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REGIONAL OVERVIEW OF LAND-BASED SOURCES OF POLLUTION IN THE WIDER CARIBBEAN REGION

UNEP

CARIBBEAN ENVIRONMENT PROGRAMME

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REGIONAL OVERVIEW OF LAND-BASED SOURCES OF POLLUTION IN THE WIDER CARIBBEAN REGION

I. Introduction

During the past two decades awareness of the steadily growing pollution of the coastal and marine areas of the Wider Caribbean Region (WCR) became increasingly apparent. In response to this concern, national research institutions and international organizations have undertaken technical actions as well as the preparation of legal instruments for the prevention and control of marine and coastal pollution within the Wider Caribbean Region.

As early as 1973 the International Co-ordination Group of Co-operative Investigation of the Caribbean and Adjacent Regions (CICAR) sponsored by IOC-UNESCO noted the increasing concern regarding marine pollution issues in the WCR; therefore, the CICAR Group recommended that a workshop be convened to that effect in 1976 in co-operation with the United Nations Environment Programme (UNEP) and the Western Central Atlantic Fisheries Commission (WECAF) of FAO (1). Based on the recommendations of the workshop a project to monitor petroleum pollution in the WCR was initiated in 1979 under the sponsorship of UNEP and IOC-IOCARIBE.

With the adoption in 1981 of the Action Plan for the Caribbean Environment Programme, governmental and non-governmental representatives, assisted by UNEP and the Economic Commission for Latin America and the Caribbean (ECLAC), developed a regional framework through which concerted actions could be implemented to protect coastal and marine areas of the WCR from pollution.

One of the major accomplishments of the Caribbean Environment Programme (CEP) in the area of marine pollution was the adoption of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region. This Convention was signed in 1983 in Cartagena de Indias, Colombia, in 1983 (2). This Convention was adopted along with the Protocol "Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region" (Protocol concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region), both of which entered into force in 1986.

Several Articles of the Cartagena Convention refer to the need that appropriate measures be taken to prevent, reduce and control pollution caused by discharges from land-based sources, ships, dumping, seabed activities, etc. Additionally, Article 13 calls for scientific and technical co-operation to protect and develop the marine and coastal environment of the WCR.

The Fourth Intergovernmental Meeting of the Action Plan for the Caribbean Environment Programme and the First Meeting of the Contracting Parties to the Cartagena Convention was convened in Guadeloupe, France in 1987 (3). This meeting examined the status of implementation and adopted the Assessment and Control of Marine Pollution as one of the four major elements of the Action Plan of CEP.

As a follow-up, a UNEP-CEP-IOC-UNESCO Workshop was convened in San José, Costa Rica in 1989 to review priorities for marine pollution monitoring, research, control and abatement. The Workshop proposed a comprehensive joint IOC-UNESCO UNEP-CEP Programme for Marine Pollution Assessment and Control (CEPPOL) in the WCR (4).

The CEPPOL Programme, which was initiated in August 1990, had seven components relevant to the assessment and control of the quality of the marine and coastal environment of the WCR. Among the above-mentioned components, the control of domestic, industrial and agricultural land-based sources of pollution (LBSP) became one of the most important activities of the programme.

The present report summarizes the results of the above-mentioned CEPPOL activity and provides information on the LBSP inventories undertaken in 25 countries of WCR. This comprehensive information has been compiled from national LBSP inventories, mainly from point sources, together with the assessment of the types and amounts of major pollutants reaching the coastal and marine environment from the above sources as well as information on legislative and administrative measures relevant for their control. The detailed results of the inventories are presented in tables and maps. Additionally, a regional overview is provided taking into account sub-regional differences and total pollution loads affecting the entire WCR. This report includes a review of management practices to control pollution currently as well as being implemented together with conclusions and recommendations.

II. Geographic Coverage

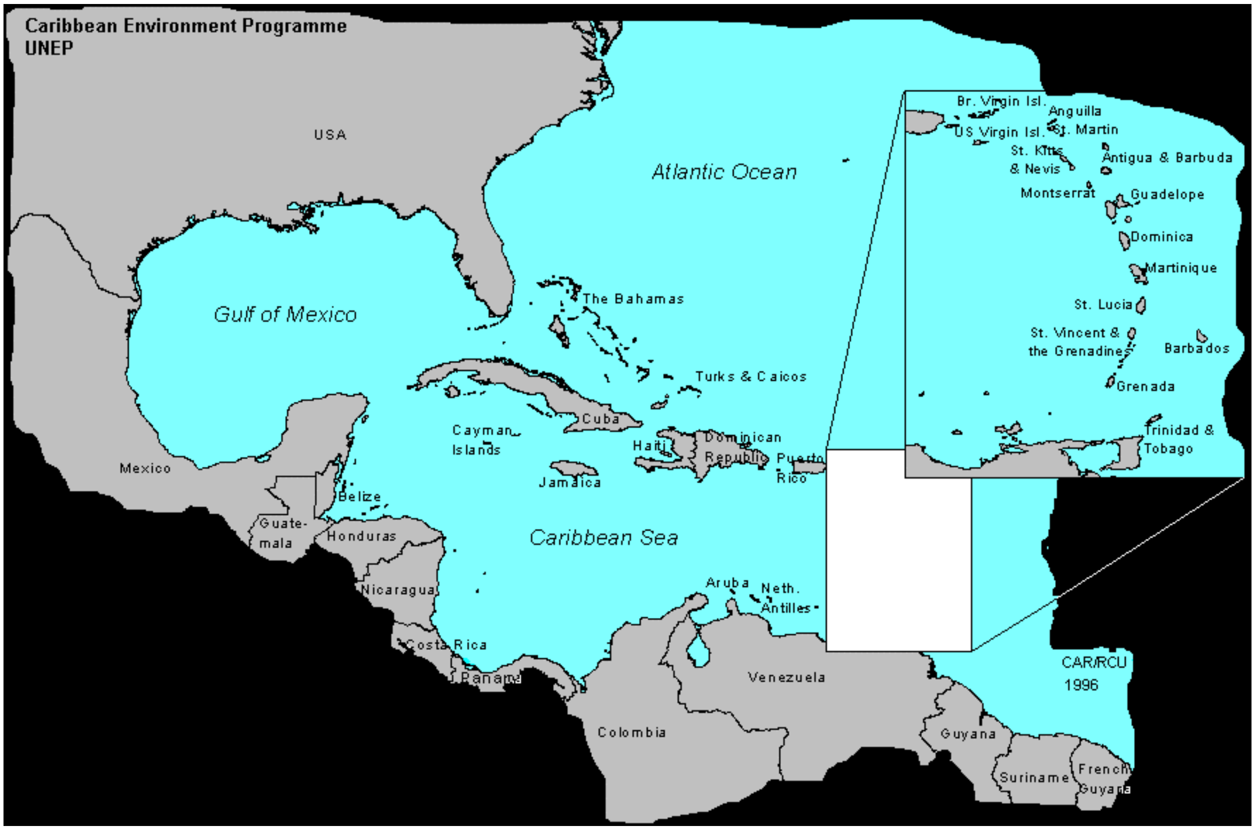
For the purpose of this report, geographic coverage is based on the definition used in the Convention for the Protection and Development of the WCR as stated in article 2:

> "The "Convention area" means the marine environment of the Gulf of Mexico, the Caribbean Sea and areas of the Atlantic Ocean adjacent thereto, south of 30^{o} north latitude and within 200 nautical miles of the Atlantic coast of the States referred to in article 25 of the Convention".

Moreover, the "Convention area" includes twelve continental States, thirteen Island States, the Commonwealth of Puerto Rico, three overseas Departments of France, a Territory shared by

Netherlands and France (St. Maarteen) (**Fig. 1**), and eleven dependent Territories.

Fig. 1. Map of the Wider Caribbean Region



Based on recent statistics provided by the World Resources Institute (5) and additional sources (6, 7), it has been estimated that the population of coastal dwellers in the WCR will reach between 60 to 65 million persons by the year 2000.

III Background Information

As in other regions of the world in the WCR the major sources of coastal and marine pollution originating from land-based sources vary from country to country, depending on the nature and intensity of the specific development activities. In the coastal areas these activities affect the water quality of rivers discharging into the coastal zone. Activities related to human settlements, agriculture and industry have been identified as major contributors to the pollutant loads reaching coastal and marine waters in the WCR.

In order to mitigate and control the impact of pollution originating from land-based sources on coastal marine resources it is essential that the type and levels of pollutants be identified. This process involves the determination of the sources, localization of the discharges, volume of the wastes, concentration of potential pollutants, etc. However, point sources account for only a fraction of the land-based sources of pollution affecting the coastal and marine environment of the WCR. NOAA's National Coastal Pollutant Discharge Inventory Programme (NCPDI) has identified the following sources:

i) Point sources (industries and sewage treatment plants);

ii) Urban non-point runoff (stormwater runoff and combined overflow discharges);

iii) Non-urban non-point runoff (cropland, pastureland and forestland runoff);

iv) Upstream sources (pollutants carried into the coastal zone as part of river's streamflow); and

v) Irrigation return flows (irrigation water return to a lake, stream or canal).

An evaluation reveals land-based sources of pollution resulting from types (ii), (iii) and (v) are very difficult to assess in the WCR. However, pollution resulting from these sources have been dealt with through management measures, such as Section 6217 of the Coastal Zone Act Re-authorization Amendments of 1990 (CZARA) and the Coastal Zone Management Act of 1972 (CZMA) being enforced in the United States.

Regarding concerted actions conducive to the evaluation of land-based sources of coastal and marine pollution in the WCR, very little information is available. Most of the available information has been gathered by NOAA's NCPDI Programme (8, 9, 10). The database generated by the above-mentioned programme contains pollutant loading estimates from point, non-point and riverine sources located in coastal areas that discharge into the estuarine, coastal and oceanic waters of the United States. Pollutant loadings for the US Gulf of Mexico coast have been estimated for 31 estuaries and four sub-estuaries extending from the southern tip of Florida west to the Texas/Mexico border.

Several documents on the state of marine pollution of the region were prepared in the early 1980s (11, 12, 13). The only survey conducted to date in the Caribbean to estimate pollutant loads from industrial and domestic point sources was sponsored by UNEP/CARICOM/PAHO (5). The survey carried out by PAHO included eleven CARICOM countries and provided estimated levels of BOD_5 and total suspended solids from domestic and industrial point sources together with the volume of the discharged wastes. Additional information on pollutant loading from point sources for specific heavily contaminated coastal locations within the WCR have been obtained for Havana Bay, Cuba (15); Cartagena Bay, Colombia (16); Kingston Harbour, Jamaica (17); Lake Maracaibo, Venezuela (18) and the Coatzacoalcos Estuary, Mexico (19).

Based on all the information available to date the type of pollutants from land-based sources which may constitute the greatest real or perceived threat to coastal and marine ecosystems as well as the public health of coastal dwellers of the WCR, are the following: sewage, oil hydrocarbons, sediments, nutrients, pesticides, litter and marine debris and toxic wastes needs to be emphasized.

1. Sewage

Sewage has been identified as one of the most significant pollutants affecting the coastal environment of the WCR, particularly in developing countries. The ecological and health problems posed by the discharge of untreated sewage in coastal waters of the WCR needs to be examined on a short and a long term basis for its mitigation and eventual control. In the short term it is imperative to make an assessment of the availability and operational conditions of the sewage treatment plants serving coastal communities within the region. In this regard, an initial report from PAHO (20) indicated that only 10% of the sewage generated in the Central American and Caribbean island countries were properly treated. A more recent survey conducted in eleven CARICOM countries by PAHO reported that the percentage of the population served by sewage systems varied from 2 to 16%.

Concerning the operational conditions of the sewage treatment plants operating in the CARICOM countries, a recently published survey conducted by CEHI/PAHO (21) has been summarized in **Table 1**.

The information presented in Table 1, shows the inadequate number of sewage treatment plants in operation, considering the population of the surveyed countries, together with the poor operating conditions of the available treatment plants. The report also indicates that approximately two thirds of the plants surveyed were poorly maintained package plants used in

TABLE 1. Population of the CARICOM countries and the British Virgin Islands, number

of Sewage Treatment Facilities (STF) available and operating conditions (2)

Country	Population 1990 x 10^3	STF Total Surveyed		Operating Conditions %				
				G	M	P	NO	?
Antigua & Barbuda	66	20	17	12	35	24	24	5
Bahamas	241	27	18	39	17	22	22	-
Barbados	253	12	12	25	58	17	-	-
Belize	184	3	2	-	50	-	-	50
British Virgin Islands	13	110	10	10	70	20	-	-
Dominica	81	-	-	-	-	-	-	-
Grenada	110	5	5	20	60	20	-	-
Guyana	755	2	2	-	-	50	50	-
Jamaica	2,480	109	28	39	32	21	4	4
Monserrat	13	1	1	-	100	-	-	-
St. Kitts & Nevis	45	4		-	75	25	-	-
St. Lucia	136	17	13	23	23	15	39	-
St. Vincent & the Grenadines	120	1	1	-	-	100	-	-
Trinidad & Tobago	1,320	92	25	12	42	11	35	-
Total	5,817	303	138	25%	36%	22%	13%	4%

G = Good; M= Moderate; P= Poor; NO= Not operational; ?= Undetermined

the absence of municipal sewerage systems. With regards to the disposal of the effluents from the surveyed sewage treatment plants, the CEHI/PAHO report described the following waste disposal practices: Re-use of effluent 31 plants (21%); sub-surface discharge, 20 plants (14%); marine disposal, mainly on the shoreline, 42 plants (28%); lagoons and streams, 32 plants (22%); and on site disposal, 21 plants (14%). The above information clearly shows that the disposal practices of discharging mostly untreated wastewater are likely to adversely affect the quality of coastal waters. The CEHI/PAHO report also pointed out that of the 138 plants surveyed only 82 regularly monitor the quality of their effluent. However, monitoring data was available from only 54 plants of which only a third provided unreliable data.

The information presented in the NCPDI report provides an insight into the relative importance of sewage treatment plants as point-sources discharging into the estuarine and coastal areas of the U.S. Gulf Coast. In 1990 there were 1,293 municipality owned sewage treatment plants serving the U.S. Gulf Coast. Most of these plants provided secondary treatment and discharged approximately 3,790 x 10^3 m^3 a day of treated wastewaters, mainly into estuarine environment, with only six of the 113 municipalities discharging into coastal areas (22). Based on the projected demographic growth of the US Gulf coast, it has been estimated that sewage loadings in the state of Florida are expected to increase up to 300% by the year 2000 (23). Similar trends can be expected for the rest of the Gulf coastal states. The sludge generated by the above mentioned sewage treatment plants are commonly incinerated and disposed of in landfills.

