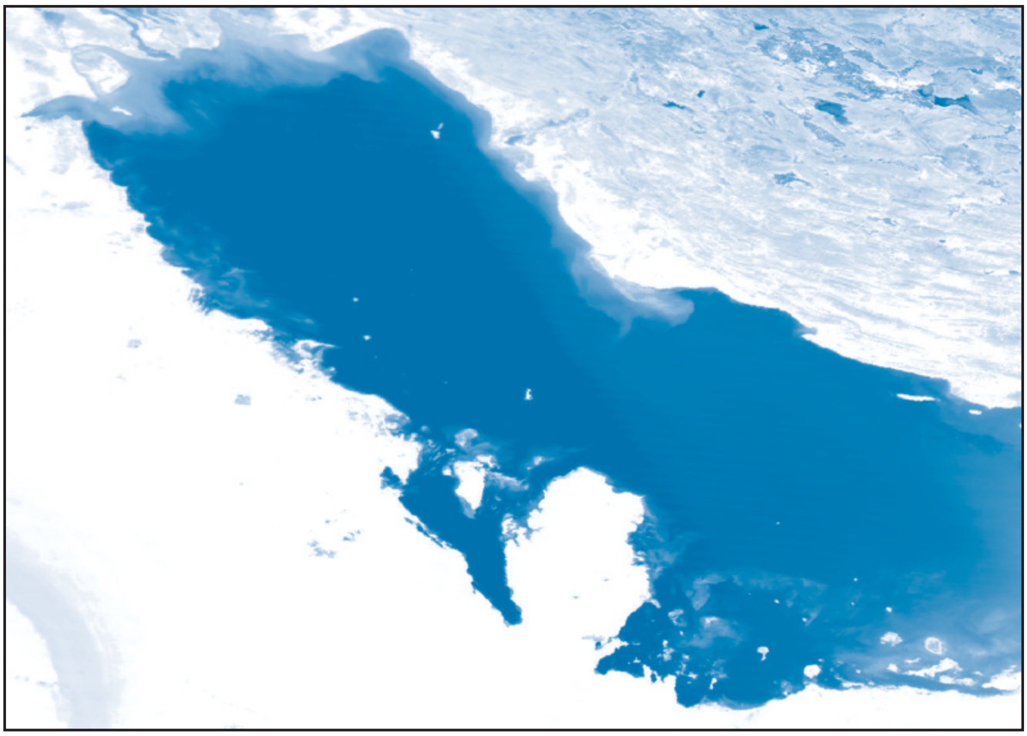


Figure 5.12

Distribution (%) of desalination plants production in the RSA

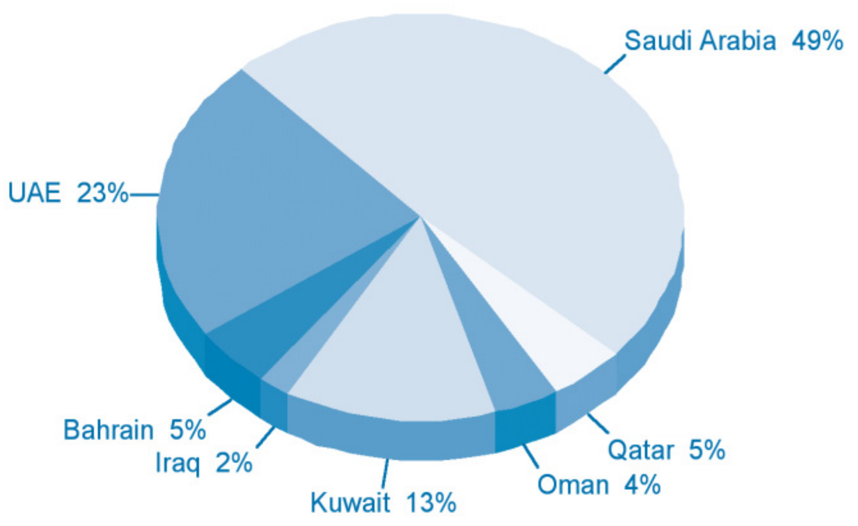
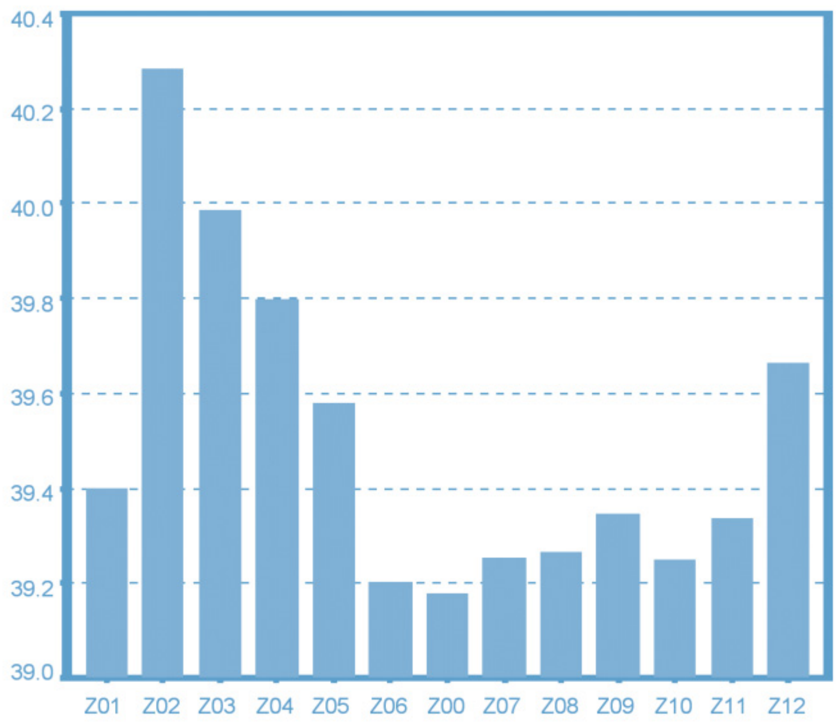


Figure 5.13

Annual average salinity in Kuwait (1983-2004)



Note: Z2, location of Doha Power plants & Z12, Location of Ras Azzor Power plant

Figure 5.14

Distribution (%) of power plants generation in the RSA

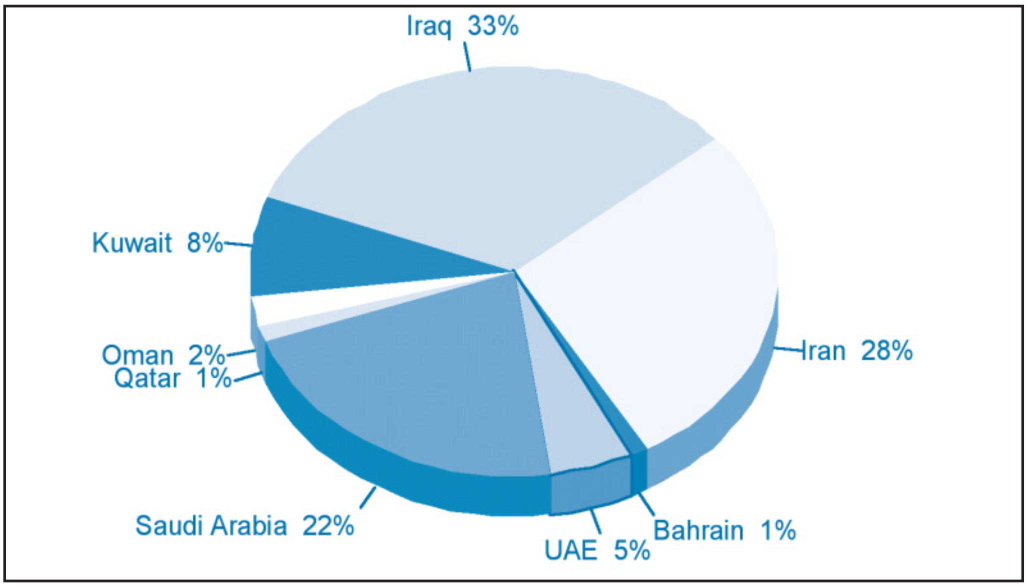


Figure 5.15

Estimated load of pollution per unit production of electricity

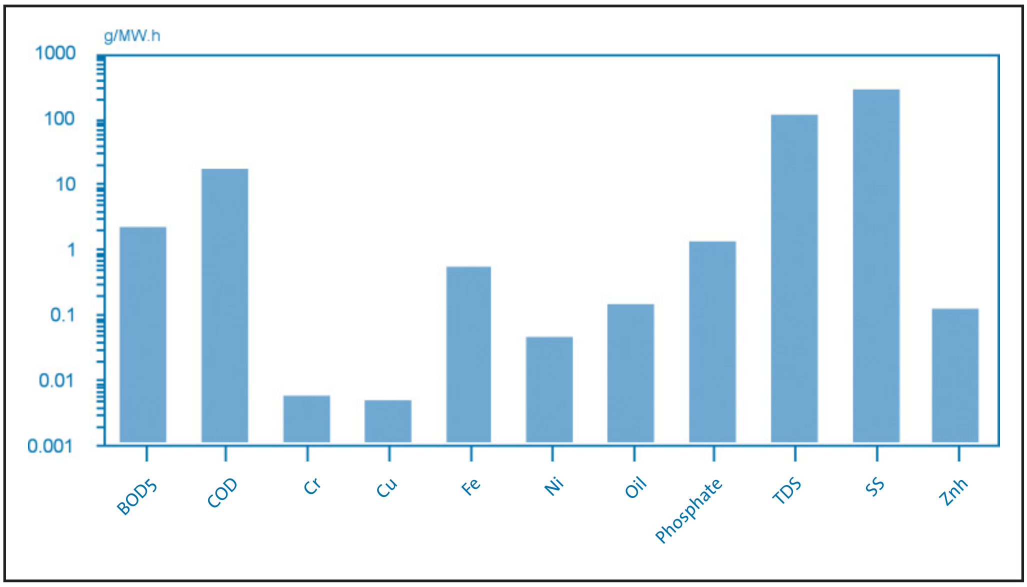
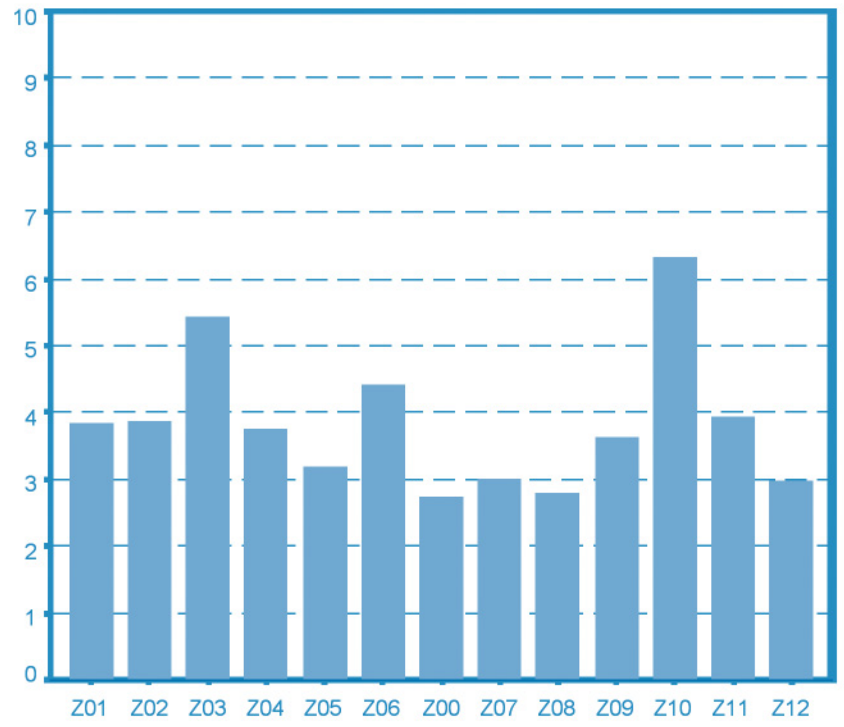


Figure 5.16

Annual average of ammonia, Kuwait (1986-2004)



Note: Z10 is 1 mile off Petroleum Industrial Company outfall.

Figure 5.17

Growth of plankton in the northern RSA

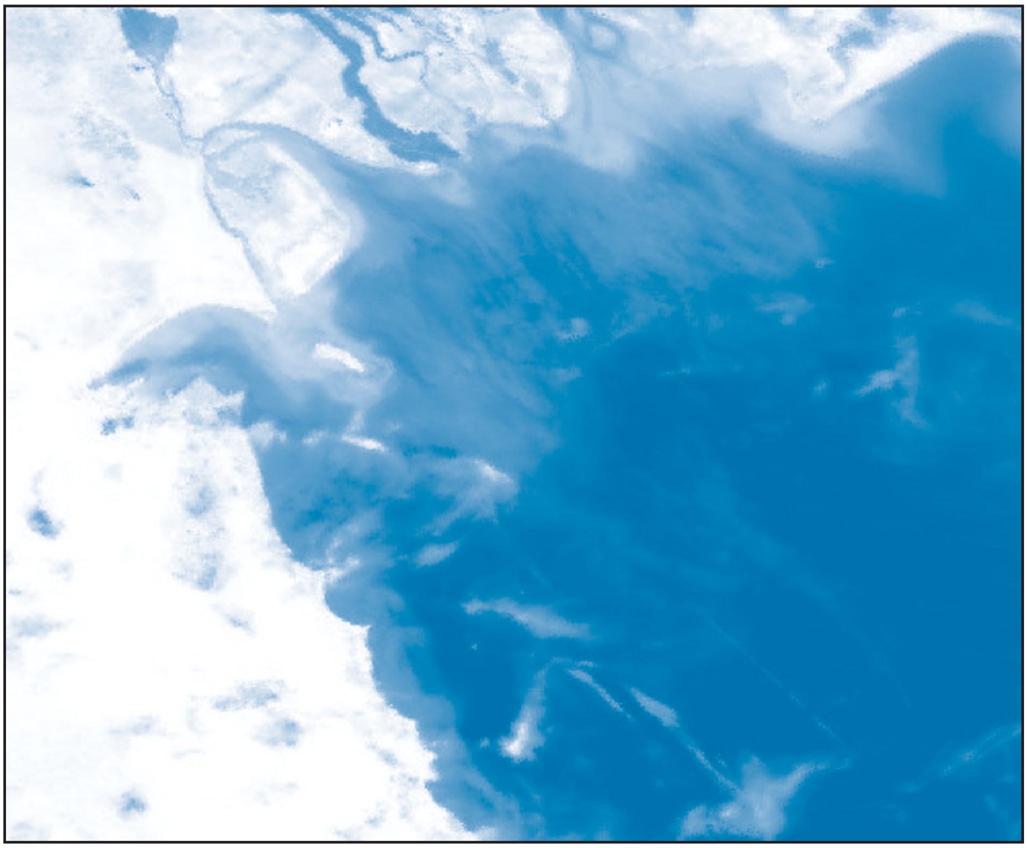


Figure 5.18

High biological activity as shown by algae patches near Halul Island Qatar (May 2005)

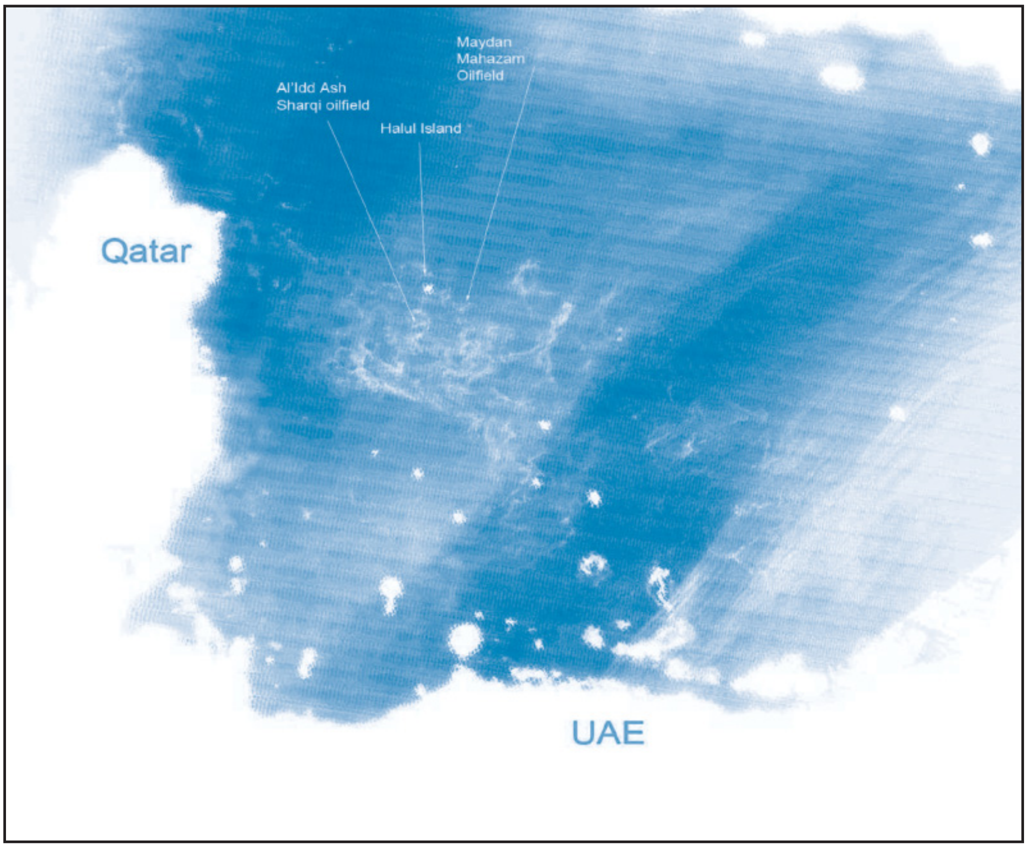


Figure 5.19

Estimated carbon emissions related to energy production (million tonnes) in the RSA

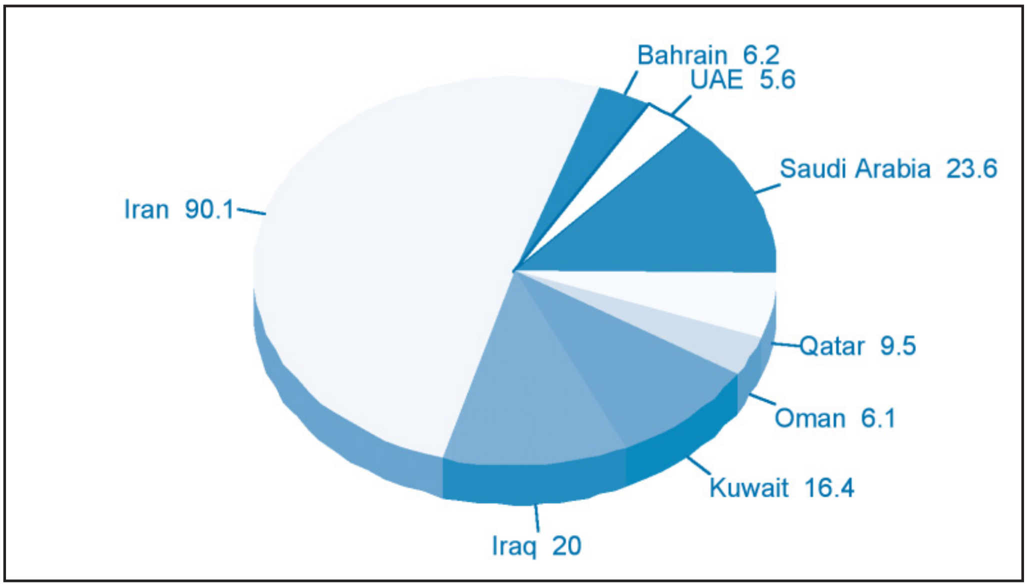
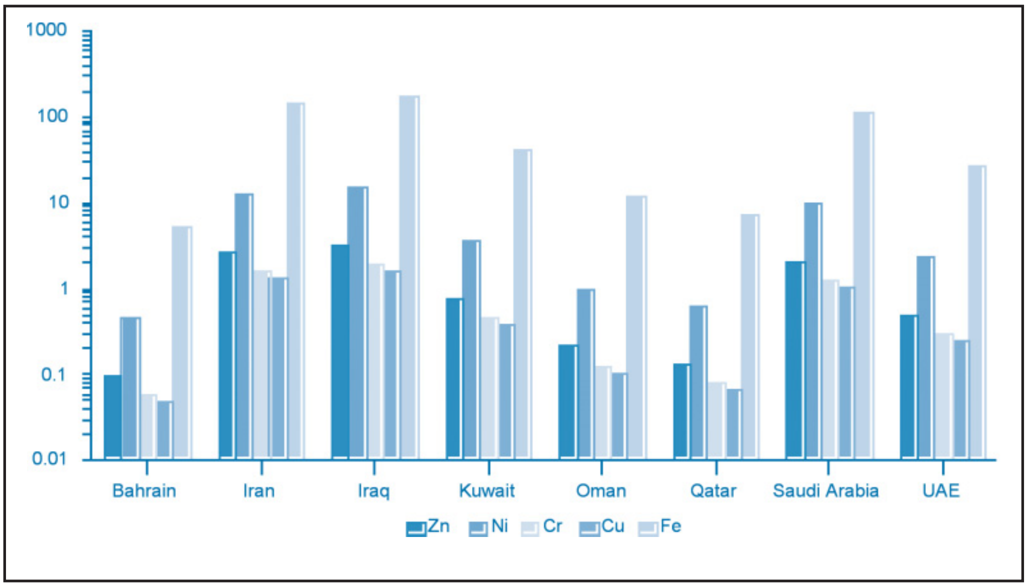


Figure 5.20

Trace metal load based on power plants production (tonnes/yr) in the RSA



6 - South Asian Seas

INTRODUCTION

This overview of the state of the environment in relation to land-based sources of marine pollution in the South Asian Seas (SAS) Region during the past 10 years is based on information obtained from available unpublished documents and draft national action plans (Integrated Coastal and Marine Area Management Project Directorate/Department of Ocean Development, Chennai, India, 2000; Anonymous (SACEP) 2004a; Anonymous (SACEP) 2004b; Government of Pakistan 2000). The available documents, however, do not provide information on reduction of adverse impacts stemming from land-based sources of pollution nor trends during the decade since initiation of the UNEP/GPA in 1995.

The SAS Region includes parts of the Bay of Bengal and the Arabian Sea in the northern Indian Ocean, as well as the seas bordering Bangladesh, India, Maldives, Pakistan, and Sri Lanka (Figure 6.1). Bangladesh, India, and Pakistan are parts of the Indian subcontinent, while the island of Sri Lanka shares a part of the continental shelf with India. Maldives is constituted of coral atolls. Although landlocked, Bhutan and Nepal are now members of the SAS Region since they have a significant influence upon land-based pollution as a result of their geographic location. In addition, their high elevation and seismicity coupled with land use have a major influence upon sedimentation in the coastal areas.

The countries constituting the SAS Region have an aggregate population of about 1.4 thousand million (UNDP 2002), almost a fifth of the world's total (Table 6.1). High population density, low income, low development indicators, and high dependence upon natural resources for livelihood characterize all the countries. Additionally, diverse forms of political instability stemming from religious, ethnic, and language differences, as well as resource scarcities contribute towards the low level of socio-economic development of the majority of the people. Nearly 500 million people exist on an income of less than US$1/day (Table 6.1); this exceeds the total population of the European Union or of North America. Dealing adequately with the sources of land-based marine pollution requires parallel attention to the causes of poverty, particularly in relation to sanitation, cultivation practices, land use, and unsustainable use of coastal and marine resources.

The major sources of coastal and marine pollution originating from land vary among the SAS countries, which show great disparity in size and demography (Table 6.1). These countries also share some common features linked to their large populations of poor people. The nature and intensity of development activities, human population size, income level, and state and type of industry and agriculture are among the factors contributing to each country's unique pollution problems. Additionally, the nature and form of regional collaboration also have a marked influence on enhancing knowledge and on building capacity at the national level. Eventually, only the national governments and their executing agencies can reduce the impacts of marine pollution on the required scale. One of the shared features among the SAS countries that retard progress is weakness in governance, particularly with regard to law enforcement (ADB 2001).

The priority issues for the SAS Region were recently identified in UNEP/GPA (2005) as:
- Sewage;
- Litter - solid waste(industrial and municipal);
- Agricultural chemicals;
- Oil hydrocarbons;
- Sediment; and
- Physical alteration and destruction of habitats.

These six priority issues have emerged from regional workshops and national studies, which generally present the governments' viewpoint. Recently, civil society organizations and environmental NGOs have begun to play a more activist role in the public interest. Alternative viewpoints are emerging, particularly with regard to industrial discharges in coastal areas and their human impact. In consideration of this, there appears to be adequate justification for the addition of persistent toxic substances (PTS) to the list of priority issues, as a significant regional issue.

In order to mitigate and control the impact of pollution on coastal and marine ecosystems and resources, it is essential that the types and loads of pollutants be identified. This involves determination of the sources and their location, the volume and concentration of the pollutants, and their dispersion. Point sources of pollution are sources that can be traced to a particular location, such as industries and sewage treatment plants. Though easy to identify, point sources account for only a fraction of the land-based marine pollution. Non-point or diffuse sources are harder to identify, and include urban storm water runoff and overflow discharges, as well as forest and agriculture runoff. Pollution sources located relatively far away from coastal areas can still have an impact on these areas. For example, pollutants from sources and activities within a drainage area can be carried to the coast by rivers. In the SAS Region numerous cities and industries with inadequate waste management are situated along major rivers such as the Ganges, Narmada, and Indus. Pollution from distant sources can also enter into the marine environment through atmospheric deposition.

The tsunami of 26 December 2004, which seriously affected Sri Lanka, India, and Maldives, demonstrated that in addition to land-based sources of pollution induced by human activity, natural events result in substantial but episodic contributions mainly in the form of sediment and litter. An estimated 1.1 thousand million tonnes of debris and litter resulted from the tsunami in Sri Lanka (Ministry of Environment and Natural Resources 2005, UNEP 2005). Some of this debris adversely impacted natural coastal habitats such as seagrass beds and coral reefs (UNEP 2005).

LAND-BASED SOURCES OF POLLUTION

Sewage

Sewage is one of the most significant pollutants affecting the coastal and marine environments of the SAS Region. Except in a few urban areas, the sewage treatment facilities are inadequate. Reported treatment capacity in Mumbai (15%) and Karachi (6%) reflects the gap that must be bridged in order to provide adequate treatment only in the major coastal cities (SACEP/UNEP 2000). The inadequate number of sewage treatment plants in operation, combined with the poor operating conditions of the existing plants and the practices of discharging mostly untreated wastewater are likely to have an adverse impact on the quality of coastal waters. As a consequence of steadily growing coastal populations in most of the countries, the amount of poorly treated or untreated sewage wastewater being discharged into coastal waters is increasing. During the next decade, several of the biggest cities in the SAS Region, including Mumbai, Kolkata, Dakha, Chennai, and Karachi will rank among the largest in the world. This has serious implications for the health of the region's coastal and marine environments.

Sewage can cause public health problems either from contact with polluted waters or from consumption of contaminated fish or shellfish. Furthermore, the discharge of untreated sewage effluents also produces long-term adverse, but localized impacts on the ecology of critical coastal ecosystems due to the contribution of nutrients and other pollutants. Sewage pollution causes nutrient enrichment around population centres, and high nutrient levels and even eutrophication near treatment facilities and sewage outfalls. Elevated nutrient concentrations promote increased algal and bacterial growth, degradation of seagrass and coral reef ecosystems, reduced fisheries production, along with risks to human health.

BOD is commonly used as an indicator of sewage load (1,000 kg/m^3 of sewage generate 250 µg/l BOD). Based upon this estimate the total daily load entering the coastal waters is massive in comparison with regions with advanced sewage treatment systems (Table 6.2). The sewage load in the SAS Region has progressively increased during the past decade in the absence of adequate expansion of treatment systems. In a separate estimate 7,000 million l/day of sewage are generated in the coastal areas of all the South Asian countries.

Unfortunately, in most instances, sewage does not only contain human waste but also various environmentally harmful household compounds. This problem is further exacerbated by the common practice of discharging untreated or inadequately treated industrial wastewater into the domestic wastewater stream. The situation at Ankleshwar, India, located in Gujarat's Golden Corridor, the biggest industrial estate in Asia, is illustrative: the liquid wastes are simply dumped into storm sewers, canals, and ditches (The Hindu 1995). As a result, most sewers contain a variety of toxic and non-biodegradable substances, making their treatment less effective and more costly. Some of the effluents go directly to the Amlakhari River, which passes through villages that use the water from this river. Six effluent outlets carry the waste, both treated and untreated, through the open countryside to the mouth of the Narmada. The above situation is a common feature in the vicinity of industrialized coastal townships in Bangladesh, India, Pakistan, and in Sri Lanka.

Litter: solid waste and marine debris

In the SAS region solid waste generally arises from domestic and industrial sources. Domestic waste also includes hospital waste, which pose a serious threat of infection and communicable diseases. The quantity of solid waste generated by the coastal population of the SAS Region was estimated at 11,650 tonnes/day (average of 0.5 kg/person/day). The composition of the solid waste reported for Karachi (SACEP/UNEP 2000) and for Kolkata (The Hindu 1995) may be regarded as roughly representative for the SAS Region. The major part is compostable material, while other recoverable material, which may have immediate commercial value, is very low (Table 6.3). The waste from rural areas is mostly composed of paper, plastics, and biodegradable matter.

Only a fraction of the solid waste generated is collected; the rest is dumped in a haphazard manner in open areas (Gov't of Bangladesh 1999, Gov't of India 1999, Gov't of Pakistan 1999, Gov't of Sri Lanka 1999). The collected waste is dumped in open areas outside the city/town limits and incinerated in the open air. Even though the quality of the emissions is supposed to be monitored, it is believed that most often they contain toxic compounds as well as harmful bacteria, as the wastes also contain hospital wastes, plastics, and compostable matter. Much of this material is carried into coastal waters during the rainy season. Rivers, streams, and mangrove swamps are also used as dump sites.

The most common manner of waste disposal in the SAS Region is dumping in sanitary landfills as they are the cheapest and use simple treatment methods. In 1995, Bombay generated about 7,000 tonnes/day of solid waste, while the installed capacity of sanitary landfills barely matched this production rate (The Hindu 1995).

It is likely that the rate of production may have outstripped existing treatment capacity during the last decade (Table 6.4). The more advanced types of sanitary landfills with superior management are rare, requiring large extents of land and proper drainage to prevent leachates from polluting surface and groundwater. Poorly managed landfills become a nuisance because of the foul smell and may also become dangerous as a result of the excessive production of methane gas. Residents of Visakhapatnam, a coastal city in India, forced its municipality to close a landfill site because it was producing methane gas (The Hindu 1995). Poorly managed landfills in coastal areas can also become sources of marine debris, especially in the rainy season when waste is washed out to sea. The major problem with landfill sites is their limited lifespan. In general, the use of sanitary landfills in the SAS Region is not well documented. At present little published information is available on the amount of solid waste generated in the SAS Region and how it is handled prior to final disposal. However, many local interventions by NGOs and community groups in India are demonstrating that a multi-pronged approach to urban solid waste management is both effective and cost-efficient (The Hindu 1995).

The increasing amounts of solid waste in the coastal zone are detrimental to the economies of many countries, especially those dependent on coastal fisheries and on tourism. Some objects, such as glass and hypodermic needles, are a potential health risk. Scientists have documented an increasing number of injuries and death among marine mammals, fish, sea turtles, and birds due to entanglement in solid waste. Furthermore, animals can mistake plastic items and pelagic tar as food. Marine animals that accidentally ingest plastic may feel a sense of fullness and slowly starve to death.

Solid waste dumped at sea come from shipping, commercial fisheries, and other offshore activities. Ship-generated waste account for approximately 80% of the solid waste in the coastal areas. The disposal of solid waste by ships in nearshore areas is regulated by Annex V of the MARPOL 73/78 Convention. Compliance with this convention requires countries to provide port reception facilities for waste generated by shipping activities. At present, however, many of the SAS countries lack such facilities. This could result in solid waste being disposed of at sea from where it is transported by wind and currents to the shore, often distant from the original source.

The most effective way to reduce this pollution is to stop it at the source. To this end, increasing public awareness, strengthening local legislation, promoting proper garbage collection, transportation, and disposal system, including the development of port reception facilities as required under Annex V of MARPOL, are some potential measures to address ship-generated solid waste pollution in the region.

Agricultural chemicals

The SAS Region is one of the world's major agricultural regions. In addition to local consumption, some varieties of rice (e.g., Basmati), wheat, cereals, etc. are also exported, mostly from India and Pakistan. During the past decade the cultivation of high yielding varieties has expanded with the inevitable increase in the application of agro-chemicals. In Bangladesh, the rice cropping area in the coastal zone is about 5.6 million ha, about 40% of which is used for high yielding varieties (Islam 2004). In India rice and cereals are major crops in the coastal areas. Average fertilizer consumption is about 75 kg/ha, while insecticides are used at a rate of about 13.3 kg/ha. In Pakistan agricultural activity is sparse in the coastal areas. However, in areas adjoining the Sindh coast a large quantity of rice and other crops are produced, accompanied by fertilizer and pesticides application. In Sri Lanka, even though agricultural activities are not widespread in the coastal areas, the application of 77 kg/ha of fertilizers and 1.6 kg/ha of pesticides has been reported. In view of the growing populations in Bangladesh, India, and Pakistan, agricultural activity may be expected to increase during the coming years. Although the intensity of agro-chemical application is not as high as in developed countries, the absolute quantity used is higher.

Agricultural run-off containing large amount of nutrients in the form of nitrogen and phosphorous compounds, as well as residues of insecticides mostly belonging to organo-phosphorous and synthetic pyrethyroid groups reach the rivers and eventually the coastal waters.

Nutrients

Continued economic growth and development has drastically changed the traditional land-use patterns in the SAS Region. Agricultural development has been rapid, with fertilizers being an important source of nutrients to the coastal zone. Coastal areas have also seen increased population growth accompanied by changes in adjacent land use, aggravating the pressures on the marine and coastal environments. Sewage from coastal settlements is also a major source of nutrients in coastal waters. Nutrients enter the coastal waters from both point and non-point sources. In addition, nutrients, especially nitrogen, also enter the marine environment through atmospheric deposition, with vehicular traffic being an important source of atmospheric nutrients.

Nutrient enrichment is an increasing concern in coastal wetlands (estuaries and lagoons) in the SAS Region. The discharge of nutrients associated with agricultural runoff is a major cause of eutrophication in coastal waters, especially in areas of limited water circulation. Eutrophication may cause algal blooms, changes in aquatic community structure, reduced biological diversity, fish kills, and oxygen depletion. Habitat degradation will in turn cause reduced fisheries production and loss of the recreational and tourism potential of the coastal zone.

