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UPDATED CEP TECHNICAL REPORT NO. 33 LAND-BASED SOURCES AND ACTIVITIES IN THE WIDER CARIBBEAN REGION

DOMESTIC AND INDUSTRIAL POLLUTANT LOADS AND WATERSHEDS INFLOWS

UNEP

CARIBBEAN ENVIRONMENT PROGRAMME

Prepared by the Regional Activities Centre
for the Protocol Concerning Pollution from Land-Based Sources and Activities (LBS):
Centro de Ingeniería y Manejo Ambiental de Bahías y Costas (Cimab)

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Implementation of the project was guided by participants of the 9th-14th Intergovernmental Meetings on the Action Plan for the CEP and the 6th-10th Meetings of the Contracting Parties to the Cartagena Convention as well as the 2nd-5th Meetings of the Interim Scientific, Technical and Advisory Committee to the LBS Protocol. Specific guidance was also contributed by the Ad-Hoc Working Groups established at the 4th and 5th Meetings of the Interim Scientific, Technical and Advisory Committee to the LBS Protocol.

The methodology used in this report was developed and/or reviewed by LBS RAC Cimab and experts from the region that participated in workshops in Caracas, Venezuela and Havana, Cuba in 2005 and 2006, respectively, as well as input contributed by various national and technical Government Focal Points, CEP Regional Activity Centres and other regional experts.

Data used in this report were contributed by various national and technical Government Focal Points, CEP Regional Activity Centres and other regional experts involved in the management of land-based sources of pollution in the WCR.

Comments and/or further updated data to an earlier draft of this report were submitted by the Governments of Costa Rica, French Guiana, Jamaica, Mexico, Netherlands Antilles, and USA, LBS RAC Institute of Marine Affairs of Trinidad and Tobago, the Coastal and Marine Research Institute (INVEMAR) of Colombia, the GEF REPCar Project, and the Pan-American Health Organization (PAHO).

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ACRONIMS AND ABBREVIATIONS

AMEP: Assessments and Management of Environmental Pollution
CEHI: Caribbean Environmental Health Institute, St Lucia.
CEP: Caribbean Environmental Program
CEPIS: Pan-American Centre for Sanitary Engineering and Environemntal Sciences, (*Centro Panamericano de Ingeniería Sanitaria*) Perú
CEPPOL: Programme for Marine Pollution Assessment and Control
CGSM: Ciénaga Grande de Santa Marta, Colombia
CICAR: Co-operative Investigation of the Caribbean and Adjacent Regions
CIMAB: Center for Ingenering and Environmental Management of Bays and Coastal Areas (*Centro de Ingeniería y Manejo Ambiental de Bahías y Costas*), Cuba.
Cimab: Centre of Engineering and Environmental Management of Bays and Coasts
CIRA/UNAN: Centro para la Investigación en Recursos Acuáticos de la Universidad Nacional Autónoma de Nicaragua.
EPA: Environmental Agency Protection, USA
GEF: Global Environmental Facility
IMA: Institute of Marine Affaire, Trinidad & Tobago
INVEMAR: Instituto de Investigaciones Marinas y Costeras, Colombia.
IOC-UNESCO: Inter-governmental Oceanographic Commission
ISTAC: Interim Scientific Technician Advisory Committee of the Protocol Concerning to the Pollution from Land-Based Sources and Activities of Cartagena Convention**.**
LBS: Pollution from Land-Based Sources and Activities
NEPA: National Environmental and Planning Agency, Jamaica
NOAA: U.S. National Oceanic and Atmospheric Administration
PAHO: Pan American Health Organization
SIDA: Swedish International Development Agency
SIDS: Small Island Development State
UDO: Universidad de Oriente, Venezuela.
UN: United Nations
UNDP: United Nation Development Programme
UNEP: United Nation Environment Programme
UNEP-CAR/RCU: United Nation Environment Program - Caribbean Regional Coordination Unit
UNOPS: United Nations Office for Project Services
WCR: Wider Caribbean Region
WECAFC: Western Central Atlantic Fisheries Commission

EXECUTIVE SUMMARY

This report complies with a mandate from the Eleventh Inter-Governmental Meeting of the Caribbean Action Plan and the Eighth Meeting of the Conference of the Contracting Parties to the Cartagena Convention held in Montego Bay, Jamaica in October 2004, at which the decision was taken to Update CEP Technical Report No. 33, starting from National Technical Reports that should be presented by the WCR countries, as well as reports and UN Agencies publications with financial assistance from SIDA. The original purpose of the project was focused in the implementation of political national and regional related with the evaluation and control of the polluting loads discharged in the WCR coming from the land-based sources and activities.

Update CEP Technical Report No. 33 was carried out during the period 2005-2010 in two phases. First phase involved the hosting of two workshops in Caracas and Havana in 2005 and 2006, respectively, dealing with Methodologies for Estimating Domestic and Industrial Pollutant Loads from land-based sources in WCR, where the environmental quality indicators and the methodologies settled down according to the technical and financial capacities of WCR countries. These methodologies are directed, also, to future projects, databases and monitoring related with the polluting loads control discharged in the region. The CEP Technical Report No. 33 (1994) methodology was based on "Management and Control of the Environment" WHO/PEP/89.1 from which a shortened and slightly modified version was prepared though USA, Puerto Rico and the US Virgin Islands used the NOAA's Coastal Pollution Discharge Inventory (NCPDI) methodology for point pollution sources.

Second phase entailed the assessment and analysis of National Technical Reports presented by Barbados, Belize, Colombia, Costa Rica, Cuba, French Guiana, Guadeloupe, Martinique, Guatemala, Jamaica, Nicaragua, Panama, Dominican Republic, Trinidad & Tobago, and Venezuela in addition to other information available up to 2009, to provide updates on the pollutant loads discharged in the WCR. The rest of loads pollutants discharged in WCR were estimated starting from the discussed methodologies and approved in the workshops taken place in Caracas and Havana, and the polluting loads estimates coming from non-point pollution sources.

This updated report is grouped into six chapters and provides an update on the domestic and industrial pollutant loads discharged in WCR, sanitation coverage expansion and treatment, as well as the pollutant loading from watersheds inflows according to the available information in the WCR countries. Likewise, it presents the projected changes of pollutant loads for the years 2015 and 2020 in fulfilling UN Millennium Development Goals.

Chapter 1 on geographical coverage summarizes the division of the WCR into five sub-regions (Gulf of Mexico, Western Caribbean, Southern Caribbean, Eastern Caribbean, and North-eastern and Central Caribbean) to facilitate the assessment and synthesis of the pollutant loads discharged in WCR and defines, according to the characteristics of most of the WCR countries, the small island states as completely coastal and the large mainland states and large islands with a coastal zone up to 25 km inland, in order to estimate the upstream coastal population.

Chapter 2 on sanitation coverage calculates the size of the upstream coastal population (70 million inhabitants) and the domestic wastewater flow discharged into the WCR (203 m^3 sec^{-1}). This chapter also discusses the sanitation coverage characteristics with and without connections to sewerage. Overall sanitation coverage is over 60 million inhabitants (85%) with a significant proportion of low-cost home systems. The contribution daily per capita (Ipcd) reaches 209 liters of domestic wastewater discharged per inhabitant per day in WCR.

