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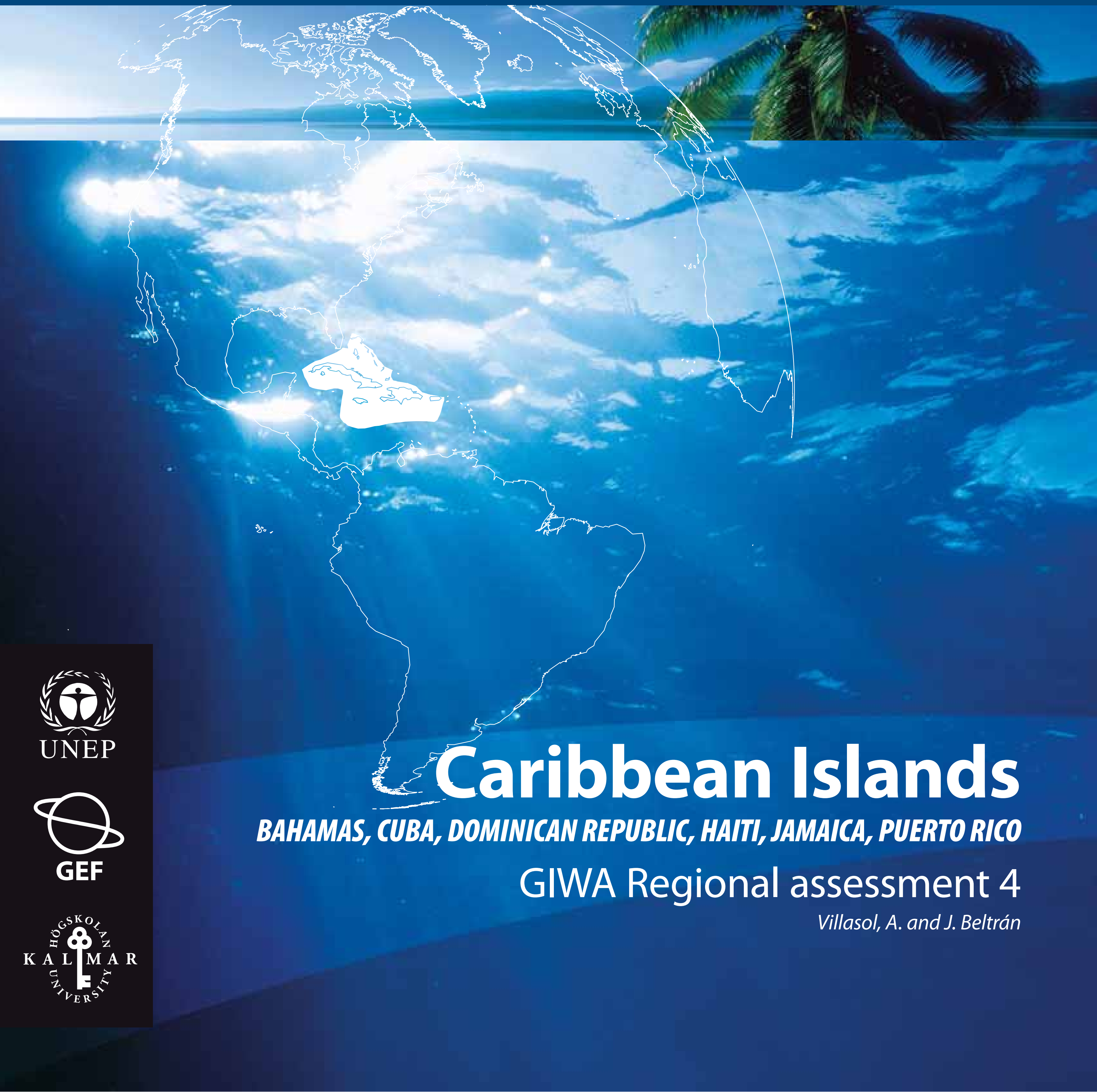

Caribbean Islands

BAHAMAS, CUBA, DOMINICAN REPUBLIC, HAITI, JAMAICA, PUERTO RICO

GIWA Regional assessment 4

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UNEP

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Executive summary

The Caribbean Islands GIWA region 4 is located in the Wider Caribbean region, to the southeast of the Gulf of Mexico, west of the Atlantic Ocean and north of the Caribbean Sea. The region comprises the seas and islands of the Greater Antilles group, including the largest Caribbean islands of Cuba, Hispaniola (divided between Haiti in the west and the Dominican Republic in the east), Jamaica, Puerto Rico and the Archipelago of The Bahamas.

The Caribbean Islands region possesses a diverse and irregular coastline that gives rise to a unique ecosystem formed by the integration of coastal features including harbours, bays, beaches, rocky shores, estuaries, mangrove swamps, cays, and coral reefs. The rivers of the region have very short courses with limited flow rates, and there are relatively few lakes, which are of limited size. Groundwater is found mostly in fissured carbonated rocks; karstic aquifers are available throughout Cuba, Hispaniola and Jamaica and supply the local population with the bulk of their drinking water. Most of the island populations inhabit the coastal plains, which also support the majority of the economic activities. The marine-coastal interface is characterised by a high biodiversity, with a multiplicity of tropical ecosystems and landscapes, and a varied autochthonous flora and fauna. There is a complex interaction of three distinct ecosystems: coral reefs, mangroves, and seagrass beds.

The countries in the Caribbean Islands region show a number of similarities in terms of geology, geography, climate and colonial history. The Caribbean Islands region has an estimated population of 34 million, with Cuba being the most populous country, and also the largest in terms of area, and The Bahamas having the least populated country. The region has experienced considerable economic growth, with GDP per capita increasing by 35% between 1975 and 1995. The countries of the region are intermittently dependent on the inflow of foreign currency for their economic growth. For example, the predominant economic activity for many countries in region, particularly the Bahamas and Jamaica, is tourism.

Some governments in the region have begun to realise the importance of the environment; at the regional level, the Caribbean Action Plan was adopted in 1981. The Cartagena Convention, was adopted in 1983 as the legal instrument for the implementation of the Caribbean Action Plan. The Convention includes: the Oil Spills Protocol; the Specially Protected Areas and Wildlife (SPAW) Protocol; and the Land-Based Sources of Marine Pollution (LBSMP) Protocol. The governments of the nations and territories of the Wider Caribbean region established the Caribbean Environment Programme (CEP) in support of the Convention and its Protocols.

The GIWA assessment evaluated the relative importance of various impacts on the international aquatic systems of the Caribbean Islands region. The environmental and socio-economic impacts were assessed for present and future conditions, and overall impacts and priorities were identified. The assessment considered all the concerns as moderate. The priorities were therefore assigned based on common judgement built on discussion during the GIWA Workshop and from further assessment of the individual scores. The concerns for the Caribbean Islands region were ranked in descending order:

1. Pollution
2. Freshwater shortage
3. Habitat and community modification
4. Unsustainable exploitation of fish and other living resources
5. Global changes

The GIWA assessment ranked pollution as the priority concern due to its prevalence in many locations in the region and the magnitude of its impacts. Suspended solids were considered to be the most severe pollution issue. Human activities including deforestation, inadequate management of agricultural land, urbanisation, and various pollutants, have increased erosion rates and resulted in greater sedimentation and turbidity in streams, rivers and coastal waters. The prevalence of suspended sediments has decreased biodiversity, severely degrading shallow coastal waters.

The predominant sources of nutrient contamination in the region include poorly or untreated sewage, agriculture and industrial activities. Eutrophication has been severe in the bays of the region, particularly Havana Bay and Kingston Harbour. Oil spills pose a significant threat, originating from the petrochemical industry, the transport of oil in tankers and from the extraction and refinement of petroleum. The countries of the region have inadequate solid waste collection systems, and as a result, many citizens dispose of their waste in mangrove swamps, drainage channels and along riverbanks, and consequently pollute rivers, streams, and eventually the coastal waters into which they drain. Furthermore, due to the expansion of industrial and mining activities and the increased application of agro-chemicals there has been greater contamination of surface water and aquifers by chemical toxins and heavy metals.

Demand for freshwater has grown rapidly in the region as a result of demographic growth, and from industrial, agricultural and tourism expansion. In many countries there have been significant reductions in river discharges and a loss of deltaic wetlands and riparian vegetation. At the same time, human activities are polluting existing water supplies. Furthermore, the overabstration of water from aquifers is exacerbating salt water intrusion of groundwater supplies.

The economic activities in the region, particularly fishing and tourism, are highly dependent on habitats such as such as coral reefs, mangroves and sea grass beds. These habitats are being impacted by human activities, by for example destructive fishing practices and the discharge of ship-generated wastes into the marine environment, land-based sources of pollution, land clearance for coastal development; and tourism activities from for example damage caused by anchors and divers.

Large numbers of small-scale fishers intensely exploit the fishery resources for a source of food and employment, and to supply the tourist and export markets. These pressures have led to the widespread depletion of these resources including lobster, finfish, conch, and small pelagics, and as a result many local fisheries had collapsed by the mid-1980s. In addition fishers are using increasingly destructive methods to fish the declining resource.

The region, due to its morphology and geophysical location, is very vulnerable to the impacts of global changes, and the associated natural disasters, such as storms and hurricanes, including El Niño Southern Oscillation (ENSO) events. The impact of ENSO events on coral reefs is particularly significant, since the survivability of reefs is dependent on temperature and salinity stability in coastal waters. The natural capacity of ecosystems to adapt to future climate changes may have been weakened by anthropogenic stresses.

The Casual chain analysis determined the root causes of the prioritised pollution concern by performing separate analysis on land-based sources of pollution and marine traffic related pollution. For the latter, the entire region was studied, but only Havana Bay was selected as a demonstrative hotspot which has experienced significant environmental degradation as a result of land-based sources of pollution.

Maritime traffic contributes significant quantities of pollutants to the marine environment within close proximity of the coastline, and has increasingly threatened the environmental and socio-economic integrity of the islands.

The root causes behind maritime traffic in the Caribbean Islands region were as follows:

- *Geophysical and geopolitical characteristics:* The region is traditionally vulnerable to shipping collisions and accidents due to the intensity of marine traffic transiting its narrow channels and shallow waters.
- *Economic:* The economies of the Caribbean Islands region are dependent on income from foreign sources, and often countries accept a certain amount of environmental violations in order to secure preferential tariffs. All of the countries in the Caribbean Islands region lack the hard currency necessary to execute environmental projects and to invest in waste management infrastructure at ports. The cruise industry is expanding rapidly, but there are no economic incentives for cruise ships to dispose of their wastes at ports.
- *Knowledge:* There is a lack of readily available information and monitoring of discharges for policy makers to make informed decisions to address marine traffic related pollution. The general public continues to lack a sufficient understanding of the relationship between development and environmental protection, and of the short and long-term benefits and disadvantages of economic and environmental protection measures.
- *Legal:* There are weaknesses in legislation and regulations at both the national and international level. There is a generous margin for ships to avoid compliance with the MARPOL agreement, for example, it is difficult for the polluting vessels to be arraigned in a court by the country where the pollution impacted, as violations and offences should be prosecuted under the jurisdiction of the Flag State.

- *Governance:* Governments in trying to achieve rapid economic growth, implemented unsustainable development strategies. Environmental policies, often take a low priority when they appear to impede short-term economic development. National governments often fail to meet their executive responsibilities of the MARPOL agreement, largely due to a lack of political commitment in addressing pollution from marine traffic. Despite the potential risk of a large spill, governments have not responded with adequate contingency planning and response capabilities.
- *Technology:* The Caribbean countries lack the funding, training and technology to efficiently monitor MARPOL violations, and there is a general absence of marine traffic control services including navigation aids and surveillance.

The following policy options were discussed for marine related pollution in the entire Caribbean Islands region:

- *Policy option 1: Providing sufficient waste receiving and treatment infrastructure at ports:* There is an urgent need to increase the capacity of the Caribbean countries to collect, dispose, treat and recycle waste generated by shipping, particularly cruise ships, in order to reduce public health risks and protect the environmental integrity of the islands and their coastal and marine systems. This should be achieved through the improvement of ship-generated waste management facilities and facilitating compliance with the "Special Area" designation of the Caribbean Sea for MARPOL 73/78 Annex V wastes. This policy option will follow-up activities highlighted as necessary in the implementation completion report (ICR) for the WCISW Project (June 25, 1999).
- *Policy option 2: Strengthening political and legal instruments: regulating discharges, spills and accidents.* The intensiveness of maritime traffic near the shores of most Caribbean islands makes it imperative to have effective legal tools in order to regulate their activities and minimise their impact on the region's populations and ecosystems. The strengthening of legal frameworks, essentially at the national as well as the regional level, combined with the means of enforcing these regulations (see Policy option 3) will place tighter controls on the shipping industry and give enforcement agencies greater indictment powers.
- *Policy option 3: Strengthening of institutions responsible for enforcement of maritime regulations:* Appropriate enforcement of laws and conflict resolution mechanisms are needed, in order to fulfil the objectives of maritime environmental legislation. There is a need to build capacity in enforcement agencies through training programmes and the acquisition of appropriate staff and technologies. There should be greater utilisation of surveillance techniques to detect pollution offences in order to prosecute polluting shipping companies and to deter others. Once enforcement agencies have adequate capacity they will be able to ensure strict adherence to legislation.

Havana Bay is a well-documented example of where land-based pollution from the surrounding urban and industrial landscape has contaminated the coastal and marine environment, with transboundary consequences for the entire region. The root causes behind land-based pollution were as follows:

- *Economic:* Major economic growth during the 1970s and 80s led to the uncontrolled development of Havana Bay. The adoption of cleaner technologies by industries surrounding the Bay has been hindered by 30 years of importing highly polluting Soviet Union technology and economic restrictions imposed by the US trade barrier. Furthermore, Cuba lacks the necessary funds to update the Havana sewage system, and improve industrial and waste treatment infrastructure.
- *Knowledge:* Monitoring, control and, to a lesser degree, assessment activities are still weak and insufficient. Although there are highly qualified personnel, there continues to be a lack of resources, and scientific activities are not integrated, with insufficient certification of laboratories. In general, the public lack an understanding of the importance of preserving the environment and are not aware of the international implications of the pollution problem in Havana Bay.
- *Legal:* The degree to which legal instruments are applied in the practical management and control of environmental pollution in Havana Bay is generally weak. Although Cuba has signed the Cartagena agreement on land-based pollution, the government has allocated insufficient human and financial resources to meeting its obligations.
- *Governance:* Management is highly fragmented and there is an absence of an overall institution responsible for the rehabilitation of the Bay. Stakeholders are not consulted during the planning and implementation of development projects.
- *Technology:* There are currently inadequacies in the infrastructure for the gathering, treatment and final disposal of domestic sewage. Industries lack appropriate, efficient and cost effective pollution prevention technologies.

The following options were discussed for land-based sources of pollution in Havana Bay:

- *Policy option 4: Create a Havana Port Authority:* The Port Authority would be created to plan, oversee and coordinate the rehabilitation of the Bay. It would have political power and authority over existing institutions concerned with environmental mangement in Havana Bay. The new institution can become the focal point for communications with funding and implementing organisations, and serve as a liaison on the technical aspects of the implementation of the LBS Protocol. The institution, once established, should have the capacity to implement further environmental initiatives, for example policy options 5 and 6, and facilitate stakeholder participation in future programmes.

- *Policy option 5: Develop sewage treatment and collection infrastructure:* Local authorities should be actively encouraged to fully participate and implement future sewage infrastructure improvements, based upon the demonstrations and the success of the sewage treatment plant constructed as part of the GEF project entitled 'Demonstrations of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean'. The policy option aims to reduce the quantities of untreated or insufficiently treated domestic sewage entering the Havana Bay, in order to improve the environmental quality and health status of the Bay, and to limit the contribution it makes to the pollution load of the waters of the Caribbean Islands region.
- *Policy option 6: Converting industries to environmentally sound technologies:* The adoption of Environmentally Sound Technologies (ESTs) by industries should significantly improve their environmental performance relative to technologies currently employed in Greater Havana. ESTs will reduce their contribution to the pollution of Havana Bay and its inflowing rivers by disposing all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. It is anticipated that such technologies will also offer a commercial advantage to industries, by using less resources, and by recycling more of their wastes and products.

The provision of sufficient waste reception facilities and additional pressure placed on the shipping industry by strengthened legislative framework and enforcement capability, can reduce marine pollution in the Caribben Islands region by preventing and discouraging indiscriminate disposal waste off-shore. The policy options presented for Havana Bay may be replicable at other sites in the region as other countries in the Caribbean Islands region face many of the same environmental problems found in this bay.

Acknowledgement

The regional Task team would like to recognise the valuable contributions of experts, advisors, members of non-government organisations and representatives of the countries of the Caribbean Islands region in the elaboration of this report.

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We want to recall the memory of Dr. Manuel Alepuz Llansana, former Director of the Center of Engineering and Environmental Managements of Bays and Coasts (Cimab), first Regional Coordinator for region 4 Caribbean Islands; who deceased during the process of creation of this project.

Abbreviations and acronyms

AMA	Cuban Environment Agency
AMEP	Assessment and Management of Environmental Pollution
BEST	Bahamas Environment Science and Technology Commission
BOD	Biological Oxygen Demand
CAR	Cartagena Convention
CARIPOL	Caribbean Petroleum Pollution Monitoring Project
CAR/RCU	Caribbean Regional Coordinating Unit
CCA	Causal Chain Analysis
CCCCC	Caribbean Community Climate change Centre
CEDI	Caribbean Environment and Development Institute
CEP	Caribbean Environmental Programme
CETRA	Cuba's Center of Transport and Engineering
CIDA	Canadian International Development Agency
CIGEA	Cuba's Center of Environmental Education Management
CIMAB	Centre of Engineering and Environmental Management of Bays and Coastal Areas of Cuba
CITMA	Cuban Ministry of Environment and Technology
CLC	International Convention on Civil Liability for Oil Pollution Damage
CNAP	Cuba's Center for Protected Areas
CRED	Center for Research on the Epidemiology of Disasters
CPACC	Caribbean Planning for Adaptation to Climate Change
CTO	Caribbean Tourism Organization
DDHC	Dispersed hydrocarbons petroleum
ECLAC	Economic Commission for Latin America and the Caribbean
ENSO	El Niño Southern Oscillation
EST	Environmentally Sound Technologies
FAO	United Nations Food and Agriculture Organization
GDP	Gross Domestic Product
GEF	Global Environment Facility
GNP	Gross National Product
GPA	Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities
ICCL	International Council of Cruise Lines
ICR	Implementation Completion Report
IMO	International Maritime Organization
INRH	National Institute for Water Resources
IOPC FUND	International Oil Pollution Compensation Fund
IPCC	Intergovernmental Panel on Climate Change
ITOPF	International Tankers Owners Pollution Federation
LBS	Pollution from Land-Based Sources Protocol
MACC	Mainstreaming Adaptation to Climate Change
MARPOL	International Convention for the Prevention of Pollution from Ships
MINSAP	Ministry of Public Health
MPN	Most Probably Number
MSD	Marine Sanitation Devices
NRCA	Jamaican Natural Resources Conservation Authority
OECS	Organization of Eastern Caribbean States
OPRC	International Convention on Oil Pollution Preparedness, Response and Cooperation
PERC	Perchlorethylene
PMH	Metropolitan Park of Havana
PNUMA/ORPALC	Regional Office for Latin America and the Caribbean of the United Nations Programme for the Environment
POP	Persistent Organic Pollutant
PTS	Persistent Toxic Substances
RCRA	US Resource Conservation and Recovery Act
SIDS	Small Islands Developing States
SOLAS	International Convention for the Safety of Life at Sea
SPAW	Specially Protected Areas and Wildlife Protocol
TBT	Tri-Butyl-Tin
UNCED	United Nations Conference on Environment and Development'

UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCC	United Nations Framework Convention on Climate Change
WCISW	Wider Caribbean Initiative on Ship generated Waste
WHO	World Health Organization
WTTC	World Travel and Tourism Council

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Regional definition

This section describes the boundaries and the main physical and socio-economic characteristics of the region in order to define the area considered in the regional GIWA assessment and to provide sufficient background information to establish the context within which the assessment was conducted.

Boundaries of the region

GIWA region 4 Caribbean Islands is located in the Wider Caribbean region which comprises the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30° N and within 200 nautical miles of the Atlantic coasts of the United States. The Caribbean Islands region is located to the southeast of the Gulf of Mexico, west of the Atlantic Ocean and north of the Caribbean Sea, extending from 65° 18´ W to 84° 57´ W and from 27° 30´ N to 17° 32´ N (Figure 1).

The region comprises the seas and islands of the Greater Antilles group, including the largest Caribbean islands of Cuba, Hispaniola (divided between Haiti in the west and the Dominican Republic in the east), Jamaica, Puerto Rico and the archipelago of The Bahamas. The final extent of GIWA region 4 Caribbean Islands was determined by the Task team based on the geographical, ecological, economic and social characteristics of the countries in the region. One particularity of the

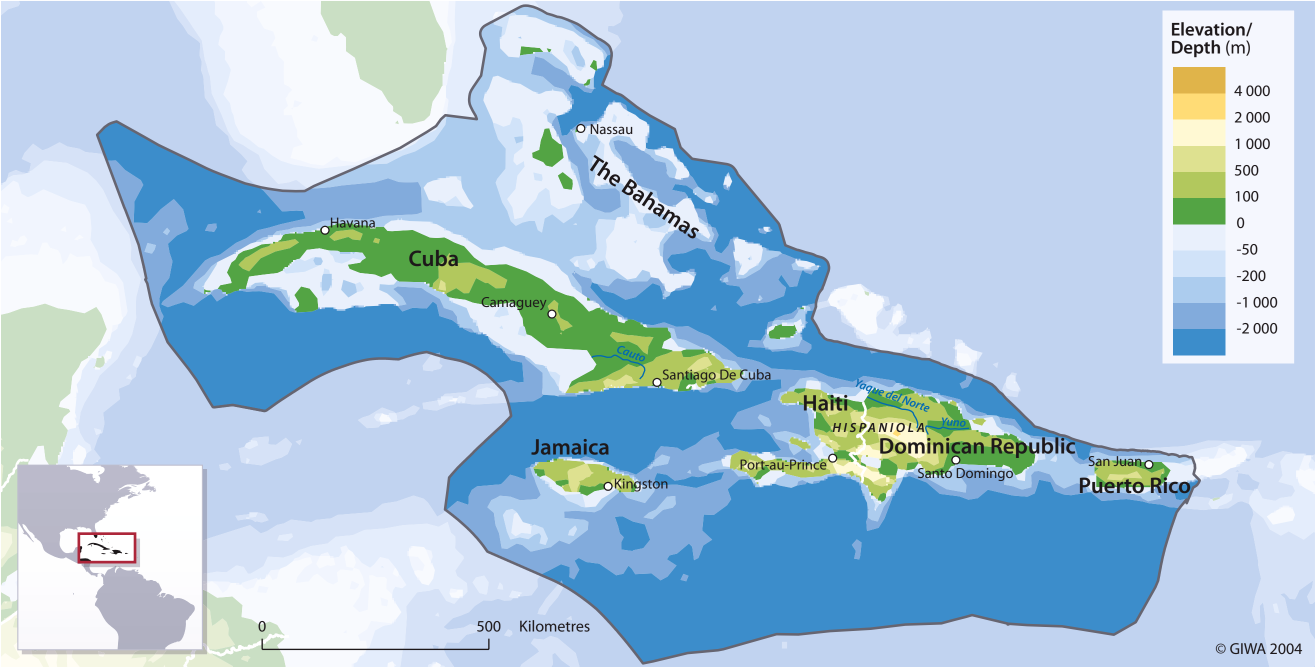


Figure 1 Boundaries of the Caribbean Islands region.

boundaries of the Caribbean Islands region is that it does not include Turks & Caicos, or the Cayman Islands, which are analysed in GIWA region 3 Caribbean Sea.

Physical characteristics

The Caribbean Islands region covers an area of 224 570 km^2 with more than 11 000 km of coastline (Table 1). The main urban agglomerations and major harbours of the region are Havana Port in Cuba, Kingston Harbour in Jamaica, Nassau Port in The Bahamas, Port-au-Prince Port in Haiti, Haina Port in Santo Domingo in the Dominican Republic and San Juan Harbour in Puerto Rico. The total population of the region is approximately 34 million (Encyclopedia Microsoft Encarta 2002, Collard 2000, UNDP 2003).

The geography of the Caribbean Islands region is characterised by an archipelago formed from the tectonic activity of the Caribbean plate, and marks the geomorphologic and climatic transitional zones between the Caribbean Sea, the Gulf of Mexico and the Atlantic Ocean. Due to its location, the area has historically been the passageway for ships transiting between these seas and thus the landscapes of the region's main islands are among the most altered by early occidental human activity in the American continent.

The region is part of the American Mediterranean sub-group of the American continent which comprises of Central America and the Antilles. The latter can be divided into two groups: the Greater Antilles, and the Lesser Antilles and The Bahamas. The Caribbean Islands region includes both the Greater Antilles and The Bahamas. A continental base lies north of Cuba, stretching to The Bahamas and the Florida Peninsula.

During the Upper Jurassic period, the breaking up of the American Continent resulted in the formation of a sea. Sediments from erosion in regions of high relief were deposited on the continental slope. These sediments subsequently sunk to the bottom of the newly formed sea during the fracture of Pangaea (formerly the early American continent prior to the tectonic split). It is for this reason that the rocks forming the ocean crusts consist of ferromagnesian minerals. The submerged crest and valley system runs parallel to the eastern coast of the Yucatan Peninsula, with outcroppings in the Cozumel Island along the Cuban and Hispaniola coasts. These territories represent an ancient continental crust. The mountainous regions to the east of the Cuban archipelago are part of the Los Caimanes Ridge, which share a sub-continental base that has a geologic-geographical link with Central America (Honduras and Guatemala).

Table 1 The Caribbean Islands region countries.

Country	Area (km^2)	Coastline (km)
The Bahamas	13 940	3 540
Cuba	114 530	3 740
Dominican Republic	48 400	1 290
Haiti	27 750	1 770
Jamaica	10 990	1 020
Puerto Rico	8 960	500
Total	224 570	11 860

(Source: Encyclopedia Microsoft Encarta 2002, Collard 2000)

The highest summit in the region is peak Duarte, with an elevation of 3 175 m above sea level, located in the Central Mountain Range of the Hispaniola Island (Encyclopedia Microsoft Encarta 2002). The main mountain ranges have a general east-west orientation and associated river basins are generally small. Consequently, there is a characteristic absence of major rivers, unlike in other parts of Central and South America.

The east-west geomorphologic orientation of mountains and hills covering the majority of the central areas of these islands make the coastline the focus for dense human presence (Sullivan Sealey & Bustamante 1999) and a larger variety of ecosystems associated with the presence of freshwater, lagoons and marine coasts. Typical features of Caribbean coastal morphology are secluded bays and archipelagos. The southern areas of the islands, exposed to warmer and more humid winds, have developed a more tropical flora and fauna, while northern areas are generally dryer. Human presence in the Caribbean has traditionally been connected to trade and sugar cane crops, but is now increasingly influenced by the development of tourism. It is for this reason that populations and infrastructure are concentrated around harbours and coastal zones, making the Caribbean Islands one of the most interesting settings in which to study the balance between the preservation of natural coastal ecosystems and increasing human activity.

Climate

The Caribbean Islands region enjoys a tropical climate with mean annual temperatures of approximately 25°C, with limited seasonal variation. At sea level, meteorological conditions are under oceanic influence, with warm southern winds and northeast winds balancing and regulating temperatures. In mountainous areas the climate is tempered, although there is not a significant variation in temperature. Figure 2 shows the annual distribution of rainfall in Havana, Cuba.

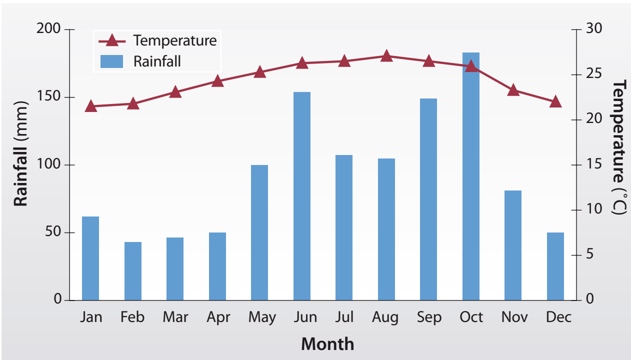


Figure 2 Annual distribution of rainfall and temperature in Havana, Cuba.
(Source: Academia de Ciencias de Cuba 1999)

Due to its geographical location, the region is prone to natural disasters such as earthquakes, hurricanes, tropical storms, flooding and landslides. Hurricanes are the most frequent hazard, occurring usually between June and November and represent around 40% of the major incidents recorded, resulting in significant damage to houses, infrastructure and ecosystems (UNEP 2002b).

Rainfall differs significantly among the islands, due essentially to variable oceanic and climatic influences. The distribution of rainfall also varies within a specific island and between the northern side and the more humid southern side of a mountain range. Table 2 shows the main characteristics of rainfall distribution in the region.

The infiltration of rainwater into geological layers is limited in some parts, depending on the nature of the terrain and underground layers.

Table 2 Characteristics of rainfall distribution in the Caribbean Islands region.

Country	Rainfall
The Bahamas	Mean annual rainfall is approximately 1 143 mm. Most of the rain occurs during the summer season.
Cuba	Mean annual rainfall is approximately 1 320 mm. More than 60% of the rain falls between May and October.
Dominican Republic	Rainy period is April to June. Like Haiti, the rain is mostly carried by either Southern humidity or in the tail of hurricanes. Mean annual rainfalls is 1 525 mm, but the mountainous areas of the north record much higher rainfall data. The rainy season starts in June and ends in November.
Haiti	Rainy periods occur between April and June and also from October to November. The recorded rainfall ranges from 3 600 mm in the western end of the southern peninsula, to 600 mm on the southwest coast of the northern peninsula. Mean annual rainfall at Port-au-Prince is 1 346 mm, but the northwest peninsula of the country only receives 508 mm annually.
Jamaica	There are large regional variations in mean annual rainfall. Annually, more than 5 000 mm of rain falls in the mountains of the northeast. In Kingston the mean annual rainfall is 813 mm. The heaviest rainfall occurs in May, June, October and November.
Puerto Rico	Mean annual rainfall is 1 500 mm. The country normally receives sufficient freshwater due to a great number of small streams flowing seasonally from the hills to the coastline and into the San-Juan Bay in particular. The country experiences occasional drought causing freshwater shortages.

(Source: Sealey 2000, Encyclopedia Microsoft Encarta 2002)

In Cuba, for example, out of a total 38 130 million m^3 of rainfall, it is estimated that 83% remains as surface water and the 17% is stored as groundwater (CITMA 2001).

The countries of the region are variably under water stress, depending on climatic conditions regulating rainfalls, the size of population (both indigenous and tourist) and the demands for irrigation for export crops. Haiti is under the greatest water stress as a result of having the largest population density and the least efficient water extraction, due to the geology and the limited resources of the country.

The climatic characteristics of the region generate strong inter-seasonal and inter-annual differences in water availability. Meteorological phenomena such as El Niño and tropical storms and hurricanes alternate with lengthy drought periods, not only in the arid or semi-arid areas but also in the humid zones of the southern half of the islands. As a consequence, the annual or monthly average estimates of water resources do not always reflect the true hydrological conditions and water availability.

Marine characteristics

The GIWA region Caribbean Islands is located between the Atlantic Ocean and the Gulf of Mexico and the Caribbean Sea. The Yucatan Channel, a passage of 190 km between Cuba and the Yucatan Peninsula, connects the latter two. The marine ecosystems found in the region are the result of the interaction of these three main oceanic features and their characteristics (Encyclopedia Microsoft Encarta 2002).

Sea temperature

The warm currents from the Atlantic and the vertical movements of the water masses determine the surface sea temperature in the Caribbean Sea. The temperatures of the surface waters are homogeneous and register values between 21°C and 30°C throughout the year. In general, the influence of the wind can cause local variations of about 1°C in the surface temperature. During the summer season, prior to the hurricane season, water temperatures fluctuate less and remain around 28-30°C. The highest thermal variations are observed from 100 to 200 m depth, due to the vertical movement of the waters. At greater depth, the temperature of the water is almost constant, at around 4.5°C (Encyclopedia Microsoft Encarta 2004).

Salinity

The salinity distribution in the Caribbean is determined by the variability of freshwater from rivers, the incidental solar radiation and the marine currents. Annually, the surface waters have a salinity that fluctuates between 34‰ and 37‰. In general, the highest salinity surface waters

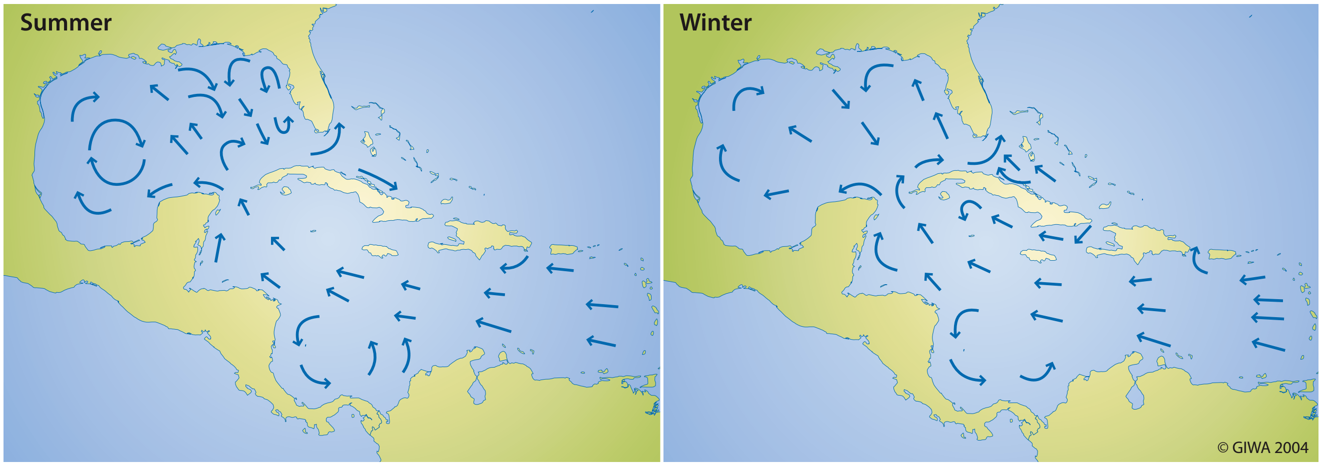


Figure 3 Surface circulation during summer (left panel) and winter (right panel).
Source: Redrawn from NIMA 2000)

are observed in the western part of the Caribbean Sea, decreasing gradually toward the east, as a result of less saline surface flow of equatorial waters from the Atlantic Ocean. Below depths of 500 m the salinity gradually decreases to approximately 35‰ (Encyclopedia Microsoft Encarta 2004).

Currents

The water circulation in the Caribbean Sea is caused by the equatorial currents of the Atlantic Ocean, as well as winds, sea level variance and by the rotation of the Earth (Figure 3). This has further implications on changes in the submarine terrain and the configuration of coastlines. The potent flows of the North Equatorial Current and the South Equatorial Current of the Atlantic Ocean forms the Caribbean Current that crosses this sea from east to west, ending in a north-western direction, with a velocity of 50 to 75 cm/s. In the Yucatan channel the velocity increases to 150 cm/s and above. The surface waters cross the whole Caribbean Sea in approximately 2 to 3 months (Encyclopedia Microsoft Encarta 2004).

Along the western and southern coasts of the Caribbean Sea, circular current flexions form several closed and semi-closed circulation systems that practically disappear during the winter (Figure 3).

Sea level

Tides are comparatively minor in the region. The surface system of currents, together with the power of the Earth's rotation, causes the vertical displacement of the water bodies, which in turn influences the characteristics of the bottom and the configuration of the coast.

Freshwater ecosystems

Rivers

The rivers of the Caribbean Islands region have very short courses with limited flow rates in comparison to the rivers of Central and South America. For the majority of the rivers, their flows are longitudinal to the east-west axis of the archipelago. The most extensive rivers in the region are concentrated in the largest territories of Hispaniola and Cuba (see Table 3). In other islands, rivers are comparatively small but support important aquatic ecosystems.

The volume of water supplied by the streams and rivers in the Caribbean Islands region is limited, except in rainy seasons and during tropical cyclones. During these wet periods, many riverbeds that remain dry the rest of the year become active, temporarily reviving nearby flora and fauna. In the cases of tropical storms or cyclones, the flow is often so sudden and voluminous that many rivers and streams move their riverbeds or even change flow directions, dragging sediments along downstream and disturbing downstream swamps and lagoons and their associated ecosystems by depositing large quantities of eroded

Table 3 Main rivers of the Caribbean Islands region.

Country	River	Length (km)	Location of river mouth
Cuba	Cauto	241	South
	Zaza	145	South
	Sagua la Grande	144	North
Dominican Republic	Yaque del Norte	296	North
	Yuna	150	North
	Yaque del Sur	183	South
	Ozama-Isabela	130	South

(Source: Collard 2000)

soil facilitating the eutrophication processes, at increasing the consume of dissolve oxygen for mineralise the organic material associate of those sediments (Riley & Chester 1978).

Lakes

The Caribbean Islands region contains very few lakes and they are of limited size. Swamps or artificial lakes constitute the majority of silent watersheds in the region where upstream water is retained in order to irrigate crops. In Cuba, water retention for agricultural use by small dams was one of the earliest measures taken by the Revolutionary Government in 1959. Although each one of these small artificial lakes has retained a particular environment with bordering flora and fauna, the retention of water by numerous dams has hindered any natural development of freshwater fish species and led to the quasi-extinction of many species.

Groundwater

In the Caribbean Islands region, groundwater is found mostly in fissured carbonated rocks. The main karstic aquifers in calcareous rocks are found in western Cuba, which directly supply domestic needs, crop irrigation and industry with high-quality water. Karstic aquifers are available throughout Cuba, Hispaniola and Jamaica and supply the local population with the bulk of their drinking water. Waters originated from those underground layers are typically bicarbonated-calcic, with a mineral concentration between 0.4 mg/l and 0.7 mg/l and a flow fluctuating between 1.5 l/s and 2 l/s (Fagundo et al. 1996).

River and lake fisheries

Freshwater fishing is not prominent in the majority of the Caribbean Islands region, and there is no data available to evaluate the magnitude of these small-scale activities. Among those recognised as the most common Caribbean freshwater species are: American eel (*Anguilla rostrata*), Mountain mullet (*Agostonomous monticola*), River goby (*Awaous tajasica*), Sirajo goby (*Sicydium plumieri*) and Bigmouth sleeper (*Gobiomorus dormitor*). Freshwater species, such as the River goby, are targeted to use as bait when fishing for much larger marine fish.

Terrestrial ecosystems

Most of the indigenous forest in the largest islands of the region was deforested by early settlers for construction or to clear land for intensive culture of sugar cane and maize. The early ecosystem degradation is irreversible and has since led to severe soil erosion. The disappearance of the forest has also led to the early extinction of many autochthonous flora and fauna. Such phenomena took place in all islands of the region, but particularly on the islands of Cuba, Hispaniola and Puerto Rico, where sugar cane cultivation was particularly intensive. The Bahamas and Jamaica were affected to a lesser extent by this radical transformation of their landscape. Today, the landscape of the Caribbean Islands reflects current land use, which is predominantly the cultivation of sugar cane and other types of cash crops. Only a very limited amount of tropical forest remains. Landscapes bordering rivers, lakes or other small watersheds are usually sources of regeneration of the original flora and fauna.

Coastal ecosystems

The Caribbean Islands region possesses a diverse and irregular coastline that gives rise to a unique ecosystem formed by the integration of coastal features including harbours, bays, beaches, rocky shores, estuaries, mangrove swamps, cays, and coral reefs. Most of the island populations inhabit the coastal plains, which therefore also support the majority of the economic activities. The marine-coastal zone of the region is characterised by a high biodiversity, with a multiplicity of tropical ecosystems and landscapes, and a varied autochthonous flora and fauna. The coastal zone of the Greater Antilles and The Bahamas contains some of the most productive and biologically complex ecosystems in the world. The marine seascape of the region supports a complex interaction of three distinct ecosystems: coral reefs, mangroves, and seagrass beds.

Coral reefs

Approximately 7% of the world's coral reefs resources are located in the Wider Caribbean particularly in the Greater Antilles and The Bahamas (i.e. GIWA region Caribbean Islands). Currently, 29% of the reef areas in the Wider Caribbean are considered under high risk due to an array of causes, the main threats being posed by human activities, especially those which cause marine pollution (Figure 4) (Wilkinson 1998, UNEP 2000, 2001b). Coral reef fauna in the Caribbean Islands are the most diverse in the world, in terms of higher taxonomic variety. The framework built by corals and algae supports a variety of sponges, sea whips, sea anemones, worms, tubeworms, shrimps, crabs, lobsters, snails, clams, starfish, brittle stars, feather stars, sea urchins, sea cucumbers, and fish. In The Bahamas bank or bank-barrier, reefs are relatively common. Atoll-like structures are found in The Bahamas and small atoll-like reefs, more commonly known as basin or cup reefs, are found in Puerto Rico. The Greater Antilles (Cuba, Hispaniola and Puerto Rico) generally has more extensive reefs than the Lesser Antilles (Stanley 1995, UNEP/CEP 1996, Geoghegan et al. 2001).

Mangroves

In the Caribbean Islands region mangroves are found on almost every coastline, although there are wide variations in mangrove coverage depending on the geographic characteristics of each island (Figure 4). Low-relief coastal plains with ample freshwater inflows foster the most

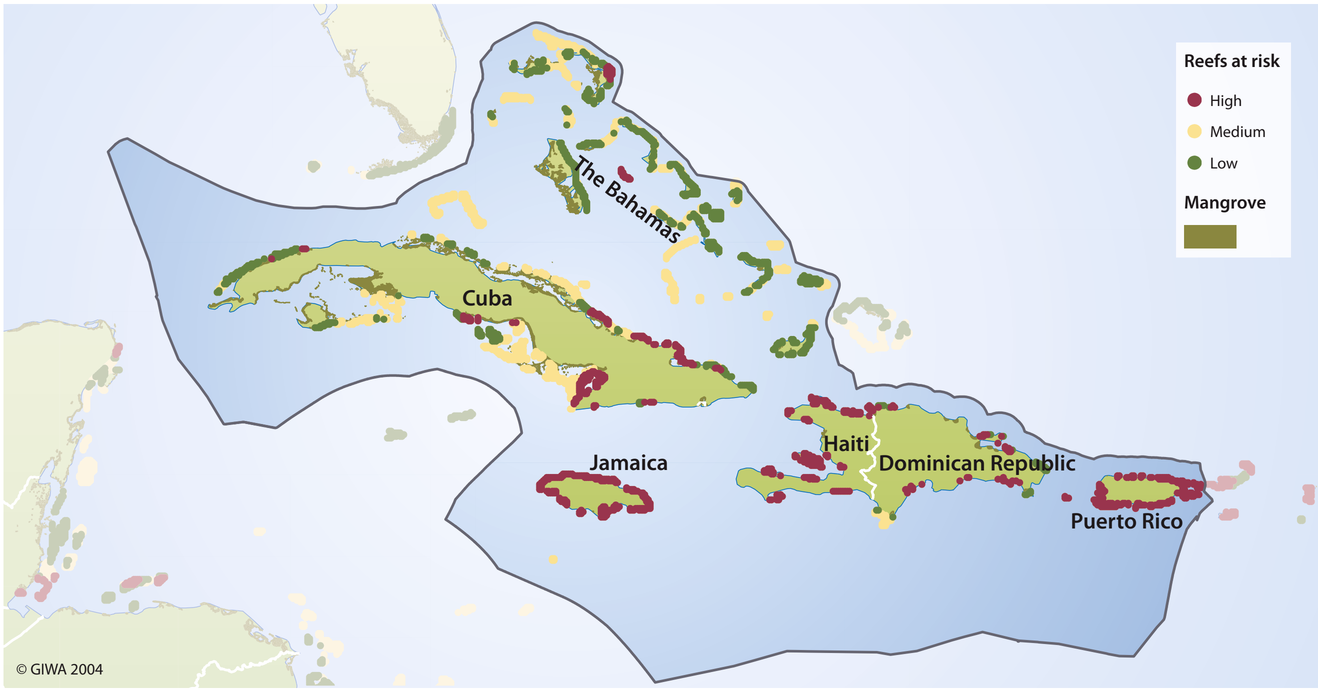


Figure 4 Coral reefs and mangroves in the Caribbean Islands region.
(Source: Bryant et al. 1998, UNEP/WCMC 2000)

complex and largest forests. The most impressive forests in Caribbean are found along the coasts of the Greater Antilles. In the Eastern Caribbean steep shorelines, limited freshwater run-off from low, dry islands and exposure to powerful waves limit mangrove development, although small, sheltered locations at protected river mouths support mangroves in many areas. Of the indigenous mangrove species occurring in the Caribbean Islands, the red (*Rhizophora mangle*), black (*Avicennia germinans*) and white (*Laguncularia racemosa*) are the most widely distributed. Depending on the environment, mangroves can grow into trees of 40 m and above (Stanley 1995, UNEP/CEP 1996, Geoghegan et al. 2001).

Seagrass beds

Seagrass beds are important spawning and nursery grounds for fish in the region. Mangroves and seagrasses show similar species diversity distribution patterns, with the Caribbean being one of the areas of greatest diversity. In the region, seagrass meadows are usually dominated by Turtlegrass (*Thalassia testudinum*). They are coated with numerous epiphytes, both microscopic and macroscopic, and are interspersed with other seagrasses such as *Halodule wrightii* and *Syringodium filaforme*, and major benthically rooted algae like *Halimeda*, *Penicillus*, *Udotea*, *Rhipocephalus*, and *Caulerpa* (Thoraug 1981 in Stanley 1995). The seagrass beds stabilise bottom sediments that could otherwise damage corals.

Mammals and birds

The coastal areas in the Caribbean Islands region provide habitats for both terrestrial and sea birds. Mangroves, in particular, provide exceptionally sheltered conditions for the nesting of some seabirds, such as the Black-capped petrel (*Pterodroma hasitata*). This is the only endemic bird in the region, and unfortunately is already on the list of endangered species due to the alteration of coastal habitat in the region (pollution, coastal development etc.).

The presence of seagrass in the coastal zones of the Caribbean Islands region protects coasts from erosion, and species such as *Thalassia* provide grazing for sea turtles, manatees and invertebrates (Stanley 1995, UNEP/CEP 1996, Geoghegan et al. 2001). The region provides important habitat for endangered sea birds and marine mammals (e.g. West Indian manatee) but no estimates of numbers of these are available in the Caribbean Islands region (UNEP/CEP 1996, Sullivan Sealey & Bustamante 1999).

Marine ecosystems

Phytoplankton

Up-welling of cold bottom water, rich in disolved nutrients, stimulates the high biological productivity of the Caribbean Islands region. In the Caribbean, large zones of phytoplankton blooms exist off the north coast of Venezuela and near the southeast border of the peninsula of

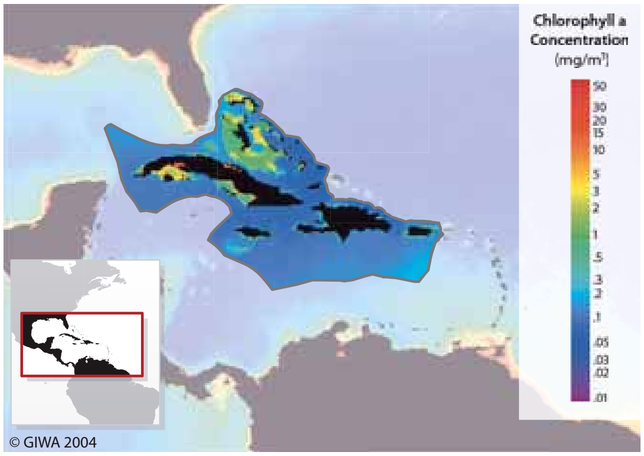


Figure 5 Chlorophyll a concentrations in the seas of the Caribbean Islands region.
(Source: NASA 2004)

Florida, providing a major source of biological surface activity during the winter (Figure 5). Smaller systems, for example those off the extreme southeast coast of Cuba and by the east of the Yucatan platform of Nicaragua, appear with great frequency during summer months. The phytoplankton blooms that are concentrated in the Yucatan frontal zones are transported north and east across the seas of the region by the Gulf Stream.

Fisheries

Table 4 shows the variety of aquatic resources in the region that are commercially viable for both domestic consumption and export. The region's marine fisheries are mainly comprised of the following species: chromises (damselfishes), gobies, groupers, grunts, hamlets (seabass), jacks, parrotfishes, seabass, puffers, snappers and wrasses.

The region also contains numerous populations of shark, located mostly around The Bahamas in the Atlantic Ocean part of the region. There are a total of 76 different species of sharks, but only 14 are endemic to the region, among which are the Cuban ribbontail catshark (*Eridacnis barbouri*), the Bahamas sawshark (*Pristiophorus schroederi*) and the Caribbean roughshark (*Oxynotus caribbaeus*).