Very little information exists regarding the number and operating conditions of sewage treatment plants serving coastal communities from most of the rest of the countries of the WCR. In the meantime, the population of coastal dwellers in most of the countries of the regions continues to grow steadily, thus increasing the amounts of poorly treated or untreated sewage wastewaters being discharge into the coastal marine environment. Consequently, the potential for public health problems via primary contact with coastal waters and by consumption of contaminated fish or shellfish is a matter of great concern (24, 25). Moreover, the discharge of untreated sewage effluents may also produce a long-term adverse impact on the ecology of critical coastal ecosystems in localized areas due to the contribution of nutrients and other pollutants (26).

With reference to the demographic growth of the coastal populations of the regions, based on the information provided in item II of the present report, a population growth of 58% has been estimated for 13 countries of the WCR during the 1980-2000 period (**Table 2**). Concerning the increasing flow of visitors to many countries of the region, the past decade has witnessed an increasing growth of the region's tourism, an industry dependant on the quality of the natural environment. Estimates provided by the Caribbean Tourism Organization (CTO) indicate that the total stayover tourist arrival to the Caribbean region is close to 12 million visitors per year, statistics for the 1987-1992 period showed that the number of visitors to the region increased at a yearly rate of 9% during the above-mentioned period. It is important to point out that the CTO statistics do not include the tourists visiting the coastal resort areas of the Gulf of Mexico, Central America, the Mexican Caribbean and the northern coast of South America.

With regard to daily visitors from cruise vessels, recent CTO statistics for the 1991-1992 period showed that the number of these visitors is close to 8 million per year, increasing at a yearly rate of 7.5%. To respond to this increasing influx of tourist, hotels and recreational facilities are being built at many locations within the region that lack the necessary municipal

TABLE 2. Estimated population growth in the coastal areas of 13 countries of the WCR for the 1980-2000 period (5,6,7)

Country	Population x 10^3 1980	2000	Yearly Growth %
Barbados	100	146	2.3
Colombia	2,926	3,926	1.7
Cuba	6,628	8,942	1.7
Dominican Republic	2,287	5,797	5.4
Guadaloupe (FR)	142	196	1.9
Guyana	213	425	5.0
Jamaica	1,016	1,689	3.3
Martinique (FR)	217	279	1.4
Mexico (Gulf Coast)	4,000	7,200	4.0
Suriname	140	216	2.7
Trinidad and Tobago	623	1,110	3.9
U.S.A. (Gulf Coast)	11,991	16,615	1.9
Venezuela	5,158	9,324	4.0
TOTAL	**35,441**	**55,865**	**3.0 (Aver.)**

sewerage systems, requiring hotels to operate their own treatment plants. However, according to the CEHI/PAHO report of 1991, previously mentioned in the present report and based on their survey of treatment plants operating in the CARICOM countries, only 25% of the treatment plants operated by hotels and resort complexes were in good operating condition.

An additional problem related to the disposal of untreated or poorly treated sewage wastewaters in the coastal areas of the Wider Caribbean region is the increasing traffic of ships and recreational vessels within the region. According to Annex IV of MARPOL 73/78, large ships are permitted to discharge sewage wastewaters within four miles of the nearest land, unless they have approved treatment plants on board. However, despite this regulation Annex IV of MARPOL is not yet in force and its requirements remain optional for the time being. Of particular concern is the intense traffic of coastal cargo vessels and recreational boats in the Wider Caribbean region since most of these vessels do not have holding tanks for Annex IV wastes. Therefore, their wastewaters are likely to be discharged in marinas and near-shore coastal areas due to a lack of port reception facilities for Annex IV wastes in most of the countries of the region.

In view of the demographic growth of the coastal areas of the Wider Caribbean region, a multi-sectorial action plan will be necessary in the long-term to ensure adequate treatment and disposal of the increasing loads of sewage wastewaters being discharged in near-shore coastal areas. These ambitious objectives can probably be achieved by a combination of regulatory actions, economic assistance, technical innovation and incentives. The main obstacle in reaching these goals stems principally from inadequate coastal zone management schemes adopted by many countries of the region.

2. Oil Hydrocarbons

The Wider Caribbean region is one of the largest oil producing areas of the world with a production of approximately 170 x 10^6 tons yr^{-1} being contributed by the following countries: Colombia, Mexico, Trinidad and Tobago, United States of America and Venezuela (27). Most of the oil produced in the Wider Caribbean Region is shipped within the region resulting in an intricate network of distribution routes. A report commissioned by the U.S. Department of Transportation and the U.S. Coast Guard (26) provides information regarding the waterborne trade of petroleum and petroleum products within the Wider Caribbean region. Of particular concern are tanker movements through restricted channels and in the vicinity of ports which increase the possibility of shipping accidents resulting in oil spills. In addition to the number of tankers operating in the region, there are also numerous tank barges which operate in the Wider Caribbean region in support of extensive oil refineries and petrochemical industries. In spite of regulations established in Annex I of MARPOL 73/78, tankers and barges do not always use port facilities for the disposal of bilge and tank washing and wastes; consequently, significant discharges of oil into the coastal areas of the Wider Caribbean region does occur (29). It is estimated that almost 50% of the oil imported by the USA is off loaded along its Gulf Coast (30).

An additional source of accidental oil spills in the marine environment of the WCR, apart from those caused by maritime accidents, is offshore oil and gas exploitation. These operations are of particular importance in the Gulf of Mexico where a considerable amount of offshore oil platforms are in operation. Outside the Gulf of Mexico similar operations are conducted in Lake Maracaibo, Venezuela along and the east coast of Trinidad and Tobago. The release of crude oil from offshore operations generally occurs as a consequence of pipeline breakage, well blowouts, platform fires, overflows and equipment malfunctioning. According to a report from the US Mineral Management Service charged with the administration of offshore oil programme in federal waters in the US Gulf coast during the first 30 years of the programme there were 106 incidents resulting in significant oil pollution. Moreover, during the same period, there were 145 well blowouts, 767 fires on offshore structures, 31 pipeline breaks and 224 major accidents (31). Perhaps the best known example of an oil spill caused by offshore oil and gas drilling operations is the case of the IXTOC I well oil spill off the Mexican Gulf coast in 1979. The IXTOC I well blowout caused the release of approximately 0.5 x 10^6 tons of light crude oil into the Gulf of Mexico over a nine months period before the well was finally capped (32).

Another potential source of oil contamination from offshore operations is the so called "produced water" released from the oil-bearing strata with the oil and gas at the time of production. The "produced water" is discharged into the marine environment together with waste drilling mud. In 1990 the daily input of "produced water" into the marine environment of the US Gulf coast was approximately 384,000 m^3. Produced waters may contain substances that exert high oxygen demand, together with PAHs, benzene, ethylbenzene, xylene and heavy metals, such as lead, copper, nickel and mercury (33).

Natural seepage of petroleum hydrocarbons from submarine oil deposits also constitutes a significant source of oil pollution into the marine environment of the WCR. Unlike the previously described sources of oil pollution, natural oil seepages are very difficulty to estimate. The occurrence of this natural phenomenon has been evidenced by the presence of tar in sediment cores of the Gulf of Mexico, particularly from the Sighbee Knolls. More dramatic evidence was provided recently (34) when the presence of petroleum hydrocarbons from a natural seepage source was determined in a water layer at a depth of between 150 and 250 meters entering from the North Atlantic into the central Caribbean Sea. It was estimated that the above described water layer contained 1 x 10^6 tons of crude oil.

With the exception of the estimated amounts of oil spills caused by maritime accidents in the Caribbean Sea Basin, very little information is readily available concerning land-based and offshore sources of oil pollution in the above-mentioned sub-region.

Information on oil pollution levels in coastal and marine waters of the WCR stems mainly from the UNEP-IOC/IOCARIBE CARIPOL Programme initiated in 1979. The data gathered by CARIPOL indicated that the concentration of dissolved/-dispersed petroleum hydrocarbons (DDPHs) are generally low in offshore waters and relatively high levels in enclosed coastal areas (35, 36, 37, 38, 39). Moreover, recent information provided by a preliminary overview on land-based sources of marine pollution in the WCR, compiled by the CEP Programme, pointed to oil refineries and petrochemical plants as major sources of coastal oil pollution within the region (40).

With reference to the accumulation of petroleum hydrocarbons in sediments and marine organisms, particularly toxic compounds such as polynuclear aromatic hydrocarbons (PAH's) present in oil, NOAA Status and Trends Programme has been gathering PAH's data at 51 sites along the US Gulf coast (41). Similar type of information has also been obtained by the CARIPOL Programme along the Mexican Gulf coast and coastal areas of the Caribbean region (42, 43, 44, 45).

The impact of oil pollution on the ecology of coastal and marine ecosystems and species of the WCR, such as coral reefs, seagrass beds, mangrove forests and offshore populations of shell fish and fish, is particularly destructive following massive oil spills caused by maritime accidents which, has been broadly documented (46, 47, 48, 49, 50). However, information required to ascertain the ecological and health risks caused by long-term chronic oil discharges into the coastal marine environment of the WCR, is still very limited (51, 52).

3. Sediments

A considerable amount of river-borne particulate material is introduced every year into the coastal areas of the WCR via rivers of the region (**Table 3**). Most of the suspended and dissolved materials carried by these rivers are controlled by natural geochemical processes. However, it must be kept in mind that the present suspended and dissolved river loads are being enhanced by contributions from human activities such as the erosion of the river basin watershed caused by deforestation, urbanization, agricultural activities and by a variety of pollutants being discharged into these waters. Most of the rivers discharging in the coastal waters of the WCR carry sediment loads ranging from 100 to 1000 mg/l with a total estimated load of approximately 10^9 tons/yr (53). This is approximately 12% of global sediment input from rivers to the oceans which has been estimated to be 8×10^9 tons/yr (54).

TABLE 3. Estimated sediments loads from rivers reaching the Wider Caribbean Coastal areas (53)

Rivers/Regions	Sediment loads 10^6 t/y
Mississippi River	320
Other rivers discharging into the Gulf of Mexico	121
Rivers of Central America and the Antilles*	300
Magdalena River	235
Orinoco River	85
Other rivers from Colombia and Venezuela*****	50

***** Estimations calculated based on the drainage area and an erosion rate of 200 tons km^2/y.

With reference to the impact of human activities on the sediment loads carried by the rivers of the WCR, deforestation of the river basin watersheds is probably the one which causes major concern. A survey conducted by FAO in 1979 estimated 221×10^6 hectares of forested lands in the Caribbean region, and predicted a reduction of 175 x 106 hectares by the year 2000 due to deforestation practices (55). A recent report from the World Resources Institute (56) revealed a reduction of approximately 9% of the forested areas of 17 countries of the WCR for the 1979-1989 period (**Table 4**) (57).

TABLE 4. Land-use percentage changes in croplands, pasturelands and forest and woodlands in seventeen countries of the WCR during the 1977-1989 period (56)

Country	Percentage change (1977-1989)		
	Cropland	**Pastureland**	**Forestlands**
Barbados	0	0	0
Belize	12.8	15.2	(1.1)
Costa Rica	5.5	24.0	(17.9)
Colombia	3.5	6.8	(5.6)
Cuba	5.3	14.3	(11.8
Dom. Republic	5.5	0	(3.1)
Guatemala	8.3	7.8	(17.0)
Haiti	2.7	(3.0)	(30.0)
Honduras	2.3	7.2	(18.8)
Jamaica	1.5	(7.9)	(5.1)
Mexico	1.9	0	(12.0)
Nicaragua	2.8	11.5	(23.5)
Panama	4.6	15.9	(19.4)
Trinidad & Tobago	3.7	0	(4.3)
Suriname	53.7	11.1	(0.3)
Venezuela	5.9	2.9	(8.6)
Average	4.8	6.67	(9.27)

Continued economic growth and development in the WCR has required changes in the traditional use of the land, such as increased agricultural development at the expense of forestlands. The negative aspects of these land use changes have not been properly addressed to date, particularly the impact of these activities on valuable coastal ecosystems caused by siltation and the introduction and intensive use of agrochemical compounds. Data on the distribution of sediments and the turbidity of coastal waters of the WCR is insufficient to assess the magnitude of the adverse effects of present day land use practices. Limited information/data (remote sensing (58), coral reef surveys, etc.) already exists, however, interpretation is required to establish time-scales patterns and consequences of land use changes in drainage basins of the WCR. The increased turbidity of coastal waters, as a result of riverine transport of eroded soils to the sea, has been known to produce siltation of coastal ecosystems. These trends have the potential to place continuous stress on critical coastal ecosystems, such as coral reefs. Studies conducted on the siltation of coral reefs along the Caribbean coast of Panama, Costa Rica, Nicaragua, etc. (59, 60) also confirm the negative impact of siltation caused by sediment loads carried by the rivers in that particular sub-region.

Another source of particulate soil materials entering the coastal areas of the WCR by direct disposal or via rivers, is related to mining operations. The mining of bauxite is particularly important for the economies of Jamaica, Suriname, Guyana and to a lesser degree for the Dominican Republic and Haiti (61). In the case of Jamaica bauxite wastes are not discharged into rivers or coastal areas, but on deposition ponds. With regard to the other mentioned countries, there is a lack of information concerning the final disposal of wastes from bauxite mining operations. Other mining operations within the WCR involve the mining and processing of ores for the production of nickel oxide mainly carried out in Cuba and the Dominican Republic. These mining operations are carried out close to coastal areas but at present there is very little information on the disposal of mine tailings in rivers of adjacent coastal waters.

An additional source of suspended materials being introduced into the coastal areas of the region is the practice of waste disposal at sea (ocean dumping), e.g. dredge spoils, industrial wastes, etc. At present, ocean dumping is regulated by the London Dumping Convention (LDC) of 1972, to which thirteen countries of the WCR are Contracting Parties. With regard to the volume and type of wastes being disposed at sea in the WCR, the only available information corresponds to the ocean dumping activities conducted off the US Gulf coast.