Chapter 3 provides details on the update of domestic pollutant loads and summarizes organic loads (BOD_5 and COD), suspended solids (TSS) and nutrients (TN and TP) discharged in each sub-region in the WCR. Comparison among the data reported in CEP Technical Report No. 33 (1994) and this updated report shows reductions in domestic pollutant loads dischaged in the WCR, in particular in nutrients, despite the gradual population increase due probably to a larger control of sewage discharged and the differences among methodologies used in both reports. Likewise, in 1994 Report only 25 countries were considered versus 28 states and 18 dependent territories of 4 states in this updated report.

Chapter 4 provides details on the updating of industrial pollutant loads and includes the estimated industrial loads discharged into the WCR by sub-region. Comparison among the data reported in CEP Technical Report No. 33 (1994) and this updated report shows, in general, a strong decrease in industrial pollutant loads in the WCR despite the progressive industrial development, which be the result, probably, to differences in the methodologies used in both reports and improved treatment capacities in oil refinery, sugar factories, refinery and distillery, drinks and spirits, food processing plants, pulp and paper, chemical industries, textiles, basic industry (iron, steel, machinery, non ferrous metals), soaps and perfumes, mining, plastics, lathe operations, power stations, galvanisation and others. The methodology used in this update report includes the direct methods use by means of the taking of samples, flow mensurations and analytic methods normalized for laboratory tests. The indirect methods used include the production indicators and consumption, the emission factors estimate, extrapolation, balance of materials and others methods of quick evaluation. Likewise, a discussion on hydrocarbon dumping in WCR associated with industry, transport and offshore operations is showed. Chapter 4 does not quantify the pollutant loads from petroleum to the WCR because of the scarcity of reliable data. Offshore exploitation is increasing in the region, in particular in Gulf of Mexico, Southern Caribbean and Eastern

Caribbean, while in North-eastern and Central Caribbean offshore drilling-exploration is being conducted.

Chapter 5 focuses on discharges from watersheds and summarizes pollutant loadings to the WCR though the data are incomplete for the lack of information about the Mississippi and Orinoco watersheds and others. Comparison among the data reported in CEP Technical Report No. 33 (1994) and this updated report shows an increase in pollutant loads, characteristic of a larger exploitation in the basins and, probably, to differences in the estimate methodology. Likewise, this chapter includes a discussion on the problems associated with improper watershed management as a result of extensive agricultural cultivation, increasing urbanization, industrial development and deforestation. Chapter 5 also reports the results of studies in the meso-American reef (Belize, Guatemala, Honduras and a part of Mexico), Eastern Caribbean and North-eastern and Central Caribbean that summarizes sediment and nutrient pollutant loadings discharged into the WCR from non-point pollution sources.

Chapter 6 outlines the projected change in domestic pollutant loading in 2015 and 2020 based on current trends assuming efforts are taken to meet the UN Millennium Development Goals. In comparing these values with the data provided in this updated report, only slight increments of these loads are observed, despite the estimated population increase. This demonstrates the importance to WCR of fulfilling UN Millennium Development Goals with regard to sewage management.

The table described below shows the pollution total loads discharged inWCR from urban and industrial activity, drainage area from watersheads and the total flow contributed by land-based sources and activities and the watersheads inflows according to the available information.

WCR	Drainage area (km^2)	Flow [1] ($m^3.sec^{-1}$)	Average annual load ($t.yr^{-1}$) x 10^3				
			BOD_5	COD	TSS	TN	TP
Gulf of Mexico	4, 508,020	29,100	318 [2]	669 [2]	217,213	1,678	164
Western Caribbean	291,439	3,004	427	1,851	5,819	15	5
Southern Caribbean	1, 278,743	3,364	3,364 [3]	14,670 [3]	202,383	644	125 [3]
Eastern Caribbean	105,242	1,004	210	389	56	3	1
North-east and Central	378,871	3,055	722	2,780	7,688	36	13
Total	**6, 500,000**	**81,203**	**5,000**	**20,000**	**433,000**	**2,400**	**300**

[1]The industrial wastewater flow is not included due to the lack of information.
[2]Organic loadings from watersheads' Gulf of Mexico are not included due to the lack of information.
[3]Organic loadings and phosphorous from Rio Orinoco watersheads are not included due to the lack of information.

Discharge to the Mexico Gulf is the smallest per drainage area with a flow 0.006 $m^3.sec^{-1}.km^{-2}$, perhaps indicative of scarce rainfall in watersheds inflows and appropriate land-use and management that reduces runoff.

Discharge to Southern Caribbean is larger with a flow 0.035 $m^3.sec^{-1}.km^{-2}$, perhaps indicative of larger rainfall in watersheds inflows and inappropriate land-use and management. In the rest, the flow discharged to the WCR behaves according to the drainage area' size.

The conclusions are:

- Since the 1994 Report, sanitation coverage in the WCR has increased and reaches 85% of the upstream coastal population, facilitated by the extended use low-costc appropriate technologies.

- Since the 1994 Report, the domestic pollutant loads discharged in the WCR show reductions, in particular decreasing nutrient loading. However, further reduction and control in pollution is required through the political will of governments at different levels (national, regional and local) to promote institutional capacity building and environmental awareness, as well as greater investments and technical support in the sanitation sector.

- Since the 1994 Report, the industrial pollutant loads discharged in the WCR have decreased appreciably, in particular decreasing nutrient loading. However, further reduction and control of pollution is required through the influence of relevant authorities on waste disposal compliance approved and established in countries of the region in order to enhance institutional capacities and environmental awareness of the commercial sector, as well as greater investments and technical support in the industrial sector with the target of promoting the implementation of the standard ISO 14001:2004 “Environmental management systems-Requirements with guidance for use”

- Sediment loading is the main pollutant contribution from watersheds in the WCR. Best management practices to improve the control of runoff from agriculture and impervious surfaces are required for effective sediment control and nutrient reductions.

- Data reported suggest that the highest runoff discharge rates and average annual loads of TSS and TP drain from sub-region I (Gulf of Mexico) and sub-region III (Southern Caribbean). However, the data reported display relatively lower average annual loads of BOD_5, COD and TN draining from sub-region I (Gulf of Mexico), which is surprising given that it displays the greatest flows of domestic wastewater to the WCR (49%). Perhaps this is due to sub-region I exhibiting enhanced management of domestic wastewaters, On the other hand, the relatively higher discharge rates and average annual loads reported for sub-region III (Southern Caribbean) may be a result of far greater runoff rates generated per square area (0.035 $m^3.sec^{-1}.km^{-2}$) when compared to the other sub-regions (range: 0.006 - 0.010 $m^3.sec^{-1}.km^{-2}$) causing increased erosion and pollutant transport.

- The enter in force of LBS Protocol at the Region, constitutes the main tool for the WCR countries to achieve a decrease of the polluting loads currently coming from land-based sources of marine pollution, derived from the collaboration and funding mechanism of the sub regional, regional or worldwide that could be developed inside the context of this important juridical instrument.

RECOMMENDATIONS

- To promote the ratification of LBS Protocol by the countries forming parties of the Cartagena Convention, due to the importance of this juridical instrument for working in the decrease of polluting loads that inputs to the WCR, coming from activities and land-based sources of marine pollution.

- To further advance the use of mathematical models and other evaluation techniques, such as Geographical Information Systems (GIS), to calculate pollutant loads coming from non-point pollution sources to the WCR and to facilitate the fulfillment of the Annex IV of the LBS Protocol, referring to the evaluation of the non point sources of agricultural pollution.

- To continue national and regional efforts in the standardization of methodologies, data analysis and interpretation, data sharing, and capacity building for continued monitoring and assessment of pollutant loads discharging to the marine environment, thus ensuring that the carrying capacity of coastal and marine ecosystems are not exceeded.