Lobsters are probably the most famous species of the Caribbean coastal areas. The region hosts approximately eight different lobster species: Atlantic deep-sea lobster (*Acantharacaris caeca*), Banded lobster (*Eunephrops manningi*), Red lobster (*Eunephrops bairdii*), Sculptured lobster (*Eunephrops cadenasi*), Caribbean lobster (*Metanephrops binghami*), Mitten lonsterette (*Nephropides caribaeus*), Ruby lobsterette (*Nephropsis neglecta*); and Atlantic pincer lobster (*Thaumastocheles zaleucus*).

Endemic species are found in a number of locations within the region. However, the inventory and descriptions of many species are considered incomplete, and there are probably other endemic species that have not been recorded.

Socio-economic characteristics

The countries in the Caribbean Islands region show a number of similarities in terms of geology, geography, climate and population, and colonial history. This has shaped the common socio-economic characteristics of the region such as a concentration of racially and culturally mixed populations in the coastal zones, an emphasis on cash crops such as sugar cane and maize, and the growth and importance of tourism. However, the countries of the Caribbean Islands region show significant disparities regarding their political regimes, population distribution and access to public services, economic stability and priorities for economic development.

Table 4 Aquatic resources of commercial importance in the Caribbean Islands region.

Commercial fishing				Sport fishing		Tourist resources	Other resources	
Fish and turtles			Invertebrates					
Demersal	Coastal pelagic	Ocean pelagic	Coastal	Open sea	Coastal		Aquaculture	Not food related
Grouper (Serranidae)	Dolphin fish (*Coryphaena hippurus*)	Squids	Shrimps	Marlin (Istiophoridae)	Permit (*Trachinotus* spp.)	Whale and dolphin watching	Shrimps	Sponges
Snappers (Lutjanidae)	Several shark species	Tunas and bonitos	Queen conch (*Strombus gigas*)	Dolphin fish (*Coryphaena hippurus*)	Tarpon (*Tarpon atlanticus*)	Diving at coral reefs	Several fish species	Corals
Grunts (Haemulidae)	Wahoo (*Acanthocybium solandri*)	Sharks	Spiny lobster (*Panulirus argus*)		Snook (*Centropomus decimalis*)	Attraction for ecotourism	Oyster	Turtle shells
Green turtle (*Chelonia mydas*)	Jacks (Carangidae)	Marlin (Istiophoridae)	Oysters (Bivalves)		Mullets (Mugilidae)		Algae	Shells
Hawkbill turtle (*Eretmochelys imbricata*)	Swordfish (*Xyphias gladius*)	Swordfish (*Xyphias gladius*)	Crabs		Sardines			
Loggerhead turtle (*Caretta caretta*)								

(Source: PNUMA/ORPALC/Cimab in press)

Table 5 Population in the Caribbean Islands region.

Country	Population	Population growth rate (%)	Population density (inhabitants/km²)	Urban population (%)	Urban population growth rate 1995-2001 (%)	Total life expectancy (years)
The Bahamas	304 910	0.9	22	88	1.6	72
Cuba	11 184 020	0.4	100	77	0.5	76
Dominican Republic	8 581 480	1.6	177	65	2.4	71
Haiti	6 964 550	1.4	251	34	3.3	54
Jamaica	2 665 640	0.5	243	56	1.8	75
Puerto Rico	3 937 320	0.6	427	ND	ND	77
Total	33 637 920					

Note: ND = No Data. (Source: Encyclopedia Microsoft Encarta 2002, Collard 2000, UNDP 2003)

The region's socio-economic evolution has resulted in spatial variations in the degradation of the environment and a shift in activities impacting on ecosystems. From the 16th to the 20th century, the clearance of land for export crops (sugar cane, tobacco, maize) depleted the fragile tropical forest ecosystems of these islands, but more recently, the growth in economic activities, such as tourism, trade and heavy or transformation industries, has shifted the burden of economic development on natural ecosystems away from the inland areas towards coastal zones.

Population

The estimated total population for the GIWA region Caribbean Islands is 34 million (Table 5) (Encyclopedia Microsoft Encarta 2002, Collard 2000, UNDP 2003). Population sizes of countries within the region show a great disparity (Figure 6). The most populated country of the region is Cuba, which is also the largest in terms of area, and the least populated country is The Bahamas with only 304 910 inhabitants (UNDP 2003).

Population dynamics

Density data from Table 5 and Figure 6 shows a very unequal distribution of population throughout the region. The very high population density in Haiti, combined with the difficult political, social and economic conditions of this country may explain some of the pressure on natural resources. Jamaica has a similar population density, but natural resource management and the controlled development of tourism including appropriate management of foreign currency inflow has allowed the country to limit its population's pressure on natural resources as well as minimise urban migration. Jamaica has the largest area of preserved parks and ecosystems in the region.

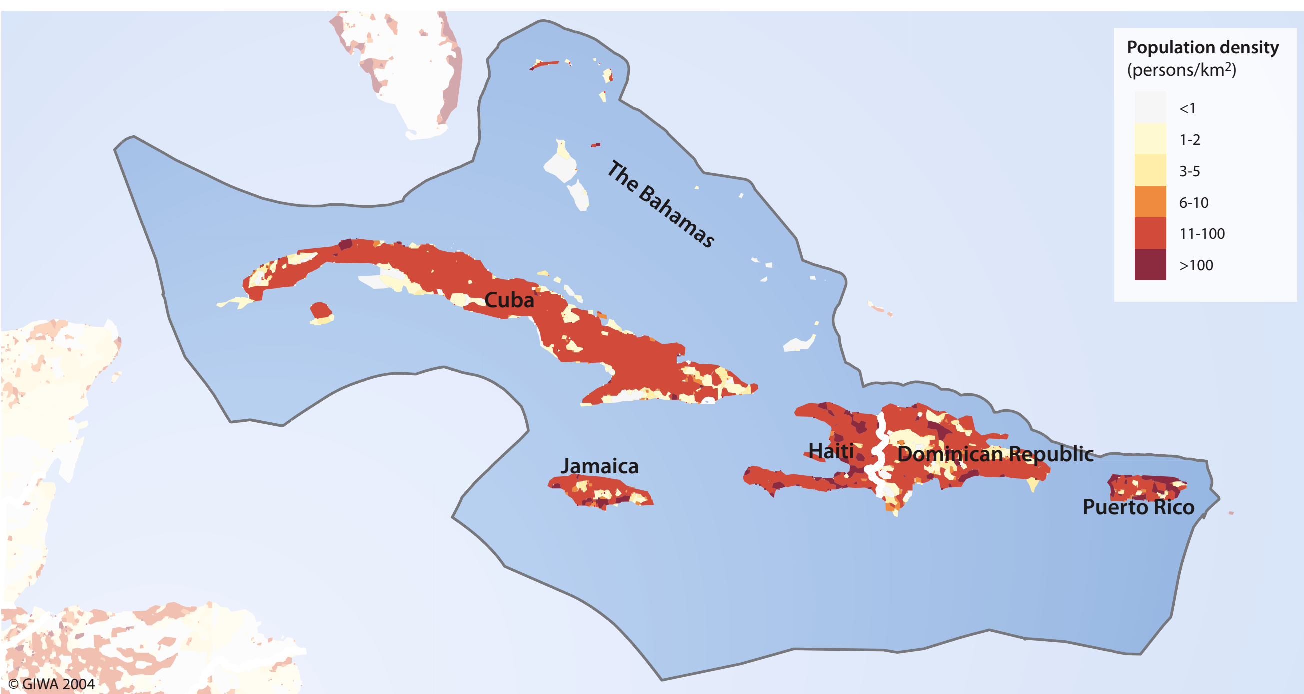


Figure 6 Population density in the Caribbean Islands region.
(Source: ORNL 2003)

The Bahamas has an exceptional concentration of its population around the capital city of Nassau, due to the widespread distribution of its territory in archipelagos with each one having very limited natural resources. The accumulation of population around a single urban centre creates problems in managing land-based pollution of aquatic ecosystems via the disposal of soil sediments, human-originated nutrients and important quantities of solid waste in areas that are surrounded by an aquatic environment and that not always dispose of either the technology, nor the land space (as it is the case in Nassau) to treat human originated waste efficiently.

Most likely because it is the largest territory of the region, and due to past intensive and highly mechanised practices in agriculture, Cuba has a moderate population density, but a high urban population. However, a reorganisation of the agricultural sector has created rural employment opportunities and led recently to a reversal in urban migration trends.

In the past, the Dominican Republic has successfully managed to maintain rural communities and limit urban migration. However, with the highest population growth rate in the region, people have now begun to migrate to coastal areas at an increasing rate, in search of employment in the tourism sector. Although the tourism industry in the Dominican Republican is often the financial source of environmental assessment programmes, uncontrolled urbanisation inducing solid waste pollution and soil erosion with serious habitat destruction is to be found in the peripheries of tourist resorts, where migrating populations in search of employment often settle in poor conditions.

Table 6 Age structure of the population in the Caribbean Islands region.

Country	Age structure (%)		
	<15	15-64	>64
The Bahamas	29	66	5
Cuba	22	69	9
Dominican Republic	35	61	4
Haiti	42	54	4
Jamaica	31	62	7
Puerto Rico	24	65	11

(Source: Collard 2000, CIA 2003)

Structure and ethnic composition

The age structure of the population in the Caribbean Islands region is shown in Table 6. The heterogeneity of ethnic, cultural and linguistics is a characteristic of the countries that belong to the Caribbean Islands region. The common colonial heritage of the region has resulted in a concentration of the countries' populations in urban settlements on the coast consisting of a diverse colonial and slave antecedent culture, since many of indigenous tribes (Caribbean Indians) were largely eradicated by disease. The majority of the population is of African slave descent that historically was located in mostly inland areas working on sugar cane or tobacco farms, whereas European populations predominantly inhabited major harbours participating in trade and shipping of export crops. In Cuba, the Dominican Republic and Puerto Rico, the end of slavery and the mechanisation of agriculture pushed the African population toward the urban coastal areas, mixing with the European population, reversing the urban/rural population distribution and creating a new and mostly urban Creole culture.

Gender, education and awareness

Most of the countries of the Caribbean Islands region, with the exception of Haiti, show great achievement in both literacy rates and balanced access to education between males and females (Table 7). In Cuba, and particularly in Jamaica, women are achieving a greater level of education than men, who remain the main workforce for agriculture. Women's employment is generally absorbed by the service sector, including health, education and tourism. Due to its particular politico-economic situation, Cuba provides the most intensive environmental educational and awareness campaigns.

Table 7 Economic activity, literacy and education by gender for countries in the Caribbean Islands region.

Country	Economic activity rate Adult females (%)		Economic activity rate Adult males (%)		Youth literacy rate (% age 15-24)		Tertiary education Ratio Girls:Boys	Literate Ratio Females:Males		Government education expenditures (% GNP)
	1995	2001	1995	2001	1990	2001	2001	1990	2001	1995-2002
The Bahamas	66.5	67.3	81.2	80.4	96.5	97.3	ND	1.02	1.02	3.6
Cuba	46.8	49.5	76.9	76.5	99.3	99.8	1.11	1.00	1.00	6.7
Dominican Republic	37.4	40.4	85.9	85.8	87.5	91.4	ND	1.02	1.02	2.1
Haiti	56.7	56.1	81.2	80.1	54.8	65.3	ND	0.96	1.01	1.5
Jamaica	67.5	68.3	79.9	79.6	91.2	94.3	1.86	1.09	1.07	6.8
Puerto Rico	ND	ND	ND	ND	ND	100	ND	ND	1.01	ND

Note: ND = No Data. (Source: UNDP 2003, UN 2003)

Access to water, health and sanitation

Table 8 demonstrates the great contrast among countries of the Caribbean Islands region regarding access to water, health and sanitation. All countries, with the exception of Haiti, offer good access to an improved water source. Nevertheless, access to sanitation is a concern in the Dominican Republic and is particularly acute in Haiti. Cuba has the highest physician/inhabitant ratio in the world, with 590 physicians for every 100 000 inhabitants (Norway, at the top of the UNDP Human Index list, has 413 physicians for every 100 000 inhabitants). Cuba also has good access to water and sanitation services. Conversely, The Bahamas lacks physicians, but offers exceptional sanitary and water access despite having to supply a population dispersed over a widespread territory.

Economic conditions

The Gross Domestic Product (GDP) per capita for the Caribbean region, according to sources of the World Bank, increased by 35% between 1975 and 1995 (UNEP 2000). However, the variance in Gross National Product (GNP) and GDP distribution between the three major economic sectors (agriculture, industry and services) indicates a disparity in the rate of development in the Caribbean Islands region (Table 9).

The economic growth of The Bahamas, Jamaica and Puerto Rico can be largely attributed to the growth in the service sector, particularly in tourism and financial services, although Puerto Rico has also developed and maintained a solid industrial base serving mostly continental US companies. Jamaica's growth has also been promoted to a certain extent by international loans, making it the region's largest borrower of foreign capital, with 8.3 % of GDP consumed by debt servicing (UNDP 2003).

Cuba and the Dominican Republic have experienced more paralleled growth in all three of the main sectors (agriculture, industry and services), and economic development has been more sustainable and less sensitive to disturbances in the global economy.

Economic growth in Cuba has been shaped by its socialist political system and in response to economic restrictions imposed by the US-Cuban trade barrier. The Dominican Republic achieved its growth through harnessing foreign investment for agriculture and tourism, trade of agricultural products with the US, and the development of a medium-sized industrial sector. However, in the Dominican Republic significant inequalities exist in wealth distribution among its population, demonstrated by it having the worst GINI coefficient in the region, (measure equitable income distribution) (UNDP 2003).

Although data is not available for Puerto Rico, the US mandated government of the island remains a net receiver of US federal and private investments to sustain the island's strong economy, and has shown tremendous growth in its industrial base and in the service sector in the last 15 years. Puerto Rico's impressive growth may be solely a result of the magnitude of these investments, but has progressively increased its productivity and self-sufficiency in both the industrial (oil refining, pharmaceuticals, manufacturing, food processing) and in particular the service sector, including tourism.

Haiti has experienced the worst economic performance in the region; a reflection of social unrest, political instability, exhausted resources and poorly coordinated economic development. The country has the lowest GDP per capita, 341 USD, in the region and also the highest dependence on the agricultural sector (Table 9).

Table 8 Population with access to water, sanitation and health.

Country	Population access to improved sanitation (%)	Population access to improved water source (%)	Physicians per 100 000 inhabitants
The Bahamas	100	97	106
Cuba	98	91	590
Dominican Republic	67	86	216
Haiti	28	46	25
Jamaica	99	92	140
Puerto Rico	ND	ND	ND

Note: ND = No Data. (Source: UNDP 2003)

Table 9 Gross national product in the Caribbean Islands region.

Country	Annual GDP 2001 (USD)	GDP per capita 2001 (USD)	Real GDP per capita growth 2001* (%)	GDP by sectors (%)		
				Agriculture	Industry	Services
The Bahamas	4 557 00 000	14 855	-0.5	3.0	5.0	92.0
Cuba	28 596 000 000	2 545	2.5	7.4	36.5	56.1
Haiti	3 494 000 000	431	-1.7	29.4	22.2	48.4
Jamaica	7 784 000 000	2 990	0.7	6.6	32.1	61.3
Dominican Republic	21 211 000 000	2 500	2.7	11.3	34.3	54.4
Puerto Rico	43 010 000 000	11 100	-0.2	1.0	45.0	54.0

*Note: * Data reported as annual average for 1995-2001. (Source: UN 2003, UNDP 2003, CIA 2003)*

Table 10 Foreign currency inflow: aid, foreign investment and tourism in the Caribbean Islands region.

Country	Foreign aid (% of GDP)		Net foreign direct investment inflows (% GDP)		Other private flows (% GDP)		Tourists arrivals	
	1990	2001	1990	2001	1990	2001	1995	2001
The Bahamas	0.1	ND	-0.6	5.2	ND	ND	1 598 000	1 577 000
Cuba	ND	ND	ND	ND	ND	ND	742 000	1 561 000
Dominican Republic	1.4	0.5	1.9	5.6	ND	2.5	1 776 000	2 649 000
Haiti	5.9	4.4	0.0	0.1	0.0	0.0	145 000	143 000
Jamaica	5.9	0.7	3.0	7.9	-1.0	9.9	1 147 000	1 248 000
Puerto Rico	ND	ND	ND	ND	ND	ND	ND	ND

Note: ND = No Data. (Source: UN 2003, UNDP 2003)

The Bahamas has a relatively strong GDP per capita due to foreign sources of income, such as tourism and offshore financial services. The country experienced a decline in growth associated with the slowdown in the US economy in 2001-2002. In contrast, Cuba's economy was severely affected between 1990-1993 by the collapse of the former Soviet Union, which was the primary source of direct aid, main investor and key importer of Cuban goods. Cuba avoided economic collapse by promptly restructuring its economy, particularly its agricultural sector, from predominantly export intensive, to a balance between subsistence and export crops.Also, to reverse the economic downturn of the mid-1990s it was necessary to open the country to other potential sources of foreign currency such as direct aid and foreign investments, mostly from European countries, and from expanding tourism.

The economic outlook for the Caribbean Islands region is fairly positive in comparison to other Small Islands Developing States (SIDS), such as those in the Indian and Pacific Oceans. However, due to the given resources available to the countries in the region, economic growth remains very much dependent on the inflow of foreign currency and investments (Table 10). That inflow mainly originates from four potential sources: (i) trade of agricultural products and low value-added manufacturing products; (ii) direct cash inflow from tourism; (iii) foreign aid; and (iv) foreign private investments in both agriculture exports and tourism.

All of these sources are volatile and dependent on the economic situations of North American and European countries, which constitute the region's main trading partners, providers of foreign aid, investors, and the origin of the majority of tourists to the region.

In conclusion, it appears that the countries of the region are intermittently dependent on the inflow of foreign currency for their sustainable development. The negative effect of the slowdown in tourism in 2001-2002, mentioned previously, highlighted the different approaches to economic development in the region. The slowdown was felt most severely in countries such as The Bahamas and Jamaica which are highly dependent on the tourism industry. In countries where the tourism industry is less significant, for example Cuba, Puerto-Rico and the Dominican Republic, the economic downturn was less damaging.

Table 11 Occupation by sector in the Caribbean Islands region.

Country	Unemployment (%)		Agriculture (% active pop.)		Industry (% active pop.)		Services (% active pop.)	
	1995	2001	1970	1990	1970	1990	1970	1990
The Bahamas	10.9	7.7	7.6	5.2	21.4	15.5	71.0	79.3
Cuba	ND	ND	30.1	18.2	26.4	30.4	43.5	51.5
Dominican Republic	15.8	15.9	47.5	24.8	14.4	29.1	38.1	46.0
Haiti	ND	ND	74.4	67.8	7.1	8.8	18.5	23.4
Jamaica	16.2	16.0	33.1	24.8	17.9	23.3	49.0	52.0
Puerto Rico	ND	12.0	ND	3.0	ND	20.0	ND	77.0

Note: ND = No Data. (Source: UNDP 2003, UN 2003, CIA 2003)

Occupation and income

The average unemployment rate for the region is between 7 and 16%, with Haiti having the highest rate of unemployment and Puerto Rico the lowest (Table 11). The service industry is, with the exception of Haiti, the main sector of employment and includes activities such as health, education, trade, retail and tourism.

The growth of the tourism sector has created employment opportunities and stimulated the service sector in the majority of the countries in the region. However, according to data from the Inter-American Development Bank (2004), the growth in urban employment is not sufficient to absorb the growth in urban migration in most of the countries in the region. Countries like Haiti, the Dominican Republic and Jamaica show an endemic surplus in urban labour not always absorbed by the growth of the tourism industry as expected Inter-American Development Bank 2004). Tourism has not created employment in these urban areas, with the exception of specific resorts and key historical cities like Santo Domingo and Havana, because the

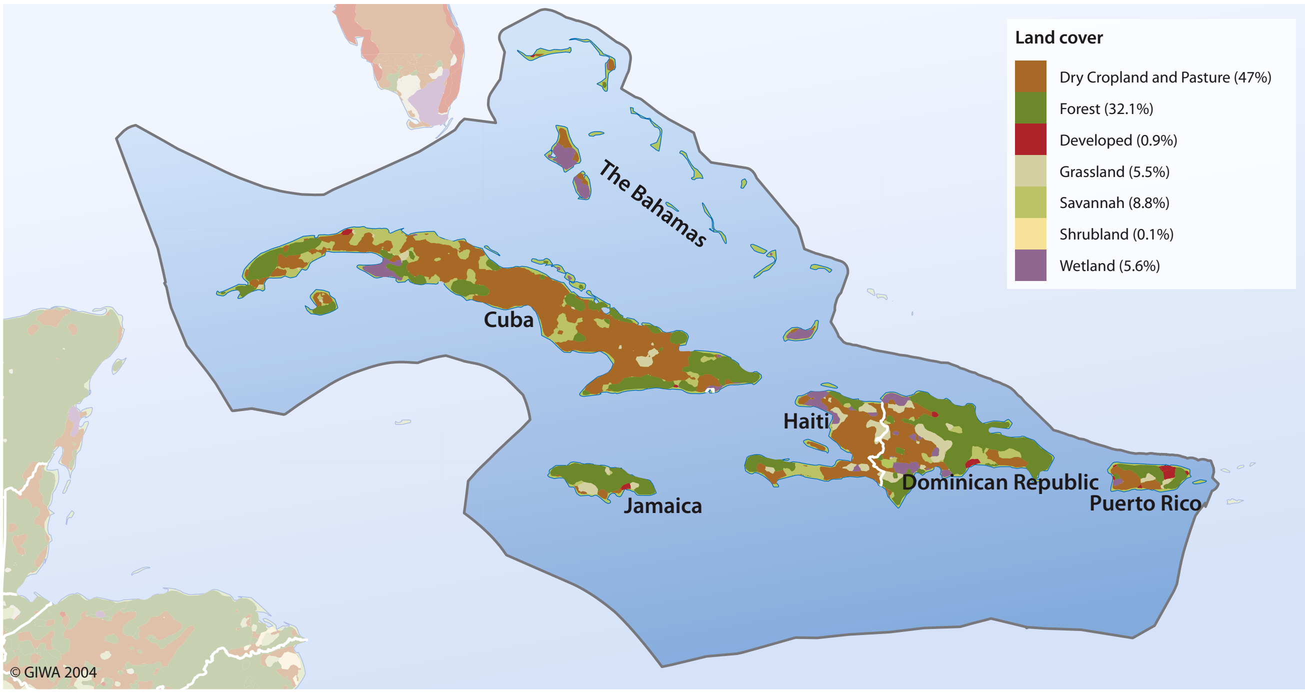


Figure 7 Land cover in the Caribbean Islands region.
(Source: based on USGS 2002)

majority of tourism resorts are located near natural tourist attractions e.g. pristine coastal ecosystems, but still within a reasonable distance of an international airport (Inter-American Development Bank 2004).

Economic sectors

Agriculture

Figure 7 and Table 12 outline land use in the Caribbean Islands region. Among the main crops in the region are the following: sugar cane, tobacco, citrus, coffee, cocoa, potatoes, beans, bananas, corn, manioc, cotton, rice, coconut, mangoes, pineapples and different vegetables.

Industry

Industry in the region is not a major economic sector. Haiti and The Bahamas have very little industrial capacity, and Haiti's economy is primarily domestic and based on agriculture. However, The Bahamas has almost no industry whatsoever (industry is 3% of GDP) and its economy is essentially based on services.

Table 12 Land use in the Caribbean Islands region.

Country	Arable land (%)	Crops (%)	Pastures (%)	Woodland and forest (%)	Other land uses (%)	Irrigated land (km^2)
The Bahamas	1	0	0	32	67	ND
Cuba	24	7	27	24	18	9100
Dominican Republic	21	9	43	12	15	2300
Haiti	20	13	18	5	44	750
Jamaica	14	6	24	17	39	350
Puerto Rico	4	5	26	16	49	390

Note: ND = No Data. (Source: Collard 2000)

Puerto Rico has the strongest industrial base (45% of GDP) as a result of US government tax incentives for US companies to base manufacturing operations in the country. Some of the largest US pharmaceutical, food processing, apparels, textile and electronics companies have manufacturing operations based in the vicinity of San Juan. Industry stimulates the local Puerto-Rican economy, although there is currently a threat from the re-location of some manufacturing operations to Asian countries like China which have prospects of cheap labour.

Cuba, Jamaica and the Dominican Republic have also managed to maintain a reasonable industrial sector. Early industrial activities in these countries were based on the manufacture of agricultural or mineral by-products, like liquors from sugar cane and exportable processed agricultural goods (cigars and processed tobacco in Cuba and the Dominican Republic), the extraction and cleaning of bauxite in Jamaica and ferronickel in the Dominican Republic. Further efforts to diversify industrial production have shown mixed results. Jamaica succeeded in developing a textile and a paper industry. Cuba attempted to manufacture machine tools and other ferrous by-products when it still had the opportunity to export in the Eastern Block. Following the collapse of the former Soviet Union, Cuba successfully managed to develop a food processing industry that today serves the local market. The Dominican Republic also has a thriving food processing industry.

Although industrial activity is limited, the lack of environmental regulations or enforcement has resulted in considerable impacts from this sector. Located near the main harbours and cities, industrial plants tend to cause air and water pollution. Pollution in Havana Bay will be further discussed in the Causal Chain Analysis.

Energy
All countries are dependent on the import of fuel for their energy requirements. Oil imports, mainly from Mexico, Venezuela and the United States, remain the main source of energy for the region. Cuba has tried to curb this dependence by promoting energy saving among the population and by building networks of small, hydroelectric dams on its rivers. This initiative had mixed results and frequently during the 1990s, when energy imports from the former Soviet Union were drastically reduced, Havana was subject to blackouts. This same problem exists for other countries in the region and the lack of alternative energy resources has often made them more reliant on wood fuel, therefore accelerating deforestation (Haiti, Dominican Republic).

Trade
Trade flows are characterised by the export of agricultural products, ore and low value-added manufactured derivatives of agricultural products (liquor, food). Imports include a variety of products e.g. textiles, manufactured goods, foodstuff, cars, machinery, computers and electronics. The main trading partners in the area are the United States (except for Cuba) and the European Union (the main buyers of agricultural goods) and Asian countries (the main providers of finished manufactured goods). Inter-regional trade within the Wider Caribbean region includes oil, food and textile, but remains limited in volume.

Services (not tourism-related)
The service sector is emerging as the strongest economic activity in the region (Table 9). The Bahamas has developed offshore banking services and Cuba has created employment opportunities in administration, education, security and health services.

Tourism
Tourism is the fastest and most promising sector of activity for all countries of the region, with the exception of Haiti, which has not yet been able to exploit its tourism potential (Table 13). The number of tourists into the region continues to grow. Between 1995 and 2000 (data for Puerto Rico not included in the calculation), the region witnessed a 32% growth in tourist arrivals, reflecting both the importance and the potential of the tourism sector for local economies. The net inflow of foreign currency from tourism has been very positive for the island economies.

Table 13 International tourism receipts by country of destination.

Country	International tourism receipts (million USD)			Average annual growth (%)	
	1990	1995	2000	1990-1995	1995-2000
The Bahamas	1 324	1 346	1 719	0.3	5.0
Cuba	243	963	1 737	31.7	12.5
Dominican Republic	900	1 568	2 860	11.7	12.8
Haiti	460	56	54	4.0	-0.7
Jamaica	740	1 069	1 333	7.6	4.5
Puerto Rico	1 366	1 828	2 388	6.0	5.5

(Source: WTO 2004)

Environmental preservation status
Cuba and Jamaica have developed extensive networks of national parks (Table 14), albeit for different reasons. Environmental conservation measures carried out in Jamaica were essentially concerned with curbing the high rate of deforestation resulting from aggressive agricultural practices and tourism infrastructure development. Conversely, the creation of national parks in Cuba have been concerned with matters of philosophy and national pride (CNAP 2000).

Table 14 Protected areas and national parks in Cuba.

Cuban province *	Number of protected areas			Protected area (km^2)		
	National	Local	Total	Land	Marine	Total
Cuba	81	155	236	19 960	6 790	26 750
Pinar del Río	10	20	30	1 720	376	2 096
La Habana	0	9	9	144	75	219
Ciudad de La Habana	0	6	6	16.4	6.6	23
Matanzas	7	16	23	2 480	612	3 092
Villa Clara	7	8	15	448	1 700	2 148
Cienfuegos	4	7	11	180	29	209
Sancti Spíritus	4	14	18	658	156	224
Ciego de Avila	3	8	11	360	353	713
Camagüey	9	12	21	1 740	2 080	3 820
Las Tunas	3	5	8	380	152	532
Holguín	7	13	20	880	46	926
Granma	4	6	10	1 390	0	1 390
Santiago de Cuba	3	9	12	894	110	1 004
Guantánamo	14	10	24	7 570	116	7 686
Isla de la Juventud	6	12	18	1 090	986	2 076

*Note: * Protected areas situated in more than one province are recorded in the province where it has the largest share of its total area. (Source: Hernandez 1998 in CNAP 2002)*

Countries in the Caribbean Islands region offer a variety of approaches to environmental management. Haiti has neither a culture nor a state level power for managing environmental issues. However, both The Bahamas and Jamaica, which have been dependent on tourism for a considerable amount of time, have achieved a number of important inroads in conservation, such as the designation of vast lands as protected areas.

However, the majority of the conservation programmes are funded by foreign organisations, such as UNEP, GEF, UNDP and the World Bank, several NGOs, and foreign aid agencies, such as the Canadian International Development Agency CIDA (Buff Bay in Jamaica, Rio Almendares in Cuba). The Caribbean Islands region is part of UNEP's Regional Seas Program, which created the Caribbean Action Plan as a global focus of regional coordination for the protection and development of the marine environment. This effort was carried out for the economic prosperity and the environmental health of the region (UNEP/DEC 2000). Figure 8 shows the international protected areas in the Caribbean Islands region.

Environmental initiatives

International and regional environmental conventions and protocols adopted and political and commercial alliances in the Caribbean Islands region are shown in Tables 15 and 16.

The Caribbean Action Plan (1981)

The Caribbean Action Plan emerged as a result of many years of work by governmental and non-governmental representatives of the Caribbean community. Assistance in the development of the plan was provided by the United Nations Environment Programme (UNEP) and the Economic Commission for Latin America and the Caribbean (ECLAC). The program objectives, adopted in 1981, include the following: assistance to all countries of the region, recognising the special situation of the smaller islands; coordination of international assistance activities; strengthening existing national and sub-regional institutions; and technical cooperation in the use of the region's human, financial and natural resources.

The Cartagena Convention (1983)

In 1983 the Cartagena Convention (CAR) was adopted as the legal instrument for the implementation of the Caribbean Action Plan. The Convention is a framework agreement setting out the political and legal foundations for actions to be developed in the implementation of the Plan. These actions are directed by a series of operational Protocols designed to address special issues and to initiate concrete actions. The Convention Protocols include: the Oil Spills Protocol, concerning cooperation among countries in the region in combating oil spills and the preparation and updating of contingency plans; the Specially Protected Areas and Wildlife (SPAW) Protocol, an instrument for dealing

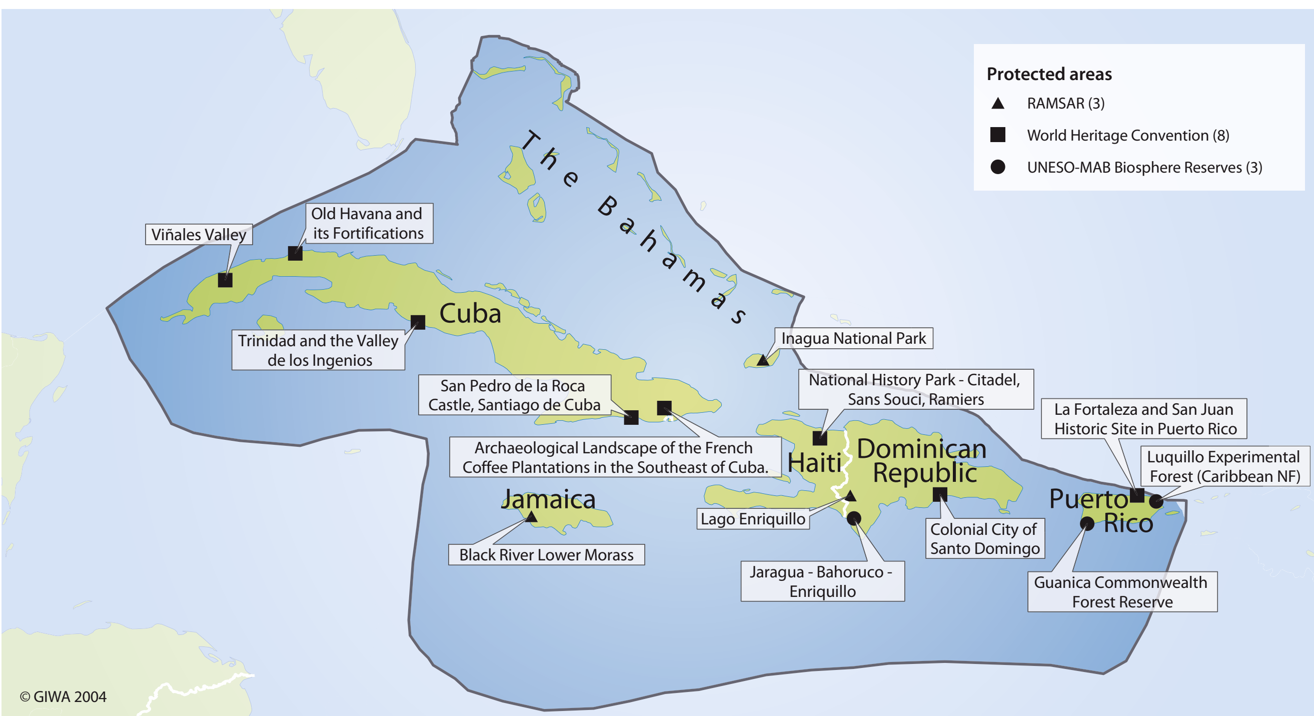


Figure 8 International protected areas in the Caribbean Islands region.
(Source: UNEP/WCMC 2003)

Table 15 Regional environmental conventions and protocols adopted and political and commercial alliances in the Caribbean Islands region.

Country	Political and commercial alliances/ organisations [1]					Cartagena Convention		Oil Spill Protocol [2]		Protected Species and Wildlife Protocol [3]		Pollution from Land-based Sources Protocol [4]	
	OEA	OECS	ACP (Lomé Convention)	COM	CARICOM	Signed	Ratified/ Accepted	Signed	Ratified/ Accepted	Signed	Ratified/ Accepted	Signed	Rat./Acc.
The Bahamas	√		√	√	√								
Cuba							September 1988		September 1988	January 1990	August 1998		
Haiti													
Jamaica	√		√	√		March 1983	April 1987	March 1983	April 1987	January 1990			
Dominican Republic	√		√	√	√		November 1998		November 1998		November 1998	August 2000	
Puerto Rico	√		√			March 1983	October 1984	March 1983	October 1984	January 1990		October 1999	

Notes: [1] OEA: Organization of American States, OECS: Organization of Eastern Caribbean States, ACP: Afican Caribbean and Pacific countries, CARICOM: Caribbean Community and Common Market. [2] Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region. [3] Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (SPAW). [4] Protocol Concerning Pollution from Land-Based Sources and Activities in the Wider Caribbean Region (LBS). (Source: PNUMA/ORPALC/Cimab in press)

Table 16 International conventions adopted in the Caribbean Islands region.

Country	CDB	CITES	CMS	Basel	Montreal Protocol		UNFCCC	UNCCD	Ramsar	WHC	UNCLOS
					London	Copenhagen					
The Bahamas	√	√		√	√	√	√		√		√
Cuba	√	√		√	√	√	√	√		√	√
Haiti	√						√	√		√	√
Jamaica	√	√			√	√	√	√	√	√	√
Dominican Republic	√	√					√	√		√	

Note: CDB: Convention on Biological Diversity, CITES: Convention on International Trade of Endangered Species, CMS: Convention on the Conservation of Migratory Species, Basel: Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, Montreal Protocol: on Substances That Deplete the Ozone Layer, UNFCCC: United Nations Framework Convention on Climate Change, UNCCD: United Nations Convention to Combat Desertification, Ramsar: Convention on Wetlands, WHC: UNESCO Convention for the Protection of the World Cultural and Natural Heritage, UNCLOS: United Nations Convention on the Law of the Sea.

with marine nature conservancy measures to protect, preserve and manage sensitive areas and threatened or endangered species of flora and fauna; and the Land-Based Sources of Marine Pollution (LBSMP) Protocol, an instrument for dealing with environmental pollution reaching the marine environment from land-based sources and activities, both point and non-point source. The governments of the nations and territories of the Wider Caribbean region established the Caribbean Environment Programme (CEP) in support of the Convention and its Protocols. A regional coordinating unit (UNEP-CAR/RCU) has been established in Kingston, Jamaica and serves as a Secretariat for the CEP.

Caribbean Environmental Programme

The Caribbean Environment Programme (CEP) was set up in the region as part of the UNEP Regional Seas Programme. CEP is facilitated by the Caribbean Regional Coordinating Unit (CAR/RCU) in Jamaica, which serves as the Secretariat to CEP. The objectives of the Secretariat are to provide assistance to all countries in the region, strengthen national and sub-regional institutions, coordinate international assistance, and stimulate technical cooperation among countries. CAR/RCU also serves as the Secretariat to the Cartagena Convention and its Protocols.

One of CEP's main sub-programmes is the Assessment and Management of Environmental Pollution (AMEP) programme. This provides regional coordination for the Land-Based Sources Protocol. AMEP supports the activities required for the establishment of necessary measures to prevent, reduce and control marine pollution and to assist in the development of integrated environmental planning and management of coastal and marine areas. This programme is responsible for the regional management and coordination of global agreements such as the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA), Agenda 21, and the Basel Convention.

Assessment

Table 17 Scoring table for the Caribbean Islands region.

Assessment of GIWA concerns and issues according to scoring criteria (see Methodology chapter)

- 0 No known impacts
- 1 Slight impacts
- 2 Moderate impacts
- 3 Severe impacts

The arrow indicates the likely direction of future changes.

- ↗ Increased impact
- → No changes
- ↘ Decreased impact

Caribbean Islands	Environmental impacts	Economic impacts	Health impacts	Other community impacts	Overall Score**	Priority***
Freshwater shortage	2.0* ↗	2.0 ↗	1.5 →	1.0 →	2.0	2
Modification of stream flow	2					
Pollution of existing supplies	2					
Changes in the water table	2					
Pollution	2.1* ↗	2.3 →	2.0 ↗	2.5 →	2.4	1
Microbiological pollution	2					
Eutrophication	2					
Chemical	2					
Suspended solids	3					
Solid waste	2					
Thermal	1					
Radionucleid	1					
Spills	2					
Habitat and community modification	2.0* →	2.5 →	1.5 →	2.3 →	2.0	4
Loss of ecosystems	2					
Modification of ecosystems	2					
Unsustainable exploitation of fish	2.0* →	1.8 →	1.3 →	1.8 →	1.8	5
Overexploitation	3					
Excessive by-catch and discards	1					
Destructive fishing practices	2					
Decreased viability of stock	1					
Impact on biological and genetic diversity	1					
Global change	1.4* ↗	2.7 ↗	1.7 →	2.0 →	2.0	3
Changes in hydrological cycle	2					
Sea level change	1					
Increased UV-B radiation	1					
Changes in ocean CO_2 source/sink function	1					

* This value represents an average weighted score of the environmental issues associated to the concern.

** This value represents the overall score including environmental, socio-economic and likely future impacts.

*** Priority refers to the ranking of GIWA concerns.

This section presents the results of the assessment of the impacts of each of the five predefined GIWA concerns i.e. Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, Global change, and their constituent issues and the priorities identified during this process. The evaluation of severity of each issue adheres to a set of predefined criteria as provided in the chapter describing the GIWA methodology. In this section, the scoring of GIWA concerns and issues is presented in Table 17. Detailed scoring information is provided in Annex II of this report.

The assessment is based upon the opinions of experts of different specialist backgrounds and from several institutions and geographical regions of the Caribbean Islands region. It was undertaken by objectively weighting each of the five concerns and their associated issues against each other.

Freshwater shortage

Freshwater shortage was assessed as having moderate impacts in the region. The rivers of the Caribbean Islands region have very short courses with limited flow rates and the most extensive rivers are concentrated on Cuba and Hispaniola. The region has no transboundary freshwater resources. Providing adequate supplies of freshwater can present a significant challenge to local governments within the Caribbean Islands region (GEF 2004b). Demand for freshwater has grown rapidly in the region as a result of demographic growth, and from industrial, agricultural and tourism expansion. These activities have also polluted existing water supplies.

The recharge of freshwater is highly dependent on rainfall to feed surface intakes and replenish groundwater. Management of water resources is further complicated by the local geology, which is dominated by either porous limestone that does not sustain streams, or by dense volcanic rocks that limit infiltration. Changes in rainfall patterns may cause more severe and longer droughts, limiting stream flow and reservoir storage or increasing flooding and inundation (GEF 2004b).

The economic success of the region is highly dependent on freshwater supplies, particularly for agriculture and tourism. Table 18 shows the distribution of water supplies and use between the countries and by extraction sector. The high demand for freshwater has led to overextraction from aquifers and the rapid depletion of surface resources. Inevitably, this has a detrimental effect on watershed and coastal biological communities, many of which are dependent on a specific balance of water availability and salinity for their survival.

Table 18 Water supplies in the Caribbean Islands region.

Country	Renewable resources of water		Extraction of water per year		Extraction by sector (1997)		
	Total (km^3)	Per capita (m^3)	Total (km^3)	Per capita (m^3)	Industrial (%)	Agriculture (%)	Domestic (%)
The Bahamas	ND	ND	ND	ND	ND	ND	ND
Cuba	30.5	3 104	8.10	870	2	89	9
Dominican Republic	20	2 430	2.97	446	6	89	5
Haiti	11	1 460	0.04	7	8	68	24
Jamaica	8.3	3 269	0.32	159	7	86	7
Puerto Rico	ND	ND	ND	ND	ND	ND	ND

Note: ND = No Data. (Source: UNEP 2000)

Freshwater reserves for the region are estimated to be the sum of the annual precipitation (288 km^3) and internal renewable water resources (82 km^3); a total of 370 km^3 and an average of 2 804 m^3 per inhabitant (FAO AQUASTAT 2004). This is the lowest figure for freshwater reserves in the entire Latin American and Caribbean region, with the exception of the Lesser Antilles (GIWA region 3 Caribbean Sea). The UN Food and Agriculture Organization (FAO) estimates that a country faces water scarcity when it has 2 000 m^3 or less of freshwater per inhabitant per year. However, the Caribbean Islands region has a legacy of poor water resource management concerning groundwater supplies within the river basins. The management approach to freshwater resources is unsustainable and consequently freshwater shortages are adversely affecting biodiversity in the watershed and coastal zone (GEF 2004b).

Environmental impacts

Modification of stream flow

The issue of stream flow modification was assessed as moderate. According to the GIWA experts the impact of stream flow modification in Jamaica and Haiti is severe, as there have been significant reductions in river discharges and a loss of deltaic wetlands and riparian vegetation. In Jamaica, the flows of many rivers have been reduced as a result of increased sediment loads. In the Dominican Republic and Puerto Rico there has also been a decreasing trend in the annual discharge of the rivers, causing a significant loss of riparian vegetation.

In Cuba a decrease in stream flow has allowed saline intrusions in certain freshwater rivers and coastal lagoons as the hydrodynamic equilibrium of the saline water wedge has been altered. One third of Cuba's croplands are irrigated and 35% of the surface run-off is diverted by dams and channelling (Portela & Aguirre 2000). The Almendares River, despite being the most important river in Havana, has a relatively short course of 40 km and is particularly shallow. For the majority of the year it becomes merely a trickle, as a result of the construction of dams upstream and heavy pumping in the middle and upper basins. The overexploitation of the river is so great that it has often dried up for an entire winter season. Close to its mouth the stream becomes a wider, deeper and darker volume of lifeless and muddy water (Portela & Aguirre 2000).

Pollution of existing supplies

The impacts of pollution of existing supplies were assessed as moderate. The discharge of untreated or only partially treated sewage, increased run-off of sediments from exacerbated soil erosion and the intensive use of chemicals in agriculture and industry constitute the main causes of the pollution of existing water supplies and subsequently lead to a deterioration of public health. Siltation is so significant that often water used for domestic activities is heavily laden with sediments, despite having passed through the treatment processes (GEF 2004b). In addition, a rise in sea level may cause saltwater intrusion in coastal aquifers and may impair the water quality of shallow lenses, which are important sources for public water supplies (GEF 2004b). Sources of potable water throughout the region do not reach national or World Health Organization (WHO) standards for health and quality.

Freshwater supplies have been particularly polluted by the discharge of untreated sewage (PNUMA/ORPALC/Cimab in press). Wastewater treatment facilities are inadequate in many locations. In Puerto Rico, reports of fish plagued with disease are an indicator of pollution of some rivers and/or lakes (USGS 1998). In The Bahamas, local experts believe that fish mortality is due to the hypoxic conditions created by pollution (BEST 2002), although the direct link to pollution has not been determined.

Due to reduced soil fertility and to enhance crop resistance to pests and diseases, the Dominican Republic has increased its use of agro-chemicals over the last decade. This increased application is threatening potable water supplies as well as the biological integrity and sustainability of drainage basins and coastal areas. Agro-processing also produces effluents that degrade and contaminate rivers with a high biological oxygen demand.

Manufacturing and processing plants such as breweries, paint, paper manufacture and diesel-powered generating plants proliferate within coastal and watershed areas of all Caribbean countries in order to take advantage of water and transportation infrastructure. The industrial sector frequently discharges untreated effluents directly into rivers and stores wastes in unlined holding ponds. Industrial pollution is a particularly pressing problem for the larger countries, such as Jamaica and the Dominican Republic (INPA 2001, NRCA 2001), given their comparatively high level of industrialisation related to the production of sugar, rum, oil refining, petrochemicals, and paint and metal processing.

In Jamaica there have been discharges of industrial effluent into sinkholes resulting in the rapid movement of waste towards local aquifers and nearby springs (GEF 2004b). There are also concerns over solid waste management in Jamaica, since haphazard waste disposal and unlined landfills allow hazardous leachates to enter the groundwater. As the proposed Land Policy document of Jamaica points out, there is a "direct relationship between the use of land for domestic, commercial, industrial or agricultural purposes, the generation of waste by these uses, and the impact on the quality of both surface and groundwater resources" (GEF 2004b).

Over 1.2 million tonnes of industrial hazardous wastes are produced in Cuba annually (CIGEA 1998). Cuba is now implementing techniques to reduce hazardous waste production in the form of new industrial plants and retrofits, and through source reduction or recycling. Again, much of the untreated effluent and waste products not only pollute the watershed and groundwater supplies, but also threaten downstream coastal areas and the natural biological diversity of habitats and species that they support (CITMA 2001).

Many of the islands depend on groundwater as a source of potable water. The overuse of groundwater reservoirs in lowlands causes a lowering of the water table, resulting in groundwater supplies becoming increasingly vulnerable to saline intrusion. Additionally, a progressive rise in sea level is further exacerbating saltwater intrusion (UNEP/GEF 1998, UNEP/CEP 1998). In some agricultural regions of Cuba, saltwater intrusions into the aquifers can be found at a distance of up to 15 to 30 km from shore. In the Cauto River basin salt-water intrusions have contaminated most of the groundwater reservoirs (Portela & Aguirre 2000).

Changes in the water table

The GIWA assessment considered the impact of changes in the water table as moderate. However, the severity of this issue and the availability of information varied considerably in the region. Generally, there has been a lack of studies on the exploitation and status of groundwater supplies. The tourism industry in particular has a significant impact on freshwater resources, since water is used intensively in hotels, swimming pools, golf courses and for personal use by tourists. The high demand for freshwater contributes to overextraction from aquifers (GEF 2004b).

According to the GIWA experts in Puerto Rico, Jamaica and the Dominican Republic, the impact of this issue is estimated as slight, judging by the drying up of some springs. In Cuba, however, the impact was estimated as moderate, due to the salinisation of aquifers in many areas of the country (CITMA 2001). In Haiti, the impact was considered severe because saltwater intrusion is reported in many aquifers of the country and some have dried out permanently. In The Bahamas, groundwater within limestone aquifers is the only source of freshwater. There are no surface water supplies. Groundwater supplies have consequently been severely overexploited, resulting in saltwater intrusion of aquifers, dried out springs and the exhaustion of aquifers (BEST 2001).

Socio-economic impacts

Economic impacts

According to the GIWA experts the economic impacts of freshwater shortage are moderate. Freshwater is an important input for a variety of economic activities in the region and any shortages can have significant economic impacts. In Haiti and The Bahamas it was considered severe. Freshwater demand per capita by tourists is many times that of residents of the countries of the Caribbean Islands region. Accordingly, without sufficient access to high-quality water resources, the tourist industry cannot thrive, and would almost certainly go into recession or collapse entirely.