Over 100×10^6 tons per year of dredged materials are disposed in near shore coastal areas int he US Gulf coast, representing about 20% of the national total (62). Dredge materials are generally contaminated sediments containing toxic heavy metals, organic pollutants, etc. originating from domestic and industrial point discharges and non-point sources. Present trends on coastal and offshore dumping activities in the USA, indicate a decrease in the volumes of certain authorized materials such as dredge spoils and industrial wastes and an increase in the volume of sewage sludge in the dumped at sea (63). Concerning the disposal at sea of sewage sludge in the USA legislation to phase out this practice has been proposed by USEPA (64).

Conversely, information on the amounts of waste materials disposed at sea in areas outside the US Gulf coast and enforcement of regional and international standards for disposal of authorized materials within the WCR are not readily available.

4. Nutrients

Among the priority pollutants entering the coastal and marine environment of the WCR, there is increasing concern regarding nutrient enrichment, particularly nitrogen and phosphorous compounds, of coastal waters from point and non-point sources. The continuous discharge of these nutrients in enclosed coastal area is a major cause of the eutrophication phenomena. The ecological effects of this phenomena include algal blooms, changes in aquatic community structure, decreased biological diversity, fish kills and oxygen depletion events (65, 66). Concerning the development of algal blooms, a significant shift occurs in the phytoplankton community structure in response to nutrient enrichment in conjunction with other factors (67).

Within the WCR it is important to point out the studies being conducted by the USEPA Gulf of Mexico Program along the US Gulf coast that clearly illustrates the progressive effects of eutrophication on coastal waters caused by the introduction of nitrogen and phosphorous compounds from point and non-point sources of pollution. Estimates compiled by the above-mentioned programme in 1987, indicated that the coastal waters of the US Gulf coast received via point and non-point sources of pollution contributions of 916,390 tons of nitrogen and 39,930 tons of phosphorous (68). Moreover, a more recent report from the USEPA Gulf of Mexico Program estimated that 936 tons of nitrogen and 189 tons of phosphorous per day were discharged into the Gulf of Mexico from surface waters of the USA via the Mississippi River (69). Analysis of the results indicated that the regions of the Ohio River Basin and the upper Mississippi River Basin are major sources of both nitrogen and phosphorous reaching the US Gulf coast, mainly from non-urban non-point sources.

Continued economic growth and development has drastically changed the traditional land use patterns of the WCR. The detrimental implications of such changes, particularly agricultural development, has not been properly addressed by programmes of a national or regional nature. A recent report from the World Resources Institute (70) provided data on the use of fertilizers in sixteen countries of the WCR. This information is presented in **Table 5**. Within the WCR many States and Territories are developing their economies through the tourist trade, an industry that is directly related to the quality of the coastal environment. It is important to note when coastal eutrophication occurs in the nearshore areas, it prevents recreational use and alters the ecological and aesthetic quality of the environment.

The eutrophication process is an important factor in the degradation of coastal ecosystems in several areas of the Wider Caribbean. Several documented studies on the impact of eutrophication in the region, are as follows: in Puerto Rico (71) the impact of moderate eutrophication on a shallow nearshore mangrove/seagrass ecosystem has been determined. Lake Maracaibo, Venezuela, is probably one of the few areas of the Wider Caribbean where extensive

TABLE 5. Average annual fertilizer use in 17 countries of the WCR, changes during the

1979-1989 period (70)

Country	Fertilizer use in Kg/Hectare of cropland	
	1979	**1989**
Barbados	162	91
Belize	36	71
Colombia	55	90
Costa Rica	143	191
Cuba	133	192
Dominican Republic	41	50
Guatemala	53	69
Guyana	22	29
Haiti	4	3
Honduras	13	20
Jamaica	55	105
Nicaragua	31	55
Panama	44	62
Trinidad and Tobago	61	28
Suriname	49	74
U.S.A. (Gulf Coast) *****	106	95
Venezuela	51	162
Average	62.3	81.6

***** For 1979 data compiled in 1982 (10) and for 1989 estimated the national average annual use of 1989 (70)

studies on the impact of nutrient enrichment on the ecology of coastal waters has been carried out. The results of the study indicated that nutrient enrichment can interact with other pollutants, such as petroleum hydrocarbons, to produce a subtle but important alteration in the composition of the phytoplankton standing crop. This type of pollution has motivated a shift in the relative abundance of planktonic algae and could also affect demersal and pelagic food chains (72). It has also been reported that in Cartagena Bay and the adjacent "Cienaga de Tesca", Colombia, seasonal episodes of massive fish kills do occur, caused by the depletion of dissolved oxygen in the nearshore waters of the Bay. These fish kills have been attributed to nutrient enrichment caused by the discharge of untreated sewage and agricultural nutrient runoff prevalent in that area, probably combined with the stratification of the water column (73).

Nutrient enrichment of the coastal areas of the WCR is sure to increase if no action is taken. Coastal regions have experience rapid population growth together with changes in adjacent land-use. To control the sources of nutrient enrichment and to reverse the adverse effects of eutrophication, it will be necessary to reverse the adverse effects of eutrophication, it will be necessary to improve the effectiveness of sewage treatment plants and to control the runoff from non-point sources and atmospheric deposition of nutrients by changing their levels of application and use, as well as to encourage changes that will promote long-term benefits and cause the least damage to interrelated ecosystems.

5. Pesticides

The extensive use of pesticide (insecticide, herbicides, fungicides, etc.) due to intensive agricultural activity within the WCR is well documented, and its impact on land and coastal marine ecosystems is reasonably evident. Through runoff, erosion and misapplication, significant quantities of pesticides are reaching the coastal and marine environment where they may affect non-target species, and, through the contamination of seafood, may become a public health problem. Pesticide compounds, once applied, reach the coastal areas of the region via rivers and by atmospheric transport. It has been estimated that about 90% of pesticides which are applied do not reach the targeted species (74). Consequently, pesticide contamination is a serious concern because of its high toxicity and tendency to accumulate in the coastal and marine biota.

The overall application of pesticides with active ingredients in the WCR seems to be on the increase. A recent report from the World Resources Institute (75), based on information gathered from 14 countries of the region, showed a general increase in the use of pesticide compounds during the 1974-1984 period (**Table 6**). For the countries where a marked decline in the use of pesticides was observed, in the particular case of the United States with a reduction of 15%, this has been attributed to changes in agricultural practices to reduce the use of pesticides and also to the introduction of new less persistent pesticides with lower application rates (76). With regard to the other countries where pesticide use has declined, there is no available information. However, it is reasonable to assume that reductions in the use of pesticides was accomplished by the use of newer pesticides with lower application rates.

TABLE 6. Average annual pesticide use in 14 countries of the WCR, changes during the

1974-1984 period (75)

Country	Pesticide use in metric tons		Change
	1974-1977	**1982-1984**	**%**
Colombia	19,344	16,100	(17)
Costa Rica	3,037	3,667	21
Dominican Republic	1,961	3,297	68
Guatemala	4,627	5,117	11
Guyana	705	658	(7)
Honduras	940	859	(9)
Jamaica	861	1,420	65
Mexico	19,148	27,630	44
Nicaragua	2,943	2,003	(32)
Panama	1,542	2,393	55
Suriname	974	1,720	77
US Gulf Coast *****	5,320	4,500	(15)
Venezuela	6,923	8,143	18

***** Data from 1982 (10) and 1987 (76), respectively.

Most of the monitoring programmes developed to determine the presence of pesticide residues accumulated in sediments and the marine biota of the WCR, have concentrated their efforts on the determination of a limited number of pesticides known to have a long-term environmental impact and considerable toxicity. The above-mentioned programmes have included the determination of pesticides, such as DDTs, Chlordanes, Dieldrin, Endrin, Aldrin, HCB's, Heptachlor and its epoxides, Endosulfan, among others.

With reference to the levels of pesticide residues accumulated in sediments and marine organisms of the coastal and marine areas of the WCR, most of the published information relates to surveys conducted by NOAA's Status and Trends Mussel Watch Programme (MWP) (77).

The results reported by the MWP surveys of 1986 and 1987 indicated that among the pesticides present in the analyzed samples the DDTs were still the most abundant compounds. Moreover, the DDTs were considerably higher in oyster tissues than in sediments. Recently the MWP has extended its activities from the US Gulf coast to other coastal areas of the WCR (78). More recent information concerning the accumulation of pesticides in sediments of the US Gulf coast is being gathered by the USEPA Gulf of Mexico Programme (79) in order to set up quality criteria levels for 25 pesticides in sediments. An important amount of information on the levels of pesticides in sediments and marine organisms in coastal lagoons and river estuaries along the Mexican Gulf coast, has been recently published (80, 81, 82). Concerning similar type of information from the Caribbean Sea Basin very limited amount of data is available (83).

During the last decade pesticide usage patterns have increasingly changed in the WCR, with a strong tendency to replace persistent compounds with less persistent pesticides such as organophosphorus compounds, carbamates, phyrethroids, etc. At present very little information is available on the behaviour of the above-mentioned compounds when applied in the tropical coastal marine environment, including degradation rates, fractionization partition and biological uptake, and transfer through food chains to humans. Data on the presence of these second and third generation pesticides in sediments collected from the Caribbean coasts of Costa Rica, Nicaragua and Panama have been recently obtained (84). It was determined that only residues of the pesticide chlorophyrifos showed widespread distribution in the analyzed sediments. Moreover, during the above-mentioned survey frequent fish-kills were observed after the application of the pesticides, indicating their high toxicity to non-target organisms.

Efforts to reduce the impact of pesticides on coastal and marine ecosystems of the region, over the last decades, have been carried out on the US Gulf coast. Decline in the use of pesticides in that particular sub-region has been attributed to land-set aside for coastal erosion control and to the introduction of newer pesticides with much lower application rates (85). Some modified agricultural practices have been developed to reduce the use of pesticides and their subsequent transport to the aquatic environment. The concept of Best Management Practices (BMPs) has also been applied to control the water quality problem caused by pesticides. Moreover, techniques for Integrated Pest Management (IPM) were also used to reduce the use of pesticides and maintain high levels of production.

6. Solid Waste and Marine Debris

The appropriate management of solid wastes from land-based sources in the WCR is a problem of great concern as it affects the ecological and aesthetic quality of the coastal and marine environment. This problem has arisen because of the increasing amount of solid wastes being generated within the region, coupled with deficient collection systems and inadequate disposal practices. Faulty disposal practices such as using rivers and streams and mangrove swamps as dumpsites are evident in many countries of the region. On the other hand, although well managed landfills should not constitute a sources of solid wastes reaching the coastal and marine environment, the fact is that poorly managed landfills exist in many coastal areas of the

WCR. These sources plus runoff induced by high precipitation may turn landfills into important sources of floating solid wastes in route to the sea. At present, there is no published information concerning the amount of solid wastes being generated in the WCR or the way these wastes are handled prior to final disposal.

An additional source of solid wastes affecting the coastal areas of the region is generated by shipping, commercial fisheries, offshore activities, etc. These ocean based sources generate a considerable amount of floating solid wastes that are reaching coastal areas as marine debris. The disposal of solid wastes by ships in nearshore coastal areas in regulated by Annex V of the MARPOL 73/78 Convention. The Maritime Environment Committee of IMO (MECP 31) in July 1991 designated the WCR as a "Special Area" under the above regulations. However, in order to comply with Annex V of MARPOL, most of the countries of the region will need to provide port reception facilities for Annex V wastes generated by shipping activities. In view of the lack of the above facilities in many countries of the region, IMO and the World Bank with the assistance of UNEP-CAR/RCU commissioned a survey to assess the need for port reception facilities for Annex V wastes within the region (86).

The IMO/World Bank survey included a visit to 23 ports located in seven countries of the Wider Caribbean. Of the surveyed ports only 13 allowed the off-loading of solid wastes, and most of these did not provide adequate facilities for off-loading, storage, collection and final disposal of the ship generated wastes. The remaining surveyed ports, a total of 10, did not allowed off-loading of solid wastes. The report also estimated the amount of solid wastes which may arrive for off-loading at each of the surveyed ports. In this regard, it is important to point out that the ports with the potential for receiving relatively high loads of Annex V wastes were located in small island countries, such as Antigua and Barbuda, Bahamas, Barbados, St. Lucia and St. Kitts and Nevis. Most of these countries do not have adequate facilities for handling their own solid wastes generated from domestic and commercial sources. Therefore, the lack of adequate port reception facilities for Annex V wastes within the WCR, could result, in the disposal at sea of solid wastes (marine debris) no only from shipping but also from other offshore activities despite the MARPOL Annex V provisions.

The solid wastes disposed at sea within the WCR are transported by wind and currents, and tides will take them to shore, often far from their original sources. In this regard, most of the available published information on the deposition of marine debris in the coastal areas of the region is from the Gulf of Mexico, which is a unique repository of marine debris (87). Early observations concluded that the Florida Keys acted as an "island sieve" downwind from the Florida straits, just as the Lesser Antilles and the Bahamas collected debris from the north Equatorial and Antilles currents, respectively (88). It was also stated that the "Key West, Cape Cañaveral stretch of shore were one of the major Caribbean-Gulf of Mexico trash ground".

Since 1985, beach clean-up operations have been established with the participation of volunteers along the US Gulf coast. Information on beach clean-up activities for the 1990 exercise have recently been made available by the USEPA Gulf of Mexico Programme Marine

Debris Action Plan (89). During the 1990 exercise approximately 566 tons of marine debris were collected from 1,379 miles of Gulf beaches. The highest concentrations of marine debris concentrated along the beaches of the States of Texas and Louisiana. Of the trash collected 63.9% was plastic, followed by metal containers 10.8%, glass containers 10% and paper products of various kinds 8.4%. The remainder of the collected trash was evenly distributed among wood, rubber and cloth. A total of 36,643 volunteers participated in the 1990 exercise.

Information on the accumulation of marine debris in the coastal areas of the WCR have been increasing at a rapid pace after the early reports prepared in 1988 (90) as part of Activity 4.4.4 of the CEPPOL Programme.

Among the solid wastes deposited in coastal areas of the WCR is the recurring accumulation of pelagic tar in the exposed windward beaches of the region. Of special interest on the above subject are the results obtained by the UNEP/IOC-IOCARIBE CARIPOL Project. Heavy accumulations of pelagic tar were determined along the beaches of the Southern Florida coast, the Cayman Islands and Curaçao, and on the windward beaches of Barbados, Grenada and Trinidad and Tobago, among others (91, 92, 93). Additional studies demonstrated that pelagic tar levels in the waters of the eastern Gulf of Mexico and the Florida straits were substantially higher compared to other regions of the world, and that as much as 50% of the pelagic tars entered the Gulf of Mexico through the Yucatán strait (94, 95).