In order to control the sources of nutrient enrichment and to reverse the adverse effects of eutrophication, it is necessary to improve the effectiveness of nutrient reduction in sewage treatment plants and to control runoff from non-point sources by improving management practices in agriculture. In addition, practices that promote long-term benefits and cause the least damage to inter-related ecosystems should be encouraged. The discharge of sewage into coastal waters in areas important for tourism such as Hikkaduwa, Sri Lanka, has resulted in increased algal growth on coral reefs. Tourism at this and several other locations is directly linked to the health and beauty of the fringing coral reefs.

Pesticides

Pesticides (insecticides, herbicides, fungicides, etc.) are extensively used in conjunction with agriculture within the SAS Region. It has been estimated that 90% of the applied pesticides does not reach the target species. These compounds reach the coastal and marine environments via rivers and by atmospheric transport. Pesticides are highly toxic and in the marine environment may affect living organisms and present a public health risk through seafood contamination. The environmental effects of pesticides depend on the chemicals used, the quantities applied, the biophysical layout of the farm, including the amount of vegetation cover, slope, drainage, and the presence of riparian buffer zones along rivers and streams. Water-soluble pesticides are potentially more damaging because they easily enter the coastal environment.

Frequent floods in the Indian subcontinent mobilize substantial quantities of pesticides into coastal waters.

Areas under particular threat are those with little water exchange and circulation, where pesticide residues are not quickly flushed out. The impact of pesticides in the marine and coastal environments includes changes in reef community structure, such as decrease in live coral cover and increase in algae and sponges, as well as damage to seagrass beds and other aquatic vegetation by herbicides. Marine organisms may be affected either directly, as the pesticide moves through the food chain and accumulate in the biota, or by loss or alteration of their habitats. This, in turn, could lead to decreased fisheries production. Pesticides may also cause fish kills in areas of poor water circulation. They also contaminate groundwater and drinking water supplies.

Reducing pollution of the coastal and marine environments by pesticides require a change in agricultural practices and in the handling of pesticides. The introduction of more recently developed pesticides with lower application rates should be considered. Some pesticides and insecticides are sediment-binding, and the amount reaching the coastal environment could be reduced by controlling soil erosion in agricultural areas. As yet, not much data are available about the behaviour of these pesticides in the tropical marine environment, including degradation rates, fractionization partition, as well as on biological uptake and transfer through the food chain to humans.

The Survey of the Environment for India (The Hindu 1995) reported that the chemical industry is expected to grow since agricultural chemical sales doubled and agro-chemical exports nearly tripled between 1987 and 1991. Industry analysts have predicted a similar growth in the future (The Hindu 1995). The impact on the marine environment from agricultural chemicals may have become more damaging during the past decade and requires verification. There is increasing likelihood that, in absolute terms, the quantities of pesticides used in the next decade may increase in the SAS Region as population growth continues and the demand for food rises.

Oil hydrocarbons

Although the countries in the SAS Region are not major oil producers, land-based activities generate a considerable quantity of oil hydrocarbons that eventually enter the marine environment. The main continuous source of oil discharges include:

- Road vehicles and associated services;
- Mechanized boats and associated services;
- Industrial use of oil in the form of machinery oil, furnace oil, and processing of crude oil into petroleum products;
- Coastal oil refineries; and
- Ship breaking.

Contribution to marine oil pollution is also made by oil tankers, which transport an estimated 500 million tonnes annually through the SAS Region. Unmonitored and illegal activities such as discharging bilge washings result in eventual deposition of tar balls on the beaches. Oil spills are rare, although serious episodes have occurred during the past decade, including the 2003 grounding of a tanker in Karachi in which about 27,000 tonnes of crude oil were released into the sea (Figure 6.2). In Bangladesh and India more than 50% of the oil pollution in the marine environment comes from the numerous river craft and steamers plying their waterways.

Ship-breaking yards are operational in Bangladesh, India, and Pakistan. In Bangladesh, where ship-breaking started on an industrial scale in recent years, nearly 50 ship-breaking units operate on the seashore from Kulna to Fauzderhat in Chittagong and near Mongla port in Khulna. The lubricants, engine oils, and debris form major pollutants during ship dismantling operations. The waste oil is not properly collected and is disposed of in the adjacent sea (Gov't of Bangladesh 1999). In India ship-breaking operations are carried out over a distance of about 10 km on the beaches of Alang in Gujarat. On average 5 ships are broken per day (Gov't of India 1999). In Pakistan the ship- breaking industries at Gadani are a major source of pollution to the adjoining coastal areas (Gov't of Pakistan 1999). The frequency of ship-breaking fluctuates from year to year in these countries.

The impact of oil pollution on the ecology of coastal and marine ecosystems and the species that inhabit them is particularly destructive following massive oil spills caused by maritime accidents. However, information required to completely understand the ecological and health risks caused by long-term chronic oil discharges into the coastal and marine environments is limited. Oil and gas extraction and exploration in Bangladesh and India are continuing. In the past decade, Bangladesh has become an important gas producer in the SAS Region. As oil and gas production and imports grow, particularly by India in the face of growing energy demand, precautionary approaches are required in the coming decade.

Sediments

The SAS Region receives one of the largest sediment loads in the world. After the Amazon, the Ganges-Brahmaputra-Meghna (GBM) Rivers system constitutes the world's second largest hydrologic region. The total drainage basin of about 1.75 million km^2 is shared by Bangladesh, Bhutan, India, and Nepal, and discharges into the Bay of Bengal. India and Pakistan share the Indus River, which discharges into the Arabian Sea. Sediments discharged into the Bay of Bengal from the GBM system constitute the highest sediment load in the world (Milliman and others 1995). These sediments interact with the coastal dynamics and low-level seismic activity to stabilize and support the world's largest continuous mangrove tract, the Sunderbans, in Bangladesh (Samarakoon 2004a). Similarly, the sediments discharged by the Indus to the Arabian Sea support mangroves at its delta. Although the sediment loads discharged by the other major rivers in the SAS Region, mainly in India, are relatively small, they are of local significance. The sediment loads from the smaller rivers in Sri Lanka also have a significant local impact by providing material for beach replenishment.

The supply of river sediments to the sea forms an important source of nutrients for living organisms in the aquatic environment. Also, when stabilized, sediments help to create coastal habitats including mud flats, mangroves, and beaches. River sediment is also the main contributor of sand for beach formation and replenishment. The habitats formed by river sediments contribute in many ways to a country's economy: livelihoods based upon the natural production of food and fibre, biodiversity, tourism, and provision of coastal land as in Bangladesh, among others. They also serve as natural barriers against coastal hazards, as effectively demonstrated during the cyclones in Bangladesh and India, and during the tsunami of December 2004.

On the other hand, the over-supply of sediments also causes severe problems associated with the elevation of riverbeds and flooding. Upstream deforestation, particularly in mountainous terrain, and other land-use practices that expose the soil are the major causes of increased landslides and elevated river sediment loads. For example, in Nepal a higher incidence of landslides has occurred in the high and mid-mountains where the slopes are commonly used for agriculture and grazing and which have large areas of degraded forests (Gyawali 2001; Table 6.5). Surface drainage and erosion of agricultural land mobilize diverse agro-chemicals into the sediment flows. This may result in the transportation of sediment-bound pesticides and herbicides to the marine environment. Therefore, the river basins and the land uses within them should be taken into consideration when addressing the impacts of sediments on the marine environment.

Rapid economic growth in India and more modest levels in Bangladesh and Pakistan are driving development activities, especially in coastal areas, and increasing the demand for materials, mainly sand, for construction. These activities may sometimes reduce sediment availability and at other times increase it, with subsequent ecological impacts on the coastal and marine environments. In Sri Lanka, owing to the over-extraction of river sand and serious coastal erosion, attention is given to offshore sand mining for augmenting the sand supply. During the past decade Sri Lanka has extracted about 10 million m^3 of offshore sand (Samarakoon 2004b). India is now in the process of planning the implementation of the Sethusamudra project to provide shipping access through the Palk Straits. The impact of sediments mobilized during construction is regarded as one of the major environmental impacts that may require mitigation during implementation (see http://www.efl/Sethupress2.html).

Sediments in suspension shade seagrass beds, which when prolonged may cause dieback by impeding photosynthesis. Smothering by excessive sediment deposition also produces similar consequences. Live coral may be unable to self-clean under the sustained presence of sediment in suspension and its continuous deposition. Eventually, death may result from a combination of impeded photosynthesis and smothering (Linden and others 2002). Sediment impacts may also aggravate coral bleaching and death caused by elevated sea temperatures (Linden and others 2002).

Physical alteration and destruction of habitats

The distribution and significance of coastal ecosystems differ among the SAS countries. For instance, mangroves in Bangladesh, India, and Pakistan are significant because of their large areal extents and multiple uses. In contrast, mangroves are sparsely developed in Sri Lanka due to the absence of sediment discharges and coastal processes that create the wide inter-tidal conditions in which mangroves thrive. In this country, estuaries and coastal lagoons are more common and more economically significant. Large estuaries and backwaters also provide livelihoods to coastal populations in India. Maldives is formed entirely from coral atolls. Extensive coral reefs also occur in the Palk Straits, Gulf of Mannar, and in the Andaman Islands. Seagrass beds occur in the Palk Straits, Gulf of Mannar, in some coastal stretches in Sri Lanka, and within estuaries and lagoons.

Degradation of mangroves is regarded as a serious issue in Bangladesh, India, and Pakistan. Many factors, such as timber extraction, coastal development, and alteration of hydrographic regimes contribute to this situation. In Bangldesh and Pakistan changes in the quantity and quality of freshwater flows have been implicated in the extensive degradation of mangroves. This trend is likely to continue in the future as freshwater shortages increase and river flows are diverted for irrigation purposes. There is growing concern that the proposed 'Rivers Linking Project' in India may radically transform river flow regimes in Bangladesh, with serious implications for the Sunderbans mangroves (Ahmad and others 2004). Downstream coastal residents of the Indus are similarly concerned over agricultural withdrawals from the Indus by their government.

Mangroves require a minimum quantity of freshwater to maintain their ecological health. This is an area that requires adequate knowledge as well as regulatory measures to ensure optimal freshwater flow levels.

The issue of PADH is mainly focused on the impacts of sediment mobilization caused by four sectors: tourism, ports, aquaculture, and mining (sand and aggregate extraction). A joint study by the International Ocean Institute, India, and the GPA Coordinating Office concludes that globalization and its changing trends have aggravated anthropogenic impacts on coastal habitats. Economic opportunity has superseded considerations of long-term sustainability. The following needs have emerged with respect to addressing this issue:

- Integration of management of land and sea;
- Horizontal and vertical integration of management; and
- Strengthening equitable law enforcement.

Persistent toxic substances

Available reports do not adequately show the status of the coastal and marine environments in the SAS Region with respect to pollution by persistent toxic substances (PTS). However, the Centre for Science and Environment, India, in its periodical 'Down to Earth' (Vol 8, No. 7, August 31, 1999) reported by way of measurement that mercury in groundwater in Ankleshwar is 118 - 176 times the WHO standard, while Vapi, situated in the same area, has 96 times this standard. This is an area that warrants serious investigation and documentation for the SAS Region. In general, law enforcement in this region is not at the desired level and in such a regulatory environment PTS may be released at levels exceeding acceptable environmental standards. Ship-breaking is another source of toxic chemicals.

Chittagong, Bangaldesh

Chittagong is a city of nearly two million inhabitants located between the banks of the heavily-polluted Karnaphuli River and the Bay of Bengal. The city is the hub of Bangladesh's commercial and manufacturing industry, due mainly to Chittagong Port, which handles more than 80% of Bangladesh's foreign trade. Around 1,500 vessels call at the port each year, and many never leave again. 'Dead' ships wind up as part of Chittagong's ship-breaking industry, where tens of thousands of workers take apart entire ships with little more than their bare hands and blow torches. According to the ILO, the average ship contains seven tonnes of asbestos, along with mercury, PCBs, lead, chromium, cadmium, dioxins, and toxic sulphuric fumes. The main Chittagong ship-breaking area called Fauzdarhat is located on a 16 km stretch of the Bay of Bengal that was once covered by a mangrove forest. It is the second largest ship-breaking operation in the world after Alang, India, employing about 100,000 people directly and indirectly. With a tidal flux ideal for the beaching of large vessels, Chittagong scraps around 50% of the world's large-scale ships. Since the number of end-of-life tankers is expected to grow in coming years, this business and its hazards are also expected to rise. Since the inception of ship-breaking in 1969, the area's environment has dramatically deteriorated. The coastal waters are now polluted with asbestos, heavy metals, high concentrations of oil in the soil and water from numerous oil spills, PCBs, PAHs (which cause malignant tumors), and Tributyl Tin (TBT or Organotins), a nerve toxin and endocrine disruptor that accumulates in the blood, liver, kidneys, and brain. A research report on the area's pollution has been published by Det Norske Veritas, an international risk consulting firm.

In November 2003, UNDP signed an agreement with the Government of Bangladesh to launch a project aimed at improving shipbreakers' working conditions and reducing pollution. The project is slated to run through June 2006. Greenpeace, the Basel Action Network, and the International Transport Union are demanding that the IMO mandate ship owners to decontaminate ships prior to sending them to Asia's scrap yards. It is hoped that the Basel Convention's 2003 decision to recognize end-of-life ships as waste will lead to an international legal framework that will force ship owners to take responsibility for the disposal of ships' toxic wastes.

(Source: Polluted Places - info@pollutedplaces.org)

Toxic pollutants are organic and inorganic compounds, either synthesized or chemically transformed natural substances. When accidentally released into the marine environment, they can have severe adverse effects on marine ecosystems. Many compounds are very persistent in the aquatic environment, bio-accumulate in marine organisms, and are highly toxic to humans through the consumption of contaminated seafood. The sources of toxic pollutants are primarily industrial point sources, such as oil refineries and petrochemical plants, organic and inorganic chemical industries, wood/pulp plants, pesticide production and formulation, metal and electroplating industries. Toxic substances also enter the marine environment from non-point sources through rivers and streams and from the atmosphere.

Toxic substances are generally released as a result of manufacturing operations, effluent discharges, and accidental spills. The waste generated may contain heavy metals, carcinogenic hydrocarbons, dioxins, various types of pesticides, noxious organic and inorganic substances, etc. With increasing industrial development in the SAS Region, the discharge of toxic pollutants is a potential problem for every country in the region.

Limiting the amount of toxic substances entering the coastal and marine environments usually involves a legislative approach, with appropriate legislation not only implemented, but also actively enforced. In future planning efforts special attention should be given to the location of industrial sites in order to limit their impact on important coastal and marine ecosystems. Finally, each industry producing hazardous wastes needs to have an effluent and recipient monitoring programme in place for compliance control.

CONCLUSION

The knowledge base

The problem of land-based marine pollution in the SAS Region is influenced by many factors. Therefore, the dimensions of every facet of the problem require adequate data, information, and understanding for developing integrated solutions. One of the shortcomings in acquiring appropriate understanding is the general tendency in the SAS Region to adopt an intellectual approach. The outcome is that most studies result in 'normative' solutions including guidelines, standards, and instructions on what should be done. In this approach the main actors who can contribute to the solutions are usually left out. In the absence of adequate interventions many poor communities have demonstrated the capability to solve their local waste problems (The Hindu 1995). On a larger scale, the Korangi community sanitation and waste management project and the Orangi industrial waste management projects in Pakistan have demonstrated the potential that exists for both community and private sector participation to implement solutions (Leitmann 1994).

Emerging trends

Economic growth and development, which perhaps are not sustainable, are accelerating in the SAS Region. In the face of globalization and competition, both from the increasing demand for products and production efficiency, market forces are setting the pace of economic growth. In this context strong institutional mechanisms and good governance principles need to guide the behaviour of both political leaderships and the vast population in the SAS Region that contribute to the existing problems. In the absence of these requirements, 'business as usual' and self-interest and profits before public interest will continue in the next decade, as they have in the past. The likely consequences will be deterioration in all relevant environmental and social indicators.

Hotspots

Human settlements with large populations and numerous small and medium-scale industries, large industries, as well as power plants are situated along the coasts of the SAS Region. The combination of discharges of raw sewage and untreated industrial waste has caused low to serious degradation of the coastal and marine environments at several locations in the region. Pollution hotspots related to the GPA issues include areas near the mouths of rivers along which are situated numerous cities such as Mumbai, Kolkata, Dakha, Chennai, and Karachi, as well as industries with inadequate waste management. Areas under particular threat from land-based pollution are those with little water exchange and circulation. Sewage is of particular concern in these hotspots. In addition, the common practice of discharging inadequately treated industrial wastewater into the domestic wastewater stream results in most sewers containing a variety of toxic and non-biodegradable substances. This situation is common in the vicinity of industrialized coastal townships in Bangladesh, India, Pakistan, and in Sri Lanka.

Some major environmental hotspots include Ankleshwar, India, and ship-breaking yards in Bangladesh, India, and Pakistan, which are a major source of pollution of the adjacent coastal areas. A notable hotspot related to ship-breaking is the Chittagong ship-breaking area in Bangladesh, where the environment has dramatically deteriorated. Pollution is also severe in harbours such as Karachi Harbour.

The locations in Table 6.6 have been identified as places where human health and the environment are significantly impacted by pollution in South Asia and reported on the website info@pollutedplaces.org, 'polluted places' (A project of the Blacksmith Institute, 2 Park Avenue, 29th Floor, New York NY10016).

Has the situation concerning the GPA issues improved or worsened in recent years?

Increasing human populations, urbanization, and industrialization in the SAS Region in the past decade have led to increased pressures on the region's coastal and marine environments. The region contains three (Bangladesh, India, and Pakistan) of the six countries that account for one-half of global annual population growth (UN Population Division 2001). During the next decade, several of the big cities in the region, such as Mumbai, Kolkata, Dakha, Chennai, and Karachi will rank among the largest in the world. Increased wastes from land-based urban, industrial, and agricultural activities are discharged untreated or inadequately treated into coastal areas. Coastal and marine water pollution has increased throughout the region, mainly due to direct discharges from rivers, increased surface run-off, and drainage from land-based urban, industrial and agricultural activities and oil spills and other contaminants from shipping (UNEP 2002).

As a result of steadily growing coastal populations in most of the countries, the sewage load in the SAS Region has progressively increased during the past decade in the absence of adequate expansion of treatment systems. This is exacerbated by the high level of poverty in the region. In addition, the rate of production of solid waste may have outstripped existing solid waste management capacity during the last decade. Changes in land use have aggravated the pressures on the marine and coastal environments from sediments and other land-based pollution categories. Agricultural development has been rapid and the impact on coastal areas from agricultural chemicals may have become more severe during the past decade.

Progress in protecting the marine environment

In recent decades, the SAS countries have taken several steps towards protecting the coastal and marine environments from land-based sources of pollution. There has been a gradual move towards integrated planning and development of coastal and marine areas through national, regional, and global initiatives (UNEP 2002). A major multilateral effort that aims at coastal and marine environmental protection at the regional level is the South Asian Seas Programme, one of UNEP's Regional Seas programmes. To address the critical problems facing the coastal and marine environments of the SAS region, the South Asian Seas Action Plan (SASAP) was adopted in March 1995 and is supported by Bangladesh, India, Maldives, Pakistan, and Sri Lanka. One of SASAP's priorities focuses on National Action Plans and pilot programmes to implement the GPA. Another immediate priority is environmental assessment and monitoring, including the required data collection and management (see http://www.sacep.org).

Mechanisms for implementing coastal environment management continue to be developed in the countries (UNEP 2002). At the local level, many poor communities have taken the initiative to solve their waste management problems. On a larger scale, both community and private sectors have joined forces to protect the environment, as seen in the Korangi community sanitation and waste management project and the Orangi industrial waste management projects in Pakistan.

The way forward

Much expectation was stimulated by the determination shown by world leaders at the Millennium Assembly held by the UN in September 2000 to progress toward achievement of the eight Millennium Development Goals (MDG). One of the interlinked MDGs is to ensure environmental sustainability. A specific goal is to 'Halve by 2015 the proportion of people without access to safe drinking water and basic sanitation'. Progress toward achievement of this target could contribute significantly towards reduction of sewage loads, which are the main contributor to marine pollution in South Asia. However, much of the enthusiasm and optimism that were initially generated soon vanished since the anticipated official development assistance that was crucial for implementation of the required measures did not materialize (Sachs 2005). This suggests that unless investments are made on the scale envisioned in the UN MDG programme to address interlinked problems of poverty and environmental sustainability, the impacts of land-based pollution in the SAS region may persist through the next decade.

Services to poor people in the SAS Region would have to acquire increased emphasis. This may be done by putting poor people at the centre of service provision by enabling them to monitor and discipline service providers, by amplifying their voice in policy-making, and by strengthening the incentives for providers to serve the poor (World Bank 2004). Dealing adequately with the sources of land-based marine pollution requires parallel attention to poverty particularly in relation to sanitation, cultivation practices, land use, and unsustainable use of coastal and marine resources. At the same time, better control and monitoring of wastes discharged from urban, industrial, and agricultural areas as well as improved land-use practices are also required.

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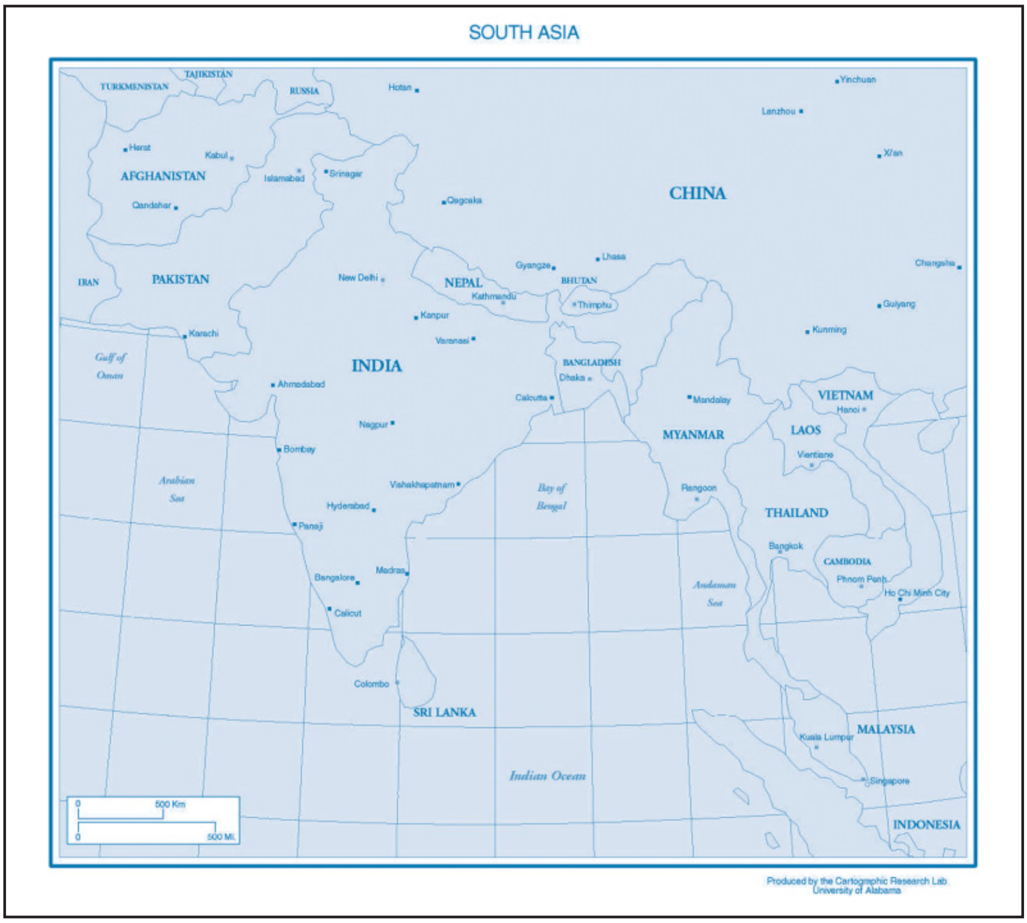


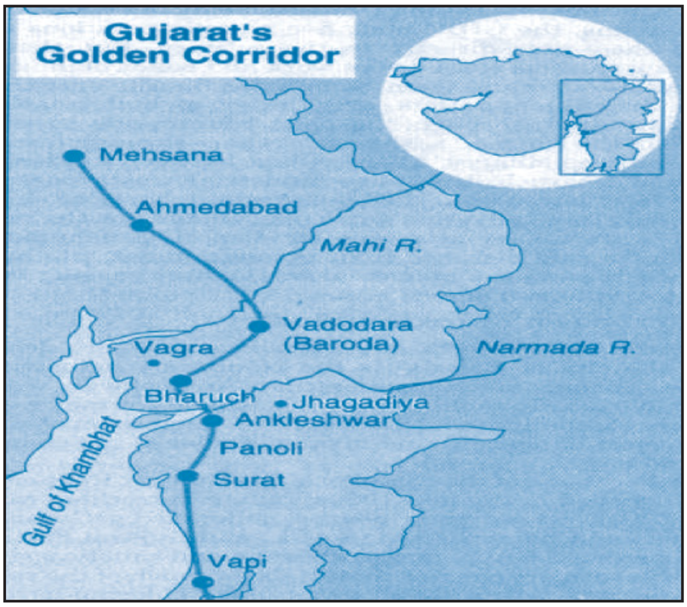
Figure 6.1

The South Asian Seas Region

Figure 6.2

Grounding of an oil tanker at Karachi Port, 27 July 2003

Figure 6.3



Ankleshwar, Asia's largest industrial estate is one of 190 industrial complexes in Gujarat's Golden Corridor, so called because of the money brought by rapid development.

The industrial belt runs 450 km from Vapi to Mehsana.

Table 6.1

Some development indicators for the SAS Region

Country	Population (millions)	Human Development Index	GDP/ capita (PPP US$)	GDP index	% population below income poverty line (US$1/day)
Medium human development					
Maldives	0.3	0.743	4,485	0.63	No data
Sri Lanka	18.9	0.741	3,530	0.59	6.6
India	1,008.9	0.577	2,358	0.53	44.2
Low human development					
Pakistan	141.3	0.499	1,928	0.49	31.0
Bhutan	2.1	0.494	1,412	0.44	No data
Nepal	23.0	0.490	1.327	0.43	37.7
Bangladesh	137.4	0.478	1,602	0.46	29.1
High human development (an Asian reference country)					
Republic of Korea	46.7	0.882	17.380	0.86	<2

(Source: UNDP 2002)

Table 6.2

Daily sewage load as BOD from SAS countries

County	Daily BOD load (million kg)
Bangladesh	12.80
India	98.70
Maldives	0.28
Pakistan	15.30
Sri Lanka	1.80

(Source: SACEP/UNEP 2000)

Table 6.3

Percentage composition (by weight) of waste from Karachi and Kolkata

Waste type	Karachi	Kolkata
Leaves	--	13.05
Paper	3.6	3.18
Rags	7.1	3.60
Metal	0.2	0.6
Glass pieces	2.5	0.38
Fine pieces	18.2	--
Compostable material	52	--
Moisture	43.1	--
Hay and straw	--	6.31
Coconut shell pieces	--	4.96
Ignited coal	--	8.08
Ash and earth	--	33.58
Earthenware	--	6.66
Stone	--	1.83
Leather	--	0.86
Plastics and polythene	2.1	0.65
Bones	--	0.42

Table 6.4

Landfill sites in Bombay (1995)

Landfill site	Capacity (tonnes/day)	Approximate Area (Ha)	Probable Future life (years)
Deonar	2,800	200	Up to 15
Mulund	2,500	40	25-30
Marve	700	10	5-8
Gorai Road	550	30	20-25

Table 6.5

Land use in Nepal and soil erosion rates. Relatively lower rates of erosion are recorded from protected areas, viz. South of Kathmandu Valley and Phewatal watershed

Location	Land Use	Erosion Rate (tonnes/ km²)
A. Siwalik Range		
1. Eastern Nepal, south aspect sand stone foothills	1 Different land use ranging from forest to grazing	780-3,680
2. Far western Nepal, South aspect from foothills of Surkhet	1 Degraded forest	2,000
	2 Degraded forest, gullied land	4,000
	3 Severely degraded heavily grazed forest, gullied land	20,000
B. Mahabarat Lekh, Central Nepal, very steep slopes on metamorphic and sedimentary Rocks	1 Degraded forest and agri. fields	3,150-14,000
	2 Gullied land	6,300-4,200
C. Middle mountain		
1. Northern foothills of Kathmandu Valley	1 Degraded forest scrub land	2,700-4,500
	2 Overgrazed shrub land	4,300
	3 Severely gullied land	12,500-57,000
2. South of Kathmandu Valley	1 75 percent dense forest	800
3. Phewatal Watershed	1 Protected pasture	920
	2 Overgrazed grassland	34,700
	3 Overgrazed grassland	2,200
	4 Gullied overgrazed grassland	2,900

(Source: Anonymous 2004b)

Table 6.6

Some potential pollution hotspots in South Asia

Location	Type of industry/waste
Bangladesh	
Chittagong	Ship-breaking
India	
Ankleshwar, Gujarat	Chemical
Aruputo Village, Kolkata	Leather trimmings
Bidar, Karnataka	Pharmaceuticals
Edulabad, Andhra Pradesh	Solid waste and sewage
Eloor, Kerala	Chemical industry effluent
Howrah, West Bengal	Iron foundry waste
Kanpur, Uttar Pradesh	Tannery waste
Kodaikanal, Tamil Nadu	Mercury contamination
Ranjpet, Tamil Nadu	Tannery waste

(Source: info@pollutedplaces.org)

7 - Seas of East Asia

INTRODUCTION

This report covers the geographic area encompassing the following seas in the Western Pacific, as defined by PEMSEA (2003): Yellow Sea, East China Sea, South China Sea, Sulu Sea, Celebes Sea, and the Indonesian Seas (Figure 7.1). Not meant to be exhaustive, the report focuses primarily on the status of the nine UNEP GPA pollution source categories in the coastal and marine environments of Northeast Asia (China, Japan, Korea, and Russia) and Southeast Asia (Brunei Daru Salam, Cambodia, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam). Covering for the most part the decade 1995-2005, the report emphasizes the most significant advancements and achievements of efforts to address pollution of the coastal and marine environments from land-based sources in the region.

Rapid industrialization and economic growth have taken a heavy toll on the environment of the seas of East Asia. Most of the pollutants entering the marine environment come from land-based sources, and have changed virtually every dimension of the coastal and marine environments. This has, in turn, impacted the lives of the human inhabitants, which are intricately linked by extreme dependency upon the products and services of the sea. Increasing habitat fragmentation on the region's coasts has depleted the wide variety of resources that used to be the main source of sustenance and survival of coastal inhabitants.

The combination of high population density and growth, rapid industrialization and urbanization, as well as poverty has accelerated environmental degradation through the removal of coastal habitats, leading to a substantial increase in marine pollution. In most of the countries, more than 60% of some habitats, particularly mangroves and coastal wetlands, have been modified causing severe loss of biodiversity. About three-quarters of known or suspected species extinctions have occurred on isolated islands in the region (UNEP 1999). Estimates of the economic costs of environmental degradation in Asia range from 1 - 9% of Gross National Products (ADB 1997). In addition, natural hazards (e.g., cyclones, floods, storm surges, earthquakes, droughts, landslides, and volcanic eruptions) that regularly affect the region have extremely damaging impacts on both the environment and the fragile economies (ESCAP 2000).

Interestingly, the sources of pollution and their contribution to the national aquatic environments in the South China Sea countries identified in the 1990s remain basically the same today (Table 7.1). However, with the rapid pace of industrialization in the region, most of the 'medium' contributions could easily be transformed into 'high' contributions in practically all of the countries.

With the exception of China, Japan, Korea, and Singapore, marine water quality is not regularly and strictly monitored in many countries of East Asia. Where monitored, the results are far from satisfactory. For example, a 1997 study in China found that only 19% of this country's coastal waters met Grade I water quality standards; by 1999, this was reduced to 15%, with the most severe sewage and agricultural pollution in coastal areas of the Pearl River Estuary. Of China's four major sea areas, the East China Sea was the most polluted, followed by the Bohai Sea, the Yellow Sea, and the South China Sea (Talaue-McManus 2000).

LEGAL AND INSTITUTIONAL FRAMEWORK AND MULTILATERAL COOPERATION

The legal and institutional framework for protecting the sea is manifested in international agreements and treaties to which member countries in the region are signatories. These legal instruments forge a new international awareness of the need for ocean conservation (ESCAP 1999). Working along the provisions of UNCLOS, they provide a legal foundation for the sustainable development of coastal and marine resources, curtailing the "free for all" approach that had previously encouraged unregulated exploitation (ESCAP 2000). This approach had also prevented individual nations from implementing conservation and resource management strategies by fostering the development of national policy and legislation for protection of the coastal and marine environments. Although the countries are making progress in meeting their obligations under these international agreements, progress is slow and many countries find the requirements less of a priority and beyond their economic or political capabilities.

The countries in both Northeast and Southeast Asia have a long history of cooperation in environmental issues. This cooperation stemmed from the realization that environmental problems, especially those that require long-term and difficult solutions, could be better addressed by collaborative efforts through the sharing of knowledge and the pooling of resources. Such unified positions on international environmental issues of common interest have also allowed the two sub-regions to be vocal and effective in international fora. Opportunities for cooperation are currently promoted through three principal means: (i) The Association of South-East Asian Nations (ASEAN) Senior Officials on the Environment (ASOEN); (ii) Other Sub-regional Cooperation Programmes; and (iii) International programmes and projects. Established in 1989, ASOEN targets conservation issues, the marine environment, and multilateral environment agreements. It also includes a task force on haze. Cooperation was enhanced in 1994 by the Bandar Seri Begawan Resolution on Environment and Development, which led to the development of the ASOEN Strategic Plan for Action on the Environment. This plan includes: (i) the ASOEN Strategic Plan for Action on the Environment (1994-1998), which, in turn adopted the Cooperation Plan on Transboundary Pollution in 1995, addressing among others, movement of hazardous waste, and transboundary shipborne pollution; established a Regional Centre for Biodiversity Conservation in the Philippines; and promoted an integrated framework for the management of Southeast Asia's coastal zones; and (ii) ASOEN Strategic Plan for Action on the Environment (1999-2004), which includes the ratification of the ASEAN Agreement on Transboundary Haze Pollution as well as programmes relating to the protection of biodiversity.

Further information on initiatives at the national, regional, and international levels is given in Appendix I.

STATE OF THE MARINE ENVIRONMENT RELATED TO THE GPA ISSUES

The coastal and marine environments of the East Asian Region are currently facing three separate, but interactive threats: pollution from both land and sea-based sources; direct threats to the ecological balance of the marine environment through overfishing and unsustainable extraction of resources; and direct physical damage to coastal and marine ecosystems from urban and tourist-related development (UNEP 2004). Much of the pollution affecting the marine environment is derived from land-based human activities and enters the oceans and coastal zones as either direct discharge from the region's rivers or through atmospheric deposition. For the most part, these pollutants produce the GPA source categories, which are the focus of this report. These categories are: sewage, persistent organic pollutants (POPs), radioactive substances, heavy metals, oils (hydrocarbons), nutrients, sediment mobilization, litter, and physical alteration and destruction of habitats (PADH). The current status of these source categories in the Seas of East Asia, mainly for the period 1995-2005, is briefly discussed below.