- Given limitations on available resources and the complexity of assessing pollutant loading directly, especially from non-point sources, consideration should be given to further identification and use of alternative indicators of pollutant loadings and their impacts on the marine environment.

- The 2015 and 2020 scenarios' display of slight increments in domestic pollutant loading despite the estimated upsteam coastal population increase, illustrate the importance of expanding sanitation coverage and treatment facilities in the WCR countries in compliance with the UN Millennium Development Goals and satisfying the effluent limits established in LBS Protocol of the Cartagena Convention.

INTRODUCCION

WCR receives pollutant loads from urban and industrial activities and from runoff from watersheds through point and non-point sources of pollution. Sewage and nutrient pollution from agricultural sources constitute the largest threat to critical coastal habitat. It is essential for WCR countries to prevent, reduce and control sources of pollution in order to protect human health and marine resources under the LBS and Oil Spill Protocols to the Cartagena Convention. In addition, this updated report is a second assessment of pollutant loads discharged in WCR and it is hoped that the report will be able to show some trends after management strategies have been put in place since the original 1994 report was published.

In recent decades, there has been greater awareness among citizens of the increase in the level of marine pollution in WCR, and diagnostic studies have been undertaken to determine the impacts on coastal and marine water quality from land-based sources and activities. Several legal instruments have been drafted to address these land-based threats to coastal and marine resources.

In 1973, CICAR sponsored by IOC-UNESCO, in co-operation with UNEP and WECAFC of FAO recommended a workshop to evaluate the marine pollution [1]. As a result of this workshop, a project was set up to monitor oil pollution in WCR.

In 1981, the Action Plan for the CEP was adopted. It established the foundation for the adoption in March 1983 in Cartagena de Indias, Colombia, of the "Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region" known as the Cartagena Convention which entered into force in 1986 together with the "Protocol Concerning to the Cooperation in Combating Oil Spills in the Wider Caribbean Region" [2].

In 1987, the Fourth Intergovernmental Meeting of the Action Plan for CEP and the First Meeting of the Contracting Parties to the Cartagena Convention was conducted in Guadeloupe, where AMEPProgramme was adopted as one of the main actions for WCR [3].

In 1989, a workshop was conducted in San José, Costa Rica, sponsored by UNEP-CEP-IOC-UNESCO where the CEPPOL program for Marine Pollution Assessment and Control in the WCR was proposed. CEPPOL was initiated in 1990. The control of land-based sources of domestic, industrial and agricultural pollution became one of its most important activities [4].

In 1994, CEP Technical Report No. 33 was presented, summarizing results from the CEPPOL Programme. The report highlighted inventories of land-based sources of pollution in 25 countries of the region with a regional perspective, and included analyses on sub-regional differences in loadings and the evaluation of the main pollutant loads affecting the WCR [5].

On 6 October 1999, in Oranjestad, Aruba, the “Protocol Concerning to the Pollution from Land-Based Sources and Activities”, known as LBS Protocol of the Cartagena Convention was adopted with the purpose of addressing threats to the coastal and marine environment of the WCR from land-based activities [6].

In September 2000, 191 nations adopted the UN Millennium Declaration, which has defined issues related to peace, security and development, and identified the environment, human rights and governance as key concerns for human development. In consequence, the UN Millennium Development Goals of the Millennium Declaration were agreed to, and as part of the objective of “Ensuring Environmental Sustainability”, regional goals have been included “To reduce in half for the year 2015 the proportion of people without access to fresh water and sanitation services” and “For the year 2020 to have achieved a considerable improvement in the life quality of at least 100 million inhabitants of marginal neighbourhoods”. A complementary goal for Latin America and Caribbean was also included, aiming to reduce by 50% the number of inhabitants without access to treatment systems or sewage final disposal for the year 2015 [7].

In this framework, this study has been conducted with the aim of presenting Update CEP Technical Report No. 33 (1994) on domestic and industrial pollutant loads discharged in WCR, together with sanitation coverage extension and treatment facilities, and the watersheds inflows contribution, starting from the National Technical Reports presented by Barbados, Belize, Colombia, Costa Rica, Cuba, French Guiana, Guadeloupe, Martinique, Guatemala, Jamaica, Nicaragua, Panama, Dominican Republic, Trinidad & Tobago, and Venezuela, UN Agencies publications and other reports, and the methodologies approved at the Workshops in Caracas and Havana in 2005 and 2006, respectively [8,9,10]. It also presents the projected changes of domestic pollutant loads in the region for the years 2015 and 2020, in fulfilment UN Millennium Development Goals.

The update report was presented in the Final Workshop of the Project “Regional Network in Marine Science and Technology for the Caribbean: *Know-Why Network*" and the Regional Workshop “Terminal Lessons Workshop for GEF Contaminated Bays and Regional Verification for GEF CReW Projects" taken place in Havana in March and November of 2009, respectively.

Likewise, it was revised twice by the WCR countries for its improvement and make whole, and it was discussed, also, in the ISTAC meeting taken place in Panama City in 2010.

1. GEOGRAPHICAL COVERAGE

The Cartagena Convention defines the Wider Caribbean Region as the marine environment of the Gulf of Mexico, the Caribbean Sea and zones adjacent to the Atlantic Ocean south of 30^{o} North Latitude and within 200 nautical miles of the Atlantic coasts of the signatory states of the Convention (Figure 1). WCR is integrated for 28 states and 18 dependent territories of 4 states.

Figure 1. WCR states and territories

WCR has been divided into five sub-regions to facilitate the search, analysis and compilation of the accessed data and in fulfilment of the mandate from the Eleventh Inter-Governmental Meeting of the Caribbean Action Plan, concerning the Update CEP Technical Report No. 33 (1994) on domestic and industrial pollutant loads discharged in WCR and watersheds inflows [11] (Figure 2).

The small island states belonging to WCR with extensive marine areas and limited access to multiple resources are considered entirely coastal, whilst the large continental states and large islands extend their coastal zone 25 km inland, according to the characteristics of most of the WCR countries, in order to calculate the upstream coastal population.