Marine debris and pelagic tars present in the coastal areas of the region are detrimental to the economies of many countries, particularly those dependent on the tourist trade. Moreover, plastic bags, discarded nets and ropes, may strangle, suffocate and exhaust marine animals and seabirds due to entanglement (96). Scientists have documented an increasing number of injuries and death among marine mammals, fish, sea-turtles and birds due to entanglement. Furthermore, animals can mistake plastic pellets and pelagic tar as food sources. Some marine animals accidentally feeding on plastic may feel a false sense of fullness and, as a result, slowly starve to death (97, 98. 99).

7. Toxic Substances

These priority pollutants are organic and inorganic compounds either synthesized or chemically transformed natural substances, that are capable of producing adverse effects on the structure and function of land and coastal ecosystems when improperly utilized, discharged or accidentally released into the environment. The contamination of the coastal environment in the WCR by the above-described toxic compounds is a matter of great concern. Taking into account that they are very persistent in the aquatic environment, these compounds bio-accumulate in marine organisms and are highly toxic to humans via the consumption of seafood (100). Quantifying the potential human health effects resulting from the presence of toxic compounds in the marine environment and their accumulation in marine organisms has been well documented. According to the US National Academy of Sciences (101) the levels of toxic substances in the seafood from certain areas of the Gulf coast warrant strict control measures.

The sources of toxic pollutants are mainly industrial point sources, such as the petroleum industry (oil refineries and petrochemical plants), chemical industries (organic and inorganic), wood/pulp plants, pesticide production and formulation, metal and electroplating industries, etc. These industries can release toxic substances from manufacturing operations, effluent discharges and accidental spills. The wastes generated may contain heavy metals, carcinogenic hydrocarbons (PAHs), dioxins, different types of pesticides, noxious organic and inorganic substances, etc. In addition to the discharge of the above pollutants from direct point sources or via municipal point sources, these wastes can also reach the coastal marine environment from non-point sources via rivers and streams and through the atmosphere.

When addressing the issue of evaluating the disposal of these toxic pollutants in the coastal and marine environment of the WCR, as in many other regions of the world, the discharge of toxic pollutants is potentially present in every country of the region, considering the increased industrial diversification taking place in many countries of the region. Major industrial activity centres within the WCR are concentrated in a few "hot spot" areas, such as the Texas-Louisiana US Gulf coast; the industrial area of Lake Maracaibo, Venezuela the "El Mamonal" industrial complex in Cartagena Bay, Colombia; the west coast of Trinidad; Kingston Harbour, Jamaica; Havana Bay, Cuba. These areas were studied most extensively. Among the above-mentioned industries, capable of releasing toxic pollutants into the coastal marine environment, oil refineries are the most widespread within the region. In **Table 7** recent information is presented on the number of oil refineries operating in the WCR, as well as their refining capacity (102).

With respect to the quantity of toxic substances being generated and discharged into the coastal and marine environment of the WCR, the only available information has been compiled by the USEPA Gulf of Mexico Programme for the US Gulf coast (103). The report indicated that during 1989, approximately 5,910 tons of toxic compounds from permitted point sources were discharged into surface waters reaching the US Gulf coast. Additionally, accidental spills and discharges continue to occur particularly in the Mississippi River in the State of Louisiana (104). Efforts to determine the amount of toxic pollutants entering the coastal and marine environment of the WCR, excluding the US Gulf coast, has not yet been persued by the CEPPOL Programme.

IV. Objectives and Elements of the CEPPOL Programme

The overall objective of the CEPPOL Programme is to establish a regionally co-ordinated comprehensive "Marine Pollution Assessment and Control Programme" catering to the immediate and long-term requirements of the Cartagena Convention and its protocols (including those that are in the process of development).

TABLE 7. Number of oil refineries and oil refining capacity in countries of the Wider Caribbean Region (102)

Country	Number of Oil Refineries	Refining Capacity	
		10^3 b/day	10^6 t/y
Barbados	1	3	0.1
Colombia	4	274	13.6
Costa Rica	1	15	0.7
Cuba	3	280	13.9
Guatemala	1	16	0.8
Dominican Republic	2	48	2.4
Honduras	1	14	0.7
Jamaica	1	34	1.7
Martinique (FR)	1	12	0.6
Mexico	8	1,574	78.4
Netherlands Antilles	2	470	23.4
Nicaragua	1	16	0.8
Panama	1	40	2.0
Puerto Rico	2	123	6.1
Trinidad and Tobago	2	246	12.3
USA (Gulf States)	59	6,620	331.0
US Virgin Islands	1	545	27.1
Venezuela	6	1,171	58.5
Total	97	11,501	574.1

The specific objectives are the following:

(i) To organize and carry out a regionally co-ordinated marine pollution monitoring and research programme, concentrating on contaminants and pollutants affecting the quality of the coastal marine environment of the WCR and to interpret and assess the results of the programme;

(ii) To generate information on the sources, levels, amounts, type, trends and effects of marine pollution within the WCR as an additional component upon which the formulation of proposals for preventive and remedial actions can be based;

(iii) To formulate proposals for technical, administrative and legal actions for pollution control abatement and prevention measures and to assist the Governments of the region in implementing an evaluating their effectiveness; and

iv) To support and, when necessary, to develop/establish the capabilities of national institutions to carry out marine pollution monitoring and research, as well as to formulate and apply pollution control and abatement measures.

The CEPPOL Programme consists of a series of inter-linked components of research, baseline studies, pollution monitoring, preparation of pollutant inventories, identification of priority actions, abatement and preventive measures, as well as providing assistance to the Governments of the WCR in the implementation of these actions and measures and in the evaluation of their effectiveness. The concrete activities established for the programme for the period 1990-1995 are as follows:

4.4.1 Control of Domestic, Industrial and Agricultural Land-Based Sources of Pollution.

4.4.2 Baseline Studies on Pesticide Contamination and Formulation of Control Measures.

4.4.3 Monitoring and Control of the Sanitary Quality of Bathing and Shellfish Growing Waters.

4.4.4 Monitoring and Control of Pollution by Oil and Marine Debris.

4.4.5 Site-Specific Studies on Damaged Ecosystems and Development of Proposals for Remedial Actions.

4.4.6 Development of an Environmental Quality Criteria.

4.4.7 Research on the Significance of Organotin as a Pollutant of the Wider Caribbean Region.

4.4.8 Research on the Significance of Increased Turbidity and Eutrophication in the Wider Caribbean Region as a Result of Changing Land-use Activities.

4.4.9 Co-ordination of the CEPPOL Programme.

Among the above-listed activities, the evaluation of the domestic, industrial and agricultural land-based sources of coastal marine pollution, is an essential element of the programme for the attainment of meaningful pollution control measures. It is also important to focus on pollutants and sites that will require urgent attention, and to facilitate the implementation of the remaining activities of the programme.

V. Scope and Purpose of CEPPOL Activity 4.4.1 "Control of Domestic, Industrial and Agricultural Land-Based Sources of Pollution"

The following text summarizes the results of this activity of the CEPPOL Programme and presents data collected by national institutions in the countries of the WCR, together with an evaluation of the state of marine pollution within the region and priorities for its abatement and control. In order to satisfy the main objective of CEPPOL Activity 4.4.1 which is to reduce the pollution load reaching the coastal and marine environment in the WCR from land-based sources, the following methodology was used:

(i) Preparation of national inventories of land-based sources of marine pollution (LBSP);

(ii) Assessment of the types and amounts of pollutants reaching the coastal marine environment of the WCR; and

(iii) Information on legal and administrative measures regulating the control of LBSP in the different countries of the region.

The preparation of the LBSP inventories was designed to cover all relevant activities discharging wastewater which may contribute to the impairment of coastal marine ecosystems and threaten public health. To achieve the above goals a sectorial approach was used which included the following sources of coastal marine pollution of the WCR: domestic, industrial, agrochemical and river discharges. It is important to point out that, the USA LBSP inventory for the US Gulf coast included both point and non-point sources, the remaining inventories prepared by the countries of the region were limited point sources of pollution. Moreover, with respect to the evaluation of pollutant discharges from river sources, only a few countries were able to provide limited information for a small number of pollutants.

Based on the information included in the LBSP inventories to be undertaken in 25 countries of the region, an assessment of the waste loads from each source was prepared. This exercise represents the first regional evaluation of LBSP affecting the coastal marine environment of the Wider Caribbean Region. Thus, a comprehensive account of the types and amounts of pollutants, mainly from point sources, and their geographical distribution within the region, was accomplished.

VI. Basic Approach and Implementation

The complex task of undertaking LBSP inventories in a large geographical area like the WCR, with the co-operation of 33 States and Territories of diverse cultures, socio-political systems and different stages of development, required a comprehensive approach with a methodology that was adequate to all the countries of the region.

During the preparatory phase of CEPPOL Activity 4.4.1, a number of methodologies were considered for the preparation of the LBSP inventories. The methodology selected was based on the WHO document "Management and Control of the Environment" WHO/PEP/89.1 (105), from which a shortened and slightly modified version was prepared. Moreover, the chosen methodology ensured a standard approach to evaluate point sources of pollution and provided for a comparative assessment of pollutants stemming from the different sources in the various countries of the WCR.

It is to be noted that the LBSP inventories for the USA, Puerto Rico and the US Virgin Islands, employed was NOAA's Coastal Pollution Discharge Inventory (NCPDI) used methodology for permitted point sources.

The participation of the countries of the region was secured by the Regional Co-ordinating Unit of CEP through the CEPPOL focal points nominated by these countries. During 1991 circular letters were sent to these focal points within them to nominate institutions and personnel to undertake the preparation of the national LBSP inventories. The national focal points were provided with copies of the guidelines. Those who accepted the invitation were also provided with a modest financial contribution. At the time of this writing 27 countries are participating in the exercise, 25 of which have completed the LBSP inventories.

In December 1991, the Secretariat convened a meeting to evaluate the progress made in the implementation of the national LBSP inventories. A number of the participants stated their doubts about the factors outlined in the methodology to calculate pollutant discharge. It was decided during the meeting that each country should use, in the first place, its own experience to calculate the pollutant discharge and that the methodology should be used in the absence of available information or inadequate measurements to characterize the source of pollution both qualitatively and quantitatively. On the other hand, it was pointed out that the factors proposed by WHO's methodology had already been used in other regions with relatively good results.

The assessment of the pollution loads being discharged into the coastal marine areas of the WCR from different waste sources was arrived at by analyzing original country survey data, as well as statistical information from other data sources.

In order to evaluate the geographical distribution of the pollution load being discharged from land-based sources of pollution and facilitate the analysis of the results, the WCR was divided in 6 sub-regions (**Table 8, Figure 2**)

TABLE 8. Sub-regional areas within the Wider Caribbean Region and related countries

I.	Gulf of Mexico	Cuba, Mexico and the United States
II.	Western Caribbean	Belize, costa Rica, Guatemala, Honduras, Mexico, Nicaragua and Panama
III.	Northeastern and Central Caribbean	Bahamas, Cayman islands, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico and Turks and Caicos Islands
IV.	Eastern Caribbean	Anguilla, Antigua and Barbuda, Barbados, British Virgin Islands, Dominica, Grenada, Guadaloupe, Martinique, Monserrat, St. Maarteen, St. Lucia, St. Kitts and Nevis, St. Vincent and the Grenadines and US Virgin Islands
V.	Southern Caribbean	Colombia, Netherlands Antilles, Trinidad and Tobago and Venezuela
VI.	Equatorial Atlantic North West	French Guyana, Guyana and Suriname

VII. Results of the Pollution Sources Inventory

The primary purpose of the national LBSP inventories is to identify all major waste discharges from point sources, individually and by geographical location as well as to determine the nature and magnitude of the above-referred discharges.

With respect to industrial sources, some data was obtained directly from the source, but data was largely incomplete and varied from country of country within the different sub-regions. It was therefore necessary to use additional sources of information. The data has been summarized in **Tables 9** and **10** indicating the loads in tons per year, generated by both domestic and industrial point sources. The pollutants included in the inventories were BOD_5, TSS, TN, TP and Oil and Grease loads. We have also information about heavy metals, phenols and other toxic compound loads but the available information only allows us to de qualitative evaluation.

The domestic pollutant loads discharge with the exception of the US Gulf coast, were in most cases subjected to a reduction. As has been described in item III of this report, there is very little information on the number of coastal communities with sewage treatment facilities, only serve only about 10% of the population of the region.