Sewage

The current level of sewage treatment in the region is low, with large quantities of sewage discharged into the environment. For example, in the South China Sea, China, Indonesia, Malaysia, Philippines, Thailand, and Vietnam release a minimum of about 430,000 tonnes/yr of BOD into aquatic systems interacting with the sea (PEMSEA 2003). BOD is a popular index of water quality resulting from organic pollution. However, only just over 10% of the organic component is removed by sewage treatment in the countries bordering the sea.

In Japan, the percentage of the population connected to a sewerage system was 58% in 1998 (NPEC 2002). Tohoku and Chugoku in the Northwest Pacific, as well as many other areas stand at 50%. Since 1999, urban sewerage systems covered a total length of 130,000 km with a treatment capacity of 27 million m^3/ day in China (NPEC 2002). However, the amount of wastewater is rapidly increasing due to increases in population and urbanization. Currently, the wastewater treatment rate in China is only 25.8%. In Korea, there were 114 sewage treatment plants in 1998, with a treatment capacity of 16.62 million tonnes/day, accounting for a 66% supply rate. Secondary treatment (activated sludge) is the most common method used. Many rural areas in Korea still have a supply rate of less than 11% (NPEC 2002). No data are available for the fraction of the sewage treated (primary and secondary).

Organic waste still comprises the greatest amount of the different kinds of municipal solid waste generated in some countries in the region (Figure 7.2) (ESCAP 1995, World Bank 1995, 1998, UNEP/SPREP 1997). The composition of waste varies significantly among the countries, with low- to middle income countries mostly producing 70% organic wastes. ESCAP (1995), World Bank (1995, 1998), and UNEP/SPREP (1997) have given estimates of municipal solid wastes generated in the Asia-Pacific region (Figure 7.3). Northeast and Southeast Asia would be producing the highest and third largest amount, respectively, of solid waste in the next few years. The level of waste generation appears to be related to the degree of urbanization and industrialization in the countries. A World Bank study (World Bank 1999) concluded that as a whole Asia-Pacific, generating conservatively some 1.5 million tonnes of municipal solid waste each day, would double this amount by the year 2025. A challenge to the government pollution prevention agencies in East Asia is to estimate the sewage load from the total solid waste that goes into the seas of East Asia.

PEMSEA (2003) has shown the extent of sewage pollution in the East Asian region using the sewage pollution index. As shown in Figure 7.4, the highest values of this index are found throughout the entire region.

Persistent organic pollutants (POPs)

In East Asia available data on POPs are found mainly in scattered national reports in some of the countries. Waste generated by agriculture and aquaculture, which enters water bodies in a diffuse mode, is reported to make up the second most important group of pollutants in the region (Koe and Aziz 1995); these include fertilizers and pesticides. Fertilizers, when leached into aquatic environments, add to the nutrient loading contributed by domestic sources. The current use of fertilizers and pesticides in the region may be deduced from Table 7.2. Very little information on these pollutants is available on a regional scale and when available, may not be reliable. China uses the highest amount of fertilizer at 1,000 kg/ha/yr and Cambodia the least at 22 kg/ha/yr.

China reported more than 89,000 tonnes of pesticides used in its South China Sea areas in 1995. Indonesia used about 29,000 tonnes annually during the period 1992 - 1996. In 2001, in the Straits of Malacca organochlorine pesticides were detected in low concentrations (0.100 - 2.278 ppt), with none higher than the limit of 20,000 ppt for organochlorine in marine biota prescribed in the Indonesian Seawater Quality Standard (Ismail and others 2003).

In Southeast Asia endosulphan and lindane were found at high levels in sediments and river waters, particularly Malaysia and Thailand, suggesting the recent use of these chemicals. The levels of persistent toxic substances (PTS) in marine organisms such as fishes and mussels have been extensively studied in the region and the spectrum of PTS in collected samples has been reported, although there were indications that the levels were declining.

In Cambodia, the use of agrochemicals is likely to increase substantially in the coming years (Kingdom of Cambodia National Environmental Action Plan 1998-2002). Incorporating national standards to regulate the importation, manufacture, sale, or application of agrochemicals is needed to strengthen the Agricultural Materials Law, in addition to banning the import and/or use of Class I (extremely hazardous) pesticides, especially in ecologically sensitive sites such as Tonle Sap.

Organotin antifouling paint, which is used for the keels of ocean-going vessels, is especially toxic to marine molluscs and their larvae. Some levels of the antifouling substance TBT reported in the mussel, Perna viridis, in the region are given in Table 7.3.

ESCAP (2000) included some POPs under hazardous waste, for example, by-products from a broad spectrum of industrial, agricultural and manufacturing processes, nuclear establishments, and hospitals and other health-care facilities. These include wastes such as solvents, chlorine-bearing wastes, and pesticide/organophosphate/herbicide/urea/fungicide-bearing wastes, which easily make their way to the coastal areas. Hernandez (1993), UNEP (1994), ESCAP (1995), and Nelson (1997) gave a conservative estimate of the past (1993, 2000) and future (2010) trends in some POPs (under hazardous waste) generation in some countries in the region (Table 7.4).

Disposal methods of hazardous waste in the region range from composting, open dumping, landfilling, incineration, and other means. Open dumping is the most widespread practice and in coastal cities in the region, waste is dumped along the coastline and into the sea.

Radioactive substances

Recent information on radioactive substances impacting the seas of East Asia is scarce; only isolated accounts are available. Rahim Mohamed (2003) showed that the concentrations of the natural radionuclides ^{210}Po (Polonium) and ^{210}Po in the waters of Kuala Selangor, Malaysia, are highly dependent on the degree of wave action, geology, and degree of freshwater runoff. In a related study, Rahim Mohamed and others (2005) showed that the activity of both nuclides in total phase (dissolved and particulate) is 100 times greater in the Straits of Malacca than in the southern part of the South China Sea. The calculated inventories and fluxes of the two substances were affected by the northeast and southwest monsoons. The high distribution coefficients of the two substances, indicating strong absorption onto suspended particles, may have profound implications for the stability of food chains at the study sites.

Information regarding disposal practices for radioactive waste is limited and few systematic country surveys have been conducted. In Japan, low level radioactive waste generated from 46 operating nuclear power plants is packed into 2,000-liter drums and temporarily stored in on-site storehouses (ESCAP 2000). Special enclosed containers are used to package eight drums together, which are then transported by sea and land to the Rokkasho-mura Burial Centre in Aomori Prefecture for permanent storage (Hidao Tanaka 2002, pers. comm.).

In Indonesia one role of nuclear power plants is clearly to conserve strategic oil and gas resources and protect the environment from harmful pollutants as a result of the use of fossil fuels. Analyses, especially on the electric system, show that the introduction of nuclear power plants in early 2000 for the Java-Bali electric system represents an optimal solution. Low-level radioactive waste generated from four nuclear research centres is conditioned into cement matrices in blocks, following which the embedded waste blocks are transported to the Radioactive Waste Management Centre at Serpong for permanent burial (Suyanto and Yatim 1993). In Korea and other neighbouring countries such as India and Pakistan permanent land burial methods are used for the disposal of radioactive waste (Greenpeace 1998). Thailand has plans to bring two 1,000 MW-class reactors on line in 2006, and one more each year thereafter. There are five candidate sites, but they have not been publicly announced for fear of public opposition. Currently, there is no nuclear power use in Vietnam, although uranium (U) ore has been found in the northern and central regions of the country. These uranium deposits have been estimated to hold about 210,000 tonnes of U^{308}, with a low average uranium oxide content of 0.06%.

Heavy metals

Data available on heavy metals in the region are incomplete. Vietnam, whose major rivers are all transboundary, reports an annual load of at least 96,560 tonnes/yr, 96 times more than that disposed of by Japan in 1988. Around 80% of this load comes from the Dong Nai-Saigon River. In contrast, China reports the release of only 25 tonnes/yr. Metal-specific data should bear out whether limits have already been exceeded. In its national report Vietnam indicates that the amounts of Pb, Zn, and Cu range from 7 - 10 times the allowable limits in its Northern Economic Zone (Talaue-McManus 2000).

While some mercury is released into the Gulf of Thailand through seepage from the ocean floor, this is not a significant problem. Industrial mercury, released in much higher concentrations, presents a much higher danger to the organisms in the gulf.

There has also been some controversy as to whether or not mercury pollution is related to petroleum production (ESCAP 2000). In a recent study (Panutrakul and Wattayakorn, pers. comm.), the levels of mercury in the sediments in Manila Bay and the Gulf of Thailand ranged from 30.2 - 257.4 ng/g dry weight and 20.0 - 70.1 ng/g dry weight, respectively. In 2001 Pb, Cd, Cu, Zn, and Ni were detected in low concentrations in the Straits of Malacca, although none was higher than the limits prescribed in the Indonesian Seawater Quality Standard of 1988 (Nuchsin and others 2003).

It is of interest to note that Thailand has recently installed at least 5,000 cans at convenience stores and mobile phone shops in major cities to collect hazardous waste from old batteries and mobile phones (Bangkok Post, June 29, 2005). These electrical units contain hazardous heavy metals, mainly Cd, Ni, and cobalt (Co), which damage the nervous system or cause cancer once they enter the food chain and accumulate in the body, apart from contaminating the environment. In Thailand alone, about 9 million old batteries are dumped into the environment each year, while at least 20 million mobile phones are in use and will soon be disposed of as waste. Considering the close connection between the rivers and seas in Thailand, the likelihood that a portion of this waste could contaminate the coastal waters is high. Phadungsakchayakul and others (2003) found mercury accumulated in the different organs of the striped dolphin *(Stenella coeruleoalba)*, a spinner dolphin *(S. longirostris)*, as well as in three dugongs *(Dugong dugon)* stranded on the shores of the Andaman Sea and Gulf of Thailand. The concentrations ranged from 17.6 - 49.19 ug/g (wet weight). Interestingly, Suksunthon and others (2003) found Cd, Pb, Cu, Zn, and Mn at high concentrations in four species of seagrasses in the eastern part of the Gulf of Thailand. Dugongs are almost exclusively dependent upon seagrasses (especially *Halophila ovalis*) for food. A comparison of recently reported concentrations (µg/g) of Cd, Cu, Pb, and Zn in the mussel, *Perna viridis*, from regional studies is given in Table 7.5

These results indicate that this widely distributed mussel is a potential heavy metals bio-monitoring agent in the region.

Oils (hydrocarbons)

In Asia and the Pacific, one of the most significant sources of pollution is oil from ships. Accidental oil spills have been frequently reported along oil transport routes and at points of discharge and loading of oil carriers. In the Straits of Malacca alone, 490 shipping accidents were reported during the period 1988 - 1992, resulting in a considerable amount of oil being spilled (Straits Times 1993). The shipping of oil coupled with increasing emphasis on offshore oil exploration makes some areas in East Asia extremely vulnerable to oil pollution. Some high risk areas have been identified, especially in relation to oil spills (Figure 7.5) in the South China Sea, which is a major oil transport route. Oil spills also cause severe pollution in ports in Indonesia and Malaysia. In addition, the cleaning of oil tanks in and around ports has led to the frequent formation of tar balls on the southwestern beaches of these and neighbouring countries.

In 2001 in the Straits of Malacca the highest hydrocarbon concentration (10.053 ppm) was detected around Bintan and Batam Islands, exceeding the standard of 5 ppm for marine biota. The high values were probably a consequence of oil from tankers plying the busy route (Nuchsin and others 2003). Zakaria and Okuda (2001) showed that about 30% of tar ball pollution on the coast of Peninsular Malaysia was derived from Middle East oil, while land-based sources included agricultural, industrial, and domestic wastes.

Five cruises undertaken by the Malacca Straits Research and Development Centre from 1999-2002 revealed some interesting results on the concentrations of hydrocarbons in the waters of the Straits of Malacca. Figure 7.6 shows that lower levels of hydrocarbons were detected in both the northern and southern parts of the straits, while the highest levels were found in the central area. There were no significant changes in the concentrations of these substances among the years of the study. Specific legislation addressing marine petroleum hydrocarbon pollution is extremely few in Malaysia and the rest of Southeast Asia. Often, duplication of some of the provisions provided in the national legislation and overlapping of jurisdictions of the enforcement officers prove to be inefficient for monitoring the state of the environment.

In Japan oil pollution incidents are the most frequent form of marine pollution. Between 150 - 180 incidents of marine pollution occur annually, especially along the coast between Hokkaido and Kyushu (NPEC 2002). In this Japanese region 113 oil pollution incidents were recorded in 2000.

In the Gulf of Thailand the input of oil from land-based sources such as municipal, refinery and other industrial wastes, as well as urban runoff is of particular concern. Low-level hydrocarbon pollution has been found to frequently occur in the Upper Gulf of Thailand and the eastern seaboard (Wattayakorn 2003). Several PAHs were identified in water, sediment, and biota samples. Boonyatumanond and others (2003) compared the concentrations of PAH from surface sediments in coastal areas in Thailand with those from worldwide surveys and found that Thailand is moderately contaminated with PAHs. Especially high concentrations ranging from 512 - 8,399 ng/g (dry weight) and showing a mixed signature of petrogenic and pyrogenic origins were detected in canal sediments. The increasing trend of PAH contamination in sediments and coastal waters in the upper part of the gulf provides a warning sign of potential risk (Wattayakorn 2003).

In East Asia data on oil fluxes from rivers entering the South China Sea are available only from China. The estimate in Guangdong Province (Han, Rong, Pearl, Moyang, and Jian) was 9,698 tonnes/yr; in Quangxi (Nanliu, Qing, Maoling), 823 tonnes/yr; and in Hainan Province (Nandu, Changhua, Wangquanhe), 368 tonnes/yr (Talaue-McManus 2000).

The relative contribution to pollution of various sources of oil varies, and depends on several factors including population density, extent of shipping, mineral exploration, and the degree of industrialization of the littoral countries. In the South China Sea all these factors are intensifying so that absolute oil inputs will increase from at least three sources. The average annual growth rate for oil demand in five South China Sea countries is projected to be 5% for the period 1993 to 2005 (Table 7.6).

Nutrients

The urban and agricultural areas of the region produce such high concentrations of organic wastes that the nutrient filtering mechanisms of the coastal zone are unable to neutralize their effects (ESCAP 1999). Rivers running through Cambodia, China, Malaysia, Thailand, and Vietnam deliver at least 636,840 tonnes of nitrogen to coastal waters overlying the Sunda Shelf. Of this, China contributes at least 55% and Vietnam and Thailand 21 and 20%, respectively (Talaue-McManus 2000). The nutrient flux for some rivers that drain into the South China Sea from three countries is shown in Table 7.7. Unfortunately, data for coastal rivers in many of the countries are either lacking or not accessible.

In 2001 the concentrations of inorganic phosphate in surface waters of the Straits of Malacca ranged from 0.09 μgA/l - 1.18 μgA/l (mean 0.53 μgA/l), with levels in coastal areas higher than in the deeper areas (Nuchsin and others 2003). Nitrate concentrations, on the other hand, ranged from 0.11 μgA/l - 3.20 μgA/l (mean 1.32 μgA/l), with higher levels recorded along the coast. The higher levels of both phosphates and nitrates nearer the coast were attributed to the inputs from the mainland (Nuchsin and others 2003). By the year 2050 and under a 'business as usual' scenario, East Asia will have the highest amount of dissolved inorganic nitrogen exported by rivers compared to other world regions (LOICZ Newsletter 30, March 2004).

In 1999 the Bohai, Yellow, and East China Seas received a total of 1,500 million tonnes of industrial wastewater discharges, of which inorganic nitrogen and phosphates were the most important pollutants, from 12 major coastal cities in China (PEMSEA 2003). In 2001, 77 red tide events affecting 15,000 km^2 were recorded offshore of China where nutrient pollution was severe.

The uneven spatial distribution of the coastal populations, as well as agriculture and industrial activities in the region have led to spatial differences in nutrient inputs to coastal ecosystems. Hence, the Seas of East Asia are characterized by between 200 to greater than 500 $kg/km^2/yr$ of inorganic nitrogen exported from watersheds to coastal ecosystems (LOICZ Newsletter 30, March 2004). This spatial heterogeneity in future relative and absolute nutrient export to the coastal zone is likely to persist in the region.

Jacinto and others (1997) discussed the use of nutrients as tracers of water masses in explaining both the horizontal and vertical nutrient profiles across a cruise track between the Philippines and Vietnam. Nutrient concentrations were higher in stations nearer the Vietnam shelf (average values of 2 μM for nitrate, 0.35 μM for nitrite, 1.8 μM for ammonia, and 0.70 μM for phosphate in the top 50 m) and within higher temperature and lower salinity regimes compared to adjacent stations. These could indicate river runoff, with the boundary current flowing south along Vietnam interacting with the waters from rivers flowing out of Vietnam and Thailand.

In general, major eutrophication in the Seas of East Asia has been recorded only in estuarine and coastal areas of the Philippines and Thailand, especially where there is high nutrient loading from agriculture and domestic sewage. The impacts of eutrophication are most significant in enclosed bays, harbours, and lagoons with limited water circulation, for example, Manila Bay (UNEP 2005).

Sediment mobilization

As suspended load, sediments are a major pollutant in the region. However, very little quantitative data is available, including from national reports, of the actual sediment load that has entered the region's aquatic systems. Primarily in the form of silt, the load per square kilometre of drainage basin is three to eight times higher than the world average and contributes to the high turbidity of coastal waters (ESCAP 2000).

Two-thirds of the world's total sediment transport to the oceans occurs in South and East Asia, due to a combination of active tectonics, heavy rainfall, steep slopes, and erodible soils disturbed by unsound agricultural and logging practices (UNEP 1999). In Indonesia, Malaysia, Philippines, and Thailand deforestation of round wood takes place over a total of about 50,000 km^2 of forest, contributing to soil erosion, siltation, and increased suspended solids in the aquatic systems (PEMSEA 2003).

In general, high silt loads adversely affect most shallow-water coastal ecosystems, e.g., coral reefs and seagrass beds (Hodgson 1990, Terrados and others 1998), having immediate observable impacts including the smothering of coral reefs and burial of macrophytes such as seagrasses and seaweeds. In addition, these sediments also impact upon the wider oceanic ecosystem. The effect of siltation on seagrass is manifested primarily through reduced light availability in the water column (Vermaat and others 1997), increased sedimentation and burial (Duarte and others 1997), and possibly by changing sediment conditions (Terrados and others 1998). This is critical in mixed tropical seagrass beds where inter-specific competition for space, light, and nutrients is intense. Hence, even small changes in light regime can affect species composition and depth distribution of the communities (Fortes 2004)

Sediment deposition and suspended sediments affect coral community structure differently. Adult coral colonies of some species may survive silt cover for short periods (for example, hours to days). However, coverage for longer periods is lethal to virtually all species (Ruitenbeek 1999). On the other hand, siltation is of primary importance in the development of mangroves (Fortes 2001). Highest productivity values are usually reported in mangroves associated with rivers (Twilley and others 1986). Primary production of mangrove habitats depends on a continuous nutrient supply from land or sea (Duarte and others 1998). This nutrient-dependence has led to the hypothesis that mangrove growth may be nutrient-limited. High siltation loads can also be beneficial for mangrove habitat expansion. In the Philippines and Thailand high siltation in the rivers enhance seedling growth (Duarte and others 1998), possibly by helping them to counter the high mortality rates experienced by newly established unprotected seedlings (Clarke and Myerscough 1993). High siltation rates also increase sediment accretion, forming new habitats for colonization by plant and animal communities (Panapitukkul and others 1998).

In some Southeast Asian countries increased efforts in damming and diversion of river courses are allied with erosion/sedimentation problems on the coast. Studies in the Philippines (Hodgson and Dixon 1992) and Indonesia (Cesar and others 1996) have demonstrated that the costs of environmental damage to coral reefs from logging-induced sedimentation greatly exceed the economic benefits of logging. Cesar and others (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. In the Mahakam River Delta, around 2 million m^3 of sediments were dredged to maintain navigation channels, which presumably were silted as a result of erosion caused by massive logging in the interior of Kalimantan (Hinrichsen 1998).

Marine Litter

Marine litter (or driftage) is a serious and worsening problem in marine and coastal environments worldwide. Marine litter is carried over long distances on ocean currents and winds. It is found almost universally in the marine and coastal environments (oceans and seas, salt marshes, estuaries, beaches), not only in densely populated regions, but also in remote places far away from any obvious sources.

As in many parts of the world, the main sea- or ocean-based sources of marine litter found in East Asian waters include shipping, ferries and cruise liners, fishing vessels, aquaculture and mariculture facilities, as well as offshore oil and gas platforms. On the other hand, the main land-based sources of marine litter in the region include coastal municipal landfills (waste dumps), riverine and canal transport of waste, discharge of untreated municipal sewage, storm water, industrial facilities, solid waste from landfills, untreated waste water, and tourism (recreational visitors to the coast). The coastal population of Cambodia, China, Indonesia, Malaysia, Philippines, Thailand, and Vietnam generates in total over 66 million tonnes of solid wastes/yr (PEMSEA 2003). In Northeast Asian countries (e.g., China, Japan, Korea and Russia) there is growing concern about driftage and buried objects on the coasts. Floating waste, especially plastics, are the main pollutants, and since 1996 research on this issue has been conducted annually in order to determine the actual extent of pollution caused by litter on the beaches (NPEC 2003). By 2004, 24 local governments in the four countries had conducted research on this issue in 48 coastal areas in the region. This number has since been increasing. The average count (and percentage by weight) of collected material per 100 m^2 was 427 pieces (2,133 g) in 2003. The composition of the collected material is shown in Table 7.8.

Physical alteration and destruction of habitats

Physical alteration and destruction of coastal habitats (PADH) in East Asia result mainly from natural hazards such as major storms or earthquakes; reclamation and land-filling during coastal development; a decline in water quality; and changes in sedimentation or in the hydrodynamics of coastal systems brought about largely by shoreline modification (e.g., by dredging of harbours and shipping channels, construction of embayment and marinas, and the reclamation of coastal wetlands for development purposes). Both marine and freshwater habitats are under serious pressure from human activities such as urbanization and agricultural expansion (Tuxill and Bright 1998). Coastal erosion triggered by human activities is also evident in many countries of the region. In Malaysia, for example, coastal erosion has affected every state and by 1998, some 1,400 km^2 or 29% of a total shoreline of 4,809 km^2 was eroded (ESCAP 2000). The region's coastal areas are one of the major attractions of the tourism industry, which is the fastest growing sector in the regional economy.

Offshore oil and gas production is developing rapidly on the Gulf of Thailand, east of Malaysia, west of Borneo and Palawan, and in the Celebes Sea. Mining activities in the coastal zone include the extraction of sand, gravel, and rock, while each year more than 6 million tonnes of salt are extracted from seawater. Elsewhere, corals are mined for the manufacture of agricultural and construction lime. Seagrass beds are reclaimed or removed to set up seaweed farms, while mangrove areas are continually being destroyed to give way to fishponds, which in many cases prevent access to resources by inhabitants. Alteration of shallow water habitats poses perhaps the greatest threat to the biological diversity of marine and other aquatic organisms that depend on these habitats for food, protection, and nursery areas. After Australia, Northeast and Southeast Asia harbour the second highest number of seagrass species, having 20 of the 50 species recorded worldwide (Fortes 1994, 1995). It has been estimated that between 20 and 25% of seagrass areas in Indonesia, Malaysia, Philippines, and Thailand have been damaged by a combination of coastal development, elevated sedimentation, destructive fishing methods, land-based pollution, thermal discharge, petroleum product spills, as well as dredge and fill operations (Fortes 1995).

Subsidies provided by governments have sometimes contributed to overfishing, which is evident in many of the region's major fishing areas. Overfishing can cause serious, long-term damage to fisheries resources and the targeting of particular species can disrupt the ecological balance, depleting the prey of other species and reducing populations of top predators. Diesel fuel tax exemptions are common fishing subsidies in the region. However, a study by FAO (FAO 1998) found that the number of subsidies in developing countries has been greatly reduced in recent years, with the remaining subsidies being for offshore fishing, artisanal fisheries and fisheries co-operatives, as well as for fishing operations in remote and under-developed areas.

Intensive and large-scale habitat loss and degradation (e.g., when a major oil spill occurs, an entire mangrove forest is converted to fishponds, or when hectares of seagrass beds are reclaimed) is by far the leading cause of biodiversity loss in the region. In some cases, habitats are gradually degraded over time, aggravated by natural catastrophes such as storms and tsunamis. In either case, plant and animal species are lost and many animals are forced to migrate from their natural habitats. Baille and Groombridge (1996) reported that in areas where forest degradation and conversion have been most intense, such as South and Southeast Asia, a significant proportion of the endemic primate species face extinction. Habitat loss accounts for the decline of 68% of all threatened reptile species and 58% of threatened amphibian species.

A picture of the regional extent of habitat degradation can be seen in the reported immediate causes of fisheries overexploitation in some of the countries in the region (Table 7.9), together with the causes of and losses of mangrove, seagrass, and coral reefs (Tables 7.10 and 7.11, respectively). Issues 7 - 11 in Table 7.8 fall under the GPA categories. Demographic and development pressures are obviously the common drivers, as also reported by Talaue-McManus (2000). It is important to note that many of the causes and impacts of the issues are transboundary in nature.

Table 7.10 shows that the region's mangroves have been decimated because of mainly shrimp farming; only 1,852,000 ha remained in the late 1990s (Modified from Talaue-McManus 2000). This is expected to be reduced further, considering the continuing removal of mangroves for aquaculture expansion, as dictated in the current development plans of most coastal Southeast Asian countries.

EMERGING ISSUES

In recent years countries in Northeast Asia (Russia, China, Republic of Korea, DPR Korea, and Japan) have recognized certain new or emerging environmental issues in the region. These include transboundary movement of pollutants, coral bleaching, climate change through global warming, and electronic waste (e-waste). The impacts of transboundary movement of pollutants and e-waste will be felt in the coastal and marine waters of the region in the next decade.

Transboundary movement of pollutants

The Seas of East Asia are under considerable pressure as a dumping ground for pollutants, particularly because of demands on industries to dispose of their wastes in more environmentally benign, hence, more costly ways. Despite international agreements, between 1994 and 1997, industrialized nations sent a total of 3.5 million tonnes of hazardous waste to Asia-Pacific countries (ESCAP 2000). For example, in 1995, Chinese customs identified 22 separate incidents involving some 3,000 tonnes of foreign hazardous waste and in the following year, uncovered almost one case per week of mislabelled hazardous waste, mostly from the United States, Republic of Korea, and Japan in particular (Greenpeace 1997). In June 1998, 640 tonnes of Californian waste was found dumped in a Beijing suburb; the waste included toxic sludge, used syringes, and decomposing animal bodies (Greenpeace 1997). Other countries such as Indonesia, Philippines, and Thailand have become dumping grounds of significant quantities of hazardous waste exported from industrialized countries both within and outside the region (Greenpeace 1998). On the other hand, many attempts to dump hazardous waste in the region have not been successful largely due to increased awareness created through the negotiation of the sub-regional Waigani Convention on transboundary movement of hazardous and radioactive wastes.

Coral bleaching

According to a recent report "Coral Bleaching and Coral Reefs" in The Sea Bulletin (December 2004) by T. Goldberg, global warming of 1 - 2°C over 100 years would cause devastating bleaching events to occur on large tracts of coral reefs in the region. The report states that reefs could die from coral bleaching within 30 years. Coral reefs are highly sensitive to the first signs of environmental perturbation. In the late 1980s large areas of coral reefs in the region were damaged or killed by coral bleaching. The bleaching events of 1997 and 1998 coincided with the distribution of water of up to 3°C above normal. This event was the worst on record and caused the most extensive bleaching of coral reefs in the three oceans (Wilkinson 2002), affecting reefs in Australia, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam.

Climate change

Climate change impacts on the coastal zones of East Asia include accelerated sea level rise and more frequent and severe storm events. Unsustainable resource use and environmental degradation from large human populations and development in coastal areas of Southeast Asia increase pressures on areas already subjected to numerous climate-change related stresses. These include loss of the coastal ecosystems which buffer impacts from waves, storm surges, and sedimentation and which provide fisheries products and ecosystem services (Lal and others 2001).

Major delta areas of Southeast Asia are like to be subjected to stresses associated with sea level rise, changes in hydrographic regimes, salt-water intrusion, siltation, and land loss. Table 7.12 shows the potential loss of land and exposure of population for selected magnitudes of sea level rise in four countries in Southeast Asia. Low-lying coastal cities such as Jakarta, Bangkok, Tianjin, Shanghai, Guangzhou, Tokyo, and Manila will bear the brunt of these impacts. For instance, the first three have experienced changes in relative sea level of as much as 5 cm/yr during the 1980s and 1990s as a result of subsidence associated with groundwater withdrawal. In addition, increases in temperature can lead to increased eutrophication in wetlands and freshwater supplies.

Electronic waste

Hilty (2005) reported that in 2004 more than 180 million personal computers (PC) were sold worldwide. In the same year, an estimated 100 million obsolete PCs entered waste streams and were either recycled or completely disposed of. A PC may contain up to 4 g of gold and other valuable materials that can be recovered at a profit, particularly if done in low-income countries. On the other hand, when Waste Electrical and Electronic Equipment (WEEE) or e-waste is disposed of or recycled without any controls, there are predictable negative impacts on the environment and human health. E-waste contains more than 1,000 different substances, many of which are toxic, such as Pb, Hg, As, Cd, selenium (Se), hexavalent chromium, and flame retardants that emit dioxins when burned.

In many parts of the world both formal and informal recycling industries that deal with the rapidly growing streams of WEEE have emerged. Computers are only one type of WEEE.
There is a trend towards pervasive computing (more and more everyday commodities will contain microprocessors in the future). IBM expects that in the next 5-10 years about 1,000 million people will be using more than a thousand million networked objects throughout the world.

CONCLUSION

Assessment of the situation

For a variety of reasons, data and information available on the GPA source categories of pollution in East Asia are scanty and incomplete. Very few of the studies conducted could be considered regional, as most have been the outcome of studies undertaken at the national or even local level, using local approaches. This makes it difficult to predict environmental trends. Where these are mentioned, however, they are to be construed only as 'plausible futures'. In addition, many of the available data and information do not recognize the pollutants according to the GPA categories, e.g., in many cases heavy metals, fertilizers, radioactive substances, and pesticides are combined under 'hazardous substances or chemicals', while sewage, nutrients, and some of the POPs are considered under 'organic pollutants'. This makes it difficult to conduct a reasonably credible assessment of the GPA source categories at the regional level.

In the South China Sea, domestic, agricultural, and industrial wastes, along with sediments and solid wastes, are the major sources of pollutants impacting the coastal and marine waters (Table 7.13). Land-based sources play a major role in both inland and coastal pollution. Ship-based sources contribute relatively small amounts, but may have severe impacts when large volumes are released such as during major oil spills (Talaue-McManus 2000).

Considering the above findings, two general inter-dependent indicators of these 'plausible scenarios' have emerged, suggesting clear signs of the imminent consequences to the environment of the region's actions. These are the emergence of pollution hotspots, high-risk areas, and the increasing incidences of HABs. This is discussed in the following sections.

Hotspots

According to PEMSEA (2004), the seas of East Asia have been turned into an alarming global hotspot as a result of unchecked and unmitigated human activities including rapid urbanization and industrialization, multiple-use conflicts, the exploitation of resources, and over-population, compounded by political turmoil, security risks, and the general lack of awareness and interest in the foregoing issues. Several hotspots have been identified in the East Asian Seas countries. For example, the South China Sea TDA national reports (Talaue-McManus 2000) identified 35 pollution hotspots in sub-regions interacting with the South China Sea (Appendix II). Pollution loads on aquatic environments are influenced by population distribution and growth, industrial and agricultural development inland as far as catchments extend. The pollution hotspots incorporating high-risk areas in relation to oil pollution are shown in Figure 7.5.

Has the situation concerning the GPA issues improved or worsened during recent years?

In general, coastal and marine water pollution has increased throughout East Asia in the decade 1995-2005. This is mainly due to domestic and industrial effluent discharges, atmospheric deposition, oil spills, and other wastes and contaminants from shipping. Sand/silt, nutrients, toxic chemicals, and oil also come from land-based sources. Urban air quality has deteriorated in the wake of rapid growth in urbanization and industrialization, increasing traffic, and increased energy consumption. The threats posed by haze, acid rain, and transboundary pollution have also increased significantly in recent years.

In East Asia, urbanization and globalization have spawned the creation of sub-regional growth zones, promoting international trade and economic interdependency (Figure 7.7) (PEMSEA 2003). This, however, could be a ‘double-edged’ sword. On the one hand, greater commitment to environmental protection is expected to be manifested by the countries due largely to the positive effects of recent experiences. On the other hand, the increase in the intensity of development activities, using much greater volumes of raw materials and hence a much greater risk of non-compliance with regulations may likewise be manifested, especially in those countries with less political will to implement environmental policies.

The occurrence of HABs in the Western Pacific region has alarmingly become more frequent (Fortes and Fukuyo 2005), as shown in Figure 7.8. From 1970 to 2000, there was an increase in the frequency of occurrence of HABs, characterized by an increase in the diversity of organisms, their geographical distribution, and in the severity of their impacts (Fukuyo, pers. comm.). Hence, the problems associated with HABs have increased. For example, ciguatera has recently been reported in the Philippines, while the HAB species, *Phaeocystis* in China and Vietnam, *Heterocapsa* in Japan and Hong Kong, *Cochlodinium* in Japan, Korea and China, Malaysia, and Indonesia, as well as Cyanobacteria toxin (polycavernoside A) have been reported in the Philippines. Interestingly, areas where HABs occurred have similar environmental conditions (eutrophication, upwelling) or similar dispersal mechanism (ships, ballast waters) of the organisms.

The health of many waterways in some of the countries, nevertheless, improved dramatically in the mid-1990s, mainly due to the construction of modern sewage treatment plants and an intensive reforestation effort. The Singapore River, which flows through the city, was once extremely polluted but is now a symbol of successful environmental clean-up and a popular recreational site.

Has progress been made in protecting the marine environment during the last 10 years?

Significant progress that directly or indirectly protects the ecological integrity of coastal environments in East Asia has been made. Minimizing the quantities of waste requiring disposal through source reduction, as well as material recovery, reuse and recycling is increasingly being recognized as the central basis of an integrated approach to waste management. Waste minimization by waste exchange is another option practised in some countries. For example, the Industrial Waste Exchange of the Philippines serves as a link between companies that mutually benefit from waste exchange. Recycling of waste materials grew from less than 10% in 1990 to 22% in 1998. A number of countries such as Hong Kong have introduced at least partial privatization into their waste management systems (Fernandez 1993, ESCAP 1995).