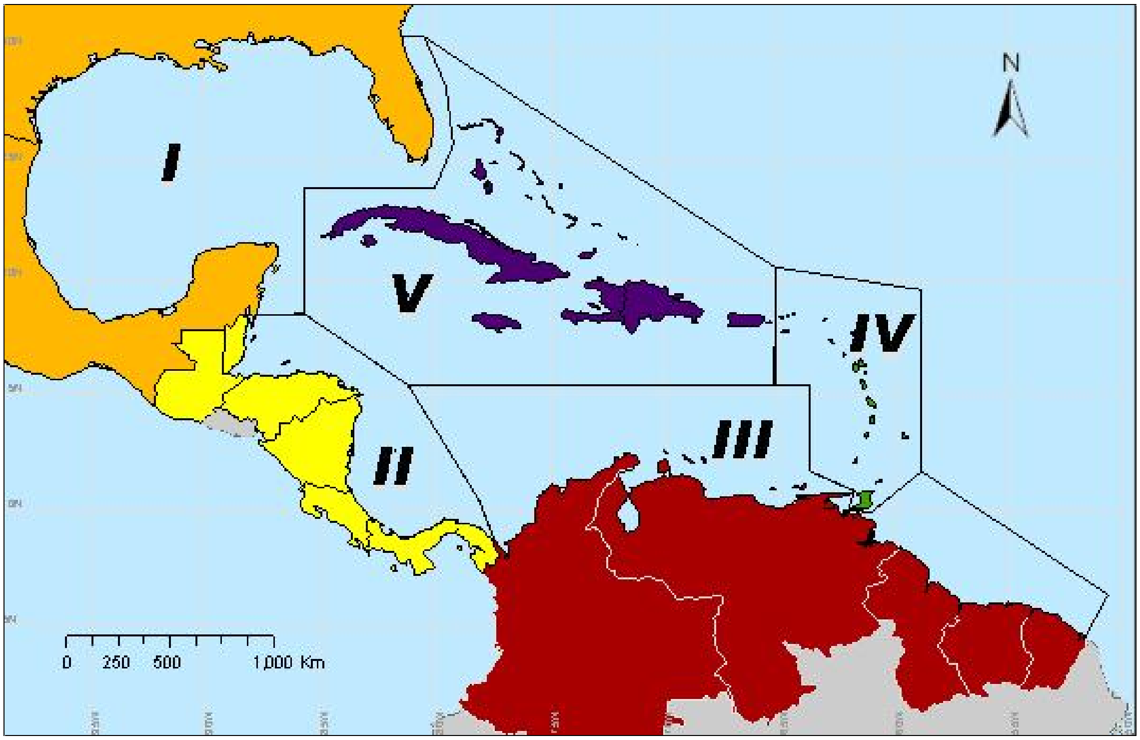

Figure 2. Division of the WCR into 5 sub-regions

Sub-region I Gulf of Mexico; includes the United States of America and Mexico.
Sub-region II Western Caribbean; includes the countries of Central America with coastlines on the Caribbean Sea: Belize, Guatemala, Honduras, Nicaragua, Costa Rica and Panama.
Sub-region III Southern Caribbean; includes the countries of the South American continent: Colombia, Venezuela, Guyana, French Guiana, Suriname, Aruba and the Netherlands Antilles.
Sub-region IV Eastern Caribbean; includes the islands Anguilla, Antigua and Barbuda, Barbados, British Virgin Islands, Dominica, Grenada, Guadeloupe, Martinique, Montserrat, St. Martin, St. Lucia, St. Bartholomi, St. Kitts and Nevis, St. Vincent and the Grenadines, U.S. Virgin Islands and Trinidad & Tobago.
Sub-region V North-eastern and Central Caribbean; includes Bahamas, Cayman Islands, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico and the Turks and Caicos Islands.

Tourism is one of the main economic activities in WCR countries. Less than 1% of the world's population live in sub-regions II, III, IV and V, and each year receive close to 6% of tourists from all over the world. This economic activity, which represents between 30-50% of the Gross Domestic Product for the region, without considering sub-region I, exerts great pressure on the sustainability of coastal ecosystems [12]. The polluting loads contribution comes from the tourist activity in WCR and their temporary population are not part of the objectives of this update report, included the solid waste pollution but should be considered in regional future projects because of their impact in the environmental quality of the WCR.

2. SANITATION COVERAGE

2.1. Upstream coastal population and domestic wastewater discharged in WCR

Domestic wastewater comprises all discharges from households, commerces, hotels, septage and any entity whose discharge includes toilet flushing (black water), discharges from showers, wash basins, kitchens and laundries (grey water) or discharges from small industries, provided their composition and quantity are compatible with treatment in a domestic wastewater system [6].

In the flow assessment of the domestic wastewater discharged in WCR an indirect method is used that kept in mind the contribution per capita of drinkable water given by each country, the coastal tributary population's size, the type and extension of the sanitation covering, and a return coefficient to the sewer system of 0.8. The population with local sanitation technologies, of low cost, and those absent populations of sanitation covering, a coefficient of return of 0.5 are considered. The sum of both flows is considered the domestic wastewater total flow discharged by each country in the region. National Technical Reports of 15 WCR countries provide their domestic wastewater flows discharged in WCR.

Table 1 shows the estimated upsteam coastal population (size of the population up to 25 km from the coast in continental states and the large islands according to the characteristics of most of the WCR countries, and the total population of the small islands), the domestic wastewater flow discharged into the WCR in cubic meters per second and the contribution per capita of domestic wastewater discharged in the coastal area in liter per inhabitant per day (Ipcd).

The upstream coastal population in WCR is some 70 million inhabitants. Sub-region V (North-eastern and Central Caribbean) some 27 million inhabitants is the largest upstream coastal population followed by sub-region I (Gulf of Mexico) some 21 million inhabitants, whilst sub-regions II (Western Caribbean) and IV (Eastern Caribbean) with close to three million each, are less populated.

The daily total contribution per capita (Ipcd) reaches some 209 liters of domestic wastewater discharged per inhabitant per day into the WCR. USA has the larger domestic wastewater flows discharged in WCR with 88 cubic meters per second and a Ipcd of 486, influenced by the high index of water consumption some 600 liters per inhabitant per day and a sewage sanitation coverage some 100%.

Table 1. Upstream coastal population, domestic waste water flow discharged ($m^3.sec^{-1}$) and daily contribution per capita ($l.inh^{-1}.day^{-1}$) in WCR [8, 14,15,16,17,18,19]

Countries and territories	Upstream coastal population x 10^3	Flow discharged in WCR ($m^3.sec^{-1}$)	Daily contribution per capita ($l.inh^{-1}.day^{-1}$)
Sub-region I			
United States of America	15, 677	88.26	486
Mexico	5, 372	12.02	193
Subtotal	*21, 049*	*100.28*	*412*
Sub-region II			
Belize	156	0.33	182
Guatemala	124	0.19	129
Honduras	1,364	0.74	47
Nicaragua	147	0.11	67
Costa Rica	188	0.30	131
Panama	901	2.85	273
Subtotal	*2,880*	*4.52*	*138*
Sub-region III			
Colombia	4, 588	6.98	131
Venezuela	10,101	31.24	267
Guyana	600	0.68	98
French Guiana	215	0.18	138
Suriname	386	0.45	101
Aruba	NA		
Netherlands Antilles	194	0.29	129
Subtotal	*16,084*	*39.82*	*215*
Sub-region IV			
Anguilla	13	0.01	95
Antigua & Barbuda	69	0.08	95
Barbados	280	0.33	101
British Virgin Islands	23	0.03	102
Dominica	69	0.08	95
Grenada	90	0.10	100
Guadeloupe	416	0.43	90
Martinique	436	0.51	100
Montserrat	91	0.10	92
St. Lucia	168	0.19	100
St. Martin	NA		
St. Bartholomi	NA		
St. Kitts & Nevis	39	0.04	98
US Virgin Islands	109	0.25	200
Trinidad & Tobago	1,066	1.38	112
S.V. and the Grenadines	118	0.14	99
Subtotal	*2, 987*	*3.67*	*106*

Countries and territories	Upstream coastal population x 10^3	Flow discharged in WCR ($m^3.sec^{-1}$)	Daily contribution per capita ($l.inh^{-1}.day^{-1}$)
Sub-region V			
Bahamas	304	0.36	103
Cayman Islands	9	0.01	97
Cuba	7, 732	24.12	270
Dominican Republic	5, 624	9.52	146
Haiti	6, 996	8.15	101
Puerto Rico	3, 927	9.09	200
Jamaica	2,758	3.58	112
Turks & Caicos Islands	17	0.02	101
Subtotal	*27,367*	*54.86*	*173*
Total	**70, 000**	**203**	**209**

NA: Not available

Figure 3 shows the percentage of domestic wastewater flow discharged in WCR by sub-region. The largest flow comes from sub-region I (Gulf of Mexico) some 49% followed sub-region V (North-eastern and Central Caribbean) some 27%, while the less significant amounts come from sub-region IV (Eastern Caribbean) and sub-region II (Western Caribbean) some 2%. Some 203 $m^3.sec^{-1}$ of domestic wastewater are discharged in WCR.