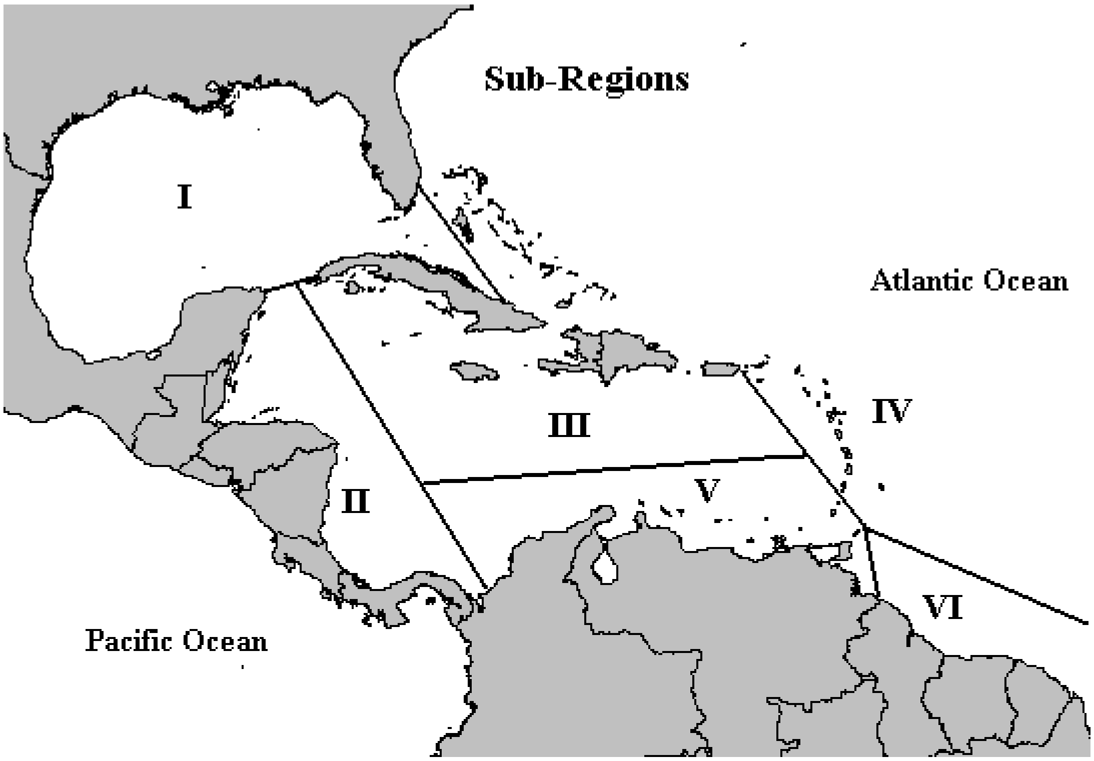


Figure 2: Sub-Regions in the Wider Caribbean Region

TABLE 9 Waste Loads from Domestic Sources in the Wider Caribbean Region by Sub-Region (t/y)

Country/Sub-Region	BOD	TSS	TN	TP	Oil and Grease
Sub-Region I					
Cuba(NE Coast)	53,734	50,811	4,198	5,915	5,985
Mexico(Gulf Coast)	24,529	20,964	4,184 25,688	1,810	8,379
USA(Gulf Coast)	37,393	44,552		11,416	27,006
			34,070		
Sub-Total	115,656	116,327		19,141	41,370
Sub-Region II					
Belize	1,905	2,100	650	320	240
Costa Rica	530	1,079	210	25	20
Honduras	9,626	8,235	625	823	450
Mexico(Car. Coast)	3,756	3,232	607	261	1,256
Panama	969	1,781	327	38	35
Sub-Total	16,785	16,427	2,419	1,467	2,001
Sub-Region III					
Cuba (Car. Coast)	9,413	3,481	572	296	112
Dom. Republic	40,573	60,000	3,027	4,182	5,125
Jamaica	4,227	6,658	1,097	133	350
Puerto Rico	16,819	20,000	530	890	500
Turks & Caicos Is.	47	75	13	2	2
Sub-Total	71,079	90,214	5,239	5,503	6,089
Sub-Region IV					
Antigua & Barbuda	29	45	7	1	1
Barbados	3,838	3,300	290	378	290
Brit. Virgin Is. Dominica	85	145	26	3	2
Grenada	51	81	13	2	2
St. Lucia	86	136	22	3	2
St. Kitts & Nevis	25	40	29	2	1
St. Vin. & Gren.	250	390	66	9	5
US Virgin Islands	26	40	7	1	1
	400	440	250	132	200
Sub-Total					
	4,790	4,617	710	531	504
Sub-Region V					
Aruba	61	52	20	4	1
Colombia	26,300	42,120	7,118	986	620
Netherlands Ant.	85	5	40	1	1
Trinidad & Tobago	1,000	1,567	1,585	59	28
Venezuela	232,725	185,000	77,575	32,425	18,325
Sub-Total	260,171	228,744	86,338	33,475	18,975
GRAND TOTAL	**506,482**	**456,329**	**128,796**	**60,117**	**68,939**

The inventory of industrial loads covered a variety of production sources. Therefore, an attempt was made to summarize within broad categories of industries and to identify areas with high concentration of industrial activities within the WCR.

For the assessment of pollutant load carried by the rivers of the region, the survey has not yet been completed. Only the pollutant loads carried by five rivers of the region were included in the national reports.

1. ***Domestic sewage***

Information on domestic pollution loads introduced into the coastal areas of the WCR is presented in **Table 9**. Additionally, information was gathered concerning the number of coastal dwellers in each of the sub-regions to provide an adequate basis for the preparation of the domestic waste source inventory.

The total population of coastal dwellers of the WCR were estimated at about 50 million inhabitants. In addition, there is a considerable number of tourist visiting resort areas of the WCR year round. The tourist contribution to domestic waste loads was not included in the national inventories.

2. ***Industrial wastewater***

Data on the pollutant loads from the industrial sector within the WCR was compiled by identifying their geographical distribution as well as the type and magnitude of industrial pollutant loads. Information on these pollutant loads is presented in **Table 10** by sub-region.

The distribution of the heavily polluting industries within the WCR is shown in **Table 11.** An attempt was made to summarize industries within broad categories in order to identify sub-regions with high industrial pollution loads. Six major categories of industries producing large pollutant loads were identified:

- (i) oil refineries;
- (ii) sugar factories and distilleries;
- (iii) food processing operations;
- (iv) manufacture of beer, liquor and soft drinks
- (v) pulp and paper factories; and
- (vi) chemical industries (organic and inorganic).

The areas with the heaviest pollution loads were located in Sub-Regions I and V. In **Table 12** information is also presented on the relative contribution of pollutant loads based on the type of industry. For example, oil refineries contribute with 70% of the total industrial BOD_5 loads and 80% of the oil pollution loads. These oil pollution loads represent a loss of about US$

116 x 10^6 per year, considering an oil price of US$ 16 per barrel.

Table 10

Table 11

Table 12

3. *River discharges*

Due to the lack of information on pollution load carried by rivers in the national LBSP inventories, only a limited assessment of the loading from rivers can be made at this time (**Table 13**). As expected, rivers like the Mississippi and the Magdalena discharge a considerable amount of suspended and dissolved materials, while others with much less flow may carry significant loads due to human activities in their watershed (agricultural development, deforestation, urbanization, etc.). Based on the limited amount of information gathered for only seven rivers of the region, with flows varying from 10 to 17,000 m^3/s, it is possible to consider that the BOD_5 load of the rivers surveyed is the same order of magnitude as the estimated for domestic and industrial sources. The same estimates can be stated for TSS load as well as for the other pollutants.

With reference to nutrient loadings (TN and TP) the information available is not sufficient to estimate the impact of agricultural and urban/rural runoff on the coastal water of the WCR.

VIII. Results of Pollution Load Assessment

In **Figures 3-7** summarizes the integrated pollutant loads generated by both domestic and industrial sources in which the waste discharges of each country in the different sub-regions were compared on a national and sub-regional basis and then grouped by pollutant loads and sources for each sub-region.

1. *Organic matter (BOD_5)*

The annual pollution loading for BOD_5 from domestic point sources amounted to 0.5×10^6 t/y (**Figure 3**). This load is related to two factors: the population of coastal communities and the unavailability of adequate sewage treatment facilities. For example, coastal inhabitants of Sub-Regions I and V, located along the coast of the Gulf of Mexico and the Southern Caribbean, generated estimated BOD_5 loads of 1.1×10^5 t/y, and 2.6×10^5 t/y, respectively. However, the population of Sub-region I was estimated at 16 million while the population of Sub-region V was estimated at 10 million. In order to explain this apparent anomaly regarding the BOD_5 generated in the above-mentioned sub-regions, it is important to consider that the US Gulf coast is serviced by 1,293 permitted sewage treatment plants which provide secondary treatment. On the other hand, the rest of the WCR including Sub-Region V does not have adequate municipal and disposal treatment systems. The estimated BOD_5 loading for the remaining sub-regions varies from 4.7×10^3 t/y to 7.1×10^4 t/y. There is a high correlation between the number of inhabitants of the sub-regions and the organic matter loads.

Table 13

2. *Suspended solids*

Large amounts of suspended solids (TSS) are carried naturally to the coastal waters by rivers. Aditionally there are comparatively minor contributions of TSS originating from domestic and industrial point sources. The different origin and characteristics of domestic and industrial suspended solid loads should, however, be taken into consideration.

Figure 4 presents the TSS loads from domestic and industrial sources. The highest TSS loads both from domestic and industrial sources are observed in Sub-Regions I and V. It is important to point out the exceptionally, high values of TSS loads registered in the Gulf of Mexico (Sub-Region I). According to the information presented in **Table 10**, 87% of the industrial TSS loads were in the Mexican Gulf coast. The TSS loads from industrial activities is one of the two orders of magnitude higher than the TSS loads eliminated from domestic sources.

3. *Oil and grease discharges*

The estimated annual oil and grease pollution loads from domestic and industrial sources are presented in **Figure 5**. The contribution from domestic sources amounted to 1.1 x 10^5 t/y, and the oil and grease loads from industrial sources were approximately 1 x 10^6 t/y. Thus, 90% of the oil pollution loads entering the WCR coastal areas are related to industrial sources, mainly from a vastly network of oil refineries operating in the region. There are about 100 oil refineries in the WCR with a refining capacity of more than 500 x 10^6 of oil per year, 75% of which operate in Sub-Region I. However, oil pollution loads from domestic sources were higher in Sub-region V with relatively high loads also from industrial sources. Sub-region III also showed relatively high oil and grease discharge estimations, particularly in Puerto Rico.

4. *Nutrient discharges*

The major contribution of nutrient loads (TN and TP) to the coastal areas of the WCR are mainly non-point agricultural runoff and rural runoff sources with relatively smaller contribution from domestic and industrial point sources. In the present report only nutrient load estimations from point sources will be discussed. In **Figures 6** and **7** presents the distribution of TN and TP from domestic and industrial sources in the different sub-regions. The estimated total nutrient pollution loads from domestic sources amounted to 1.3 x 10^5 t/y of nitrogen and 5.8 x 10^4 t/y of phosphorous. The highest nutrient pollution loads have been estimated in Sub-regions V and I, respectively, for both domestic and industrial sources. The nutrient loads Sub-regions II, III and IV are lower by one or two orders of magnitude.

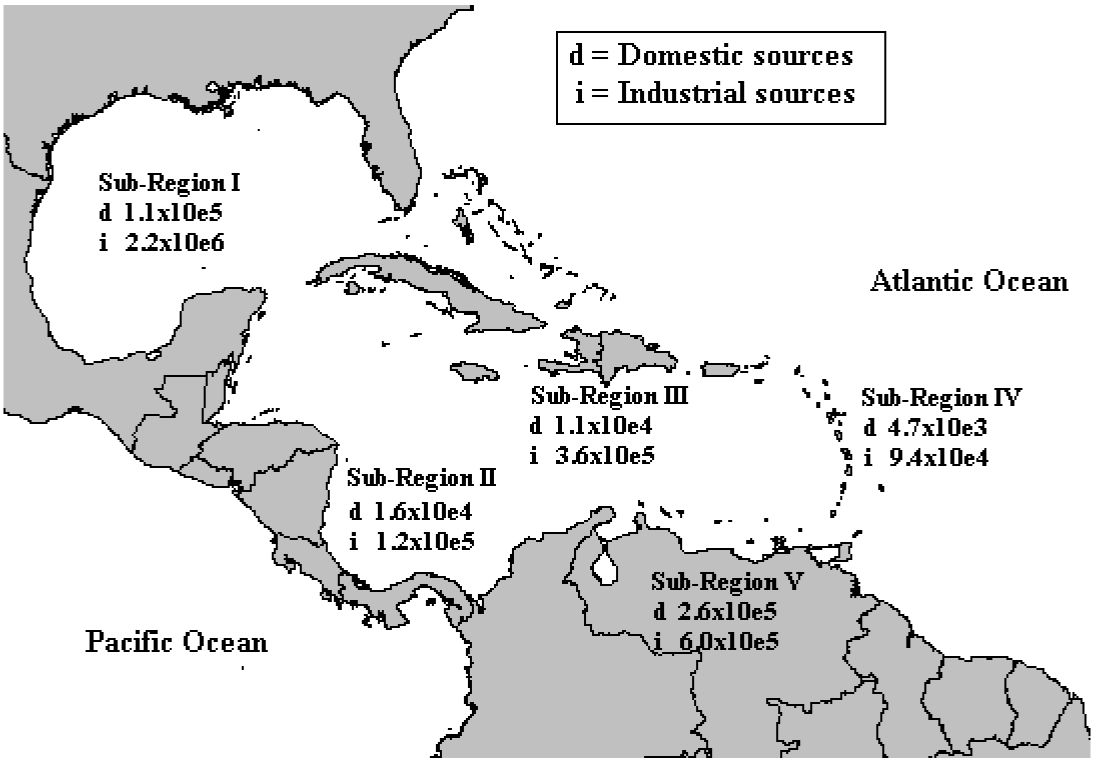


Figure 3: Distribution of loads by BOD5 (t/y) by sub-region of the Wider Caribbean Region

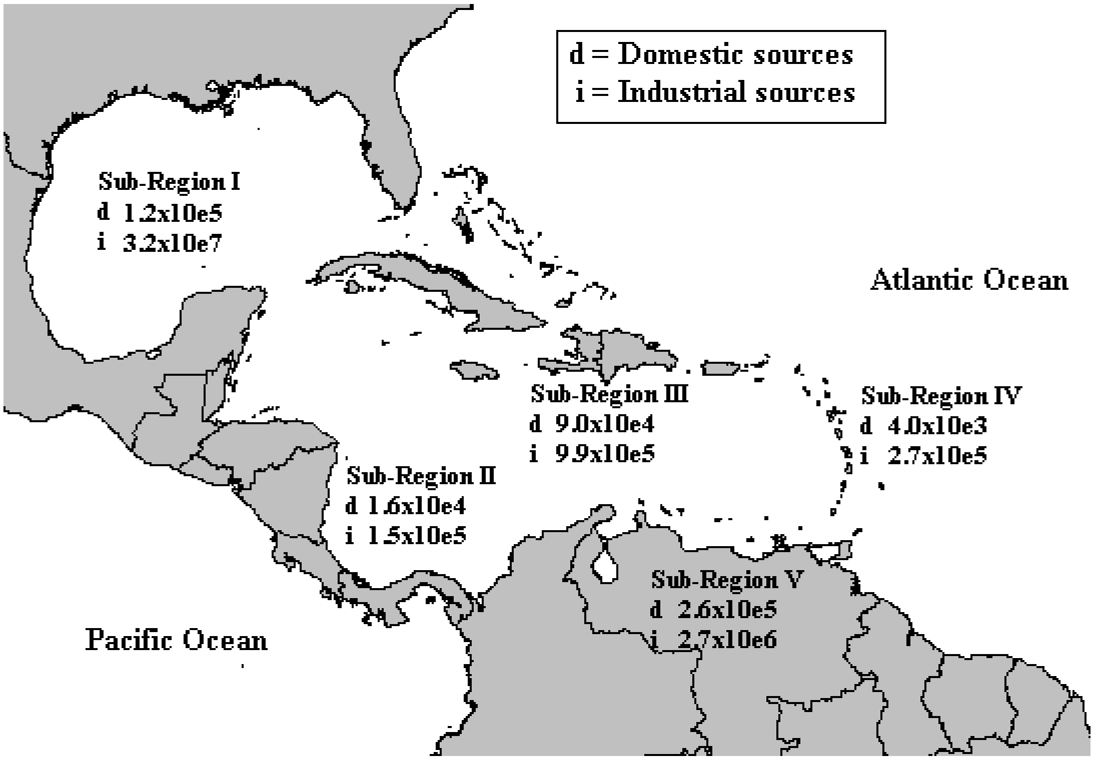


Figure 4: Distribution of TSS loads (t/y) by sub-regions of the Wider Caribbean Region

5. ***Toxic substances***

Concerning the discharge of toxic substances from industrial operations, in **Table 10** includes qualitative information on the discharge of heavy metals and phenols. Most of these metals originate from industrial discharges and to a lesser extent from domestic sources. Unfortunately, quantitative estimates were not available for most of the countries of the region.