Countries are also expanding the participation of the private sector through contracts for the collection and treatment of medical waste, the storage of low-level radioactive waste, and the remediation of closed landfills. In some countries, including Australia, Japan, Philippines, Republic of Korea, and Singapore, a number of different economic tools have been integrated into their strategic waste management plan to ensure that waste in all its forms is minimized, that revenues for waste management are raised, and that, wherever possible, the polluter/user pays principle is applied.

Some progress is being made in the establishment of appropriate legal and regulatory frameworks for aquaculture in a number of the countries, including Malaysia and Thailand. In 1998, Thailand's Ministry of Agriculture, recognizing the accelerated loss of valuable agricultural land to aquaculture, banned the conversion of rice paddies to shrimp farms.

Although accurate data on the total amount of oil spills are not available, their frequency and distribution has led to the development of strict control regulations in many countries of the region. This could partly be the reason for the significant decline in both the amount of oil spilled and the number of oil spill incidents in East Asia in 1995 - 1997 compared with the 1966 - 1994 period (PEMSEA 2003). However, international trade is anticipated to triple in the next 20 years and between 80- 90% of this is expected to be by shipping (Etkin 1997). The projected increase in shipping traffic, increased tanker traffic routes, and greater oil production, storage, and pipeline transport increase the risk of vessel, pipeline, and facility spills. Vessels also require regular maintenance, in which a wide range of highly toxic paints, paint removers, solvents, degreasers, and other compounds are utilized. For example, organotin antifouling toxins cause cumulative pollution of harbours and marinas and become trapped in food chains. As a consequence, organotin was banned by the IMO in 1998.

In recent years, significant progress has been made in the development of integrated coastal zone management (ICZM) plans for the Philippines, Indonesia, Singapore, Thailand, and Malaysia. A key factor in the successful implementation of these plans has been the extent of community participation, as demonstrated in the Philippines, which was one of the first countries to experiment with community partnerships. In Malaysia, the most recent initiative towards ICZM is the pilot project being undertaken in Sabah, Sarawak, and Pulau Pinang to formulate plans at the State level.

In its efforts to strengthen the capacity of governments, NGOs, and the private sector in coastal zone management, the Food and Agriculture Organization (FAO) has collaborated with a range of institutions, including the World Fish Centre (formerly ICLARM), United Nations Statistics Division, World Conservation Union (IUCN), and other UN agencies sponsoring ICZM activities. These international efforts have included pilot projects to test alternative management approaches and the publication of guidelines on managing the environmental impact of aquaculture.

In Japan, the compliance rate for COD with environmental standards remained constant at around 80% between 1980 and 1996 (NPEC 2002). However, this decreased to 75% after 1997, as reflected in the deterioration of the water quality in river mouths. On the other hand, the compliance rate with BOD standards has been constantly improving, reaching 80% in 1997 to the present (NPEC 2002). Most countries in the region show a 90-100% compliance rate with the suspended particulate matter standards.

GEF is currently supporting projects in the region to help address degradation of the coastal and marine environments. One of these projects is 'Partnerships for the Environmental Management of the Seas of East Asia' (PEMSEA). An integral part of this regional effort is the on-the-ground implementation of ICM and risk assessment and management in sub-regional sea areas and the impacts of human activities on marine ecosystems (PEMSEA 2004).

A landmark initiative, which is most significant in addressing environmental issues in both Southeast and Northeast Asia, stems from the recently developed Sustainable Development Strategy for Seas of East Asia (PEMSEA 2003). It is a regional implementation of the World Summit on Sustainable Development (WSSD) requirements for coasts and oceans. The decision was initiated at a meeting of 11 East Asian countries held in Dalian in July 2000. Joined by Japan in 2002, all countries endorsed the strategy in principle. In December 2003, the strategy was adopted at a Ministerial Meeting within the East Asian Congress held in Putra Jaya, Malaysia. Embodied in the Putra Jaya Declaration, the strategy now serves as the overall framework for the sustainable development of the Seas of East Asia.

As a whole, major improvements have emerged in the institutional framework in the region. These are largely through (I) the creation of multi-stakeholder agencies at higher levels of governance with the objective of formulating goals, rules, and regulations; providing guidance to the executive branches of government; monitoring performance; and providing policy inputs; (II) the design of formal and informal coordination mechanisms for integrating cross-sectoral concerns; (III) the recognition that devolution of certain responsibilities and functions to local authorities creates potential for the improved monitoring and management of resources; and (IV) judicial activism and interventions have increased and made the executive more responsive in meeting environmental standards and safeguards (ESCAP 2000).

The way forward

A holistic and comprehensive approach to pollution management in the seas of East Asia is required. This approach should make the distinction of practical technology for different users and integrate waste minimization and reuse with water pollution control. This should be supported by improved institutional, legal, and regulatory frameworks that promote division of labour among stakeholders, including different levels of government and private sector. The initiative should enhance capacities, find effective and viable investment and cost recovery instruments, and create political and public support for urban pollution management. There is, however, a need to intensify efforts towards development of indigenous capabilities in the countries of the region in terms of expertise, equipment manufacture, process technology guidelines, design, construction, installation, operation, and maintenance of waste treatment and disposal and pollution abatement facilities.

Current institutional approaches to manage marine and coastal resources in the region has evolved to include at the forefront, coordination among national government sectors, ministries, and departments as part of a cooperative network of national, state, and local management with active participation of civil society (ESCAP 2000). This combines both top-down and bottom-up elements with a willingness to form mutually advantageous partnerships between all levels of governance, supported by an open system of education and communication.

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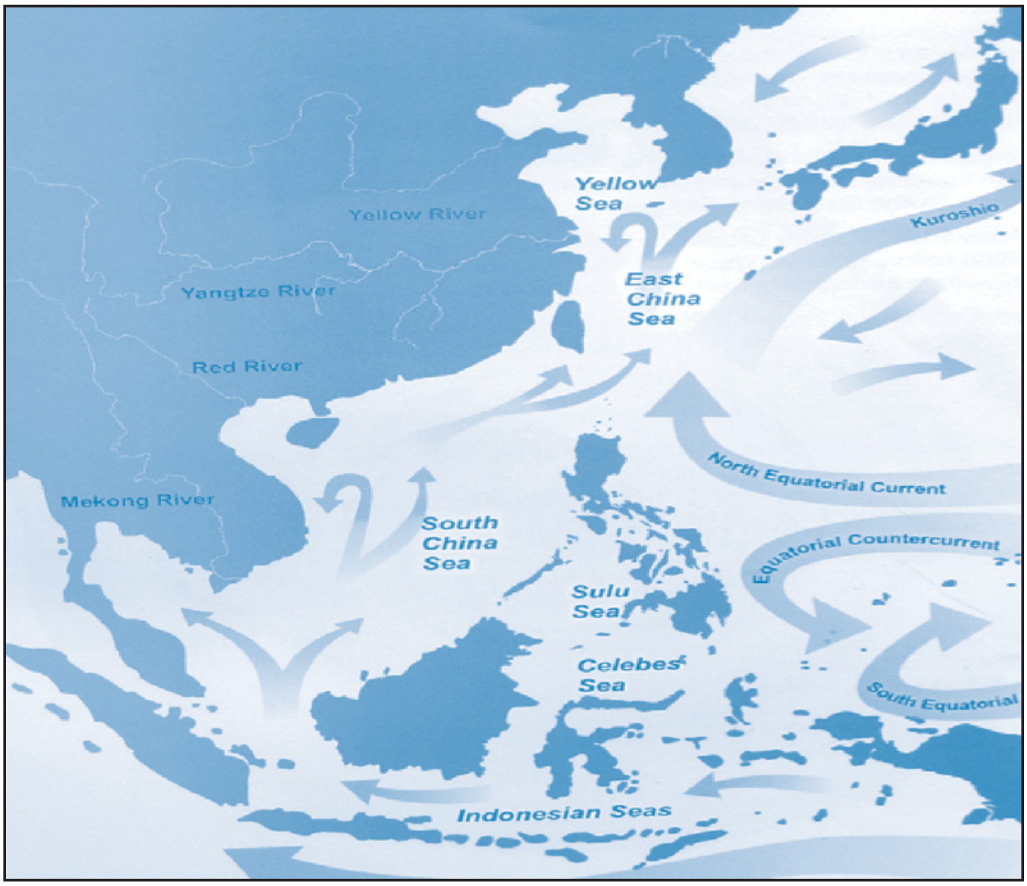
Figure 7.1

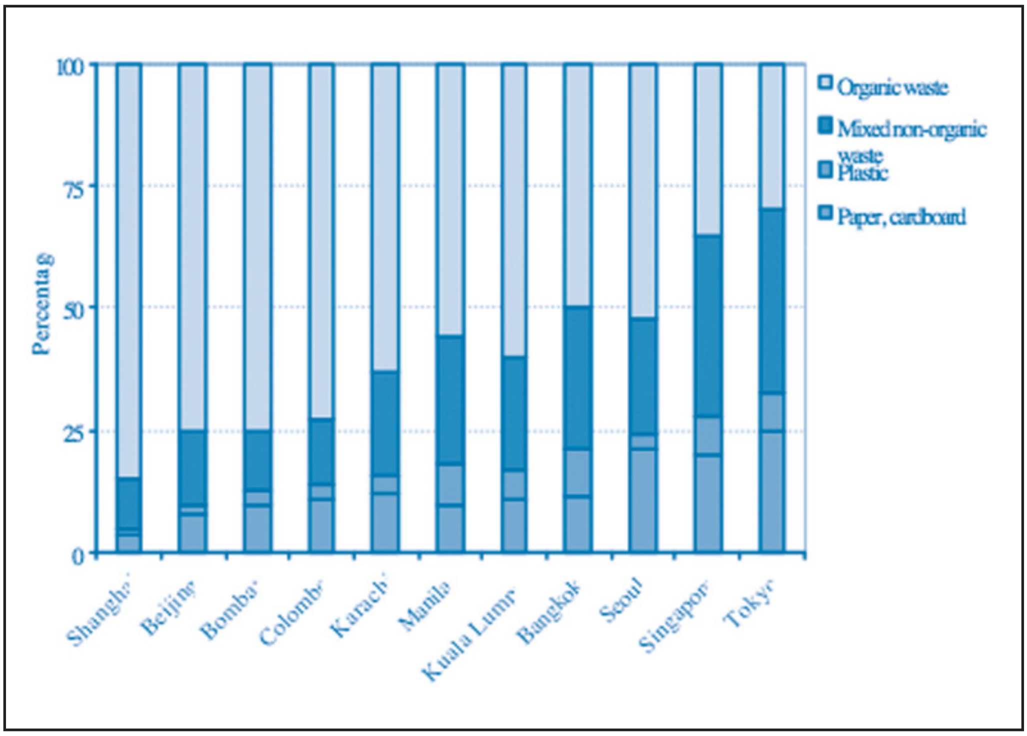
The Seas of East Asia



(Source: PEMSEA 2003)

Figure 7.2

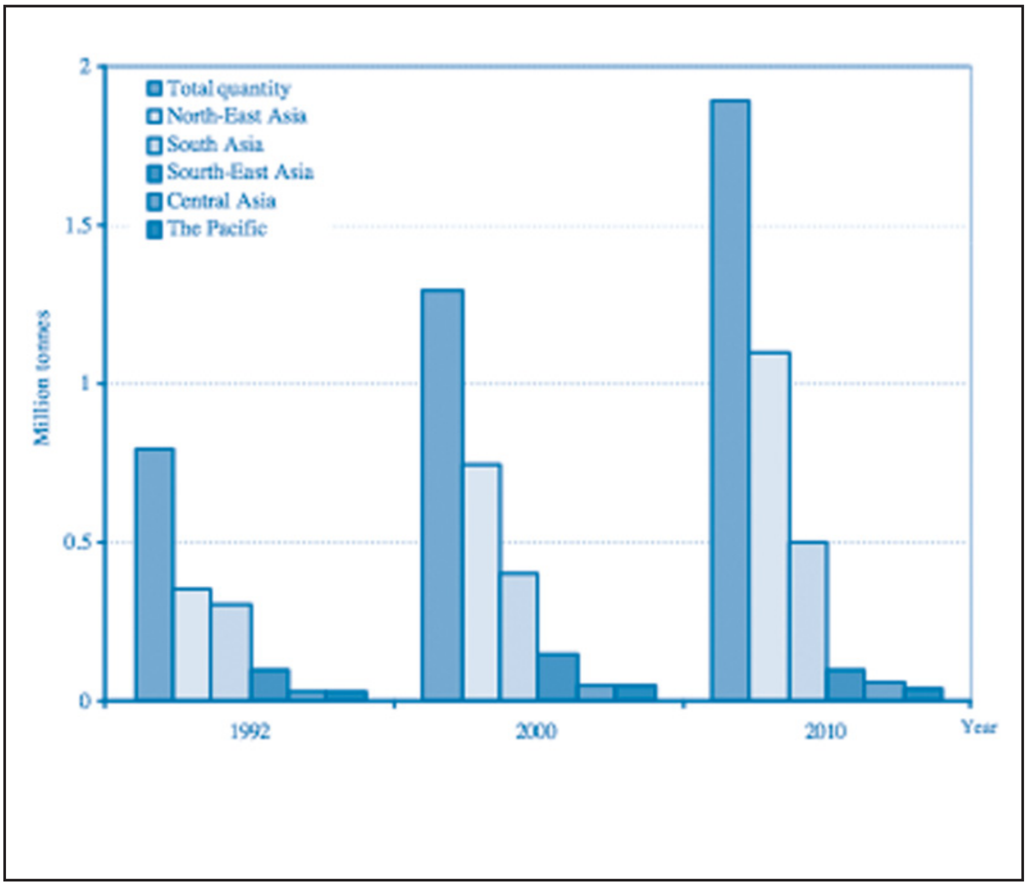
Composition of municipal solid waste generated in Asia-Pacific countries



(Source: ESCAP 1995, World Bank 1995, 1998, UNEP/SPREP 1997)

Figure 7.3

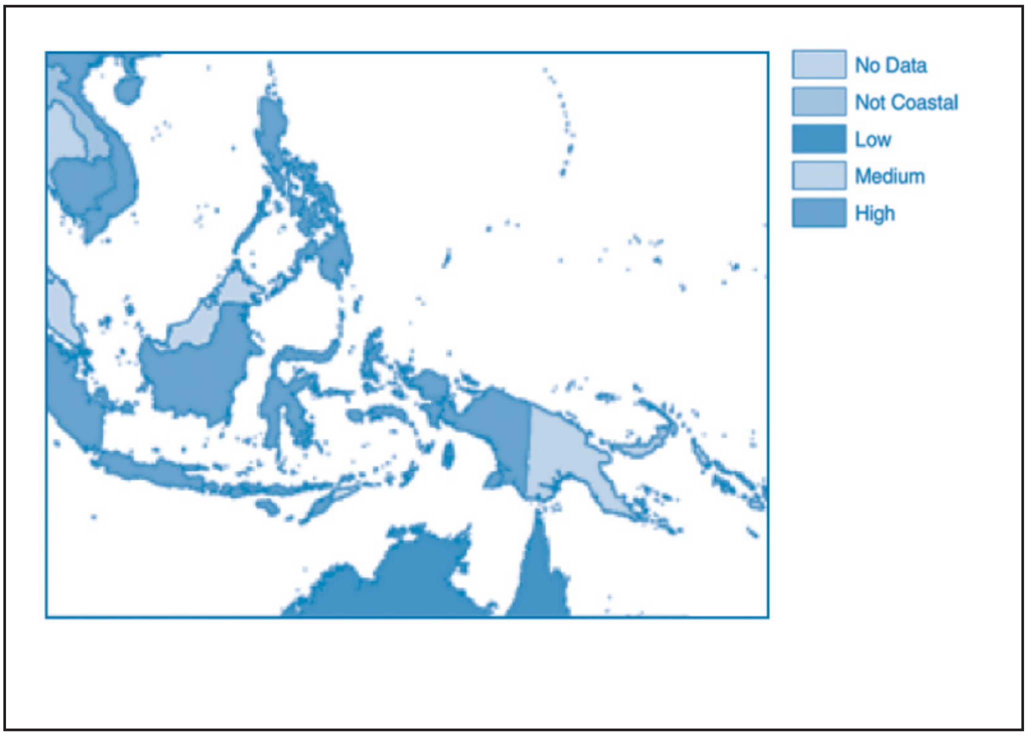
Estimated generation of municipal solid waste for Asia-Pacific



(Source: ESCAP 1995, World Bank 1995, 1998, UNEP/SPREP 1997)

Figure 7.4

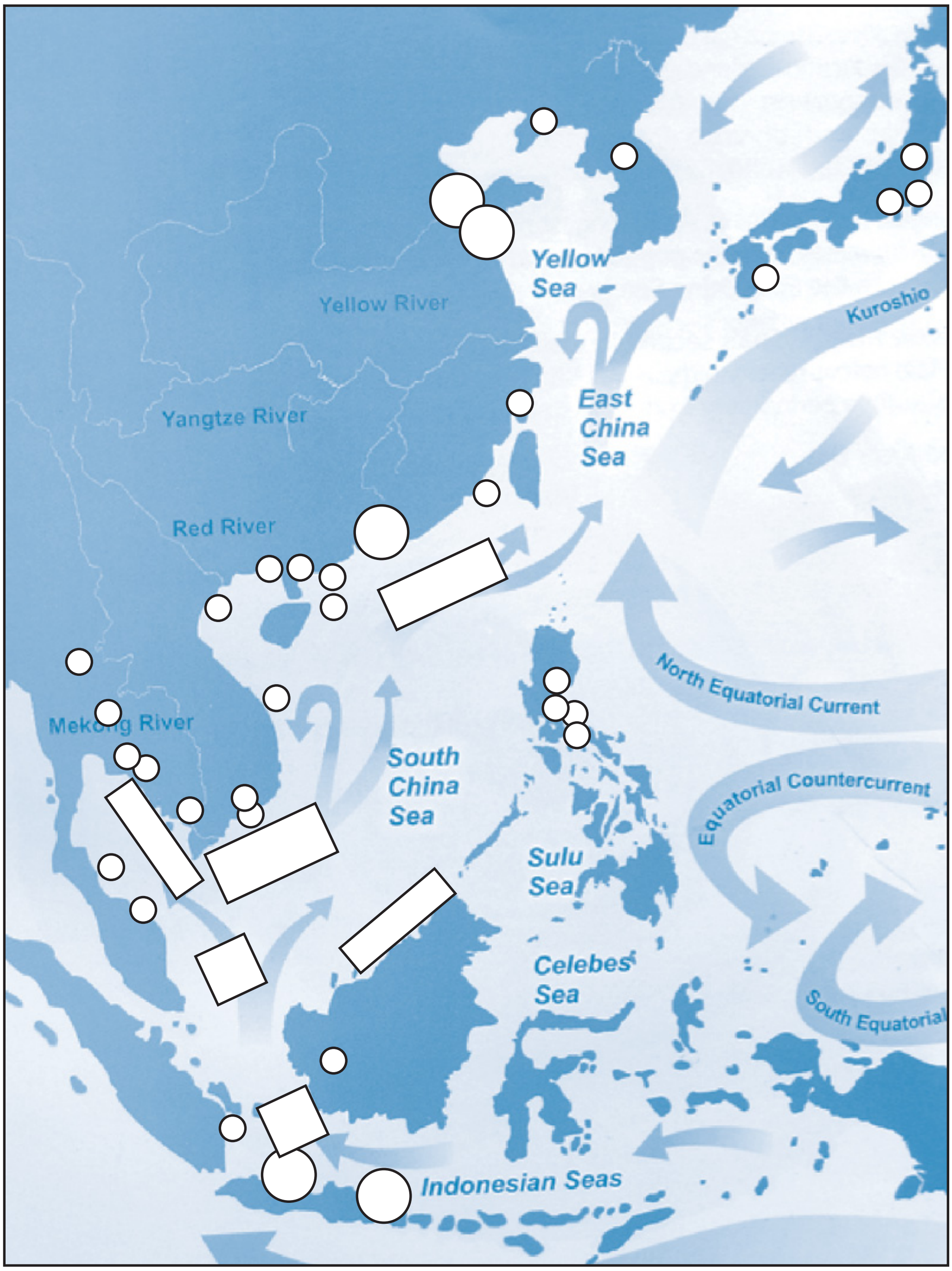
Sewage pollution index in Southeast Asia and a part of China



(PEMSEA 2003)

Figure 7.5

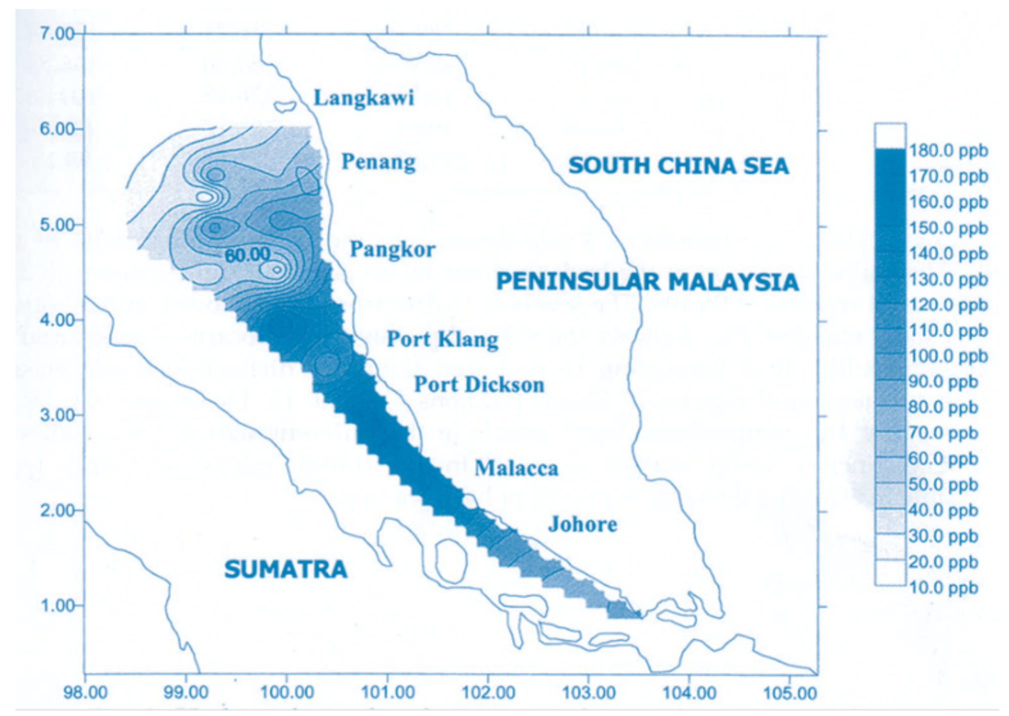
Pollution hotspots (dots) and high-risk areas (boxes) in the Seas of East Asia (large dots: BOD estimates of about 1 million tonnes/yr; small dots: 20,000 - 500,000 tonnes/yr)



(Source: Modified from Talaue-McManus 2000 and PEMSEA 2003)

Figure 7.6

Hydrocarbon distribution in the surface waters of the Straits of Malacca (1999-2002)



(Source: Law and others 2003)

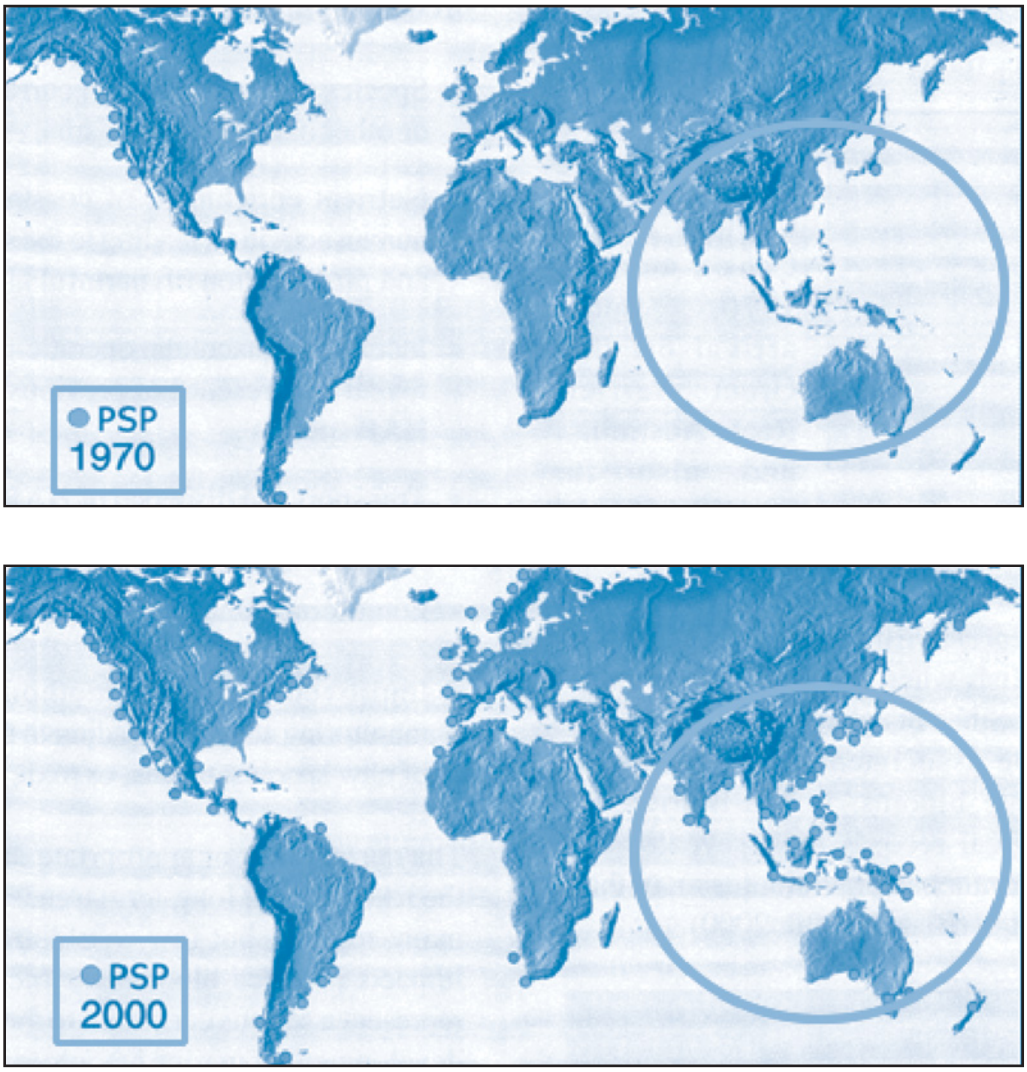
Figure 7.7

The six sub-regional growth zones in East Asia

(PEMSEA 2003)

Figure 7.8

Occurrence of HABs in the Western Pacific region, as indicated by the increase in the number of occurrences of paralytic shellfish poisoning (PSP) in 1970 and 2000



(Source: Fortes and Fukuyo 2005)

Table 7.1

Sources of pollution and their contributions to the aquatic environments in some South China Sea countries (H: high; M: medium; L: low)

Sources	Cambodia	China	Indonesia	Malaysia	Philippines	Thailand	Vietnam
Domestic waste	H	H	H	M	H	H	H
Agricultural waste	M	H	H	M	H	H	H
Industrial waste	M	H	H	H	H	H	H
Sediments	M	H	H	M	H	H	H
Solid waste	H	H	H	M	H	H	H
Hydrocarbons	L	M	H	M	M	M	M
Ship-based	M	M	M	M	M	M	M
Atmosphere	M	M	M	M	M	M	M

(Source: Modified from Talaue-McManus 2000)

Table 7.2

Utilization of fertilizers and pesticides in some South China Sea countries

Country	Rice fields (x 000 ha)	Aquaculture (x 0,000 ha)	Fertilizer use (tonnes/yr)	Pesticide use (tonnes/yr)
Cambodia	1,835	No data	>40,000	No data
China	3,425	2,476	3,636,685	>89,000
Indonesia	4,966	243	>5 600 000	28,706
Malaysia	No Data	7	No data	No data
Philippines	1,236	20	181,084	No data
Thailand	8,613	No data	No data	No data
Vietnam	1,500	No data	110,250	No data

(Source: Modified from Talaue-McManus 2000)

Table 7.3

Concentrations (ng/g wet weight) of TBT in Perna viridis reported from regional studies

Location	TBT	Sources
Hong Kong (1999)	16 -330	Sudaryanto et al. 2002
Thailand (1994-1995)	3 - 680	Kan-atireklap et al. 1997
Malaysia (1992)	14.2 - 23.5	Tong et al. 1996
Philippines (1994-1997)	<1.0 - 640	Prudente et al. 1999
Indonesia (1998)	2.2 - 38	Sudaryanto et al. 2002
Cambodia (1998)	2.4 - 88	Sudaryanto et al. 2002
Vietnam (1998)	2.1 - 64	Sudaryanto et al. 2002
St. of Malacca Malaysia)(2003)	11 - 350	Ismail et al. 2003

(Source: Modified from Ismail and others 2003)

Table 7.4

Conservative estimates of annual production of some POPs (under hazardous waste, x 000 tonnes) in some countries in NE and SE Asia

Country	1993	2000	2010
NE Asia			
China	50,000	130,000	250,000
Hong Kong	35	88	165
Indonesia	5,000	12,000	23,000
Japan	82	220	415
SE Asia			
Malaysia	377	400	1,750
Philippines	115	285	530
R. of Korea	269	670	1,265
Singapore	28	72	135
Thailand	882	2,215	4,120
Vietnam	460	910	1,560

(Source: Modified from Hernandez 1993, UNEP 1994, ESCAP 1995, Nelson 1997)

Table 7.5

Reported concentrations (µg/g) of Cd, Cu, Pb, and Zn in the mussel, Perna viridis, from regional studies

Location	Weight Basis	Cd	Cu	Pb	Zn	Original sources
Gulf of Thailand	Dry	0.17-3.25	2.94-14.99	0.19-3.75	24.93-212.5	Ruangwises & Ruangwises 1998
Tolo Harbour, Hong Kong	Dry	0.45-1.44	6.02-23.99	2.02-4.36	90-135	Wong et al. 2001
Guangdong market, China	Wet	0.38	2.05	0.18	9.9	Fang et al. 2001
Culture sites, Hong Kong	Dry	0.31-0.87	19-20	4.34-25.9	96.7-201	Wong et al. 2001
Peninsular Malaysia (20 sites)	Dry	0.25-1.35	6.31-20.21	1.27-8.76	53.82-135.5	Ismail et al. 2003

(Source: Ismail and others 2003)

Table 7.6

Oil demand by selected countries (x 000 barrels/day)

Country	1993	2000	2005	Av. Annual Growth for 1993-2005 (%)
China	2,743	4,031	5,001	5.1
Indonesia	756	1,170	1,556	6.2
Japan	4,822	5,086	5,188	0.6
Malaysia	290	414	522	5.0
Philippines	253	367	466	5.2
South Korea	1,552	2,217	2,740	4.8
Thailand	517	839	1,096	6.5
Asia-Pacific	**14,197**	**18,469**	**21,630**	**3.6**

(GEF/UNDP/IMO 1997, cited by Talaue-McManus 2000)

Table 7.7

Nutrient flux (tonnes/yr) of BOD, nitrogen (N), and phosphorus (P) for some rivers that drain into the South China Sea

Country / River	BOD	Total N	Total P
Cambodia			
Tonle Sap Lake-River System	6,022	1,084	303
Coastal rivers	No data	No data	No data
Mekong, Cambodia section	4,64	894	255
China			
Guangdong	566,385	340,050	3,768
Quangxi	57,668	8,602	507
Hainan	140	No data	No data
Thailand	299,224	130,044	7,137
Total South China Sea	**1,015,936**	**636,840**	**58,202**

(Source: Modified from Talaue-McManus 2000)

Table 7.8

Composition of litter collected on beaches in NE Asia

Collected Material	% by number	% by weight
Plastic	72.2	48.7
Formed styrene	18.5	5.7
Glass/Ceramic	3.5	11.8
Other artificial objects	2.2	21.2
Paper	1.6	1.4
Metals	1.0	3.9
Rubber	0.7	4.6
Cloth	0.3	2.9

(Source: NPEC 2003)

Table 7.9

Immediate causes of fisheries over-exploitation in Southeast Asia and vicinity (x: reported by countries)

Key Issues	Cam	Chi	Indo	Mal	Phil	Thai	Viet
1. Overfishing	x	x	x	x	x	x	x
2. Inappropriate exploitation patterns			x	x	x	x	x
3. Destructive fishing practices	x	x	x	x	x	x	x
4. Small & large scale fisheries conflicts	x			x	x		x
5. Losses due to by-catch		x	x	x	x	x	x
6. Post-harvest losses	x	x	x	x	x	x	x
7. Siltation	x	x	x	x	x	x	x
8. Habitat destruction	x	x	x	x	x	x	x
9. Reduced biodiversity	x		x	x	x	x	x
10. Land-based pollution	x	x	x	x	x	x	x
11. Oil spills			x	x	x	x	x

(Source: Modified from Talaue-McManus 2000)

Table 7.10

Mangrove area and causes of loss in 7 countries of East Asia (x: main causative factor)

Country	Original estimated cover (10^3ha)	Area inlate 1990's (10^3ha)	% area lost	Shrimp culture	Woodchip, Pulp, charcoal	Human settlement	Domestic use
Cambodia	170	85	50	x			x
China	42	15	65	x		x	
Indonesia	No data	936	No data	x	x	x	
Malaysia	505	446	12	x	x	x	
Philippines	400	160	60	x	x	x	x
Thailand	280	160	57	x			
Vietnam	400	253	37	x			x

(Source: Modified from Talaue-McManus 2000)

Table 7.11

Major factors causing degradation of coral reefs and seagrass beds in 6 countries (x: Factors reported)

Country	Overexploitation		Destructive fishing practices		Sedimentation		Pollution associated with development	
	Coral	Seagrass	Coral	Seagrass	Coral	Seagrass	Coral	Seagrass
Cambodia	x	x	x	x		x		x
China	x	x		x		x		x
Malaysia	x	x	x	x	x	x	x	x
Philippines	x	x	x	x	x	x		x
Thailand	x	x			x	x	x	x
Viet Nam	x	x	x	x	x	x	x	x

(Source: Talaue-McManus 2000, for coral reefs; Fortes 2004, for seagrass)

Table 7.12

Potential land loss and population exposed in SE Asia for selected magnitudes of sea level rise (SLR) and under no adaptation measures

Country	SLR (cm)	Land loss (km^2)	Loss %	Population exposed (millions)	%
Indonesia	60	34,000	1.9	2.0	1.1
Japan	50	1,412	0.4	2.9	2.3
Malaysia	100	7,000	2.1	>0.05	>0.3
Vietnam	100	40,000	12.1	17.1	23.1

(Source: Modified from Nicholls and Mimura 1998

Table 7.13

Ranked 'perceived' sources of pollution among countries bordering in the South China Sea. The quality of the database, and the perceived contribution of the sources to the state of the aquatic environments in the countries are also indicated

Source	Rank & Data base	Contribution to pollution of national aquatic environments (L = Low, M = Moderate, H = High)						
		Ca	Ch	Indo	Mal	Phil	Tha	Viet
Domestic waste	1-Flair	H	H	H	M	H	H	H
Agricultural waste	2-Poor	M	H	H	M	H	H	H
Industrial waste	2-Poor	M	H	H	H	H	H	H
Sediments	3-Poor	M	H	H	M	H	H	H
Solid waste	4-Flair	H	H	H	M	H	H	H
Hydrocarbons	5-Poor	L	M	H	M	M	M	M
Ship-based sources	6-Poor	M	M	M	M	M	M	M
Atmospheric	7-Poor	M	M	M	M	M	M	M

(Source: Modified from Talaue-McManus 2000)

APPENDIX I

National, regional, and international initiatives to address coastal and marine pollution in the East Asian Seas Region

National initiatives

In response to environmental imperatives, several governments have embarked on programmes to reform their urban environmental management policies and promote decentralized and participatory development (ESCAP 2000). This has enabled the mobilization of resources for the provision of improved urban infrastructure at a cost that imposes a lesser burden on scarce governmental finances. In general, urban management policies in the countries of Asia and the Pacific have centred around five principal areas: (i) enhancing urban management through decentralization and institutional and capacity strengthening; (ii) improving financial administration and mechanisms; (iii) improving housing and shelter stocks; (iv) funding urban infrastructure improvements such as water supply, sanitation, solid waste management, transport, health, parks, and playground; and (v) enacting and improving legislation and regulatory standards for urban environmental management (ESCAP 2000).