Agriculture is an important economic sector which is heavily dependent on freshwater supplies for irrigation purposes. The production of sugar cane, maize, rice and beans throughout the region requires a supply of freshwater up to three times more than domestic requirements (FAO

AQUASTAT 2004). The pressure on available freshwater supplies will continue to increase as long as agriculture continues to expand in the region. An insufficient supply of irrigation water is often the principal restricting factor for agricultural expansion. In Haiti, the agricultural sector contributes more than 20% to the total GDP (World Bank 2001 in Martin 2002) and employs a large percentage of the population, thus the decline in freshwater supplies has significantly impacted the entire economy.

Although industrial activity is limited in the region, it makes an essential contribution in terms of GDP, and is an important source of employment and income for the urban population. Considering the supply of water is essential for the functioning of these industries, water shortages can plague economic activity and access to water in the amount and quality demanded by these industries is a significant challenge for the region.

For the region to achieve sustainable development it is imperative that it has adequate supplies of freshwater; water is not only an environmental asset, but also a key economic resource. If properly managed, the water resources of the region will be a powerful tool for development (Martin 2002).

Health impacts

The health impact of the freshwater shortage concern was assessed based on the size of the population of each country in relation to the overall region. Since there is a limited number of people affected by freshwater shortages in the majority of the countries in the region, the number of people affected by the concern was assessed as moderate. In countries such as Jamaica, The Bahamas and Haiti however, a significant number of people are affected.

According to the GIWA experts, Haiti experiences the most severe health impacts, since the severity of the impact is high, the population is dense, and the frequency permanent. The evaluations of the Dominican Republic and Haiti were based on expert opinion, due to a lack of relevant reports allowing evaluation.

Many of the threats to human health are a direct result of inadequate sanitation treatment. This is further compounded by insufficient drainage, resulting in standing pools of contaminated water. During severe weather conditions, for example hurricanes, floods, and heavy rainfall, these pools present a major threat of sewage-related outbreaks of disease. Inadequately treated sewage contributes to health-related problems, both through the contamination of drinking water supplies, and through the presence of pathogens in the watershed and coastal water environment (GEF 2004b).

In Jamaica unsanitary conditions, caused by an inadequate water supply, are causing a proliferation of diseases. Occurrences of illness usually coincide with periods of low rainfall or a dry season. The most vulnerable groups to disease are young children (5 years and under) and the elderly, who have weaker immune systems. Seepage from poorly constructed pit latrines has resulted in the contamination of groundwater throughout the Caribbean Islands region, with subsequent health impacts.

Cuba reports that its health problems related to water supply primarily affect the rural population. The principal illnesses that have been observed and are being monitored are typhoid fever, dysentery, hepatitis A, parasites, and acute diarrhoea, with numerous cases of gastrointestinal disease around the country but with no fatalities (CITMA 2001). Hygiene conditions have undergone significant degradation since 1989 in Cuba. For example, nearly all water (93%) consumed in Cuba underwent chlorination treatment as recently as 1989, but by 1994 that figure had fallen to 40%. As a result, water-borne diseases such as acute diarrhoea and viral hepatitis A became much more common between 1989 and 1992; the rate of growth of these diseases was 8 and 241% respectively (Ministerio de Salud Publica 1996 in Portela & Aguirre 2000).

Table 19 shows the population with access to drinking water and sanitation facilities in the region.

Table 19 Population with access to drinking water and sanitation facilities in the Caribbean Islands region.

Country	Population with access to drinkable water (1995) [1]			Population with access to sanitation facilities (1995) [2]		
	Total (%)	Rural (%)	Urban (%)	Total (%)	Rural (%)	Urban (%)
The Bahamas	94	86	95	100	100	100
Cuba	91	72	98	86	74	92
Dominican Republic	73	55	88	77	68	89
Haiti	39	39	38	26	16	43
Jamaica	39	39	38	ND	ND	ND
Puerto Rico	ND	ND	ND	ND	ND	ND

Note: ND = No Data, [1] Refers to persons having hook-ups in the home or ready access.
[2] Refers to persons furnished with sewerage and excreta disposal services. (Source: ECLAC 2003)

Other social and community impacts

The GIWA assessment identified the social and community impacts of the freshwater shortage concern as being slight and occasional, although large disparities between Haiti and The Bahamas were evident. According to the GIWA experts, the social impacts from freshwater shortage in Haiti are severe; some communities require women and children to transport water over long distances between the source of water and their residence (Ministry of the Environment

2001). This frequent and arduous obligation diverts efforts away from other duties and economic activities and therefore inhibits economic development. In The Bahamas access to freshwater is extremely limited in some areas, making living conditions difficult. As in Haiti, simple tasks, such as cooking and bathing, involve transporting water over long distances (BEST 1995).

Conclusions and future outlook

Even though generally the freshwater shortage concern is considered as moderate for the entire region, there are exceptions like Haiti, where many people are acutely affected by the concern. In other parts of the region, such as The Bahamas, the problem of freshwater shortage remains endemic even though it has not reached alarming proportions due essentially to low population densities.

In areas with high population densities and strong domestic demand, freshwater is rapidly becoming scarce and some aquifers have been exhausted. This has adversely affected economic and human development, particularly in Haiti, which was considered to be the most severely impacted country in the region. Freshwater supply is a particular concern in remote areas and isolated archipelagos (e.g. Cayos of Cuba and the archipelagos of The Bahamas). The problem becomes more acute following developments of tourist resorts, which have extremely high freshwater demands.

Agriculture is the largest consumer of freshwater and at present has sufficient existing supplies in most countries of the region. During periods of reduced freshwater availability freshwater augmentation techniques, such as damming streams and collecting waters from heavy rains in the summer, have proven to relieve the freshwater shortages.

The most severe issue for the management of freshwater resources is the pollution of existing supplies, which has reduced the quantity and quality of available water supplies for domestic consumption and agricultural purposes. This has impacted on human health, modified habitats, and caused a decrease in fish diversity.

Another priority concern for the management of freshwater resources is demand of exceeding supply. Demand for water resources is increasing rapidly as a result of economic and demographic changes. Agriculture is further employing irrigation techniques and tourism continues to expand, both of which require significant quantities of high-quality water. The increasing demands placed on freshwater supplies and other natural resources are likely to cause conflicts over allocation and use in the foreseeable future (GEF 2004b). In addition, climate change and natural disasters may also influence future freshwater availability.

There is an absence of policies aimed at improving the efficiency of freshwater supply and a lack of initiatives designed to reduce demand and conserve available supplies. This situation is exacerbated by the weak structure or absence of water tariffs and rates. In the countries of the Caribbean Islands region, water is not considered an economic good and consequently water rights, water markets and pricing are not used to manage water demand. In general, there is no incentive for consumers to use water efficiently, and the governments subsidise water use. This, in turn, creates unsustainable market conditions to the detriment to the environment (GEF 2004b).

Clearly, there is a need to integrate freshwater and coastal water management through multi-sectorial planning and management of island ecosystems. The overall mismanagement of freshwater supplies reduces available supplies necessary for economic development and ultimately must affect downstream ecosystems and biodiversity throughout the drainage basin (GEF 2004b).

IMPACT Pollution

Pollution of aquatic ecosystems, including sensitive marine and coastal habitats, is the most severe and recurrent transboundary environmental concern in the region. The predominant contaminants impacting the region domestically and/or across national borders include untreated sewage, solid waste, sediments, petroleum hydrocarbons, pesticides and agricultural run-off, primarily from land-based sources (GEF/UNDP/UNEP 1999). It has been estimated that globally, land-based activities account for almost 80% of all marine and coastal pollution and are the main contributors of pollution of inland river streams, lakes and groundwater (Miller 1996). Oil spills and vessels discharging solid waste, sewage and toxic waste from ships make up the remaining 20%.

The Caribbean Islands region is affected by four main sources of pollution:

- Shipping
- Dumping
- Coastal activities
- Land-based activities:
  - Discharge of solid waste;
  - Dumping of toxic discharges from industries and energy plants into rivers and bays;
  - Absence of treatment of urban sewage and agricultural residual waters.

Figure 9 View of Havana Bay.
(Photo: P. Blime)

These activities can damage fisheries as well as contaminate seas, beaches and coastal areas. Significant quantities of solid waste from offshore activities are deposited in the waters of the region, particularly nets from fishing-craft, packing material from merchant shipping vessels, solid waste from cruise ships, and tar balls and oily residues from tankers.

Thermal pollution and radionuclide impacts were not considered relevant in this region. There is some thermal pollution, due to the discharge of industrial thermoelectric cooling water but in limited quantities (Miller 1996), and there are no nuclear activities.

Environmental pollution

Microbiological

Pollution caused by the discharge of non-treated sewage creates an excessive input of microorganisms into the marine environment (PNUMA 1994, PNUMA/ORPALC/Cimab in press). In 1994, the Caribbean Environment Programme (CEP) of UNEP completed an overview of land-based point sources of marine pollution in the Wider Caribbean. The final report of this study (UNEP/CEP 1994) indicated that domestic wastewater, containing microbiological contaminants, was the largest point source contributor by volume to the region.

In the Bahamas only 15.6% of the population has access to sewage collection services and 44% of sewage treatment works are in poor condition or non-operational and most raw sewage is injected into deep wells (UNEP/CEP 1998). Human waste disposal in Haiti is the most pressing problem; there are no sewage collection services and only 40% (mostly urban) of the population use latrines and septic tanks, of which 80-90 % of the solids are dumped illegally into rivers and seas (UNEP/CEP 1998). Jamaica has 109 sewage treatment plants but this capacity is still insufficient. About 30 000-40 000 m^3 per day of inadequately treated sewage is being discharged into Kingston harbour (UNEP/CEP 1998).

Studies in Havana Bay (Figure 9) recorded faecal coliforms above 1 000 MPN/100 ml, exceeding the Cuban National Sanitary Standard (Norma Cubana 1999, González et al. 1997, Beltrán et al. 2000, 2001, 2002). This coastal pollution has caused a decrease in the production of the fishing resources in the estuary areas and river deltas.

Faecal coliformes found in coastal water in Santo Domingo varied between 110 and 12 000 per 100 MPN/ml, suggesting that none of the studied beaches comply with the International Standard. The coastal pollution has caused a decrease in the production of the fishing resources in the estuary areas and river deltas. The situation is becoming more critical because of the agricultural pollutants from leguminous crop, sugar cane and corn among others, for the internal consumption, brought across the Ozama River and in smaller degree from the Haina River (GEF/UNDP/UNEP 1998, García et al. 1998).

Example of ecosystem with severe sanitary problems and highly microbiological pollution, with values above the National Cuban Standard, is the Havana Bay, where values above 1 000 NMP/100 ml have been detected, even for indirect contact (Norma Cubana NC:22 1999, González et al. 1997, Beltrán et al. 2000).

Eutrophication

Eutrophication has been identified by studies including the pilot project of the GEF entitled "Demonstrations of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean" as a priority issue in the region, resulting from excess inputs of nutrients into the coastal zone and adjacent international waters (GEF/UNDP/UNEP 1999). The predominant sources of nutrient contamination in the region include poorly or untreated sewage, agriculture and industrial activities.

The severity of eutrophication varies greatly between the countries of the region. According to the GIWA experts, Cuba, Haiti, The Bahamas and Dominican Republic have experienced slight impacts, whereas Puerto Rico was considered as having moderate impacts, and Jamaica severe impacts. The GIWA assessment therefore considered that overall the entire region had moderate impacts from eutrophication.

The total estimated nutrient load from land-based sources in the Caribbean Sea is 13 000 tonnes per year of nitrogen and 5 800 tonnes per year of phosphorus (UNEP 2000). The predominant source of nutrients (nitrates, phosphates and silicon soluble compounds) is the discharge of non-treated sewage (PNUMA 1994, PNUMA/ORPALC/Cimab in press). For example, in Puerto Rico, eutrophication was explained by the discharge of non-treated sewage, as a symptom of rapid urbanisation of coastal areas. As a consequence, swamp ecosystems and seagrasses are under threat, and thus biological abundance and diversity has been adversely affected (Corredor et al. 1977, USGS 1998). In particular in San Juan Bay estuary the most common and widespread problem is eutrophication by excessive inputs of nutrients, caused mostly by sewage discharges from a variety of sources (CEDI 2000). Another significant contributor of nutrients (nitrogen and phosphorus) into the coastal waters of the region is non-point agro-chemical run-off (UNEP 2000). In Havana Bay, eutrophication is particularly severe, as the Bay receives approximately 300 000 m^3 of urban-industrial non-treated sewage per day (González et al. 1997, Valdés et al. 2002). This case will be further discussed in the Causal chain analysis.

Studies of water samples and sediments from bays in the region have demonstrated that there has been an increase in the quantities of dissolved nitrogen and phosphorus in effluents from sewer outfalls (GEF/UNDP/UNEP 1998). In Kingston Harbour, Jamaica, large concentrations of nutrients have progressively deteriorated environmental conditions. Biological inventories have demonstrated that as a consequence, biological diversity in the area has diminished considerably, especially that of commercial species (UNEP/CEP 1999). Sewage is by far the most serious cause of the continuing eutrophication in Kingston Harbour. The malfunctioning Western and Greenwich sewage treatment plants discharge the waste into the harbour through the outfall pipes, and also via the Cobre River, Sandy Gully, Portmore canals, and some other drainage channels. Eutrophication in Kingston harbour was reported by the University of the West Indies' Center for Marine Sciences to have worsened between 1993 and 1997. The water quality parameters, such as BOD, nitrogen, phosphorous and coliform content had all further deteriorated (GEF/UNDP/UNEP 1998).

The proliferation of the marine algae *Karenia brevis* can create red tides. This alga produce powerful toxins called brevetoxins, which have killed fish and other marine organisms in the region. The blooms are transported by winds, currents and tides, resulting in transboundary implications. In The Bahamas, red tides have occurred where large quantities of nutrients are found in the surface waters.

Chemical

The impact of chemical pollution was considered moderate in the region. However, in the Dominican Republic, the impact was considered slight, with minor chemical pollution from mining, urban, energy and industrial activities (heavy metals and hydrocarbon activities). In Haiti, activities generating toxic chemical residuals do not exist (PNUMA/ORPALC/Cimab in press).

The Bahamas has experienced slight impacts from chemical pollution, mainly from shipping (oils, greases and hydrocarbons as dispersed hydrocarbons petroleum (DDHCs) in surface waters) (BEST 2001). According to the GIWA experts, Puerto Rico was assessed as having a moderate impact resulting from urban, agricultural and industrial activities (heavy metals, hydrocarbons and pesticides). In Jamaica, the impact was assessed as severe, resulting from the inadequate regulation of economic activities. Major sources of chemical contamination are from industrial activities (heavy metals), agriculture (pesticides), and activities associated with oil production and the energy industry.

Overall, Cuba has experienced moderate impacts from chemical pollution. Increased development has brought with it an increase in the amount of hazardous chemical and biomedical waste. Over 1.2 million tonnes of industrial hazardous waste is produced in Cuba

Figure 10 Tractors harvesting sugar cane fields, Cuba.
(Photo: Corbis)

annually (GEF 2004b). Since the 1990s, the disposal of untreated industrial liquid waste directly into rivers, aquifers or the sea around Cuba has become common practice, although at least some of the waste receives minimal treatment. One half of this industrial waste ends up in the aquifers, thus contaminating groundwater supplies (Portela & Aguirre 2000). Cuban scientists estimate, based on internationally accepted standards, that this volume of industrial liquid waste pollutes roughly 1.84 billion m^3 of freshwater per year, creating an annual run-off per capita of 167 m^3 of industrially contaminated water (Portela 1998 in Portela & Aguirre 2000).

Despite the reduced application of chemical fertilisers, pesticides, and herbicides in Cuba as a result of import restrictions in the early 1990s, more than 1 million tonnes of fertilisers and 30 000 tonnes of pesticides and herbicides were used annually over a 25 year period (Herrera & Seco 1986 in Portela & Aguirre 2000), much of which accumulated in groundwater and lakes. There is also a trend towards using low-lying wetlands for rice cultivation, resulting in increased pesticide use (GEF 2004b).

Due to the expansion of industrial and mining activities and the increased use of agro-chemicals, such as organic solids, there has been an increase in the contamination of surface water and aquifers by chemical toxins and heavy metals. In the Caribbean, only 39% of the investigated small industries in 1995 had undertaken treatment of residual waters (UNEP/CEP 1999a).

The GEF/UNDP/UNEP study "Demonstrations of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean" carried out in 1998, which included Cuba, the Dominican Republic and Jamaica, reported findings of pollution by copper, lead and zinc in water and sediments. These heavy metals are indicative of human activities, and are related to urban-industrial wastewater discharges without treatment. The major pollution loads in the region are created by petroleum refining, food processing (particularly in sugar producing countries (Figure 10)), metallurgical (iron and steel production, non ferrous metal refining), textile, and pulp and paper industries. Petroleum exploration, exploitation, and transportation are the region's major permanent sources of operational and accidental releases of industrial wastes (GEF/UNDP/UNEP 1998).

The UNEP (2003) report Regionally Based Assessment of Persistent Toxic Substances (PTS), which also assessed Persistent Organic Pollutants (POPs), found that none of the countries in Latin America have full national inventories for PTS and POP substances, therefore no information exists on the quantities being used. In the Caribbean Islands region, very few surveys have been carried out to determine the impacts of these pollutants on aquatic resources and their status and distribution in the environment.

There is a dearth of information regarding marine pollution from pesticides in the coastal waters of the region. Studies on surface waters off the coast of Santo Domingo (Dominican Republic) have detected mean concentrations of ΣHCH of 5.1 ng/l and dieldrin of 4.1 g/l (García et al. 1998). Incidences of pesticide poisoning, mainly due to their inappropriate application by ill-informed users, are not rare and are probably considerably more frequent than shown in official statistics (GEF/UNDP/UNEP 1998).

Other localities in the Caribbean region show evidence of fish mortality in agricultural run-offs areas where pesticides have been illicitly used. In Jamaica, for example, an increase in fish mortality in coastal effluents coincides with the period of the year when pesticides are applied on coffee plantations (Chin Sue 2002). Pollution from pesticides and agricultural run-off is shown in Table 20.

Suspended solids

The impact of suspended solids was assessed as severe. Human activities, including deforestation, inadequate management of agricultural land, urbanisation, and various pollutants, have increased erosion rates and resulted in greater sedimentation and turbidity in streams, rivers and coastal waters. Deforestation, often to clear land for agriculture, is considered the most significant cause of erosion, particularly in Jamaica as well as in Haiti, where there has also been associated desertification. Additionally, the shortage of land on the small islands of the Caribbean Islands region has led to the development of steeper terrain that is often vulnerable to erosion.

Most of the rivers in the Caribbean discharge sediment loads ranging between 100 and 1 000 mg/l (UNEP/CEP 2001), with more than 1 000 million tonnes deposited in coastal waters annually (UNEP 1999c). The prevalence of suspended sediments has decreased biodiversity, severely degrading shallow coastal waters (UNEP 2000). For example, increased sedimentation and turbidity has adversely affected coral reefs by reducing light penetration needed for photosynthesis. This has also led to the scouring of coral by sand and other transported sediments, an increased mortality of juvenile coral due to loss of suitable substrata, and the direct smothering of coral (UNEP/CEP 2001).

Mining is also a source of suspended solids in the region. The mining of bauxite is particularly important for the Jamaican economy and, to a lesser extent, for the economies of the Dominican Republic and Haiti. However, there is little information about the final disposal of these wastes. In Jamaica, instead of being discharged into rivers or coastal areas the bauxite wastes are disposed in ponds. In Cuba and the Dominican Republic the mining and processing of ores for the production of nickel oxide is carried out in close proximity to the coast. Again, there is limited information on the final disposal of the these mine wastes (UNEP/CEP 2001).

The construction industry has significantly increased the run-off of sediments, particularly in the cases of Puerto Rico and The Bahamas. Furthermore, shrimp farms have been developed at the expense of swamps in The Dominican Republic, which has also exacerbated erosion, sedimentation and nutrient enrichment of coastal waters (UNEP 1999c).

Solid waste

The impacts from solid waste are considered moderate in the Caribbean Islands region. There is concern regarding the difficulties that the countries have with the collection and final disposal of industrial, municipality and ship-generated solid wastes. The lack of

Table 20 Pollution by pesticides and agricultural run-off.

		DDE (µg/kg dry weight)	Dieldrin (µg/kg dry weight)	Lindane (µg/kg dry weight)	α endosulphan (µg/kg dry weight)	β endosulphan (µg/kg dry weight)	ΣDDT (µg/kg dry weight)
Kingston Harbour, Jamaica (1995)	Sediment	6.1	9.18	0.56	0.52	0.35	ND
	Shrimp	8.3±4.2	1.6±2.21	ND	3.6±1.4	4.0±2.1	ND
Portland, Jamaica (1990-1991)	Sediment	6.1±0.4	0.1±0.005	ND	5.1±0.3	ND	ND
Southwestern part, Cuba (1992-2000)	Sediment	ND	ND	0.4-44.2	ND	ND	4.6-61.4
	Mussel	ND	ND	ND	ND	ND	1.7-23.7

Note: ND = No Data. (Source: Robinson & Manisingh 1999, Manisingh & Wilson 1995 in Mansingh et al. 2000; all of them in UNEP 2002, Dierksmeier 2002, Chin Sue 2002) environmental education magnifies this impact. According to the GIWA experts, Haiti have the most severe impacts from solid waste in the region. Solid waste is an increasing concern in the region, not only as an aesthetic nuisance but also on account of the associated health impacts for humans and wildlife.

The countries of the Caribbean Islands region have inadequate solid waste collection systems, and as a result many citizens dispose of their waste in mangrove swamps, drainage channels and along riverbanks, consequently pollute rivers, streams, and eventually the coastal waters into which they drain (GEF 2004b). These landfill sites are a source of debris to the marine environment, particularly during the rainy season, when run-off may wash wastes out to sea. Poor consideration of the location of landfill sites causes permanent and harmful contaminants to leach and seep into the surface, ground and coastal waters, thus degrading the associated ecosystems. For example, Jamaica observes many problems with solid waste disposal, in particular indiscriminate waste disposal and unlined landfills, which can allow hazardous leachate to enter the groundwater (GEF 2004b).

Around 70-80% of marine debris originates from the shipping traffic in the region, especially cruise ships and oil tankers that cause an important transboundary movement of marine debris and tar balls. In addition to locally produced waste, it is estimated that the 35 million tourists that visit the Wider Caribbean region generate more than 700 000 tonnes of solid waste each year (PNUMA 1999b in UNEP 2000). The ports in the region lack waste reception facilities, and ships consequently dump their waste at sea, which is then transported to distant locations by winds and currents. Paper and foam are a major transboundary problem in the region as such debris drifts easily between islands. Some port and government authorities in the region have expressed concern that these wastes will accelerate the deterioration of their already inadequate reception facilities (UNEP/CEP 1994). The Causal chain analysis section of this report discusses ship-generated solid waste in further detail.

The problem of solid waste extends to the entire Caribbean Sea due to global and regional ocean circulation patterns. The Bahamas pick up solid wastes from the Lesser Antilles Current. The Florida band, from Key West to Cape Canaveral, is one of the biggest solid waste disposal sites in the Wider Caribbean (UNEP/CEP 1994). According to UNEP/CEP (1991), such dumping has caused transboundary problems from contributing additional solid wastes to the Caribbean Sea. The inadequate disposal of solid wastes outside of the Caribbean Islands region have negative impacts within the region.

The harmful effects of solid wastes in the marine environment have been documented worldwide, but there is a lack of published information on the Caribbean Islands region, particularly concerning the affects of marine debris and tar balls. Research in Cuba have shown that the Sabana-Camagüey Archipelago and the Canarreos Archipelago are visibly affected by marine debris due to their proximity to heavy international sea traffic through the Old Bahamas Channel (CMC 1993). Many marine animals die from plastic or discarded fishing lines due to entanglement or accidental ingestion; a study conducted in The Bahamas has shown that floating waste has caused mortalities and reduced the reproductive success of sea turtles, marine mammals, and sea birds (BEST 2002).

Spills

The GIWA asssessment evaluated the impact from spills as moderate. Oil spills pose the most significant threat, originating from the petrochemical industry, the transportation of oil tankers and from the extraction and refinement of petroleum. About 160 million litres of oil are transported on the waters of the Caribbean Islands region everyday, thus the potential risk of a severe impact to the region is enormous due to the busy shipping lanes, particularly through the Old Bahamas Channel (UNEP 1999c).

Between 1973 and 1997, 10 oil spills were registered in the Caribbean. The volume of oil spilled in these cases varied between 50 and 6 000 tonnes, and on average 2 000 tonnes were spilled annually. However, during the period of 1998-2000, only six cases were recorded, with a reduction in the dimension of the spill; between 10 and 4 000 litres for a total of 16 tonnes (Becerra 1999).

The most recent large oil spill occurred on 7th January 1994, when the barge Morris J. Berman spilled approximately 3.7 million litres of oil off Punta Escambrón in San Juan, Puerto Rico (Figure 11). This resulted in the contamination of extensive areas, impacting on natural resources along more than 48 km of Puerto Rico's north shore, affecting fish, sea shells, sea birds and sea turtles. Thousands of dead and live oiled organisms washed ashore. The coral reef ecosystem, struck by the barge upon running aground, was almost completely destroyed (Ornitz 1996).

No large oil spills have been recorded in the region recently. However, large volumes of hydrocarbons and other substances are being discharged from tankers and private vessels in the region's seas, permanently increasing the oil concentrations in the sea (PNUMA/ORPALC/Cimab, in press). More than one third of oil spilled at sea between 1983 and 1999 was a result of accidents at ports, oil terminals and oil refineries located in the coastal zone (UNEP 1999c).

Figure 11 The barge Morris J. Berman off Punta Escambrón in San Juan, Puerto Rico.
(Photo: NOAA)

Maritime traffic is another significant source of coastal and marine pollution in the region, especially the release of oil through dumping of bilge water and tank rinsing (UNEP 2002a). In fact, this source is one of the most significant concerns related to the transboundary effects in the Caribbean and in special in the Caribbean Islands Region (UNEP/CEP 1991). For additional details, see the Causal chain analysis for Discharges from maritime traffic.

Tar balls are known to accumulate on the windward Islands of the Caribbean Islands region, indicating hydrocarbon pollution. They are composed of a mixture of hydrocarbons and saltwater, and are able to drift for long distances. Studies by the Petroleum Pollution monitoring project, CARIPOL, found large accumulations of tar balls deposited on the beaches of the Cuba and Puerto Rico (Atwood et al. 1987, Heneman 1988, CARIPOL 1987). Corredor (1991) reported that more than 50% of tar ball occurrences on the southwest coast of Puerto Rico can be correlated with the frequency of tanker arrivals at a petrochemical complex 15 nautical miles east of the sampling site (Van Vleet & Pauly 1987). Palacios et al. (1998) found quantities of tar balls in the area of Playas del Este in Havana City, but with considerable intra-annual fluctuations in the presence of these residuals on the beaches (Palacios et al. 1998). In The Bahamas virtually all the windward beaches suffer from tar pollution, which is mostly the product of oil tankers discharging residuals when cleaning at sea (BEST 2002).

Between the 1970s and late 1980s CARIPOL provided the only information of oil pollution levels in water and sediments in the coastal and marine waters of the Caribbean region. Pollution monitoring during this period indicated that the concentration of DDHCs in the marine-coastal waters are generally low in open coastal waters, but relatively high in closed coastal areas, such as bays (Atwood et al. 1987, CARIPOL 1987). The CARIPOL project found that the mean values of total hydrocarbons in sediments during its monitoring programme indicated the presence of only slight pollution in the region, with a minimal impact on the marine species analysed (Bravo et al. 1978, Botello & Macko 1982, Garay 1986, CARIPOL 1987). The mean contamination levels of dissolved/dispersed hydrocarbons in surface waters of the Caribbean Islands region (includes the Cayman Islands) was 12.6 µg/l (PNUMA/ORPALC/Cimab, in press, Atwood et al. 1987, CARIPOL 1987).

More recently, there have been studies in several countries in the Caribbean, initiated by the GEF project entitled "Planning and Environmental Management of Heavily Contaminated Bays in the Wider Caribbean", which indicated significant oil contamination in these countries. In Santo Domingo coast, Dominican Republic, 16-291 mg/kg dry weight of total hydrocarbons were detected in recent sediments, in Kingston Harbour 200-578 mg/kg dry weight, and in Havana Bay between 685-1 212 mg/kg dry weight of total hydrocarbons were detected in recent sediments. In 1998, the project concluded that the concentrations found in the sediments demonstrated that there was almost chronic oil pollution in the coastal ecosystems of the region. Havana Bay was most affected, not only in the Caribbean Islands region, but also of all the ecosystems studied by the project (GEF/UNDP/UNEP 1998). The study also observed that in coastal areas near to oil activities there are significant heavy metal concentrations in sediments. For example, the Santo Domingo coastal zone and Havana Bay, which have petrochemical complexes in the proximity of their coasts, have lead values of up to 113 mg/kg and 340 mg/kg respectively and, in smaller measures, vanadium, nickel, zinc and mercury (GEF/UNDP/UNEP 1998, Beltrán et al. 2001).

Socio-economic impacts

Economic impacts

Even if this concern only affects a limited number of the region's economic sectors, it is the important economic activities, particularly fisheries and tourism, that are affected. Therefore economic impacts of pollution were assessed as moderate.

Pollution has diminished 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, Jamaica, has affected the suitability of waters for bathing and immersion activities on the beaches and in the Bay, which has negatively impacted tourism and its recreational amenity. Marine debris and tar balls also adversely affect tourism if allowed to accumulate in coastal regions. Non-biodegradable or slowly degradable materials (plastics, metals) are a persistent nuisance for many recreational beaches in the region (GEF/UNDP/UNEP 1998). Surveys carried out in Cuba, Puerto Rico and the Dominican Republic showed that the beaches polluted with marine debris and tar balls are visited by fewer tourists, disregarding their natural beauty (Atwood et al. 1987, CARIPOL 1987, PNUMA/ORPALC/Cimab, in press).

The fisheries have been impacted by fish mortalities caused by pollution such as eutrophication and heavy metal contamination. For example Kingston Harbour receives significant concentrations of nutrients that have progressively deteriorated environmental conditions, resulting in a decline in the fisheries. Marine debris is harmful to commercially important aquatic life, through ingestion or entanglement, and is also hazardous to maritime traffic, for example, through propeller damage and collision with large solid wastes.

Large oil spills involve considerable costs for emergency response and clean-up operations. The Morris J. Berman incident in 1994 took 114 days, 15 Puerto Rican and Federal agencies, 1.5 million man-hours, over 1 000 workers, and over 87 million USD to clean-up and assess the overall damage of the oil. The polluter can also incur considerable economic costs; the Federal District Court in Puerto Rico imposed a fine of 75 million USD to the companies found guilty of negligence, plus more than 0.5 million USD in legal fees (Ornitz 1996).

Health impacts

According to the GIWA experts, the health impacts of pollution on the population of the Caribbean Islands region were considered slight. However, in the countries of Haiti, Dominican Republic and Jamaica the degree of severity was scored as moderate.

Diseases in the region have propagated from the progressive degradation of the environment's natural ability to cleanse water pollutants and pathogens (UNEP 1999c, 2000). The greatest threat to public health comes from sewage related pollution, which consists mainly of nutrient rich water that carries a variety of pathogenic microorganisms (e.g. viruses, bacteria) excreted by the carriers of various diseases in the population (GEF/UNDP/UNEP 1998). Microbiological pollution from untreated sewage effluents produces contamination vectors via three main paths:

- Direct contamination via recreational bathing in contaminated waters;
- Direct contamination via a contaminated water supply for drinking and bathing water;
- Indirect contamination via the washing of food with contaminated waters.

In The Bahamas, health authorities have advised its citizens to avoid the consumption of the marine gastropod Queen conch (*Strombus gigas*), at certain times of the year due to the presence of a Vibrio pathogen in these organisms. Consumption of conch infected with this pathogen has resulted in serious illness and even one recorded human mortality.

There is evidence of a link between solid wastes dumped at sea from vessels and deterioration in human health. Although solid wastes from marine sources only represent 1-2% of the total flow from the region, according to the report from the First Caribbean Solid Waste Management Meeting (Williams 1991), the risk of becoming ill from contact with solid wastes from marine sources will continue to increase, as solid waste is often a vector of diseases.

In The Bahamas, large quantities of nutrients in the surface waters of the archipelago have caused algal blooms, including red tides, which have resulted in food poisoning (BEST 1995, 1999). Bio-toxins accumulate in the food chain, and persons who consume scale fish and shellfish containing these accumulated bio-toxins can contract serious illnesses. One of these bio-toxins, known as ciguatera, is certainly a source of poisoning in the Caribbean.

Pollution has deteriorated the water quality at many recreational beaches throughout the region, thus affecting the health of tourist visitors, as well as the welfare of coastal biological communities and habitats. Many of the tourist resorts and hotels are unaware or unconcerned that agricultural chemicals, sewage and other domestic wastes are entering the watershed and impacting tourist beaches and parks. As long as the coastal waters are clear and blue in appearance, their clients are satisfied. However, there is a general trend toward poor water quality and eutrophication at a number of tourist beaches, and ear and throat infections are becoming more frequent among tourists (GEF 2004b).

Other social and community impacts

In the Caribbean Islands region the impact of pollution on coastal communities was estimated as moderate to severe as, according to the GIWA experts, it has caused a considerable loss or alteration of patrimonial values (historical, cultural and archaeological). This was reported in the cases of the Dominican Republic, Cuba, Puerto Rico and The Bahamas, where pollution has affected the cultural integrity of communities as a result of a decline in living conditions, a deterioration in their health status, and a loss of aesthetic and amenity values of certain locations (Sullivan Sealey & Bustamante 1999, BEST 1999, CITMA 2001). Some fishing communities have been forced to migrate as a result of pollution.

Conclusions and future outlook

The countries of the Caribbean Islands region recognise that pollution is a common problem that is degrading their marine and coastal environment. Pollution is mainly caused by the discharge of municipal and industrial solid waste and wastewater including sewage, run-off from agricultural fields, and contamination from oil and gas extraction, refining and transport. Progress in addressing the pollution concern is seriously hindered by the lack of waste disposal services and sewage treatment facilities in the region (UNEP 2001a).

In 1994, the UNEP Caribbean Environment Programme (CEP) completed an overview of land-based sources of marine pollution in the Wider Caribbean, including the Caribbean Islands region. The final report of that study (UNEP/CEP 1994) indicated that domestic wastewater was the largest point source contributor by volume to the region. Domestic wastewater was followed by six industrial categories: oil refineries, sugar refineries and distilleries, food processing, manufacture of beer and other drinks, pulp and paper factories and chemical manufacturing. Urban and agricultural non-point sources of pollution are also recognised as significant contributors to pollution in the Caribbean Islands region, although these sources were not included in the 1994 study, which focused primarily on point sources.

Maritime transport is another significant source of coastal and marine pollution, and includes the release of oil through the discharge of bilge water and by tank rinsing, the discharge of sewage, solid waste and hazardous chemicals, and the introduction of alien or invasive species to new areas through loading and off-loading of ballast water (UNEP 2002a). UNEP/CEP (1991) considered maritime traffic to be one of the most significant transboundary concerns of the Caribbean Islands region.

By degrading the marine and coastal environment, pollution has subsequently impacted on economic activities, particularly tourism and fishing. The aesthetic value of the islands for prospective tourists has been diminished and there has been a loss in revenue from non-returning tourists. The productivity of the fisheries has been impacted directly by fish mortalities and indirectly through the modification of important habitats such as coral reefs, mangroves and seagrass beds. There has also been a proliferation of water-related diseases, and food poisoning from the consumption of contaminated seafood is not uncommon.

The continued expansion of tourism will require further accommodation and service infrastructure developments, with associated impacts from increased run-off of sediments from construction sites (PNUMA/CAR/RCU 1992, UNEP/CEP 1997). It is predicted that with the further development of maritime activities, especially cruise ships and oil tankers, the quantity of wastes dumped at sea will continue to increase. In the next 20 years it is expected that with rapid population growth in the region, the production and discharge of solid wastes and sewage will increase, placing greater stress on the already inadequate waste collection and disposal services. A lack of awareness at all levels, from local communities to policy makers, of the impacts of their activities and the importance of preserving valuable ecosystems is impeding progress in addressing future pollution issues and reversing degradation trends.

Although there have been no recent oil spills there always exists a potential risk, especially with congested and narrow shipping lanes, such as the Old Bahamas Channel. Although any future spill would have transboundary consequences and severely affect the ecological and social integrity of the region, there is a lack of contingency planning for such an emergency. This issue will be further assessed in the Causal chain analysis section of this report.

IMPACT Habitat and community modification

The coastal environment of the region is characterised by the complex interaction of three distinct ecosystems: coral reefs, mangroves, and seagrass beds. These are particularly sensitive ecosystems which have experienced irreversible degradation in many locations as a result of the accumulative impact of a range of human activities. Through human interference, the Caribbean has already lost nearly 90% of its original biological habitat (GEF 2004b). The GIWA assessment considered the impacts from the modification and loss of habitat and community structure as moderate. The assessment analysed the impacts on various habitats of each country and then calculated their relative weight with regard to the total area of the region.

Environmental impacts

Modification of ecosystems or ecotones

Coral reefs

The Wider Caribbean contains over 13% of the world's coral reefs, and many species are endemic to this region. Approximately 30% of these are now considered to be either destroyed, or at extreme risk from anthropogenic threats (Wilkinson 2000). Another 20% or more of the Caribbean's coral reefs is expected to disappear from the region over the next 10 to 30 years if significant action is not taken to manage and protect them beyond existing activities.

All of the countries in the region have experienced deterioration in the health of their reefs. The most severe recent loss of coral reef habitat has been in Haiti, where coral reef continues to decline unabated as economic conditions worsen (Linton et al. 2002). Furthermore, political turmoil has facilitated further uncontrolled exploitation of the environment.

Continued population growth and economic development is increasing the pressure on coral reefs (Figure 12). For example, in the Dominican Republic increasing human populations (estimated >9 million) and economic development are the major causes of coral reef degradation, with associated sedimentation, sewage and other terrestrial pollution from agriculture, mining, industry, shipping and tourism (Linton et al. 2002). In The Bahamas, coral reef degradation is most prominent in locations within close proximity of developments on the islands of New Providence and San Salvador (Linton et al. 2002), and has been largely attributed to dredging, the removal of seagrass beds, and destructive fishing practices (BEST 1995, 1999).

In Jamaica, the Dominican Republic, and The Bahamas, tourism development has necessitated the removal of seagrass beds and mangroves which protected the coast from erosion. There has been a corresponding increase in the quantity of sediments in coastal waters, which has adversely affected the growth of coral. In Cuba, many of the shelf edge reefs are protected from human activities since they are separated from land by broad shallow lagoons. Threats to reefs of the southern archipelagos are currently low. However, tourism is growing rapidly. 2001 saw 1.8 million visitors to the region, generating 1.9 billion USD in gross revenues (Linton et al. 2002). Although tourism is an important source of foreign exchange, the associated development is causing environmental damage along the coast, including the destruction of habitats for endangered species. Reef dive tourism is not well managed, leading to significant anchor and diver damage in the intensely visited locations (Linton et al. 2002). The consistent

Figure 12 Coastal development near coral reefs, Puerto Rico.
(Photo: J. Oliver, Reefbase)

disturbance of the reefs from these activities results in the destabilising of reef communities which subsequently lose their resistance, and finally the flexibility, to subsist and to recover (UNEP/CEP 1989b). In the Dominican Republic, large areas of the coast have also been destroyed for tourism as a result of activities such as the reconditioning of beaches, which causes more sediment damage.

Land-based sources of pollution, for example from agriculture, industry, tourism, and human waste disposal are directly harmful to the coral reefs and are also changing the specific physical conditions necessary for their survival. For example, in Cuba the coral reef ecosystem is being increasingly altered by pollution from sewage, agricultural run-off and chemical contamination of reefs near areas of high population (Linton et al. 2002). Sewage pollution enriches the coral reef ecosystems with nutrients, and with associated impacts (see the Pollution section). This is particularly severe near large coastal cities such as Kingston, La Havana, Port-au-Prince and Santo Domingo (Woodley et al. 2001). In addition, deforestation, especially on the mountainsides of the high islands, has resulted in greater surface run-off, and increased sediment loads in streams and rivers that enter coastal waters, damaging coral reefs close to river mouths, most notably in Haiti, Cuba, Jamaica and the Dominican Republic.

Large-scale coral bleaching associated with unusually high sea temperatures was first recorded in the region before 1987, but has since been a frequent occurrence. A combination of extremely calm conditions during the 1997-1998 El Niño-La Niña events, coupled with a steadily rising baseline of sea surface temperatures in the tropics, is believed to have caused coral bleaching throughout the region in 1998 and 1999, although the impact was minimal compared with other regions of the world. Only The Bahamas, where there was extensive bleaching in the Exuma Cays with some mortality, and Cuba, which experienced exceptional bleaching on both coasts, were severely affected. Generally, there has been a recovery in the region, although this has been difficult to measure due to a lack of baseline data following the bleaching events.

Other diseases, such as stony corals and gorgonians, have been reported with increasing frequency (Alcolado 2003, Woodley et al. 2001). In Cuba, apart from coral bleaching, the most significant diseases affecting coral reefs are the patchy necrosis (targeting *Acropora*), the white plague which has killed massive corals, and the aspergillosis (attacking sea fans). Other diseases affecting Cuban coral reefs include the yellow blotch, the black band, and the dark spot (Alcolado 2003). In the Bahamas there has been widespread coral disease, particularly white band disease of the main *Acropora* species (Linton et al. 2002).

The biological equilibrium of the reef system has been irreversibly disturbed, and has led to the proliferation of algae and disease. The sea urchin *Diadema antillarum* was once the most important herbivore on Caribbean reefs, but mass mortality reduced its populations by more than 97% in 1983 (Lessios et al. 2001). Coral abundance has since declined as a result of bleaching, storm damage, predation, ship groundings and disease. Furthermore, they have left more reef substrate open for reef algae to grow on. Without the large numbers of sea urchins to graze down the algae, the reef substrate has become progressively overgrown with fleshy seaweeds (Miller & Gerstner 2001). The thick cover of seaweeds has prevented tiny coral larvae from recolonising the reef substrate. Diadema has begun to recover in some locations in the Caribbean, and these locations are beginning to show signs of reduced algal cover (Edmunds & Carpenter 2001).

Jamaican representatives reported that the rate of coral destruction in Jamaica is amongst the highest in the world. This is particularly evident on the northern coast of Jamaica, where the coral reefs have drastically changed since the first observations at Discovery Bay in the 1950s, when they were described as actively growing coral-dominated reef communities (Hughes 1994). Today, the reef habitat and community structure have been modified as a result of overfishing, degradation of water quality, the loss of swamp forests, as well as hurricane activity (UNEP/CEP 1989a).

Mangroves

Mangroves are habitats for land organisms, including a variety of plants, invertebrates, reptiles, birds and mammals, and for aquatic organisms like fungi, algae, gastropods, clams, oysters, crabs and fish. They also provide nursery grounds for the juveniles of many commercially important fisheries species, such as lobster that, once adults, migrate to inhabit nearby coral reefs. The mangroves act as a buffer for coastal marine ecosystems from many land-based sources of pollution, such as domestic wastes, suspended sediments, and chemical pollution. The loss of these functions may result in a deteriorating quality of other nearby ecosystems (UNEP/CEP 2001).

The Caribbean Islands region contains the greatest abundance of mangroves in the entire Wider Caribbean. However, the mangrove ecosystems have been exploited, destroyed for developments, and adversely affected by pollution. The decline of mangrove forests have consequently had associated impacts on the ecology and populations of the region.

Mangroves are cut down for housing and tourism-related development, for the construction of roads and for the development of industry and aquaculture. Clearing mangrove forests makes the coast more vulnerable to erosion, and destroys the habitat of many species (UNEP/CEP 1996). Mangroves are an important resource for the communities of the region, which exploit them for timber, fuel-wood and charcoal, shrimp and lobster (for export), and oysters and other fish sold in domestic and international markets (WWF 2001).

There has been a severe loss of mangroves in several countries of the region, most notably in Haiti and Jamaica. Over 65% of Haiti's mangroves have been lost due to coastal developments and pollution stress (Ministry of the Environment 2001). In Puerto Rico, over 75% of the country's mangrove forests were destroyed during the 1970s to reduce malarial mosquitoes, and were subsequently drained and filled for urban development (Spalding et al. 1997).

The diversion of rivers or the obstruction of natural drainage has also modified these important habitats (Ulloa 2000). In Jamaica, deforestation in coastal basins led to the erosion of 80 million tonnes of topsoil annually. This is believed to be reducing the flows of many rivers upon which mangroves rely for freshwater inputs. Because of prevailing wind patterns, Jamaican mangroves are also vulnerable to oil spills (WWF 2001).

Cuba's mangrove forests have also been affected by changes in hydrology. The government rapidly developed infrastructure and tourist facilities to accommodate the expansion of tourism. The construction of the Cayo Coco causeway in the northern keys was designed to link all the keys to each other and to the mainland in order to facilitate the transportation of tourists and improve the distribution of construction materials and supplies for the hotels. A study by the Cuban Geodesic and Cartography Institute (1990 in Portela & Aguirre 2000) concluded that the obstruction of water circulation by the causeway was leading to the disappearance of mangroves, and consequently increasing fish mortality or migration to other areas. Although this study led to the modification of future plans for causeways, it did not prevent the completion of this infrastructure development.

Other habitats

Sandy foreshore habitats have been modified by beach sand mining and renourishment, dredging, filling and constructing poorly designed shoreline structures. Shoreline structures, including piers, jetties and breakwaters, alter the patterns of sediment transport, preventing the renourishment of beaches further along the coast, and thus reducing the shore's natural protection against erosion. Beach sand mining causes sedimentation, which has a negative impact on coral reefs and other marine ecosystems (UNEP/CEP 2001).

Dredging not only physically alters marine ecosystems, but also causes the re-suspension of large amounts of sediment. Suspended sediments decrease water clarity and thus affect photosynthesis, stress corals and other suspension-feeders by making them expend energy in ridding themselves of sediment, and, in the most severe cases, smother the organisms themselves. Biodiversity of corals, other invertebrates, fish, and algae is reduced as a result. Shrimp trawling also disturbs the seabed and the associated benthic communities, re-suspends sediments and causes turbidity currents.

A Ramsar mission to the Caribbean in 2002 noted the vulnerability of the wetlands, and the urgent need for efforts through the joint commitment of national governments and the international community towards their conservation and sustainable use (GEF 2004b). In the case of Puerto Rico, 75% of the wetlands have been affected by human activities (USGS 1998). Haiti has a similar situation, although the impact on its ecosystems has not been quantified (Sullivan Sealey 1998).

Cuban wetlands are threatened by drainage, agricultural expansion and the associated pollution, production of charcoal, grazing, extraction of peat and the invasion of alien species. Large areas of the Birama swamp are now used to grow rice and as a result, a considerable amount of pesticides such as DDT, DDE, and other organochlorated products (prohibited in many countries due to the harmful effects on human health and ecosystems) are regularly sprayed by airplane. These pesticides are then carried towards the surrounding lagoon and marshes through an extensive network of canals. Furthermore, intense deforestation in the Sierra Maestra has caused the Cauto River, Cuba's largest river, to become nothing more than a stream in the dry season. This has deprived the swamp of sufficient water, resulting in salinisation. Correspondingly, there has been a considerable decline in the nutrients on which many microorganisms, crustaceans, fish and birds depend, impoverishing the landscape.

Loss of biodiversity

Habitat destruction and alteration is significantly impacting on biodiversity in the Caribbean Islands region. The region will experience increased costs for species triage to protect remnant populations of species such as the West Indian manatee (*Trichechus manatus*). Manatees are slow moving herbivores that feed on seagrass and algae, and were originally found in 19 countries. However, their populations have dramatically declined as a result of hunting and habitat degradation. They are vulnerable to hunting because of their very low reproductive rate. In the winter, the manatees are often attracted to warmer inland waterways where they are susceptible to boat collisions, injury from propellers, and entanglement in fish nets, whilst they also damage fishing equipment. Cuba and Puerto Rico have some level of protection for manatees, but unfortunately populations are still declining due to illegal fishing (UNEP/CEP 1995).

Socio-economic impacts

Economic impacts

In the Caribbean Islands region, the impact of habitat and community modification on the economic sectors was estimated as moderate to severe. The success of economic activities in the region, particularly fishing and tourism, are highly dependent on the health of coastal ecosystems. They provide food, shelter, and nurseries for commercially valuable fishes and crustaceans, and they also protect harbours and bays, and limit coastal erosion.

Caribbean economies are increasingly dependent on foreign exchange from tourism. The Wider Caribbean region is estimated to attract approximately 57% of international scuba diving tours (1.5 billion USD is forecasted to be generated by dive tours by 2005) and approximately 50% of the world's cruise ships (C/LAA 1997). About 14.5 million cruise passengers visited the GIWA region Caribbean Islands in 2000 (CTO 2002). Tourism and recreation activities account for approximately 30% of the total potential economic value of Caribbean reefs and about 50% more than their fisheries value (Cesar et al. 2003). Accommodation and facilities servicing the tourism industry are concentrated on the coast, and thus make the greatest use of coastal and marine resources (UNEP/CEP 1997). Tourists are becoming increasingly sophisticated in their choice of tourism destination. In this regard, a major factor influencing their decision is the environmental quality of their preferred destination (Fitzgerald 2003). The continued loss and degradation of the region's habitats will therefore impose serious economic consequences for not only the tourism industry but the entire economy of the region.