IX. Waste Disposal Management Practices

Most of the countries of the WCR have adopted legal instruments to control the various aspects of domestic and industrial wastewater disposal into the coastal marine environment. Of the 25 countries that undertook the LBSP inventory, only nine countries provided relevant

documents legislation on land-based sources of marine pollution. Document UNEP(OCA)/CAR WG.13/INF.12 is a compilation of information on national legislation related to land-based source of marine pollution from the countries of the WCR countries.

The degree to which these legal instruments are applied varies from country to country, and in many cases, the legislation is not enforced. The enforcement of the regulations of these legislation is also hampered by the lack of the necessary infrastructure. Moreover, these regulations tend to be dispersed in general environmental legislation such as fisheries, navigation, etc. There is little doubt that the enforcement of the above regulations may at times conflict with other local interests such as the rapid development and diversification of new industries and resort complexes, particularly in those countries with economies in transition.

Consequently, it is very clear that for many countries of the WCR to meet the obligations of the LBSP Protocol in the future, it will be necessary to seriously consider appropriate strategies to cope with increasing pollution loads affecting their coastal areas.

These strategies will depend mainly on economic factors but also on the political commitment of the different countries of the region to protect the coastal environment.

Some Governments of the WCR are already taking action for abatement and control of pollution loads affecting their coastal areas. Based on information collected by the CEPPOL Programme, the following financial and regulatory actions are being successfully applied:

(i) government investments;
(ii) international financial assistance;
(iii) service and pollution taxes; and
(iv) effective application of laws and regulations to protect the coastal marine

environment.

The above described strategies can be combined according to the needs of each country, as some are more suitable to small island countries, while others are more appropriate for large continental countries.

1. *Government investments*

A good example of this approach is the work that is being carried out in Cuba to reduce the impact of pollution loads affecting sensitive coastal areas. In this regard, the following actions are being undertaken:

a) reduction of the oil and grease pollution loads affecting the waters of Havana Bay. In order to achieve this goal the Government of Cuba established a programme to control point and non-point sources.

   The non-point sources were related to the discharge of used oil from automobiles. This oil is collected from gas stations for reprocessing. Originally, these oil was continuously discharged into the sewage system, thus polluting the waters of the Bay.

   Concerning the control of point-sources of oil pollution, investments were made to reduce the loads originating from the oil refinery and the gas plant. This caused in the oil pollution in Havana Bay to be reduced by 50%.

b) At the national level, the Government is enforcing strict comprehensive regulations for the establishment of new industries along coastal areas based on environmental impact assessments.

c) 2000 oxidation ponds and lagoons were constructed for the treatment of domestic wastes from small communities and organic wastes from food processing plants and paper mills. Previously, the above wastes were discharged into rivers, some of them reaching coastal areas.

d) Under the same programme, effluents and residues from 157 sugar refineries are being utilized for the irrigation of sugarcane fields and as fertilizers.

e) Finally, feed load residues are being utilized for soil improvement and energy production.

2. *International financial assistance*

To remedy some of the most pressing pollution control problems some countries (especially island countries) have resorted to international assistance, for example through the International Development Bank (IDB).

The Government of Barbados negotiated with the IDB a loan to improve the sewerage system in the city of Bridgetown (35,000 inhabitants). That project was completed in 1982. The project included the appropriate collection of sewage wastewaters and pumping systems, the construction of a secondary sewage treatment plant and marine outfall 300 meters long. The project was financed through the loan from IDB for US$ 29 million with a contribution of US$ 2.7 million from the Government of Barbados.

A second loan was recently obtained to treat sewage wastewater generated by hotels and the local population along the southern coast of Barbados. The project includes a collector, a primary sewage treatment plant and the construction of a marine outfall 1.1 km. long. This project will be financed through a loan from the IDB for US$ 51 million and from the European Investment Bank (EIB) for US$ 11 million with a contribution of 11 million from the Government of Barbados.

In the case of Costa Rica a project for the rehabilitation of the sewerage system of the city of Limón, that was destroyed by an earthquake in April 1991, has being negotiated with the IDB for a loan of US$ 5 million. At this point it will be necessary for the Government of Costa Rica to negotiate an additional loan to build an outfall to discharge primary treated wastewaters into the coastal environment.

Trinidad and Tobago successfully negotiated an IDB loan for the improvement of an oil refinery located at Point-à-Pierre on the west coast of Trinidad. The purpose of the project is to strengthen the capacity of Trinidad and Tobago to exploit the oil and gas of resources by boosting the capacity of the old oil refinery at Point-à-Pierre. This will allow the refinery to produce products of high market value and to enhance oil recovery in the production field.

The project financed by the IDB will cost US$ 36 million and has three components:

(i) secondary recovery project;
(ii) waterflood project; and
(iii) refinery up-grade.

The execution of these components will assist in reducing land-based sources of oil pollution, such as "produced waters", treatment facilities, sulphur recovery unit, etc.

3. *Service and pollution taxes*

There are clear advantages in developing financially self-sufficient systems to control pollution loads from land-based sources, for example, in the Netherlands Antilles (Curaçao, Bonaire, Saba, St. Eustatious and St. Maarteen) a tax system to finance sewage treatment plants is being developed.

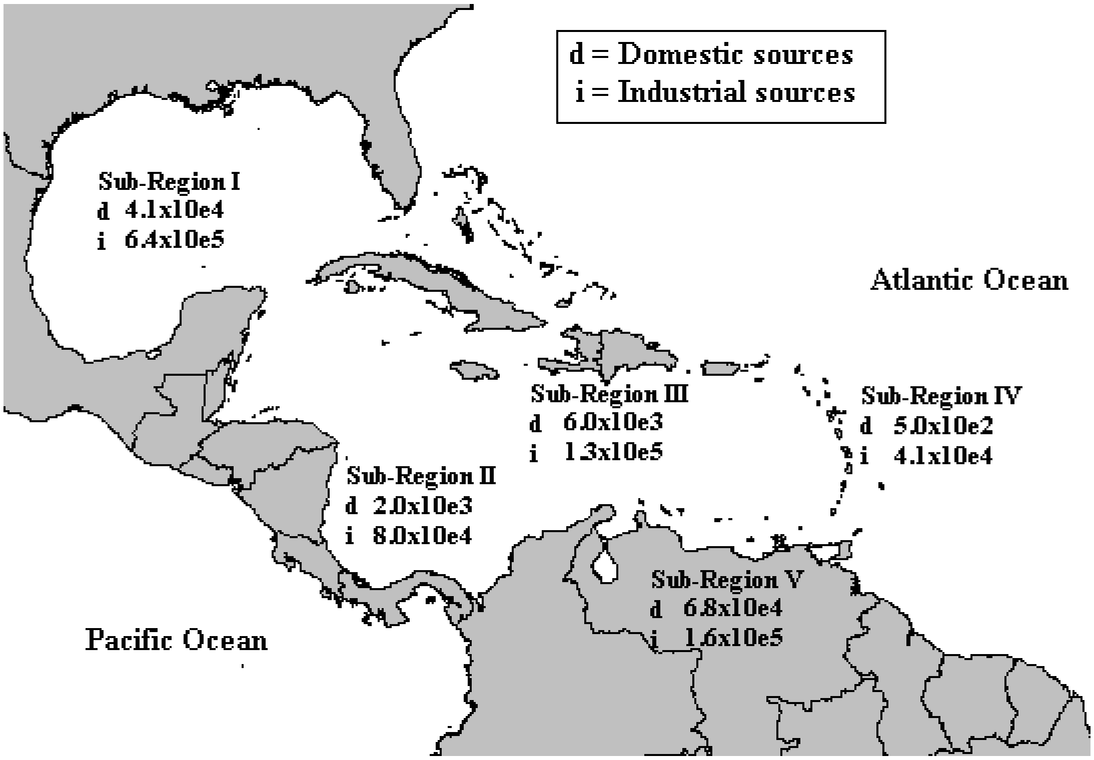


Figure 5: Distribution of oil and grease (t/y) loads by sub-regions of the Wider Caribbean Region

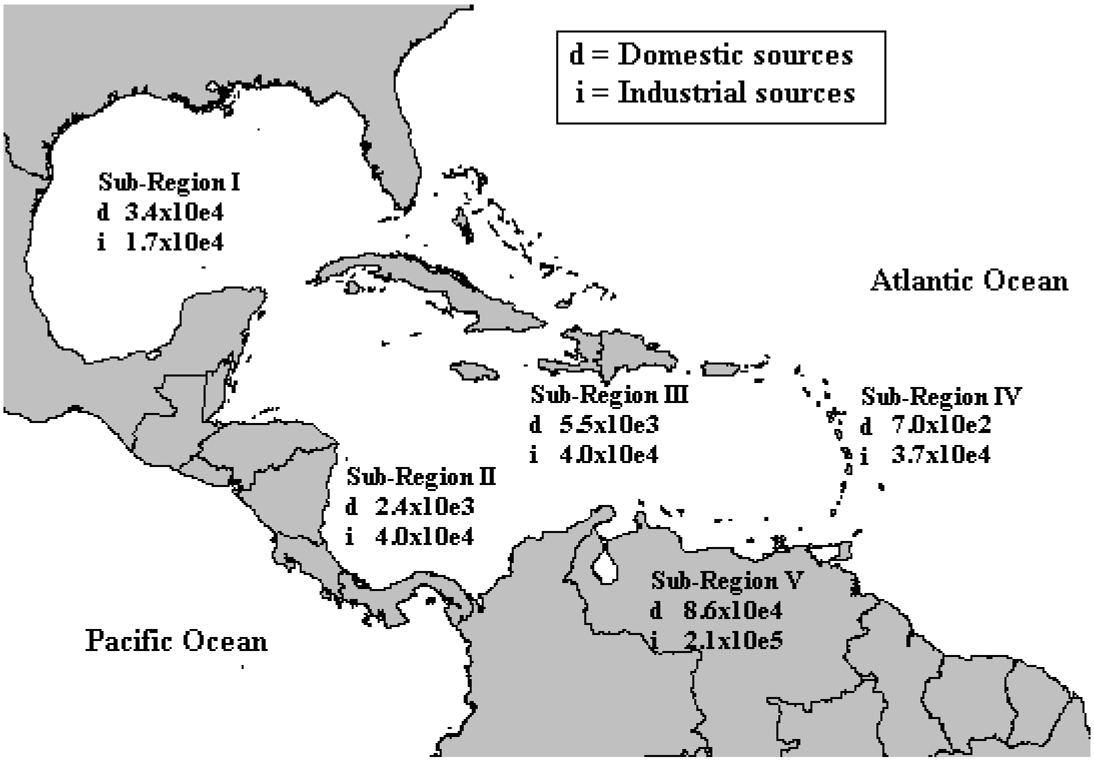


Figure 6: Distribution of total nitrogen (t/y) by sub-regions of the Wider Caribbean Region

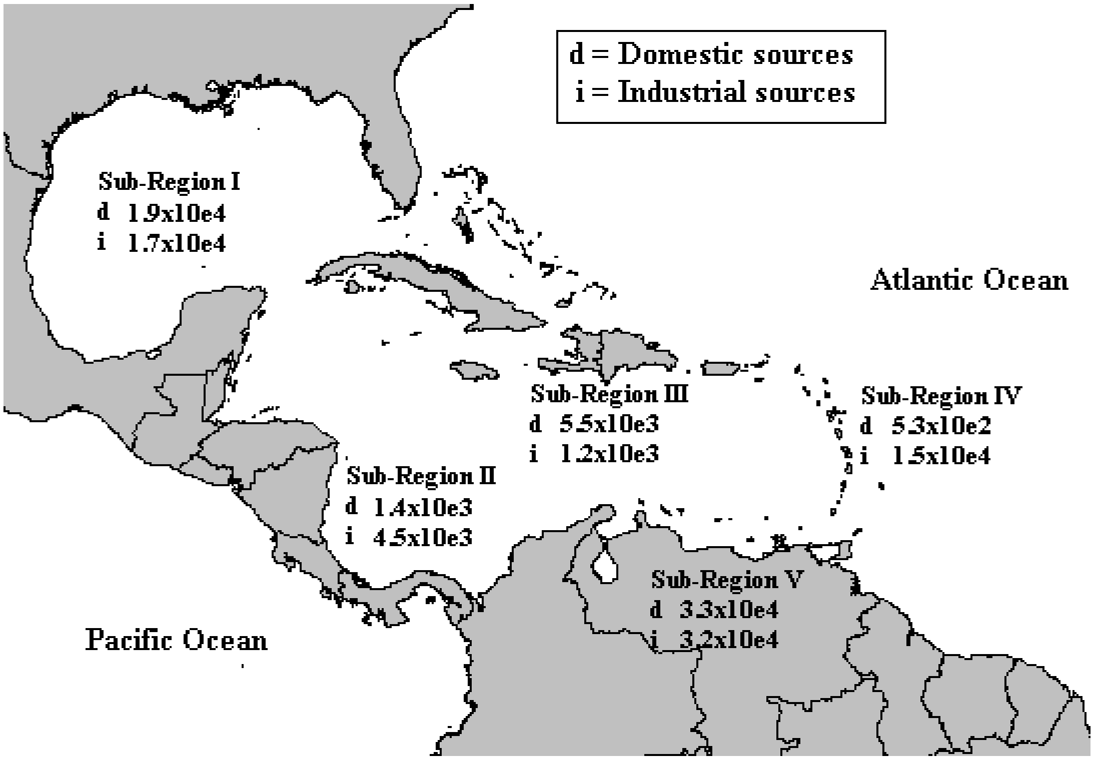


Figure 7: Distribution of total phosphorus (t/y) from point sources by sub-regions of the Wider Caribbean Region

In the particular case of the island of Curaçao, the implementation of the so called sewage structure plan will demand an investment of US$ 110 million over a period of nine years. This plan does not include the construction of sewerage systems for new housing industrial developments. The necessary funds will be obtained from Government sources through a combined sewage and pollution tax.