Regional initiatives

Some regional programmes and projects, which directly or indirectly address coastal and marine pollution in the East Asian seas, include:

UNEP Regional Seas Programme

The UNEP Regional Seas Programme includes the East Asian Seas and the Northwest Pacific (Northeast Asia). The activities of the individual Regional Seas Programmes typically include joint approaches to environmental assessment and management, legislation, and institutional and financial arrangements. National institutions within each of the regions are responsible for implementing agreed actions, with the main funding obtained through trust funds provided collectively by the governments. The long-term goal is the implementation of the relevant global environmental conventions and other agreements. In 2004, the latest Regional Coordinating Unit (for Northwest Pacific) was established in Toyama and Pusan; it is co-hosted by Japan and Korea.

IOC/WESTPAC Southeast Asian Global Ocean Observing System (SEAGOOS) and the WESTPAC Capacity Building and Implementation Plan for 2005-2012

What SEAGOOS does and can do for East Asia is explicit from its objective: "Southeast Asia is a region where the demands of its people, aggravated by the impacts of natural forces, are rapidly jeopardizing the sustainability of its fragile coastal and marine environment. In order to protect and manage its resources, the participants agree, in the spirit of mutual support and regional cooperation, and adhering to the GOOS principles, to build capacity in ocean sciences and operational ocean services, within a framework of sustainable ocean development". This objective is being achieved through the activities of working groups on Climate and Tropical Cyclones, Coastal Dynamics and Pollution, Ecosystems and Fisheries, and Natural Hazards.

The WESTPAC Capacity Building and Implementation Plan focuses on the prevailing ocean-related issues and the current and anticipated capacity building needs of the Western Pacific region. Specific interventions to be made include awareness campaigns; holding of focused workshops and training courses for students, scientists, institute directors, and decision-makers; distance learning; undertaking collaborative regional research cruises; and technology transfer. All these are aimed at:

- Enhancing research, coordination, and monitoring capacity to make them more relevant and useful for environmental management;
- Conducting and publicizing analysis and synthesis of different and effective management regimes to serve as effective learning tools for the region;
- Using the research process to enhance political support for ocean biodiversity, coastal management, and operational oceanography; and
- Strengthening the negotiating capacity of national representative marine science organizations.

Regional Action Plan to Enhance the Effectiveness of Marine Protected Areas in Southeast Asia (RAP) and the Call To Action to Establish Networks of Marine Protected Areas in Southeast Asia: Activities for Immediate Implementation

The RAP, formulated by the World Commission on Protected Areas in 2003, spelled out the framework and the programme of activities on how governments of Southeast Asia and partner regional and international agencies, programmes and organizations could enhance the effectiveness of MPAs in the region. It provides for the requirements of the design of networks of MPAs that are compatible with the continuation of long-term sustainable fishing, tourism, and other sustainable livelihood activities in the coastal environment, as these are a key cultural and economic component of the region.

The Call to Action, initiated in 2004, focuses on coordinating with and providing input to appropriate local, national, and regional agencies on the need for, purpose, design, and implementation of the MPA networks in the Coral Triangle. This triangle is the world's centre of marine biodiversity, characterized by more than 500 coral species and high biodiversity of fishes and other invertebrates. It includes portions of two biogeographic regions (Indonesian-Philippines Region and Far Southwestern Pacific Region) and encompasses five countries: East Timor, Indonesia, Malaysia (Sabah), Papua New Guinea, and Philippines. This Call to Action is Southeast Asia's response to similar calls made at WSSD, which urged the creation of national networks of marine parks by 2012 to protect dwindling fish stocks.

Other regional cooperation programmes and projects include: (i) Mekong River Commission, an inter-governmental cooperation initiative (Cambodia, Lao People's Democratic Republic, Thailand, and Vietnam) responsible for coordination in the use and development of water resources in the Lower Mekong Basin; (ii) UNEP/GEF South China Sea Project, which is concerned with coral reefs, seagrass beds, mangroves, pollution, and fisheries, and is now focused on the establishment of demonstration sites; (iii) Conservation of turtle habitats by the Philippines and Malaysia under the Turtle Islands Protected Heritage programme; cross-border cooperation in the management of a national park between Kalimantan in Indonesia and Sarawak in Malaysia; and the potential future development of a 'forest ecoregion' bordering Cambodia, Lao People's Democratic Republic, and Vietnam.

International Cooperation

Some international cooperation programmes and projects to help East Asia in its effort towards marine environmental protection and management include:

The Second United Nations Conference on Human Settlements: Habitat II, Istanbul, 1996

A major development in this direction was the organization of the Second UN Conference on Human Settlements: Habitat II, held in Istanbul in 1996, which adopted the Habitat Agenda. At the conference 24 countries in the region submitted their national reports with national plans of action outlining priorities for technical cooperation.

The Habitat Agenda provides an operational framework for the implementation of policies and programmes on urban environmental management in the Asian and Pacific Region. Many countries in this region have committed themselves to implementing the Habitat Agenda through local, national, and sub-regional plans of action. The Agenda is based mainly on six strategic principles for the implementation of enabling policies for sustainable urban development. These include decentralization, partnership, public participation, capacity building, networking, and the use of information and communication technology.

United Nations Agreement for the Conservation and Management of Straddling and Highly Migratory Fish Stocks

Adopted in 1995, this agreement seeks to minimize pollution, waste, discards, catch by lost or abandoned gear, and catch of non-target fish and non-fish species. These objectives were reiterated in the Plan of Action produced by the International Conference on the Sustainable Contribution of Fisheries to Food Security, held in Kyoto, Japan, in 1995 (FAO 1999).

Other international initiatives

The other international programmes and projects in which countries in the region participate include bilateral and multilateral projects and programmes that also contribute to the region's sustainable development objectives: Coastal Resources Management Project (USAID); Red Tides and Living Coastal Resources Management projects (AIDAB); Assessment of Marine Pollution by Heavy Metals (CIDA); Metropolitan Environment Programme (World Bank); Regional Study on Global Environmental Issues (ADB); Promotion of Market-Based Instruments for Environmental Management (ADB); Coastal and Marine Environment Management Information Systems (UNEP, ADB); Protection of the Greater Mekong Sub-Region, with various initiatives (ADB, USAID); and Regional Centre for Biodiversity Conservation (EU). Most countries in the region are members of the LOICZ Programme.

APPENDIX II

Pollution hotspots in East Asian Seas countries

Location	Demography/ Contributing cities or subregions	Pollution load
Cambodia		
1. Phnom Penh City	1,100,000 (1997)	BOD: 20,075 t/y TSS: 44,165 t/y COD: 34,130 t/y Total N: 3,285 t/y Total P: 1,000 t/y
China		
2. Han River	Shantou	COD: 37,102 t/y Oil: 384 t/y IN: 4,296 t/y IP: 697 t/y
3. Pearl Estuary	Hong Kong, Shenzhen, Dongguan, Guangzhou, Zhuhai, Macau	COD, nutrients, SS
4. Zhanjiang Bay	Zhanjiang	COD: 11,691 t/y N: 840 t/y Oil: 190 t/y
5. Behai coastal waters	Behai City	COD, nutrients, SS
6. Haikou coastal waters	Haikou	COD, nutrients, SS
Indonesia		
7. Dumai River	Riau –Batam	BOD: 17.7 – 48 mg/l
8. Pulau Nipah	Riau-Batam	
9. Siburik River	Bangka-Belitum and S. Sumatera	NO_3: 1.38 – 2.14
10. Lahat River	Same	BOD: 3 – 35 mg/l
11. Tanjung Pandan	Same	Cd: 0.005 – 0.017 mg/l
12. Palembang Harbour	Same	BOD: 4 –78 mg mg /l
13. Japat River	Jakarta	BOD: 13.5 – 15.0 mg/l
14. Jakarta Bay	Jakarta	Hg: 0.132 – 0.200 ug/l
15. Kali Mas River	West Java	BOD: 15.6 – 47.0 mg/l
16. Strait of Madura	West Java	BOD: 48 – 91 mg/l Phenol: 0.05 – 1 mg/l
17. Pulau Laut	S. Kalimantan	NO_2-N: 0.03 mg/l
18. Pontianak Harbour	W. Kalimantan	BOD: 135 – 150 mg/l
Malaysia		
19. Kota Bharu	257,792 (population); 0% access to sewerage	BOD generated: 4,705 t/y
20. Kuala Terengganu	268,294; 8.6% access	BOD generated: 4,477 t/y
21. Kuantan	238,738; 24% access	BOD generated: 3,230 t/y
22. Kuching	497,000; no data	BOD generated: 9,070 t/y
23. Kota Kinabalu	271,000; no data	BOD generated: 4,946 t/y

(Source: Talaue-McManus 2000)

Location	Demography/ Contributing cities or subregions	Pollution load
Philippines		
24. Manila Bay	Metropolitan Manila and CALABARZON industrial estate	BOD: 4.8 mg/l Coliform: 2.5 x 10^5 ppm
25. Subic Bay	Zambales specifically Subic Port and industrial estate	BOD: 160-234 mg/l Coliform: 1,888 MPN/100 ml
26. Batangas Bay	Batangas City, oil refineries and depots	BOD: 8,838 t/yr from livestock Oil: 1,233 m^3 spilled from 1986-1993
Thailand		
27. Lower Chao Phraya River		Water Quality Index Level 5
28. Pasak River		Same
29. Petchburi River		Same
30. Bangpakong River		Same
31. Rayong River		Same
32. Songkhla Lagoon		Same
Viet Nam		
33. Ha Long Bay	Open pit coal mining, oil depots, port operations	4 x 10^6 t of coal mine sludge/y
34. Hai Phong Port	Population of 564,200; 9,891 industrial firms, 3.5 x 10^6 ton port.	BOD: 3,235 t/y COD: 4,331 t/y Coliform: 1,500 MPN/ 100 ml
35. Da Nang Port	Population of 667,200; 767 industrial firms, 3 oil ports	COD: 3,236 t/y TN: 6,601 t/y TP: 62.4 t/y TSS: 194,316 t/y Coliform: 5-270 x 10^3 MPN/100 ml
36. Vung Tau- Ganh Rai	154,505 population; 2,622,000 tourists/y (1995)	Ganh Rai Bay BOD: 4-11 mg/l SS: 150-260 mg/l TN: 0.2 - 0.5 mg/l TP: 0.02 – 0.05 mg/l Oil: 0.15 – 0.25 mg/l Zn: 0.02 – 0.04 mg/l

8 - Arctic Ocean

INTRODUCTION

The Arctic Ocean and its shelf seas constitute an area of global significance in terms of their influence on global oceanic and atmospheric circulation. Figure 8.1 shows the Arctic Ocean and its regional seas and main catchment areas both inside and outside the Arctic. Vast shelf areas lie along the northern Russian coast, Alaska coast, and in the Canadian Arctic Archipelago. The circumpolar arc is enclosed by Greenland, Iceland, and Scandinavia. The Russian landmass occupies 44% of the circumpolar arc, approximately twice that of Canada, which is the next largest Arctic country.

The Arctic seas neighbouring the Polar Circle with a total area about 20 million km^2 could be divided into two categories. The first consists of typical shelf waters (with the shelf in some areas about 1,000 km wide) starting with Hudson Bay, the Canadian Arctic Archipelago, Beaufort Sea (with narrower shelf between 50 to 100 km), Chukchi Sea, East Siberian Sea, Laptev Sea, Kara Sea, Barents Sea, and White Sea. The second category consists of deep ocean waters including Norwegian Sea, Greenland Sea, Labrador Sea and Baffin Bay, as well as the Central Arctic Basin. The Lomonosov Ridge divides the Arctic Basin into the Eurasian and Canadian parts. The Arctic seas are open seas. Water exchanges are minimal through the shallow (42 m) Bering Strait and very extensive through the Fram Strait and Barents Sea. To the north, they freely exchange water with the Central Arctic Basin. The western boundary of the Barents Sea is open to water exchanges with the Norwegian and Greenland Seas. Only the Hudson Bay and White Sea are inland seas.

Severe climatic conditions characterize the shelf seas and Arctic Basin. Depending on the latitude, the polar night lasts from two to four months, as does the polar day. The average winter air temperatures over the sea range from -20 to -35 °C. The lower temperature is typical of the Laptev Sea, where temperatures in northern areas can reach as low as -50 °C. In the Kara, Beaufort, and Chukchi Seas, the climate is slightly milder due to the influence of the Atlantic and Pacific Oceans. For most of the year the Arctic shelf seas are covered with ice, which can be up to 2 m thick. Nowadays, each summer the melted ice line extends progressively further north as a result of global warming. Being free from ice year-round, the southwestern part of the Barents Sea experiences a considerably milder climate.

The Arctic seas are influenced by large-scale freshwater flows from the continent and the islands. The Kara Sea is particularly heavily influenced by rivers, receiving outflows from the Enissey, Ob', Nadym, Pur, Taz, and Pyasina Rivers, as well as from many smaller rivers. The aggregate mean annual discharge of water is about 1,300 km^3, which transports more than 150 million tonnes/yr of organic and mineral substances in suspension and solution. The Laptev Sea annually receives about 800 km^3 of freshwater and 70 million tonnes of chemicals in suspension and solution from the Rivers Lena, Khatanga, Anabar, Olenek, Yana, and others. The East Siberian Sea receives considerably less river water - about 250 km^3/yr, while the influence of river flow on the Chukchi Sea is insignificant. On the other hand, the Beaufort Sea receives a significant input of 333 km^3/yr (and approximately 42 million tonnes of sediments) from the Mackenzie River and its vast watershed. The other major riverine inputs to the Arctic Ocean come from the Hudson Bay and James Bay catchment areas. In total, the influx of river water to the Arctic Ocean is about 4 200 km^3/yr, equivalent to about 2% of the total water influx. This quantity is significant in comparison with other oceans. As a consequence of the considerable input of freshwater, the Arctic seas are well-stratified throughout the year, with the exception of shallow areas (10-15 m depth) where mixing by gales or winter convection erode the pycnocline. For most of the year, the water in the surface layer of the Arctic seas is below 0 °C and equal or close to the freezing point of the seawater.

Being a region of low temperatures, the Arctic Ocean could serve as a cold trap for atmospheric pollutants from lower latitudes. Pollution of the Arctic Ocean from land-based sources occurs through atmospheric transfer, oceanic currents, and runoff from Arctic rivers. Considerable quantities of biogenic substances and chemical compounds introduced by the rivers are then distributed by the ocean currents. Another pollutant-producing mechanism is re-suspension from bottom sediments. There is a good reason to use the catchment area concept (Ivanov and others 2000) as the basis for estimation of pollutant transport by surface waters. The completeness and reliability of estimates of pollutant transport from river catchments into the seas depend on the quality of information about the river catchments and marine basins, as well as the quantity of river runoff and its seasonal and inter-annual variations.

DEVELOPMENT OF THE LEGAL AND INSTITUTIONAL FRAMEWORK AND REGIONAL AND INTERNATIONAL COOPERATION

At the 1992 Earth Summit in Rio de Janeiro the need to manage human activities within the context of entire ecosystems and to address environmental, social, and economic objectives in an integrated manner was widely endorsed. This approach was also accepted at the formation of the Arctic Council in 1996 by the eight circumpolar countries and reconfirmed at the WSSD in Johannesburg in 2002. The work of the Arctic Council continued the activities started under aegis of Arctic Environmental Protection Strategy accepted by circumpolar countries in Rovaniemi in 1991. One of such activities was implemented by the Working Group on the Protection of the Arctic Marine Environment (PAME). PAME, which includes all eight Arctic countries, coordinates all activities directed towards protection of the Arctic marine environment. For this purpose, in 1998 PAME developed the Regional Programme of Action for Protection of the Arctic Marine Environment from Land-Based Activities - RPA (Arctic Council 1999), which has been expanded into the Arctic Marine Strategic Plan (AMSP) of 2004.

The aim of AMSP is to achieve the sustainable development of the Arctic marine environment. AMSP also represents an important opportunity to link Arctic Ocean health to the full implementation of existing international instruments and governmental commitments aimed at improving the management of ocean and coastal resources. In this regard, one of the objectives of AMSP is to promote the implementation of applicable international instruments to which Arctic Council member States are party, such as UNCLOS, the UN Framework Convention on Climate Change, the IMO Conventions and Protocols, the London Convention, the Stockholm Convention on Persistent Organic Pollutants, the Convention on Biological Diversity, the Convention for the International Trade in Endangered Species, the Convention on Wetlands of International Importance and relevant regional instruments such as the Convention for the Protection of the Marine Environment of the North-East Atlantic.

AMSP should also help to fulfill the objectives of the GPA, the proposed EU Marine Strategy, and the FAO Action Plans. The Russian Federation contributes to the aims of the GPA through its own national programme "World Ocean" and by participation in UNEP Regional Seas Programmes (e.g., Arctic, Caspian, Black and Baltic seas, Northwest Pacific Region). The protection of the Arctic Ocean is provided through Russia's participation in activities of the Arctic Council through PAME; Conservation of Arctic Flora and Fauna Working Group; Arctic Monitoring and Assessment Programme (AMAP); Emergency Prevention, Preparedness, and Response Programme; Working Group on Sustainable Development; and other organizations as well as the National Programme of Action for the Protection of the Arctic Marine Environment (NPA-Arctic).

GEF/UNEP plans to support Russian NPA-Arctic through a full size GEF Project, for which the project development (PDF-B) stage was concluded by ACOPS (www.acops.org) in 2001. Some results of these studies are used in this paper (Evseev and others 2000, Ivanov and others 2000).

The ACOPS Report 1997 (Lystsov and Tsyban 1997) was an additional source of information. In this report, a more ecosystem-based approach was applied and data on marine pollution were assessed together with data on marine microflora, chlorophyll concentrations, phyto- and zooplankton, and state of the bentofauna. Data on environmental pollution of the seas of the Russian Arctic were obtained from Russian Federation State Reports on Condition of the Environment (State Report 1991, State Report 2002) and Annual Reports of Roshydromet (Russian Federal Service on Hydrometeorology and Monitoring of Environment) on pollution of different compartments of the environment and in particular marine waters (Roshydromet 1992a, 1995, 2000, 2001, 2003, 2005). Data on environmental pollution outside of the Russian Arctic were mostly obtained from reviews by AMAP (AMAP 1997, AMAP 2002, AMAP 2003, AMAP 2004) and GESAMP (GESAMP 2001). Other important sources of information were the USA "Arctic Environmental Atlas" (Crane and Galasso 1999), Canada's National Programme of Action for the Protection of the Marine Environment from Land-based Activities (Canada NPA 2000), and many other documents produced in the five Nordic countries.

CURRENT STATUS OF THE ARCTIC OCEAN ENVIRONMENT RELATED TO THE GPA SOURCE CATEGORIES

The prioritization of the GPA source categories for the RPA was done according to three main criteria:

1. Severity of risk to human health, the environment, or economic and social benefits and uses including cultural values;
2. Shared problems where there is an existing or potential risk of transboundary effects or habitat degradation; and
3. Issues common to many sites where there is existing or potential similarity in local and national problems that will benefit from common approaches.

According to these criteria, the GPA source categories were prioritized as follows:

- High: POPs, Heavy metals;
- High - medium: Physical degradation;
- Medium: Oil hydrocarbons (OHC), Radionuclides;
- Low: Sewage, Nutrients, Sediment, Litter.

This classification is, however, provisional. Problems of physical degradation of habitats could be closely interwoven with chemical pollution or sediment displacement. Besides POPs, the less persistent pollutants could also be of interest; besides organochlorine, organophosphate compounds, etc. should also be considered.

The problem of the lack of reliable and comparable data was encountered in preparing this assessment. Very often the countries use different methodologies for the measurement of pollutant levels, which makes the results difficult to compare. Another difficulty is spatial and temporal heterogeneity in sampling - only rarely are time series of measurements at specific sites and according to a specified schedule available.

POPs and other organic compounds

Average worldwide DDT concentrations in open sea water range from 0.1 - 1 ng/l, increasing by an order of magnitude in estuaries and coastal zones. Recent measurements in water and sediment of the open Barents Sea and Kola Gulf are available (Roshydromet 2005). In open sea water (in the so-called Pechora Sea) the DDT group concentration was 2 ng/l. The average DDT concentrations for three areas of Kola Gulf were 2.0, 4.0 and 2.5 ng/l, with a maximum in the middle part of 9.1 ng/l and in the upper part of 12.4 ng/l. The latter exceeded the maximum permissible concentration (MPC) of 10 ng/l. α-HCH content varied between 1 - 8.7 ng/l. For γ-HCH the yearly average was about 1 ng/l, with the highest of up to 5 ng/l in the middle part of the gulf. Bottom sediments are highly contaminated by POPs (Table 8.1).

Relatively high levels of sediment pollution by pesticides and very high levels for the industrial pollutant PCB were recorded. In the open sea, considerably lower levels of DDT group concentrations in sediments (in the range 0 - 0.2 ng/g) were observed. Besides DDE, a notable increase in gulf sediment pollution was observed.

Samples of snow, seawater, and ice from two oceanographic stations near the North Pole were analysed for pollutants during the Joint Russian-French expedition "North Pole - 2002" in April 2002 (Roshydromet 2003). Pesticides α-HCH and γ-HCH together made up 2.29 ng/l in surface water and 1.94 ng/l in ice. Total concentrations of identified organochlorine pesticides ranged from 4.19 ng/l in surface water to 2.95 ng/l in sea ice and 2.44 ng/l in snow.

In general, AMAP (AMAP 1997) conclusions about POPs in the Arctic marine environment were confirmed in the latest AMAP review (AMAP 2004). HCH levels gradually increase along a south-north gradient (from sub-tropical waters to the Arctic Ocean), with the highest values observed in the Beaufort Sea and the Canadian Archipelago. This is considered as evidence of the cold trap theory. Under conditions of decreased temperature volatile compounds readily condense out of the atmosphere and are absorbed by particles or are partly dissolved in water. Permanent ice cover and low temperatures do not give volatile HCH molecules the possibility to outgas easily and they are retained for many years. Thus, at present the current concentrations of HCH in water, ice, and snow reflect previous high concentrations in the atmosphere. Water exchange will gradually leach out retained HCH.

For less volatile compounds AMAP conclusion (AMAP 1997) that POPs levels in the Arctic environment are generally lower than in more temperate regions is still valid. However bio-magnification by movement through the food chains and some physical processes do increase POP levels in tissues of many species and at many sites. This is especially true for those species at the top of the marine food chains. Polar bears and other marine mammals, as well as some sea birds have the highest body burden of POPs. Detrimental health effects have been observed in some of the most highly exposed or sensitive species at many sites. Reduced immunological response in polar bears and northern fur seals has led to increased susceptibility to infectious diseases. Some birds suffer from immunological, behavioural, and reproductive effects, e.g., peregrine falcons have suffered from eggshell thinning and reproductive impairment.

AMAP (AMAP 2004) also stated that POP compounds other than those included in the Long-range Transboundary Air Pollution Convention and Stockholm Convention may have reached or are approaching levels in the Arctic that could require regional or global intervention. High levels of brominated flame retardants such as polybrominated difenyl ethers (PBDEs), polychlorinated naphtalenes, as well as some current use pesticides such as endosulphan have been recorded in the Arctic, with the level of PBDEs highest in the Canadian Arctic.

Another organic pollutant regularly measured by the Russian monitoring system is phenol (or phenols). Phenol is produced in many natural processes, in particular during rotting of submerged wood. Phenols are also components of discharges by wood and pulp/paper industries. According to Russian standards the MPC for phenols is 1 µg/l. In open parts of the Barents Sea phenol concentration of 0.9 µg/l (slightly below MPC) was recorded (Roshydromet 2005). Significantly higher concentrations were found in Dvina Gulf (4 µg/l), Khatanga Gulf (2 µg/l), and Ob' Gulf (6 µg/l). These high values could be associated with the large quantities of submerged wood in the corresponding rivers where rafting was used for transport of wood on a large scale.

Heavy metals

The Arctic Ocean receives heavy metals through the usual pathways: deposition from the air, river influx, ocean transport, and local pollution. As for POPs, long-range atmospheric transport is the most important general pathway for heavy metals (including Hg, Pb, and Cd) into the Arctic marine environment. In Russia some mines and smelters are situated near the coast. Metal-laden sediments are deposited through estuarine processes and move farther offshore on the sea shelf. However, only a small part could be further transported by ocean currents and drifting ice.

High priority was accorded to heavy metals because of their biotoxicity, with Hg being of top priority. This metal is a nerve toxin and can impair reproduction in mammals. In fish its effects include decreased sense of smell, damage to gills, and blindness. In organic form Hg can be absorbed by living organisms and its ingestion by humans led to the outbreak of "Minamata disease" in Japan. Another toxic metal is Pb, which is relatively insoluble in the marine environment and forms particulates that may be deposited in bottom sediments or enter the food chain. This metal enters the marine environment by air deposition and through river outflow and water seepage. Arctic seafloor sediments have a typical Pb concentration of about 20 µg/g. Levels of Pb in seawater are variable and range from 0 - 1 µg/l. For the Central Arctic Basin a rather high value of about 2 µg/l was recorded in 2002 (Roshydromet 2003). The Russian standard MPC for Pb is 30 µg/l. Living organisms have some capacity to absorb Pb through different, though not completely understood, pathways. Pb damages the nervous system and has gastrointestinal effects. It also damages red blood cells, which could lead to anemia. In fishes Pb accumulates in gills, liver, kidneys, as well as bones, and results in tail blackening and spine damage. Furthermore, larval survival is reduced in the presence of Pb.

Another toxic metal is Cd, which could be accumulated in plants and animals, especially in mushrooms. Cd decreases the survival of fish fry and damages kidneys and liver in mammals. This metal's characteristic extremely low rate of excretion makes even low doses dangerous. In Arctic seawater in the western hemisphere Cd stays at relatively low levels, between 0 - 100 ng/l. However, in the Russian Arctic shelf and Central Basin it rises to between 0.5 - 1 µg/l. The Russian standard MPC for Cd in seawater is 10 µg/l. Cd ions may be absorbed directly from water by aquatic animals, especially fish and invertebrates, leading to the start of its accumulation and biomagnification in the food chain. Predatory seabirds that feed on fish have shown enhanced levels of Cd in their kidneys. Mammals could also accumulate this metal. Further studies of the detrimental effects of Cd are necessary. Practically all other heavy metals have some degree of biotoxicity of different types.

The results of a 2003 expedition (Roshydromet 2005) in the open part of the Barents Sea (Pechora Sea) illustrated heavy metal abundance in seawater. In waters under the ice average concentrations were as follows: Fe: 7.70 µg/l; Mn: 1.94 µg/l; Zn: 2.08 µg/l; Cu: 0.48 µg/l; Ni: 0.54 µg/l; Pb: 0.59 µg/l; Co: 0.05 µg/l; Cd: 0.10 µg/l; Cr: 0.53 µg/l; Sn: 0.19 µg/l; and Hg: 0.02 µg/l.

A quite different picture was observed in waters of Kola Gulf. Heavy metals are ubiquitous in gulf waters, with the highest concentrations usually observed in the southern part. Yearly average Cu content in 2003 did not exceed 1 MPC (1 µg/l). The concentration of Fe decreased more than 3 times (from 242.0 to 71.0 µg/l) from 2002 to 2003, and was about 1.4 MPC, with a maximum value of 4.6 MPC. The average and maximum values for Ni were lower than 1 MPC. The content of Pb decreased, with the maximum lower than 30 µg/l (1 MPC); highest values were observed in the vicinity of the harbour. In all parts of the gulf Hg was present at levels lower than MPC (0.1 µg/l). The highest value of Hg in the lower part of the gulf was 0.05 µg/l. Bottom sediments in Kola Gulf are strongly contaminated by heavy metals. As it was for waters, the highest pollution was measured in the southern (upper) part of the gulf. The average content of heavy metals in the southern part was: Cu: 165 µg/g; Ni: 307.4 µg/g; Pb: 64.1 µg/g; Mn: 348.6 µg/g; Cr: 373.9 µg/g; V: 76.0 µg/g; and Hg: 0.48 µg/g. The average concentrations of Fe and Aluminium (Al) were significant (especially near the shipping harbour) - 44,169 µg/g and 11,336 µg/g respectively. Levels of sediment pollution in the middle and lower legs of the gulf were several times lower, although still relatively high. Average pollution of bottom sediments of the middle and southern legs of the gulf by Hg was 0.48 µg/g and 0.44 µg/g respectively and 0.20 µg/g in the northern leg.

Throughout the whole Arctic, Hg in surface sediments usually varied between 0 - 0.2 µg/g. Only in certain spots does it reach 4 µg/g due to local peculiarities. Nevertheless, this is lower than the average level of Hg of 80 µg/g in the continental crust. Concerns have been expressed about the elevated organic Hg level of about 100 µg/l (Dewailly and others 2001) in the blood of indigenous people of the Canadian Arctic. Lower concentrations of Hg in blood (10 - 20 µg/l) were recorded in Russian Arctic indigenous people in the vicinity of Norilsk and Salekhard (Klopov and others 1996). This could be attributed to lower fish consumption by the Russian indigenous group. The biotoxicity of Hg needs to be further investigated.

Oil hydrocarbons (OHC)

The highest risks of oil pollution from onshore oil and gas extraction and transportation are connected with large-scale accidents. For example, in 1994 such an accident occurred near the town of Usinsk in Komi Republic in the Russian Northwest. About 40,000 tonnes of crude oil poured out of the ruptured pipeline. Although this accident happened in the Pechora catchment area, fortunately hardly any effects were observed in the Pechora Sea. A significant influence on the marine environment could be observed from the coastal settlements and industrial and military facilities onshore as well as offshore. Most devastating could be accidents involving supertankers.

Some data on oil pollution in the seas of the Russian Arctic follow, with the Russian MPC standard for OHC (50 µg/l) used as a benchmark. In 2003 in the open part of the Barents Sea (Pechora Sea) OHC were present in soluble and emulsion form in snow cover in the range 5.8 - 43.2 µg/l (average 19.4 µg/l), in sea ice 5.4 -18.5 (average 15.2 µg/l), and in water under ice 8 - 33 µg/l (average 19.4 µg/l) (Roshydromet 2005). Enhanced OHC concentrations are noted for the northwestern part of the region near the Cape "Russky Zavorot", at the southern range of Prirazlomnoe oil deposit (in snow), and in sea ice in the central part and to the north of the islands "Gulyaevskie Koshki".

Again, much greater pollution can be observed for the Kola Gulf of the Barents Sea. The gulf was polluted with an average OHC concentration of 60 µg/l. The maximum level of 200 µg/l (4 MPC) was observed in May 2003 in the region of the harbour. In the year 2000 maximum levels varied between 20 - 70 MPC. Previous values of up to 150 MPC were observed, which indicated extremely high oil pollution in the gulf. OHC content in sediment varied between 2.1 - 4.6 µg/g sediment dry weight. In 2003 in Dvina Gulf (White Sea) the average OHC content was less than 10 µg/l, with a maximum of 80 µg/l (1.6 MPC) near the bottom in the outer part of the gulf. During the same period the OHC concentrations in the surface layer of water in Enissey Gulf (Kara Sea) ranged from 8 - 62.6 µg/l near Cape Gostinny.

Radionuclides

In the past a sensitive topic was dumping of radioactive waste at sea. Solid and low level liquid radioactive wastes were dumped by the former Soviet Union in the bays of the Novaya Zemlya archipelago (Kara Sea) and in the open waters of the Barents Sea. This practice was stopped by the Russian Federation in 1992, but until May 2005 the Russian Federation had not formally adopted the 1993 protocol to the London Convention that bans marine dumping of radioactive wastes. Russia has now officially adopted this protocol. On 17 May 2005 the Government of the Russian Federation informed the IMO Secretary-General that it had accepted the ban as contained in the amendments to the Convention under Resolution LC.51(16). After 12 years the prohibition of the dumping of radioactive wastes at sea is finally in force by all Contracting Parties to the London Convention.

A general description of radionuclide sources in the Arctic is given in the section on Hotspots. Examples of localized pollution follow. Many factors define the levels of activity of radionuclides in waters and bottom sediments of the Murmansk region. On the shelf of the Barents Sea along the northern seashore of the Kola Peninsula the caesium (Cs)-137 content in the surface layer of bottom sediments decreases from west to east, from between 15 -20 Bq/kg (dry weight) in the west to between 0.5 - 1 Bq/kg (dry weight) at the Cape "Sacred Nose" and the entrance to the White Sea. Further to the east the concentration of Cs-137 begins to increase and reaches between 8 - 10 Bq/kg at the shores of Novaya Zemlya. The localized pollution of bottom sediments in the gulfs of the northern shore of the peninsula is caused by local polluters and by pollutants transported from the continent by rivers. At the mouth of the Kola Gulf the content of radionuclides in the surface layer of bottom sediments can be considered as low-level (Cs-137: 2.8 Bq/kg and strontium (Sr)-90: 0.43 Bq/kg (dry weight). In the vicinity of the Repair Technical Base "Atomflot" in Murmansk the content of radiocaesium in bottom sediments is considerably higher, reaching up to 30 Bq/kg (dry weight)). In addition to radiocaesium, trace amounts of Co-60 and europium can be found in the samples. In the direction of the mouth of the Kola Gulf the content of radiocaesium in bottom sediments gradually decreases down to levels of 2 - 3 Bq/kg (dry weight). The content of plutonium-239 and plutonium-240 in waters of the Barents Sea is in the range 0.01 - 0.05 Bq/m^3, and that of plutonium-238 between 0.001 - 0.004 Bq/m^3 (Matishov and others 1994, IAEA 1997, Crane and Galasso 1999).