Health impacts

According to the GIWA experts there have been slight to moderate health impacts from habitat and community modification, although the number of people affected was considered as moderate. The ecosystems maintain the long-term food security of the region's inhabitants, and deterioration of habitats could therefore affect their health status. There is currently a lack of studies investigating the relationships between habitat degradation and human health.

Other social and community impacts

The social and community impacts of Habitat and community modification were assessed as moderate, mainly because of its impact on employment and the food security of riparian communities. Fishing not only provides nutrition and employment but it is also a traditional and cultural way of life for many of these communities. Therefore the modification of coastal habitats and loss of marine species may alter the cultural integrity of island communities.

Conclusions and future outlook

The countries of the Caribbean Islands region are highly dependent on the coastal and marine resources for their survival. The level of pressure on these resources is closely linked with a country's social, cultural and political situation. Critical habitats, such as coral reefs, mangroves and seagrass beds, have been significantly impacted by a variety of human activities (PNUMA/ORPALC 1999). Ironically, the economic activities in the region, particularly fishing and tourism, are currently degrading these habitats on which they are highly dependent.

Marine activities have directly affected the community structure of the marine environment by for example overfishing, and also indirectly through the discharge of wastes and oil spills from shipping. Land-based sources of pollution, including untreated sewage, agro-chemicals, heavy metal contamination and solid wastes, have altered the physical conditions of aquatic systems and adversely affected biodiversity. Other activities, such as deforestation for agriculture and developments, have degraded terrestrial ecosystems, leading to greater erosion and thus surface run-off of sediments into aquatic systems with consequences for the health and abundance of living resources. There are also natural factors influencing the nature of habitats such as hurricanes, which although irregular in frequency, have widespread implications on the region's ecosystems (UNEP 2000).

Tourism developments have removed seagrass beds and mangroves which protected the coast from erosion and filtered land-based sources of pollution before reaching coastal waters. This has increased the quantity of sediments and pollutants in coastal waters, which has adversely affected coral reef ecosystems. Conversely, these developments have also increased the quantity of pollution entering the marine environment. In addition, anchor damage and diving activity is destabilising reef communities in intensely visited sites.

The many ecosystem services provided by the coastal ecosystems are neither widely recognised nor properly valued in economic terms, although the governments of the region are beginning to realise that action is needed in order to reverse current degradation trends. UNEP sponsored the Specially Protected Areas and Wildlife in the Wider Caribbean region (SPAW) Protocol in order to protect habitats and initiate the creation of marine parks. Many of the governments are now trying to initiate coastal zone planning within an integrated coastal area management framework (UNEP/CEP 1997, CIGEA 1998, PNUMA/ORPALC/Cimab, in press). However, the various initiatives have not been effective in promoting cross-sectoral and participatory planning, including the sharing of information, development objectives and plans (UNEP/CEP 1997).

Unsustainable exploitation of fish and other living resources

The GIWA assessment considered the impacts from the unsustainable exploitation of fish and other living resources as moderate. In the Caribbean, commercial fishing only dates back 50 years, but has already affected more than the 80% of the original reproductive population. UNEP (1999c) reported that the wide range of fishing activities in the Caribbean (industrial, small-scale and recreational) has had a significant impact on the region's fishery resources and the ecosystems that facilitate fish stock replenishment. The analysis provided in this section will concentrate on the marine fisheries, as there are very limited major rivers in the region.

Environmental impacts

Overexploitation

Overexploitation was assessed as having a severe impact on the transboundary aquatic ecosystems. Although there is a lack of assessments investigating the level of overexploitation in the region, the current information is considered sufficient to diagnose the critical situation facing living resources and to take urgent management actions to stop the excessive exploitation (UNEP 2000).

It is evident that living resources are being overexploited but it is difficult to make accurate estimates of the level of overexploitation, due to a severe deficit in reliable estimations of the overall landings from commercial, small-scale subsistence or recreational fishing in the region. Numerous large migratory pelagic species are important to the fisheries of the countries of the Caribbean Islands, e.g. dolphinfish, blackfin tuna, cero and king mackerels, wahoo and bullet tunas. However, the information base for management of these species is virtually non-existent (Mahon 1996, FAO 2003 in GEF 2004a).

The majority of fishery resources are coastal and are intensively exploited by large numbers of small-scale fishers. Most people in the Caribbean Islands region live in coastal communities and are highly dependent on living marine resources for employment and food. The tourism industry also requires seafood for restaurants and hotels, and some species, such as lobster and conch are in high demand for export (GEF 2004a). These pressures have led to the widespread depletion of these resources including lobster, finfish, conch, and small pelagics, and as a result many local fish stocks (with no commercial value) had collapsed by the mid-1980s (UNEP 2000, PNUMA/ORPALC/Cimab in press). Many coastal resources remain overexploited and there is increasing evidence that pelagic predator biomass has been severely depleted (FAO 1998, Mahon 2002, Myers & Worm 2003, GEF 2004a).

These coastal fisheries are also likely to be a shared by the countries of the Caribbean Islands region due to planktonic larval dispersal. In many species, larval dispersal lasts for many weeks (e.g. conch) or many months (e.g. lobster) and they are transported across EEZ boundaries into adjacent territorial waters (GEF 2004a). Therefore the depletion of these resources on one island has transboundary implications for the entire Caribbean Islands region.

This depletion has led to increased dependence and fishing pressure on offshore resources, which are already considered to be fully or overexploited. A study by the FAO has shown that around 35% of the Caribbean species are overexploited (FAO 1997c in UNEP 2000). The total reported catch for the countries in the GIWA region Caribbean Islands rose from approximately 167 000 tonnes in 1975 to a peak of 280 000 tonnes in 1986, before declining in 1995 to around 141 000 tonnes (FAO FISHSTAT 2003). In 2002 the reported catch were 75 000 tonnes (Figure 13).

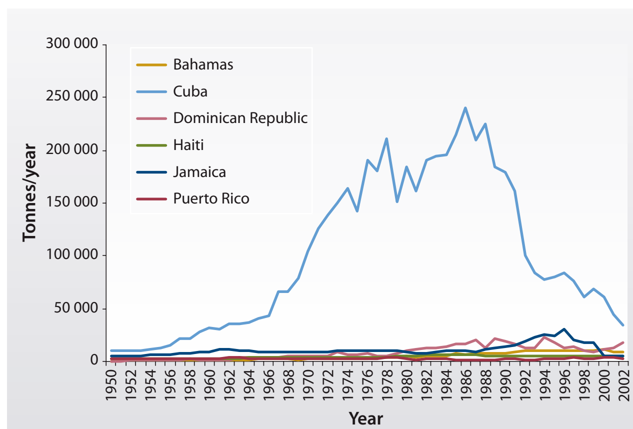


Figure 13 Total capture of fish, crustaceans and mollusks in the Caribbean Islands region.
(Source: FAO FISHSTAT 2003)

In Haiti and Jamaica overexploitation has been particularly severe; the highly commercial snapper and grouper fisheries collapsed by the mid-1970s and fish landings are now made up of smaller herbivorous fishes such as parrot fish (Figure 14) (Scaridae) or grunts (Haemulidae). Even these species have declined in size and abundance (PNUMA/

Figure 14 Caribbean red snapper (*Lutjanus purpureus*).
(Photo: W. Savary, Regulatory Fish Encyclopedia)

ORPALC/Cimab in press, UNEP 2000). The CARICOM Fisheries Resource Assessment and Management Programme (CFRAMP) declared Jamaican waters to be the most overfished in the English-speaking Caribbean. Commercial fishing of groupers has also collapsed in much of the Caribbean region. For example, In the Bahamas, the Nassau grouper has been locally exhausted in over 50% of their original species range. Other living resources such as coral reefs that are not exploited but extremely important for tourism economies and coastal defence against sea level rise, are being severely degraded by human activity (GEF 2004a).

Developments in fishing technology (including motorisation and the introduction of scuba gear) have also contributed to overfishing on the inshore and offshore banks. Long-range fishing fleets, operating out of Japan and Korea, and to a lesser extent Russia, are known to exploit the region's fisheries (PNUMA/ORPALC/Cimab in press, UNEP 2000). Additionally, government initiatives have led to substantial increases in fishing effort, although there is inadequate institutional capacity to plan, manage and monitor the fishing industry.

Overfishing has proven difficult to document, with multi-species fisheries across many different nations and countries, which would need to be studied through regular stock assessments. There is a need for a larger quantity of data and more monitoring surveys to closer observe the behaviour and the abundance of fishing resources (FAO 2003a). Although definitive proof of overfishing is lacking, the anecdotal evidence and country-level information supports the concept of a region-wide crisis in fisheries resources.

In response to overexploitation in the region, several countries have implemented measures, such as closed seasons and stricter regulations on fishing. Spiny lobster fishing regulations have been established to protect this economically valuable species; the lobster exports for The Bahamas alone in 2001/2002 were over 2 200 tonnes, with a value of almost 72 million USD (FAO 2003b). In addition, a growing number of countries are using marine fisheries reserves (no-take areas) as tools for fisheries management. Countries using closed areas in the Caribbean Islands region include Cuba and The Bahamas. Box 1 discusses the decline of the Nassau grouper and the management responses that have been employed.

Excessive by-catch and discards

The impacts of this issue in the Caribbean Islands region were slight because the fishing methods employed do not tend to catch excessive by-catch and discards. Trawling for shrimp produces the greatest by-catch and also disturbs benthic communities (UNEP/CEP 1996). This has been recorded in Cuba, in particular Cienfuegos and Nipe bays (Beltrán et al. 1994, Martín et al. 2002).

Destructive fishing practices

The issue of destructive fishing practices was assessed as having a moderate impact in the region. Some of the fishing methods applied in the region, such as trawling, are destructive to the underlying seafloor, particularly to the reefs. Trawling for shrimp, disturbs the seabed and the associated benthic communities, resuspends sediments and causes turbidity currents, thus altering the physical environment and causing

Box 1 Marine reserves for the Nassau grouper.

The Nassau grouper (*Epinephelus striatus*) is dramatically disappearing from the waters of The Bahamas, due to a combination of overexploitation and the use of irresponsible fishing practices, such as overharvesting before the species can breed. The Bahamas Reef Environment Educational Foundation (BREEF), a local NGO, has assessed that the grouper catch in 2001 was less than 225 tonnes, about a third of the 1999 catch. It was concluded that grouper stocks have declined almost to the point of no return.

Protection of spawning aggregations and a three-month ban on grouper fishing during the winter breeding season are two measures that have been suggested by the government to slow the decline. Most scientists agree that the best solution to overexploitation of fish stocks is the creation of a network of marine reserves, similar to the Exuma Cays Land and Sea Park in The Bahamas, which became a no-fishing zone in 1986.

The BREEF report concludes that a system of marine reserves would be "an effective means of promoting sustainable fisheries." Evidence from the Exuma park, the Florida Keys National Marine Sanctuary, and other protected areas around the world show that such reserves help replenish declining fish stocks.

In the late 1990s BREEF held workshops with fishermen and local government officials to discuss the creation and setting of marine reserves. The organisation then commissioned four top scientists to rate the 33 sites identified by the workshops. In January, 2001 the government selected five of these locations to be closed to fishing as demonstration sites. But the policy has not been legally implemented.

(Source: Nassau Guardian 2003)
(Photo: J.E. Randall, Fishbase)

a reduction in biological diversity (UNEP/CEP 1996). In Cienfuegos and Nipe bays (Cuba) the populations of some indigenous and commercial species have been significantly reduced as a result of shrimp trawling (Beltrán et. al. 1994, Martín et al. 2002). There are currently no restrictions on the use of trawling because governments are reluctant to impose regulations as particularly shrimp trawling, generates substantial income and benefits for the fishers and their communities.

Scuba-diving and snorkelling (with harpoon) techniques are negatively affecting the rejuvenation of fish stocks. Tourists participate in such activities, and therefore proposing and enforcing laws against such activity would receive low public support due to their reliance on the tourism industry.

More people are trying to earn a living from fishing, and fishers are using increasingly destructive methods to fish the declining resource (PNUMA/ORPALC/Cimab in press). In The Bahamas, Haiti and Jamaica, illegal fishing practices include the use of poisons, such as bleach, and explosives; which result in significant damages to coral reefs. There is a lack of monitoring and enforcement to prevent such illegal practices (PNUMA/ORPALC/Cimab in press, BEST 2002, Ministry of the Environment 2001). In Cuba there is illegal harvesting of black corals, and in Haiti illegal exploitation of corals for export under the guise of "harvesting live rock" is increasing, with apparent indifference by government officials (Linton et al. 2002).

Decreased viability of stocks through pollution and disease

The species that currently are threatened and affected by diseases and other by-products of human activities in the region are mainly of ecological and not commercially importance and the issue was therefore assessed as having a slight impact.

Fishing is plagued with the loss of reproductive potential and nursery habitat due to pollution and habitat destruction. For example, region-wide declines in coral cover continue, which adversely affects fish stocks (Gardner et al. 2003). Spawning stock are particularly sensitive to pollution and the modification of their habitats; both improved knowledge and institutional arrangements are required to implement management (GEF 2004a).

In the Caribbean Islands region, aquaculture, including shrimp breeding, was once considered a possible alternative food source following the overfishing of traditional catches. Aquaculture initiatives have expanded with investments exceeding those made in the Pacific coastal regions of Central and South America. However, these initiatives have experienced mixed success; many are plagued with disease and have received criticism for their pollution impacts on coastal environments. The most successful aquaculture ventures are of modest size, with a high market value product, but are not yet a viable alternative to the protection and management of existing fisheries (PNUMA/ORPALC/Cimab in press).

Impact on biological and genetic diversity

This issue was assessed as slight as although several alien species have been introduced in the area, there have not been any reports of changes in community structure, except in the Dominican Republic.

The introduction in the Dominican Republic of some species of tilapia (*Oreochromis aureus* and *Oreochromis mossambicus*) and carp (*Cyprinus carpio)* have had a negative influence on populations of indigenous species, affecting their abundance and distribution. Their introduction has led to the near disappearance of the Cuban cichlid (*Cichlasoma tetracanthus)*, the previously most common aquatic species in Dominican waters (Rosado pers. comm.).

Socio-economic impacts

Economic impacts

The overall economic impact of the unsustainable exploitation of living resources was considered as moderate, although there has been a moderate impact on the economies of communities dependent on the fisheries and also the associated industries. The Bahamas is an exception, as the impact of overexploitation was felt by many sectors of the economy; the fisheries itself is fundamental to the country's economy; the tourism industry serves seafood in the many restaurants and provides fishing excursions; and for coastal communities fish is a major component of their diet and their primary source of protein (BEST 1995, 1999).

Landings of conch in the Bahamas are valued at over 1.5 million USD per year and landings of scalefish are valued at over 3 million USD per year, while the lobster industry is the world's fourth largest, contributing 72 million USD to The Bahamas economy (FAO 2003b, Nassau Guardian 2003). But catches and average sizes are declining and experts warn that the industry is not being effectively managed.

Health impacts

The health impacts from the unsustainable exploitation of fish and other living resources were assessed as slight. For the majority of the population in the region, fish intake is minimal in comparison with the importance of other types of traditional food such as locally available vegetable (rice, maize), poultry and pork. Nevertheless, fish is an important source of protein, and often the only source, for riparian populations in small archipelagos, such as in The Bahamas. There are very few alternative sources of nutrition and protein in these fishing communities to compensate for decreasing fish catches. The health impacts of declining protein intake by the people of these coastal communities need further assessment, and potential substitutes identified and made available.

Social and community impacts

The social and community impacts associated with this concern were assessed as moderate, due to the non-sustainable exploitation of the fisheries resources is great concern, added by the high level of artisanal practice and the use of unselective gear as fish traps (Stanley 1995). Although the population or the communities affected are small, the degree of the impact is severe and permanent duration, and in some cases irreversible. The decline in the fisheries has significant impacts not only on the nutritional status of coastal communities, but also on employment opportunities. Fishing is an integral component of their culture and traditions. In extreme cases where the depletion of fish stocks has been very extensive and of long duration, fishing communities have disappeared, forcing its people to migrate to urban areas, or to change livelihood strategy often within the growing tourism industry.

Conclusions and future outlook

Fisheries resources in the region have clearly been affected by the intensity and nature of fishing activities, and the destruction and modification of habitats. Fishing is traditionally an important economic activity in the Caribbean Islands region. Regional data has identified that the most commercially valuable species are being overexploited and indicate a "fishing down" of the coral reef food chain. Competition between small-scale fisheries is intensifying, with more people depending on the declining fisheries for their livelihood, and increasingly employing destructive fishing methods. Additionally, there has been a recent increase in foreign large industrial fishing vessels in the regions waters, which are contributing to the overexploitation of fishery resources. The question of property rights, protected areas and enforcement of regulations, therefore needs to be addressed.

Coastal development activities and pollution have altered and removed ecosystems such as coral reefs, mangroves, seagrass beds and coastal lagoons, which provide food, shelter, and nursery and breeding grounds. Fishing is also plagued with the additional loss of reproductive potential or nursery habitat due to pollution, introduction of alien species and habitat destruction (PNUMA/ORPALC/Cimab in press).

National and regional policies need to address the issue of the sustainability of fisheries in an urgent manner as there may be significant economic consequences if stocks collapse. The living marine resources of the region are often shared between countries and the management and the recovery of depleted fish stocks will require cooperation at various geopolitical scales, but there are at present inadequate institutional, legal and policy frameworks or mechanisms for managing shared living marine resources across the region (GEF 2004a). There is a lack of capacity at the national level and information is lacking, particularly with relation to the transboundary distribution, dispersals and migrations of these organisms. This lack of knowledge represents a major barrier to sustainable management of these shared marine resources, even if an adequate mechanism for effective region-wide ecosystem-based management was in place (GEF 2004a).

There is potential for innovative initiatives throughout the region, compatible with the preservation of coastal habitat, such as protected areas or seasonal openings of specific areas, community involvement in surveillance and enforcement of fishing regulations, and a centralisation of markets for fishing resources capable of leveraging against the pressure of export markets. The unsustainable exploitation of living resources is not confined to national boundaries, and therefore mitigation actions should be integrated at the regional level, whilst operating in a participatory framework with the region's local communities.

IMPACT Global change

Global change was considered as having a moderate impact on the Caribbean Islands region. The region, due to its morphology, is very vulnerable to the impacts of global change, and the associated natural disasters, such as storms and hurricanes, including El Niño Southern Oscillation (ENSO) events. Climate change is a particular concern for Small Island Developing States (SIDS). The most significant and more immediate consequences are likely to be related to changes in sea levels, rainfall regimes, soil moisture budgets, and prevailing winds (speed and direction), as well as short-term variations in regional and local sea levels and patterns of wave action (Sem et al. 1996 in IPPC 2001). The short-term (including inter-annual) variations are likely to be strengthened by the ENSO phenomenon (IPPC 2001).

Environmental impacts

Changes in the hydrological cycle

The impacts from changes in the hydrological cycle were considered as moderate. The Caribbean Islands region have experienced an increase in mean annual temperature of more than 0.5°C during the period 1900-

1995. During the same period, mean annual total rainfall decreased by about 250 mm, but has shown great variability throughout the rainfall record (IPPC 2001). In Cuba, mean air temperature have risen by 0.6°C during the past 45 years (IPPC 2001). There have also been changes in rainfall distribution in some areas of the region, according to rainfall data reported in the Third Report of the International Panel on Climatic Changes (IPCC 2001).

The Caribbean is considered to be one of the most vulnerable regions to hurricanes. Intense ENSO events have produced an increase in the frequency and intensity of hurricanes and associated winter flooding over the past two decades (Mitrani 2000). During the last decade the Caribbean has experienced more than 42 hurricanes of different magnitude and forces, as well as tropical storms and depressions (Figure 15). According to the Division of Investigation of Hurricanes of the Oceanographic and Meteorological Laboratory of the Atlantic located in Miami, the period between the years 1995 and 2000 showed "the biggest meteorological activity (storms and hurricanes) in the North Atlantic ever registered" (CRED/OFDA 2000). In the Caribbean Islands region droughts appear to be more frequent in El Niño years, whereas conditions tend to be wetter in La Niña years. The devastating drought in the region in 1998 coincided with what is believed to be the strongest El Niño signal on record (IPPC 2001).

The impact of ENSO events on coral reefs is particularly significant, since the survivability of reefs is dependent on temperature and salinity stability in coastal waters. Increasing water temperatures have created suitable conditions for the spread of certain coral diseases. The severe ENSO events of 1997-1998 caused massive bleaching and some mortality of corals in almost the entire Caribbean Islands region especially on the coasts of Cuba and the Dominican Republic (UNEP/PAM 1999). Since the major coral bleaching event of 1998 there have been no significant bleaching events in the Caribbean, but predictions are for increases in the number and intensity of such events. With more intense bleaching events the possibility of permanent damage to reefs increases. Coral reefs protect coastlines from storm damage, erosion and flooding by reducing wave action approaching a coastline. The protection they offer also enables the formation of associated ecosystems (e.g. seagrass beds and mangroves) and allows the development of essential ecosystem services (Linton et al. 2002).

Changes in climatic conditions, with an increase or reduction in precipitation, will adversely affect the biological equilibrium of watershed and coastal ecosystems (GEF 2004b). Large-scale changes in vegetation may occur in response to shifting rainfall patterns and temperature regimes. Currently, the climate in the Caribbean is tropical, which ranges from high year round rainfall to distinct wet and dry seasons. Climate change may lead to a drier Caribbean, or

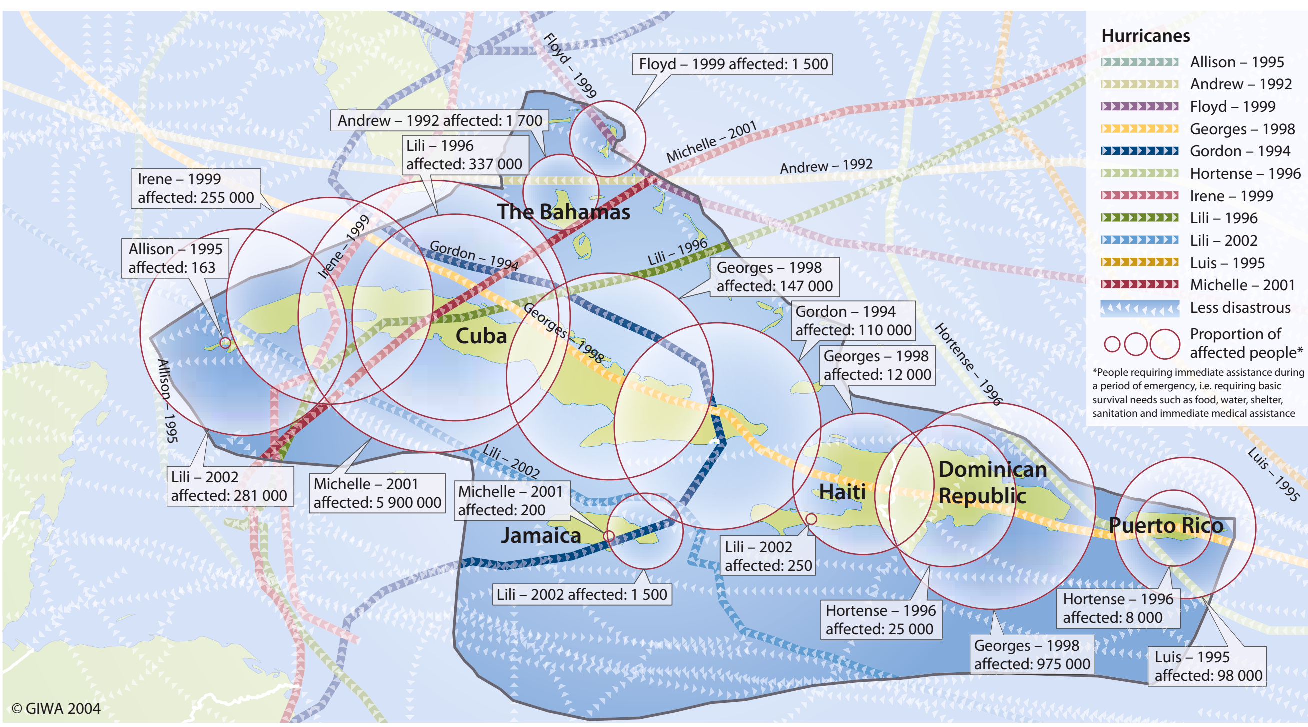


Figure 15 Hurricanes and number of affected people during 1992-2002 in the Caribbean Islands region.
(Source: NOAA 2004, Center for Research on the Epidemiology of Disasters 2004)

increase the inter-annual variability in rainfall, thereby destabilising the fragile development of both inland and coastal ecosystems. Changes in precipitation patterns are also frequently responsible for increased land degradation (GEF 2004b).

Sea level changes

According to the GIWA experts changes in sea level have had a slight impact. Global warming may cause a melting of glaciers and the polar ice caps, and thermal expansion of water, with possible alterations in sea level, which can potentially submerge vast areas of coastal wetlands, and change physical conditions necessary for the survival of coral reefs and mangroves. This may increase saltwater intrusion of freshwater pools and aquifers, threatening an important source of potable water for the population of the region who predominantly inhabit the coastal areas (UNEP/GEF 1998, UNEP/CEP 1998).

It is predicted that within 50 years sea level will rise by 0.25 to 0.30 m, and by 0.5 m or more by the year 2100. Even with a stabilisation in greenhouse gas emissions, it is expected that the rise in sea level will continue beyond the 2100 estimate, increasing annually by 5 mm (IPCC 2000). Sea level change was rather homogeneous up until the 1940s, but has since accelerated, as a result of more intensive global warming.

Sea level rise would exacerbate salinisation, which is occurring in many islands as a result of overpumping of aquifers (e.g. The Bahamas and Barbados). In some cases, higher salinity would be experienced not only in coastal aquifers but also inland at freshwater pumping plants as the salty groundwater rises (IPPC 2001). It is projected that on Andros Island, The Bahamas, where the water table presently is only 30 cm below the surface, saltwater intrusion will be increased due to high evaporation rates and continued sea level rise (Martin & Bruce 1999 in IPPC 2001). Similar projections have been made for Cuba, where groundwater supplies are already vulnerable to saltwater intrusion due to over abstraction (Planos & Barros 1999 in IPPC 2001).

Increased UV-B radiation

The impact of increased UV-B radiation in the region was assessed as slight. There have not been any studies on the impact of radiation increases on aquatic species as a result of ozone depletion. The assessment scoring was based on the Caribbean Islands region being located on the Equator, where there has been the least ozone depletion.

Changes in ocean CO_2 source/sink

According to the GIWA experts there have been no surveys conducted regarding this issue. However, studies have found that globally, changes in the ocean CO_2 sources/sinks are having negative impacts on corals reefs. Therefore, although there is no regional information, this concern was considered as having a slight impact on the region's ecosystems, based upon assessments from other parts of the world. The Bahamas is considered as a carbon sink; however there has been no investigation of its changes and associated impacts.

Socio-economic impacts

Economic impacts

The economic impact of global changes was assessed as severe, as increases in sea temperature have affected coral reefs and thus the ecosystem services that they provide. It was considered that although climatic phenomena, such as the ENSO events, are not permanent, they have prolonged economic effects. These events have severe impacts on property, infrastructure, and the ecosystems servicing the tourism industry and fisheries. There are currently no accurate predictions of the impact future global changes will have on the economic activities of the region.

Vulnerability assessment studies suggest that climate change will impose diverse and significant impacts on small island states (IPPC 2001). In the Caribbean Islands region the majority of the population, socio-economic activities, and infrastructure are located on the coast. They are therefore highly vulnerable to the impacts of climate change and sea level rise (IPPC 2001). An increase in the frequency and magnitude of tropical cyclones would be a serious concern for the region. This would increase the risk of flooding, accelerate existing rates of beach erosion, and cause displacement of settlements and infrastructure (IPPC 2001).

Health impacts

The magnitude of health impacts in the region due to the global changes was assessed as slight to moderate. Extreme events such as hurricanes often result in limiting access to freshwater, the overflowing of septic systems and an increase of exposure to disease by vectors that thrive in the event of flooding. Table 21 outlines the health impacts in Cuba associated with global climate change.

Other social and community impacts

According to the GIWA experts only a limited number of communities have been affected by this concern. Storm events disrupt the functioning of communities, leaving many islanders homeless and settlements disconnected from services due to damage to infrastructure. However, the region has always been vulnerable to adverse meteorological conditions and the communities have learnt to recover from such events. In The Bahamas, the size of the community affected can be large if a

Table 21 Increased cases due to climate change and associated costs for selected diseases in Cuba.

Disease	Increased cases	Cost of increased cases (USD)	Increased hospital admissions	Cost of increased hospital admissions (USD)	Total cost increase (USD)
Acute respiratory infection	332 620	1 468 000	99 784	1 135 000	2 603 000
Acute diarrhoeal disease	137 380	895 000	41 213	302 000	1 196 000
Viral hepatitis	11 030	48 000	3 308	66 000	113 000
Varicella	19 350	85 000	ND	ND	85 000
Meningococcal meningitis	3 000	ND	3 000	80 000	80 000
Total cost		2 496 000		1 582 000	4 078 000

Note: ND = No Data. (Source: Ortiz Bulto et al. 2002 and pers. comm. in Haites 2002)

storm hits the capital, but less if a storm hits another island within the archipelago. The frequency of such impacts in The Bahamas is low.

Conclusion and future outlook

Global change in the Caribbean Islands region is considered having moderate impact at present. However, due to the vulnerability of the islands consequences of global change might increase in the future. The analytical tools used by the IPCC are not adequate in providing long-term predictions of the effects of the climatic change in the area (IPCC 2000). However, because of the strong influence of the surrounding oceans on the climate of these islands and because the Caribbean Sea is predicted to warm by 1-2°C in the future there is expected to be changes in climatic conditions of the islands (IPPC 2001). Mean rainfall intensity is projected to increase by about 20-30% over the tropical oceans within which the Caribbean Islands are located with doubled CO_2.

The impact of a climate change-related rise in air temperature on small island states has not been investigated sufficiently. An increase in temperature is expected to affect critical ecosystems, such as coral reefs which are sensitive to temperature changes, but is not believed to have widespread adverse consequences.

Although reefs have the potential to adjust and regenerate in line with the projected rate of sea level rise, in the Caribbean Sea some species of corals live near their limits of tolerance to temperature (about 25-29°C). Therefore even relatively small projected increases in sea-surface temperature could negatively affect some of these organisms. An increase in the incidence of bleaching associated with the elevation of water temperatures above seasonal maxima similarly would pose a threat to coral reef ecosystems (IPPC 2001). Human presence such as land-use practices, infrastructure and developments in the coastal zone and topography, may obstruct the ability of mangroves to adapt and migrate landward as sea level rises. The natural capacity of ecosystems to adapt to climate changes may also be inhibited due stresses placed on them by human activities (IPPC 2001).

Sea level rise is expected to increase coastal erosion and land loss on many islands, and beaches are expected to be affected by a reduced supply of sediment from adjacent reefs. However, on some of the larger islands such as Hispaniola and Cuba increased sediment yields from watersheds may compensate for loss of beach material, at least in the short term. In addition, increased sea flooding and inundation are expected in the region. In the Caribbean Islands region, the largest settlements, critical infrastructure, and major economic activities and services are located within close proximity of the coast and are therefore at risk from sea level rise. It may not be economically viable for some of the countries in the region to invest in shoreline and other infrastructure protection (IPPC 2001).

Future global changes are predicted to have adverse impacts from the combined effect of greenhouse gas induced climate change and sea level rise. These are predicted to exacerbate coastal erosion and land loss, flooding, soil salinisation, and intrusion of saltwater into groundwater aquifers. The quantity and quality of available water supplies can affect agricultural production and human health. Similarly, changes in SST, ocean circulation, and upwelling could affect marine organisms such as corals, seagrasses, and fish stocks. Tourism, which is the most important economic sector for many of the countries, could be affected through beach erosion, loss of land, and degraded reef ecosystems, as well as changes in seasonal patterns of rainfall (IPPC 2001). The coastal region is perhaps the most economically-valuable area on most of the islands and even small changes could produce permanent environmental damage, and severely affect the islands' economies (GEF 2004b).

Environmental assessment and monitoring of the actual and potential impact of climate change on coastal areas and watersheds is emerging as major imperative for all of the countries in the Caribbean region. All Caribbean countries have signed the United Nations Framework Convention on Climate Change (UNFCC). Through the GEF-financed project entitled Caribbean Planning for Adaptation to Climate Change (CPACC) and its successor project Mainstreaming Adaptation to Climate Change (MACC), countries are examining the possible scenarios and how to deal with them. The possible effects of climate change on coastal water levels and temperatures are a threat to the fragile coral-reef ecosystems (GEF 2004b).

Global phenomena cannot be controlled directly by the countries of the region, but there have been initiatives to support Caribbean

Box 2 The Caribbean Planning for Adaptation to Global Climate Change (CPACC) project.

The GEF-funded project Caribbean Planning for Adaptation to Global Climate Change (CPACC) (1997-2001) was executed by the Organization of American States in partnership with the University of the West Indies for Environment and Development (UWICED) for the World Bank as the GEF implementing agency. The project's overall objective was to support Caribbean countries in preparing to cope with the adverse effects of global climatic changes, particularly sea level rise in coastal areas, through vulnerability assessment, adaptation planning and related capacity building.

The components of the CPACC Project were as follows:

- Design and establishment of sea level/climate monitoring network;
- Establishment of databases and information systems;
- Inventory of coastal resources and use;
- Formulation of a policy framework for integrated adaptation planning and management;
- Coral reef monitoring for climate change;
- Coastal vulnerability and risk assessment;
- Economic valuation of coastal and marine resources;
- Formulation of economic/regulatory proposals;
- Greenhouse gas inventory.

CPACC has successfully produced the network, the data, assessments, strategic framework and policy recommendations for national governments of the region, to allow them to include global climate change impacts in the national political agendas and to implement measures capable of responding to long-term and seasonal impacts (such as increase of the sea temperature, storms, hurricanes) from world atmospheric changes.

The initiative to establish a Regional Climate Change Centre was endorsed by the CARICOM Heads of Government in July 2000. The Caribbean Community Climate change Centre (CCCCC) was established as a legal entity at the CARICOM Heads of Government meeting in February 2002. The objectives were enhancing regional institutional capabilities for the coordination of national responses to the adverse effects of climate change, providing comprehensive policy and technical support in the area of climate change and related issues and spearheading regional initiatives in those areas, performing the role of executing agency for regional environmental projects relating to climate change, and promoting education and public awareness on climate change issues.

countries in preparing to cope with the adverse effects of global climatic changes, particularly sea level rise in coastal areas, through vulnerability assessment, adaptation planning and related capacity building (see Box 2).

Priority concerns for further analysis

In the Caribbean Islands region all GIWA concerns were assessed as moderate and the priorities were therefore assigned based on common judgement built on intense discussion during the GIWA Workshop and from further assessment of the individual scores. The assessment considered pollution as the most severe, current and future, transboundary water concern. The GIWA concerns were prioritised as follows:

1. Pollution
2. Freshwater shortage
3. Global change
4. Habitat and community modification
5. Unsustainable exploitation of fish and other living resources

The most significant impacts have originated from land-based sources of pollution. For example, nutrient inputs, mainly nitrates and phosphates, associated with agro-chemicals and organic wastes, from agriculture and forestry, and sewage discharges. This pollution has exacerbated eutrophication in coastal waters and led to the accumulation of organic suspended waste and algal blooms, creating "dead zones" in the numerous bays of the region, where oxygen is depleted by the decaying algae, depriving other living organisms. Marine traffic also discharges wastes, such as oily bilge and ballast water, sewage and solid wastes into the region's marine environment. Marine currents and ocean circulation transport pollutants far from their original source into the territories of other island states.

Pollution is threatening the sustainability of aquatic ecosystems in the region. Pollution has impacted marine species and modified their habitats including coral reef and mangrove ecosystems, with severe consequences for biological diversity and abundance. Furthermore, these impacts are affecting the economic activities of the Small Island Developing States (SIDS) and impeding sustainable development. Measures to control pollution and limit its impacts are currently inadequate, and the impacts are expected to escalate in the future.

As populations, both indigenous and tourist, rapidly grow, resources are becoming increasingly depleted, habitats are further modified and greater quantities of pollution are found in the aquatic systems of the region. Furthermore, global climate change will increasingly impact the ecosystems of the islands which are already stressed by anthropogenic pressures. These factors are exacerbating the rate of ecosystem degradation, on which the island populations and economies depend upon for their survival. Hughes (1994) assessment sends a very simple and straightforward message to all stakeholders and consumers of ecosystem services in the region and in other SIDS, saying that "we are close to reaching a catastrophic mutation of the ecological equilibrium and that healthy ecosystems can no longer be taken for granted and require the utmost attention by policymakers in order to effectively manage resources, in a sustainable manner".

There is a lack of an integrated approach in the region to deal effectively with any of the GIWA concerns assessed in this report. The extent of the pollution problem demonstrates the institutional weaknesses and lack of capacity to promote compliance and enforce agreements and policies (ECCLAC 1999 in UNEP 1999d). In 2000, the UNEP Caribbean Environmental Outlook described the situation: "These institutional issues, in conjunction with a lack of agreement on the long-term goal of the national development strategy, and with the very real technical and political difficulties of operationalising elusive concepts such as sustainability, make it difficult for Caribbean governments to deliver a long-term strategy for sustainable development without extensive and fundamental changes in the system of government, existing institutional arrangements and the prevailing political culture" (UNEP 1999d). There is a complex mesh of inter-linkages and synergies between the GIWA concerns, involving a number of scientific and geographical mechanisms. Table 22 shows some of these inter-linkages.

Table 22 Inter-linkages between GIWA concerns.

Concern A	Concern B	Inter-linkage mechanism involved	Examples from the region
Pollution	Habitat modification	Pollution of rivers, and coastal and marine waters leading to changes in coral reef, wetland and mangrove habitats.	Jamaica, Puerto Rico, Puerto Plata (Dominican Rep.)
Pollution	Freshwater shortages	Land-based pollution of streams and rivers, leading to contamination of surface and groundwater supplies, poor sanitation and a reduction in the overall supply of potable and irrigable water.	Havana (Cuba), Nassau (The Bahamas)
Pollution	Unsustainable exploitation of fish	Polluted effluents discharged into coastal waters contaminate habitats (coral reefs, bays), essential for nursery grounds, foraging or the food chain of marine species. Spills from maritime traffic seriously harm offshore and coastal reproductive habitats.	The Bahamas Channel, Jamaican reefs, Haitian reefs, Puerto Rico
Unsustainable exploitation of fish	Habitat modification	Fishing in coral reef areas eliminate species vital for the health of the reefs and destructive practices damage the reef directly. The introduction of non-endemic species for aquaculture is impacting on a number of endemic species.	All coral reef areas Dominican Republic
Habitat modification	Unsustainable exploitation of fish	The degradation and destruction of coral reefs and mangroves, directly affects the food chain or the reproductive capacities of numerous endemic species.	All coral reefs and mangrove forests
Unsustainable exploitation of fish	Pollution	The introduction of aquaculture in some areas has led to an increase in biological pollution and eutrophication.	Aquaculture areas Jamaica
Global change	Habitat modification	Changes in seas level and ENSO events have had dramatic consequences on coastal habitats and particularly coral reefs.	Region-wide
Global change	Unsustainable exploitation of fish	Increases in sea temperature have affected the health of coral reefs and has consequently affected the coastal food chain, thus reducing the productivity of commercial species.	Region-wide
Global change	Freshwater Shortages	Variations in temperature associated with ENSO has created drought in dry seasons and floods in rainy seasons, damaging the drinkable and irrigation water supply, as well as wetlands.	Region-wide
Global change	Pollution	ENSO generated floods have dragged large amounts of mud and sediments into rivers, bays and coastal waters, damaging further the ecosystems as a result of additional sedimentation.	Region-wide

Causal chain analysis

This section aims to identify the root causes of the environmental and socio-economic impacts resulting from those issues and concerns that were prioritised during the assessment, so that appropriate policy interventions can be developed and focused where they will yield the greatest benefits for the region. In order to achieve this aim, the analysis involves a step-by-step process that identifies the most important causal links between the environmental and socio-economic impacts, their immediate causes, the human activities and economic sectors responsible and, finally, the root causes that determine the behaviour of those sectors. The GIWA Causal chain analysis also recognises that, within each region, there is often enormous variation in capacity and great social, cultural, political and environmental diversity. In order to ensure that the final outcomes of the GIWA are viable options for future remediation, the Causal chain analyses of the GIWA adopt relatively simple and practical analytical models and focus on specific sites within the region. For further details, please refer to the chapter describing the GIWA methodology.

Overview of issues

Pollution was selected as the priority concern of the GIWA Caribbean Islands region (see Assessment, Priority concerns). Pollution was found to originate predominantly from marine traffic and land-based sources. The Causal Chain Analysis (CCA) will therefore perform separate analysis on each of these broad pollution sources in order to undertake a holistic analysis of the issues, impacts and root causes.

Concerning marine traffic pollution, the entire region will be studied, but only Havana Bay was selected as a hotspot which has experienced significant environmental degradation as a result of land-based sources of pollution.

Maritime traffic in the Caribbean Islands region, unlike in other Small Island Developing States (SIDS), contributes significant quantities of pollutants to the marine environment, due to the geographic and economic particularities of the region. The region comprises large islands and archipelagos that are located on an essential passage for maritime traffic between the Atlantic Ocean, the Gulf of Mexico and the Caribbean Sea in the south.

The intensive maritime traffic operates in confined waterways within close proximity of the coastline, and vessels discharge oily residuals, suspended solids and solid waste, which has increasingly threatened the environmental and socio-economic integrity of the islands.

The GIWA Assessment, in accordance with previous UNEP-sponsored assessment programmes (UNEP 1999b), identified land-based activities as the primary source of coastal pollution and destruction of coastal habitat, such as coral reefs and mangroves. Due to the geographic and morphologic configuration of the region's islands, as in many SIDS, populations and key economic activities such as trade, agriculture, industry and tourism are principally located in coastal areas. It is the by-products of these human activities that are severely impacting coastal and marine ecosystems.

Havana Bay is a well-documented example of where land-based pollution from the surrounding urban and industrial landscape has contaminated the coastal and marine environment, with transboundary consequences for the entire region.

Discharges from maritime traffic

Transboundary pollution in the Caribbean Islands is not limited to land-based sources of pollution, but also originates from the legal and illegal discharges from vessels transiting through its waters and between islands.

The Caribbean Islands region is different from other SIDS regions, such as GIWA regions Pacific Islands or Indian Ocean, as it has some of the most intensive maritime traffic in the world. Around 50 000 ships frequent the Caribbean waters every year, of which approximately 82.5% dock at the region's port installations (CETRA 1999). This intensity of maritime traffic is the result of three independent geo-economic characteristics of the region:

- The presence of the Panama Canal makes the Caribbean Sea, particularly in the north, an area of intensive maritime cargo freight traffic for any Atlantic-Pacific Ocean liaison.
- The presence of oil producing countries (Mexico, Columbia, Venezuela, United States and Trinidad & Tobago) and important ports for oil refining (Mexican shores, Cartagena in Columbia and San-Juan in Puerto Rico) make the waters of the Caribbean only second in oil traffic to the Persian Gulf.
- The attractiveness of the region for tourism makes the Caribbean the most visited cruise destination in the world (Ocean Conservancy 2002). 14.5 million cruise passenger visited Caribbean ports in 2000, an increase of 47% from 1995 (CTO 2002). Cruise passenger arrivals to the Caribbean Islands region is shown in Table 23.

Each one of these sub-groups of maritime traffic carries its own specific set of risks and impacts on marine and coastal ecosystems, for example the dumping of used waters (ballast, grey waters, black waters, toxic waters, etc.), the risk of collision, oil spills and the dumping of solid and suspended waste. The risk from maritime traffic is particularly significant when considering the proximity of maritime transit routes to coastlines. For example, the Old Bahamas Channel is a particularly busy channel connecting the Atlantic to the Gulf of Mexico, the Caribbean Sea and the Pacific, passing just 10 nautical miles north of Havana, Cuba.

Table 23 Cruise arrivals to the GIWA region Caribbean Islands in 2003.

Country	Cruise arrivals	Change 2003/2002 (%)
The Bahamas	2 970 000	6.0
Cuba*	-	-
Dominican Republic	398 000	61.3
Haiti	ND	ND
Jamaica	1 133 000	30.9
Puerto Rico	1 235 000	2.6

*Notes: * No cruise figures are reported. ND = No Data. (Source: CTO 2004b)*

In response to the risks and impacts caused by marine traffic, a number of international maritime agreements have been adopted aimed at protecting marine and coastal ecosystems. What concerns the conventions and regional environmental actions, the only environmental convention that covers the Caribbean Islands region with respect to protection of the environment of the marine coasts, is the Cartagena Convention.

The Cartagena Convention together with its protocols on oil spills, specially protected areas and wildlife, and on contamination from land based activities, is a mark of a comprehensive legislative work that represents the base for a better management of the marine and coastal resources in the region. However, just like other global and regional multilateral environmental conventions, the level of implementation of the obligations deriving from the convention is hard to accomplish (Table 15 in Regional definition).

It should be noted that in many cases specific information on the GIWA region Caribbean Islands is not available. Therefore, data for the entire Caribbean area and/or global average is used as a basis for the following analysis.

Regulatory framework for maritime traffic

The analysis of maritime traffic and its associated impacts has been segregated into three types of traffic: oil transport, cargo transport and cruise vessels (Figure 16).

Oil extraction, refining and transport

The main oil producing countries in America are located in or near the Wider Caribbean region. Oil extracting countries, like the United States, Venezuela, Colombia, Mexico and Trinidad & Tobago, refine their crude oil or ship it through a complex refining and distribution network throughout the region (Botello et al. 1997). Most of this oil is transported

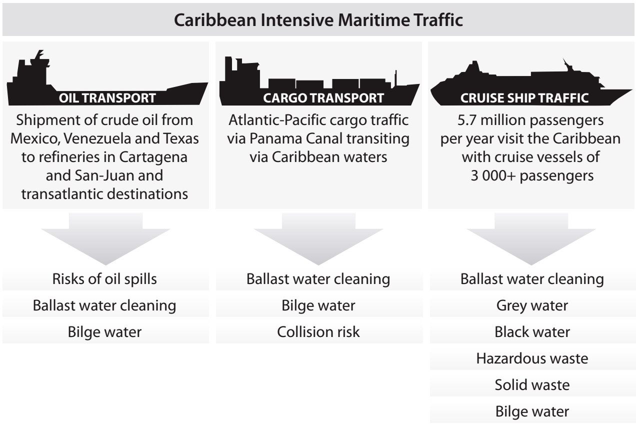


Figure 16 Types and polluting activities of maritime traffic.
(Source: GIWA Task team)

to other countries of the Caribbean region, resulting in considerable oil tanker traffic transiting the various routes of internal distribution, mobilising an average of 5 million barrels of crude oil per day in the Wider Caribbean region and around 1 million barrels in the Caribbean Islands region (Figure 17) (Botello 2000). There are approximately 100 oil refineries in the Wider Caribbean region with a processing capacity of more than 500 million tonnes of oil per year. 75% of these refineries operate on the coast of the Gulf of Mexico.

Laws and regulations

The regulation of oil related maritime traffic is under the jurisdiction of the International Maritime Organization (IMO). The IMO is the legal and legislative power of international traffic, and national governments are the executive and enforcing agencies. Most IMO regulations concerning oil spills and waste disposal from ships are included in the International Convention for the Prevention of Pollution from Ships, also known as the MARPOL 73/78 agreement (IMO 1978).

This agreement regulates the special construction and equipment requirements for the prevention of accidental pollution and the circumstances in which discharges from vessels are authorised. In addition, MARPOL 73/78 covers most of the substances that pollute waters (oil, toxic waste, solid waste, sewage, air pollution) and Annex I of the convention is dedicated to oil pollution and oil discharges, setting rules and standards for construction, operational discharges, and required technology and equipment onboard tankers. The International Convention for the Safety of Life at Sea (SOLAS) of 1974 includes special requirements for tankers in order to limit risks of oil spills in the event of another incident occurring on board (IMO 1974).