To finance the "sewerage structure plan" a household tax of US$ 56 per year will be levied to provide an estimated revenue of US$ 16.7 million over a period of nine years. An additional pollution tax of US$ 33 per household will provide US$ 10 million for the same period. Finally, an amount of US$ 12.8 million will be obtained from the sale of treated sewage waters.

With reference to the Island of Bonaire financing for the sewer structure plan" will require investment of US$ 10 million. Proposals have not yet been completed for the Islands of Saba, St. Eustatious and St. Maarteen.

4. *Enforcement of national laws and regulations*

This strategy is being applied specifically in the USA were the control of land-based sources of pollution (point sources) is exercised by issuing individual licenses, also "termed permits" for each point source discharge both domestic and industrial. Limitations on the quantity and quality of the waste are laid out in the permits, which are reviewed prior to renewal.

The system for issuing is governed by permits on the application of the Best Available Technology (BAT) for the prevention and reduction of contaminants in effluents taking into account standards of economical achievability.

The requirements for each discharge are enforced at the national level by USEPA, however, the above-mentioned requirements can be modified by the States according to the use and importance of the receiving waters, and their capacity to assimilate the pollutant loads. This system, when properly implemented, allows a certain degree of flexibility in both space and time and for a progressive regulatory policy to be persued.

The USA legislation also contemplates the control of non-point sources of coastal marine pollution through the Coastal Zone Management Act of 1972 (CZMA) which encourages the States to develop and implement management programmes to achieve the wise use of land and water resources of the coastal zone. The CZMA authorizes NOAA to issue grants for state coastal management programmes. Moreover, the Coastal Zone Rehabilitation Amendment of 1990 (CZARA) in Section 6217 requires States to establish programmes to control non-point sources of coastal pollution. These programmes must be approved by NOAA and USEPA. Beginning in fiscal year 1996, States that fail to submit an acceptable coastal non-point programme to NOAA and USEPA face statutory reductions in federal funds awarded under Section 306 of the CZMA and under Section 319 of the Clean Water Act (CWA).

X. Conclusions

1. It has been possible over a short period (2 years), to achieve a comprehensive overview of land-based point sources of marine pollution in the Wider Caribbean Region, (in which information from 25 countries has been included).

2. Results obtained through indirect methods of evaluation, can be used to compare the discharges from industries and domestic effluents for national, sub-regional and regional levels.

3. The coastal and marine environment of the north of South America and Gulf of Mexico sub-regions receive the largest amounts of pollutant loads.

4. Oil refineries constitute the most significant source of industrial marine pollution in the Wider Caribbean, contributing approximately 70% of the total BOD load and over 80% of the total oil and grease discharged from industrial point sources in the region.

5. There are six industrial categories mentioned in Table 12 that represent 85% of both organic matter BOD and oil discharges from industrial sources in the Wider Caribbean Region.

6. Of the six (6) pollutant categories examined in the inventory, BOD and Total Suspended Solids (TSS) represent two of the greatest pollutant loads entering the marine environment of the Wider Caribbean from point sources. BOD and TSS loads for the WCR are the same order of magnitude as the Mediterranean basin, although the distribution of these discharges is concentrated in a few countries for the Wider Caribbean Region while in the Mediterranean Basin it is more widespread.

7. The negative impact of organic matter (BOD) and bacteriological pollution on coastal ecosystems and the risk to public health are increasing as a result of the lack of adequate systems for the treatment and control of domestic wastewaters.

8. The BOD discharges from domestic effluents is around 10^5 t/y. This figure is similar to the total load reported by the Mediterranean Programme (MEDPOL).

9. Although the information on rivers is sparse, the preliminary data indicates that TSS loads from rivers are one order of magnitude higher than loads from industrial and domestic sources discharging directly to coastal waters.

XI. Recommendations

1. The discharge contribution including BOD and nutrients contribution from rivers should be taken into account, when developing the action plan to protect the coastal and marine ecosystems in the WCR.

2. Activities should be implemented to assess the water quality and pollution loads from rivers and non-point sources of pollution. In light of the importance of the above sources, these activities should be incorporated in Phase II of LBSP within the framework of the CEPPOL Programme.

3. The Governments of the Wider Caribbean Region should prepare adequate pollution prevention and reduction plans which should incorporate the results of this overview and follow-up studies, as well as the on-going CEPPOL Programme studies on eutrophication and damaged coastal ecosystems.

4. Government and private sector institutions should undertake public education and awareness programmes to sensitize populations to the adverse environmental, health and economic effects of LBSMP.

5. Comprehensive efforts should be made by the Governments of the Wider Caribbean Region to enforce existing, as well as develop comprehensive legislation for the prevention, reduction and control of marine pollution, while continuing efforts to develop a protocol on land-based sources of marine pollution.

6. The following financial and regulatory mechanims are suggested to manage land-based sources of marine pollution and to protect the marine environment:

   (a) government investments;
   (b) international financial and technical assistance;
   (c) service and pollution taxes;
   (d) effective enforcement of laws and regulations; and
   (e) strengthening of institutional capacities of relevant agencies.

7. The inventories should be repeated every 3-5 years and include micro-biological/sanitary aspects.

8. To analyze the impact of tourism and other development activities on the marine environment.

9. All countries in the Wider Caribbean Region should fully participate in future surveys on land-based sources of marine pollution.

10. To develop techniques to determine the quantity of pollutants discharged from point and non-point sources of marine pollution, in order to produce comparable data.

11. Governments of the Wider Caribbean Region should propose that a precautionary approach be included in their national programmes to control land-based sources of marine pollution.

XII. References

(1) IOC/FAO/UNEP (1977). International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, 1976. IOC Workshop Report No. 11, pp. 228 and Supplement.

(2) UNEP (1983). Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (including Protocol on Co-operation in combating oil spills in the Wider Caribbean Region). UNEP Regional Seas Conventions and Protocols, pp. 225.

(3) UNEP (1987). Fourth Intergovernmental Meeting on the Action Plan for the Caribbean Environment Programme and First Meeting of Contracting Parties to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, Guadeloupe, French Antilles, 26-28 October 1987. (UNEP(OCA)/CAR IG. 2/4).

(4) IOC/UNEP (1989). Regional Workshop to Review Priorities for Marine Pollution Monitoring, Research, Control and Abatement in the Wider Caribbean, San José, Costa Rica, 24-30 August 1989. IOC Workshop Report No. 59, pp. 113.

(5) World Resources Institute (1992). World Resources (1992-1993) prepared in collaboration with UNEP and UNDP. Oxford University press, New York, New York.

(6) Atlas del Golfo y Caribe de México (1988). "Diagnóstico Ambiental". (Ed.) Centro de Ecodesarrollo, Secretaría de Pesca, México DF, México, pp. 44.

(7) Culliton, T.J., M.A. Warren, T.R. Goodspeed, D.C. Remer, C.M. Blackwell and J.J. McDonough, III (1990). 50 Years of Population Change Along the Nation's Coasts, 1960-2010. Strategic Assessment Branch, Ocean Assessments Division, Office of Oceanography and Marine Assessment, NOAA, Silver Spring, MD.

(8) Arnold, F.D. and D.R.G. Farrow (1987). The National Coastal Pollution Discharge Inventory. Pollutant discharge concentration from industrial point sources. Strategic Assessment Branch, Ocean Assessments Division, Office of Oceanography and Marine Assessment. NOAA, Rockville, MD, pp. 17.

(9) Main, M.B., D.R.G. Farrow and F.D. Arnold (1987). The National Coastal Pollutants Discharge Inventory. Publicly owned treatment works in coastal areas of the USA. Strategic Assessment Branch, Ocean Assessments Division, Office of Oceanography and Marine Assessment. NOAA, Rockville, MD, pp. 20.

(10) U.S. Department of Commerce (1990). Estuaries of the United States. Vital Statistics of a National Resource Base. A Special NOAA 20th Anniversary Report. Strategic Assessment Branch Ocean Assessments Division, Office of Oceanography and Marine Assessment. NOAA, Rockville, MD, pp. 36-42.

(11) Rodriguez, A. (1981). Marine and Coastal Environment Stress in the Wider Caribbean Region. Ambio 10 (6), pp. 283-294.

(12) UNEP/ECLAC (1984). The State of Marine Pollution in the Wider Caribbean Region. UNEP Regional Seas Report and Studies No. 36, pp. 42.

(13) UNEP (1989). Regional Overview of Environmental Problems and Priorities Affecting the Coastal and Marine Resources of the Wider Caribbean Region, CEP Technical Report No. 2, pp. 39.

(14) Archer, A.B. (1984). Land-Based Sources of Pollution in Coastal, Marine and Land Areas of the CARICOM States. UNEP/CARICOM/PAHO Project for the Protection of the Coastal and Marine Environment of Caribbean Islands, pp. 64.

(15) MITRANS/UNDP/UNEP/UNESCO (1985). Final report of the UNDP Project CUB/80/001 "Investigacion y Control de la Contaminacion Marina en la Bahia de la Habana" completed in 1984, 4 Volumes.

(16) Consultores Generales Asociados Ltda. (1983). Inforne Final "Estudio del Control de la Contaminacion de la Bahia de Cartagena y las Areas de Influencia" INDERENA, Cartagena, Colombia.

(17) Wade, B.A. (1975). The Pollution Ecology of Kingston Harbour, Jamaica. Research Report form the Zoology Department of the University of the West Indies, Kingston,

Jamaica, 3 Volumes.

(18) Batelle Laboratories (1979). Study of the Effects of Oil Discharges and Domestic and Industrial Wastewaters of the Fishes of Lake Maracaibo, Volume I: Ecological characterization, pp 84, and Volume II: Fate and effects of Oil-Creole, pp 62. Creole Petroleum Corp. Caracas, Venezuela and Batelle Pacific Northwest Laboratories, Richland, Washington, USA.

(19) Toledo, A., A. V. Botello, M. Herzing, M. Paez, L. Bozada, F. Contreras, M. Chazaro and A. Baez (1989). "La Contaminacion en la Region del Rio Coatzacoalcos". Ciencia y Desarrollo, CONACYT, Vol. XV No. 86, 1989, pp. 27-46.

(20) Mood, E.W. (1977). Beach Pollution in the Caribbean Environmental Health Assessment and Suggested Health Strategy. proceedings of a Conference/Workshop on Environmental Health Strategy. Grenada PAHO.

(21) Vlugman, A. A. (1992). CEHI/PAHO Assessment of Operational Status of Wastewater Treatment Plants in the Caribbean, pp.57 and Annexes.

(22) Weber, M., R.T. Townsend, and R. Bierce. (1992). Environmental Quality in the Gulf of Mexico: A Citizen's Guide. Center for Marine Conservation. Partial funding provided by USEPA/Gulf of Mexico Program, Washington, DC.

(23) Windsor, Jr., J.G. (1985). "Nationwide Review of Oxygen Depletion and Eutrophication in Estuarine and Coastal Waters: Florida Region". Final Report to Brookhaven National Laboratory, Upton, NY and to the US Department of Commerce, NOAA, National ocean Service, Office of Oceanography and Marine Assessment, Ocean Assessment Division, Rockville, MD.

(24) Ward, R.E., and N.C. Singh (1987). Bacterial Pollution Monitoring in Castries Harbour, St. Lucia, West Indies. J. Shoreline Management Vol. 3, pp. 225-234.

(25) Broutman, M.A., and D. L. Leonard (1988). National Estuarine Inventory. The Quality of Shellfish Growing Waters in the Gulf of Mexico, NOAA, Strategic Assessment Branch, Rockville, Md.

(26) Short, F.t. (1991)."Effects of Excessive Nutrient Loading of the Eelgrass Community".

The National Estuarine Eutrophication Project: Workshop Proceedings. (eds) K.R. Hinga, D.W. Stanley, C.J. Klein, D.T Lucid and M.J. Katz, pp. 25-27. Strategic Environmental Assessment Division, National Ocean Service, NOAA, Rockville, MD.

(27) World Resources Institute (1992). Op. cit. Table 23.1.

(28) Reinburg, L. Jr. (1984). Waterborne Trade of petroleum products in the Wider Caribbean Region. Final Report No. CG-W-10-84. U.S. Department of Transportation and U.S. Coast Guard. Washington, DC. pp. 106.

(29) Ehler, C.N., D.J. Basta and T.F. LaPointe (1983). Analyzing the effects of operational discharges of oil from ships in the Gulf of Mexico. Proceedings of the 1983 Oil Spill Conference, San Antonio, Texas February 1983.

(30) USEPA Gulf of Mexico Program (1993a). Toxic Substances and Pesticides, Action Agenda (3.2) for the Gulf of Mexico, pp. 160.

(31) US Mineral Management Service (1991). Current Facts and Figures for Offshore Oil and Gas Operations, Gulf of Mexico OCS Region.

(32) Jernelov, A., and O. Linden (1981). Ixtoc: A case Study of the World's Largest Oil Spill. Ambio 10 (6), pp. 229-306.

(33) USEPA Gulf of Mexico Program (1993a). Op. cit., pp. 26-27.

(34) Harvey, G.R. (1987). A Personal Overview of Oil in the Marine Environment. Carib. J. Sci. 23 (1), pp. 5-10.

(35) Atwood, D.K., F. J. Burton, J.E. Corredor, G.R. Harvey, A.J. Mata Jimenez, A. V. Botello and B.A. Wade (1987). Petroleum Pollution in the Caribbean. Oceanus 30 (4), pp. 25-32.

(36) Celis, L., A. V. Botello, M. Mendelewicsz and G. Díaz (1987). "Actividades del Proyecto CARIPOL en la Zona Costera del Golfo de Mexico: I Hidrocarburos Disueltos". Carib. J. Sci. 23 (1), pp. 11-18.

(37) Garay-Tinoco, J.A. (1987). "Vigilancia de la Contaminación por Petroleo en el Caribe Colombiano" (punta Canoas hasta Barbacoa, Cartagena, Colombia)". Carib. J. Sci. 23 (1), pp. 51-64.

(38) Mata, A.J., J. Acuña, M.M. Murillo and J. Cortés (1987). "Estudio de la Contaminación por Petróleo en la Costa Caribe de Costa Rica": 1981-1985. J. Sci. 23 (1), pp. 41-50.