A new approach regarding protection of the environment from radiation is gaining the increasing attention of specialists. Current radiation protection is fully based on human health effects and it is assumed that if humans are protected, other organisms are protected as well. However, it was shown that this statement could be invalid, especially for the Arctic environment with its low human population density.

In October 2002 the International Commission on Radiological Protection (ICRP) approved the ICRP Publication 91 "A framework for assessing the impact of ionizing radiation on non-human species" (ICRP 2003). This Publication should help to formulate a policy, based on scientific and ethical-philosophical principles, to protect non-human species and at times even individual animals. The work on such policy formulation and monitoring requirements is now led by different organizations and scientists. It is worth noting that the problem of enhanced radiation vulnerability in the Arctic is of concern in some terrestrial environments but usually is not the case for the marine environment.

Sewage and nutrients

These two issues present generally localized problems in the Artic and are considered of low priority. For small polar circle residential settlements the risk of pollution of marine waters is usually small. However, the problem is very different for big cities with large volumes of communal as well as industrial wastes. In large cities (such as Murmansk, Archangelsk) these problems could be very acute and require significant concerted effort sometimes at an international scale (NEFCO/AMAP 2003). For example, in 2003 the Kola Gulf received 64.7 million m^3 of communal and industrial sewage, of which 94% was untreated; this originated at 40 factories, several cities, and settlements (Roshydromet 2005). In 2002, the gulf received 71.5 million m^3, 96% of which was untreated (Roshydromet 2005). Conventional sewage treatment systems often do not work well in the Arctic. This is confirmed by Canada's experience. About 50 communities with an average population of 740 people are situated on the Arctic coast. Although total volumes are not high, wastewater in the northern conditions is more concentrated than it would be in the temperate climate. At the same time, since this sewage does not contain notable volumes of industrial or institutional wastes the total release of metals and inorganic wastes is low. Some communities discharge sewage directly into the ocean while others have sewage lagoons. However, these lagoons frequently do not function properly or overflow into the surrounding areas. Some communities dispose of sewage in plastic bags, which are then placed in solid waste disposal sites. Because of the slow rate of decomposition in the Arctic, it takes a number of years for this waste to degrade. Possible pollution in these cases is, however, very localized.

Sediments

Sediments present generally localized problems in the Artic and are considered of low priority. Sediments and silt formation are important for the maintenance of many coastal habitats. Reduction or increase in the natural rate of sedimentation and silt formation could compromise the integrity of habitats and threaten the health of benthic communities. Contaminated sediments could become sources of secondary pollution in the marine environment. Seaports on the Russian Arctic coast from Murmansk to Tixi very often have enhanced levels of sediment pollution.

Litter

The issue of litter is an acute problem for the entire coastline of the Russian Arctic. The shores and waters of Kola Gulf are littered with more than 100 scrapped, rusty metallic ships (NEFCO/AMAP 2003) and other industrial trash, which increase the navigation dangers and pollute the waters. The sandy and stony shores of the Arctic seas are strewn with large quantities of timber: boards, planks, branches, and tree-trunks. Shores in the areas directly adjacent to river mouths are particularly affected. Large quantities of submerged logs are decaying on the bottom of the rivers. The timber finally breaks down and rots in the coastal zone, adversely affecting seawater quality, although living organisms have apparently adapted to these conditions. Another litter problem is presented by large quantities of abandoned iron barrels, sometimes with the remains of oil products, on the coast. Surveys conducted in the Canadian Arctic have shown that the most commonly found items were polystyrene foam and polypropylene rope. With the decline in oil and gas activities, the largest source of litter currently appears to be domestic wastes from coastal communities.

Specific problems of PADH are not considered in this paper, since they involve first of all issues of nature and biodiversity preservation at particular sites. These problems should be also discussed in connection with the rather strong effects of global warming in the Arctic.

ASSESSMENT OF GPA-RELEVANT ISSUES

Based on the foregoing analysis of pollution problems, it may be concluded that the Arctic Ocean in its open parts and away from immediate sources of pollution and shipping and fishing activities is relatively clean and has intact or slightly disturbed ecosystems. However, this situation is different for gulfs, bays, and estuaries under stress from anthropogenic activities; these areas could be described as specific hotspots. A number of these semi-closed areas of coastal hotspots are considerably polluted. The ecological condition of these hotspots is aggravated by the presence in bottom sediments of high concentrations of different pollutants of anthropogenic origin that have accumulated for many years. These accumulated pollutants could serve as secondary sources of contamination.

Hotspots

In the period 1999 to 2001 a group of about 15 international and Russian experts developed the comprehensive definition of hotspot both as pollution sources and impact areas, and proposed a methodology for their prioritization (Evseev and others 2000). In the Russian Arctic 147 hotspots were identified, of which 21 were classified as priority sites (17 terrestrial and 4 estuarine and marine impact zones - Kola, Dvina, Ob', and Taz Gulfs). Most of the hotspots were associated with activities in: ferrous and non-ferrous metallurgy (6 hotspots); mining industry (25 hotspots); transport centres (20 hotspots); power engineering industry (2 hotspots); oil and gas extraction (63 hotspots); and wood processing and the pulp/paper industry (7 hotspots). These same industries are generating hotspots that are dangerous for the marine environment in the rest of Arctic. Again estuaries of rivers with harbour facilities may present marine pollution problems.

POPs contamination is usually due to long range atmospheric or river transport (hotspot of area character). However, small local sources may sometimes play a significant role. For example, PCB contamination, though banned in the USA in 1977 (Crane and Galasso 1999), could still be found in significant quantities throughout the Arctic. Most of it originates from sediments contaminated years ago as well as leakage from storage sites and landfills in the USA, Europe, Russia, and other countries. Decommissioned military facilities (Distant Early Warning sites in America and former naval and military bases in Russia) could contribute to PCB hotspots. High PCB levels have been detected in nearshore areas close to abandoned or existing military facilities (e.g., at Cambridge Bay, Canada; Thule, Greenland; the Norwegian coast).

Elevated concentrations of PCB in Arctic seawater (~10 ng/l) were observed in coastal regions of Kara and Laptev seas, which indicate significant PCB fluxes transported by the great Siberian rivers. The total content of PCB in Enissey Gulf waters ranged between 0.5- 2 ng/l (Roshydromet 2005). The average total PCB value in Ob' Gulf was around 1 ng/l (Roshydromet 2001). Lower PCB values were observed in the Canadian Archipelago, where sea ice had higher PCB levels than seawater. North of Svalbard sea ice had a maximum value of 150 ng/l, while ice between Greenland and Svalbard had 2.5 ng/l. PCB has a temporary Russian MPC of 10 ng/l.

PCB accumulates on particles in seawater and is trapped in bottom sediments. The concentration in sediments is usually less than 1 ng/g. Values two orders of magnitude higher in Kola Gulf sediments indicate significant local sources of PCB. Elevated PCB concentrations have been detected in sediments close to landfills on Svalbard. Different individual PCBs accumulate in thymus, lungs, spleen, kidneys, liver, brain, muscles, and testes, and cause pathological changes in the immune and reproductive systems of animals. Polar bears usually have higher levels of PCB than other animals. PCB effects on immune and reproductive systems are being actively studied.

Stocks of obsolete pesticide waste are hotspots of potential danger. Treatment and disposal of such stocks, at least in northwestern Russia, was considered an environmentally sound investment project by Nordic Environment Finance Corporation and Arctic Monitoring and Assessment Programme (NEFCO/AMAP 2003). More than 50 tonnes of old and unused pesticides were identified in the Murmansk and Archangelsk regions.

Abandoned chemical waste sites with possible threat of pollution to the marine environment were identified throughout the Arctic. Very often such sites have been the results of previous military activities (e.g., Distant Early Warning sites in North America and former military bases in the Russian Arctic). Large-scale remediation work was done in Canada; about 500 polluted sites have already been cleaned up, but much more remains to be done. Remediation of former military bases is included in several Russian programmes.

Non-ferrous and ferrous metals industries are important sources of air pollution by heavy metals and contribute to the formation of hotspots in the region. The main metals taken into account are: Pb, Ni, Cd, As, Cu, Se, and Zn. Over the Polar circle in the Russian Arctic the mines and smelters are situated in Nickel, Zapolyarny, Monchegorsk (Kola Peninsula) and in Norilsk-Talnakh (Taimyr Peninsula). As a result of the combined action of sulfur oxides and heavy metals these sources are producing hotspot impact zones with completely destroyed vegetation on the scale of 100 km. The global source of Pb was represented by leaded gasoline before the transfer to unleaded gasoline. A very broad spectrum of heavy metals pollutes the air and sewage as a result of fossil fuels combustion for energy production.

Localized hotspots acting directly on the marine environment include mines and industrial activities close to the coast. Localized impacts may lead to heavy metal concentrations significantly exceeding background concentrations at distances generally within 30 km from the source, as demonstrated by the now closed Black Angel mine in Greenland (AMAP 1997) or the Red Dog Mine in northwestern Alaska, USA. In Canada two Pb-Zn mines operate in the coastal zone - Polaris Mine on Little Cornwallis Island and Nansivik Mine near Arctic Bay. Mining activities greatly increase the releases to surrounding waters. In addition, oil and gas drilling activities in the Mackenzie River estuary produced some pollution of waste by heavy metals, among which were Cr, Cu, Hg, Ni, and Pb.

The Arctic contains the world's largest petroleum reserves both on land and on the continental shelf. The main areas with current production are Norman Wells on Mackenzie River, the Prudhoe Bay oilfield on Alaska's Beaufort Sea coast, the Nenets and Yamalo-Nenets autonomous okrug, the West Siberian oil fields, and two fields on the Norwegian shelf. Offshore exploration activities are now heading towards production in the Barents Sea in the Russian (Prirazlomnoe and Shtokmanovskoe deposits) and Norwegian parts, off the west coast of Greenland and on the North Slope of Alaska. A new great pipeline is currently projected to link the deposits in northern Russia with the thawing port of Murmansk. Another transportation option is the Northern Sea Route from the Atlantic to the Pacific Oceans. Petroleum exploration, production, and transportation could all be the major sources of OHC in the Arctic.

Besides anthropogenic sources there are many natural oil seeps. These oil seeps originate, e.g., in north-flowing rivers (Mackenzie River, Ob') and discharge oil into the Arctic Ocean. Of the total oil entering globally into the marine environment at least 15% are of natural origin. It is assumed that this figure is higher for the Arctic.

The Arctic marine environment has been contaminated by radioactive fallout from atmospheric nuclear weapons testing and by radioactive releases from European reprocessing plants at Sellafield (UK) and Cape de la Hague (France). Underwater nuclear tests were performed by former Soviet Union in Chernaya Guba of the Novaya Zemlya archipelago. Although other radionuclide releases associated with poor waste management practices, accidents with nuclear submarines or nuclear weapons could be measured in Arctic waters, these are nevertheless minor in comparison with the consequences of global fallout or releases from Sellafield.

Radioactivity issues in the Arctic marine environment are currently more of a potential nature. The greatest potential problem is presented by the decommissioning of the Russian nuclear fleet and its infrastructure. Russia has built 248 nuclear submarines, 5 nuclear powered surface ships, 8 nuclear icebreakers, and one nuclear lighter ship. The total number of nuclear reactors on these vessels is more than 450 (Sarkisov 2004). In 2003, 193 of the nuclear submarines were taken out of operation and passed through different technological stages of decommissioning. Surface ships and parts of the nuclear icebreakers also need decommissioning. To that must be added the problems of decommissioning of infrastructure, including large former naval technological bases in Guba Andreeva and Gremikha (both on the coast of the Kola Peninsula) (Sarkisov 2004), as well as civil floating storage of damaged and spent nuclear fuel on the vessel "Lepse" in Murmansk harbour. The problems of spent nuclear fuel disposal are of greatest urgency. Solution of all of these problems will require many years of concentrated efforts and high capital expenses each year. Many bases of the Russian nuclear navy and elements of its infrastructure are situated on the Kola Peninsula. The civil nuclear fleet (icebreakers and lighter) has its base in Murmansk harbour, with its civil service structure being the Repair Technological Base "Atomflot". These sites are potential radioactive hotspots.

Has the situation concerning GPA issues improved or worsened during recent years?

Temporal trends of the presence of POPs in different media and biota

There was a decrease in the concentrations of some POPs in many species and in different media in the Arctic (AMAP 2004). Such decreases could be related to reduced releases to the environment. Decrease of α-HCH in air closely follows a decrease in global usage, but the decrease in marine biota

will be much slower due to the immense storage capacity of the ocean.
The concentrations of other POPs still increase in some cases. PCBs appear to be decreasing in most media. In the atmosphere the half-lives of tri- to heptachlorbiphenyl congeners vary from 3 - 17 years. This is a slower downward trend than at the lower latitudes, but definitely downward. HCH and chlordane in air also showed downward trends. From 1979 to 1996 HCH levels in the air decreased more than 20-fold, but only a modest change was observed in the concentrations in tissue of ringed seals and polar bears in the East Canadian Arctic for the same time period. The observed trends in biota correlate better with the assessed reduction of HCH in seawater (about 3% per year).

In general, concentrations of POPs for certain time intervals in different species and at various locations in the Arctic may shed light on the history of POPs pollution in different regions. Concentrations of total DDT, PCB, α-HCH, and γ-HCH were monitored for three groups of Arctic species - freshwater fish, marine mammals, and seabirds. The time intervals considered were from 1960s/early1970s to late 1990s/early 2000s and from late 1980s/early 1990s to late 1990s/early 2000s. As a rule, declines were more rapid for the earlier 25-30 year period than for more recent times. However, in the case of countries with late elimination of POPs (e.g., DDT) the recent period may give a higher decline trend. For example, in burbot in Pechora and Enissey Rivers DDT decline was about 15%/yr in 1988-1994 and for burbot in Mackenzie River only about 1.8%/yr in 1986-1999. Declines in POPs concentrations in marine mammals and seabirds are very variable and in some cases an actual increase was noted. However, the tendency for cleaning of banned POPs in physical media and biota is evident.

Temporal trends in heavy metals presence

Spectacular reductions in deposition of atmospheric Pb were observed in those regions where the use of leaded gasoline has been prohibited. Levels of Pb in biota do not decrease proportionally, and is connected with releases from large stores in sediments and soils. New additional impetus to studies of Hg levels led to the discovery of a new effective mechanism of Hg deposition on snow in a form that can become bio-available (AMAP 2002). The process is linked with the polar sunrise and is unique for these high latitudes. The Arctic plays a previously unknown role as the sink in the global Hg cycle. During snow melting at the beginning of spring this metal becomes available just at the beginning of the growth period of plants and animals. AMAP (2002) also states that, despite the significant reductions in Hg emissions in Organization of Economic Cooperation and Development countries in 1980s, the global Hg emission could be on the rise due to the burning of coal in small-sized power plants and household heaters, mostly in Asia. It should be noted that an increase in Hg levels was observed in marine birds and mammals of the Canadian Arctic. Some indications of an increase were also obtained in West Greenland. On the other hand, there are many examples of decreases in Hg levels for other sites in the Arctic. The situation regarding Hg needs further, broad field investigations.

Temporal trends in the presence of OHC

In 1999 the average OHC content in Enissey Gulf bottom sediments was 32 µg/g (Roshydromet 2000). There was no increase from 1994. For Ob' Gulf (Kara Sea) the average OHC concentration in surface waters was 47.5 µg/l while in bottom sediments it was 102 µg/g. OHC concentration in sediments rose five times from 20 in 1994 to 102 µg/g in 1999, indicating an increase in oil pollution of Ob' estuary and the adjacent marine area. In 2002 the concentrations OHC were measured in seawater, snow, and ice at the North Pole (Roshydromet 2002). In the surface water layer the OHC content ranged between 2 - 27.1 µg/l with an average of 14.75 µg/l; for snow between 8.9 - 48.5 µg/l melted water; and for ice 37.3 µg/l melted water. These data show that OHC pollution reflects the existing burden on different parts of the Arctic Ocean and indicates the necessity of intervention in some coastal waters. Due to the rapid growth of shelf oil and gas production in the future, a drastic increase in preparedness for large-scale accidents in Arctic conditions is inevitable since the probability of such accidents occurring will increase.

Temporal trends in the presence of radionuclides

The peak radionuclide concentration in Barents Sea waters in the 1960s was connected with weapon tests, while the peak observed at the beginning of the 1980s was connected with Sellafield releases. Since then, radionuclide contamination has gradually decreased. However, in 1986 some new input was made by the Chernobyl accident although its influence on the Arctic seas was not as high as, e.g., on the Baltic Sea. Another recent development was the notable growth of marine releases of technetium (Tc)-99 and iodine-129 by reprocessing plants. One of these radionuclides (Tc-99) may create some problems in the near future. Thus, in some marine foods marketed in Europe the levels of Tc-99 are higher than EU intervention levels for infant food and are approaching intervention levels for adults (AMAP 2003).

Some improvements in the situation related to the GPA issues can be reported, but long- term sustainable goals still have to be achieved.

Has progress been made in protecting the marine environment during the last ten years?

In those cases where coordinated collective actions were taken as, e.g., in the prohibition of the use of some pesticides and other types of POPs or removal of leaded gasoline, definite positive trends were found. The future impact of implementation of the Stockholm Convention on POPs holds great promise. However, a much more complex situation exists for cleaning up of many polluted estuaries and bays. While in some cases, significant positive results have been achieved, more often the situation prevails where no concerted intersectoral actions are taken. Examples are available for some sites in the Russian Arctic. For many such sites ecosystem state could be assessed with the help of biological observations. For such assessments the results of long term hydrobiological observations of the Roshydromet network could be used (Roshydromet 1992b, Roshydromet 1993, Roshydromet 1996). Such observations may include total count of bacterioplankton, separate count of saprophytic bacteria, the most probable number of hydrocarbon-oxidizing microflora and other microbiological indicators. At the same time chlorophyll a concentrations, primary production, and biodiversity at different trophic levels may be studied. These data together with hydro-chemical indices permit the determination of the state of specific coastal habitats.

The Kola Gulf (especially in the south-middle parts under the influence of Murmansk sewage effluents) can be considered as being in a state of crisis. These waters are highly polluted on a permanent basis. In the last 20 years the biomass of phytoplankton was significantly reduced. The whole structure of the community has changed, with changes in the dominant species. However, in other regions of the Barents Sea (open sea, Motovsky Gulf) phytoplankton remained unharmed and stable. Dvina Gulf of the White Sea can not be considered separately from the estuarine part of North Dvina and its influence. Chlorophyll a in gulf waters may be higher than 11 µg/l, indicating rather high availability of nutrients and the eutrophic character of the ecosystem. Taking into account high levels of phenols in the gulf and regular and accidental releases of industrial sewage from Archangelsk and Solombala pulp/paper mills, the situation for Dvina Gulf could be considered as critical, although to a lesser degree than for Kola Gulf. Of the coastal areas of the Kara Sea the most polluted in terms of OHC, chlorinated organic compounds, phenols, and heavy metals are Enissey and Ob' Gulfs. Other areas of the Kara Sea are clean or slightly polluted. Khatanga Gulf in the Laptev Sea may be considered as slightly polluted, but according to ecological indicators, the state of the ecosystems in Tixi Bay and Buor Khaya Gulf is critical. Concerted combined efforts are still necessary to limit marine pollution of these water bodies as well as some others gulfs and bays in the Arctic.

The way forward

River runoff and long-range atmospheric transport are both sources of pollution in the Arctic Ocean. Point sources such as industrial enterprises make their localized contribution through effluents and discharges. Comparison of the significance of pollution sources is in most cases difficult. In Annex V of Ivanov and others (2000) an attempt was made to calculate influx of the main pollutants to estuaries and sea areas in the Arctic by fallout and runoff. The fallout values were assessed through a combination of dry precipitation and fallout in rainfall over certain sea areas and washoff from the nearest territories and transfer with river waters. The results for the Kola impact zone (10,000 km^2), including Kola and Motovsky Gulfs and the coastal strip around peninsula, are presented in Table 8.2, as an example. These results indicate that atmospheric fallout is a crucial pathway for acidification and PCB, while for heavy metals it is runoff.

Taking into account the extensive catchment areas and large volumes of runoff, the Arctic rivers exert the most powerful influence on the character and level of pollution in the Arctic Ocean, especially of estuaries and shelf areas. More than half of the organic toxicants (including phenols and organochlorines), nitrogen, and phosphorus compounds and the bulk of oil pollution removed from the Russian territory are carried by river runoff to the Arctic Ocean. The greater part of oil hydrocarbons arrives in the Arctic Ocean with the runoff of Ob' and Enissey. In Canada the Mackenzie River and rivers of the Hudson Bay catchment area play a similar role. Therefore, controlling and limiting river pollution is the first necessary step. Atmospheric transport also significantly contributes to Arctic pollution, especially in winter. Substantial amounts of pollutants from the industrial regions of Eurasia and America reach the high latitudes and precipitate directly on the surface of the Arctic seas. Only broad international agreements could help with controlling this pollution pathway. Localized sources determine the specific character and level of pollution in hotspots in nearshore marine areas (Evseev and others 2000), and could be dealt with at a national as well as international level. Only systematic work on protection from all these pathways and sources of pollution could provide a clean and sustainable Arctic marine environment for future generations.

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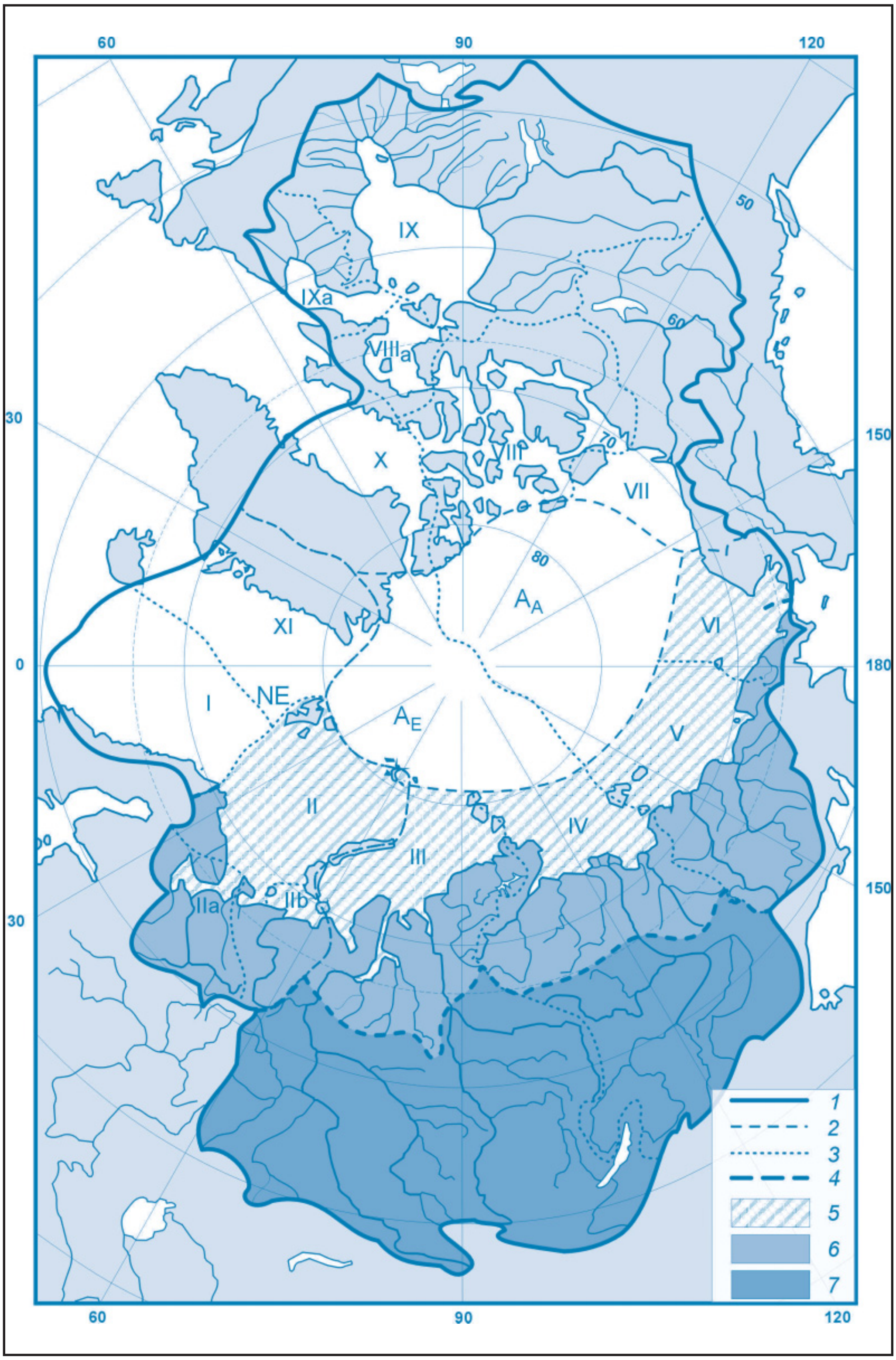
Figure 8.1

Boundaries of the catchments area of the Arctic Ocean (1); its parts (2); seas, major gulfs and straits (3); water-ecological boundary of river catchments of the Russian Arctic region (4); Russian Arctic seas (5); river catchments for basins of the Russian Arctic seas within the limits of the Arctic region (6); and areas beyond these limits (7)



Key: Parts of the ocean: the North European Basin (NE); the American sector of the Arctic Basin (AA); the Eurasian sector of the Arctic Basin (AE) Key: The seas, gulfs, straits and their catchments area: Norwegian Sea (I), Barents Sea (II), incl. the Pechora Sea (IIb), White Sea (IIa); Kara Sea (III), Laptev Sea (IV), East Siberian Sea (V), Chukchi Sea (VI), Beaufort Sea (VII), Canadian Straits (VIII), Fox Basin (VIIIa), Hudson Bay (IX), Hudson Strait (IXa), Baffin Bay (X) and Greenland Sea (XI)

Table 8.1

Pollution (av./max.) of bottom sediments (ng/g) in Kola Gulf by POPs in 2003 in comparison with 1994

Gulf Leg	α-HCH	γ-HCH	DDT	DDE	DDD	PCB
2003, South	2.2/5.0	1.9/6.0	3.7/11.9	1.3/16.0	25.5/121.4	223.2/727.0
2003, Middle	No data	No data	-/3.7	-/0.6	-/3.6	312.0/756.0
2003, North	No data	No data	-/4.8	-/0.6	-/3.6	201.5/388.0
1994, average	1.1	1.1	0	50.9	0	No data

Table 8.2

Atmospheric fallout and river runoff of pollutants in the Kola impact zone

Pollutant	Fallout	Runoff
Nickel*	4.78	113
Copper*	6.04	96.4
Lead*	5.65	64.9
$SO4^{-2}$*	12,220	95.8
NO3*	3,968	No data
Benzo(a)pyrene**	2.48	2.4
∑HCH**	17.3	2.4
∑DDT**	18.8	15.6
∑PCB**	5.6	0.012

* tonnes/yr; ** kg/yr

9 - Caribbean SIDS

INTRODUCTION

Human activities in both coastal and inland areas are threatening the health, productivity, and biodiversity of coastal and marine environments globally. The situation in the Caribbean Small Island Developing States (SIDS) region (Figure 9.1) is no different. It is becoming increasingly apparent that Caribbean coastal ecosystems and their resources are being degraded because of escalating anthropogenic pressures superimposed upon natural local, regional, and global trends. Sources of anthropogenic pressures include population growth and poorly planned coastal urban and industrial development, indiscriminate exploitation of coastal resources, as well as inappropriate agro-forestry practices.

Waste management is considered to be one of the major environmental issues in the Caribbean Community (CARICOM) region (CARICOM Secretariat 2003). Growth in urban population, industrial activity, and tourism continues to outstrip infrastructural capacity to handle waste. Based on current information, pollutants from land-based sources constitute one of the greatest threats to coastal and marine ecosystems and to public health in the Wider Caribbean Region (WCR) (UNEP 2005). In fact, pollution of aquatic ecosystems, including sensitive marine and coastal habitats, is the most predominant and recurrent transboundary environmental concern in the larger islands (UNEP 2004a). Land-based sources of pollution are estimated to account for 80 - 85% of marine pollution in the region (OECS/UNDP 1994). These include industrial, residential, and agricultural sources from which pollutants are transported to the coast in streams and water run-off by leaching and infiltration in the soil as well as direct discharges to the sea. This is compounded by the fact that, because of their small physical size, activities far inland could also have serious effects on the coastal and marine areas of these island states. In addition, the islands, particularly those in the southern Caribbean, are influenced by continental river run-off. For instance, as shown by Muller-Karger and others (1989), the plume of the Orinoco River, as tracked by satellite imagery, seasonally penetrates across the Caribbean Basin, potentially exerting a region-wide influence (Figure 9.2).

THE CARIBBEAN SIDS REGION

Bio-physical description

The Caribbean Sea covers a surface area of about 1,943,000 km^2, and possesses many productive and biologically complex and diverse ecosystems including coral reefs, seagrass beds, mangroves, coastal lagoons, and beaches. With the majority of corals and coral reef-associated species being endemic, the Caribbean Sea is a biogeographically distinct area of coral reef development particularly important in terms of global biodiversity (Spalding and others 2001). The Caribbean Sea fisheries are based on a diverse array of resources, several of them shared or migratory. With the SIDS EEZ forming a mosaic that includes the entire region, many transboundary resource management issues arise, even at relatively small spatial scales.

Based on SeaWiFS global primary productivity estimates, the Caribbean Sea is a low productivity ecosystem (<150 g C/m^2/yr) (NOAA 2003). However, there is considerable spatial and seasonal heterogeneity in productivity throughout the region. Areas of high productivity include the plumes of continental rivers, localized upwelling areas, and nearshore habitats such as coral reefs, mangrove forests, and seagrass beds. Relatively high productivity also occurs off the northern coast of South America where nutrient input from rivers, estuaries, and wind-induced upwelling is greatest (Richards and Bohnsack 1990). The remaining area of the Caribbean Sea is mostly comprised of clear, nutrient-poor waters.

Socio-economic background

The total population of the Caribbean SIDS is about 33.8 million (CIA 2005), with an average annual growth rate of 0.79% (UNEP 2005). High population densities, particularly in coastal areas, are a common feature of these small islands. In several of the states population density exceeds 200/km^2, reaching up to 580/km^2 in Barbados (CARICOM Secretariat 2003). The urban population, which is concentrated in coastal areas, exceeds that in the Latin American and Caribbean region as a whole and has shown an increasing trend over the last few decades (Figure 9.3). Key health and social indicators have generally maintained a positive trend in the majority of the Caribbean countries (UNEP 2005). The level of human development, as reflected by the UN HDI, ranges from high in Barbados to low in Haiti (UNDP 2004a). Significant variation exists among the countries with respect to poverty, with the highest poverty rate of 53% in Haiti and the lowest of 14% in Barbados (World Bank 2002).

The major economic sectors include services (including tourism), export agriculture, and mineral extraction (Figure 9.4). Historically, the export earnings of many of the islands depended on agriculture (mainly sugarcane and bananas). This sector's contribution to GDP is, however, in general decline. Tourism, on the other hand, has become one of the principal industries and the fastest growing economic sector in the region (CARICOM Secretariat 2003). According to the Caribbean Tourism Association, 2004 saw close to 10 million tourist arrivals and a similar number of cruise ship passenger visits in 12 of the Caribbean SIDS. This represents an increase of up to 13.4% (Cuba) and 106% (Dominica), respectively, over the previous year. The concentration of tourism infrastructure and activities on the coast cause major environmental problems for coastal habitats when poorly planned. Marine fisheries production is also a significant source of food, employment, and foreign exchange in these SIDS (FAO 2005).

Caribbean SIDS, like others worldwide, share a number of environmental and socio-economic challenges that make them particularly vulnerable to impacts from a wide range of internal and external forces (Briguglio 2003). Among these are scarce land resources; economic dependence on a limited range of natural resources, in most cases coastal and marine; increasing pressures on the coastal and marine environments; susceptibility to the vagaries of international trade; limited ability to develop economies of scale; and high vulnerability to natural disasters. The region has a long history of devastating tropical hurricanes and other natural disasters, with severe social and economic consequences. For example, in 2004 three hurricanes caused about US$2.8 thousand million in damages in Cuba, Dominican Republic, Grenada, Haiti, and Jamaica (CRED 2005). That same year, hurricanes and floods affected close to one million persons in the Caribbean SIDS. Of particular concern is the effect of global warming, which is projected to lead to an increase in the frequency and severity of tropical storms (IPCC 2001).

Relevant institutional and policy frameworks

Issues related to the coastal and marine environments, including the GPA source categories, are covered in a variety of frameworks ranging from national legislation, action plans, as well as regional and international non-binding and binding agreements (UNEP 2005). A major regional framework is the Caribbean Action Plan and the Caribbean Environment Programme (CEP) with its four main sub-programmes: Assessment and Management of Environment Pollution (AMEP); Specially Protected Areas and Wildlife (SPAW); Information Systems for the Management of Marine and Coastal Resources (CEPNET); and Education, Training, and Awareness (ETA). CEP is facilitated by the UNEP Caribbean Regional Coordinating Unit (CAR/RCU), which is a sub-programme of UNEP's Regional Seas Programme. The latter provides an integrated framework for the national and regional action programmes of the GPA/LBS protocol and continues to respond to the needs of the region in this regard.

In 1983, the Caribbean Action Plan led to the adoption of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention). Three protocols have been developed under the Cartagena Convention:
- Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region (SPAW);
- Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region (Oil Spills); and
- Protocol Concerning Pollution from Land-based Sources and Activities (LBS).

Unique to the region, the Cartagena Convention and its three protocols constitute the first regional framework convention for the protection of the marine and coastal resources. The CAR/RCU serves as the secretariat of the Cartagena Convention. Currently, CEP has four Regional Activity Centres (RAC) assisting in the implementation of programme activities relating to the three protocols (Oil Spills Protocol located in Curaçao, Netherland Antilles; SPAW Protocol located in Guadeloupe; and LBS Protocol - one located in Cuba and the other in Trinidad and Tobago).

The AMEP sub-programme is concerned with the assessment and management of environmental pollution and provides regional coordination for the implementation of the LBS and Oil Spills Protocols. AMEP is responsible for the regionalization of global agreements such as the GPA, Agenda 21, and the Basel Convention. Among this sub-programme's activities is the preparation of the Second Regional Overview of Land-based Sources and Activities in the Wider Caribbean Region (an update of CEP Technical Report 33). The objective is to provide an update of available information on all point and non-point source discharges and to establish a new baseline from which to measure progress under the LBS Protocol. See the CEP website (http://www.cep.unep.org/) for further information.