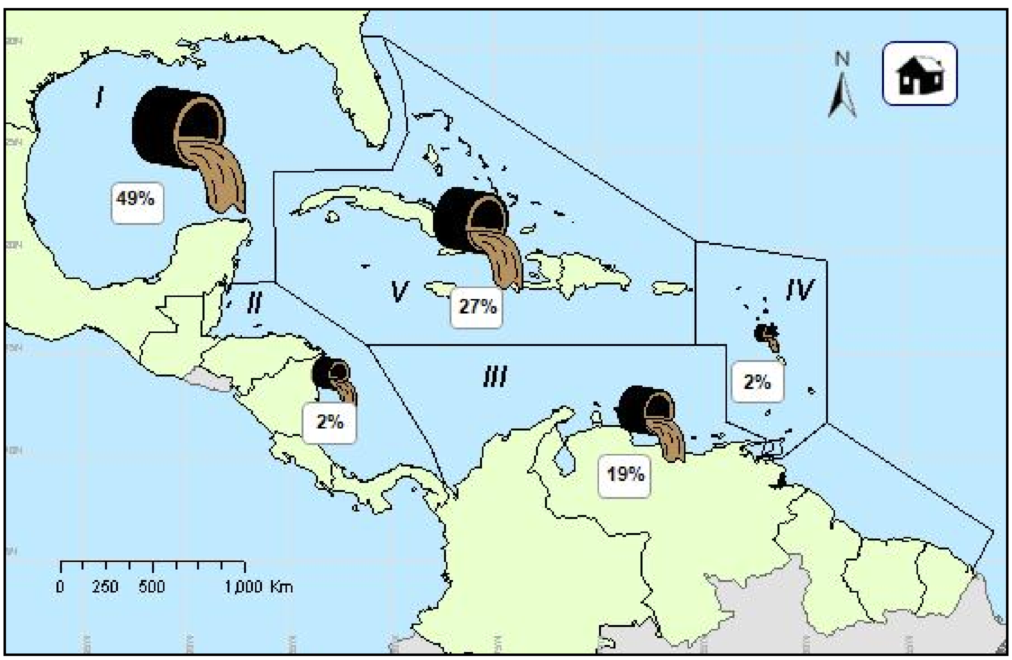

Figure 3. Percentage of domestic wastewaters flow discharged by sub-region in WCR

2.2. Sanitation coverage

In WCR countries, population and tourism infrastructure are concentrated in coastal areas. In general, the coastal area accounts for only 20% of all land area whilst 39% of the world's population lives within 100 km of coast [13]. In many of these areas the sewerage systems are either deficient or absent and some have illegal connections to storm drains which increase the domestic pollution into waterways and adjacent coastal environments.

Most of the WCR countries have limited access to basic sanitation due to a shortage of treatment plants, or because of limited domiciliary connection to sewer systems, and often employ low-cost household systems made up of septic tanks, dry latrines, with discharge of water or the simple pit latrines. This lack of infrastructure and ineffectual treatment practices increases the sewage discharge into coastal areas of the WCR causing risks to public health from direct contact with polluted water and the consumption of seafood with different degrees of contamination [8,20].

However, the socio-economic impacts of inadequate sanitation coverage are not limited to health issues. It is also related to the water availability for various uses associated with productive development, particularly the treated wastewater use for irrigation in response to the competition between agriculture and urban use. It is related as well with the impact on urban uses through the wastewater discharge in watersheds areas known as high basins, which affect downstream urban areas because of the lack of sufficient time for natural purification processes to take place [21].

Table 2 shows the sanitation coverage percentage with and without connection to sewer systems in WCR countries, the upstream coastal population with sanitation coverage according to the available information (National Technical Reports, UN Agencies publications and others report) and sewer system effluents with some treatment degree (pre-treatment, primary treatment, secondary treatment, tertiary treatment or sewage discharges through submarine outfalls).

The sanitation coverage percentages and sewerage effluents with some treatment degree in the subregión IV are affected by the lack of information in several of the countries.

Table 2. Sanitation coverage in WCR, the upstream coastal population with sanitation coverage by sub-region and sewerage effluents with some treatment degree [8,21,22]

Countries and territories	Sanitation coverage (%)	Upstream coastal population x 10^3 with sanitation coverage	Treated sewage effluent (%)
Sub-region I			
United States of America	100	15, 677	100
Mexico	87	4, 673	15.4
Subtotal		*20,350*	*57*
Sub-region II			
Belize	73	113	56.7
Guatemala	95	117	1
Honduras	94	1,282	3
Nicaragua	93	137	34
Costa Rica	96	180	38
Panama	99	892	18.3
Subtotal		*2,721*	*25*
Sub-region III			
Colombia	97	4,450	30.8
Venezuela	71	7,172	56
Guyana	97	582	50
French Guiana	79	-	41
Suriname	99	382	0.1
Aruba	NA		
Netherlands Antilles	100	200	17
Subtotal		*12,786*	*33*
Sub-region IV			
Anguilla	86	59	0
Antigua & Barbuda	96	86	65
Barbados	NA	-	0
British Virgin Islands	NA		
Dominica	86	59	0
Grenada	96	86	65
Guadeloupe	NA	-	0
Martinique	NA	-	NA
Montserrat	NA	-	100
St. Lucia	89	149	NA
St. Martin	NA		
St. Bartholomi	NA		
St. Kitts & Nevis	96	37	NA
US Virgin Islands	100	109	NA
Trinidad & Tobago	100	1,066	65
S.V. and the Grenadines	96	113	46.1
Subtotal		*1,977*	*59*

Countries and territories	Sanitation coverage (%)	Upstream coastal population x 10^3 with sanitation coverage	Treated sewage effluent (%)
Sub-region V			
Bahamas	100	304	80
Cayman Islands	99	9	40
Cuba	97	7,500	18.9
Dominican Republic	90	5,061	48.7
Haiti	46	3,218	0
Puerto Rico	100	3,927	100
Jamaica	90	2,482	NA
Turks & Caicos Islands	17	0.02	101
Subtotal	*27,367*	*54.86*	*173*
Total		**60,000**	**44***

***Average non-weighted percentage**
NA: Not available

The upstream coastal population in WCR with sanitation coverage is some 60 million inhabitants (85%) although without considering several WCR countries due to the lack of information. Sub-region V (North-eastern and Central Caribbean) and sub-region I (Gulf of Mexico) over 20 million inhabitants each contain larger population with sanitation coverage followed sub-region III (Southern Caribbean) some 12 million inhabitants. Sub-regions II (Western Caribbean) and IV (Eastern Caribbean) some two million inhabitants each are smaller.

Depending on the type of treatment selected, the appropriate domestic wastewater mangement may be expensive and constitutes a great challenge to WCR countries, including WCR countries with a high level of development, which face new problems caused by the increase in environmental pollution, they need large investments to replace current infrastructure. The growing demand for standards and regulations for protecting health and the environment makes it essential to constantly upgrade treatment systems.

In developing countries, the high cost of conventional urban treatment plants, operation and maintenance present an impediment serious to their use. Extending sanitation coverage in sewerage includes expanding the infrastructure, networks and treatment facilities, because in many cities in the region, gradual population growth leads to obsolete sewerage systems which are unable to face the growing volume of domestic wastewaters. However, work on the expansion and rehabilitation of the sewerage systems in developing countries is subject to the availability of financial resources and operational capacity for its planning and execution. The alternative is the use of more appropriate low-cost technologies which have demonstrated an ability to provide proper solutions to the problem [23].