No.	Year	Source and spill zone	Millions of litres (type of oil)
1	1971	Sain Agusta, St. Croix, U.S. Virgin Islands	13 (crude)
2	1973	Zoe Colocotronis, Cabo Rojo, Puerto Rico	5 (crude)
3	1975	Garbis, Florida Keys, United States	24-25 (crude)
4	1976	Ruptures pipeline in Corpus Christi, Puerto Rico	1 (crude)
5	1977	Unidentified ship, Guayanilla Bay, Puerto Rico	2 (crude)
6	1978	Howard Star, Tampa, Florida, United States	15-20 % crude, 80 % bunker
7	1979	Burhah Agate, Texas, United States	5-41
8	1979	Atlantic Empress, off the coast of Trinidad and Tobago	158
9	1979-1980	Itox I, marine platform explosion, Campeche, Mexico	528-1626 (crude)
10	1984	Alvenus, Louisiana, Unites States	25
11	1985	Ranger, marine platform explosion, Texas, United States	24-52
12	1986	Las Minas Refinery, Panama	8 (crude)
13	1991	Vista Bella Barge, off Saint Kitts and Nevis	2 (bunker C)
14	1994	Berman, San Juan, Puerto Rico	375 (gasoil No. 6)
15	1997	Nisos Amorgos, tanker, Gulf of Venezuela	3.2

Figure 17 Routes of oil traffic and major oil spill accidents in the Caribbean.
(Source: ITOPF 1996)

The response to an accidental oil spill occurring within the Caribbean Islands region is governed by a framework of international, regional and national response standards and procedures. Response systems are specific to each country, depending on which agreement the country has ratified. The main international agreement, aside from Annex I of MARPOL 73/78, is the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) of 1990 (IMO 1990). In the Caribbean Islands region only Puerto Rico, Jamaica and The Bahamas have signed the convention (Table 24).

The key element of regional cooperation in preventing and combating oil spills is the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean region, also called the Cartagena Convention (UNEP 1983), which addresses more specific regional needs than MARPOL 73/78. Article 11 "Cooperation in Case of Emergency" is the key paragraph addressing the risk of oils spills and the level of cooperation and coordination to expect among states. It is a convention for achieving sustainable development of marine and coastal resources in the Wider Caribbean region through effective integrated management that allows for increased economic growth. The Convention has a specific protocol regarding oil pollution; Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean region (Oil Spill Protocol of the Cartagena Convention), which entered into force on 11th October 1986.

Table 24 Conventions concerning maritime traffic in the Caribbean Islands region.

Country	SOLAS 74	MARPOL 73/78				MARPOL Protocol VI (Annex VI)	OPRC 90	Cartagena Convention
		Annex I/II	Annex III	Annex IV	Annex V			
The Bahamas	√	√	√		√	√	√	
Cuba	√	√			√			√
Dominican Republic	√	√	√	√	√			√
Haiti	√							
Jamaica	√	√	√	√	√		√	√
Puerto Rico	√	√	√		√		√	√

Note: SOLAS: International Convention for the Safety of LIfe at Sea (1974), MARPOL: International Convention for the Prevention of Pollution from Ships (1973/1978) Annex I: Prevention of pollution by oil, Annex II: Control of pollution by noxious liquid substances, Annex III: Prevention of pollution by harmful substances in packaged form, Annex IV: Prevention of pollution by sewage from ships, Annex VI: Prevention of Air Pollution from Ships, OPRC: International Convention on OIl Pollution Preparedness, Response and Cooperation (1990).
(Source: IMO 2004)

Cargo traffic

Although cargo traffic remains important in terms of total tonnage per year crossing the region, its polluting impact is less significant than other forms of marine traffic. However, cargo transport is damaging aquatic ecosystems through the discharge of ballast water, hull cleaning, oil bilge release, and grey water release. There are also potential risks of collision with coral reefs and accidental spillage of cargo, which is particularly significant considering the transfer of radioactive material throughout the region. Although significant in terms of risk, the impacts and immediate causes are assessed and discussed in detail during the analysis of cruise vessel discharges and oil transport discharges and spills. Legislation outlined for cruise ships is also applicable to cargo traffic.

Table 25 Cruise passenger arrivals in the Caribbean.

Year	Passengers	Change (%)	Year	Passengers	Change (%)
1980	3 805 000	-	1991	8 700 000	12.3
1981	3 590 000	-5.7	1992	9 400 000	8.0
1982	3 455 000	-3.8	1993	9 610 000	2.2
1983	3 550 000	2.7	1994*	9 776 000	-
1984	3 720 000	4.8	1995	9 881 000	1.1
1985	4 300 000	15.6	1996	10 954 000	10.9
1986	5 000 000	16.3	1997	12 094 000	10.4
1987	5 600 000	12.0	1998	12 422 000	2.7
1988	6 340 000	13.2	1999	12 148 000	-2.2
1989	6 710 000	5.8	2000	14 518 000	19.5
1990	7 750 000	15.5			

*Note: * New series, include cruise passenger arrivals in Haiti. (Source: CTO 2002)*

Cruise ship operations

The Caribbean is the world's major cruise destination and in 2000 14.5 million cruise passengers visited Caribbean ports (Ocean Conservancy 2002, CTO 2002). During the period 1990-2000 the industry has grown annually by 6.5% (CTO 2002) (Table 25). It experienced a slowdown in 2001-2002 following a downturn in the global tourism industry. However, since 2003, growth in the Caribbean cruise industry has been restored.

Cruise traffic typically originates from either harbours in the United States (Miami, Fort Lauderdale, New Orleans, Corpus Christi), Puerto Rico (San-Juan) or Columbia (Cartagena). Routes vary according to both the cruise line company and the season, but the bulk of cruise arrivals to the GIWA Caribbean Islands region are to The Bahamas, Jamaica (Kingston Harbour), and Dominican Republic (Santo Domingo in the south or Puerto Plata in the north). The majority of ships are built in Norway, Korea and the United States and have an average capacity of 3 000 passengers (Ocean Conservancy 2002). Their capacity has grown over the years, as technology has increasingly made it feasible to construct larger ships, which are more profitable to cruise line companies.

Laws and regulations

Annex IV MARPOL 73/78, which is optional, entered into force on 27 September 2003 (Table 24). It is generally considered that on the high seas, the oceans are capable of assimilating and dealing with raw sewage through natural bacterial action but the regulations in Annex IV prohibit ships from discharging sewage within 4 nautical miles of land, unless they have an approved treatment plant in operation. Between 4 and 12 miles from land, sewage must be comminuted and disinfected before discharge. In addition, national governments are required by MARPOL to ensure the provision of adequate reception facilities at ports and terminals for the reception of sewage.

The Annex will apply to new ships (built after the date of entry into force of the Annex) of 200 gross tonnes and above, or carrying more than 10 persons. It will also apply to existing ships (built before the date of entry into force of the Annex). Not yet fully entered into force, Annex IV is already under revision to include the requirement that ships must be equipped with an approved sewage system. Annex V of MARPOL regulates the dumping of solid waste from ships in coastal areas. The Environmental Marine Committee, belonging to International Marine Organization (MECP 31), nominated the Wider Caribbean region as a "Special Area", under the previous regulations (IMO 1997). This means that the dumping of solid waste is prohibited throughout the Caribbean waters.

Environmental and socio-economic impacts

Pollution from vessels has degraded the marine and coastal environment through oil spills, and the discharge of wastes, mainly linked to accidental factors or human navigational inaccuracies, but also by some irresponsible actions, such as tankers cleaning in close proximity to coastal areas.

Oil extraction, refining and transport

Environmental impacts

Pollution from large, accidental oil spills is particularly harmful to the ecology of coastal and marine ecosystems and the species that inhabit them. However, the ecological and health impacts caused by long-term chronic oil discharges to the marine environment of the Caribbean Islands region is less understood due to a deficiency in relevant studies.

On the Santo Domingo Coast, Dominican Republic, concentrations of 16-291 mg/kg dry weight of total hydrocarbons were detected in recent sediments; in Kingston Harbour, 200-578 mg/kg dry weight and in the Havana Bay between 685-1 212 mg/kg dry weight (GEF/UNDP/UNEP 1998). These concentrations indicated that coastal ecosystems have lightly chronic oil pollution. Havana Bay was assessed as the most impacted in the region (GEF/UNDP/UNEP 1998).

On 7 January 1994, the barge Morris J. Berman spilled approximately 3.6 million litres of oil off Punta Escambroâ in San Juan, Puerto Rico (Figure 18). This resulted in the contamination of extensive areas, impacting natural resources along more than 48 km of Puerto Rico's north shore, affecting fish, sea shells, sea birds and sea turtles. Thousands of dead and live oiled organisms washed ashore. The coral reef ecosystem that the barge struck running aground was almost obliterated (Ornitz 1996).

Socio-economic impacts

Oil spills have degraded and modified coastal ecosystems, and subsequently had considerable economic impacts. For example, the accident of the Princess Anne Marie tanker off the south coast of Pinar del Rio, Cuba, in January 1980 (Cimab 1998b), caused an oil spill that had estimated economic losses of more than 15 million USD (Villasol pers. comm.).

It took 114 days, 15 Puerto Rican and Federal agencies, 1.5 million man-hours, over 1 000 workers, and over 87 million dollars to clean-up and assess the overall damage of the oil from the Morris J. Berman (Figure 18) (Ornitz 1996). Surveys carried out in Cuba, Puerto Rico and Dominican Republic showed that the beaches polluted with tar balls are visited by fewer tourists, disregarding their natural beauty (Atwood et al. 1987, CARIPOL 1987, PNUMA/ORPALC/Cimab in press). In addition, tar accumulation on beaches also reduces tourism potential of coastal areas.

Cruise operations

Environmental impacts

Entanglement in fishing line, wire, plastic mesh and strapping, and ingesting plastic, styrofoam, and other materials, such as paper and glass, represent serious threats to marine life. They endanger survival by damaging an animals' digestive tract, causing starvation by blocking food intake, and inhibiting growth, moulting, reproduction and buoyancy. Hazardous wastes and persistent organic pollutants (POPs) and other types of chemicals are corrosive, flammable, explosive or toxic to living organisms.

Human sewage discharged from cruise ships can carry diseases, viruses, enteric bacteria, pathogens, the eggs of intestinal parasites, and excessive nutrients (Clark 1986 in Ocean Conservancy 2002). Ingesting contaminated fish or direct exposure to water contaminated with sewage pose health risks for humans. Bivalve molluscs (oysters and clams) and other filter-feeding marine species often inhabit waters containing the greatest concentration of nutrients from organic wastes, and they absorb high levels of these pollutants.

Toxic waste materials from cruise ships, such as PERC, are known carcinogens and can cause serious liver, kidney, and central nervous system damage, while others, such as the silver compounds in photo chemicals, can bio-accumulate and become toxic to shellfish (Harte et al. 1999 in Ocean Conservancy 2002). Also tributyltin (TBT), a highly toxic anti-fouling paint commonly used on the hulls of cruise ships and other large vessels, poses a serious health risk to humans and marine species alike.

Figure 18 Oil spill impact caused by the barge Morris J. Berman in 1994.
(Photo: NOAA)

Socio-economic impacts

Riparian populations, being dependent on fish for their main source of protein, are particularly vulnerable to the impacts from increased toxicity in marine species, but tourists have also been affected. The fisheries are a major economy for many of the countries in the region. The intoxication of fish may jeopardise export markets, resulting in a considerable loss of income and greater dependence on other sources of foreign currency, such as export crops, foreign aid and tourism.

Tourism is the predominant sector in the region's economy. Its success is highly dependent on the health of the region's natural assets (aesthetics of water and beaches, recreational use of water, recreational fishing, contact with and observation of aquatic and coastal flora and fauna, etc.). A large quantity of marine debris is deposited on beaches, which causes a loss in aesthetic value for tourism and recreation, harm to human health, and beach maintenance costs. If the depletion of aquatic ecosystems, as a result of increasing pollution, continues at its current rate, there may be serious economic consequences for the entire region.

Immediate causes

Oil extraction, refining and transport

The main risk with the highest destructive potential for aquatic ecosystems is oil spills originating from:

- Accidents in maritime oil transport;
- Coastal extraction of oil and refining activities;
- Onboard ballast water and oily bilge waters.

Oil spills from accidents in maritime oil transport

Accidental oil spills are a frequent problem for maritime traffic worldwide. The narrow channels and shallow waters of the northern Caribbean are exceptionally vulnerable to accidents, increasing the risk of oil spills in the GIWA Caribbean Islands region. The most significant spill for the last two decades was that of the barge Morris J. Berman grounded off Punta Escambroân in San Juan (Puerto Rico). Table 26 shows the main oil spills that have occurred in the Caribbean Islands region since 1973.

Table 26 Larger oil spills in the GIWA region Caribbean Islands since 1973.

Year	Location	Oil spill (litres)
1973	Zoe Colocotronis, Cabo Rojo, Puerto Rico	5 million crude oil
1975	Garbis, Florida Keys US	24.5 million crude oil
1976	Pipe break, Corpus Christi, TX	1 million crude oil
1977	Unknown Ship, Guayanilla Bay, Puerto Rico	2 million Venezuelian crude oil
1978	Howard Star, Tampa, Florida, US	0.4 million crude oil and 2.5 million bunker oil
1982	Tanker Princess Anee Marie, Pinar del Rio Cuba	5.3 million crude oil,0.7 million fuel oil
1991	Vista Bella Barge, off side St. Kitts & Nevis	2 million bunker oil
1994	Morris J. Berman, San Juan Puerto Rico	3.7 million fuel oil
1998	Unknown ship, Havana, Cuba	0.06 million diesel oil
2000	Unknown ship, Havana Cuba	0.4 million crude

(Source: IOCARIBE 1997, Cimab 1998a 1998b, 2000)

Oil spills from coastal extraction of oil and refining activities

Oil spills can also occur when loading off/on tankers, when discharging contaminated ballast waters during cleaning, and when cleaning waters from refineries. The pollution mechanisms involved with oil spills from oil extraction and refining activities are generally similar to those following an accidental oil spill, with the exception that they stagnate in the harbour areas, unlike accidental oil spills that drift with sea current and winds. This type of oil pollution is more aggressive and permanent on coastal habitat, particularly bays which have often have a low assimilative capacity.

Approximately 90% of petrochemical related coastal pollution in the world comes from industry sources such as refineries and petrochemical plants (UNEP/CEP 1998). In addition, more than one third of the oil spilled at sea between 1983 and 1999 was caused by accidents at ports, oil terminal and oil refineries located in coastal areas (UNEP 1999c).

Corredor (1991) reported that more than 50% of tar ball occurrence on the southwest coast of Puerto Rico can be statistically linked with the frequency of tanker arrivals at a petrochemical complex 24 km east of the sampling site.

Studies carried out by the Cuban Centre of Environmental Engineering for Bays and Coastal Area (CIMAB) in 1998 at Havana City, showed a large presence of tar balls along the whole coastline of Playas del Este. Also, a marked difference in the existence of tar balls was reported on the beaches during different times of the year (Palacios et. al. 1998). In addition, results obtained by the The Caribbean Petroleum Pollution Monitoring Project (CARIPOL) determined high accumulations of hydrocarbon tar balls along the beaches of the South Florida coasts, Cuba, Puerto Rico, Cayman Islands and Curacao, as well as the windward beaches of Barbados, Granada and Trinidad & Tobago (Atwood et al. 1987, Heneman 1988, CARIPOL 1987).

Onboard ballast water and oily bilge waters

In discharging bilge[1] and oily water residues, both international regulations (MARPOL) and national regulations, in most cases, require that oil content of the discharged effluent be less than 15 parts per million (ppm) and that it does not leave a visible sheen on the surface of the water. On the majority of ships, oily bilge water is pumped through an oil-water separator capable of reducing oil concentrations to the legal limit. The remaining oil bilge is discharged overboard or offloaded to a treatment facility while the ship is in port (Ocean Conservancy 2002). However, large volumes of hydrocarbons and other substances are still being discharged from tankers and private vessels in the region, which permanently increases oil concentrations in the sea (PNUMA/ORPALC/Cimab, in press). The Bahamas reported that many tankers and other ships have been known to clean out their bilges and tanks in their waters, releasing large quantities of oils, observed as a surface sheen on the water (GIWA Task team 2004).

Cruise ship operations

The increase in the size of ships is putting extra competitive pressure on welcoming harbours, obliging them to frequently upgrade their cruise terminal facilities and dredge harbour channels deeper and wider every year. Dredging is detrimental to nearby ecosystems, destroying coral reefs and bringing to the surface bottom sediments that deoxygenate the channels. However, the main damage to marine and coastal ecosystems from the cruise line industry occurs due to operations at sea and more specifically to the dumping of toxic substances and waste near fragile ecosystems such as coral reefs and mangroves. These wastes and operations include (see also Table 27 and Figure 19):

- Ballast and oily waters
- Grey waters
- Black waters
- Hazardous waste
- Solid waste
- Oil bilge
- Anchoring in fragile areas

The International Council of Cruise Lines (ICCL) includes 16 major cruise ship lines in the North America market and has developed voluntary guidelines for cruise industry waste management. Figure 19, provided by ICCL, assumes that all harbours are equipped with onshore reception facilities. However, according to the GIWA Task team, cruise reception facilities are absent or inadequate in many of the harbours, and instead

[1] *The bilge is the very bottom of the hull where water ends up from various operational sources such as water lubricated shaft seals, propulsion system cooling, evaporations, and other machinery.*

Table 27 Amount of waste generated on a typical cruise ship with 3 000 passengers.

Waste	Amount of waste (ship = 3 000 passengers)
Grey water	340-965 m³/ship/day
Black water	60-120 m³/ship/day
Hazardous waste*	70 litre/day/ship
Solid waste	50 tonnes/week/ship
Oil bilge	5-140 m³/day/ship

*Note: * Photo processing chemicals, paint, perchlorethylene (PERC) and other chemicals.*
(Source: Ocean Conservancy 2002)

of being received by "Onshore Waste Reception Facilities", wastes are often dumped at sea in the Caribbean Islands region.

Cruise ships are required to have onboard waste treatment systems, known as marine sanitation devices (MSDs), but the industry is not required to monitor or report MSD discharges to either the government or the public. Most of the cruise ships are now equipped with MSDs, which allow them to reduce and hold waste until the ship has cleared coastal waters.

Discharge of ballast and oily waters

Cruise line or cargo ballast water discharges are considered to have severe consequences for the marine environment. In addition, ballast water can introduce alien species or toxic substances, often leading to biological contamination of the immediate surroundings (IMO 1998). Ballast waters are considered by the IMO as oily waters and thus fall under regulations set in Annex I of MARPOL 73/78.

Discharge of grey water

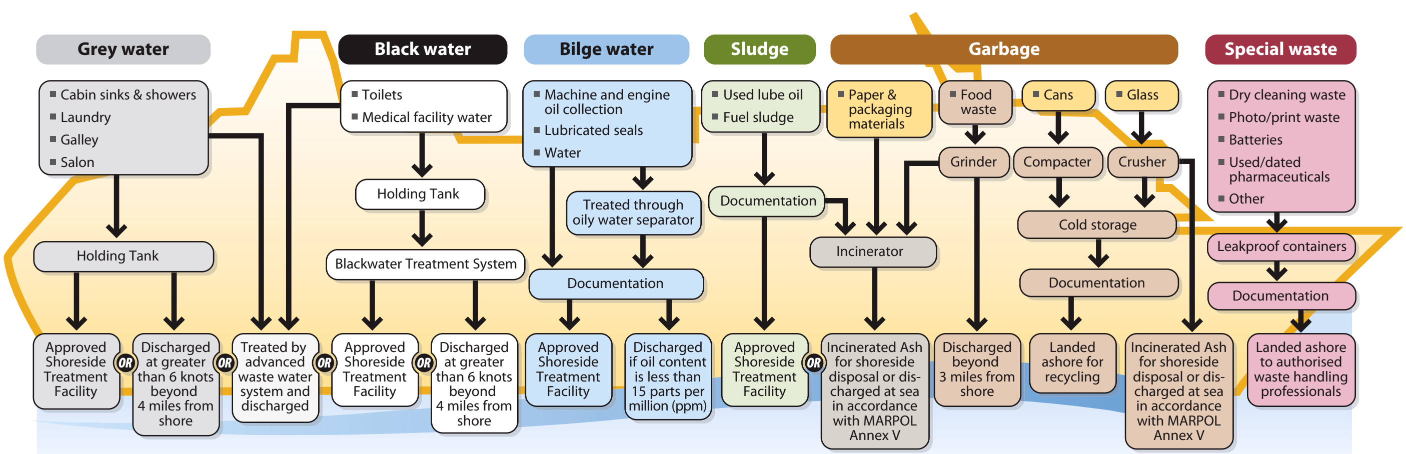
Grey water consists of non-sewage wastewater, including drainage from dishwashers, showers, laundry, baths, galleys, and washbasins. It can contain pollutants such as faecal coliforms, food waste, oil and grease, detergents, shampoos, cleaners, pesticides, heavy metals, and from some vessels, medical and dental wastes. Grey waters represent by far the largest category of liquid waste generated by cruise ships.

Discharge of black water (sewage)

Sewage, also called black water, consists of wastewater generated from toilets and medical facilities. Sewage on ships is typically diluted with limited volumes of water and is therefore more concentrated than urban sewage. The cruise line industry reports that its policy is to discharge treated black water or grey water only when underway and not while in ports but it is dificult to confirm whether practice follows policy (Ocean Conservancy 2002).

Discharge of hazardous waste

Many of the chemicals used by and disposed from cruise ships are often not found on other commercial vessels and therefore receive little regulatory attention. These include photo-processing chemicals containing silver, print shop wastes that include hydrocarbons, chlorinated hydrocarbons and heavy metals, and dry cleaning fluids containing perchlorethylene (PERC). Cruise ships also use and dispose of paint waste, solvents (including turpentine, benzene, xylene, methyl-ethyl-ketone, toluene), photo copying and laser printer cartridges, fluorescent and mercury vapour light bulbs, lead-acid, nickel-cadmium,



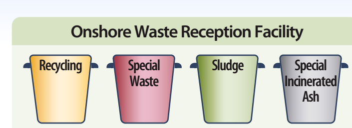


Figure 19 Ship waste cycles chart.

Cruise ships must comply with international, domestic and state laws from IMO, U.S. Coast Guard, EPA and state and port agencies. Member lines of ICCL are committed to preserving the waters upon which cruise ships sail. ICCL member lines have adopted mandatory environmental practices that meet or go beyond the requirements of international and domestic law. However, cruise reception facilities are absent or inadequate in many of the ports, and instead of being received by "Onshore Waste Reception Facilities" as shown in diagram, waste is often dumped at sea.

(Source: Redrawn from ICCL in Holland America Line 2004)

lithium, and alkaline batteries, and unused or outdated pharmaceuticals (Ocean Conservancy 2002).

Discharge of solid wastes

The dumping from cruise ships and, to a lesser extent from other ships, increases the presence of solid wastes in the coastal ecosystems. About 900 000 tonnes of solid waste is dumped into the world's oceans each year. Some 24% of the waste generated by ships comes from cruise ships (NRC 1995 in Ocean Conservancy 2002). The wind and the currents transport marine debris toward the coasts, often far from the original sources. The marine debris often consists of 65-70% plastics (Palacio et al. 1998) and is commonly not biodegradable. According to Nollkaemper (1994), residuals dumped from ships is a greater contributor of solid wastes on the beaches, rather than land-based sources of pollution, as was presented in Agenda 21 (UNCED 1992).

Table 28 shows an annual estimate of discharged solid waste for 15 ports selected in the Caribbean. It is observed that although the cruises represent only 10% of the ships that arrive to the ports in the whole Caribbean, these generate approximately 77% of the solid waste (WCISW 1996a,b). However, a large volume of the solid waste never reaches the reception ports. These quantities of solid waste are incinerated on board the ships cruises or discharged to the sea in violation of the Annex V of the MARPOL 73/78.

Table 28 Ship traffic in the Caribbean and the annual discharge of solid waste.

Type of ships	Arrive to ports		Solid waste discharges	
	Ships/year	%	Tonnes/year	%
Cruises	1 833	10.7	19 350	77
International cargo	6 490	38.0	3 766	15
Coastal traffic	6 363	37.3	1 476	5.9
Military	310	1.8	310	1.2
Fishing	252	1.5	13	0.05
Yachts	608	3.6	116	0.5
Others	1 218	7.1	21	0.08
Total	17 074		25 052	

Source: (WCISW 1996a, b)

Ports have begun to treat solid waste in the region, although the operations remain limited. Table 29 shows the amount of solid waste from ships treated annually in ports located in the region.

Discharge of oil bilge

Cruise ships can generate 5-140 m^3 bilge water per day, depending on their age and size (Eley 2000, Schmidt 2000 in Ocean Conservancy 2002). Royal Caribbean Cruise Ltd. (in Ocean Conservancy 2002) reported that approximately half of this is treated and then discharged at sea; the remainder is retained in on-board tanks and treated on shore. In 1999 Royal Caribbean Cruise Lines, whose ships frequent Bahamian waters, were found guilty of deliberately dumping oily waste from its ships as a cost-cutting measure. The company was fined 9 million USD in the United States, along with other penalties and further charges are pending (BEST 1995, 2002).

Table 29 Number of ships and amount of solid waste treated in ports located in the GIWA region Caribbean Islands.

Country	Cruise (ships/year)	Others (ships/year)	Solid waste (tonnes/year)
Cuba	11	2 935	495
Haiti	3	393	29
Jamaica	507	1 734	5 182
Dominican Republic	206	2 960	2 229
The Bahamas	320	1 500	208
Total	1 047	9 522	8 143

(Source: WCISW 1996a)

Anchoring in sensitive locations

Two very direct impacts on the survivability of Caribbean coral reefs from cruise ship operations are from collisions and anchors. In Georgetown, Grand Cayman (situated just south of Cuba, but belonging to GIWA region 3 Caribbean Sea), government scientists report that more than 120 ha of coral reef have been lost to cruise ship anchors (Pattullo 1998 in Ocean Conservancy 2002). A Norwegian cruise line ship ran aground, destroying 80% of a coral reef in a national park off Cancun, Mexico (Schultz 1998 in Ocean Conservancy 2002). The potential for similar accidents in the Caribbean Islands region is extremely high, given the intensity of cruise ships. In addition, smaller recreational vessels can have significant impact considering the numbers that visit the reefs.

Root causes

A 10 year review of the Barbados Programme of Action for SIDS (BPoA +10) will take place in Mauritius in January 2005. Amongst the primary concerns stressed at an Inter-Regional Preparatory Meeting (The Bahamas January, 2004) in preparation for the 2005 meeting were the insufficient progress in planning and implementing waste management policies and that the quantity of waste disposed of in the sea should be reduced through regional cooperation (GEF 2004b).

The capacity for the Caribbean countries to dispose, treat and recycle waste generated from cruise ships is a major problem. The majority of SIDS has limited capacity to dispose of their domestic waste and often struggle to dispose and treat waste generated from land-based tourism. In Jamaica, for example, due to a lack of national facilities, some of the oily, organic chemicals and quarantine waste had to be sent to ports in the US.

Despite a general increase in the quantities of solid wastes from cruise ships and the severity of the impacts from dumping at sea, there has been a lack of investment in disposal facilities. Some recollection equipment has been installed and final disposal is now made in controlled drains. This however does not promote a reduction in waste at source and the recycling of tradable waste materials.

In 1993, many of the countries of the Caribbean Islands region had not ratified Annex V of MARPOL because they were unwilling to provide reception facilities for cruise ships which they believed did not contribute to the local tourism income. Between 1993 and 1996 a project sponsored by the IMO and GEF, entitled the Wider Caribbean Initiative on Ship generated Waste (WCISW), was undertaken, resulting in two reports; the Strategy and Plan of Action for Reduction of the Source of Waste Generated by Ships, their Recycling and Recovery (WCISW 1996a) and the Report on Adequacy of the Existing Management Systems of Waste for Management of Waste, MARPOL 73/78 (WCISW 1996b).

In 1996, the majority of the countries integrated treatment of ships waste with the treatment of land originated waste. However, the final disposal of waste generated by cruise liners has been a major concern for many of the smaller islands as a result of:

- An absence of funds and technology;
- A lack of space in the vicinity of the harbour for the construction of treatment plants, incinerators and landfill sites;
- Waste treatment not being profitable and thus is not a priority for the Port Authorities of the region;
- An absence of national governance over the management of Port Authorities and their investment decisions.

Geophysical and geopolitical characteristics

The narrow channels and shallow waters of the northern Caribbean have intensive marine traffic, and consequently are exceptionally vulnerable to accidents, increasing the risk of oil spills in the Caribbean Islands region. This level of marine traffic activity is found because of: (i) the Panama Canal maritime cargo freight traffic; (ii) the presence of oil producing countries; and (iii) the success of the cruise line industry in the region. Incidents can occur as a result of accidental factors or human inaccuracy, but also from irresponsible actions, such as tankers cleaning empty tanks in coastal waters.

Economic

Foreign dependency

Opportunities for economic development are constrained, and the countries of the GIWA Caribbean Islands region are highly dependent on international tourism and agricultural exports. The Caribbean countries are dependent on imports from larger trading partners such as US, Mexico, Europe and Venezuela. This has a biased effect on trade agreements with other national governments and large private conglomerates, as it is suspected that smaller countries accept a certain amount of environmental violations in order to secure preferential tariffs.

The countries of the Caribbean Islands region tend to have fewer regulations regarding navigation, oil spill risk reduction, and oil discharges, due to their dependence on revenues received from the oil industry. Tourism is generally the most important source of external revenue, and the greatest single contributor to Gross National Product (GEF 2004). The countries are therefore highly and increasingly dependent on foreign currency inflows from tourists, and in particular on the high turnaround of visitors from cruise lines stopping at local harbours. Consequently, local governments are reluctant to enforce international and regional regulations and to suggest new innovative measures to preserve their endangered natural heritage.

Lack of financial resources

All of the countries in the GIWA Caribbean Islands region lack the hard currency necessary to execute environmental projects (GEF/UNDP/UNEP 1998). Mitigation and effective management are frequently constrained by the absence of cost-effective and applicable solutions, which would be realistic to the SIDS situation (politically and economically) (GEF 2004b).

Insufficient investment in waste treatment facilities

Most of the waste treatment infrastructure at harbours is financed by foreign sources. Investments by local Port Authorities are traditionally directed at extending harbours' capacity in order to remain competitive in welcoming cruise liners. They are usually oriented towards generating greater profits and involve the creation of new docking facilities to welcome more or larger boats, dredging, tourism information, shops, lodging, entertainment centres etc. Waste treatment is not seen as a source of revenue, and local regulations controlling waste treatment are generally weak and poorly enforced. They are subsequently by-passed during port development schemes.

Lack of incentives to treat or dispose waste at ports

Waste treatment is expensive for cruise line operators, and there are currently no economic incentives for any ship to treat their waste at harbours rather than dumping them at sea.

Expansion of cruise industry

Cruise ship profitability increases with the size of the ship. Due to economies of scale, a strong winter seasonal cruise demand and competitive pressure during other seasons encourages cruise line companies to commission larger ships that can welcome an increasing number of passengers. This means that: (i) the load of waste per ship is expected to increase in future; (ii) host harbours will be placed under increasing competitive behaviour toward cruise line companies, with a reduced likelihood of imposing more stringent local environmental regulations; and (iii) that harbours will need to invest, as a priority, in their capacity to physically welcome the ship (dredging, docking, harbour visitors facilities) prior to investment in waste treatment.

Knowledge

Lack of information availability

Currently there is a lack of readily available information for policy makers to make informed decisions to address marine traffic related pollution, although there have been some initiatives to resolve this root cause. The Caribbean Petroleum Pollution Monitoring Project (CARIPOL) has been the only organisation to provide information on oil pollution levels in water and sediments in coastal and marine waters in the Caribbean region during the 1970s and 1980s. The GEF/UNDP/UNEP (1998) Planning and Environmental Management of Heavily Contaminated Bays has given more recent data for several individual Caribbean coastal zones.

Although it is recognised that tourism plays a vital role for the Caribbean economies, a lack of information on the economic impacts of tourism does not allow a proper understanding of its costs and benefits. This is primarily due to the lack of reliable data and a system to adequately measure the benefits of tourism to a country's economy.

The harmful effects of solid wastes dumped at sea have been frequently documented around the world, but there is severe lack of published information in the Caribbean Islands region, particularly about the effects of marine debris and tar balls.

Lack of monitoring of discharges

MARPOL states that grey water should not be released from vessels, although due to a lack of monitoring there has been limited success in prosecuting polluting cruise companies. However, in 1998, Royal Caribbean Cruises Ltd pled guilty to multiple charges of fleet wide practices of illegally disposing of pollutants through its ships' grey water systems (Ocean Conservancy 2002). Cruise industry officials are now reporting that they identify and segregate hazardous wastes to prevent them from entering grey water waste streams, although again, due to the lack of monitoring, it is difficult to assess whether there have been improvements. Additionally, cruise ships are not required to monitor the quality of the waters in which they routinely dump their waste.

The cruise line industry also reports that its policy is to discharge treated black water or grey water only when underway and not while in ports. Again, however, it is difficult to confirm whether this occurs in practice without effective monitoring.

There have been difficulties in conducting systematic assessments in restricted areas without the consent of either national government or the relevant industry. National laws requiring assessment of waters that are near to industrial operations are not homogeneous throughout the region and are usually poorly enforced due to a lack of resources.

Limited public environmental awareness and education

The general public continues to lack a sufficient understanding of the relationship between development and environmental protection, and of the short and long-term benefits and disadvantages of economic and environmental protection measures (GEF/UNDP/UNEP 1998). This is evident by the frequent dumping of solid wastes and untreated sewage by the local populations, and by the low priority environmental concerns are given in national political agendas. This calls for sustained educational and awareness initiatives to increase the population's understanding of the value and importance of ecosystem services, both economically and culturally, and how pollution is threatening the long-term survival of their local environment. In the meantime, it is unlikely that local populations will press their governments for more stringent environmental regulations for shipping.

Legal

Weaknesses in legislation and regulations

On a global level, an accidental oil spill would have to be of a considerable magnitude in order to trigger both a national and regional response. According to IMO regulations, the cost of an oil spill must be shared between the ship's insurer, an international oil industry fund for oil spills recovery and the ship owner (who is usually insured against the obligation of financial compensation). Smaller spills, which typically do not involve tankers with their full load, are not considered as accidents or fall under national jurisdiction, and are therefore listed as spills authorised under Annex I of MARPOL.

There is also evidence from the cruise ship industry that legislation can be avoided, through the falsification of documents or monitoring devices, which are imposed by MARPOL Annex I (oil or bilge dumping) or Annex V (solid waste dumping).

Although it is illegal to discharge of hazardous material via the grey water, the US Resource Conservation and Recovery Act (RCRA), to which a majority of cruise vessels in the Caribbean are subject, does not specifically address the management and disposal of hazardous wastes on cruise ships.

There are no known regulations in place in Caribbean regarding anchoring in a coral reef area. Unless the waters are protected under the status of National Park, any ship, large or small, can legally anchor in a coral reef area. The main problem remains in the uneven state of coral reef barriers in the Caribbean and whether or not navigators know the state of a particular coral reef barrier.

A great step forward for the Caribbean region's aquatic resources was achieved when the Wider Caribbean region was declared a Special Area under MARPOL Annex V (dumping of solid waste from ships). MARPOL's designation was the first step toward a region-wide agreement that measures need to be taken to combat the dumping of solid waste. However, the agreement allows a generous margin for ships that do not intend to comply. Two cases can be noted:

- MARPOL Article 4 stipulates that violations and offences should be prosecuted under the jurisdiction of the Flag State (meaning Liberia or Panama in most cases) i.e. not the state where the pollution incident occurs. Therefore polluting vessels are more difficult to arraign in courts, unless the ship is placed under quarantine by coastal authorities.
- MARPOL specifies in Annex V that ships have the right to unload solid waste for security reasons. Cruise ships, having reached their maximum waste retention of their marine sanitary devices (MSDs) claim that due to limited harbour facilities they were unable to unload some waste cargo, and are therefore allowed to discharge their load freely and legally at sea.

Governance

Unsustainable development strategies

Most of the countries in the Caribbean Islands region are highly dependent on the inflow of foreign currency from exports or tourism. Their political agenda is oriented toward maintaining this income in the short-term. The lack of long-term perspective by governments of the region and the constraints created by specific economic situations (e.g. the economic restrictions imposed by the US-Cuba trade barriers, Dominican Republic dependency on US foreign aid) often relegated environmental policies, which take a low priority when they appear to impede short-term economic development. There is consequently insufficient investment in conserving their natural heritage through environmental initiatives. For example, there is inadequate oil spill contingency planning (land-based or accidental maritime) and a lack of capacity to treat waste from cruise ships.

Lack of political commitment

There is a lack of political commitment to improving the safety of marine traffic navigating the waters of the region, in mitigating the risks of oil spills and providing sufficient planning to respond to pollution events. At present, environmental concerns, and maritime pollution in particular, remain low on national political agendas. Political will and government resources necessary to resolve environmental issues are lacking at national and local levels since the preservation of ecosystems is not seen as a priority, often being disregarded when making national investment decisions.

Lack of compliance with international agreements

The MARPOL Convention laid down a framework for the control of marine pollution. However, despite the countries of the region adopting the convention, there is a lack of compliance with many of its regulations. National governments often fail to meet their executive responsibilities of the MARPOL agreement, as there is a lack of monitoring and enforcement infrastructure provided. This root cause can be divided into the following sub-categories:

- Lack of regional coordination among the national states;
- Lack of legislative and enforcement power at the national level;
- Lack of means to control and monitor illegal dumping (satellite systems).

Under Annex I of the MARPOL 73/78 agreement, Regulation 20 requires that every ship or vessel of 400 gross tonnes or more shall keep an oil record book documenting the discharge or disposal of all oily waste, including bilge water. However, many vessels do not keep or falsify records.

There is no real enforcement or monitoring of MARPOL Annex V which regulates the dumping of solid waste from ships in coastal areas. The Environmental Marine Committee, belonging to International Marine Organization (MECP 31), nominated the Wider Caribbean region as a Special Area, under the previous regulations (IMO 1997). This means that the dumping of solid waste is prohibited throughout the Caribbean waters. Monitoring and enforcement is the responsibility of local national governments which lack the capacity and the political will to fulfil their obligations. Waste plastic in particular can drift over long distances, and therefore the solid waste dumping ban in the Wider Caribbean Area would need to be extended to neighbouring regions (US waters and South Atlantic) in order to see an improvement in the region.

The main international agreement, aside from MARPOL 73/78, is the International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC) of 1990. However, in the GIWA Caribbean Islands region only Puerto Rico, Jamaica and The Bahamas have signed the convention.

The Cartagena Convention is actually the only regional agreement that protects the region's coastal zones. However, like other global and regional multilateral environmental conventions, there is a lack of adherence, and some difficulties implementing the obligations set out by the convention.

Lack of oil spill response planning and capacity

The International Tankers Owners Pollution Federation (ITOPF) keeps track of every country's capabilities to respond to an accidental oil spill. None of the GIWA Caribbean Islands region countries are recorded as having any element of joint regional preparedness or contingency response capability. However, there are some national level response measures, capabilities and experience.

National response to an accidental oil spill depends largely on the technology, equipment, training and human resources available. With the exception of Puerto Rico, which benefits directly from the entire US response infrastructure, no countries of the Caribbean Islands region currently have the required capability to respond alone effectively to such an incident.

The absence of contingency plans for maritime based environmental accidents such as oil spills seems to be the direct consequence of a lack of concern and coordination at both the international and regional level, The Cartagena Convention, for example, is not yet ratified by all the countries of the region.

Inadequate consideration of negative impacts from transboundary pollutants

Through the ratification of environmental conventions, the countries of the Caribbean Islands region have demonstrated a commitment to finding common solutions to transboundary environmental problems. However, national programmes are not addressing regional concerns, as initiatives to mitigate the negative impacts of pollution have focused on addressing domestic impacts, rather than those occurring outside of territorial limits in international waters. Regional cooperation regarding transboundary pollutants is hindered by the inadequate exchange of information regarding management and technical experiences (UNDP/UNEP 1999). Governments are beginning to recognise the regional implications imposed by the release of certain transboundary contaminants, and they are now attempting to implement national approaches to the mitigation of this pollution.

Technology

Insufficient utilisation of recycling techniques

In most islands, despite the limited land available to dispose of wastes in landfills, recycling has not been employed as a technique for reducing the volume of ship-generated waste. In general, there are large quantities of recyclable waste from ships. For example, glass from kitchen waste represents between 15 and 25% of the waste flow (Ocean Conservancy 2002).

There have been some recycling programmes established in the region. The authority responsible for the management of waste in Puerto Rico has managed to involve the private sector and establish many recyclers and end users for glass, aluminium, metallic, and plastics. This followed the US Environmental Protection Agency sponsored Public Law No. 70, which set a goal that 35% of waste should be recycled by year 2000. In January 1994 Puerto Rico had three important recycling centres; Owens-Illinois in Vega Alta, Industrial Fibers in Bayamon and Caguas and Alcan Recycling in San Juan. However, the initiative has had only limited success due to a lack of interest amongst the public regarding recycling and decreasing their waste contribution.

Lack of marine traffic control services

There is a general absence of marine traffic control services including navigation aids and surveillance, with the exception of the Old Bahamas Channel off the northern coast of Cuba, where navigation is controlled and monitored by the Cuban Coast Guard, with the help of a sophisticated traffic routing system (GIWA Task team 2004). There is a need to increase such practices throughout the region, especially near narrow channels and surrounding oil terminals.

Limited technological resources

The Caribbean countries lack the funding, training and technology to efficiently monitor MARPOL violations. There is limited access to sophisticated traffic and spill response technologies, such as satellite guidance systems and satellite chromatic maritime spill monitoring technologies. Countries in the region usually do not have the financial and human resources to access the services offered by satellite

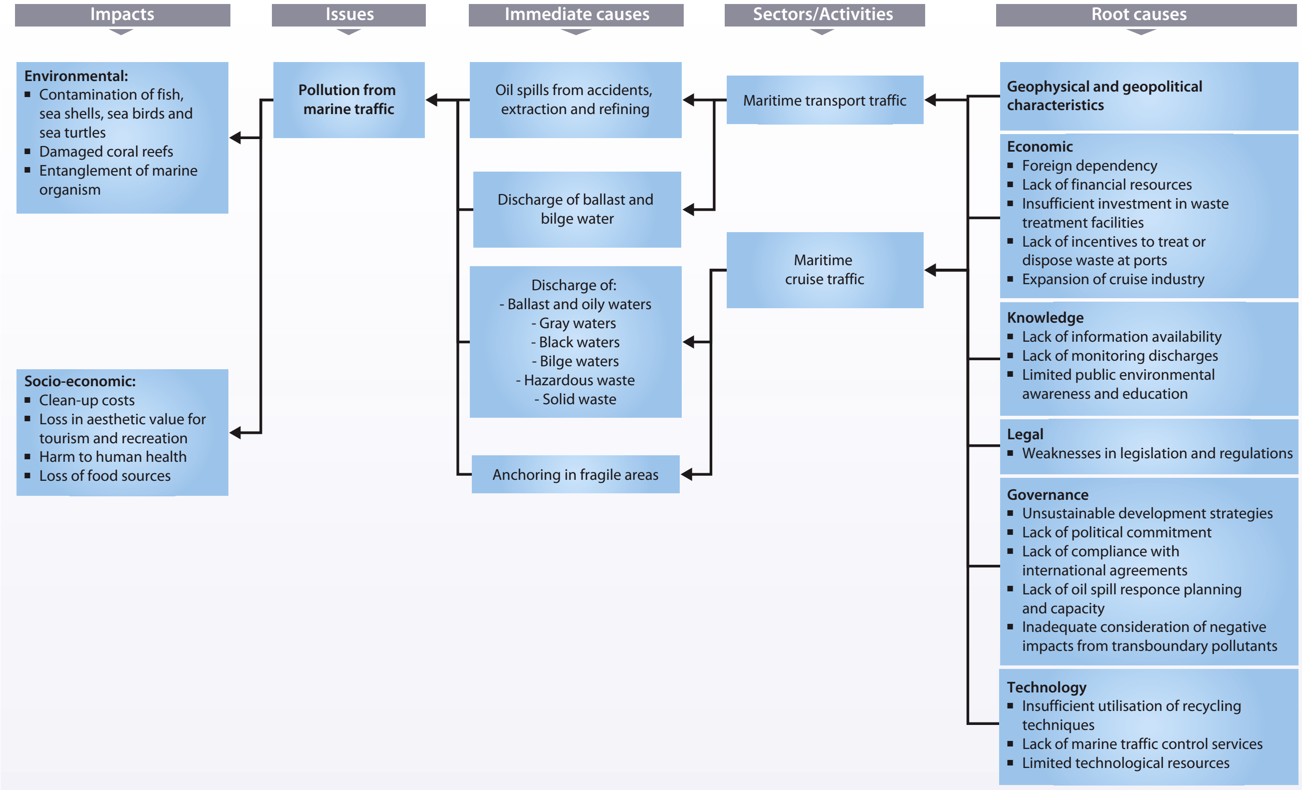


Figure 20 Causal chain diagram illustrating the causal links for pollution from maritime traffic.

companies. Monitoring spills would allow: (i) a faster response to accidental spills and (ii) improved monitoring of the volume and nature of voluntary spills and their environmental impact.

Conclusions

The linkages between root and immediate causes and their environmental and socio-economic consequences are presented in Figure 20.

Intensive marine traffic and the geographical characteristics of the region make it vulnerable to pollution from marine traffic. However, the countries of the region have demonstrated a lack of political will in addressing the issue. This has been attributed to a lack of awareness of the importance of marine and coastal ecosystems, and a desire by governments for rapid economic growth which they have tried to achieve through the implementation of unsustainable development strategies. Governments have consequently given environmental policy a low priority and provided weak legislation and regulations, despite the adoption of international agreements.

These root causes transcend all levels of governance, leaving a legacy of under investment in relevant institutions needed to manage waste, and the absence of necessary infrastructure to receive and treat ship waste at ports. In the event of a major marine pollution incident the region lacks the capacity and coordination mechanisms to adequately respond, which may result in an environmental and economic disaster, given the dependence of the population on, and fragility of, marine and coastal ecosystems.

Pollution in Havana Bay

Over the past 20 years, experts from the Caribbean have recognised pollution of coastal and marine areas as the most significant environmental threat (GEF/UNDP/UNEP 1998). The major sources of coastal and marine contamination originate from land-based sources, and its severity varies from country to country, depending on the intensity and nature of development activities. Population growth, combined with poorly managed economic development and industrialisation in the region, have led to widespread contamination of the coastal and international waters of the Caribbean (GEF/UNDP/UNEP 1998).

Caribbean has specific locations that have been heavily polluted, or hot-spots with marked eutrophication and severe pollution from untreated sewage. Typical examples in the GIWA Caribbean Islands region are Santo Domingo's Coast, Havana Bay; San Juan's Bay, and Kingston Bay, among others (PNUMA/ORPALC/Cimab, in press).

Havana Bay is one of the most contaminated bays in the region, and has subsequently been the subject of multidisciplinary investigations with the support of United Nations' agencies, international development agencies and the Cuban government. Intense development activities and large concentrations of population are the primary factors behind the poor water quality of the rivers discharging into the Bay. For example Luyano River is among the most polluted in the Caribbean Islands region (GEF/UNDP/UNEP 1998).

The focus of the Causal Chain Analysis (CCA) is to determine the root causes of heavy contamination in Havana Bay rather than the more visible causes, so that these driving issues can be addressed by policy makers. The environmental and socio-economic impacts of pollution in Havana Bay will be discussed and the transboundary issues will be traced back to their root causes. The pollution of Havana Bay has transboundary implications as regional currents and ocean circulation transports contaminants to other islands of the region, particularly The Bahamas.

Among the assessments conducted in Havana Bay, two studies are used as key references for the CCA on pollution in Havana Bay:

- United Nations regional project Cuba/80/001 Investigation and Control of the Marine Pollution in Havana Bay, developed in the first half of the 1980s (UNDP/UNEP/UNESCO 1985);
- The GEF/UNDP/UNEP project Heavily Polluted Bays of the Caribbean executed between 1996-1998 (GEF/UNDP/UNEP 1998).

System description

Geographical and hydrological characteristics

Havana Bay, the largest bay in the GIWA Caribbean Islands region, is located on the west of Cuba's northern coast. It has a semi-enclosed configuration and shallow waters, with an abrasive coast and coralline terrace. The Bay has a total area of 5.2 km^2, a volume of 47 million m^3, an average depth of 9 m, and a coastline perimeter of 18 km. The Bay borders the City of Havana and is entirely surrounded by the urban conglomerate of Greater Havana, where 19% of the total Cuban population and 25.8% of the country's economic activity takes place (UNDP/UNEP/UNESCO 1985). Havana Bay consists of a central water area, a narrow entrance channel in the northwest, and three inlets: Marimelena at the northeast, Guasabacoa at the southeast and Atarés at the southwest, where three small streams (Luyano, Martín Pérez and Arroyo Tadeo) enter the Bay (Figure 21).

The hydrographic basins of the Luyano (28.1 km^2), Martin Perez (12.2 km^2) and Arroyo Tadeo (2.2 km^2) rivers form the drainage area near to the Bay. The approximate flow of freshwater to the Bay is 330 000 m^3 per day; 50.7% and 14.1% from the main and smaller pluvial drainages respectively; 31.2% from rivers and streams; and 4% discharged by industries and establishments located on the coast (UNDP/UNEP/UNESCO 1985).

The characteristics of the Bay, semi-enclosed and shallow, do not favour the dissipation of the pollution it receives. The limited exchange of waters with the ocean occurs only every 5 to 6 days due to the long and narrow channel at the mouth. The waters of Havana Bay are stratified. The surface layer reaches a depth of 5 m, depending on meteorological conditions that regulate the volume of freshwater entering the system. The average salinity of this layer can decrease to 32‰, while the bottom layer has a more permanent salinity of 36‰.