Among the most important global action plans for the Caribbean SIDS is the Barbados Programme of Action for Sustainable Development of SIDS (BPoA), adopted in 1994 to facilitate the implementation of Agenda 21 in SIDS. Arising from the BPoA was an initiative to have the Caribbean Sea internationally recognized as a special area in the context of sustainable development. In December 2003, the UN General Assembly Resolution 57/261 - Promoting an Integrated Management Approach to the Caribbean Sea Area in the Context of Sustainable Development - was adopted. The Mauritius Strategy for the further implementation of the BPoA, which arose from the 2005 international conference on the review of implementation of the BPoA, calls for SIDS and their international development partners to fully implement the GPA, by undertaking initiatives specifically addressing the vulnerability of SIDS.

Several national and regional agencies engage in studies and projects related to pollution and conservation of coastal and marine areas. Among these are the Institute of Marine Affairs, CAR/RCU, CARICOM, Caribbean Conservation Association, Caribbean Environmental Health Institute (CEHI), and the Organization of Eastern Caribbean States (OECS) Environment and Sustainable Development Unit. Currently, several of the Caribbean SIDS governments are trying to initiate coastal zone planning within an integrated coastal area management framework. The Caribbean SIDS are participating in the project "Integrating Watershed and Coastal Area Management in Small Island Developing States of the Caribbean", which is supported by the GEF. The objective of the project is to strengthen the capacity of the participating countries to implement an integrated approach to the management of watersheds and coastal areas. UNEP is the lead GEF implementing agency in collaboration with UNDP, with UNEP-CAR/RCU and CEHI being the co-executing agencies.

The Caribbean SIDS face many challenges in addressing land-based sources of marine pollution (Table 9.1), which impact negatively on the long-term sustainability and positive benefits of many environmental interventions in the region. While many studies have been conducted in localized areas, most are sporadic and limited in scope and therefore cannot be used to determine environmental trends. Furthermore, the general quality of regional environmental data is low, as few countries have the necessary systems in place to collect quality-assured environmental data on a regular basis (UNDP 2004b). This is particularly acute in specific sub-regions and/or for selected GPA source categories. For example, much more monitoring data is available for Barbados, Trinidad and Tobago and Jamaica than for the smaller Eastern Caribbean Islands. It is therefore important to identify where these deficiencies or data gaps exist and implement measures to address them.

STATE OF THE ENVIRONMENT RELATED TO THE GPA SOURCE CATEGORIES

Sewage

Domestic wastewater is the largest point source contributor by volume to the Wider Caribbean Region (UNEP/CEP 1994a). Sewage is regarded as one of the most important and widespread causes of degradation of the coastal environment in the Caribbean (Siung-Chang 1997). This was re-enforced by the regional priority rankings of the GPA categories, which showed sewage to be the first priority (GESAMP 2001). As a result of rapidly expanding populations, poorly planned development, and inadequate or poorly designed and malfunctioning sewage treatment facilities in most Caribbean SIDS, untreated sewage is often discharged into the environment (UNEP 2004a, 2004b, 2005). Added to this is the discharge of untreated sewage from tourism facilities. According to Simmons and Associates, cited in UNEP/CEP (1997), sewage is the largest source of pollution from the tourist industry in the WCR, as 80 - 90% of the sewage generated is disposed of in nearshore coastal waters without adequate treatment.

A survey conducted in 11 Caribbean countries by the Pan American Health Organization showed that the percentage of population served by sewerage systems varied from 2 -16% (UNEP/CEP 1994a). Less than 2% of urban sewage is treated before disposal; this is even lower in rural communities. On some islands (e.g., Antigua and Barbuda, Dominica, Haiti) there is no sewerage system and sewage is disposed of mainly through septic tanks and pit latrines, many of which do not comply with minimum technical specifications (Betz 1990, UNEP 1999a).

The discharge of untreated sewage is likely to have an adverse effect on the quality of coastal waters and on the ecology of critical coastal ecosystems. One of the possible effects of sewage pollution is eutrophication near treatment facilities and sewage outfalls, with increased algal and bacterial growth, degradation of seagrass and coral reef ecosystems, and decreased fisheries production. For example, Kingston Harbour (Jamaica), which receives about 30,000 - 40,000 m^3 of inadequately treated sewage per day (UNEP/CEP 1998), has experienced increasing eutrophication for decades as a result of sewage pollution mainly from surrounding towns and from ships (Webber and Clarke 2002). Similarly, Havana Bay (Cuba) receives about 300,000 m^3 per day of urban/industrial non-treated sewage, which introduces approximately 4,800 kg of nitrogen compounds and 1,200 kg of phosphorus compounds. As a result, the bay waters are strongly influenced by algal blooms, including frequent red tides (González 1997, Beltrán and others 2000, 2001, 2002).

Microbiological pollution from the discharge of untreated sewage is severe in the Caribbean SIDS and poses a serious threat to human health from direct contact with polluted waters or from the consumption of contaminated fish and shellfish (UNEP 2004a, 2004b). Studies in Havana Bay (Cuba) have recorded faecal coliforms, as Most Probable Number (MPN)/100 ml, above 1,000/100 ml, which exceeded the Cuban National Sanitary Standard (Beltrán and others 2002).

Faecal coliformes found near several beaches in Santo Domingo varied between 110 - 12,000 MPN/100 ml, suggesting that none of the beaches comply with international standards. Health authorities in the Bahamas have advised citizens to avoid the consumption of the queen conch (Strombus gigas) at certain times of the year due to the presence of a Vibrio pathogen in this species. Consumption of conch infected with this pathogen has resulted in serious illness and even one recorded death (UNEP 2004a). Pollution has reduced the aesthetic value of the islands for prospective tourists and has caused a loss in revenue from non-returning tourists (UNEP/CEP 1997). For example, nutrient enrichment in Kingston Harbour has reduced the suitability of waters for bathing on the beaches and in the Bay, which has negatively impacted tourism.

Considerable efforts are underway to increase the proportion of population served by communal sewerage systems in spite of the high costs involved (UNEP/CEP 2000). The prohibitively high costs of building and maintaining traditional sewage treatment plants are frequently the reason for not treating sewage before its disposal. However, several biological methods of treatment are available for sewage that is not contaminated with industrial waste and which are suitable to the tropical character of the Caribbean region.

Persistent Organic Pollutants

POPs ranked second in the WCR priority rankings of the GPA contaminant categories (GESAMP 2001), although POPs may not be a priority for the smaller SIDS with limited industrial development. Several sources of POPs have been identified, with the most important being the agriculture, energy, and industrial sectors, as well as incineration of domestic, industrial, and agricultural waste (UNEP/GEF 2002). Data from Barbados, Trinidad and Tobago, and Jamaica suggest that POPs originating outside the region also reach the Caribbean with air currents (UNEP/GEF 2002). The countries of North Africa in the Sahel region apply large amounts of pesticides, including those banned in the Caribbean and the United States, to fight locusts. These pesticides are present in dust reaching the Caribbean and southern United States from North Africa, as shown in Figure 9.5 (USGS 2000, UNEP/GEF 2002).

The generalized use of pesticides and pest control is a key issue in the WCR (UNEP 1999a). Over the last decade, Caribbean SIDS have imported large quantities of pesticides, as shown in Tables 9.2 and 9.3. These compounds are extensively used in agriculture and reach the coastal and marine environments via rivers and atmospheric transport. The steep topography of most of the islands and cultivation on steep slopes encourage soil erosion and the movement of pesticides to coastal areas.

Few studies have been carried out to determine the impacts of POPs on aquatic resources and their status and distribution in the environment in the Caribbean SIDS. Although organochlorides (OC) are banned throughout most of the Caribbean, it is believed that there are sites throughout the region with heavy OC pollution loads, e.g., Kingston Harbour and Hunt's Bay, both in Jamaica (Dasgupta and Perue 2003). Studies in the Caribbean documented in UNEP/GEF (2002) showed that POPs such as aldrin, DDT, DDE, endosulfan, and lindane have been detected in sediments in Portland and Kingston Harbour, the southwest coast of Cuba, and coastal areas of St. Lucia, as well as in marine biota in these three countries.

A 1995 survey in zones influenced by agricultural activities in Kingston Harbour showed sediment samples had the following mean values (µg/kg dry weight): DDE: 6.1; dieldrin: 9.28; lindane: 0.56; α-endosulphan: 0.52; and β-endosulphan: 0.35. Shrimp tissue analysed in 1995 - 1996 had the following mean levels (µg/kg dry weight): DDE: 8.3 ± 4.2; dieldrin: 1.6 ± 2.1; α-endosulphan: 3.6 ± 1.4; and β-endosulphan: 4.0 ± 2.1. In 1990 - 1991 sediment samples from northeast Portland (Jamaica) had the following mean concentrations (µg/kg dry weight): β-endosulfan: 5.1 ± 0.3; dieldrin: 0.1 ± 0.005; and DDE: 6.1 ± 0.4 (Robinson and Mansingh 1999, Mansingh and Wilson 1995, Mansingh and others 2000, cited in UNEP 2002). In 1992 - 2001 sediment samples near coastal agricultural areas in Cuba showed the following concentrations (µg/kg dry weight): ∑DDT : 4.6 - 61.4 and lindane: 0.4 - 44.2. The concentration of ∑DDT in mussel tissue was between 1.7 - 23.7 µg/kg dry weight (Dierksmeir 2002).

In St. Lucia pesticide levels in water, sediment, and biota samples were below minimum detectable limits for selected pesticides except for one crab tissue sample from a mangrove forest in Mamiku watershed, which contained 0.158 mg/kg diazinon (Lewis and Esteban 2002). On the other hand, high levels of contamination and bio-magnification of pesticides such as dieldrin, DDT, and DDE in fish and other aquatic species have been recorded in the Caroni River basin in Trinidad (Juman and others 2002). Mean concentrations of total HCH of 5.1 ng/l and dieldrin of 4.1 g/l have been detected in surface waters off the coast of Santo Domingo in the Dominican Republic (García and others 1998). Fish mass mortality has occurred in areas of agricultural run-off where pesticides have been illegally used. For example, in Jamaica an increase in fish mortality in coastal areas coincides with the period of the year when pesticides are applied on coffee plantations (Chin Sue 2002).

The capacity to monitor POPs varies among the countries of the region. There are no facilities for the routine control of dioxins and furans, and few accredited laboratories with international recognition in this field (UNEP/GEF 2002). At both the national and regional scale legislation and regulations regarding the use of POPs are inadequate, although those related to pesticides are more advanced. Some advances have been made with regard to the harmonization of legislation in the region and ratification of the relevant international conventions (UNEP/GEF 2002). Many of the Caribbean SIDS have signed and/or ratified the Stockholm Convention. Enabling activities under this convention focus primarily on getting rid of outdated stocks of PCBs and other POPs; developing legislation to ban importation and use of POPs unless under very specific and controlled conditions; and updating inventories of POPs and related substances. Few countries have signed (Barbados, Cuba, St. Lucia) and only one (Jamaica) has ratified the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade.

Radioactive substances

Radioactive substances continue to be a serious concern at the highest political level in the region. Almost every country in the region has been targeted as a nuclear waste dumpsite by waste brokers operating from developed countries; this is expected to increase (UNEP/CEP 1991). Radioactive material is also occasionally transported by ships through the Caribbean Sea and Panama Canal, and poses a serious potential risk to the health of the region's environment and people (UNEP/CEP 1991). While most of the Caribbean SIDS have banned waste imports from industrialized countries, a number of others remain vulnerable. Most of the Caribbean SIDS are contracting parties or signatories to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Heavy metals

The sources of heavy metals in the marine environment include industrial point sources, such as the petroleum industry (oil refineries and petrochemical plants), chemical industries, pesticide production and formulation, and metal and electroplating industries. Antifouling paints used on vessels are of particular concern, considering the growing recreational boating sector and servicing facilities in the region.

In 1995 only 39% of the investigated small industries in the Caribbean had undertaken treatment of residual waters (UNEP/CEP 1999). Hg and Pb are the heavy metals of most concern at the global level because of their high toxicity in certain forms and their transport over long distances in the atmosphere. Other metals of concern are As, Cd, Cr, Cu, Ni, Se, Sn, and Zn. Heavy metals are very persistent in the aquatic environment, bio-accumulate in marine organisms, and are highly toxic to humans when consumed.

Major industrial centres within the Caribbean SIDS region are concentrated in a few areas, including Kingston Harbour, Point Lisas Bay (Trinidad), and Havana Bay. Emissions of heavy metals from domestic and industrial sources increased between 1994 and1996 in Havana Bay, with the exception of Fe, Pb, and Zn, posing a serious risk to human health and living marine resources (UNEP 1999a). Industrial pollution is a particularly pressing problem for Trinidad and Tobago given its high level of industrialization in comparison to its neighbours. Coastal areas near to oil installations show significant heavy metal concentrations in sediments. For example, the Santo Domingo coastal zone and Havana Bay, which have petrochemical complexes in the proximity of the coasts, have Pb values of up to 113 mg/kg and 340 mg/kg, respectively, as well as V, Ni, Zn, and Hg in smaller concentrations (GEF/UNDP/UNEP 1998, Beltrán and others 2002). Cu, Pb, and Zn were found in water and sediments in the Dominican Republic and Jamaica (GEF/UNDP/UNEP 1998, Beltrán and others 2002).

The Caribbean SIDS have made some progress in actively promoting and using cleaner technologies and production methods, but greater efforts are needed in this regard, as well as in monitoring and enforcement of relevant legislation.

Oils (hydrocarbons)

Oil and gas extraction, processing, storing, and shipping have the potential to cause major oil pollution problems in some parts of the Caribbean. Among the Caribbean SIDS, Trinidad is the biggest producer of oil and gas, with Aruba, the Bahamas, and the Netherlands Antilles having important refining facilities (UNEP 1999a). The Region is also characterized by high maritime traffic, including oil tanker traffic, which increases the potential risk to the region as a whole. Pollution incidents could have disastrous impacts on the Caribbean SIDs, in view of the enclosed nature of the Caribbean Sea, the high dependency of these states on the marine environment, as well as their environmental, economic, and social vulnerabilities. Limited technological capacity, as well as inadequate human and financial resources compounds this situation. This underscores the need for continued monitoring and involvement by IMO with specific focus on port and marina operations and management.

While the region is at high risk from tanker accidents and oil discharges, in many cases it is difficult to distinguish between impacts caused from marine and land-based activities. Much of the information on oil pollution levels in coastal and marine waters of the WCR comes from the UNEP-IOC/IOCARIBE CARIPOL (Caribbean Oil Pollution Database) Programme initiated in 1979.

CARIPOL data have indicated that the concentration of dissolved or dispersed petroleum hydrocarbons are generally low in offshore waters, while relatively high levels are found in some semi-enclosed coastal areas. Some studies have shown levels of total hydrocarbons in sediments from the Santo Domingo coast ranging between 16 - 291 mg/kg dry weight; in Kingston Harbour between 200 - 578 mg/kg dry weight; and in the Havana Bay between 685 - 1,212 mg/kg dry weight. These concentrations indicated slight chronic pollution by petroleum, with Havana Bay being the most impacted (GEF/UNDP/UNEP 1998).

The Oil Spills Protocol of the Cartagena Convention provides a regional framework for cooperation in combating oil spills in the Wider Caribbean Region. All Caribbean countries, except the Bahamas, Guyana, Haiti, Honduras, St Kitts and Nevis, and Suriname have ratified this protocol. Many SIDS have not ratified the International Convention for the Prevention of Pollution from Ships (MARPOL 73/74). In spite of regulations established in Annex I of MARPOL, tankers and barges do not always use port facilities for the disposal of bilge and tank washing and wastes, discharging significant quantities of oil into the coastal areas of the WCR (UNEP/CEP 2000). The OECS have developed a regional Used Oil Strategy and much work is ongoing on oil spill contingency planning both at the national and regional levels. The IMO has been at the forefront of identifying and managing the risks of pollution from maritime sources and, in conjunction with the maritime oil transportation industry and governments in the region, has been measuring the impacts or number of oil spills for decades. The Oil Spills Protocol RAC in Curaçao facilitates training, including in oil spill response and contingency planning and other activities for CAR/RCU and the IMO. It is important that an integrated approach is taken in the management of pollutants, especially oil. The focus should be on improving management and on pollution prevention (precautionary approach).

Nutrients

Nutrients were also ranked second in the WCR priority rankings of the GPA contaminant categories (GESAMP 2001). Organic and nutrient pollution is most widespread and is possibly the most serious marine pollution problem in the Caribbean (Siung-Chang 1997). In a regional overview of land-based sources and activities affecting the marine, coastal, and associated freshwater environment in the WCR, several Caribbean SIDS reported high nutrient levels in coastal areas to be of concern (UNEP 1999a). The total estimated nutrient load from land-based sources in the Caribbean Sea is 13,000 tonnes/yr of nitrogen and 5,800 tonnes/yr of phosphorus (UNEP 2000). The predominant source of nutrients is the discharge of untreated sewage, as well as non-point agricultural run-off as a result of the large quantities of agricultural fertilizers applied annually (Table 9.4). To a lesser extent aquaculture facilities as well as industrial activities and atmospheric emissions also contribute nutrients to the marine environment.

Atmospheric deposition of nutrients is of growing concern in the region. Evidence in Europe and North America indicates that total atmospheric input of fixed nitrogen has increased by 50 - 200% during the past 50 years (Paerl 1995). Atmospheric fixed nitrogen deposition on the ocean often originates from diverse and distant sources (GESAMP 2001). Figure 9.6 shows the projected ratio of the estimated deposition of oxidized forms of nitrogen in 2020 to the values for 1980. It appears that the present rate will increase by between 2 - 4 times over large areas of the Caribbean Sea (GESAMP 2001). This increased nitrogen deposition will provide new sources of nitrogen to some regions of the ocean where biological production is currently limited by nitrogen, such as in the oligotrophic Caribbean Sea. Thus, there is the possibility of considerable impacts on regional biological production and on the marine carbon cycle in some areas of the open ocean (GESAMP 2001).

The discharge of nutrients into coastal waters is a major cause of eutrophication, especially in areas of limited water circulation. Nutrient enrichment is an increasing concern in the WCR and there are indications that eutrophication is increasing in the region (GESAMP 2001). Elevated nutrient inputs into coastal areas are associated with a range of conditions, including HABs, changes in the aquatic community structure, decreased biological diversity, fish kills, and oxygen depletion in the water column. HABs are frequently the cause of very serious human illness when the biotoxins produced are ingested in contaminated seafood. The illnesses most frequently associated with marine biotoxins include paralytic shellfish poisoning and ciguatera poisoning. The risk of ciguatera poisoning is high where algal biomasses are significantly elevated due to eutrophication, such as in nutrient/sewage-enriched areas (PNUMA 1999).

In Havana Bay eutrophication is particularly severe, as the Bay receives approximately 300,000 m^3 of urban/industrial non-treated sewage per day (Valdés and others 2002).

Eutrophication comes with high social and economic costs. For HABs alone these include the cost of routine toxin monitoring programmes for shellfish and other potentially affected resources, lost opportunity costs of short-term and permanent closure of fishing areas, damage to fish and shellfish stocks, damage to submerged aquatic vegetation and coral reefs, reduction in tourism and associated industries, as well as illness and medical treatment of exposed individuals (GESAMP 2001). Controlling the sources of nutrient enrichment and reversing the adverse effects of eutrophication will require improvement in the effectiveness of nutrient reduction in sewage treatment plants and controlling run-off from non-point sources by improving management practices in agriculture.

Sediment mobilization

Sediments also ranked second in the WCR priority rankings of the GPA contaminant categories (GESAMP 2001). In a regional overview of land-based sources and activities affecting the marine, coastal, and associated freshwater environments in the WCR, almost all the countries, including several Caribbean SIDS, have included high levels of sediments in the coastal zone among the major environmental problems they face (UNEP 1999a). In fact, in the OECS sediment mobilization was ranked as the first environmental priority.

Discharges of suspended and dissolved solids have intensified due to inappropriate agricultural and land-use practices, including deforestation and poorly planned urbanization. In many Caribbean countries intensive mining of beach sand, as well as coastal construction such as of breakwaters and seawalls, have led to increased coastal erosion and sedimentation. Sand mining and beach erosion are issues of great concern in countries such as St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines (UNEP 1999a). Dredging of shipping lanes in shallow coastal waters causes serious re-suspension of sediments. In some Caribbean islands, the development of steeper terrain in combination with short steep slopes terminating in sensitive wetlands and marine environments has increased erosion and the input of sediments to coastal areas (UNEP 2004b). The region's rivers supply about 300 million tonnes/yr of suspended solids to the Caribbean Sea (PNUMA 1999).

Bauxite mining is particularly important for the economy of Jamaican and, to a lesser extent, of the Dominican Republic and Haiti. This activity releases large quantities of particulate matter that can be deposited in marine areas. In Cuba and the Dominican Republic mining and processing of ores for the production of nickel oxide is carried out in close proximity to the coast. However, there is limited information on the final disposal of these mine wastes.

Suspended solids have severe environmental impacts in the Caribbean SIDS. Damage to coastal habitats such as coral reefs by elevated sediment levels is a major concern. Increased water turbidity reduces the productivity of coral reefs and seagrass beds, as a consequence of reduced light penetration. In cases of high sediment loads physical smothering of coral reefs, seagrasses, and associated filter feeders and other benthic organisms is also possible. The increase in turbidity has caused changes in benthic or pelagic biodiversity in some areas. In Antigua and Barbuda, for example, the high turbidity of inshore water and elevated algal cover on reefs are linked to the impacts of coastal development, with sedimentation being a major influence on the condition of reefs (Smith and others 2000). The impact of sedimentation in coastal areas is exacerbated by the destruction of mangrove forests and seagrass beds, which act as natural filters, reducing the sediment load in freshwater before it enters the sea.

A related problem is the transport of pesticides and herbicides bound to sediments to the marine environment. Sediments have been implicated in the introduction of pathogenic bacteria into the marine environment. For instance, in 2000 fish kills in the Windward Islands were linked to bacteria introduced in sediments as a result of flooding in the Orinoco Basin (Hoggarth and others 2001).

The CEP has published a set of guidelines for sediment control practices in the insular Caribbean (UNEP/CEP 1994b). All islands in the region should make an effort to apply these guidelines to reduce erosion and sedimentation, as well as to improve watershed management.

Litter

A variety of land-based and marine activities result in the introduction of debris or litter into the marine environment. Household waste continues to be a problem throughout the region. In several Caribbean SIDS the largest proportion of total solid waste generated is composed of domestic waste, followed by commercial waste (UNEP 2003). Expansion of the tourism industry and an increase in the number of stop-over as well as cruise ship tourist arrivals have also resulted in an increase in the quantity of waste generated by the tourism industry. There is also transboundary movement of litter, which ends up on the shoreline of other countries.

The Caribbean SIDS do not have adequate solid waste collection and disposal systems. As a result waste is disposed of in mangrove swamps, drainage channels, and along riverbanks, eventually reaching the coastal waters (GEF/CEHI/CARICOM/UNEP 2001). Limited availability of land for waste disposal further compounds the waste management problem, since the most common method of waste disposal in the Caribbean SIDS is land-filling. Poorly managed landfills in coastal areas can become sources of debris to the marine environment, especially in the rainy season. Solid waste collection coverage in major Caribbean cities varies from 60% to over 90% of the population, with the exception of Haiti where it is much lower (UNEP 2005).

In the Caribbean SIDS the composition of solid waste continues to change from mostly organic to inorganic, non-biodegradable material. For example, in Trinidad and Tobago, the amount of organic waste dropped from 44% in 1980 to 27% in 1994, while plastic grew from 4% to 20% (UNEP 2000). Generally, litter is mainly composed of plastics although glass, metal containers, paper products, and other solid materials also are common constituents. Current disposal methods are, however, unable to cope with the changing composition of solid waste, nor the increasing amounts of waste being generated as a result of growing human populations and economic development, especially in the coastal zone.

Several of the Caribbean SIDS have embarked on solid waste recovery and recycling programmes (CEHI/UNEP 2003). The OECS Solid and Ship Generated Waste Management Project was a flagship project to upgrade the entire waste management structure in the sub-region. Almost all the countries have relevant legislation such as Litter Acts for the control of litter in public places. In 2002 a project (the EuroColumbus Project), which aims at the creation of a Caribbean operational plan for waste reduction and recycling, was officially launched.

Physical alteration and destruction of habitats

Mangrove wetlands, seagrass meadows, and coral reefs play an important ecological role in the Caribbean SIDS. This includes harbouring high biological diversity, providing nursery grounds for the juveniles of many commercially important fish species, as well as providing coastal protection and stabilization against storm surges and erosion. Damage to coastal habitats may be potentially devastating for the Caribbean SIDS, in view of the projected global increase in the frequency and magnitude of extreme events such as storms and hurricanes (IPCC 2001). Mangroves and seagrass beds also purify freshwater before it reaches marine areas, including coral reefs. Along with their living resources, these habitats also underpin important economic activities such as fisheries and tourism, providing food and livelihoods for thousands of people as well as substantial national incomes.

PADH was identified as the principal environmental problem for the smaller islands (UNEP 2004b). The ultimate causes of PADH are exponential population growth and anthropogenically-driven changes in the coastal zone and in the adjacent watersheds (Kjerfve and others 2002). Although these sources have changed little in recent decades, they have intensified dramatically. Excavation, sand and aggregate extraction, oil and gas exploration and exploitation, tourism, aquaculture development, construction of ports, marinas and coastal defenses, as well as other activities linked to urban expansion are among the factors leading to degradation and loss of coastal habitats in the region.

There is a general consensus that eutrophication is among the most serious world-wide threats to coral reefs (GESAMP 2001). Over 70% of the region's reefs are affected by discharges of untreated sewage. The impacts of sewage have been particularly severe near large coastal cities such as Kingston, La Havana, Port-au-Prince, and Santo Domingo (Woodley and others 2000). Reef condition has also deteriorated as a result of storm damage and destructive fishing methods such as the use of poisons and explosives, and physical damage from fishing gear and boat anchors.

Recent studies have revealed a trend of serious and continuing long-term decline in the health of Caribbean coral reefs (Wilkinson 2002, Gardner and others 2003). Signs of stress are particularly evident in reefs in shallow water and close to population centres. In some areas up to 80% of shallow-water reefs have been destroyed (Gardner and others 2003). Estimates of four individual threats (coastal development, marine-based threats, overfishing, as well as sediment and pollution from upland sources) to coral reefs in the WCR are provided by Burke and Maidens (2004). Much of the coral reefs throughout the Caribbean are subjected to multiple sources of stress operating over several spatial and temporal scales, with overfishing being the most pervasive threat to Caribbean coral reefs (Table 9.5). Integrating these four threats into the Reefs at Risk Threat Index shows that nearly two-thirds of the region's coral reefs are threatened by human activities.

Areas with high threat levels include the Eastern Caribbean, most of the Southern Caribbean, and the Greater Antilles (Figure 9.7).

In the absence of greater efforts to manage and protect these reefs another 20% or more of the region's reefs are expected to be lost over the next 10 - 30 years (Wilkinson 2000).

Dramatic changes in the community structure of coral reefs have taken place over the past two decades. Prior to the 1980s, scleractinian (stony) corals dominated Caribbean coral reefs and the abundance of macroalgae was low. Over the past two decades a combination of anthropogenic and natural stressors has caused a reduction in the abundance of hard corals and an increase in macroalgae cover (Richards and Bohnsack 1990, Kramer 2003). This has been exacerbated by the mass mortality of an important algal grazer, the sea urchin (Diadema antillarum) in 1983 (Lessios and others 2001). The overfishing of algae-grazing fishes has also contributed to this problem, which is thought to be widespread in the Caribbean (CARICOMP 1997).

Caribbean coral reefs have also been affected by a range of coral diseases, starting with black band disease in the early 1970s followed by white band disease in the late 1970s. Other diseases of stony corals and gorgonians have been reported with increasing frequency (Woodley and others 2000). An important threat to Caribbean reefs is coral bleaching as a result of elevated sea surface temperatures. Since the early 1980s coral bleaching incidents have been reported, with increasing frequency in the last decade (Figure 9.8). Repeated bleaching events in the Caribbean over the past decades have caused widespread damage to reef-building corals and contributed to the overall decline in reef condition (Spalding 2004).

The problems of algal infestation, coral diseases, and near extinction of herbivorous sea urchins described above occurred simultaneously during the 1970s, 1980s, and early 1990s (USGS 2000). Many reefs were affected, including those in areas where human populations and activities were low, implicating external causative agents. Each event coincided with increases in warm water associated with El Niño weather patterns and peaks in African dust production and transport across the Atlantic. Based on data recorded in Barbados, the years of highest cumulative dust flux occurred in 1983 - 1985 and 1987 (Figure 9.9). This has been linked to increasing aridity and desertification in Northern Africa, which began in the mid-1960s, peaked in the 1970s and 1980s, and began to decline in the 1990s. Various peaks in the dust record at Barbados and elsewhere in the western Atlantic (Prospero and Nees 1986) coincide with benchmark perturbation events on reefs throughout the Caribbean (Figure 9.9). The mechanisms by which dust may affect corals include direct fertilization of benthic algae by Fe or other nutrients interacting with ammonium and nitrite, as well as nitrate-rich submarine ground water and by broadcasting of bacterial, viral, and fungal spores.

Over the past two decades there has been severe loss of mangroves in most of the Caribbean SIDS (FAO 2003). Eleven of the Caribbean SIDS showed decreasing mangrove cover between 1990 and 2000, with Antigua and Barbuda, Barbados, Dominica, Dominican Republic, and Haiti showing losses greater than 20% (Table 9.6). On the other hand, mangrove loss was not significant in five of the Caribbean SIDS. Cuban coastal wetlands are threatened by drainage and agricultural expansion. Shrimp farms have been developed at the expense of mangrove swamps in the Dominican Republic, which has also exacerbated erosion, sedimentation, and nutrient enrichment in coastal waters (UNEP 1999b). In some countries including the Bahamas, Dominican Republic, and Jamaica tourism development has necessitated the physical removal of seagrass beds and mangroves. This has also led to a corresponding increase in the quantity of sediments in coastal waters, which has adversely affected coral growth. In addition to physical removal, the alteration of fresh water input to mangrove areas through silting of rivers as a result of deforestation and increased erosion has caused mangrove death, as occurred in Jamaica.

The SPAW Protocol of the Cartagena Convention aims to protect sensitive habitats and initiate the creation of marine parks. A number of MPAs have been established in the region and many have been proposed, but inadequate funding, poor enforcement, and lack of local involvement in the management process have limited their effectiveness. The Soufriere Marine Management Area in St. Lucia is a notable example of a successful protected area in the region, and is now designated as part of a World Heritage Site.

EMERGING ISSUES

Several emerging issues have come to the fore during the last decade, some of which bear high relevance to the Caribbean SIDS. These include:

- Changing perspectives on the delivery of contaminants to the ocean: It is becoming increasingly apparent that atmosphere/ocean linkages are an important part of the issue of the effects of land-based activities on the marine environment and associated freshwater systems (GESAMP 2001). This has already been shown for the Caribbean SIDS by the transport and impact of dust, nutrients, and harmful substances to the region from North Africa;

- Increasing coral diseases: There are reasons to believe that the frequency and severity of coral diseases are increasing, and that they are having significant negative impacts on reefs. 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 continue to be reported. The possible effect of global warming on coral bleaching is another concern. As noted by GESAMP (2001), a new consensus is emerging that global climate change may indeed threaten the long-term viability of coral reefs on a global basis. The problem will be exacerbated by anthropogenic stresses that compromise the ability of reefs to recover from human-derived stress;

- Emerging and re-emerging infectious diseases and links to environmental change: In coastal areas, population pressure leading to coastal degradation has increased epidemics of waterborne diseases such as cholera. This may also have increased the impact of toxins resulting from HABs (UNEP 2004c). There is also concern about the increase in illnesses related to swimming in polluted water and consumption of contaminated seafood (GESAMP 2001);

- Nutrient enrichment and oxygen depletion: As a result of increasing agricultural expansion and growing human populations, the input of nutrients to the Caribbean Sea from land-based sources is expected to increase (UNEP 2003). The implications for the oligotrophic waters of the Caribbean Sea are largely unknown. Furthermore, abnormal algal blooms stimulated by nutrient enrichment could lead to oxygen depletion in coastal waters, with significant consequences for coastal habitats and their resources; and

- The importance of using integrated national development planning and land-use to address many of the GPA concerns in less of a source category manner and more from a resource management perspective.

CONCLUSION

Land-based pollution and PADH are among the major threats to the coastal and marine environments of the Caribbean SIDS. Sewage, nutrients, sediment mobilization, and POPs are of particular concern. Increasing human population and poorly-planned urban and industrial development, much of which is concentrated in coastal areas, as well as inappropriate agro-forestry practices are contributing to this problem. Compounding this is the continuing limited capacity of these states to manage waste, coupled with inadequate environmental, technological, and economic policies. More focus is required on addressing the constraints to reducing land-based pollution, including obtaining improved monitoring data; more comprehensive risk assessments; and determining the relative contributions of pollutants from both land- and marine-based sources such as shipping.

Hotspots

Several coastal hotspots have been identified in some of the larger industrialized islands (Siung-Chang 1997). These include heavily contaminated bays such as Havana Bay (Cuba), Santo Domingo (Dominican Republic), Kingston Harbour (Jamaica), and Point Lisas Bay (Trinidad). Other hotspots may be localized around specific countries and related to direct point or non-point discharges. On a regional scale, the entire Caribbean Sea may be considered a hotspot in terms of risks from shipping and threats to coral reefs. Hotspots may also occur where there are potential transboundary impacts, such as close to the Orinoco River mouth.

Has the situation concerning GPA issues improved or worsened during recent years?

The absence of clear targets and indicators makes it difficult to assess progress (or lack thereof) in concrete terms. Encouraging progress has been made in some areas, for instance, the management of solid waste, and to some extent liquid waste, in the region (CARICOM Secretariat 2003). Cooperation among international organizations, governments, and industry, as depicted by the operations of RAC/REMPEITC-Carib show that results can be achieved. The impacts from oil spills have decreased dramatically over the last decade and can be directly attributed to the ratification and enforcement of IMO Marine Pollution Instruments and their implementation through the CEP and the Oil Spill Protocol RAC.

Overall progress, however, has been slow, largely because of the high costs of installing and maintaining appropriate waste management systems. Pressures associated with residential, commercial, and tourism development; increasing population, waste production, and demand for services; changing lifestyles; climate change; and underlying social and economic priorities have increased. Progress continues to be outpaced by these pressures, with slow implementation, enforcement, and inadequate monitoring, among others, compounding the problems. As a result, the physical and ecological degradation of coastal areas, including pollution of near-shore waters from land-based activities, are accelerating in the region (MRAG 1998).

Has progress been made in protecting the marine environment in the last 10 years?

In recent decades, important institutional, legislative, and policy reforms related to marine environmental issues have taken place in the Caribbean SIDS. The regional and sub-regional agencies have responded positively to the challenges in the types of programmes, projects, and activities that have been developed and implemented in the region in response to dealing with the GPA source categories. For example, the CEP and the three RACs have developed and implemented various projects and activities geared towards protection of the region's marine environment, including from land-based sources of pollution (see http://www.cep.unep.org/).