In sanitation coverage in WCR, several critical elements which have not been resolved have been identified, in particular:

- the state of economic development in WCR countries,
- the lack of government support for the sanitation sector,
- inadequate knowledge of sanitation among the population,
- the need to change existing methods and funding criteria for treatment plants,
- inadequate environmental policies in the sector,
- institutional weaknesses,
- the need to formulate technological and engineering standards appropriate for domestic wastewater treatment in developing countries, and
- a large number of urban treatment plants are abandoned or work improperly.

Consequently, the great challenge is linked in reducing impacts from sanitation coverage extension and sewer system efficiency as well as implementing alternative improved on-site household systems, improving environmental awareness and technical capacity in sanitation sector, adequate national environmental policies and the programs management improvement, as it is pointed out in the UN Millennium Development Goals.

The aims for the Region are the reduction of 50% between 1990 and 2015 of the number of people that don't have access to drinkable water and the reduction of 50% between 1990 and 2015 of the number of people that don't have access to sanitation services. Also, as a result of the option of incorporating objectives that can be pertinent for the region and to incorporate the goal of having achieved for the year 2020 a considerable improvement in the lives of, at least, 100 million inhabitants of "hovels" it is incorporated like complementary goal for the year 2015, the reduction to 50% of the inhabitants that don't have access to domestic wastewater treatment or final disposition [7].

Further, governments and the sanitation sector must work together to fulfill the effluent limits established in Annex III of the LBS Protocol depending on the characteristics of receiving waters (Class I or Class II waters).

2.3. Most appropriate treatment technologies

Developing countries in WCR need to fulfill their necessities of domestic wastewater treatment through more appropriate, low-cost technologies, according to their socio-economic conditions and with the support of financial international organizations to finance the initial and operational costs. Among these methodologies they are stabilization ponds, up-flow anaerobic reactors and the submarine outfalls, as well as improved on-site household systems.

Submarine outfall may be an appropriate technology and relatively economical with very low operation and maintenance costs, and can be used for final disposal of sewage, when the dynamic characteristics of the receiving waters facilitate the dilution process and when they are combined with mili-screens.

Submarine outfall effluents discharge into the sea can reach dilutions in the order from 100 at 1 in consistent form during the first minutes of discharge, what reduces the organic matter concentration and other nutrients at levels that they would not have ecological adverse effects however it is a treatment system that does not consider water reused.

Should wastewater re-use not be possible, the option of the long submarine outfall with mili-sieves may be a disposal method and treatment more attractive than conventional urban treatment plants (second treatment for activated sludge) which discharge to the nearby coast in terms of reliability, efficiency, cost and low operational and maintenance requirements [24].

Nevertheless, sewage discharges through submarine outfalls close to fishing areas and sensitive biological communities such as coral reefs, and shellfish populations should be avoided. Such areas need permanent monitoring to determine any potential impacts from continued nutrient enrichment through submarine outfalls discharge.

In addition to consideration of Class I and Class II waters under the LBS Protocol, the submarine outfall option must be assessed in terms of local needs and potential environmental impacts in the area of study, according to that settled down in the Article VII of LBS Protocol where the Environmental Impact Assessment process is a forecast tool and preventive in the taking of decisions.

Table 3 shows the WCR countries which have reported the use of submarine outfalls for the sewage final disposal in the region. Venezuela reports the largest quantity of submarine outfalls.

Table 3. Submarine outfalls reported in WCR countries [8,24]

WCR Countries	Submarine outfalls
Venezuela	39
Puerto Rico *	10
Mexico	9
USA	5
Colombia	2
Cuba	2
US Virgin Islands	2
Costa Rica	1
Panama	1
Martinique	1
French Guiana	0
Guyana	1
Total	**73**

*** Highest per capita use in WCR**

The appropriate low-cost technologies that can be used for WCR according to the characteristics of the place are associated to the wastewater collection and transfer. The recommended technologies are [25]:

- *Conventional sewerage*; where sewage is collected by an underground pipe system to treatment facilities.

- *Small bore (settled) sewerage;* in principle, the design of the settled system is the same as conventional system. However, before the sewage enters a septic tank where most settleable solid are removed, thus only the liquid effluent is reticulated.

- *Cluster system;* a common collection and disposal system grouping several houses or trade. It is used to collect sewage from areas with significantly varying housing densities.

- *Cistern-flush toilet;* use large amounts of water. The toilet bowl consists of a siphon which provides a water seal against bad odors from the effluent. Provide the highest level of convenience and have a very clean and hygienic appearance.

- *Pit latrine;* designed for the on-site disposal of human excreta. It consists of a concrete squatting plate or riser, which is placed over an earthen pit. It can be used with good results in rural areas.

- *VIP latrine;* the ventilated improved pit (VIP) is design for the on-site disposal of human excreta. VIP latrines do not need water for flushing. They rely on soil absorption and they are simple to construct.

- *Septic tank;* designed for the on-site treatment of sewage. The tank is usually located underground and consists of two compartments allowing for one to three days of hydraulic retention. Septic tanks must be connected to a flush toilet therefore they are not suitable where water supply is scarce or unreliable.

- *Biogas-Bio fertilizer plant;* a concrete plant used for the anaerobic degradation of organic waste and agro-industrial waste and wastewater to produce biogas and biofertilizer. However, it does not work well with human excreta alone.

- *Sanitary bio-latrine unit (SBU);* installed where the bio digester plants have been built to collect the waste from a VIP latrine. Effluents require tertiary treatment.

- *Portable chemical toilets;* a small toilet room built over a watertight waste holding tank. They are often used at many events where large numbers of people congregate and difficult access places or far-away for collection systems and sewage transfer.

- *Wetland filtration wastewater disposal systems;* they can be used in rural areas and small communities for the sewage treatment. Wetland gives sub-products and aggregate values by means of effluent re-use that can minimize the installation costs. Likewise, they reduce the biochemical oxygen demand, suspended solids, nitrogen and phosphorus at so low levels that they don't cause eutrophication process in the coastal waters and they can be considered as a tertiary treatment.

3. DOMESTIC POLLUTANT LOADS. UPDATE

3.1. Domestic pollutant loads discharged in WCR

In the WCR, improperly treated domestic wastewater can be an important source of marine pollution and represents a threat to human health, sustainable development and marine resources. In many locations, sewage is frequently discharged into rivers, streams, lakes or directly into the sea without being properly treated. Organic matter, nutrients and total suspended solids contained in sewage discharged in WCR contribute to the eutrophication, turbidity and siltation coastal ecosystems with irreparable damages to important resources, such as coral reefs. The ecological effects of this phenomenon include the proliferation of algae, changes in the structure of aquatic communities, reduced biological diversity, as well as fish-kills due to oxygen depletion. The eutrophication process is a determining factor in the degradation of coastal ecosystems in WCR [26].

The water quality indicators selected in the workshops in Caracas and Havana in 2005 and 2006, respectively to calculate pollutant loads discharged in WCR are biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total nitrogen (TN) and total phosphorous (TP). The estimation methodology includes the use of direct methods for estimating domestic pollutant loads discharged in WCR through the taking of samples, flow mensurations and analyses; however, indirect methods were used in those cases with scarce information.

