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.
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.

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...
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).

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.
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.

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 GtWA 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 Escambró 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.
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 Escambrón in San Juan (Puerto Rico). Table 26 shows the main oil spills that have occurred in the Caribbean Islands region since 1973.

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

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 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...
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 difficult 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,

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

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

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

<table>
<thead>
<tr>
<th>Type of ships</th>
<th>Arrive to ports</th>
<th>Solid waste discharges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ships/year</td>
<td>%</td>
</tr>
<tr>
<td>Cruises</td>
<td>1,833</td>
<td>10.7</td>
</tr>
<tr>
<td>International cargo</td>
<td>6,490</td>
<td>38.0</td>
</tr>
<tr>
<td>Coastal traffic</td>
<td>6,363</td>
<td>37.3</td>
</tr>
<tr>
<td>Military</td>
<td>310</td>
<td>1.8</td>
</tr>
<tr>
<td>Fishing</td>
<td>252</td>
<td>1.5</td>
</tr>
<tr>
<td>Yachts</td>
<td>608</td>
<td>3.6</td>
</tr>
<tr>
<td>Others</td>
<td>1,218</td>
<td>7.3</td>
</tr>
<tr>
<td>Total</td>
<td>17,074</td>
<td></td>
</tr>
</tbody>
</table>

(Source: WCISW 1996a,b)

Discharge of oil bilge

Cruise ships can generate 5-140 m³ 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).

**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

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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.

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

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 km², a volume of 47 million m³, 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 Avarés 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 km²), Martin Perez (12.2 km²) and Arroyo Tadeo (2.2 km²) rivers form the drainage area near to the Bay. The approximate flow of freshwater to the Bay is 330 000 m³ 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
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 & Reiners 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).
- 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.
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 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 deposited 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, agrochemical 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 contaminants from solid wastes such as cars and other means of transportation, which leak 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 1970s 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 & Aguire 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 phosphorous) (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.
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.