The marine currents behave similarly, with surface layers flowing out and bottom currents entering into the Bay. The flow rate of these two opposing currents increases and decreases in relation to the ebb and flood of the tide. The currents reach their highest velocity during half tide, decreasing at high and low tide. This hydrological regime is a river-dominated estuary. Stratification occurs because usually the riverine flow is sufficient in producing a plume of low-density freshwater, which flows over higher-density seawater, and tides and wave power are not strong enough to mix the water column. The salinity regime varies from

Figure 21 Aerial view of Havana Bay, Cuba.
(Photo: Sciencephoto)

partially stratified to moderately stratified, depending on the influx of freshwater from the rivers. However, during dry periods and/or when freshwater supply decreases, the water column can become vertically mixed (UNDP/UNEP/UNESCO 1985).

The most important pollution source to Havana Bay is the Luyano River, which carries about 90% of the organic pollutant load to the Bay (GEF/UNDP/UNEP 1998). Other sources are the oil refinery (the main source of oil pollution), and the large volume of untreated wastewater discharged by an obsolete sewage infrastructure. Other sources of pollution in the Havana coastal waters, but which are not directly connected to the Bay, are the Almendares River (west of the city and draining the entire southwestern part of Greater Havana), and the less polluted Cojimar River, east of Greater Havana (GEF/UNDP/UNEP 1998).

Socio-economic characteristics

Havana Bay is the main port of Cuba, with 534 ha of land facilities for maritime traffic, including: 267 ha of specialised terminals; 85 ha of commercial terminals; 92 ha of navy and port services; and 90 ha designated for port development (La Rosa et al. 1998).

There is moderate to advanced mechanisation in the port, if compared to other ports of the Wider Caribbean region. It receives the waste of approximately 1 020 ships per year, of these 22% are tankers. The organisations in charge of the municipality solid wastes management are the DPSC (Havana Municipalities Services) and ERPMP (Havana Raw Materials Recovery Company). The cargo traffic is considered near to 4 million tonnes per year (Alfonso & Reiniers 1997): 46% from petroleum and its products; 24% from containers; 14% from clean grains; 7% from metals; 6% from general cargo; and 3% from dirty grains.

The socio-economic functions of Havana Bay can be described as follows:

- Havana Port with 20 000 workers.
- Industry, which use seawater in the cooling systems of thermoelectric power stations, oil refinery and fertiliser plants.
- Tourism and recreation. Havana Bay is co-adjacent to the historical city centre and Old Havana, which is listed as an UNESCO World Heritage site. Additionally, the riverbanks of the Bay provide a recreational amenity for local residents and tourists.

Institutional framework

Governance over the Bay, including the harbour operations, is the responsibility of various governmental organisations, each with specific mandates:

- The Ministry of Transport, the Ministry of Energy and the local government of the Havana province are the main organisations in control of urban planning and environmental regulations in the Havana Bay area, in close cooperation with the Ministry of Environment and Technology (CITMA).
- The National Institute for Water Resources (INRH) is responsible for hydrological and drainage studies in Cuba. The National Directory of Aqueducts and Sewage is the directorate within the INRH that is specifically in charge of sewage and drainage.
- The Ministry of Public Health (MINSAP) is responsible for the sanitary aspects of water and is concerned with the quality of piped water distributed to the population and with fighting microbial disease spreading through freshwater supplies.

The Centre of Engineering and Environmental Management of Bays and Coastal Areas of Cuba (CIMAB) is concerned with the research and control of marine pollution, and the characterisation of the environmental situation of Havana Bay and adjacent coastal areas. CITMA and CIMAB undertake an annual diagnosis of the environmental quality of the Havana Bay waters. An Integrated Plan of Environmental Management and the establishment of an environmental surveillance network was executed based upon an understanding of water and sediment dynamics, an inventory and characterisation of land-based sources of pollution, and on studies of ecosystem composition and structure.

The regional planning authority is the Group for the Integrated Development of the Capital, which operates in cooperation with the Parque Metropolitano de la Havana (PMH). These two organisations are responsible for land-use management in Greater Havana and the urban areas surrounding the Bay. PMH, in particular, regulates urban planning and the impact of tourism on the area. Although PMH only has limited resources available, it has engaged in a number of rehabilitation projects such as the 700 ha park upstream of the Almendares River, with the participation of CIDA, the Canadian development agency.

From an international perspective, there have been serious attempts at controlling the diverse effects of pollution and its transboundary effects. Many protocols and conventions have been signed over the past few years. Among the most noteworthy are:

- International Convention for the Prevention of Pollution from Ships (MARPOL 73/78).
- Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matters (London Convention 1972).
- Protocol Relating to Intervention in the High Seas in Cases of Oil Pollution Casualties (1969).
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC Convention 1990).
- International Convention on Civil Liability for Oil Pollution Damage (CLC).
- International Oil Pollution Compensation Fund (IOPC FUND).
- The Cartagena Convention (1986), which has provided the framework for fostering regional cooperation in the Wider Caribbean. Under this convention, the countries in general agreed to prevent, reduce, and control pollution from ships, land-based sources, air-borne sources and seabed activities.
- A protocol to the Cartagena Convention on the prevention, reduction, and control of marine pollution from land-based sources and activities (LBS Protocol) was adopted in 1999.

Environmental and socio-economic impacts

The severity of environmental and socio-economic impacts is related to the distribution of pollution in the Bay. The Marimelena inlet is the least environmentally damaged, although it is affected by hydrocarbons discharged by an oil refinery. The most polluted part of the Bay is the Atarés inlet, which is impacted by highly polluted pluvial drainage from the city. The centre and entrance channel receive occasional discharges from the sewer system of the city, which has an outlet to the sea to the east of the Havana Bay through the "Playa del Chivo" collector (González et al. 1997, Beltrán et al. 2000, 2001, 2002). The untreated sewage of the city also has transboundary impacts on adjacent coastal areas and the Caribbean Sea.

Environmental impacts

- Eutrophication and greater concentrations of suspended sediments cause an increase in the plankton population, a general increase in turbidity, and deoxygenated water. These factors have contributed to an observed decrease in organisms. Furthermore, as light is prevented from penetrating down, the productivity of photosynthetic plant life is reduced.
- Solid wastes harm marine species through ingestion and entanglement.

Figure 22 View of the Havana Bay from the Old Havana: The ship terminal is in the foreground and the oil refinery is in the background.
(Photo: P. Blime)

- Chemical pollution can be toxic to living organisms.
- Greater turbidity and the deposition of toxic materials in freshwater and coastal environments have modified habitats and harmed aquatic life.

Socio-economic impacts:

- The contamination of the Bay's water by industrial and chemical wastes is a major concern considering that the water is used for sanitary purposes. For example, bio-medical pollution in the Havana Bay has been so severe that authorities have been forced to close access to the waters of almost one third of the Bay.
- Solid waste pollution in bays and coastal areas has resulted in serious problems, such as damage to small vessels e.g. propeller damage, and harm to humans.
- Solid waste deposited on the beaches of Havana Bay has been particularly damaging for the region's tourism potential.
- Microbiological pollution jeopardises the quality of both the water and of the fish consumed locally and has consequently created serious health concerns (Ward & Singh 1987, Broutman & Leonard 1988, Short 1991). Studies by CITMA and CIMAB revealed zones in the Havana Bay with values of faecal coliforms above 1 000 NMP/100 ml, exceeding the Cuban National Sanitary Standard, (Norma Cubana NC:22 1999, González et al. 1997, Beltrán et al. 2000, 2001, 2002).
- Microbiological pollution is making the water unsuitable for recreational use and is deteriorating sanitation conditions around the Bay (pathogenic microorganisms).
- Sewage discharges contain bacterial, pathogenic viruses or protozoan pathogens that impact on marine organisms and human health. Disease is widespread in coastal areas where the inhabitants lack basic health protection services.
- Dredging costs have risen as a result of increased sedimentation in order that approach channels remain navigable.
- The degradation of the Luyano River from various pollution sources has significantly influenced the quality of life of a population of 140 000 inhabitants in the Luyano Basin (GEF/UNDP/UNEP 1998).

Immediate causes

The pollution in Havana Bay originates from a number of sources, particularly the Luyano River (organic and nutrient matter are the main pollutants), the Arroyo Matadero pluvial drainage (suspended solid is the main pollutant), the oil refinery (hydrocarbon is main pollutant) and food processing industries. Waste is discharged into the Bay from 53 industries, 3 small urban wastewater collectors and more than 10 pluvial drains (GEF/UNDP/UNEP 1998, Valdés et al. 2002) (Figure 22).

Discharge of port and shipping wastes

Port activity is a major source of contamination for the Bay. It is estimated that the ships served in the port generate 150 000 tonnes of refuse per year (Portela & Aguirre 2000). Ship-generated waste is cremated in the port incinerators to avoid the introduction of vectors to the country, and the residuals (ash, scum) are deposed of through the municipal sewage system.

Eutrophication

Eutrophication is caused by the nutrient enrichment of rivers and the Bay as a result of industrial and urban chemical discharges, agro-chemical run-off and increases in nutrient rich sediment. Havana Bay receives 300 000 m^3 of freshwater per day from rivers, pluvial drainages and industries, which contains 4.8 tonnes per day of nitrogenous compound and 1.2 tonnes per day of phosphorous compound (Beltrán et al. 2000, 2001, 2002). This stimulates algal blooms that have caused frequent red tides, as in July 1997, June 2001 and October 2002 (González et al. 1997, Beltrán 2000, 2001, 2002). Agro-chemicals are intensively applied in the region, which enrich aquatic systems with nutrients via surface run-off and groundwater flow. Furthermore, oil refineries produce 70% of the entire Biological Oxygen Demand (BOD) load in the Caribbean (UNEP/CEP 1998), and dredging activities release nutrients previously stored in the seabed.

Microbiological pollution

Microbiological pollution is a serious problem for Havana Bay. The immediate source of this pollution is from the discharge of significant volumes of untreated sewage. Sewage enters into Havana Bay, and subsequently the coastal environment, as settlements in its catchment area lack or have malfunctioning sewage systems. The sewage systems that do exist are often connected with pluvial drainage and therefore still enter the aquatic environment untreated (Ward & Singh 1987, Broutman & Leonard 1988, Short 1991). Sewage discharges from ships in Havana Bay create additional risks for water quality and subsequently the health of local inhabitants.

Industrial discharges

Although the countries in the region are not considered as heavily industrialised, existing industries are contributing significantly to pollution of the coastal and marine environment. There are more than 300 industrial facilities, warehouses, and workshops and some 4 000 service entities located around the Bay. 53 industrial facilities are located in the immediate proximity of the Bay, and another 84 industries produce waste that discharges indirectly into the Bay through tributary streams (Portela & Aguirre 2000). Another major polluter is the old Luyano Gas Plant, which uses outdated technology that has frequent operational failures and is based on the use of naphtha (Portela & Aguirre 2000).

The industrial wastes discharged are either untreated or without adequate treatment technologies. Wastewater from industry frequently contains dissolved salts, phenol and sulphur compounds, and toxic substances such as heavy metals and persistent organic pollutants (POPs). These are often discharged directly into the Bay and enhance the concentration of toxic substances through river draining and by atmospheric deposition (UNEP/CEP 1997, 1998).

Dumping of solid wastes

Rivers, watercourses and swamps have been converted into dumps, the solid wastes from which enter into Havana Bay. Another associated problem is the leaking of contaminates from solid wastes such as cars and other means of transportation, which leach into the ground or enter surface waters. The dumps are often located in coastal regions and the toxins are quickly washed into coastal waters via surface run-off and groundwater flow.

Land degradation

Considerable quantities of suspended sediment are transported by rivers and watercourses and introduced to the coastal areas of the region every year. Previously, geo-chemical and mixing processes regulated the amount of dissolved and suspended materials in the rivers. However, in recent years their concentrations have increased significantly as a result of increased run-off of sediments due to land degradation from land-use changes and unsustainable land-use management. Uncontrolled agricultural, forestry, urban-industrial activities, and housing developments have increased erosion, which has exacerbated the quantities of sediments entering freshwater and marine systems via surface run-off, consequently increasing the turbidity of these systems.

Hydrocarbon pollution

Hydrocarbon spills are entering aquatic systems directly, but also through groundwater seepage and by the re-suspension of sediments with historic oil contamination. The Nico Lopez oil refinery has frequent spills which used enter the sea directly, prior to the construction of a concrete barricade around the facility to prevent contamination (Portela 1998 in Portela & Aguirre 2000).

Inadequate disposal of biomedical wastes

A number of hospitals and medical centres in the periphery of Havana regularly dump their medical and biologically contaminated waste in sewage openly connected to streams flowing into the Bay. In Havana, this constitutes the most hazardous waste and needs urgent attention (GIWA Task team 2004). Medical waste disposal in the Luyano River from medical centres located in the Luyano district led to large portions of the Bay (stretching from the mouth of the Luyano River to the centre of the Bay and as far as the Ensenada de Guasabacoa), being officially prohibited for drinking, sanitary, bathing and any recreational purposes, in fear of possible human contamination. This measure has proven difficult to enforce.

Root causes

Economic

Rapid and uncontrolled economic growth

During the l970s and 1980s an exceptional increase in industrial investment and international trade led to the uncontrolled development of the Bay, with consequential environmental impacts. By the end of the 1980s, Cuban fuel imports averaged 96 million barrels annually, a four-fold increase on the average during the 1950s (CEPAL 1999 in Portela & Aguirre 2000). The sensitive ecosystems surrounding Havana port became a favoured location for the largest industrial investments, also serving as a major cargo transport system, and thus experienced the greatest severity of the associated impacts. Paradoxically, the current decline in foreign trade and industrial activity may be reducing the pollution load from these sources to the marine environment (Portela & Aguirre 2000).

Economic and political particularities

The 1963 USA trade restrictions on Cuba combined with the 30-year reliance on heavily polluting Soviet technology and the quasi impossibility of getting agricultural or industrial inputs after the collapse of the Soviet Union in 1992 has seriously impeded Cuba's ability to access cleaner and more efficient technologies. The economic restrictions have also narrowed the markets for Cuban products, and restricted investment in the country. The inflow of foreign currency to the country has therefore been limited and thus inhibited development and the access to imports.

Limited funding opportunities for infrastructure renovation

Cuba lacks the necessary funds to update the Havana sewage system and improve industrial and waste treatment infrastructure. A number of projects funded by NGOs and inter-governmental organisations have demonstrated on a small-scale that investments in waste disposal infrastructure can reduce the pollution burden on the environment.

Knowledge

Lack of monitoring and assessment

Due to the economic circumstances of Cuba monitoring, control and, to a lesser degree, assessment activities are still weak and insufficient. The general strategic problem is that although there are highly qualified personnel, there continues to be a lack of resources, and scientific activities are not integrated, with insufficient certification of laboratories (GEF/UNDP/UNEP 1998). In addition, there is limited systematic training of the staff responsible for monitoring activities in new environmentally sound technologies (Sardiñas 2001). Cuba has a considerable number of highly trained scientists who could effectively reverse environment degradation trends and reduce vulnerability, but unfortunately they are given insufficient resources and their advice is not heeded if it is perceived to impede economic growth (Portela & Aguirre 2000).

Limited public awareness of benefits of protecting the environment

The public and industry do not consider the benefits of maintaining the quality of the environment in order to remain attractive to tourists, and thereby maintaining the economic stability of the region while protecting the natural resource for future generations. In general, the public is unaware of the international implications of the pollution problem in Havana Bay. Decision-makers still lack adequate knowledge of the main problems that affect biological diversity in the territory (Sardiñas 2001).

Legal

Weak legislation and lack of compliance with regional agreements

Cuba, like many of the countries in the Caribbean Islands region, has adopted national legal instruments to control various aspects of domestic and industrial wastewater disposal to coastal and marine waters. The degree to which these legal instruments are applied in the practical management and control of environmental pollution in Havana Bay is generally limited (UNDP/UNEP 1999).

Presently, port operations are subject to weak environmental regulations that have proven difficult to implement due to the fragmented governance over harbour operations. Environmental regulations are defined by a combination of urban planning for various periods (1 year, 5 years, 25 years) and executive orders, which can cause conflict in the planning organisation of managing the future of Havana Bay, especially under the tremendous economic stress specific to the Cuban political and economic situation.

Cuba has signed several international agreements that provide a regulatory framework to be applied in national legislation. Despite these provisions, current laws and regulations lack cohesion and are often outdated and not enforceable (UNDP/UNEP 1999). Additionally, the implementation of legislation is hindered by inadequate integration between central and sectoral government institutions. Much of the existing legislation is administered by numerous ministries and agencies, and is poorly enforced (GEF/UNDP/UNEP 1998).

Although Cuba has signed the Cartagena agreement on land-based pollution, the government has allocated insufficient human and financial resources to improving environmental standards in urban zones and in the industrial sector. This has resulted in a slow progression towards meeting the obligations of the Cartagena Convention.

The problem of overlapping and conflicting responsibilities regarding the implementation of environmental law was partly addressed by the promulgation in 1997 of Law No. 81, Law of the Environment, which expresses the functions and attributions of the Ministry of Science, Technology and Environment in article 12 of the Law 81, carried out through the Environmental Policy Directorate, the Environmental Agency, the National Centre for Biosafety and the Environmental Units of the Territorial Delegations (Sardiñas 2001).

Governance

Weak institutional framework for the integrated management of Havana Bay

Management of Havana Bay is fragmented with government agencies and stakeholders specialising in a narrow framework. Urban planning, environmental regulation of industry and energy plants, and harbour operations are compartmented with government agencies having conflicting responsibilities. For example, oil transport is the responsibility of the Ministry of Energy and Cargo under the Ministry of Trade, even though legally CITMA is responsible for environmental governance and shipping operations in the Bay. The ministry gives low priority to environmental considerations compared with the drive for economic growth.

This distribution of governance is problematic for the implementation of a comprehensive approach to pollution management in Havana Bay. Although efficient in their sector, the various agencies may not have all the necessary instruments for a multi-disciplinary approach to the integrated management of Havana Bay. In most cases, the absence of a central authority for bay and coastal zone environmental management results in a weakness which prevents effective planning and management of environmental resources (GEF/UNDP/UNEP 1998). This situation has serious impacts on decision-making and results in a duplication of efforts; ineffective communication and cooperation between various departments with conflicting and competing objectives; inadequate legislative mandates; and the lack of a clear definition of environmental entities in development planning. In fact, CITMA is the only organisation with the expertise and a multi-departmental jurisdiction on all environmental and urban planning issues. CITMA is working in close cooperation with CIMAB, an organisation testing waters and monitoring hydrological changes and water quality around Cuba for both CITMA and MINSAP.

The National Port Association under the Ministry of Transportation is currently responsible for the ports of Cuba. There is an absence of a single authority that can manage and plan the cohabitation of multiple activities within the same geographical area. There is no Port Authority in Havana as is found in other countries of the region, such as Kingston in Jamaica or San Juan in Puerto Rico. Despite increasing tourism arrivals in Cuba, the harbour operations in Havana still concentrate on cargo shipping and the transportation of oil. Havana has the potential to become an important destination for cruise liners, although this is dependent on the political situation in Cuba. In addition, donor pollution control initiatives are often poorly coordinated, leading to non-optimal solutions (UNDP/UNEP 1999).

Limited stakeholder participation

Cuba's political system is highly centralised, with key decisions such as large industrial or urban development investments being made at the national level. Public participation in the design and implementation of action plans is limited (Sardiñas 2001). This discourages stakeholders from debating, communicating innovative concepts, and actively participating in the planning and implementation of projects to prevent and mitigate the threat posed by pollution in Havana Bay.

Technology

Obsolete sewage infrastructure

There are currently inadequacies in the infrastructure for the gathering, treatment and final disposal of domestic sewage. The sanitary sewer system in Havana was built over 100 years ago and has not received maintenance, reinforcement or enhancement for decades. It is unable to support the current population needs. In Havana, 64% of its 2.2 million inhabitants live in residences connected to the central sanitary sewer system, despite the system only having a maximum capacity for 600 000 people instead of the 1.4 million it currently serves (Portela & Aguirre 2000). One of the more acute problems is the illegal connection of the sewage drain to the storm drain system.

The antiquated underground network frequently ruptures, increasing the risk of epidemic outbreaks. Particularly affected areas are Old Havana, Central Havana, Cerro and some Plaza municipalities. The systems lack of capacity results in much of Havana's untreated sewage being deposited on the shores alongside the Malecon or in the Playa del Chivo beach, a highly polluted district barely half a mile east of the entrance to the channel leading into the Port of Havana (Portela & Aguirre 2000).

Urban planners have not developed sufficient sanitary services to accommodate urban population growth, leaving the peripheral of Havana deprived of sewage infrastructure. Another major obstacle to improving the situation is the lack of available resources. With the exception of Old Havana, which benefits from significant income from tourism and from its status as a UNESCO World Heritage Site, the city buildings remain old and in poor condition and would require significant investment to construct adequate water canalisation.

The sewage treatment facilities serving the city of Havana therefore need to be upgraded. The Cuban authorities are willing to invest in basic improvements to primary and secondary sewage treatment, but financial constraints inhibit their ability to enhance tertiary treatment in order to reduce the discharges of nutrients (nitrogen and phosphorus) (UNDP/UNEP 1999).

Lack of appropriate, efficient and cost effective pollution prevention technologies

The industrial zone surrounding the Bay was developed during a period when industrial growth was a priority rather than long-term sustainability and environmental protection. The technologies and processes used by industries and in energy production are inefficient and outmoded, contributing significant pollution to the Bay.

The energy industry is especially polluting in Cuba, as a result of operations run at a minimal cost with antiquated technologies, due to the country's dependence on costly foreign fuel sources. Energy providers are unable to adopt cleaner technologies due to import restrictions and a lack of available funds for investment. Energy demand has further increased by rapidly growing populations (exacerbated by the recent growth in the tourist population), which stretches the energy industry's available funds, again restricting investment, forcing continued use of the current polluting operating procedures.

There is an absence of an appropriate incentives framework, promoting environmentally sound production and consumption patterns. Despite the severe consequences of current medical waste disposal practices, there are no incentives for medical institutions to dispose of their waste in a different manner and it is difficult to obtain the necessary technologies to safely dispose or recycle wastes. The inadequate management of solid wastes (collection and transport, reuse, recycle and final disposition) has affected the landscape, ecological quality as well as modifying the habitats of the Bay (UNEP 1999a). The authority responsible for managing solid waste in Havana does not dispose of ship waste.

Conclusions

The linkages between root and immediate causes and their environmental and socio-economic consequences are presented in Figure 23.

Havana Bay, Cuba, is experiencing acute environmental degradation as a result of land-based sources of pollution. The pollution is not effectively controlled due to a lack of coordination of multiple activities in the Bay and its catchment basin. An integrated approach to environmental management is not facilitated by the absence of a coordinating mechanism between government agencies and stakeholders, which often maintain conflicting responsibilities and policies. Stakeholders are unable to participate in the decision-making process or communicate their environmental concerns. The Cartagena Convention provided a framework in order to address many of these issues, but Cuba has made slow progress in implementing its obligations. Weak institutions and poor environmental management, further hindered by a chronic lack of resources rather than scientific limitations, are the main reasons for the continued degradation of the Havana Bay. This is typical of countries throughout the Caribbean marine and coastal environment (GEFUNDP/UNEP 1998).

Sewage and waste collection and treatment systems are dilapidated and do not service the peripheral of Greater Havana. Industries employ antiquated technologies that are inefficient and highly polluting. This lack of investment in waste management services and cleaner technologies has been partly attributed to slow economic growth linked with the specific international political situation of Cuba.

In both case studies, an information deficiency has not allowed informed decision making. The enforcement of national legislation and international agreements is hindered by the lack of monitoring of shipping and land-based economic activities.

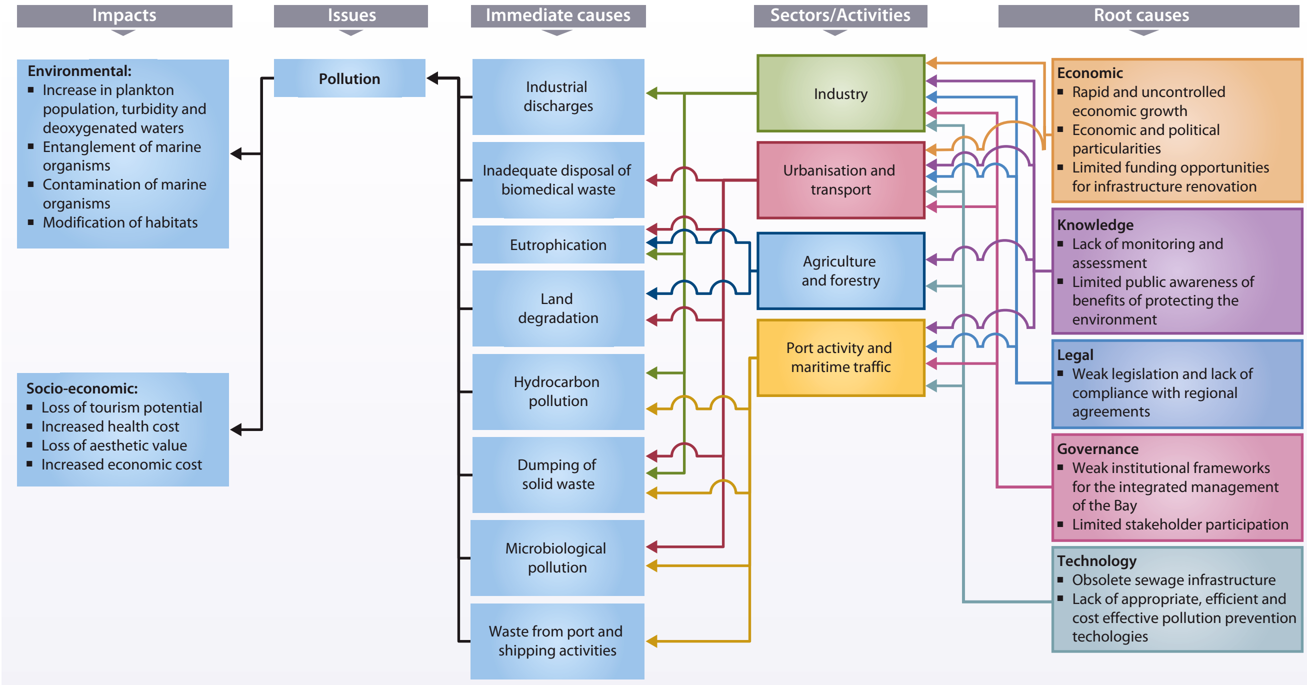


Figure 23 Causal chain diagram illustrating the causal links for pollution in Havana Bay.

Policy options will need to directly address some of the prominent root causes, such as some of the governance issues, while other root causes, such as poor stakeholder involvement need to be taken into account during the planning and implementation of policy options.

Policy options

This section aims to identify feasible policy options that target key components identified in the Causal chain analysis in order to minimise future impacts on the transboundary aquatic environment. Recommended policy options were identified through a pragmatic process that evaluated a wide range of potential policy options proposed by regional experts and key political actors according to a number of criteria that were appropriate for the institutional context, such as political and social acceptability, costs and benefits and capacity for implementation. The policy options presented in the report require additional detailed analysis that is beyond the scope of the GIWA and, as a consequence, they are not formal recommendations to governments but rather contributions to broader policy processes in the region.

In the GIWA region Caribbean Islands pollution was identified as the priority concern, originating from marine traffic and land-based sources. The Policy options section aims to describe the pollution issues that need to be resolved or mitigated, and will describe alternative courses of action that may be taken by policy-makers in the region. Each course of action will have a set of projected outcomes with the trade-offs of each action discussed. Specific policy actions are firstly evaluated for marine traffic, and then for land-based sources of pollution in Havana Bay.

Discharges from maritime traffic

Definition of the problem

Maritime traffic discharges significant quantities of pollutants, which increasingly degrade the marine environment and adversely affect the populations of the region. The causal chain analysis identified the following root causes of marine traffic related pollution:

- Geophysical and geopolitical characteristics: Intensive marine traffic in narrow channels and shallow waters.
- Economic: Due to a dependency on foreign sources of revenues; Lack of financial resources; insufficient investment in waste treatment facilities; lack of incentives to treat or dispose of waste at ports; and expansion of cruise industry.
- Knowledge: Lack of information availability; lack of monitoring of discharges; and limited public environmental awareness and education.
- Legal: Weaknesses in legislation and regulations.
- Governance: Unsustainable development strategies; lack of political commitment; lack of compliance with international agreements; and insufficient oil spill response planning and capacity.
- Technology: Lack of marine traffic control services and limited technological resources; and insufficient utilisation of recykling techniques.

Policy options will need to address some of the fundamental underlying root causes, such as the governance issues, while other more technical root causes, such as lack of waste reception facilities, can be resolved within an improved legal and management framework. It was found that marine traffic related pollution is directly associated with deficiencies in the management of ship-generated waste, which is highly interlinked with the overall difficulties with terrestrial waste management. There is a need to integrate these two waste management systems. However, the lack of available land for the construction of sanitary disposal services and objections to the practice of incineration on a large-scale has created constraints to finding straightforward solutions to this problem.

Projects executed in the region concerning pollution from marine traffic

With regards to ship-generated waste in the Wider Caribbean region, the GEF-funded Wider Caribbean Initiative on Ship-Generated Waste (WCISW) Project was executed between 1994 and 1998. This project, implemented by the International Maritime Organization (IMO), was conceived as the first phase of a long-term process to clean up and protect the Caribbean Sea. The project's objective was "to provide a regional strategy for the ratification of Annexes I, II and V of MARPOL 73/78 by the 22 Wider Caribbean countries, by providing governments with: (i) information on the legal, technical and institutional measures required; and (ii) a forum for reaching a regional consensus on the actions to be taken" (GEF/UNDP/UNEP 1999).

The project envisaged that a second phase would build on this project's results "by investing in port reception facilities, waste management infrastructure, and institutional training programs with the ultimate goal of ending discharge of all ship-generated waste into international and territorial waters of the Caribbean Sea, protecting the environmental integrity of Caribbean coastal and marine systems" (GEF/UNDP/UNEP 1999).

The Organization of Eastern Caribbean States (OECS) Ship-Generated Waste Management Project was designed to take the WCISW Project's objective through to the implementation stage in the OECS sub-region (eastern Caribbean), providing for port reception facilities, waste management infrastructure and institutional training programmes to facilitate compliance with MARPOL 73/78 Annex V. These were precisely the follow-up activities highlighted as necessary in the Implementation Completion Report (ICR) for the WCISW Project (World Bank 2003). In the Caribbean Islands region such a follow up project to the WCISW Project has not been executed.

Construction of policy options

An initial list of policy options aimed at addressing the root causes of marine traffic related pollution was developed as follows:

- Increase regional cooperation among stakeholders to review and improve the legal framework of maritime traffic and its ability to be enforced properly;
- Lobby for the Caribbean Area to be created as a "Special Area" under MARPOL Annex II (oil) and IV (toxic waste);
- Foster help from the international community and from the cruise ship industry to finance proper waste treatment infrastructure;
- Provide education and awareness programmemes to local populations;
- Register coral reefs areas as protected marine parks where anchoring is not permitted and provide means for surveillance and enforcement;
- Create national level contingency plans for marine and environmental authorities;
- Improve national and regional planning and cooperation in verifying illegal discharges from vessels;
- Finance harbour-based waste treatment facilities via a prepaid pass to all Caribbean harbours for cruise lines;
- Create incentives for investment in local recycling of solid waste materials;
- Make waste unloading a mandatory and non-payable requirement at all major harbours in the region;
- Increase involvement of stakeholders benefiting directly from the inflow of tourists;
- Review the role of tourism in ensuring the preservation of coastal ecosystems;
- Study the negative impact tourism may have on ecosystems and thus how such activity should be managed to remain sustainable.

Performance of chosen policy options

Policy option 1
Providing sufficient waste receiving and treatment infrastructure at ports

In the Caribbean Islands region there has not been a follow up to the WSISW project as there has been in the Eastern Caribbean. There is a need to provide port reception facilities, waste management infrastructure and institutional training programmes to facilitate compliance with MARPOL 73/78 Annex V (dumping of solid waste).

This policy option will follow-up activities highlighted as necessary in the Implementation Completion Report (ICR) for the WCISW Project (June 25, 1999). The option is therefore based upon the success and lessons learned from the GEF OECS Ship-Generated Waste Management Project completed in 2003 for the Caribbean countries of Antigua & Barbuda, Dominica, Grenada, St. Kitts & Nevis, St. Lucia and St. Vincent & the Grenadines (World Bank 2003).

A lack of waste reception facilities at ports was identified as a major root cause leading to the illicit dumping of wastes by ships at sea. There is an urgent need to increase the capacity of the Caribbean countries to collect, dispose, treat and recycle waste generated by shipping, particularly cruise ships, in order to reduce public health risks and protect the environmental integrity of the islands and their coastal and marine systems. This should be achieved through the improvement of ship-generated waste management facilities and facilitating compliance with the "Special Area" designation of the Caribbean Sea from 1997 for MARPOL 73/78 Annex V on dumping of solid wastes. The policy option would aim to reduce marine pollution in the Caribbean Islands region by preventing and discouraging indiscriminate disposal of waste off-shore to significantly enhance public health and environmental quality by strengthening the countries' capacities to manage effectively and dispose of waste in an environmentally sustainable manner. The project will reduce the pollution of international and territorial waters caused by ship-generated solid waste by improving the collection, treatment and disposal of such waste. Improvements in collection and disposal will ensure that ship-generated waste is properly transported and disposed of at sanitary landfills.

This will require a combined effort at the regional and at the national level to provide waste reception facilities at all harbours in the Caribbean Islands region with facilities of sufficient capacity for waste collection and storage, to receive and treat wastewater, bilge water, toxic waste and solid waste.

By providing this infrastructure, ships have the option not to dump at sea, making the discharge of wastes fully illegal without the recourse that they were unable to offload wastes at ports. The discharge and treatment of waste should become a standard practice under port authority control. The treatment of such waste needs to be economically viable for the shipping operators and enforced where necessary in order to change their attitudes and behaviours. The 'Seasonal Regional Passport' has been identified as an effective scheme that will create a funding mechanism and generate economic incentives for both the port authorities to provide waste reception facilities and for shipping operators to offload wastes onshore (see Box 3).

Box 3 The cruise line seasonal passport.

An incentive for port authorities to invest in waste treatment infrastructure would be to create a Caribbean wide cruise ship "Caribbean Cruising Passport" (CCP) that would be sold at the beginning of the season and would allow access to a number of installations and harbour hosted facilities, including the treatment of their waste. This passport would allow the ports to receive income at the beginning of the season and therefore reduce the risk posed by the stability of international politics on the volume of tourists in the region – thus shifting the level of risk factor from the port authorities to cruise ship operators. Only a fraction of the port operations would be pre-financed and other facilities would still generate profits (recreational facilities, hotels, etc.).

Port authorities, rather than applying the polluter pays principle, may find that by cooperating and establishing a joint initiative such as the passport scheme, with a number of prepaid services such as waste discharge and treatment, they will not reduce the profitability of their operations, but will encourage cruise operators to cease discharging wastes into coastal waters. The charge for an annual passport and the mechanism for distributing the revenues received from the scheme would need to be determined in consideration of many parameters. However, the advantages of such a system would be the following:

- It would reduce the incentives for ships to dump their waste at sea;
- It would help finance the required infrastructure to treat waste and extend harbour capacity;
- It would create a de facto partnership between cruise lines and port authorities and facilitate dialogue on environmental issues;
- It would harmonise port charges around the region and eliminate price wars aimed at attracting more cruise operators to dock at specific destinations and would instead shift competitive differentials to the added value a port authority can offer the tour operators;
- It would provide some economic security for port authorities from fluctuations in international tourism markets.

The consideration lessons learned by OECS Ship-generated waste project (World Bank 2003) are taken into consideration when performing this policy option.

Political and legal framework

A legal framework to create and govern the operation of entities responsible for waste management and to define their relationship with government will ensure effectiveness of the policy option. The legal framework of the countries in the Caribbean Islands region may need to be updated to integrate waste management legislation, through for example, the enactment of a ship-generated waste bill. Ship waste management authorities may need to be created in countries that do not have sufficient institutional arrangements to implement the policy option.

Political feasibility (stakeholder analysis)

Any solution to the dumping of waste at sea would be jeopardised without the broad agreement and active participation of all countries in the Caribbean Islands region. Regional cooperation between port authorities and uniform implementation is necessary regarding the regulation, charging and practices for waste collection and treatment, so that a port's competitiveness is not jeopardised. For example, if a polluting port does not provide waste reception facilities, it will have an unfair competitive advantage over ports that insist that waste collection and treatment is payable and mandatory.

Figure 24 Cruise ships at the seaport of Nassau along New Providence Island, Bahamas.
(Photo: Corbis)

Regional agencies and other international agencies and donors, therefore need to work with the governments of the region, to assist in developing a coordinated strategy for ship-generated waste management at the regional and national levels. Regular meetings between stakeholders will assist in achieving regional coordination.

A lesson learnt from the OECS GEF project is that joint procurement can provide benefits, including economies of scale, harmonisation, speed of processing documentation, and efficient use of limited human and financial resources. However, experience in this project suggests that these benefits must be balanced with specific country concerns, situations and capacities. Another lesson learnt was that to achieve regional success in addressing ship-generated waste, flexibility and a realistic timetable should be employed when dealing with the multiple countries of the Caribbean Islands region, with varying development capacities and needs (World Bank 2003).

Port authorities need to have necessary incentives to encourage them to invest in waste reception facilities, as they are capital intensive and are not seen as profitable (see Root cause: Lack of investment in port waste reception facilities). If the ports are able to receive profits from the passport system they will be encouraged to develop waste reception facilities and enforce the application of the initiative.

Regulations aimed at cruise line operators are difficult to enforce at sea and cruise ships are reluctant to use waste reception facilities voluntarily due to their cost, and therefore to influence their practices it is recommended that a combination of financial incentives and stringent environmental regulations be employed. If the treating and recycling of waste is made cost-effective, the cruise operators will be encouraged to use facilities.

Administrative feasibility

In accordance with the WSSD Plan of Implementation paragraph 60 c, support should be provided to small island developing states to develop capacity and strengthen "efforts to reduce and manage waste and pollution…" (WSSD 2002). International organisations, such as the GEF may be able to finance waste treatment infrastructure.

The design of a project for this policy option should take into account the flaws of the OECS GEF project. For example, the project design provided funds for the purchase of equipment to manage ship-to-dock waste collection and transport. This effectively took over an existing and functioning private sector activity, without any consideration of the future role of the private sector. The system for collecting waste and transporting it by barge from shipside to dock was also not adequately designed, with limited attention paid to financial viability and capacity (World Bank 2003).

Pre-project design studies and evaluations must be undertaken by persons/firms who are not only competent in the technical content but who are also aware and sensitive to local nuances and local socio-cultural and political conditions. Project design and implementation also needs to take into account countries that are made up of multiple islands of different size, capacity and development needs.

There should be formal agreements with the port authorities or relevant authorities regarding the roles and responsibilities for collecting and disposing of ship-generated waste.

Cost recovery mechanisms can be used to minimise government subsidies, by securing payment for waste facilities from shipping and cruise line companies. By creating an easily enforceable permit such as the seasonal regional passport, ships would not have any incentive to evade waste reception facilities at harbours since they have already paid for the service. National governments will therefore avoid expenditure on surveillance and monitoring at sea. Lastly, the passport would generate revenues to cover costs of operation.

Efficiency

This policy option will create incentives for port authorities to invest in waste receiving and treatment infrastructure and also for cruise ships to use the facilities. This will consequently address the current deficiencies in ship-generated waste management. It is anticipated that such action will lead to a reduction in waste being discharge into the waters of the Caribbean Islands region without affecting the competitiveness of ports receiving cruise ships and other vessels.

Significant investment will be required in order for port reception facilities to be of an adequate standard and to ensure human resources have the necessary technical skills for maintenance and repair. The costs of collecting, treating and disposing of wastes within an integrated waste management system will also be considerable. However, the proposed passport system could provide a mechanism for the ports to receive a return on their investments. The subsequent improvements in environmental quality will increase the productivity of key economic sectors, particularly tourism and the fisheries. It is anticipated in the medium to long-term the policy option is economically efficient.

Policy option 2
Strengthening political and legal instruments: Regulating discharges, spills and accidents

The intensiveness of maritime traffic near the shores of most Caribbean islands (see Root cause: Geophysical and geopolitical characteristics) makes it imperative to have effective legal tools in order to regulate their activities and minimise the impacts on the region's populations and ecosystems. This policy option directly addresses the root causes of weaknesses in legislation and regulations, and also the lack of compliance with international agreements regarding marine pollution from shipping. The strengthening of legal frameworks, essentially at the national as well as the regional level, combined with the means of enforcing these regulations (see Policy option 3) will place tighter controls on the shipping industry and give enforcement agencies greater indictment powers. Misdemeanours towards the marine environment should no longer continue in Caribbean waters unchecked. Many ship-generated sources of pollution are the result of deliberate actions, perhaps indirectly due for example to inadequate facilities, but still knowingly permitting the pollution of ecosystems. It is the responsibility of governments to send the right signals to polluters on their determination to eradicate illicit dumping at sea.

National maritime legislation should be based upon MARPOL 73/78 which has been adopted by all the nations of the region. However, there are concerns regarding the applicability of Article 4 of the convention, which stipulates that violations and offences should be prosecuted under the jurisdiction of the Flag State (meaning Liberia or Panama in most cases) i.e. not the state where the pollution incident occurs. With an increasing number of maritime environmental accidents around the world, perhaps coastal states should have some jurisdiction. In practice, MARPOL Article 6 requires the cooperation of all involved parties to resolve the violation issues. The coastal state should thus, in theory, be able to fine polluters, however this needs further investigation and clarification.

If Article 4 does infer that countries victim of environmental accidents cannot receive compensation, it is suggested a revision to Article 4 should be called for at the international level. The countries of the Caribbean Islands region also have the option to create an exclusive economic zone with its own legislation on water. National territorial waters can be unified under a homogenous jurisdiction, such as in the EU or the United States. MARPOL violating boats will therefore, to avoid prosecution, have to commit their offences outside territorial waters, which will greatly reduce the impact of maritime pollution on coastal ecosystems.

If MARPOL Article 4 allows countries to fine offending vessels, national governments should include maritime waste disposal in their registry of prosecution and heavily fine violators. National laws should also apply to the local fleet. This legal framework, should it be enforced, would allow a realignment of the economic balance between polluters and the polluted and provide necessary funding for recovery, clean-up, prevention, inspection and monitoring operations. If MARPOL Article 4 does not allow national governments to fine violating ships, they are powerless to regulate polluting vessels in their territorial waters. If national law is very specific about the penalties for waste dumping in Caribbean waters and that national institutions show their determination to enforce such law, most vessels will be deterred from infringing regulations.

Political and legal framework

This policy option proposes making a legislative framework to effectively control the shipping industry and give enforcement agencies greater indictment powers. Policy option 3 addresses the enforcement institutional weaknesses in order that the enhanced legislative framework can be effectively implemented.

Political feasibility (stakeholder analysis)

There may be difficulties amending Article 4 of the MARPOL convention, as many nations will be reluctant to change an otherwise relatively effective international agreement. The governments of the Caribbean Islands region may be disinclined to invest in enforcement agencies to effectively police the shipping industry, so as not to detract potential shipping companies from using their ports (See Root cause: Foreign dependency). However, the potential economic benefits from fining polluting vessels may provide an incentive for these nations to enforce international maritime law. There may be dissatisfaction within the shipping industry if national governments, other than their flag state, are given prosecuting powers. There would be concern that the judicial procedures of these countries would give an unfair hearing.

Administrative feasibility

To justify legislative changes there needs to the necessary infrastructure at ports adequately collect, treat and dispose of ship-generated wastes. Shipping companies also need appropriate incentives, other than regulatory mechanisms, to encourage them to voluntarily use waste reception facilities, so as to avoid resentment and instead foster partnerships between shipping and port authorities regarding the control of pollution.

Since the responsibility of enforcing the MARPOL and Cartagena conventions is given to national governments, they should also be the main provider of financial support for such operations. Nevertheless, governments have not allocated sufficient funds for the implementation of necessary enforcement instruments due to economic constraints and environmental issues being given a low priority in their political agendas. By applying the polluter pays principle, a small enforcement force could fine polluters and thus generate revenues, which in turn would finance its expansion. However, governments will have to resist corruption and not redistribute the funds to other governmental activities.

Efficiency

This policy option should address many of the weaknesses in regulations and legislation identified in the causal chain analysis, by giving more power to nations to prosecute vessels polluting in their territorial waters. It will strengthen the legislative framework provided by MARPOL 73/78 Annex V in order to place further pressure on the shipping industry to dispose of their waste in a responsible and appropriate manner, whilst ensuring they minimise the risk of spills and accidental release of contaminants from their vessels.

Legislation will not alone prevent ships from polluting the Caribbean Sea, and although the countries of the Caribbean Islands region will have more power to prosecute offending vessels it is unclear whether they would take advantage of new legal instruments. In addition, stricter legislation may increase the reluctance of the shipping industry to cooperate with environmental initiatives.

Policy option 3
Strengthening of institutions responsible for enforcement of maritime regulations

Appropriate enforcement of laws and conflict resolution mechanisms are needed, in order to fulfil the objectives of maritime environmental legislation. There has been a failure to enforce legislation due to corruption and the misuse of enforcement powers, which often leads to mistrust and poor relationships with the public, and consequently a lack of cooperation (see Root cause: Weaknesses in legislation and regulations, and lack of compliance with agreements). There is a need to build capacity in enforcement agencies to tackle these fundamental problems, through training programmes and the acquisition of appropriate staff and technologies. Once these agencies have adequate capacity they will be able to ensure strict adherence to legislation. For example, increased monitoring will reduce the falsification of oil record books and ensure onboard pollution control and monitoring devices are operational and fully maintained in accordance with MARPOL Annex I (oil or bilge dumping) or Annex V (waste discharge).

There are a variety of surveillance techniques that can be employed to detect pollution offences. Most oil discharge violations are detectable if the oil is at concentration higher than 15 ppm, which is the maximum allowed by MARPOL. The detection can be made by airplane, coastal towers, or by observing the oil slick in the wake of vessels from another boat. These techniques require a significant budgetary allocation that has not been received to date. More recent techniques involving satellite observations are more reliable. Satellites can give real-time imagery in order to identify the nature, quantity and extent of the waste being discharged from a boat, track escaping boats and record in video the timing and length of the discharge. Access to the paid services of the observation satellites by the countries of the Caribbean Islands region or by a regional organisation would allow effective and timely detection of pollution offences and accidental spills, at a lower premium than other techniques. These technologies can provide evidence that can be used when prosecuting MARPOL violating vessels, and its efficiency will subsequently deter other polluters.

Regional cooperation in enforcing Annex I, IV and V of MARPOL 73/78 (oil pollution, oil discharges, waste discharge) will bring mutual benefits for every country in the region, due to the transboundary nature of marine pollution. Regional enforcement of the convention will prevent ships violating the convention avoiding enforcement agencies. A regional approach would also facilitate multi-lateral exchange of information on recorded violators, through basic technologies such as a regional database. Such stringent and integrated management would make it difficult to evade prosecution and would be extremely dissuasive of any attempt to violate the agreement.

Although no large-scale enforcement agency is foreseen in the near future, the establishment of an organisation to facilitate coordination between the various enforcement bodies of each nation would ensure greater integration. Prior to integration, national maritime enforcement agencies should enforce regulations within their own territorial waters.

Political and legislative framework

Currently, the nations of the Caribbean Islands do not have the power to prosecute a vessel from a flag state outside of the region and therefore have little incentive to pursue offending vessels. The strengthening of the regulatory framework, as outlined in Policy option 2, will therefore need to complement this policy option.

Political feasibility

Government commitment to enforcing maritime regulations may prove difficult to maintain, as the environmental, economic and health benefits that will be achieved by reducing ship-generated pollution will only be realised in the long-term. The enforcement agencies may be reluctant to accept institutional reforms and unwilling to utilise new technologies. A regional organisation may be interested in utilising satellites to improve coordination and environmental monitoring in the region. The region's countries will have access to pollution monitoring satellite technologies whilst benefiting from economies of scale and cost-efficiency.

Administrative feasibility

The countries of the Caribbean Islands region lack the funding, the training and the technology to efficiently monitor MARPOL violations (see Root cause: Limited technological resources). However, an enforcement agency may use the fines paid by offending vessels to become self-sustaining and finance its own expansion, and eventually acquire capabilities to enforce maritime law beyond national territorial waters. However, strengthening the enforcement agencies may prove difficult whilst corruption is prevalent, and as a result investments may not achieve their intended objectives.

An appropriate organisation would need to be identified or created to coordinate any regional initiative. Coordination may prove problematic due to the multiplicity of the various maritime enforcement agencies and their differing procedures and abilities. In many countries there is an absence of such agencies.

Efficiency

The strengthening of institutions responsible for enforcement of maritime regulations will ensure vessels navigating the waters of the Caribbean Islands region, abide by international maritime law. In strengthening the capacity of enforcement agencies there will be greater monitoring of illegal discharges.