The indirect method kept in mind the estimation domestic wastewater flow discharged in WCR and the sewer system effluents percentages with some treatment degree. The domestic wastewater discharged in WCR without solution of sewer systems was considered without treatment. The typical domestic wastewater concentration for the region and the effluent resulting concentration of a primary or secondary treatment were established according to the means values following: BOD_5 = 30-60 $g.inhab^{-1}.day^{-1}$; COD = 80-120 $g.inhab^{-1}.day^{-1}$; TSS = 50-90 $g.inhab^{-1}.day^{-1}$; TN = 1.5 - 2.2 $g.inhab^{-1}.day^{-1}$; TP = 0.5 - 1.0 $g.inhab^{-1}.day^{-1}$ [9,10].

National Technical Reports of 15 countries provide a pollutant loads estimate discharged in WCR with the methodology use described above.

Table 4 shows the domestic pollutant load discharged by sub-region in WCR, in tons per year according to the available information up to 2009 (National Technical Reports, UN Agencies publications and other reports).

Table 4. Domestic pollutant load ($t.yr^{-1}$) discharged by sub-region in WCR [8,9,10,15,17]

Domestic pollutant load discharged in WCR ($t.yr^{-1}$)					
Countries and territories	**BOD_5**	**COD**	**TSS**	**TN**	**TP**
Sub-region I					
United States of America	83,497	208,742	111,329	16,699	8,349
Mexico	38,089	86,874	35,202	4,279	1,471
Subtotal	*121,586*	*295,616*	*146,531*	*20,978*	*9,820*
Sub-region II					
Belize	813	1,875	791	100	37
Guatemala	640	1,455	582	70	23
Honduras	2,558	5,815	2,329	280	93
Nicaragua	395	898	359	43	14
Costa Rica	984	2,237	895	107	36
Panama	9,099	20,747	8,397	1,019	349
Subtotal	*14,489*	*33,027*	*13,353*	*1,619*	*552*
Sub-region III					
Colombia	20,193	46,236	18,996	2,339	830
Venezuela	83,649	192,218	79,977	9,968	3,631
Guyana	2,317	5,272	2,115	254	85
French Guiana	308	970	290	170	40
Suriname	1,560	3,546	1,418	170	56
Aruba	NA				
Netherlands Antilles	1,006	2,287	915	109	36
Subtotal	*109,033*	*250,529*	*103711*	*13,010*	*4,678*
Sub-region IV					
Anguilla	49	112	45	5	2
Antigua and Barbuda	263	598	239	28	9
Barbados	1,050	2,394	968	117	40
British Virgin Islands	94	213	85	10	3
Dominica	264	600	240	29	9
Grenada	346	788	317	38	13
Guadeloupe	1,505	3,420	1,368	164	54
Martinique	1,755	3,989	1,595	191	64
Montserrat	315	717	289	35	12
St. Lucia	671	1,526	610	73	24
St. Martin	NA				
St. Bartholomi	NA				
St Kitts and Nevis	154	350	140	17	5
US Virgin Islands	875	1,989	795	95	32
Trinidad & Tobago	4,117	9,416	3,851	472	166
S.V. and the Grenadines	458	1,042	418	50	17
Subtotal	*11,919*	*27,158*	*10,964*	*1,328*	*452*

Domestic pollutant load discharged in WCR (t.yr^{-1})					
Countries and territories	**BOD_5**	**COD**	**TSS**	**TN**	**TP**
Sub-region V					
Bahamas	1,154	2,632	1,066	129	44
Cayman Islands	34	78	31	3	1
Cuba	73,313	167,504	68,295	8,350	2,913
Dominican Republic	22,504	52,044	22,134	2,814	1,069
Haiti	28,285	64,285	25,714	3,085	1,028
Puerto Rico	8,600	21,500	11,467	1,720	860
Jamaica	12,413	28,212	11,284	1,354	451
Turks and Caicos Islands	68	156	62	7	2
Subtotal	*146,375*	*336,413*	*140,055*	*17,465*	*6,370*
Total	**403,000**	**943,000**	**414,000**	**54,000**	**22,000**

NA: Not available

In general, these results are associated with the upstream coastal population's size and the sanitation coverage extension, as well as the levels and specific features of the domestic wastewaters treatment.

3.2. Organic matter of domestic origin

Figure 4 shows the organic matter inflow, represented by BOD_5 and COD, contained in sewage discharged by sub-region in WCR. Sub-region V (North-eastern and Central Caribbean), sub-region I (Gulf of Mexico) and sub-region III (Southern Caribbean) contribute the larger pollutants loads, whereas sub-region IV (Eastern Caribbean) and sub-region II (Western Caribbean) contribute the lower quantities.

It is considered that the 30% of the organic pollutant loading is comprised of BOD_5 and 70% is comprised of COD. The relationship BOD_5/COD has a value of 0.43 what demonstrates the effluent bio-degradability discharged in WCR and the feasibility of applying biological treatments for their depuration.

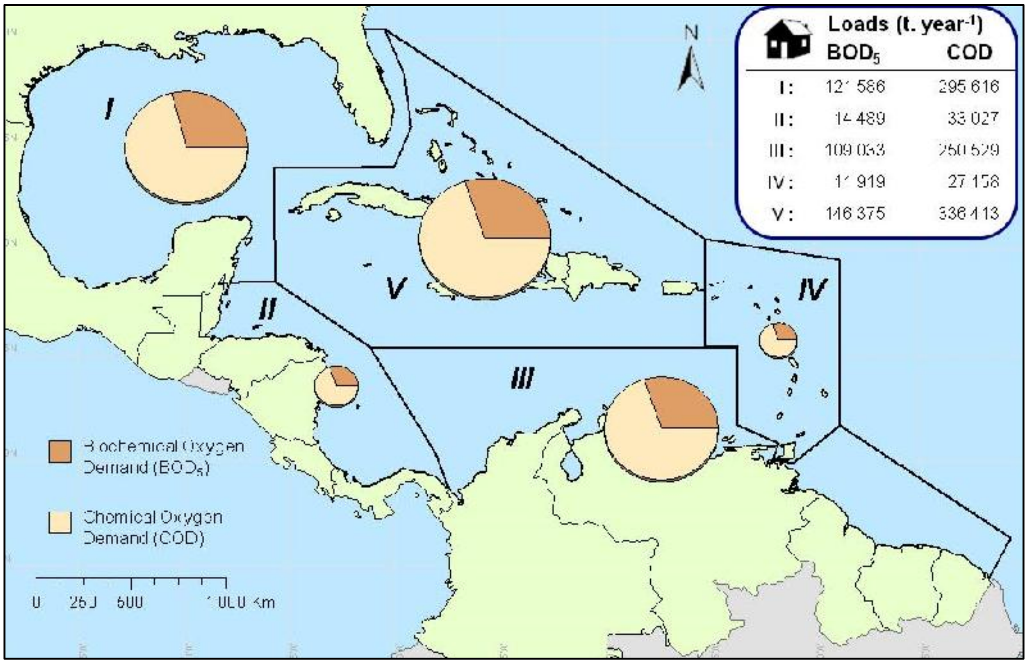

Figure 4. Organic matter inflow (BOD_5 and COD) of domestic origin by sub-region in WCR ($t.yr^{-1}$)

3.3. Total Suspended Solids of domestic origin

Figure 5 shows the total suspended solids contribution (TSS) contained in sewage discharged in WCR by sub-region. The largest pollutants loads comes from sub-region I (Gulf of Mexico), sub-region V (North-eastern and Central Caribbean) and sub-region III (Southern Caribbean), whereas sub-region IV (Eastern Caribbean) and sub-region II (Western Caribbean) contribute the lower quantities.