(39) Wade, B., M. Provan, V. Gillete, and P. Carrol (1987). Oil Pollution of Jamaican Costal Waters and Beaches. Results of the IOCARIBE/CARIPOL Monitoring Programme (Jamaica): 1980-1983. Carib. J. Sci. 23 (1), pp. 93-104,

(40) UNEP (1992). Meeting of Experts on Land-Based Sources of Marine Pollution, Veracuz, México, 6-10 July 1992. Preliminary Consolidated Regional Overview on Land-Based Sources of Pollution. UNEP(OCA)/CAR WG.9/3.

(41) Wade, T.L., E.L. Atlas, J.M. Brooks, M.C. Kennicutt II, R.G. Fox, J. Sericano, B. García-Romero, and D. DeFreitas (1988). NOAA Gulf of Mexico Status and Trends Program: Trace Organic Contaminant Distribution in Sediments and Oysters. Estuaries 11, pp. 171-179.

(42) Bravo, H., Salazar, A. V. Botello, and E.F. Mandelli (1978). Polyaromatic Hydrocarbons in Oysters from Coastal Lagoons of the Gulf of Mexico. Bull. Environ. Contam. 19, pp. 171-177.

(43) Botello, A.V., and S.A. Macko (1982). Oil Pollution and the Carbon Isotope Ratio in Organisms and Recent Sediments of Coastal Lagoons in the Gulf of Mexico Ocean. Acta (SP), pp. 56-62.

(44) Garay, J.A. (1986). "Concentración y Composición de los Hidrocarburos Derivados del Petróleo en Aguas, Sedimentos y Peces de la Bahía de Cartagena, Colombia". CIOH, Bol. Cient. 6, pp. 41-62.

(45) Martínez Canals, M., and M. Martínez Benítez (1987). "Distribución de Hidrocarburos Aromáticos Polinucleares en el Litoral Norte de las Provincias de La Habana y Matanzas, Cuba". J. Sci. 23 (1), pp. 85-92.

(46) Knapp, A.H., T.D. Sleeter, R.E. Dodge, S.C. Wyers, H.R. Frith, and S.R. Smith (1983). The Effects of Oil Spills and Dispersant Use on Coral Reefs. A review and multidisciplinary experimental approach. Oil and Petrochemical Pollution 1 (3), pp. 157-169.

(47) Getter, C.D., G.B. Thomas, and B.C. Koons (1985). Effects of Dispersed Oil on Mangroves: Synthesis of a seven year study. Mar. Poll. Bull. 16 (8), pp. 318-324.

(48) Gallegos, M., and A. V. Botello (1986). "Petróleo y Manglar en: Serie Medio Ambiente y

Desarrollo No. 3. Centro de Ecodesarrollo, Secretaría de Pesca, México DF, México.

(49) Cubit, J.D., C.D. Getter, B.C. Jackson, S.D. -Arrity, H.M. Coffey, R.C. Thompson, E. Weil, and M.J. Marshall (1987). An Oil Spill Affecting Coral Reefs and Mangroves on the Caribbean Coast of Panama. In: Proceedings of the 1987 Oil Spill Conference. American Petroleum Institute, Washington DC., pp. 401-406.

(50) Thorgaugh, A., and J. Marcus (1987). Preliminary Effects of Seven Dispersants on Subtropical/Tropical Seagrasses. In: Proceedings of the 1987 Oil Spill Conference. American Petroleum Institute, Washington DC., pp. 223-224.

(51) Capuzzo, J.M., and M.N. Moore (1986). Acute and Chronic Effects of Toxic Chemical in Aquatic organisms. In: Toxic Chemicals and Aquatic Life: Research and Management. Symposium, Seattle, WA., pp. 16-18.

(52) Barron, M.G. (1990). Bio-concentration: Will Water-Borne Organic Chemicals Accumulate in Aquatic Organisms. Environ. Sci. Technol. 24 (11), pp. 1612-1618.

(53) Martin, J.M., and M. Meybeck (1976). Review of River Discharges in the Caribbean and Adjacent Regions. IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions. IOC Workshop Report No. 11, Supplement, pp. 29-46.

(54) Milliman, J.D., (1981). Transfer of River-Borne Particulate Materials to the Oceans. In: River Inputs to Ocean Systems. Proceedings of a Review Workshop held at FAO Headquarters, Rome, Italy, 26-30 March 1979, pp. 5-12.

(55) FAO (1979). Overview on Natural Resources for Food and Agriculture in the Caribbean Region (E/CEPAL/PROY./3 L. Inf. 10).

(56) World Resources Institute (1992). Op. cit. Table 17.1.

(57) Leonard, J.H. (1987). Natural Resources and Economic Development in Central America: A Regional Environment Profile. International Institute for Environment and Development, Washington, DC., pp. 279.

(58) La Pointe, T.F., and D.J. Basta (1981). The Use of Coastal Zone Color Scanner (CZCS) Imagery to Identify Nearshore Ocean Areas Affected by Land-Based Pollutants

NOAA, Washington, DC., pp. 25.

(59) Morelock, J., K. Boulon and G. Galler (1979). Sediment Stress Coral Reefs. In: Proceedings, Energy Industry and the Marine Environment in Guayanilla Bay. Center for Energy and Environmental Research, University of Puerto Rico, pp. 46-58.

(60) Cortés, J. and M.J. Risk (1985). A Reef Under Siltation Stress: Costa Rica. Bull. Mar. Sci. 36 (2), pp. 339-356.

(61) UN/DIESA (1979). Marine and Coastal Area Development in the Wider Caribbean Region: An Overview. E/CEPAL/PROY. 3/L. INF. 13.

(62) USEPA Gulf of Mexico Program (1993a). Op. cit. pp. 27-28.

(63) Burroughs, R.H. (1988). Ocean Dumping: Information and Policy Development in the USA. Marine Policy (12): pp. 96-104.

(64) Basta, D.J., B.P. Chambers, C.N. Ehler, and T.F. La Pointe (1982). Identifying and Evaluating Alternative Dump Sites: An Operational Framework for Strategic Assessment and Estimated of Sludge Generated by P.O.M.W.T.P. NOAA, Washington DC. pp. 26.

(65) Turner, R.E. and N.N. Rabalais (1991). "Eutrophication and its Effects on the Coastal Habitats", Coastal Zone 1991. pp. 61-74. In: S.H. Bolton (ed.) Coastal Wetlands Proceedings of the Seventh Symposium on Coastal and Ocean Management, 8-14 July 1991 Long Beach, CA American Society of Civil Engineers Press, New York, NY.

(66) Lowe, J.A., D.R.G. Farrow, A.S. Pait, S.J. Anerstam, and E.F. Lavan (1991). Fish kills in coastal waters 1980-1989. NOAA, Rockville, MD, pp. 69.

(67) Smayda, T. (1991). "Increasing Worldwide Frequency of Nuisance Algal Blooms" page 41 In: K.R. Hinga, D.W. Stanley, C.J. Klein, D.T. Lucid and M.J. Katz (eds.). The National Estuarine Eutrophication Project, Workshop Proceedings. Strategic Environmental Assessment Division, Office of Ocean Resource Conservation and Assessment, NOAA, Rockville, MD.

(68) USEPA Gulf of Mexico Program (1993b). Nutrient Enrichment Action Agenda (3.2) for the Gulf of Mexico, pp. 161.

(69) Lovejoy, S.B. (1992). Sources and Quantities of Nutrients Entering the Gulf of Mexico Program from Surface Waters of the USA. USEPA Gulf of Mexico Programme, Nutrient Enrichment Committee. Publication USEPA 800-R92-002.

(70) World Resources Institute (1992). Op. cit. Table 18.2

(71) Corredor, J., J.M. Morel, E. Otero and F. Nieves (1977). Studies of Eutrophication of the Marine Ecosystem in La Parguera, Puerto Rico. In: "Simposio sobre los Recursos Naturales. Departmento de Recursos Naturales de Puerto Rico. San Juan, Puerto Rico.

(72) Parra Pardi, G. (1986). "La Conservación del Lago Maracaibo Diagnóstico Ecológico y Plan Maestro. (ed.) Departamento de Protección Integral y Relaciones Públicas de LAGOVEN, S.A. Filial de PDVSA", pp. 80.

(73) Consultores Generales Asociados Ltda. (1983). Inforne Final "Estudio del Control de la Contaminación de la Bahía de Cartagena y las Areas de Influencia" Informe Final. Cartagena, Colombia.

(74) The World Environment, 1972-1992. Eds. M.K. Tolba, A. El-Kholy, et.al. UNEP (Chapman and Hall), pp. 293-294.

(75) World Resources Institute (1992). Op. cit. Table 18.2.

(76) Pait, A.S., D.G.R. Farrow, J.A. Lowe and P.A. Pacheco (1989). The National Pollutant Discharge Inventory: Agricultural Pesticide Use in Estuarine Drainage Areas. A Preliminary Summary for Selected Pesticides. NOOA, Strategic Assessment Branch, Rockville, MD.

(77) Sericano, J.L., E.L. Atlas, T.L. Wade, and J.M. Brooks (1990). NOAA's Status and Trends Mussel Watch Programme: Chlorinated Pesticides and PCBs in oysters (Crassostrea virginica) and sediments of Gulf of Mexico, 1986-1989. Mar. Environ. Res., 29, pp. 161-203.

(78) Tripp, B.W., J.W. Farrington, E.D. Golberg and J. Sericano (1992). International Mussesl Watch Programme. The Initial Implementation Phase. Mar. Poll. Bull. 24, pp. 371-373.

(79) USEPA Gulf of Mexico Program (1993b). Op. cit., pp. 15-18

(80) Rosales, M.T., A.V. Botello, H. Bravo and E.F. Mandelli (1979). PCBs and Organochlorine Pesticides in Oysters from Coastal Lagoons of the Gulf of Mexico, Mexico. Bull. Environm. Contamin. Toxicol. 21, pp. 652-656.

(81) Botello, A.V. (1990). "Impacto Ambiental de los Hidrocarburos Organoclorados y Microorganismos Patógenos Específicos en Lagunas Costeras del Golfo de México. Informe Final Proyecto OEA-CONACYT", pp. 69.

(82) Botello, A.V., G. Ponce-Vélez, A. Toledo, G. Díaz-González and S. Villanueva (1992). "Ecología, Recursos Costeros y Contaminación en el Golfo de México. Ciencia y Desarrollo", CONACYT Vol. XVII No. 102, 1992, pp. 28-48.

(83) Mansingh, A. (1986). Management of Pests and Pesticides in Tropical Islands: Trends and Needs. CFNI Symposium, Kingston, Jamaica.

(84) Personal communication from Laurence D. Mee, Head of the Marine Environmental Studies Laboratory, IAEA, Monaco.

(85) USEPA Gulf of Mexico Program (1993b). Op. cit. pp. 24-25.

(86) Environmental Resources Limited (1991). Port Reception and Disposal Facilities from Garbage in the Wider Caribbean. IMO/World Bank, p. 287.

(87) USEPA Gulf of Mexico Program (1993c). Marine Debris Action Agenda for the Gulf of Mexico. EPA 800-K-93-002, p. 97 and 2 Appendices.

(88) Wilber, R.J. (1987). Plastics in the North Atlantic. Oceanus 30 (3), pp. 18-25.

(89) USEPA Gulf of Mexico Program (1993c). Op. cit. pp. 17-33.

(90) Heneman, B. (1988). Persistent Marine Debris in the North Sea, Northwest Atlantic Ocean, Wider Caribbean Region, and the West Coast of Baja California. Center of Environmental Education, Washington, DC.

(91) Atwood, D.K., A.V. Botello and B.A. Wade (1987). Results of the CARIPOL Petroleum Monitoring Project in the Wider Caribbean. Mar. Poll. Bull. 18 (10), pp. 540-548.

(92) Vásquez-Cortes, J.M., A.V. Botello and S. Villanueva (1987). "Actividades del Proyecto CARIPOL en la zona costera de México. Breas y Alquitranes en Playas". Carib. J. Sci. (23) (1), pp. 19-28.

(93) Newton, W. (1987). Tar on Beaches, Bonaire, Netherlands Antilles. Carib. J. Sci. 23 (1), pp. 131-138.

(94) Van Vleet, E.S., W.M. Sackett, F.F. Weber, Jr., and S.B. Reinhardt (1983). Spatial and Temporal Variations of Pelagic Tar in the Eastern Gulf of Mexico, pp. 363-368. In: Advances in Organic Geochemistry, (M. Bjoroy, ed.). John Wiley, London.

(95) Van Vleet, E.S., W.M. Sackett, S.B. Reinhardt and M.E. Mangini (1984). Distribution, Sources and Fate of Floating Oil Residues in the Eastern Gulf of Mexico. Mar. Poll. Bull. 15, pp. 106-110.

(96) USEPA Gulf of Mexico Program (1993c). Op. cit. pp. 9-11.

(97) Van Vleet, E.S. and G.G. Pauly (1987). Characterization of Oil Residues Scraped from Stranded Sea Turtles from the Gulf of Mexico. Carib. J. Sci. 23, pp. 77-84.

(98) Balazs, G.H. (1984). Impact of Ocean Debris on Marine Turtles, pp. 387-429. In: R.S. Shomura and H.O. Yoshida, eds., Proceedings of the Workshop on the Fate and Impact of Marine Debris. Honolulu, HI, 27-29 November 1984. NOAA Technical Memorandum, NMFS NOAA-TM-NMFS-SWFC-54.

(99) Barros, N.B., D.K. Odell and G.W. Patton (1989). Ingestion of Plastic Debris by Stranded Marine Mammals from Florida. Abstract from the Second International Congress on Marine Debris, Honolulu, HI., 2-7 April 1989.

(100) USEPA (1992). Public Health Action Plan for the Gulf of Mexico. Gulf of Mexico Program, John Stenis Space Center, MS.

(101) National Academy of Science (1991). Seafood Safety. Committee on Evaluation of the Safety of Fishery Products. Food and Nutrition Board. Institute of Medicine. Washington, DC.

(102) International Petroleum Encyclopedia (1992). Pennwell Publishing Co., Box 1260, Tulsa, OK. 74101.

(103) USEPA Gulf of Mexico Program (1993a). Op. cit. pp. 19-20.

(104) Louisiana Department of Environmental Quality (1992). Water Quality Inventory, pp. 62-

69.