There would need to be significant investment in pollution surveillance equipment in order to adequately monitor pollution. For example, satellite services although very effective, are nevertheless expensive and it would make more sense that such services be negotiated in bulk and made available to a larger number of countries with the same concern. However, despite considerable initial investments, capital raised by fining offending shipping companies make the policy option economically feasible in the medium to long-term.

Pollution in Havana Bay

Definition of the problem

The GIWA assessment, in accordance with previous UNEP-sponsored assessment programmes (e.g. UNEP 1999b), identified land-based activities as the primary source of coastal pollution and destruction of coastal habitat such as coral reefs and mangroves. Havana Bay, Cuba, was identified as a location particularly degraded as a result of land-based sources of pollution.

The Causal chain analysis identified the root causes of water pollution in the Havana Bay as:

- Economic: Rapid and uncontrolled economic growth; trade restrictions have narrowed the market for Cuban products and restricted investments in the country; limited funding opportunities for infrastructure renovation.
- Knowledge: Lack of monitoring and assessment; limited public awareness of benefits of protecting the environment.
- Legal: Weak legislation and lack of compliance with regional agreements.
- Governance: Weak institutional frameworks for the integrated management of Havana Bay; limited stakeholder participation.
- Technology: Obsolete sewage infrastructure; lack of appropriate efficient and cost effective pollution prevention technologies.

Policy options need to address important organisational, structural, managerial, and political failures that have led to poor planning, limited access to technology and equipment and a lack of resources available for enhancing the Bay environment. The absence of sewage disposal services and treatment in all the countries in the Caribbean Islands region is a key priority needing urgent attention.

Due to the magnitude of the pollution problem and the circulation by marine currents, the problem of pollution in one bay becomes the transboundary problem of a much larger region. Management has traditionally not considered the transboundary nature of pollution, and subsequently mitigation initiatives have focused on addressing domestic impacts, rather than those occurring outside of national jurisdictional limits in international waters. There is a growing realisation of the negative externalities imposed by the release of transboundary contaminants, and the value to the region of demonstrating national approaches to the mitigation of these contaminants. Cuba, like other countries in the region, is seeking to introduce abatement programmes for these pollutants (GEF/UNDP/UNEP 1999).

The Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean region (UNEP 1983) provides a legal framework to address transboundary pollutants. Under Article 4, parties are invited to, individually or jointly, take measures "to prevent, reduce and control pollution and ensure sound environment management". Although this agreement provides a framework to tackle transboundary pollution, Cuba lacks the capacity to implement and enforce its obligations.

Governmental initiatives aimed at addressing land-based sources of pollution in Havana Bay

At the regional level, a protocol to the Cartagena Convention on land-based sources of marine pollution (LBS Protocol) was adopted in 1999. The contracting parties to the Convention have utilised various studies on contamination in the Wider Caribbean in developing this protocol, with an aim towards regulating the sources most impacting the Wider Caribbean region. The main body of the LBS Protocol sets forward general obligations, institutional responsibilities, and procedures for acceptance and ratification. Specific technical annexes establish priority source categories and activities and contaminants of concern in the convention area; factors to be used in determining effluent limitations; and management practices, and specific obligations applicable to specific pollution sources in the region. The LBS Protocol also obligates the signatories to develop national plans to implement best management practices for non-point sources and to implement coastal zone management programmes. Cuba has not ratified the Protocol.

The Cuban government has also demonstrated its commitment to reversing degradation trends in Havana Bay through the implementation of a series of initiatives aimed at addressing contamination problems in the Bay. The most significant activities may be summarised as follows (GEF/UNDP/UNEP 1999):

- A pollution-intensive old alcohol distillery has been deactivated;
- Construction of sewage treatment plants in the Quibu River Basin and the Almendares River Basin;
- The design of a new submarine outfall in Playa del Chivo;
- Plans for the management of solid wastes and oil spills in Playas del Este;
- Construction of a ship waste incinerator;
- Supply of equipment for the port cleaning unit, including oil skimmers and barges for liquids and solids;

- Construction of a solid waste trap to clean the Luyano River;
- Planning and design of waste treatment plants for the Luyano and Martin Perèz river basins, and the Tadeo stream;
- Design of a solid waste management system for Havana Bay;
- Design of a comprehensive management system for solid and liquid ship waste.

Additionally, in 1998 the Cuban Government established a Governmental Working Group concerned with sanitation, conservation and development in Havana Bay. The group is chaired by the Ministry of Transportation and the Government of the City of Havana and the Ministry of Science, Technology and Environment are vice-chairs. This group are acting as a port authority until the new rules and regulations are approved. (GEF/UNDP/UNEP 1999). Cuban environmental protection and biodiversity projects are financed by the National Fund for Environment created following the promulgation of Article 67 of the Law of the Environment and in the Joint Resolution No. 1/99 of the Ministries of Finances and Prices and of Science, Technology and Environment (Sardiñas 2001).

Major projects executed in Havana Bay

Most of the projects implemented so far have been initialised by the Cuban Government and funded by either GEF, development agencies of foreign governments (such as Canada's CIDA) or NGOs. Projects in Havana Bay regarding urban and water rehabilitation include:

Planning and Management of Heavily Contaminated Bays and Coastal Areas in the Wider Caribbean

This programme was implemented in 1998 by UNDP with GEF funds in cooperation with the governments of Colombia, Costa Rica, Cuba and Jamaica. The Cuban component of the project included an assessment phase and an initial phase of clean-up that included treatment, dredging, solid waste removal, monitoring and capacity building. This project was expected to last for 15 years but became the project Demonstration of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean.

Demonstration of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean

This GEF-UNDP project is a follow up to the Pilot Phase PRIF project called Planning and Management of Heavily Contaminated Bays and Coastal Areas in the Wider Caribbean. The project sites are Havana Bay (Cuba), Puerto Limon (Costa Rica), Cartagena Bay (Colombia) and Kingston Harbour (Jamaica). As a follow-up to the PRIF and ongoing baseline, the GEF project is leveraging national co-financing to help Cuba and Jamaica overcome a number of key barriers to the adoption of best practices that limit the contamination of their national and adjacent international waters. The project is implementing demonstrations/pilot projects to test innovative technical, management, legislative and educational approaches for reducing the input of priority international waters contaminants, the nutrients nitrogen and phosphorus, to Havana Bay, Kingston Harbour and the adjacent Wider Caribbean. It will further strengthen and/or help create new institutions responsible for the rehabilitation and sustainable management of the two bays (GEF/UNDP/UNEP 1999).

Luyano River Water Treatment Project

The Cuban government, UNDP and GEF are currently running a rehabilitation project around the Luyano River, which includes the construction of a wastewater treatment plant. As part of the initiative, the Government of Norway is providing funding through UNDP for construction of "zero emission" homes near the Bay that release no pollutants. UNDP has supported ongoing efforts to clean up the Bay since 1994. The Government of Belgium has also provided funding for the clean up through UNDP, and Japan is also considering making a contribution.

Revitalisation of the Metropolitan Park of Havana (Parque Metropolitano de la Habana)

This joint Cuban-Canadian initiative involved the planning, implementation, monitoring and evaluation of one of Havana's largest environmental projects. The project, which ran from 1995 and was completed in 2002, aimed to revitalise a 700 ha area around the lower basin of Almendares River, a large urban river highly polluted by industrial dumping, solid waste and sewage discharges, and sedimentation caused by deforestation. Using community-based strategic planning approaches, the project engaged civil society in planning and built local government-community partnerships for implementation as well as authority strengthening. The Canadian International Development Agency (CIDA) was the main funding partner for this project. The Canadian Urban Institute, the Cuban Group for the Integrated Development of the Capital and Oxfam in Canada and in Belgium were the main implementing organisations (Canadian Urban Institute 2003).

Construction of policy options

An initial list of policy options aimed at addressing the root causes of pollution in Havana Bay was developed as follows:

- Create a Port Authority in Havana Bay with governance and executive powers over the enforcement of land use and environmental regulations around the Bay;

- Monitor environmental concerns and development around the Bay;
- Undertake a comprehensive assessment report on sewage contamination;
- Import sewage treatment technology and appropriate training with assistance from international organisations;
- Disseminate information and establish awareness campaigns on bay environmental issues;
- Strengthen the legal framework regulating medical waste management in order to promote appropriate medical waste disposal;
- Import cleaner industrial processes and technologies;
- Strengthen the framework regulating industrial operations by introducing new and enforceable environmental standards;
- Investigate the use of recycling technologies to be employed by waste management in Havana;
- Construct a plan of action for the full implementation of the Cartagena Convention;
- Investigate a possible taxation scheme for the tourism industry to contribute to the financing of waste disposal infrastructure in Havana;
- Create a board of stakeholders and experts to discuss issues and make recommendations regarding the management of activities in the Bay. The Board will issue recommendations to: (i) the Port Authority (if created); (ii) the Havana district government; and (iii) the national government.

Performance of chosen policy options

Policy option 4
Create a Havana Port Authority

There is a need to develop and strengthen national environmental institutions responsible for the management of the Havana Bay (GEF/UNDP/UNEP 1999). There is currently a fragmentation of responsibilities that makes coordination dificult and there is no organisation that can oversee the rehabilitation of the Bay (see Root cause: Weak institutional frameworks for the integrated management of Havana Bay).

This policy option would create a Havana Port Authority through the merger of the various managerial and regulatory organisations concerned with the management of the Bay. The Authority would have political power and authority over existing institutions involved in the rehabilitation of Havana Bay. The new inter-institutional organisation should contain relevant stakeholders and can become the focal point for communications with funding and implementing organisations, and to serve as liaison on the technical aspects of the implementation of the LBS Protocol. The Port Authority should support Cuba's national action programme aimed at reducing contamination in the Bay.

The Authority would be entrusted with environmental control and sustainable development of the Havana Port, facilitating an integrated approach, in order to prevent sector domination in the administration of environmental initiatives. Stakeholders in the management of the Bay should be encouraged through the Authority to develop environmental awareness, necessary skills and capabilities, in order to improve the environmental management of Havana Bay. Unifying governance over harbour operators under a single Port Authority would create more incentives to reduce environmental degradation caused by shipping operations in the Bay. It would also be liable to protect environmental standards and responsible for monitoring, managing and planning all activities in and around the Bay. The organisation once established will be able to effectively plan and coordinate projects aimed at reversing the environmental degradation trends in Havana Bay.

Legal and institutional framework

Legislative and regulatory changes may be necessary to enhance the coordination of institutional mechanisms. Recommendations will be needed regarding changes in existing legislation to enhance the integration and coordination of the relevant institutions, projects and programmes concerned with rehabilitating Havana Bay. The policy option should be implemented in accordance with the Cartagena Convention and its protocols.

Political feasibility (stakeholder analysis)

The Government of Cuba has demonstrated its commitment to protecting the natural environment, including coastal and marine ecosystems by enacting policies, strategies, and programmes to mitigate the negative impacts of pollution. It has placed a high priority on implementation of the Caribbean Action Plan, and, as a sign of commitment to regional action, has ratified the Cartagena Convention but not the LBS Protocol. However, there is a risk that the government may not realise the long-term benefits of an integrated approach and that stakeholders are not actively engaged.

Consultations should be undertaken with relevant stakeholders during the planning and development of a new Authority. The institutional framework will be strengthened by involving the different stakeholders in constructive discussions and through establishment of appropriate incentive structures. Information about the policy option should be disseminated to stakeholders and the public. However, the participation of stakeholders may prove problematic given Cuba's highly centralised political system, with key decisions traditionally made at the national level.

Administrative feasibility

The policy option would require financing from funding agencies, such as the GEF, as well as from Cuba in kind. An implementing agency and focal point for the planning and implementation of the policy option would need to be identified. Such a policy option would require significant investment for necessary infrastructure, technical staff and training costs. The Port Authority could operate under both the Ministry of Transport and the Ministry of Environment (CITMA).

Strategic planning studies should be used to ascertain the functional structure, training, adequate management necessary for the successful creation of the Port Authority. Assessments will need to determine the precise linkages between environmental and socio-economic systems, which the design and planning of the newly formed Port Authority can be based upon.

Efficiency

This policy option primarily addresses the root causes of weak institutional frameworks for the integrated management of Havana Bay, but will also act as a focal point for the implementation of international agreements (partly addressing Root cause: Weak legislation and lack of compliance with regional agreements). Additionally, the creation of the Authority will facilitate stakeholder involvement (see Root cause: Lack of stakeholder participation). The main objective will be a strong national environmental institution responsible for management of the Havana Bay.

The creation of a new institution is often costly and logistically challenging. However it is anticipated, that these costs will be justified by the resultant environmental and economic benefits.

Policy option 5
Develop sewage treatment and collection infrastructure

Local authorities should be actively encouraged to fully participate and implement future sewage infrastructure improvements, based upon the demonstrations and the success of the sewage treatment plant, constructed as part of the GEF project entitled "Demonstrations of Innovative Approaches to the Rehabilitation of Heavily Contaminated Bays in the Wider Caribbean" (GEF/UNDP/UNEP 1999). The treatment technologies used in the GEF project could be modified as necessary, and may be replicated in other districts of Havana Bay. Future sewage treatment plants should be designed and operated in accordance with the Global Programme of Action for Land-based Activities (GPA) and any regional standards adopted by the Contracting Parties resulting from adoption of the LBS Protocol to the Cartagena Convention. Improvements in the environmental status of Havana Bay can be achieved by building upon the GEF project by transforming it into a national or regional programme.

The World Summit on Sustainable Development (in Johannesburg 2002) identified the special needs of Small Islands Developing States (SIDS) within its Johannesburg Plan of Implementation. Section VII which included a recommendation to "Provide support to Small Island developing States to develop capacity and strengthen efforts to reduce and manage waste and pollution and building capacity for maintaining and managing systems to deliver water and sanitation services in both rural and urban areas" (WSSD 2002).

In the SIDS situation it is frequently not realistic to try and develop a centralised sewage treatment system. The capital cost of such a system is high and the maintenance is intensive and expensive. In Cuba, the obsolete domestic sewage system makes it difficult for it to be directly linked up to a central system. There are feasible and cost-effective alternatives, which can be developed on a community-by-community basis that, are very simple to maintain. The technology for this is also highly applicable to individual resorts and hotels (GEF 2004b). These approaches and mechanisms, once developed and proven, could be of tremendous advantage to other countries in the Caribbean Island region with similar problems. Cuba has several ongoing development programmes for alternative, environmentally sound technologies related to wastewater treatment. Demonstrations of more sustainable and cost-effective technologies, which are expected to be applicable to other countries in the region, are urgently needed (GEF/UNDP/UNEP 1999).

Legal and institutional framework

The implementation of the GEF project was the responsibility of the Ministry of Science, Technology and Environment, through its Delegation for the City of Havana, and coordinated all the activities with the Council of Administration of the City of Havana and other involved institutions, including the National Institute of Hydraulic Resources, the Ministry of Transportation, and the Port Authority of Havana (GEF/UNDP/UNEP 1999). If Policy option 4 is developed, the newly formed Port Authority will have the institutional capacity in environmental management to implement the policy option in cooperation with the above institutions, which will now have greater capacity following the completion of the GEF project. The policy option should be coordinated with and fulfil the relevant articles and protocols of the Cartagena Convention.

Political feasibility (stakeholder analysis)

The Government of Cuba has demonstrated its commitment to addressing pollution from the discharge of domestic sewage. It is anticipated that the government would wish to improve its sewage system further. There may be conflicts among institutions/stakeholders of various national and local authorities. However, Cuba does not have any major political conflicts.

Public education and awareness campaigns will be necessary to ensure the public are motivated to participate in such a project. The inclusion of stakeholders in the design and implementation of the policy option would ensure the longevity of the project. The demonstration already undertaken by the GEF project included a high level of stakeholder participation, and disseminated information to the public and relevant stakeholders.

Administrative feasibility

Cuba does not possess the necessary financial resources to implement such a policy option. There will be a need for international funding. Appropriate technologies should be employed which require low equipment and high labour, while still utilising a commercial technology for sewage treatment plants with nutrient removal. The increasing tourist revenues anticipated from the improved conditions in the Bay may act as an incentive for the government to invest in further sewage treatment works.

Project activities should be constantly reviewed and effective information exchange of experience and know-how from the GEF sewage treatment works and the new sewage infrastructure developments proposed in this policy option. In accordance with Article 7 of the LBS Protocol, an Environmental Impact Assessment should be undertaken during the planning and implementation of any project.

Efficiency

This policy option primarily addresses the root causes of obsolete sewage infrastructure and the lack of appropriate efficient and cost effective pollution prevention technologies. It will also encourage stakeholder involvement and increase the public profile of environmental issues and demonstrate the benefits that can be achieved by controlling pollution. Ultimately the policy option will reduce the quantities of untreated or insufficiently treated domestic sewage entering the Havana Bay, in order to improve the environmental quality and health status of the Bay, and to limit the contribution it makes to the pollution load of the waters of the Caribbean Islands region. Such a sewage infrastructure project would require considerable financing, but it is anticipated that there is an urgent need to address this pollution issue.

Figure 25 View of Havana Bay.
(Photo: CIMAB)

Policy option 6
Converting industries to environmentally sound technologies

This policy option is based on guidelines made by the UNEP International Environmental Technology Centre (UNEP/IETC 2003).

This policy option aims to promote to industries the adoption of Environmentally Sound Technologies (ESTs) to significantly improve the environmental performance relative to technologies currently employed in Greater Havana. By employing ESTs industries will reduce their contribution to the pollution of Havana Bay and its inflowing rivers including the Luyano and Martin Perez rivers. In addition these technologies will allow industries to use resources in a more sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. As stated in Chapter 34 of Agenda 21, ESTs protect the environment, are less polluting, use resources in a sustainable manner, recycle more of their wastes and products, and handle all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes (UNCED 1992).

ESTs in the context of pollution are process and product technologies that generate low or no waste, for the prevention of pollution. They also cover end of the pipe technologies for treatment of pollution after it has been generated. Encouraging the adoption and use of ESTs would require a combination of voluntary approaches and a regulatory framework that fosters both innovation and environmental accountability. The Cuban government would have to enact policies that lower the costs and stimulate a demand for ESTs, in order for industries to adopt such technologies.

The World Summit on Sustainable Development (WWSD 2002) identified the special needs of SIDS within its Johannesburg Plan of Implementation. Section VII which included a recommendation for the international community to transfer environmentally sound technologies and provide assistance for capacity building. Additionally, at an Inter-Regional Preparatory Meeting (The Bahamas, January 2004) leading up to the Review of the Barbados Programme of Action for SIDS (BPoA +10) a primary need of SIDS was that the international community should provide support to SIDS for the development, transfer and implementation of appropriate technologies.

This policy option could be designed and implemented by CITMA, the Municipality of La Havana and the Havana Port Authority. Such programme would include an awareness campaign aimed at industries to give them the opportunity to convert on a voluntary basis and at the local population of Havana Bay, so that greater pressure is placed on industry to convert to cleaner technologies. The programme would be targeted at industries such as energy, cargo transport, food processing, paper, and medical centres.

Legal and institutional framework

Cuba's ability to access cleaner and more efficient technologies has been hindered by a reliance on highly polluting Soviet technology for 30 years, and US economic restrictions (See Root cause: Economic and political particularities). There is also reluctance from industries to adopt cleaner technologies on a voluntary basis, due to the economic costs involved.

Therefore legislation and incentives may be required to ensure industries are financially able to adopt these technologies and that they are available to import. To guide this process, actions are urgently needed to establish policy objectives and priorities within a strategic framework which are supportive of environmentally sound technologies, ultimately leading to their adoption and use. Policy measures should consider a mix of approaches to motivate action and penalise inaction within an overall policy framework that considers both positive and negative drivers for voluntary action.

The Cuban government has already established economic mechanisms for the prevention of pollution through the Law of the Environment in its Chapter IX, Articles 61 to 64, and in accordance with it, Resolution No. 13.99 of the Ministry of Finances and Prices was promulgated. This Resolution establishes the reduction or exemption from duties on the import of technologies and equipment for the control and treatment of polluting effluents (Sardiñas 2001).

Political feasibility (stakeholder analysis)

The Cuban government has demonstrated its commitment to promoting the use of environmentally sound technologies through the promulgation of Resolution No. 13.99. Broad-based consultations with experts and stakeholders are necessary to ensure the long-term acceptance and commitment to such a programme. Governments, the private sector and the public must all be involved.

The feasibility of industries adopting technologies may prove problematic and therefore policies that lower costs and stimulate a demand for ESTs may be necessary to achieve environmental benefits. Appropriate education and awareness campaigns would strengthen the ability of communities to demand producers to take action to control the quantities of pollution released during production. Adoption by industries of ESTs will thus be more likely.

Administrative feasibility

The environmental performance of the new technologies employed in Havana Bay will be influenced by factors such as the availability of supporting infrastructure and human resources for the management, monitoring and maintenance of the technology.

Appropriate technology and associated equipment should be employed, which is relatively simple to operate and suitable for local maintenance and repair. Simpler technologies and equipment are less dependent on specific components and are generally more adaptable to market fluctuations than advanced technologies. The adoption of cleaner technologies may be less problematic in Cuba than in many developing countries due to the number of highly qualified scientists, that can adapt technologies to suite the specific needs of industries in Havana. The adoption and use of the technologies must reflect local circumstances and meet the local needs and priorities of Havana Bay, to increase the likelihood of successful application.

In order that the industries of Havana Bay have the necessary technical and management skills, capacity building should be undertaken including local governments, institutions and stakeholders, industrial organisations and users. Policy makers need to have adequate capacity to identify, assess, evaluate and select appropriate ESTs for industries. Currently the link between economic development and environmental technologies is not well understood by these policy makers in Cuba.

Efficiency

It is anticipated that the adoption of environmentally sound technologies will result in a reduction in industrial pollution entering the Havana Bay and thus improve water quality and reduce the impacts on the ecology and the people of the Bay. The use of cleaner technology would minimise the volumes and hazards of gaseous, liquid and solid wastes; reduce the risk of accidents involving chemicals and processes; and consume less raw materials, water, and energy; and use substitute chemicals and processes that are less hazardous to human and ecological health (Fitzgerald 2003). These technologies will also allow industry to recycle what was previously waste and generate revenues by supplying other industries and sectors. Investments by industries in the use of ESTs could be relatively modest in comparison to overall capital investments.

Through international exchange of experiences and technologies, other contaminated bays in the Caribbean Islands region, such as Kingston Harbour (Jamaica), may adopt similar environmentally sound technologies based on demonstrations in Havana Bay.

However, the new technologies can have negative impacts on the environment as well as positive. Widespread use of new materials and large production processes can lead to unpredicted health impacts. In order to observe significant environmental improvements, a programme of converting industries to cleaner technologies would have to be sustained after the initial implementation of the policy option.

Conclusions and recommendations

This report presents the results of the GIWA assessment of the transboundary waters of region 4 Caribbean Islands. The assessment considered pollution as the priority concern of the region. Pollution is mainly caused by the discharge of ship-generated, municipal and industrial solid waste and wastewater (including sewage), run-off from agricultural fields, and contamination from oil and gas extraction, refining and transport. Pollution is a common problem that is degrading the region's marine and coastal environment, and aversely affecting the economic activities of the region.

Despite the region's tropical climate with relatively high rainfall, freshwater shortage is becoming an increasing concern. This can be attributed to increasing demand as result of rapid population growth and the expansion of water intensive economic activities such as irrigated agriculture and tourism. Saline intrusion has occurred in many of the region's aquifers as a result of overabstraction, and is predicted to increase due to sea level rise and further exploitation.

A variety of human activities have modified critical habitats, such as coral reefs, mangroves and sea grass beds. This has been primarily attributed to the clearance of land for coastal developments, pollution (land-based sources and from marine activities), destructive fishing practices and tourism activities.

Fisheries resources in the region have been affected by the intensity and nature of fishing activities, and the destruction and modification of habitats. Most commercially valuable species are being overexploited and as competition between small-scale fisheries intensifies, increasingly destructive fishing methods are being employed.

In the Caribbean Islands region, impacts from global changes are not considered at present to be critical, as the impacts have not been permanent. However, the region, comprised of Small Island Developing States (SIDS), is considered to be particularly vulnerable to future climatic changes. Predicted increases in sea temperature may cause further coral bleaching, and sea level rise will exacerbate coastal erosion and flooding events. The natural capacity of ecosystems to adapt to climate changes may have been weakened by stresses placed on them by the other GIWA concerns.

The Causal chain analysis (CCA) performed separate analysis on land-based sources of pollution and marine traffic related pollution. For the latter, the entire region was studied, but only Havana Bay was selected as a demonstrative hot-spot which has experienced significant environmental degradation as a result of land-based sources of pollution.

The root causes behind pollution were identified to serve as a foundation for the selection of policy options. Maritime traffic contributes significant quantities of pollutants to the marine environment of the Caribbean Islands region with vessels discharging for example oily residuals, suspended solids and solid waste, which has increasingly threatened the environmental and socio-economic integrity of the islands. This has been partly attributed to the inadequate and underinvested waste reception facilities at ports in the region.

Additionally, the region is traditionally vulnerable to shipping collisions and accidents due to the intensity of marine traffic transiting its narrow channels and shallow waters. However, the countries have not responded to this risk with adequate contingency plans and response capabilities. Although all countries have signed the MARPOL agreement, due to weak national legislation and poor enforcement, governments have not fulfilled their obligations by ensuring vessels abide by international maritime laws. The lack of measures aimed at tackling ship-generated pollution stems from a legacy of under investment in relevant institutions needed to effectively manage waste and the general low priority given to environmental issues by governments of the region.

Havana Bay is a well-documented example of where land-based pollution from the surrounding urban and industrial landscape has contaminated the coastal and marine environment, with transboundary consequences for the entire region. Major economic growth during the 1970s and 1980s led to the uncontrolled development of Havana Bay. There were insufficient provisions to cope with the increased waste resulting from economic and demographic growth. The Havana sewage system is antiquated with domestic and industrial wastes discharged untreated or inadequately treated into rivers and directly into the Bay. The adoption of cleaner technologies by industries has been hindered by 30 years of importing highly polluting Soviet Union technology and economic restrictions imposed by the US trade barrier.

Although the Cuban Government has signed international agreements which have laid down a legal framework for tackling these pollution concerns, current laws and regulations lack cohesion and are often outdated and not enforceable. Management is highly fragmented and there is an absence of an overall institution responsible for the rehabilitation of the Bay. Furthermore, stakeholders are not consulted during the planning and implementation of many developments.

The policy option analysis described alternative courses of action that may be taken by policy makers in the region, and discussed the projected outcomes and trade-offs of each action. From an initial list, policy options were selected that addressed specific or multiple root causes identified in the CCA.

The following policy options were discussed for marine related pollution in the entire Caribbean Islands region:

1. Providing sufficient waste receiving and treatment infrastructure at ports;
2. Strengthening political and legal instruments: regulating discharges, spills and accidents;
3. Strengthening of institutions responsible for enforcement of maritime regulations.

Policy option 1 aims to provide port reception facilities, waste management infrastructure and institutional training programmes to facilitate compliance with MARPOL 73/78 Annex V. This will significantly enhance public health and environmental quality by strengthening the countries' capacities to manage and dispose of waste in an environmentally sustainable manner. The provision of waste reception facilitates will give shipping companies the option not to dump their waste at sea.

Policy option 2 aims to strengthen political and legal instruments in order to effectively regulate discharges, spills and accidents. This option intends to give greater indictment powers to enforcement agencies. To support a stricter legislative framework, it is recommended that capacity should be built in the relevant enforcement agencies in order to effectively monitor pollution incidents and to enforce maritime regulations (Policy option 3).

It is anticipated that the provision of sufficient waste reception facilities and additional pressure placed on the shipping industry by a strengthened legislative framework and enforcement capability, will reduce marine pollution in the Caribbean Islands region by preventing and discouraging indiscriminate disposal of waste off-shore.

The following options were discussed for land-based sources of pollution in Havana Bay:

4. Create a Havana Port Authority;
5. Develop sewage treatment and collection infrastructure;
6. Converting industries to environmentally sound technologies.

Policy option 4 proposes creating a Havana Port Authority to oversee and coordinate the rehabilitation of the Bay. The Authority would have political power and authority over existing institutions concerned with the management of Havana Bay. It can become the focal point for communications with funding and implementing organisations, and serve as a liaison on the technical aspects of the implementation of the protocol to the Cartagena Convention on land-based pollution. The institution, once established, should have the capacity to implement further environmental initiatives, for example Policy options 5 and 6, and facilitate stakeholder participation in future programmes.

Policy option 5 aims to replicate previous sewage treatment projects implemented in the Havana region. The development of sewage treatment infrastructure will reduce the quantities of untreated or insufficiently treated domestic sewage entering the Havana Bay, in order to improve its environmental quality and the health status of the Havana population. This will subsequently limit the contribution the Bay makes to the pollution load of the waters of the Caribbean Islands region.

Policy option 6 aims to promote the adoption of Environmentally Sound Technologies (ESTs) by industries to significantly improve their environmental performance relative to technologies currently employed in Greater Havana. By employing ESTs industries will reduce their contribution to the pollution of Havana Bay and its inflowing rivers by disposing all residual wastes in a more environmentally acceptable way than the technologies for which they are substitutes. It is anticipated that such technologies will also offer a commercial advantage to industries, by using less resources, and by recycling more of their wastes and products.

In addition, other countries in the Caribbean Islands region face many of the same environmental problems found in the Bay. Thus, some of the policy options for Havana Bay may be replicable at other sites in the region.

The policy options are a preliminary analysis of conceptual ideas and actions that are currently being considered. Therefore, although they are promising, more detailed assessment of the options is necessary.

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Annexes

Annex I
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Annex II
Detailed scoring tables

I: Freshwater shortage

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
1. Modification of stream flow	2	45	Freshwater shortage	2.0
2. Pollution of existing supplies	2	20		
3. Changes in the water table	2	35		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small 0 1 2 3 Very large	2	50
Degree of impact (cost, output changes etc.)	Minimum 0 1 2 3 Severe	2	30
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	2	20
Weight average score for Economic impacts		**2.0**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small 0 1 2 3 Very large	2	50
Degree of severity	Minimum 0 1 2 3 Severe	1	30
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	1	20
Weight average score for Health impacts		**1.5**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small 0 1 2 3 Very large	1	50
Degree of severity	Minimum 0 1 2 3 Severe	1	30
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	1	20
Weight average score for Other social and community impacts		**1.0**	

II: Pollution

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
4. Microbiological	2	20	Pollution	2.1
5. Eutrophication	2	10		
6. Chemical	2	10		
7. Suspended solids	3	15		
8. Solid wastes	2	25		
9. Thermal	1	2		
10. Radionuclide	1	2		
11. Spills	2	16		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small 0 1 2 3 Very large	2	50
Degree of impact (cost, output changes etc.)	Minimum 0 1 2 3 Severe	2	25
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	25
Weight average score for Economic impacts		**2.3**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small 0 1 2 3 Very large	2	50
Degree of severity	Minimum 0 1 2 3 Severe	2	25
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	2	25
Weight average score for Health impacts		**2.0**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small 0 1 2 3 Very large	2	50
Degree of severity	Minimum 0 1 2 3 Severe	3	25
Frequency/Duration	Occasion/Short 0 1 2 3 Continuous	3	25
Weight average score for Other social and community impacts		**2.5**	

III: Habitat and community modification

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
12. Loss of ecosystems	2	60	Habitat and community modification	2.0
13.Modification of ecosystems or ecotones, including community structure and/or species composition	2	40		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	2	50
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	3	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	25
Weight average score for Economic impacts		**2.5**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	2	50
Degree of severity	Minimum – Severe (0 1 2 3)	1	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	1	25
Weight average score for Health impacts		**1.5**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	2	50
Degree of severity	Minimum – Severe (0 1 2 3)	2	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	25
Weight average score for Other social and community impacts		**2.3**	

IV: Unsustainable exploitation of fish and other living resources

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
14. Overexploitation	3	40	Unsustainable exploitation of fish	2.0
15. Excessive by-catch and discards	1	20		
16. Destructive fishing practices	2	20		
17. Decreased viability of stock through pollution and disease	1	10		
18. Impact on biological and genetic diversity	1	10		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large (0 1 2 3)	1	50
Degree of impact (cost, output changes etc.)	Minimum – Severe (0 1 2 3)	2	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	3	25
Weight average score for Economic impacts		**1.8**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large (0 1 2 3)	1	50
Degree of severity	Minimum – Severe (0 1 2 3)	1	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	25
Weight average score for Health impacts		**1.3**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large (0 1 2 3)	1	50
Degree of severity	Minimum – Severe (0 1 2 3)	3	25
Frequency/Duration	Occasion/Short – Continuous (0 1 2 3)	2	25
Weight average score for Other social and community impacts		**1.8**	

V: Global change

Environmental issues	Score	Weight %	Environmental concern	Weight averaged score
19. Changes in the hydrological cycle	2	35	Global change	1.4
20. Sea level change	1	35		
21. Increased UV-B radiation as a result of ozone depletion	1	15		
22. Changes in ocean CO_2 source/sink function	1	15		

Criteria for Economic impacts	Raw score	Score	Weight %
Size of economic or public sectors affected	Very small – Very large 0 1 2 3	3	34
Degree of impact (cost, output changes etc.)	Minimum – Severe 0 1 2 3	3	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33
Weight average score for Economic impacts		**2.7**	
Criteria for Health impacts	**Raw score**	**Score**	**Weight %**
Number of people affected	Very small – Very large 0 1 2 3	2	34
Degree of severity	Minimum – Severe 0 1 2 3	2	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	1	33
Weight average score for Health impacts		**1.7**	
Criteria for Other social and community impacts	**Raw score**	**Score**	**Weight %**
Number and/or size of community affected	Very small – Very large 0 1 2 3	1	34
Degree of severity	Minimum – Severe 0 1 2 3	3	33
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	33
Weight average score for Other social and community impacts		**2.0**	

Comparative environmental and socio-economic impacts of each GIWA concern

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	2.0	2.5	2	2.5	1.8	2.0	1.5	1.8	**2.0**
Pollution	2.1	2.4	2.3	2.5	2.0	2.5	2.5	2.8	**2.4**
Habitat and community modification	2.0	1.6	2.5	2.5	1.5	1.3	2.3	2.0	**2.0**
Unsustainable exploitation of fish and other living resources	2.0	2.2	1.8	2.0	1.3	1.6	1.8	2.2	**1.8**
Global change	1.4	1.5	2.7	3.0	1.7	2.0	2.0	2.0	**2.0**

If the results in this table were not giving a clear prioritisation, the scores were weighted by assigning different relative importance to present/future and environmental/socio-economic impacts in the following way:

Weight averaged environmental and socio-economic impacts of each GIWA concern

Present (%) (i)	Future (%) (j)	Total (%)
50	50	100

Environmental (k)	Economic (l)	Health (m)	Other social and community impacts (n)	Total (%)
25	25	25	25	100

Concern	Types of impacts					Rank
	Time weight averaged Environmental score (o)	Time weight averaged Economic score (p)	Time weight averaged Human health score (q)	Time weight averaged Social and community score (r)	Time weight averaged overall score	
	(a)x(i)+(b)x(j)	(c)x(i)+(d)x(j)	(e)x(i)+(f)x(j)	(g)x(i)+(h)x(j)	(o)x(k)+(p)x(l)+(q)x(m)+(r)x(n)	
Freshwater shortage	2.25	2.25	1.90	1.65	**2.0**	**2**
Pollution	2.26	2.38	2.25	2.65	**2.4**	**1**
Habitat and community modification	1.80	2.50	1.40	2.13	**2.0**	**4**
Unsustainable exploitation of fish and other living resources	2.10	1.88	1.43	1.98	**1.8**	**5**
Global change	1.43	2.84	1.84	2.00	**2.0**	**3**

Annex III
List of conventions and specific laws that affect water use in the region

Global environmental conventions relating to marine and coastal environment of special importance to the Caribbean

- Basel Convention on the Control of Transboundary Movements of Transboundary Wastes and their Disposal: Basel, 22 March 1989.
- Convention on Biological Diversity (CBD): Nairobi, 22 May 1989.
- Convention on International Trade In Endangered Species of Wild Fauna and Flora (CITES): Washington , 3 March 1973.
- International Convention on Civil Liability for Oil Pollution Damage (CLC): Brussels, 29, November 1969. (With amendments in 1976, 1984)
- International Convention for the Prevention of Pollution of the Sea by Oil (OILPOL): London, 12, May 1954 (with amendments in 1962 and 1969)
- International Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter: Convention on the prevention of marine pollution due to discharge of waste and other materials (London Convention): London, Mexico City, Moscow, Washington DC, 29 December 1972. (And its protocol of 1996).
- International Convention for the Prevention of Pollution from Ships (MARPOL 73/78): London, 2, November, 1973, as modified by the Protocol of 1978 relating thereto.
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar): 2, February, 1971.
- International Convention for the Safety of Life at Sea (SOLAS): 1 November, 1974.
- United Nations Convention on the Law of the Sea (UNCLOS): Montego Bay, 10, December, 1982.
- Central America: Regional agreement on the transfrontal movement of dangerous waste; adopted at the XIII Summit of Presidents of the Central American Isthmus (1992); it prohibits the import and transit of waste considered dangerous for Central America from countries that do not comprise in the Agreement, as well as the spill of dangerous waste in the sea and inner waters.

Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region and its protocols

The Cartagena Convention

The Convention was adopted in 1983 and constitutes the only legal regional agreement related to the protection of the environment in the Wider Caribbean Region and has been ratified by twenty one (21) countries. The convention calls for the achievement of regional, sub regional, bilateral and multilateral agreements for the protection of the marine environment. The Contracting Parties shall, individually or jointly, take all appropriate measures in conformity with international law and in accordance with this Convention and those of its protocols in force to which they are parties to prevent, reduce and control pollution of the Convention area and to ensure sound environmental management, using for this purpose the best practicable means at their disposal and in accordance with their capabilities.

Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region

The 21 contracting parties to the Cartagena Convention ratified the protocol in 1983 and shall, within their capabilities, co-operate in taking all necessary measures, both preventive and remedial, for the protection of the marine and coastal environment of the Wider Caribbean Region, particularly the coastal areas of the islands of the region, from oil spill incidents. The contracting Parties shall, within their capabilities, establish and maintain, or ensure the establishment and maintenance of, the means of responding to oil spill incidents and shall endeavor to reduce the risk thereof.

Protocol Concerning Pollution from Land-Based Sources and Activities in the Wider Caribbean Region (LBS)

The adoption of this Protocol took place on 6 October 1999 in Aruba. Sixteen Member States signed the Final Act to adopt the Protocol, six have now signed the Protocol and two have ratified it. Each Contracting Party shall, in accordance with its laws, the provisions of this Protocol, and international law, take appropriate measures to prevent, reduce and control pollution of the Convention area from land-based sources and activities, using for this purpose the best practicable means at its disposal and in accordance with its capabilities. The Contracting Party shall further on national, regional and sub regional levels develop and implement appropriate plans, programs and measures for means of preventing, reducing or controlling pollution of the Convention area from land-based sources and activities on its territory.

Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (SPAW)

It was adopted in 1990, the SPAW protocol entered into force in 1999. Each Party to this Protocol shall, take the necessary measures to protect, preserve and manage in a sustainable way, areas of the Wider Caribbean Region in which it exercises sovereignty, or sovereign rights or jurisdiction, areas requiring special needs for protection to safeguard their special values and where there are threatened or endangered species of flora and fauna. Each Party shall regulate and where necessary, prohibit activities having adverse effects on these areas and species. Each Party shall endeavor to co-operate in the enforcement of these measures, without prejudice to the sovereignty, or sovereign rights or jurisdiction of other Parties. Each Party shall, to the extent possible, consistent with each Party's legal system, shall manage species of fauna and flora with the objective of preventing species from becoming endangered or threatened.

The Global International Waters Assessment

This report presents the results of the Global International Waters Assessment (GIWA) of the transboundary waters of the Caribbean Islands region. This and the subsequent chapter offer a background that describes the impetus behind the establishment of GIWA, its objectives and how the GIWA was implemented.

The need for a global international waters assessment

Globally, people are becoming increasingly aware of the degradation of the world's water bodies. Disasters from floods and droughts, frequently reported in the media, are considered to be linked with ongoing global climate change (IPCC 2001), accidents involving large ships pollute public beaches and threaten marine life and almost every commercial fish stock is exploited beyond sustainable limits - it is estimated that the global stocks of large predatory fish have declined to less that 10% of pre-industrial fishing levels (Myers & Worm 2003). Further, more than 1 billion people worldwide lack access to safe drinking water and 2 billion people lack proper sanitation which causes approximately 4 billion cases of diarrhoea each year and results in the death of 2.2 million people, mostly children younger than five (WHO-UNICEF 2002). Moreover, freshwater and marine habitats are destroyed by infrastructure developments, dams, roads, ports and human settlements (Brinson & Malvárez 2002, Kennish 2002). As a consequence, there is growing public concern regarding the declining quality and quantity of the world's aquatic resources because of human activities, which has resulted in mounting pressure on governments and decision makers to institute new and innovative policies to manage those resources in a sustainable way ensuring their availability for future generations.

Adequately managing the world's aquatic resources for the benefit of all is, for a variety of reasons, a very complex task. The liquid state of the most of the world's water means that, without the construction of reservoirs, dams and canals it is free to flow wherever the laws of nature dictate. Water is, therefore, a vector transporting not only a wide variety of valuable resources but also problems from one area to another. The effluents emanating from environmentally destructive activities in upstream drainage areas are propagated downstream and can affect other areas considerable distances away. In the case of transboundary river basins, such as the Nile, Amazon and Niger, the impacts are transported across national borders and can be observed in the numerous countries situated within their catchments. In the case of large oceanic currents, the impacts can even be propagated between continents (AMAP 1998). Therefore, the inextricable linkages within and between both freshwater and marine environments dictates that management of aquatic resources ought to be implemented through a drainage basin approach.

In addition, there is growing appreciation of the incongruence between the transboundary nature of many aquatic resources and the traditional introspective nationally focused approaches to managing those resources. Water, unlike laws and management plans, does not respect national borders and, as a consequence, if future management of water and aquatic resources is to be successful, then a shift in focus towards international cooperation and intergovernmental agreements is required (UN 1972). Furthermore, the complexity of managing the world's water resources is exacerbated by the dependence of a great variety of domestic and industrial activities on those resources. As a consequence, cross-sectoral multidisciplinary approaches that integrate environmental, socio-economic and development aspects into management must be adopted. Unfortunately however, the scientific information or capacity within each discipline is often not available or is inadequately translated for use by managers, decision makers and policy developers. These inadequacies constitute a serious impediment to the implementation of urgently needed innovative policies.

Continual assessment of the prevailing and future threats to aquatic ecosystems and their implications for human populations is essential if governments and decision makers are going to be able to make strategic policy and management decisions that promote the sustainable use of those resources and respond to the growing concerns of the general public. Although many assessments of aquatic resources are being conducted by local, national, regional and international bodies, past assessments have often concentrated on specific themes, such as biodiversity or persistent toxic substances, or have focused only on marine or freshwaters. A globally coherent, drainage basin based assessment that embraces the inextricable links between transboundary freshwater and marine systems, and between environmental and societal issues, has never been conducted previously.

International call for action

The need for a holistic assessment of transboundary waters in order to respond to growing public concerns and provide advice to governments and decision makers regarding the management of aquatic resources was recognised by several international bodies focusing on the global environment. In particular, the Global Environment Facility (GEF) observed that the International Waters (IW) component of the GEF suffered from the lack of a global assessment which made it difficult to prioritise international water projects, particularly considering the inadequate understanding of the nature and root causes of environmental problems. In 1996, at its fourth meeting in Nairobi, the GEF Scientific and Technical Advisory Panel (STAP), noted that: *"Lack of an International Waters Assessment comparable with that of the IPCC, the Global Biodiversity Assessment, and the Stratospheric Ozone Assessment, was a unique and serious impediment to the implementation of the International Waters Component of the GEF"*.

The urgent need for an assessment of the causes of environmental degradation was also highlighted at the UN Special Session on the Environment (UNGASS) in 1997, where commitments were made regarding the work of the UN Commission on Sustainable Development (UNCSD) on freshwater in 1998 and seas in 1999. Also in 1997, two international Declarations, the Potomac Declaration: Towards enhanced ocean security into the third millennium, and the Stockholm Statement on interaction of land activities, freshwater and enclosed seas, specifically emphasised the need for an investigation of the root causes of degradation of the transboundary aquatic environment and options for addressing them. These processes led to the development of the Global International Waters Assessment (GIWA) that would be implemented by the United Nations Environment Programme (UNEP) in conjunction with the University of Kalmar, Sweden, on behalf of the GEF. The GIWA was inaugurated in Kalmar in October 1999 by the Executive Director of UNEP, Dr. Klaus Töpfer, and the late Swedish Minister of the Environment, Kjell Larsson. On this occasion Dr. Töpfer stated: *"GIWA is the framework of UNEP´s global water assessment strategy and will enable us to record and report on critical water resources for the planet for consideration of sustainable development management practices as part of our responsibilities under Agenda 21 agreements of the Rio conference"*.

The importance of the GIWA has been further underpinned by the UN Millennium Development Goals adopted by the UN General Assembly in 2000 and the Declaration from the World Summit on Sustainable

The Global Environment Facility (GEF)

The Global Environment Facility forges international co-operation and finances actions to address six critical threats to the global environment: biodiversity loss, climate change, degradation of international waters, ozone depletion, land degradation, and persistent organic pollutants (POPs).

The overall strategic thrust of GEF-funded international waters activities is to meet the incremental costs of: (a) assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them; (b) building the capacity of existing institutions to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns; and (c) implementing measures that address the priority transboundary environmental concerns. The goal is to assist countries to utilise the full range of technical, economic, financial, regulatory, and institutional measures needed to operationalise sustainable development strategies for international waters.

United Nations Environment Programme (UNEP)

United Nations Environment Programme, established in 1972, is the voice for the environment within the United Nations system. The mission of UNEP is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.

UNEP work encompasses:

- Assessing global, regional and national environmental conditions and trends;
- Developing international and national environmental instruments;
- Strengthening institutions for the wise management of the environment;
- Facilitating the transfer of knowledge and technology for sustainable development;
- Encouraging new partnerships and mind-sets within civil society and the private sector.

University of Kalmar

University of Kalmar hosts the GIWA Co-ordination Office and provides scientific advice and administrative and technical assistance to GIWA. University of Kalmar is situated on the coast of the Baltic Sea. The city has a long tradition of higher education; teachers and marine officers have been educated in Kalmar since the middle of the 19th century. Today, natural science is a priority area which gives Kalmar a unique educational and research profile compared with other smaller universities in Sweden. Of particular relevance for GIWA is the established research in aquatic and environmental science. Issues linked to the concept of sustainable development are implemented by the research programme Natural Resources Management and Agenda 21 Research School.

Since its establishment GIWA has grown to become an integral part of University activities. The GIWA Co-ordination office and GIWA Core team are located at the Kalmarsund Laboratory, the university centre for water-related research. Senior scientists appointed by the University are actively involved in the GIWA peer-review and steering groups. As a result of the cooperation the University can offer courses and seminars related to GIWA objectives and international water issues.

Development in 2002. The development goals aimed to halve the proportion of people without access to safe drinking water and basic sanitation by the year 2015 (United Nations Millennium Declaration 2000). The WSSD also calls for integrated management of land, water and living resources (WSSD 2002) and, by 2010, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem should be implemented by all countries that are party to the declaration (FAO 2001).

International waters and transboundary issues

The term "international waters", as used for the purposes of the GEF Operational Strategy, includes the oceans, large marine ecosystems, enclosed or semi-enclosed seas and estuaries, as well as rivers, lakes, groundwater systems, and wetlands with transboundary drainage basins or common borders. The water-related ecosystems associated with these waters are considered integral parts of the systems.

The term "transboundary issues" is used to describe the threats to the aquatic environment linked to globalisation, international trade, demographic changes and technological advancement, threats that are additional to those created through transboundary movement of water. Single country policies and actions are inadequate in order to cope with these challenges and this makes them transboundary in nature.

The international waters area includes numerous international conventions, treaties, and agreements. The architecture of marine agreements is especially complex, and a large number of bilateral and multilateral agreements exist for transboundary freshwater basins. Related conventions and agreements in other areas increase the complexity. These initiatives provide a new opportunity for cooperating nations to link many different programmes and instruments into regional comprehensive approaches to address international waters.

The conceptual framework and objectives

Considering the general decline in the condition of the world's aquatic resources and the internationally recognised need for a globally coherent assessment of transboundary waters, the primary objectives of the GIWA are:

- To provide a prioritising mechanism that allows the GEF to focus their resources so that they are used in the most cost effective manner to achieve significant environmental benefits, at national, regional and global levels; and
- To highlight areas in which governments can develop and implement strategic policies to reduce environmental degradation and improve the management of aquatic resources.