The number of environmental strategies and action plans has increased, as has the signing of environmental agreements and the number of projects and activities undertaken by the countries and regional and international organizations (UNEP 2005). There is also greater environmental awareness, both by the public and at the highest political levels. Improvement has occurred, for example, in waste management and control of deforestation, in some of the countries. There have been improved pollution control and management measures; establishment of more protected areas; increased activities by regional agencies, etc. However, the pressures have also increased. The question might be better phrased: Are the Caribbean SIDS responding as quickly as they should to the increased pressures? Based on the foregoing, it would appear that despite the efforts and achievements in some areas, progress is generally being outweighed by growing pressures.

The way forward

The way forward should include greater focus on implementation, rather than development of more policies, strategies, and action plans. Implementation could be improved by ensuring that existing policies, strategies, and action plans are realistic and accompanied by a strategic planning and financing strategy. There is a pressing need to integrate National Programmes of Action developed under the GPA Framework and of activities to implement the LBS and Oil Spills Protocols and other relevant agreements into existing National Environmental Management Policies and Strategies as well as in economic development planning frameworks. Strengthening of regional and sub-regional organizations should be continued, with the creation of a network of agencies and institutions. The CEP has a key coordinating role along with its four RACs and other regional organizations such as the BASEL Caribbean Centre in Trinidad, CEHI in Saint Lucia, and UWI. Regional networks and agencies help to facilitate the coordinated implementation of MEAs and the GPA/LBS.

The Caribbean SIDS need to focus less on a sectoral approach in dealing with environmental issues, and a move towards an integrated, ecosystem approach where feasible. Integrated national development planning involving all stakeholders must form the core framework for environmental interventions. All the public should be involved in consultation, problem identification, designing, and implementing the solutions. Dealing with the GPA source categories should be related to human health and should facilitate development, e.g., provide jobs, reduce vulnerability, etc.

Regular and long-term monitoring of land-based sources of pollution, both at the source and in the coastal and marine environment, as well as its impacts on sensitive habitats, natural living resources, and human health is urgently required. Focus is needed on the monitoring of key parameters in regional hotspots.

There is a pressing need to generate relevant data, which can be transformed into useful information to guide decision-making. At the same time, the lack of data should not be used as an excuse for inaction; many effective measures could be put in place even with limited data.

The economic value of the goods and services provided by marine ecosystems must be considered in development planning and decision-making. There is growing recognition that these natural benefits do have real economic value and that these values need to be included in decision-making processes. Sustaining the economic and social opportunities that are offered by these ecosystems depends on maintaining a high quality marine environment.

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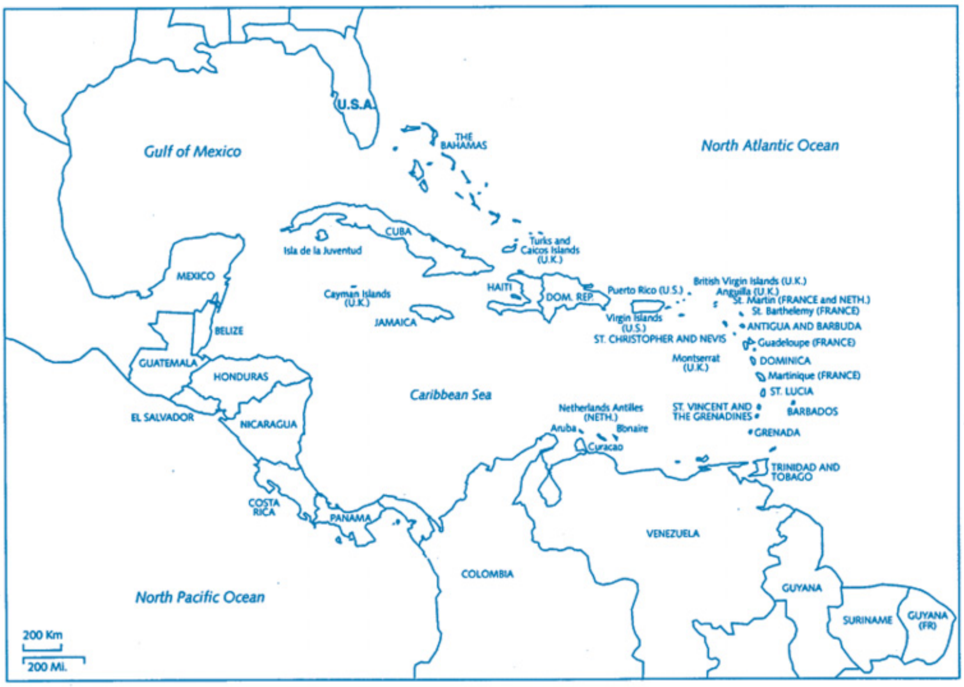
Figure 9.1

The Wider Caribbean Region and the Caribbean Small Island Developing States



(Source: UNEP 1999a)

Figure 9.2.

Satellite image showing the Orinoco River plume in the Caribbean Sea (1979)

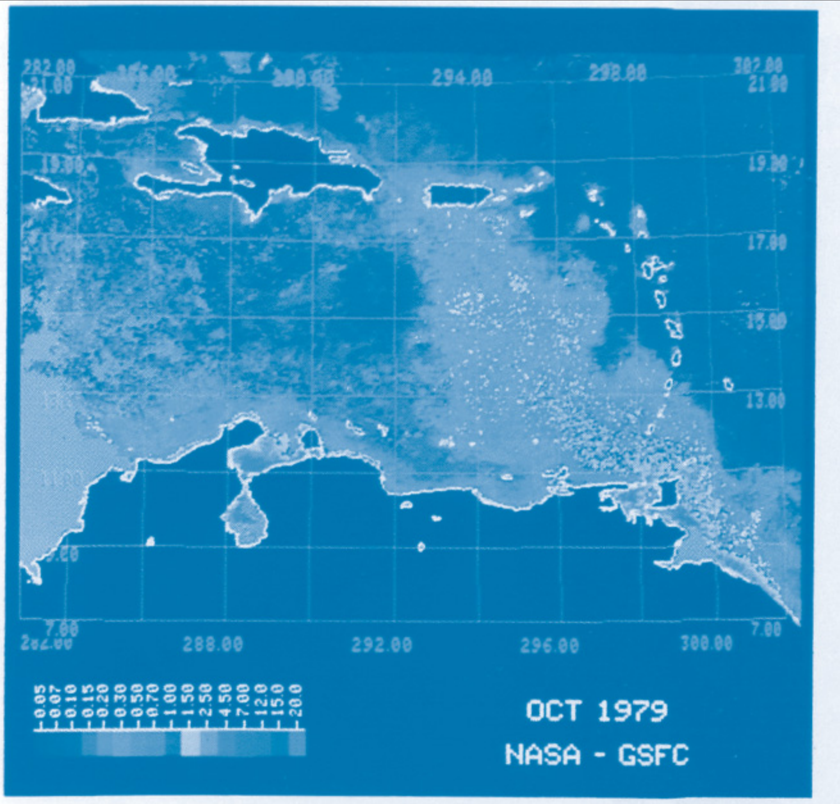
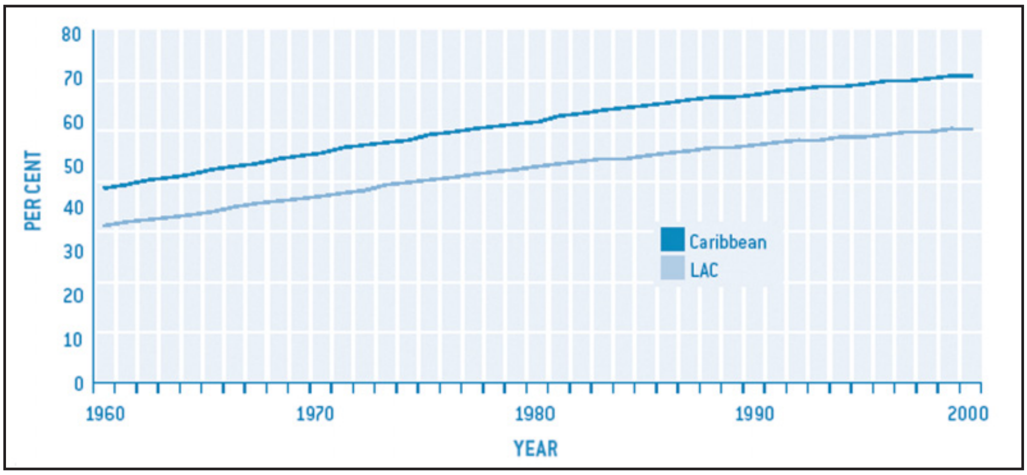


PLATE 5. October 1979. CZCS composite of 9 overviews of the Caribbean Sea in October 1979. The Orinoco plume occupied the eastern Caribbean and flowed northwestward past Puerto Rico. A small plume veering offshore near 10° N, 59° W was evidence of an anticyclonic eddy east of Trinidad.

(Source: Muller-Karger and others 1989)

Figure 9.3

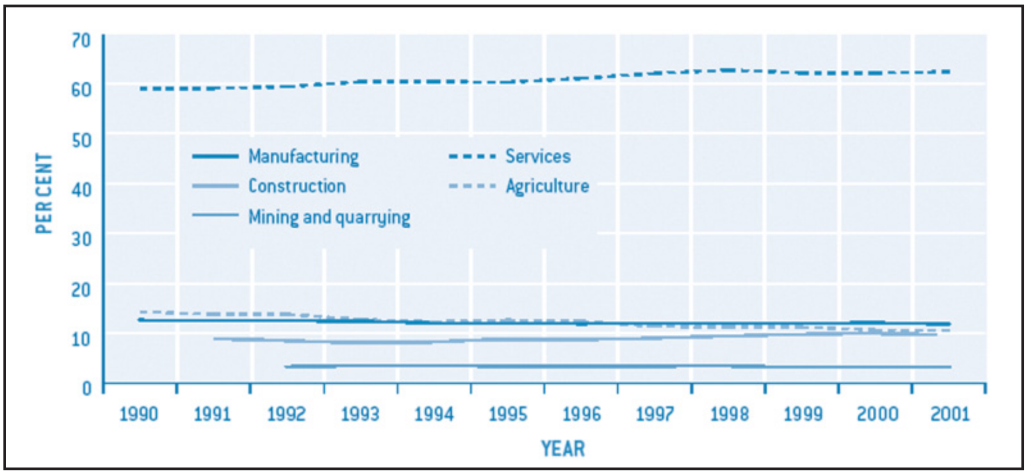
Urban population as a percentage of total population in the Caribbean sub-region and the Latin American and Caribbean region (LAC) as a whole (1960-2000)



(Source: UNEP /DEWA/GRID-Geneva 2004)

Figure 9.4

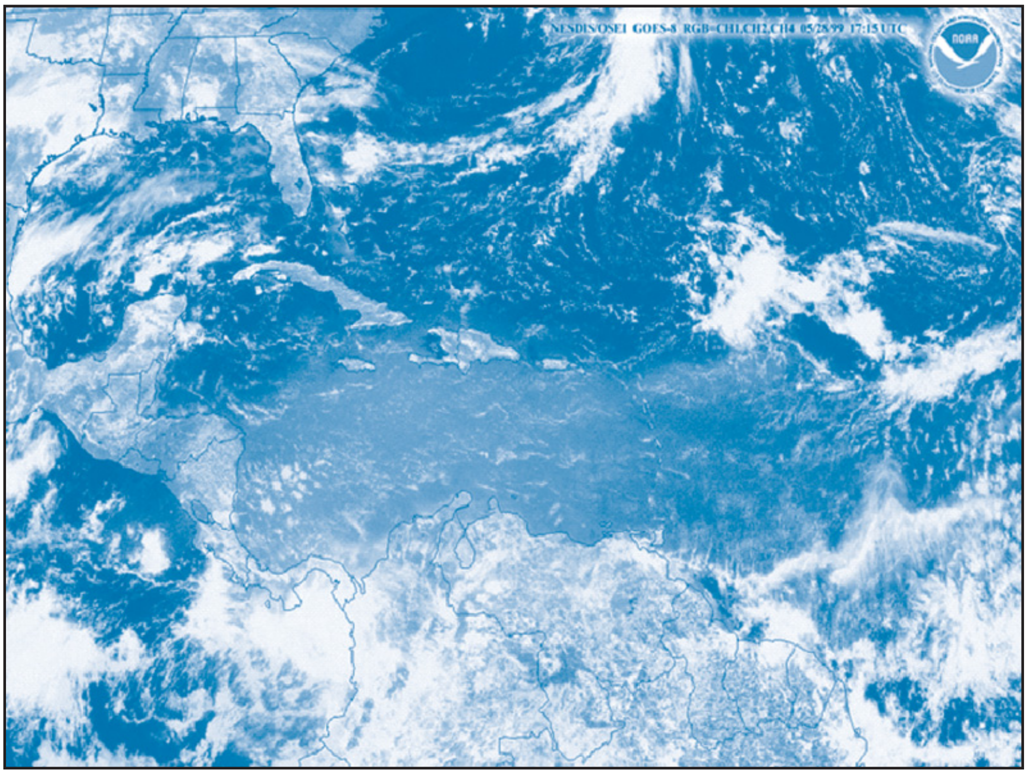
Contribution to GDP of major economic sectors in some Caribbean countries, including the SIDS



(Source: ECLAC 2004)
Countries include: Cuba, Haiti, Dominican Republic, Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, Guyana, Jamaica, St. Kitts and Nevis, St. Vincent and the Grenadines, St. Lucia and Trinidad and Tobago.

Figure 9.5

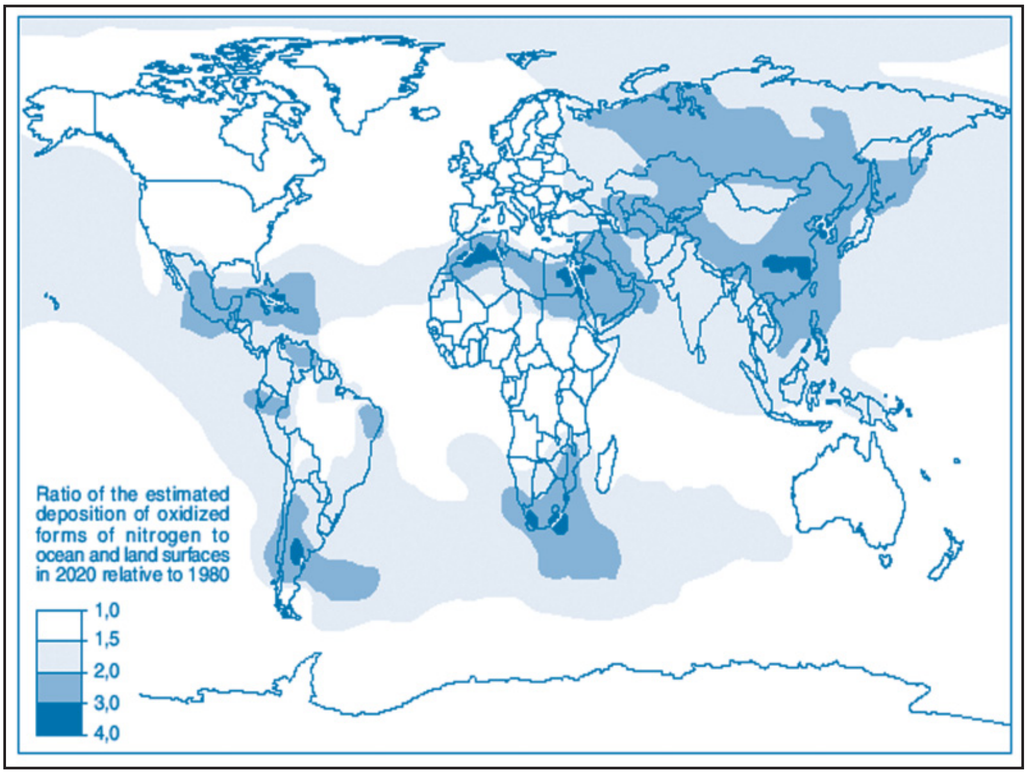
May 28, 1999 satellite image of SE United States, Central America, and the Amazon region showing a huge African dust cloud over the Caribbean



(Source: USGS 2000)

Figure 9.6

Increase in reactive nitrogen deposition (1980-2020)



(Source: GESAMP 2001, adapted from Galloway and others 1994 and Watson 1997)

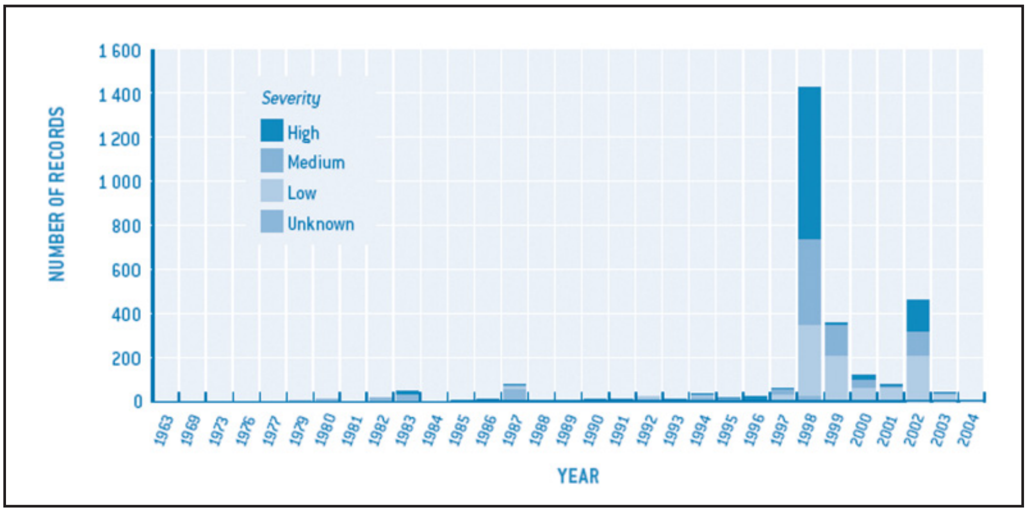
Figure 9.7

Reefs at Risk Threat Index in the Caribbean

(Source: Burke and Maidens 2004)

Figure 9.8

Frequency of total annual coral bleaching events reported for Caribbean reefs

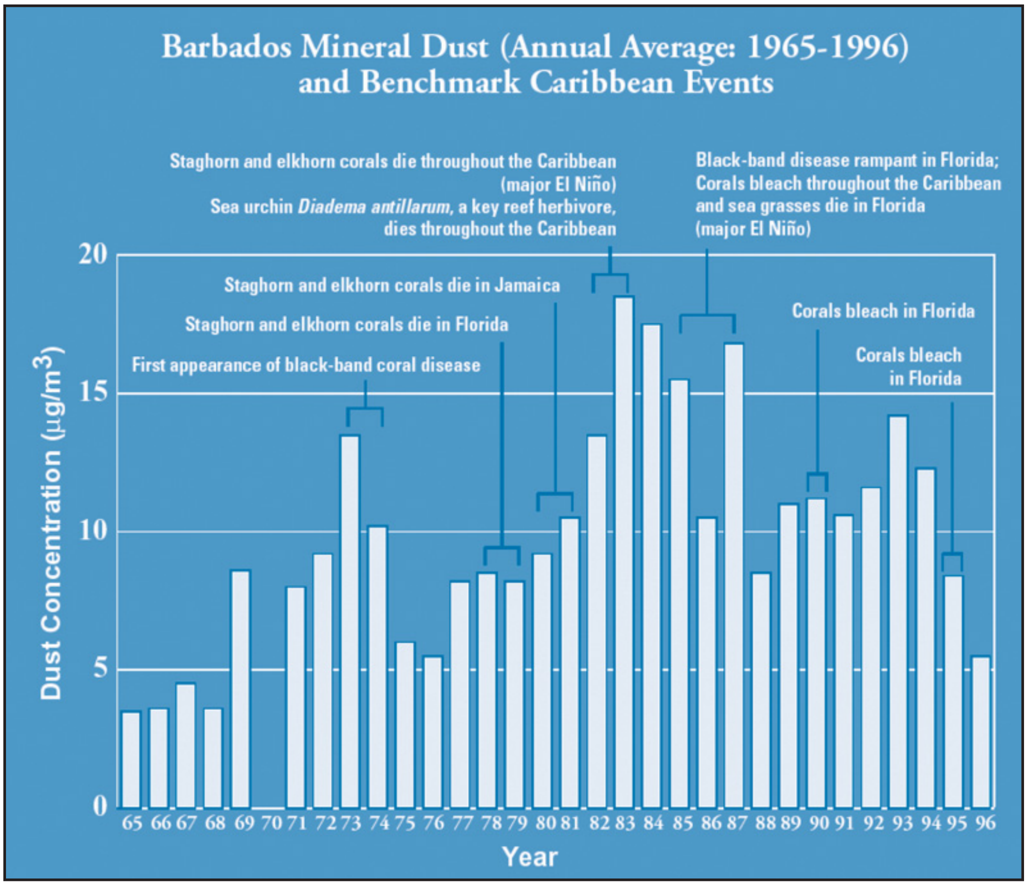


Source: Reefbase (2004)

Figure 9.9

Overall increase in African dust reaching Barbados since 1965. Peak years for dust deposition were 1983 and 1987.

These were also the years of extensive environmental change on Caribbean coral reefs



(Source: USGS 2000, Courtesy of Dr. Joe Prospero, University of Miami)

Table 9.1

Some major cross-cutting challenges facing Caribbean SIDS in addressing Land-Based Sources of marine pollution (CAR-RCU, pers. comm. 2006)

Policy/Legal/Institutional	Technical/technological	Financial	Other
- Lack of political priority afforded to environmental issues; - Inadequate appropriate policy, institutional, legal and regulatory frameworks; - Poor implementation of existing policies; - Limited enforcement capacity; - Lack of an integrated approach to national development planning; - Lack of national and regional coordination mechanisms that promote sharing of data, lessons learnt and transfer of appropriate technologies and practices; - Overlap and duplication of programmes, projects, and activities at national and regional levels; - Much of the work on pollution management done on a project rather than a programme basis.	- Lack of appropriate environmental targets and indicators; - Inadequate trained human capacity; - Lack of appropriate scientific monitoring programmes at national and regional levels; - Limited availability of environmental data, compilation, and analysis, especially in specific sub-regions and/or for selected GPA source categories; - Insufficient application of appropriate tools especially in science and technology for the collection and use of environmental data and statistics; - Use of outdated technology, which results in delays in producing environmental data and information on a timely basis.	- Limited financial resources; - High start up costs in the use of ICTs for monitoring and assessment; - High cost of the effective incorporation of risk reduction strategies into existing plans and policies.	- Public apathy; - Lack of awareness, especially among decision-makers; - Limited dissemination of information to the general public and decision- makers

Table 9.2

Total imports (tonnes) of pesticides in selected Caribbean SIDS 1996-2000

Country	Total pesticide imports				
	1996	1997	1998	1999	2000
Antigua & Barbuda	-	-	272 .4	533.7	104.4
Dominica	574.2	499.3	410.5	4,783.2	608.7
St. Vincent & Grenadines	679.4	1,480.2	783.7	2,09.2	-
Grenada	114.9	65.9	150.5	76.5	69.0
St. Lucia	-	-	-	1,289.6 tonnes solid* 434,142 litres liquid*	

(Source: Converted from kg and rounded from Dasgupta and Perue 2003)
*Proceedings of the 5th Meeting of the Coordinating group of Pesticide Control Boards of the Caribbean.

Table 9.3

Imports of Atrazine and Endosulfan, 1998-1999 (tonnes active ingredient)

Country	Atrazine	Endosulfan
Dominican Republic	5.04	42.1
Trinidad & Tobago	61.0	2.1
Jamaica	4.2	6.0

(Source: UNEP/GEF 2002)

Table 9.4

Use of fertilizers in selected Caribbean SIDS

Country	Year	Total (tonnes)
Barbados	1990	9,661
	1995	3,826
	1997	5,719
Grenada	1996	1,624
	1998	1,311
	1999	875
Jamaica	1995	111,790
	1998	87,064
	1999	89,601
St. Vincent & the Grenadines	1980	4,468
	1990	9,290
	2000	5,509

(Source: CARICOM Secretariat 2003)

Table 9.5

Percentage of coral reefs at medium and high risk from four individual threats in Caribbean SIDS; Reefs at Risk Threat Index

(L: low; M: medium; H: high; VH: very high)

Country	Coastal development	Sedimentation & pollution from inland sources	Marine-based pollution	Overfishing	Reefs at risk Threat Index (%)			
					L	M	H	VH
Antigua & Barbuda	71	29	29	100	0	39	50	11
Aruba	100	0	74	100	0	0	85	15
Bahamas	5	0	1	22	75	24	2	0
Barbados	100	60	15	100	0	0	86	14
Cuba	21	28	8	68	32	32	33	3
Dominica	96	100	14	100	0	0	63	37
Dominican Republic	59	45	10	79	18	8	63	10
Grenada	85	57	23	100	0	20	41	40
Haiti	92	99	7	100	0	0	45	55
Jamaica	55	61	31	69	32	2	34	32
Netherland Antilles	43	0	45	36	37	15	39	9
St. Kitts & Nevis	95	100	26	100	0	0	77	23
St. Lucia	99	100	40	100	0	0	39	61
St. Vincent & the Grenadines	64	16	29	100	0	38	48	14
Trinidad & Tobago	99	87	1	100	0	0	99	1
Virgin Islands (US)	58	34	44	61	0	9	73	18

(Source: Burke and Maidens 2004)

Table 9.6.

Change in mangrove area in Caribbean SIDS

(n.s. – not significant)

Country	1980 (ha)	1990 (ha)	Total change 1980-1990 (%)	Annual change 1980-1990 (%)	2000 (ha)	Annual change 1990-2000 (%)	Total change 1990-2000 (%)
Antigua & Barbuda	1,570	1,200	-23.5	-2.4	900	-2.5	-25
Aruba	420	420	n.s.	n.s.	420	n.s.	n.s.
Bahamas	170,000	145,000	-14.7	-1.3	140,000	-0.3	-3.4
Barbados	30	16	-46.7	-4.7	10	-3.8	-37.5
Cuba	530,500	529,800	n.s.	n.s.	529,000	n.s.	n.s.
Dominica	40	13	-67.5	-6.8	9	-3.1	-30.8
Dominican Republic	33,800	26,300	-22.2	-2.2	18,700	-2.9	-28.8
Grenada	295	262	-11.2	-1.1	230	-1.2	-12.2
Haiti	17,800	15,000	-16.5	-1.6	10,000	-3.3	-33.3
Jamaica	23,000	10,800	-53.0	-5.3	9,300	-1.4	-13.9
Netherland Antilles	1,140	1,138	n.s.	n.s.	1,130	n.s.	n.s.
St. Kitts & Nevis	84	80	-4.8	-0.5	75	-0.6	-6.3
St. Lucia	200	200	n.s.	n.s.	200	n.s.	n.s.
St. Vincent & the Grenadines	60	52	-13.3	-1.3	45	-1.3	-13.5
Trinidad & Tobago	9,000	7,200	-20.0	-2.0	6,600	-0.8	-8.3
Virgin Islands (US)	978	978	n.s.	n.s.	978	n.s.	n.s.

(Source: FAO 2003)

Summary and Conclusions

INTRODUCTION

In the foregoing chapters, assessments of the state of the coastal and marine environments relevant to the GPA source categories in nine regions (West and Central Africa, Southern Africa, Eastern Africa, Black Sea, ROPME Sea Area, South Asian Seas, East Asian Seas, Arctic Ocean, and Caribbean Small Island Developing States) were presented. This chapter summarizes the major general trends and findings that have emerged from these assessments. Geographically, the regions range from tropical to polar and from large continental landmasses to small island developing states. The countries include those very low on the UN Human Development index, characterized by significant levels of poverty, as well as those with at a high level of the Human Development index. A common feature among the regions is the importance of the coastal and marine environments and their natural resources to social and economic development of the coastal states. A high dependency of livelihoods and even human survival on these resources is evident in almost all the regions, especially in those with high poverty levels.

Escalating anthropogenic pressures arising from population growth and poorly managed development in the coastal zone, as well as the indiscriminate exploitation of coastal resources and inappropriate agro-forestry practices are threatening the sustainable development of the coastal zone in all the regions. The main drivers of coastal and marine environment degradation are similar in all the regions, where the coastal areas are often the focus of intense urbanization, industrialization, tourism development, as well as rapid population growth. Coastal and marine environments are also influenced by activities further inland, for example, agriculture and forestry, especially through river outflow. Among the pressures on these environments is pollution from the GPA source categories and physical alteration and destruction of habitats. Land-based pollution from both point and diffuse sources not only degrades these environments and their resources but also constitutes a considerable risk to human health.

GENERAL TRENDS

Status regarding the GPA source categories

All the regions show some commonalities with respect to the GPA source categories, in that they are all affected, although by different combinations of these categories, as shown in the following Table. On the other hand, the intensity of the impacts varies among the regions.

GPA issues of major concern by regions

Region	Sewage	POPs	Radio-active substances	Heavy metals	Oils	Nutrients	Litter	PADH
W. Africa	X					X	X	X
S. Africa	X					X	X	X
E. Africa	X	X		X	X	X	X	X
Black Sea	X	X		X	X	X		
ROPME*	X (3)	X (5)	X (7)	X (6)	X (1)	X (3)	X (4)	X (2)
S. Asian Seas*	X (1)	X (3)			X (4)		X (2)	X (6)
E. Asian Seas	X	X		X	X	X	X	X
Arctic Ocean*	X (4)	X (1)	X (3)	X (1)	X (3)	X (4)	X (4)	X (2)
Caribbean SIDS*	X (1)	X (2)	X		X	X (2)		X

X: indicates where issue is of major concern; (numbers): priority rankings assigned in the four regions; all others: issues of greatest concern based on the regional assessment (no ranking given).*

The following emerges from the foregoing expert assessments, in terms of the GPA issues of major concern in the various regions:

1. Sewage and physical alteration and destruction of habitats (PADH) are of major concern in nearly all the regions.
2. POPs, oils, nutrients, and litter are second in terms of the number of regions where they are of major concern as GPA issues;
3. Radioactive substances are of concern in only two regions - Arctic Ocean and Caribbean SIDS;
4. Eastern Africa, East Asian Seas, and the Caribbean SIDS are affected by the largest number of GPA issues.

Hotspots

Environmental hotspots attributed to the GPA categories are evident in all the regions. In general, these hotspots include semi-enclosed areas with low water circulation such as gulfs and bays, as well as estuaries and river mouths that are heavily impacted by land-based pollution from urban and industrial areas and increased sediment loads. Hotspots are also linked to urban and industrial centres and ports. The major concerns in the hotspots include sewage, nutrients, oils (hydrocarbons), heavy metals, litter, and sediments. For two regions, the entire region could be considered as hotspots: the Caribbean SIDS (Caribbean Sea) and the East Asian Seas.

Has the situation concerning GPA issues improved or worsened during recent years?

Improvements have been made in relation to specific GPA issues in some areas. In general, however, the situation with regard to the GPA issues worsened over the past 10 years in all the regions as a result of the intensification of the main drivers of environmental change. For instance, the increasing occurrence of harmful algal blooms in some regions is indicative of intense and increasing eutrophication from anthropogenic activities.

In many cases, however, the absence of clear targets and appropriate indicators, as well as inadequate data and information make it difficult to assess improvements in concrete terms. For many developing countries the conduct of long-term monitoring programmes is not a feasible option because of many constraints including lack of financial resources, personal and institutional capacity. However, assessments of the state of the environment are required in order to improve environmental management in these countries. The use of 'smart' or 'proxy' indicators could be useful, in the absence of other required data and information.

Has progress been made in protecting the marine environment during the last 10 years?

Progress in the protection of coastal and marine environments from land-based activities is reflected in various achievements at local, national, regional, and international levels in all the regions. These include improvements in data collection, assessment and monitoring; strengthening of institutional frameworks; development and implementation of appropriate policies and legislation; and adoption of regional and international agreements and action plans. Regional initiatives and policy frameworks that specifically relate to the GPA issues have been developed, for example, the Protocol for the Protection of the Marine Environment against Pollution from Land-based Sources of the Kuwait Convention (ROPME Sea region), and the Protocol Concerning Pollution from Land-based Sources and Activities of the Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region. In more than 70 countries national programmes of action for the protection of the marine environment from land-based activities are in various stages of preparation or implementation. Many countries have had varying degrees of success in developing ICAM plans. Minimizing the quantity of waste produced at the source and material recovery, reuse and recycling have increasingly been adopted.

Despite the efforts and achievements in addressing the GPA issues, progress in protecting the marine environment during the last decade has been generally outweighed by growing pressures compounded by slow implementation, poor enforcement, inadequate monitoring, lack of data and information, and poor environmental governance.

The way forward

For each region the way forward in relation to the protection of coastal and marine environments from land-based pollution and PADH is proposed. Although some elements of the way forward are very specific to each region, the following includes some general but important elements that have emerged:

1. A holistic, comprehensive, and integrated approach to management of land-based pollution in coastal and marine areas is required. This should include both top-down and bottom-up elements with mutually advantageous partnerships between all levels of governance, supported by an open system of education, awareness-raising, and communication;
2. There should be greater focus on implementation of the existing, rather than development of more policies, strategies, and action plans. This needs to be accompanied by improved institutional, legal, and regulatory frameworks;
3. Implementation of the relevant multilateral environmental agreements is urgently required;
4. The social and economic value of coastal and marine ecosystems and their resources should be an important consideration in development planning;
5. Interlinked problems of poverty and environmental sustainability need to be addressed. Among the priorities of governments should be the sustainable development of society and the wellbeing of the coastal populations;
6. Systematic work is required on the protection of coastal and marine environments from all pathways and sources of pollution;
7. The gaps in scientific knowledge and information should be addressed, and the application of new knowledge in developing appropriate policies improved; and
8. Establishment of appropriate long-term assessment programmes to detect trends related to the effects of land-based activities on the coastal and marine environments.

It should be noted that the elements of the way forward proposed for all the regions have repeatedly been enunciated at various national, regional, and international fora. The needs and gaps indicated, however, continue to persist as a consequence of economic, institutional, legislative, governance, and other constraints faced by the countries.

CONCLUSION

Countries have achieved some improvements in the state of the environment in relation to specific GPA issues in localized areas and made considerable progress in developing and implementing appropriate policy responses at national, regional, and international levels. Nevertheless, over the past decade the coastal and marine environments in all nine regions continue to be degraded by land-based sources of pollution and PADH. Progress over the last decade has been generally outweighed by growing pressures compounded by slow implementation, poor enforcement, and poor environmental governance, among other things. An important concern that emerged from the regional papers, as well as from the June 2005 workshop relates to the lack of adequate quantitative data for assessment and monitoring, especially time series and the use of a standard set of indicators to measure progress. On the other hand, the lack of data and information should not be used as an excuse for inaction; many effective measures can be developed and implemented even in the absence of reliable data.