In order to meet these objectives and address some of the current inadequacies in international aquatic resources management, the GIWA has incorporated four essential elements into its design:

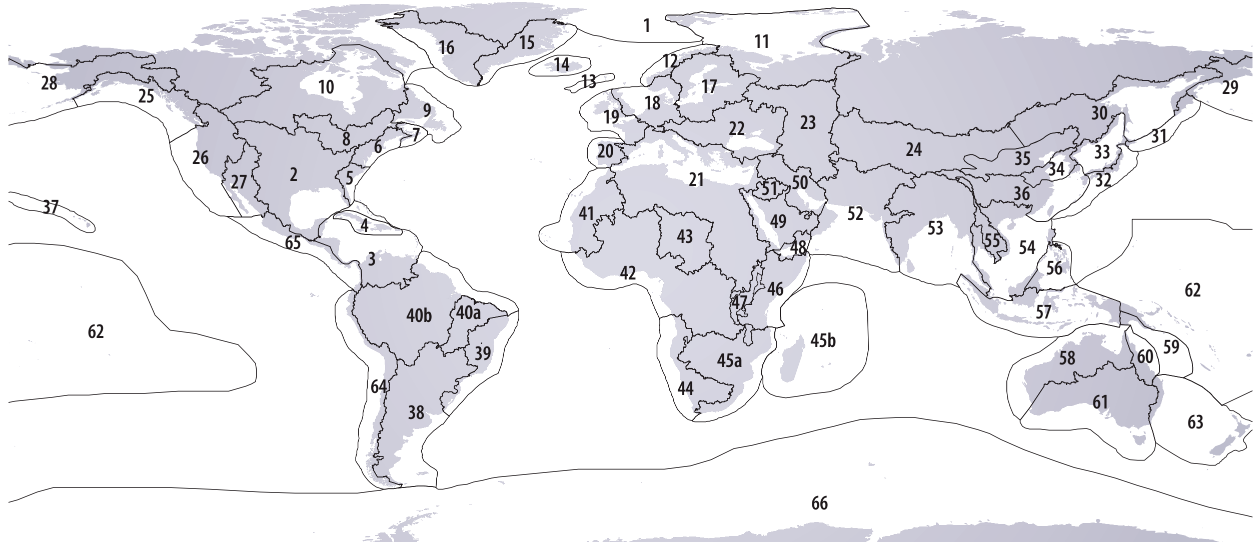
- A broad transboundary approach that generates a truly regional perspective through the incorporation of expertise and existing information from all nations in the region and the assessment of all factors that influence the aquatic resources of the region;
- A drainage basin approach integrating freshwater and marine systems;
- A multidisciplinary approach integrating environmental and socio-economic information and expertise; and
- A coherent assessment that enables global comparison of the results.

The GIWA builds on previous assessments implemented within the GEF International Waters portfolio but has developed and adopted a broader definition of transboundary waters to include factors that influence the quality and quantity of global aquatic resources. For example, due to globalisation and international trade, the market for penaeid shrimps has widened and the prices soared. This, in turn, has encouraged entrepreneurs in South East Asia to expand aquaculture resulting in the large-scale deforestation of mangroves for ponds (Primavera 1997). Within the GIWA, these "non-hydrological" factors constitute as large a transboundary influence as more traditionally recognised problems, such as the construction of dams that regulate the flow of water into a neighbouring country, and are considered equally important. In addition, the GIWA recognises the importance of hydrological units that would not normally be considered transboundary but exert a significant influence on transboundary waters, such as the Yangtze River in China which discharges into the East China Sea (Daoji & Daler 2004) and the Volga River in Russia which is largely responsible for the condition of the Caspian Sea (Barannik et al. 2004). Furthermore, the GIWA is a truly regional assessment that has incorporated data from a wide range of sources and included expert knowledge and information from a wide range of sectors and from each country in the region. Therefore, the transboundary concept adopted by the GIWA extends to include impacts caused by globalisation, international trade, demographic changes and technological advances and recognises the need for international cooperation to address them.

The organisational structure and implementation of the GIWA

The scale of the assessment

Initially, the scope of the GIWA was confined to transboundary waters in areas that included countries eligible to receive funds from the GEF. However, it was recognised that a truly global perspective would only be achieved if industrialised, GEF-ineligible regions of the world were also assessed. Financial resources to assess the GEF-eligible countries were obtained primarily from the GEF (68%), the Swedish International Development Cooperation Agency (Sida) (18%), and the Finnish Department for International Development Cooperation (FINNIDA)



1 Arctic
2 Gulf of Mexico (LME)
3 Caribbean Sea (LME)
4 Caribbean Islands
5 Southeast Shelf (LME)
6 Northeast Shelf (LME)
7 Scotian Shelf (LME)
8 Gulf of St Lawrence
9 Newfoundland Shelf (LME)
10 Baffin Bay, Labrador Sea, Canadian Archipelago
11 Barents Sea (LME)
12 Norwegian Sea (LME)
13 Faroe plateau
14 Iceland Shelf (LME)
15 East Greenland Shelf (LME)
16 West Greenland Shelf (LME)
17 Baltic Sea (LME)
18 North Sea (LME)
19 Celtic-Biscay Shelf (LME)
20 Iberian Coastal (LME)
21 Mediterranean Sea (LME)
22 Black Sea (LME)
23 Caspian Sea
24 Aral Sea
25 Gulf of Alaska (LME)
26 California Current (LME)
27 Gulf of California (LME)
28 East Bering Sea (LME)
29 West Bering Sea (LME)
30 Sea of Okhotsk (LME)
31 Oyashio Current (LME)
32 Kuroshio Current (LME)
33 Sea of Japan/East Sea (LME)
34 Yellow Sea (LME)
35 Bohai Sea
36 East-China Sea (LME)
37 Hawaiian Archipelago (LME)
38 Patagonian Shelf (LME)
39 Brazil Current (LME)
40a Brazilian Northeast (LME)
40b Amazon
41 Canary Current (LME)
42 Guinea Current (LME)
43 Lake Chad
44 Benguela Current (LME)
45a Agulhas Current (LME)
45b Indian Ocean Islands
46 Somali Coastal Current (LME)
47 East African Rift Valley Lakes
48 Gulf of Aden
49 Red Sea (LME)
50 The Gulf
51 Jordan
52 Arabian Sea (LME)
53 Bay of Bengal S.E.
54 South China Sea (LME)
55 Mekong River
56 Sulu-Celebes Sea (LME)
57 Indonesian Seas (LME)
58 North Australian Shelf (LME)
59 Coral Sea Basin
60 Great Barrier Reef (LME)
61 Great Australian Bight
62 Small Island States
63 Tasman Sea
64 Humboldt Current (LME)
65 Eastern Equatorial Pacific
66 Antarctic (LME)

Figure 1 The 66 transboundary regions assessed within the GIWA project.

(10%). Other contributions were made by Kalmar Municipality, the University of Kalmar and the Norwegian Government. The assessment of regions ineligible for GEF funds was conducted by various international and national organisations as in-kind contributions to the GIWA.

In order to be consistent with the transboundary nature of many of the world's aquatic resources and the focus of the GIWA, the geographical units being assessed have been designed according to the watersheds of discrete hydrographic systems rather than political borders (Figure 1). The geographic units of the assessment were determined during the preparatory phase of the project and resulted in the division of the world into 66 regions defined by the entire area of one or more catchments areas that drains into a single designated marine system. These marine systems often correspond to Large Marine Ecosystems (LMEs) (Sherman 1994, IOC 2002).

Large Marine Ecocsystems (LMEs)

Large Marine Ecosystems (LMEs) are regions of ocean space encompassing coastal areas from river basins and estuaries to the seaward boundaries of continental shelves and the outer margin of the major current systems. They are relatively large regions on the order of 200 000 km^2 or greater, characterised by distinct: (1) bathymetry, (2) hydrography, (3) productivity, and (4) trophically dependent populations.

The Large Marine Ecosystems strategy is a global effort for the assessment and management of international coastal waters. It developed in direct response to a declaration at the 1992 Rio Summit. As part of the strategy, the World Conservation Union (IUCN) and National Oceanic and Atmospheric Administration (NOAA) have joined in an action program to assist developing countries in planning and implementing an ecosystem-based strategy that is focused on LMEs as the principal assessment and management units for coastal ocean resources. The LME concept is also adopted by GEF that recommends the use of LMEs and their contributing freshwater basins as the geographic area for integrating changes in sectoral economic activities.

Considering the objectives of the GIWA and the elements incorporated into its design, a new methodology for the implementation of the assessment was developed during the initial phase of the project. The methodology focuses on five major environmental concerns which constitute the foundation of the GIWA assessment; Freshwater shortage, Pollution, Habitat and community modification, Overexploitation of fish and other living resources, and Global change. The GIWA methodology is outlined in the following chapter.

The global network

In each of the 66 regions, the assessment is conducted by a team of local experts that is headed by a Focal Point (Figure 2). The Focal Point can be an individual, institution or organisation that has been selected on the basis of their scientific reputation and experience implementing international assessment projects. The Focal Point is responsible for assembling members of the team and ensuring that it has the necessary expertise and experience in a variety of environmental and socio-economic disciplines to successfully conduct the regional assessment. The selection of team members is one of the most critical elements for the success of GIWA and, in order to ensure that the most relevant information is incorporated into the assessment, team members were selected from a wide variety of institutions such as universities, research institutes, government agencies, and the private sector. In addition, in order to ensure that the assessment produces a truly regional perspective, the teams should include representatives from each country that shares the region.

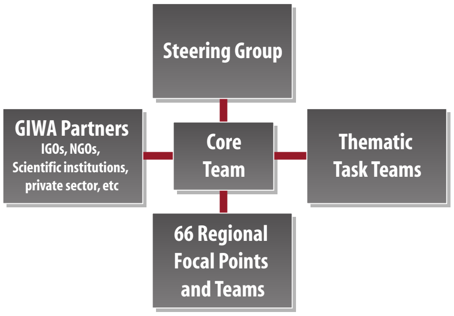


Figure 2 The organisation of the GIWA project.

In total, more than 1 000 experts have contributed to the implementation of the GIWA illustrating that the GIWA is a participatory exercise that relies on regional expertise. This participatory approach is essential because it instils a sense of local ownership of the project, which ensures the credibility of the findings and moreover, it has created a global network of experts and institutions that can collaborate and exchange experiences and expertise to help mitigate the continued degradation of the world's aquatic resources.

GIWA Regional reports

The GIWA was established in response to growing concern among the general public regarding the quality of the world's aquatic resources and the recognition of governments and the international community concerning the absence of a globally coherent international waters assessment. However, because a holistic, region-by-region, assessment of the condition of the world's transboundary water resources had never been undertaken, a methodology guiding the implementation of such an assessment did not exist. Therefore, in order to implement the GIWA, a new methodology that adopted a multidisciplinary, multi-sectoral, multi-national approach was developed and is now available for the implementation of future international assessments of aquatic resources.

UNEP Water Policy and Strategy

The primary goals of the UNEP water policy and strategy are:

(a) Achieving greater global understanding of freshwater, coastal and marine environments by conducting environmental assessments in priority areas;

(b) Raising awareness of the importance and consequences of unsustainable water use;

(c) Supporting the efforts of Governments in the preparation and implementation of integrated management of freshwater systems and their related coastal and marine environments;

(d) Providing support for the preparation of integrated management plans and programmes for aquatic environmental hot spots, based on the assessment results;

(e) Promoting the application by stakeholders of precautionary, preventive and anticipatory approaches.

The GIWA is comprised of a logical sequence of four integrated components. The first stage of the GIWA is called Scaling and is a process by which the geographic area examined in the assessment is defined and all the transboundary waters within that area are identified. Once the geographic scale of the assessment has been defined, the assessment teams conduct a process known as Scoping in which the magnitude of environmental and associated socio-economic impacts of Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources, and Global change is assessed in order to identify and prioritise the concerns that require the most urgent intervention. The assessment of these predefined concerns incorporates the best available information and the knowledge and experience of the multidisciplinary, multi-national assessment teams formed in each region. Once the priority concerns have been identified, the root causes of these concerns are identified during the third component of the GIWA, Causal chain analysis. The root causes are determined through a sequential process that identifies, in turn, the most significant immediate causes followed by the economic sectors that are primarily responsible for the immediate causes and finally, the societal root causes. At each stage in the Causal chain analysis, the most significant contributors are identified through an analysis of the best available information which is augmented by the expertise of the assessment team. The final component of the GIWA is the development of Policy options that focus on mitigating the impacts of the root causes identified by the Causal chain analysis.

The results of the GIWA assessment in each region are reported in regional reports that are published by UNEP. These reports are designed to provide a brief physical and socio-economic description of the most important features of the region against which the results of the assessment can be cast. The remaining sections of the report present the results of each stage of the assessment in an easily digestible form. Each regional report is reviewed by at least two independent external reviewers in order to ensure the scientific validity and applicability of each report. The 66 regional assessments of the GIWA will serve UNEP as an essential complement to the UNEP Water Policy and Strategy and UNEP's activities in the hydrosphere.

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The GIWA methodology

The specific objectives of the GIWA were to conduct a holistic and globally comparable assessment of the world's transboundary aquatic resources that incorporated both environmental and socio-economic factors and recognised the inextricable links between freshwater and marine environments, in order to enable the GEF to focus their resources and to provide guidance and advice to governments and decision makers. The coalition of all these elements into a single coherent methodology that produces an assessment that achieves each of these objectives had not previously been done and posed a significant challenge.

The integration of each of these elements into the GIWA methodology was achieved through an iterative process guided by a specially convened Methods task team that was comprised of a number of international assessment and water experts. Before the final version of the methodology was adopted, preliminary versions underwent an extensive external peer review and were subjected to preliminary testing in selected regions. Advice obtained from the Methods task team and other international experts and the lessons learnt from preliminary testing were incorporated into the final version that was used to conduct each of the GIWA regional assessments.

Considering the enormous differences between regions in terms of the quality, quantity and availability of data, socio-economic setting and environmental conditions, the achievement of global comparability required an innovative approach. This was facilitated by focusing the assessment on the impacts of five pre-defined concerns namely; Freshwater shortage, Pollution, Habitat and community modification, Unsustainable exploitation of fish and other living resources and Global change, in transboundary waters. Considering the diverse range of elements encompassed by each concern, assessing the magnitude of the impacts caused by these concerns was facilitated by evaluating the impacts of 22 specific issues that were grouped within these concerns (see Table 1).

The assessment integrates environmental and socio-economic data from each country in the region to determine the severity of the impacts of each of the five concerns and their constituent issues on the entire region. The integration of this information was facilitated by implementing the assessment during two participatory workshops that typically involved 10 to 15 environmental and socio-economic experts from each country in the region. During these workshops, the regional teams performed preliminary analyses based on the collective knowledge and experience of these local experts. The results of these analyses were substantiated with the best available information to be presented in a regional report.

Table 1 Pre-defined GIWA concerns and their constituent issues addressed within the assessment.

Environmental issues	Major concerns
1. Modification of stream flow 2. Pollution of existing supplies 3. Changes in the water table	**I Freshwater shortage**
4. Microbiological 5. Eutrophication 6. Chemical 7. Suspended solids 8. Solid wastes 9. Thermal 10. Radionuclide 11. Spills	**II Pollution**
12. Loss of ecosystems 13. Modification of ecosystems or ecotones, including community structure and/or species composition	**III Habitat and community modification**
14. Overexploitation 15. Excessive by-catch and discards 16. Destructive fishing practices 17. Decreased viability of stock through pollution and disease 18. Impact on biological and genetic diversity	**IV Unsustainable exploitation of fish and other living resources**
19. Changes in hydrological cycle 20. Sea level change 21. Increased uv-b radiation as a result of ozone depletion 22. Changes in ocean CO_2 source/sink function	**V Global change**

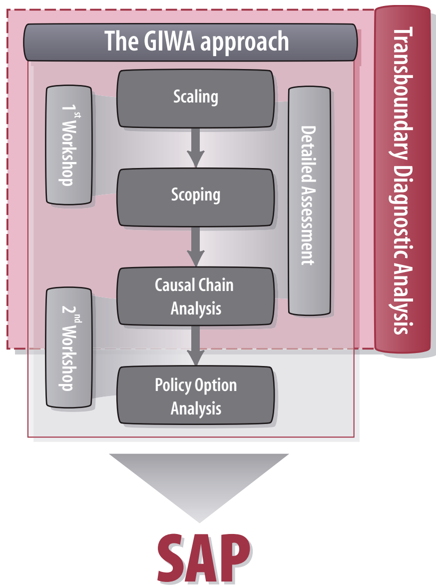

Figure 1 Illustration of the relationship between the GIWA approach and other projects implemented within the GEF International Waters (IW) portfolio.

The GIWA is a logical contiguous process that defines the geographic region to be assessed, identifies and prioritises particularly problems based on the magnitude of their impacts on the environment and human societies in the region, determines the root causes of those problems and, finally, assesses various policy options that addresses those root causes in order to reverse negative trends in the condition of the aquatic environment. These four steps, referred to as Scaling, Scoping, Causal chain analysis and Policy options analysis, are summarised below and are described in their entirety in two volumes: *GIWA Methodology Stage 1: Scaling and Scoping*; and *GIWA Methodology: Detailed Assessment, Causal Chain Analysis and Policy Options Analysis*. Generally, the components of the GIWA methodology are aligned with the framework adopted by the GEF for Transboundary Diagnostic Analyses (TDAs) and Strategic Action Programmes (SAPs) (Figure 1) and assume a broad spectrum of transboundary influences in addition to those associated with the physical movement of water across national borders.

Scaling – Defining the geographic extent of the region

Scaling is the first stage of the assessment and is the process by which the geographic scale of the assessment is defined. In order to facilitate the implementation of the GIWA, the globe was divided during the design phase of the project into 66 contiguous regions. Considering the transboundary nature of many aquatic resources and the transboundary focus of the GIWA, the boundaries of the regions did not comply with political boundaries but were instead, generally defined by a large but discrete drainage basin that also included the coastal marine waters into which the basin discharges. In many cases, the marine areas examined during the assessment coincided with the Large Marine Ecosystems (LMEs) defined by the US National Atmospheric and Oceanographic Administration (NOAA). As a consequence, scaling should be a relatively straight-forward task that involves the inspection of the boundaries that were proposed for the region during the preparatory phase of GIWA to ensure that they are appropriate and that there are no important overlaps or gaps with neighbouring regions. When the proposed boundaries were found to be inadequate, the boundaries of the region were revised according to the recommendations of experts from both within the region and from adjacent regions so as to ensure that any changes did not result in the exclusion of areas from the GIWA. Once the regional boundary was defined, regional teams identified all the transboundary elements of the aquatic environment within the region and determined if these elements could be assessed as a single coherent aquatic system or if there were two or more independent systems that should be assessed separately.

Scoping – Assessing the GIWA concerns

Scoping is an assessment of the severity of environmental and socio-economic impacts caused by each of the five pre-defined GIWA concerns and their constituent issues (Table 1). It is not designed to provide an exhaustive review of water-related problems that exist within each region, but rather it is a mechanism to identify the most urgent problems in the region and prioritise those for remedial actions. The priorities determined by Scoping are therefore one of the main outputs of the GIWA project.

Focusing the assessment on pre-defined concerns and issues ensured the comparability of the results between different regions. In addition, to ensure the long-term applicability of the options that are developed to mitigate these problems, Scoping not only assesses the current impacts of these concerns and issues but also the probable future impacts according to the "most likely scenario" which considered demographic, economic, technological and other relevant changes that will potentially influence the aquatic environment within the region by 2020.

The magnitude of the impacts caused by each issue on the environment and socio-economic indicators was assessed over the entire region using the best available information from a wide range of sources and the knowledge and experience of the each of the experts comprising the regional team. In order to enhance the comparability of the assessment between different regions and remove biases in the assessment caused by different perceptions of and ways to communicate the severity of impacts caused by particular issues, the results were distilled and reported as standardised scores according to the following four point scale:

- 0 = no known impact
- 1 = slight impact
- 2 = moderate impact
- 3 = severe impact

The attributes of each score for each issue were described by a detailed set of pre-defined criteria that were used to guide experts in reporting the results of the assessment. For example, the criterion for assigning a score of 3 to the issue Loss of ecosystems or ecotones is: "*Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.*" The full list of criteria is presented at the end of the chapter, Table 5a-e. Although the scoring inevitably includes an arbitrary component, the use of predefined criteria facilitates comparison of impacts on a global scale and also encouraged consensus of opinion among experts.

The trade-off associated with assessing the impacts of each concern and their constituent issues at the scale of the entire region is that spatial resolution was sometimes low. Although the assessment provides a score indicating the severity of impacts of a particular issue or concern on the entire region, it does not mean that the entire region suffers the impacts of that problem. For example, eutrophication could be identified as a severe problem in a region, but this does not imply that all waters in the region suffer from severe eutrophication. It simply means that when the degree of eutrophication, the size of the area affected, the socio-economic impacts and the number of people affected is considered, the magnitude of the overall impacts meets the criteria defining a severe problem and that a regional action should be initiated in order to mitigate the impacts of the problem.

When each issue has been scored, it was weighted according to the relative contribution it made to the overall environmental impacts of the concern and a weighted average score for each of the five concerns was calculated (Table 2). Of course, if each issue was deemed to make equal contributions, then the score describing the overall impacts of the concern was simply the arithmetic mean of the scores allocated to each issue within the concern. In addition, the socio-economic impacts of each of the five major concerns were assessed for the entire region. The socio-economic impacts were grouped into three categories; Economic impacts, Health impacts and Other social and community impacts (Table 3). For each category, an evaluation of the size, degree and frequency of the impact was performed and, once completed, a weighted average score describing the overall socio-economic impacts of each concern was calculated in the same manner as the overall environmental score.

Table 2 Example of environmental impact assessment of Freshwater shortage.

Environmental issues	Score	Weight %	Environmental concerns	Weight averaged score
1. Modification of stream flow	1	20	Freshwater shortage	1.50
2. Pollution of existing supplies	2	50		
3. Changes in the water table	1	30		

Table 3 Example of Health impacts assessment linked to one of the GIWA concerns.

Criteria for Health impacts	Raw score	Score	Weight %
Number of people affected	Very small – Very large 0 1 2 3	2	50
Degree of severity	Minimum – Severe 0 1 2 3	2	30
Frequency/Duration	Occasion/Short – Continuous 0 1 2 3	2	20
Weight average score for Health impacts		**2**	

After all 22 issues and associated socio-economic impacts have been scored, weighted and averaged, the magnitude of likely future changes in the environmental and socio-economic impacts of each of the five concerns on the entire region is assessed according to the most likely scenario which describes the demographic, economic, technological and other relevant changes that might influence the aquatic environment within the region by 2020.

In order to prioritise among GIWA concerns within the region and identify those that will be subjected to causal chain and policy options analysis in the subsequent stages of the GIWA, the present and future scores of the environmental and socio-economic impacts of each concern are tabulated and an overall score calculated. In the example presented in Table 4, the scoping assessment indicated that concern III, Habitat and community modification, was the priority concern in this region. The outcome of this mathematic process was reconciled against the knowledge of experts and the best available information in order to ensure the validity of the conclusion.

In some cases however, this process and the subsequent participatory discussion did not yield consensus among the regional experts regarding the ranking of priorities. As a consequence, further analysis was required. In such cases, expert teams continued by assessing the relative importance of present and potential future impacts and assign weights to each. Afterwards, the teams assign weights indicating the relative contribution made by environmental and socio-economic factors to the overall impacts of the concern. The weighted average score for each concern is then recalculated taking into account

Table 4 Example of comparative environmental and socio-economic impacts of each major concern, presently and likely in year 2020.

Concern	Types of impacts								Overall score
	Environmental score		Economic score		Human health score		Social and community score		
	Present (a)	Future (b)	Present (c)	Future (d)	Present (e)	Future (f)	Present (g)	Future (h)	
Freshwater shortage	1.3	2.3	2.7	2.8	2.6	3.0	1.8	2.2	**2.3**
Pollution	1.5	2.0	2.0	2.3	1.8	2.3	2.0	2.3	**2.0**
Habitat and community modification	2.0	3.0	2.4	3.0	2.4	2.8	2.3	2.7	**2.6**
Unsustainable exploitation of fish and other living resources	1.8	2.2	2.0	2.1	2.0	2.1	2.4	2.5	**2.1**
Global change	0.8	1.0	1.5	1.7	1.5	1.5	1.0	1.0	**1.2**

the relative contributions of both present and future impacts and environmental and socio-economic factors. The outcome of these additional analyses was subjected to further discussion to identify overall priorities for the region.

Finally, the assessment recognises that each of the five GIWA concerns are not discrete but often interact. For example, pollution can destroy aquatic habitats that are essential for fish reproduction which, in turn, can cause declines in fish stocks and subsequent overexploitation. Once teams have ranked each of the concerns and determined the priorities for the region, the links between the concerns are highlighted in order to identify places where strategic interventions could be applied to yield the greatest benefits for the environment and human societies in the region.

Causal chain analysis

Causal Chain Analysis (CCA) traces the cause-effect pathways from the socio-economic and environmental impacts back to their root causes. The GIWA CCA aims to identify the most important causes of each concern prioritised during the scoping assessment in order to direct policy measures at the most appropriate target in order to prevent further degradation of the regional aquatic environment.

Root causes are not always easy to identify because they are often spatially or temporally separated from the actual problems they cause. The GIWA CCA was developed to help identify and understand the root causes of environmental and socio-economic problems in international waters and is conducted by identifying the human activities that cause the problem and then the factors that determine the ways in which these activities are undertaken. However, because there is no universal theory describing how root causes interact to create natural resource management problems and due to the great variation of local circumstances under which the methodology will be applied, the GIWA CCA is not a rigidly structured assessment but should be regarded as a framework to guide the analysis, rather than as a set of detailed instructions. Secondly, in an ideal setting, a causal chain would be produced by a multidisciplinary group of specialists that would statistically examine each successive cause and study its links to the problem and to other causes. However, this approach (even if feasible) would use far more resources and time than those available to GIWA[1]. For this reason, it has been necessary to develop a relatively simple and practical analytical model for gathering information to assemble meaningful causal chains.

Conceptual model

A causal chain is a series of statements that link the causes of a problem with its effects. Recognising the great diversity of local settings and the resulting difficulty in developing broadly applicable policy strategies, the GIWA CCA focuses on a particular system and then only on those issues that were prioritised during the scoping assessment. The starting point of a particular causal chain is one of the issues selected during the Scaling and Scoping stages and its related environmental and socio-economic impacts. The next element in the GIWA chain is the immediate cause; defined as the physical, biological or chemical variable that produces the GIWA issue. For example, for the issue of eutrophication the immediate causes may be, inter alia:

- Enhanced nutrient inputs;
- Increased recycling/mobilisation;
- Trapping of nutrients (e.g. in river impoundments);
- Run-off and stormwaters

Once the relevant immediate cause(s) for the particular system has (have) been identified, the sectors of human activity that contribute most significantly to the immediate cause have to be determined. Assuming that the most important immediate cause in our example had been increased nutrient concentrations, then it is logical that the most likely sources of those nutrients would be the agricultural, urban or industrial sectors. After identifying the sectors that are primarily

[1] This does not mean that the methodology ignores statistical or quantitative studies; as has already been pointed out, the available evidence that justifies the assumption of causal links should be provided in the assessment.

responsible for the immediate causes, the root causes acting on those sectors must be determined. For example, if agriculture was found to be primarily responsible for the increased nutrient concentrations, the root causes could potentially be:

- Economic (e.g. subsidies to fertilisers and agricultural products);
- Legal (e.g. inadequate regulation);
- Failures in governance (e.g. poor enforcement); or
- Technology or knowledge related (e.g. lack of affordable substitutes for fertilisers or lack of knowledge as to their application).

Once the most relevant root causes have been identified, an explanation, which includes available data and information, of how they are responsible for the primary environmental and socio-economic problems in the region should be provided.

Policy option analysis

Despite considerable effort of many Governments and other organisations to address transboundary water problems, the evidence indicates that there is still much to be done in this endeavour. An important characteristic of GIWA's Policy Option Analysis (POA) is that its recommendations are firmly based on a better understanding of the root causes of the problems. Freshwater scarcity, water pollution, overexploitation of living resources and habitat destruction are very complex phenomena. Policy options that are grounded on a better understanding of these phenomena will contribute to create more effective societal responses to the extremely complex water related transboundary problems. The core of POA in the assessment consists of two tasks:

Construct policy options

Policy options are simply different courses of action, which are not always mutually exclusive, to solve or mitigate environmental and socio-economic problems in the region. Although a multitude of different policy options could be constructed to address each root cause identified in the CCA, only those few policy options that have the greatest likelihood of success were analysed in the GIWA.

Select and apply the criteria on which the policy options will be evaluated

Although there are many criteria that could be used to evaluate any policy option, GIWA focuses on:

- Effectiveness (certainty of result)
- Efficiency (maximisation of net benefits)
- Equity (fairness of distributional impacts)
- Practical criteria (political acceptability, implementation feasibility).

The policy options recommended by the GIWA are only contributions to the larger policy process and, as such, the GIWA methodology developed to test the performance of various options under the different circumstances has been kept simple and broadly applicable.

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Table 5a: Scoring criteria for environmental impacts of Freshwater shortage

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 1: Modification of stream flow "An increase or decrease in the discharge of streams and rivers as a result of human interventions on a local/ regional scale (see Issue 19 for flow alterations resulting from global change) over the last 3-4 decades."	■ No evidence of modification of stream flow.	■ There is a measurably changing trend in annual river discharge at gauging stations in a major river or tributary (basin > 40 000 km^2); or ■ There is a measurable decrease in the area of wetlands (other than as a consequence of conversion or embankment construction); or ■ There is a measurable change in the interannual mean salinity of estuaries or coastal lagoons and/or change in the mean position of estuarine salt wedge or mixing zone; or ■ Change in the occurrence of exceptional discharges (e.g. due to upstream damming.	■ Significant downward or upward trend (more than 20% of the long term mean) in annual discharges in a major river or tributary draining a basin of >250 000 km^2; or ■ Loss of >20% of flood plain or deltaic wetlands through causes other than conversion or artificial embankments; or ■ Significant loss of riparian vegetation (e.g. trees, flood plain vegetation); or ■ Significant saline intrusion into previously freshwater rivers or lagoons.	■ Annual discharge of a river altered by more than 50% of long term mean; or ■ Loss of >50% of riparian or deltaic wetlands over a period of not less than 40 years (through causes other than conversion or artificial embankment); or ■ Significant increased siltation or erosion due to changing in flow regime (other than normal fluctuations in flood plain rivers); or ■ Loss of one or more anadromous or catadromous fish species for reasons other than physical barriers to migration, pollution or overfishing.
Issue 2: Pollution of existing supplies "Pollution of surface and ground fresh waters supplies as a result of point or diffuse sources"	■ No evidence of pollution of surface and ground waters.	■ Any monitored water in the region does not meet WHO or national drinking water criteria, other than for natural reasons; or ■ There have been reports of one or more fish kills in the system due to pollution within the past five years.	■ Water supplies does not meet WHO or national drinking water standards in more than 30% of the region; or ■ There are one or more reports of fish kills due to pollution in any river draining a basin of >250 000 km^2 .	■ River draining more than 10% of the basin have suffered polysaprobic conditions, no longer support fish, or have suffered severe oxygen depletion ■ Severe pollution of other sources of freshwater (e.g. groundwater)
Issue 3: Changes in the water table "Changes in aquifers as a direct or indirect consequence of human activity"	■ No evidence that abstraction of water from aquifers exceeds natural replenishment.	■ Several wells have been deepened because of excessive aquifer draw-down; or ■ Several springs have dried up; or ■ Several wells show some salinisation.	■ Clear evidence of declining base flow in rivers in semi-arid areas; or ■ Loss of plant species in the past decade, that depend on the presence of ground water; or ■ Wells have been deepened over areas of hundreds of km^2;or ■ Salinisation over significant areas of the region.	■ Aquifers are suffering salinisation over regional scale; or ■ Perennial springs have dried up over regionally significant areas; or ■ Some aquifers have become exhausted

Table 5b: Scoring criteria for environmental impacts of Pollution

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 4: Microbiological pollution "The adverse effects of microbial constituents of human sewage released to water bodies."	■ Normal incidence of bacterial related gastroenteric disorders in fisheries product consumers and no fisheries closures or advisories.	■ There is minor increase in incidence of bacterial related gastroenteric disorders in fisheries product consumers but no fisheries closures or advisories.	■ Public health authorities aware of marked increase in the incidence of bacterial related gastroenteric disorders in fisheries product consumers; or ■ There are limited area closures or advisories reducing the exploitation or marketability of fisheries products.	■ There are large closure areas or very restrictive advisories affecting the marketability of fisheries products; or ■ There exists widespread public or tourist awareness of hazards resulting in major reductions in the exploitation or marketability of fisheries products.
Issue 5: Eutrophication "Artificially enhanced primary productivity in receiving water basins related to the increased availability or supply of nutrients, including cultural eutrophication in lakes."	■ No visible effects on the abundance and distributions of natural living resource distributions in the area; and ■ No increased frequency of hypoxia[1] or fish mortality events or harmful algal blooms associated with enhanced primary production; and ■ No evidence of periodically reduced dissolved oxygen or fish and zoobenthos mortality; and ■ No evident abnormality in the frequency of algal blooms.	■ Increased abundance of epiphytic algae; or ■ A statistically significant trend in decreased water transparency associated with algal production as compared with long-term (>20 year) data sets; or ■ Measurable shallowing of the depth range of macrophytes.	■ Increased filamentous algal production resulting in algal mats; or ■ Medium frequency (up to once per year) of large-scale hypoxia and/or fish and zoobenthos mortality events and/or harmful algal blooms.	■ High frequency (>1 event per year), or intensity, or large areas of periodic hypoxic conditions, or high frequencies of fish and zoobenthos mortality events or harmful algal blooms; or ■ Significant changes in the littoral community; or ■ Presence of hydrogen sulphide in historically well oxygenated areas.

Issue 6: Chemical pollution "The adverse effects of chemical contaminants released to standing or marine water bodies as a result of human activities. Chemical contaminants are here defined as compounds that are toxic or persistent or bioaccumulating."	■ No known or historical levels of chemical contaminants except background levels of naturally occurring substances; and ■ No fisheries closures or advisories due to chemical pollution; and ■ No incidence of fisheries product tainting; and ■ No unusual fish mortality events. If there is no available data use the following criteria: ■ No use of pesticides; and ■ No sources of dioxins and furans; and ■ No regional use of PCBs; and ■ No bleached kraft pulp mills using chlorine bleaching; and ■ No use or sources of other contaminants.	■ Some chemical contaminants are detectable but below threshold limits defined for the country or region; or ■ Restricted area advisories regarding chemical contamination of fisheries products. If there is no available data use the following criteria: ■ Some use of pesticides in small areas; or ■ Presence of small sources of dioxins or furans (e.g., small incineration plants or bleached kraft/pulp mills using chlorine); or ■ Some previous and existing use of PCBs and limited amounts of PCB-containing wastes but not in amounts invoking local concerns; or ■ Presence of other contaminants.	■ Some chemical contaminants are above threshold limits defined for the country or region; or ■ Large area advisories by public health authorities concerning fisheries product contamination but without associated catch restrictions or closures; or ■ High mortalities of aquatic species near outfalls. If there is no available data use the following criteria: ■ Large-scale use of pesticides in agriculture and forestry; or ■ Presence of major sources of dioxins or furans such as large municipal or industrial incinerators or large bleached kraft pulp mills; or ■ Considerable quantities of waste PCBs in the area with inadequate regulation or has invoked some public concerns; or ■ Presence of considerable quantities of other contaminants.	■ Chemical contaminants are above threshold limits defined for the country or region; and ■ Public health and public awareness of fisheries contamination problems with associated reductions in the marketability of such products either through the imposition of limited advisories or by area closures of fisheries; or ■ Large-scale mortalities of aquatic species. If there is no available data use the following criteria: ■ Indications of health effects resulting from use of pesticides; or ■ Known emissions of dioxins or furans from incinerators or chlorine bleaching of pulp; or ■ Known contamination of the environment or foodstuffs by PCBs; or ■ Known contamination of the environment or foodstuffs by other contaminants.
Issue 7: Suspended solids "The adverse effects of modified rates of release of suspended particulate matter to water bodies resulting from human activities"	■ No visible reduction in water transparency; and ■ No evidence of turbidity plumes or increased siltation; and ■ No evidence of progressive riverbank, beach, other coastal or deltaic erosion.	■ Evidently increased or reduced turbidity in streams and/or receiving riverine and marine environments but without major changes in associated sedimentation or erosion rates, mortality or diversity of flora and fauna; or ■ Some evidence of changes in benthic or pelagic biodiversity in some areas due to sediment blanketing or increased turbidity.	■ Markedly increased or reduced turbidity in small areas of streams and/or receiving riverine and marine environments; or ■ Extensive evidence of changes in sedimentation or erosion rates; or ■ Changes in benthic or pelagic biodiversity in areas due to sediment blanketing or increased turbidity.	■ Major changes in turbidity over wide or ecologically significant areas resulting in markedly changed biodiversity or mortality in benthic species due to excessive sedimentation with or without concomitant changes in the nature of deposited sediments (i.e., grain-size composition/redox); or ■ Major change in pelagic biodiversity or mortality due to excessive turbidity.
Issue 8: Solid wastes "Adverse effects associated with the introduction of solid waste materials into water bodies or their environs."	■ No noticeable interference with trawling activities; and ■ No noticeable interference with the recreational use of beaches due to litter; and ■ No reported entanglement of aquatic organisms with debris.	■ Some evidence of marine-derived litter on beaches; or ■ Occasional recovery of solid wastes through trawling activities; but ■ Without noticeable interference with trawling and recreational activities in coastal areas.	■ Widespread litter on beaches giving rise to public concerns regarding the recreational use of beaches; or ■ High frequencies of benthic litter recovery and interference with trawling activities; or ■ Frequent reports of entanglement/suffocation of species by litter.	■ Incidence of litter on beaches sufficient to deter the public from recreational activities; or ■ Trawling activities untenable because of benthic litter and gear entanglement; or ■ Widespread entanglement and/or suffocation of aquatic species by litter.
Issue 9: Thermal "The adverse effects of the release of aqueous effluents at temperatures exceeding ambient temperature in the receiving water body."	■ No thermal discharges or evidence of thermal effluent effects.	■ Presence of thermal discharges but without noticeable effects beyond the mixing zone and no significant interference with migration of species.	■ Presence of thermal discharges with large mixing zones having reduced productivity or altered biodiversity; or ■ Evidence of reduced migration of species due to thermal plume.	■ Presence of thermal discharges with large mixing zones with associated mortalities, substantially reduced productivity or noticeable changes in biodiversity; or ■ Marked reduction in the migration of species due to thermal plumes.
Issue 10: Radionuclide "The adverse effects of the release of radioactive contaminants and wastes into the aquatic environment from human activities."	■ No radionuclide discharges or nuclear activities in the region.	■ Minor releases or fallout of radionuclides but with well regulated or well-managed conditions complying with the Basic Safety Standards.	■ Minor releases or fallout of radionuclides under poorly regulated conditions that do not provide an adequate basis for public health assurance or the protection of aquatic organisms but without situations or levels likely to warrant large scale intervention by a national or international authority.	■ Substantial releases or fallout of radionuclides resulting in excessive exposures to humans or animals in relation to those recommended under the Basic Safety Standards; or ■ Some indication of situations or exposures warranting intervention by a national or international authority.
Issue 11: Spills "The adverse effects of accidental episodic releases of contaminants and materials to the aquatic environment as a result of human activities."	■ No evidence of present or previous spills of hazardous material; or ■ No evidence of increased aquatic or avian species mortality due to spills.	■ Some evidence of minor spills of hazardous materials in small areas with insignificant small-scale adverse effects one aquatic or avian species.	■ Evidence of widespread contamination by hazardous or aesthetically displeasing materials assumed to be from spillage (e.g. oil slicks) but with limited evidence of widespread adverse effects on resources or amenities; or ■ Some evidence of aquatic or avian species mortality through increased presence of contaminated or poisoned carcasses on beaches.	■ Widespread contamination by hazardous or aesthetically displeasing materials from frequent spills resulting in major interference with aquatic resource exploitation or coastal recreational amenities; or ■ Significant mortality of aquatic or avian species as evidenced by large numbers of contaminated carcasses on beaches.

Table 5c: Scoring criteria for environmental impacts of Habitat and community modification

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 12: Loss of ecosystems or ecotones "The complete destruction of aquatic habitats. For the purpose of GIWA methodology, recent loss will be measured as a loss of pre-defined habitats over the last 2-3 decades."	■ There is no evidence of loss of ecosystems or habitats.	■ There are indications of fragmentation of at least one of the habitats.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by up to 30 % during the last 2-3 decades.	■ Permanent destruction of at least one habitat is occurring such as to have reduced their surface area by >30% during the last 2-3 decades.
Issue 13: Modification of ecosystems or ecotones, including community structure and/or species composition "Modification of pre-defined habitats in terms of extinction of native species, occurrence of introduced species and changing in ecosystem function and services over the last 2-3 decades."	■ No evidence of change in species complement due to species extinction or introduction; and ■ No changing in ecosystem function and services.	■ Evidence of change in species complement due to species extinction or introduction	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure	■ Evidence of change in species complement due to species extinction or introduction; and ■ Evidence of change in population structure or change in functional group composition or structure; and ■ Evidence of change in ecosystem services[2].

[2] Constanza, R. et al. (1997). The value of the world ecosystem services and natural capital, Nature 387:253-260.

Table 5d: Scoring criteria for environmental impacts of Unsustainable exploitation of fish and other living resources

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 14: Overexploitation "The capture of fish, shellfish or marine invertebrates at a level that exceeds the maximum sustainable yield of the stock."	■ No harvesting exists catching fish (with commercial gear for sale or subsistence).	■ Commercial harvesting exists but there is no evidence of over-exploitation.	■ One stock is exploited beyond MSY (maximum sustainable yield) or is outside safe biological limits.	■ More than one stock is exploited beyond MSY or is outside safe biological limits.
Issue 15: Excessive by-catch and discards "By-catch refers to the incidental capture of fish or other animals that are not the target of the fisheries. Discards refers to dead fish or other animals that are returned to the sea."	■ Current harvesting practices show no evidence of excessive by-catch and/or discards.	■ Up to 30% of the fisheries yield (by weight) consists of by-catch and/or discards.	■ 30-60% of the fisheries yield consists of by-catch and/or discards.	■ Over 60% of the fisheries yield is by-catch and/or discards; or ■ Noticeable incidence of capture of endangered species.
Issue 16: Destructive fishing practices "Fishing practices that are deemed to produce significant harm to marine, lacustrine or coastal habitats and communities."	■ No evidence of habitat destruction due to fisheries practices.	■ Habitat destruction resulting in changes in distribution of fish or shellfish stocks; or ■ Trawling of any one area of the seabed is occurring less than once per year.	■ Habitat destruction resulting in moderate reduction of stocks or moderate changes of the environment; or ■ Trawling of any one area of the seabed is occurring 1-10 times per year; or ■ Incidental use of explosives or poisons for fishing.	■ Habitat destruction resulting in complete collapse of a stock or far reaching changes in the environment; or ■ Trawling of any one area of the seabed is occurring more than 10 times per year; or ■ Widespread use of explosives or poisons for fishing.
Issue 17: Decreased viability of stocks through contamination and disease "Contamination or diseases of feral (wild) stocks of fish or invertebrates that are a direct or indirect consequence of human action."	■ No evidence of increased incidence of fish or shellfish diseases.	■ Increased reports of diseases without major impacts on the stock.	■ Declining populations of one or more species as a result of diseases or contamination.	■ Collapse of stocks as a result of diseases or contamination.
Issue 18: Impact on biological and genetic diversity "Changes in genetic and species diversity of aquatic environments resulting from the introduction of alien or genetically modified species as an intentional or unintentional result of human activities including aquaculture and restocking."	■ No evidence of deliberate or accidental introductions of alien species; and ■ No evidence of deliberate or accidental introductions of alien stocks; and ■ No evidence of deliberate or accidental introductions of genetically modified species.	■ Alien species introduced intentionally or accidentally without major changes in the community structure; or ■ Alien stocks introduced intentionally or accidentally without major changes in the community structure; or ■ Genetically modified species introduced intentionally or accidentally without major changes in the community structure.	■ Measurable decline in the population of native species or local stocks as a result of introductions (intentional or accidental); or ■ Some changes in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).	■ Extinction of native species or local stocks as a result of introductions (intentional or accidental); or ■ Major changes (>20%) in the genetic composition of stocks (e.g. as a result of escapes from aquaculture replacing the wild stock).

Table 5e: Scoring criteria for environmental impacts of Global change

Issue	Score 0 = no known impact	Score 1 = slight impact	Score 2 = moderate impact	Score 3 = severe impact
Issue 19: Changes in hydrological cycle and ocean circulation "Changes in the local/regional water balance and changes in ocean and coastal circulation or current regime over the last 2-3 decades arising from the wider problem of global change including ENSO."	■ No evidence of changes in hydrological cycle and ocean/coastal current due to global change.	■ Change in hydrological cycles due to global change causing changes in the distribution and density of riparian terrestrial or aquatic plants without influencing overall levels of productivity; or ■ Some evidence of changes in ocean or coastal currents due to global change but without a strong effect on ecosystem diversity or productivity.	■ Significant trend in changing terrestrial or sea ice cover (by comparison with a long-term time series) without major downstream effects on river/ocean circulation or biological diversity; or ■ Extreme events such as flood and drought are increasing; or ■ Aquatic productivity has been altered as a result of global phenomena such as ENSO events.	■ Loss of an entire habitat through desiccation or submergence as a result of global change; or ■ Change in the tree or lichen lines; or ■ Major impacts on habitats or biodiversity as the result of increasing frequency of extreme events; or ■ Changing in ocean or coastal currents or upwelling regimes such that plant or animal populations are unable to recover to their historical or stable levels; or ■ Significant changes in thermohaline circulation.
Issue 20: Sea level change "Changes in the last 2-3 decades in the annual/seasonal mean sea level as a result of global change."	■ No evidence of sea level change.	■ Some evidences of sea level change without major loss of populations of organisms.	■ Changed pattern of coastal erosion due to sea level rise has became evident; or ■ Increase in coastal flooding events partly attributed to sea-level rise or changing prevailing atmospheric forcing such as atmospheric pressure or wind field (other than storm surges).	■ Major loss of coastal land areas due to sea-level change or sea-level induced erosion; or ■ Major loss of coastal or intertidal populations due to sea-level change or sea level induced erosion.
Issue 21: Increased UV-B radiation as a result of ozone depletion "Increased UV-B flux as a result polar ozone depletion over the last 2-3 decades."	■ No evidence of increasing effects of UV/B radiation on marine or freshwater organisms.	■ Some measurable effects of UV/B radiation on behavior or appearance of some aquatic species without affecting the viability of the population.	■ Aquatic community structure is measurably altered as a consequence of UV/B radiation; or ■ One or more aquatic populations are declining.	■ Measured/assessed effects of UV/B irradiation are leading to massive loss of aquatic communities or a significant change in biological diversity.
Issue 22: Changes in ocean CO_2 source/sink function "Changes in the capacity of aquatic systems, ocean as well as freshwater, to generate or absorb atmospheric CO_2 as a direct or indirect consequence of global change over the last 2-3 decades."	■ No measurable or assessed changes in CO_2 source/sink function of aquatic system.	■ Some reasonable suspicions that current global change is impacting the aquatic system sufficiently to alter its source/sink function for CO_2.	■ Some evidences that the impacts of global change have altered the source/sink function for CO_2 of aquatic systems in the region by at least 10%.	■ Evidences that the changes in source/sink function of the aquatic systems in the region are sufficient to cause measurable change in global CO_2 balance.

The Global International Waters Assessment (GIWA) is a holistic, globally comparable assessment of all the world's transboundary waters that recognises the inextricable links between freshwater and coastal marine environment and integrates environmental and socio-economic information to determine the impacts of a broad suite of influences on the world's aquatic environment.

Broad Transboundary Approach

The GIWA not only assesses the problems caused by human activities manifested by the physical movement of transboundary waters, but also the impacts of other non-hydrological influences that determine how humans use transboundary waters.

Regional Assessment - Global Perspective

The GIWA provides a global perspective of the world's transboundary waters by assessing 66 regions that encompass all major drainage basins and adjacent large marine ecosystems. The GIWA Assessment of each region incorporates information and expertise from all countries sharing the transboundary water resources.

Global Comparability

In each region, the assessment focuses on 5 broad concerns that are comprised of 22 specific water related issues.

Integration of Information and Ecosystems

The GIWA recognises the inextricable links between freshwater and coastal marine environment and assesses them together as one integrated unit.

The GIWA recognises that the integration of socio-economic and environmental information and expertise is essential to obtain a holistic picture of the interactions between the environmental and societal aspects of transboundary waters.

Priorities, Root Causes and Options for the Future

The GIWA indicates priority concerns in each region, determines their societal root causes and develops options to mitigate the impacts of those concerns in the future.

This Report

This report presents the GIWA assessment of the Caribbean Islands region – an archipelago comprising drainage basins and coastal areas that contain some of the world's most diverse and productive habitats. A variety of human activities are impacting the region's sensitive and unique ecosystems, upon which the population is so dependent for their social well-being and economic survival. Pollution, originating from both land-based sources and marine traffic, is of particular concern, but despite considerable and widespread environmental and socio-economic impacts, there has been a lack of appropriate measures aimed at mitigating this concern. The past and present status and future prospects are discussed, and the transboundary issues of pollution are traced back to their root causes. Policy options are analysed that aim to address these driving issues in order to significantly improve environmental quality and secure the region's future prosperity.