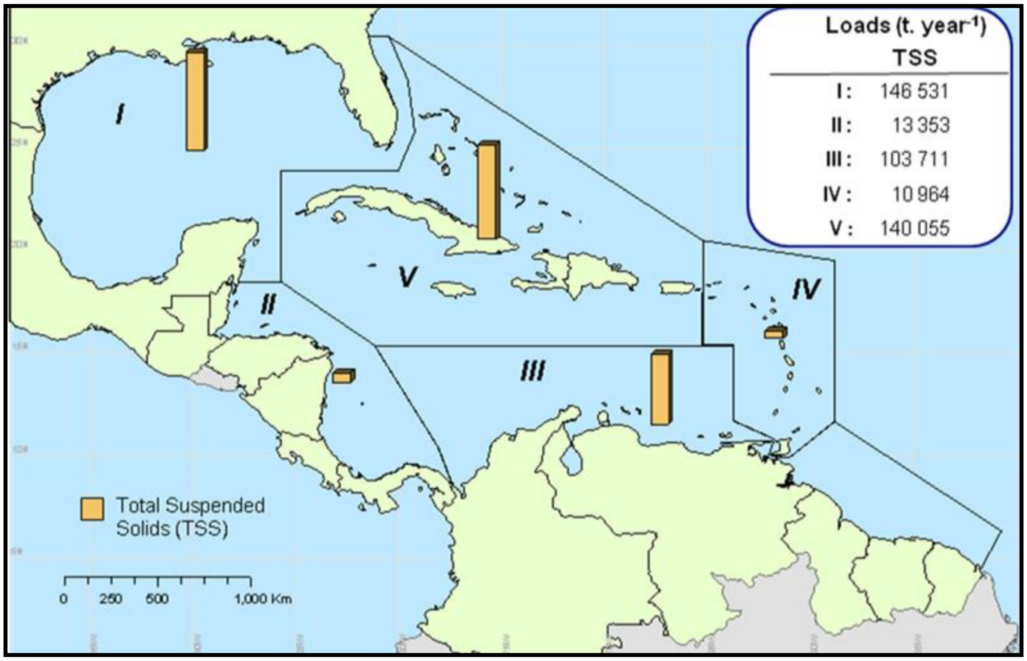

Figure 5. Total suspended solids inflow (TSS) of domestic origin by sub-region in WCR ($t.yr^{-1}$)

3.4. Nutrients of domestic origin

Figure 6 shows the nutrient loadings (TN and TP) contained in sewage discharged by sub-region in WCR.

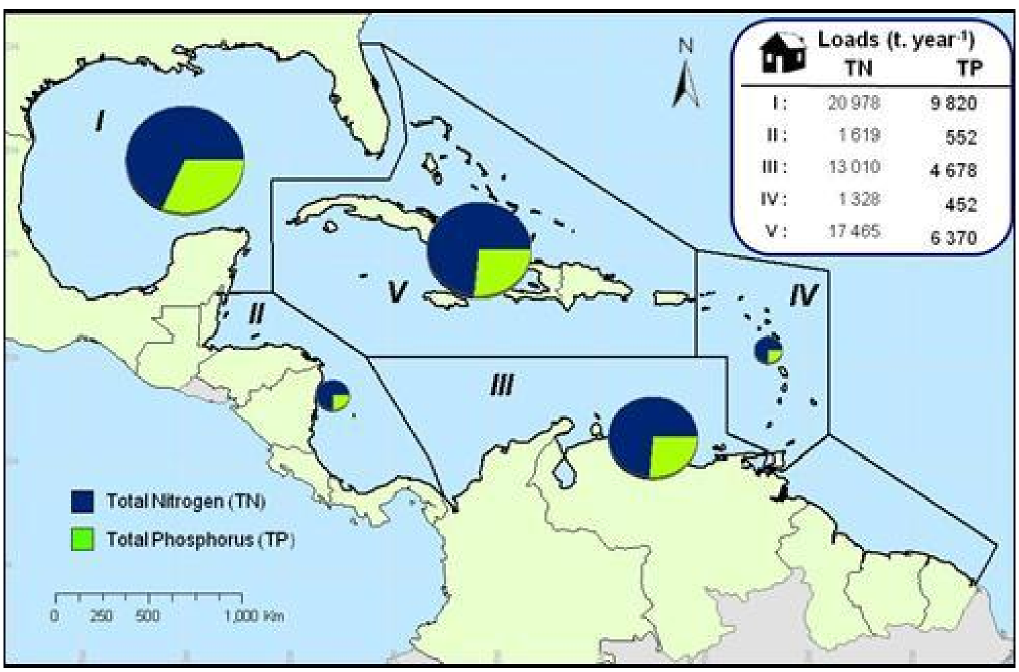

Figure 6. Nutrients inflow (TN and TP) of domestic origin by sub-region in WCR ($t.yr^{-1}$).

The largest total nitrogen pollutants loads and total phosphorous comes from sub-region I (Gulf of Mexico), sub-region V (North-eastern and Central Caribbean) and sub-region III (Southern Caribbean), whereas sub-region IV (Eastern Caribbean) and sub-region II (Western Caribbean) contribute the lower quantities.

3.5. Comparison with original CEP Technical Report No. 33

Table 5 shows the comparative levels of domestic pollutant loads, except COD, discharged by sub-region in WCR in tons per year, reported in CEP Technical Report No. 33 (1994) and in this updated report. These results should only be taken as reference for future regional projects due to the available scarce information for the execution of the work and probably, differences among methodologies used in both reports.

Table 5. Comparative levels of the domestic pollutant loads discharged in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report [5,8,15]

Sub-region	CEP Technical Report No. 33 (1994) and updated report	BOD_5	TSS	TN	TP
I	CEP TR No. 33 (1994)	65, 678	68, 748	30, 479	13, 487
	Updated Report	121,586	146,531	20,978	9,820
II	CEP TR No. 33 (1994)	13, 029	13, 195	1, 812	1, 206
	Updated Report	16,239	14,953	1,812	619
III	CEP TR No. 33(1994)	260, 171	228, 744	86, 338	33, 475
	Updated Report	109,224	103,895	12,901	4,662
IV	CEP TR No. 33(1994)	4, 790	4, 617	710	531
	Updated Report	11,919	10,964	1,328	452
V	CEP TR No. 33 (1994)	124, 813	141, 025	9, 437	11, 418
	Updated Report	146,375	140,055	17,465	6,370
Total	**CEP TR No. 33 (1994)**	**468, 000**	**456, 000**	**128, 000**	**60, 000**
	Updated Report	**405,000**	**416,000**	**54,000**	**22,000**

The methodology selected in CEP Technical Report No. 33 (1994) was based on "Management and Control of the Environment" WHO/PEP/89.1 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 WCR countries. United States of America, Puerto Rico and the US Virgin Islands used NOAA's Coastal Pollution Discharge Inventory (NCPDI) methodology [5].

Nevertheless, it is unquestionable the improvement in the domestic wastewater treatment capacities and disposition, and in the environmental awareness observed in WCR in recent years.

The diagnostic studies that have been undertaken to determine the impacts on coastal and marine water quality from land-based sources and activities at regional level as well as several legal instruments drafted to address these land-based threats to coastal and marine resources through UNEP-CAR/RCU have contributed greater awareness among citizens.

In general, a reduction in the domestic pollutant loadings discharged in WCR is observed, in particular in the sub-region III and in the nutrients load, despite the gradual population growth. BOD_5 some 13% decrease, TSS 8% decrease, TN 57% decrease and TP 63% decrease.

3.5.1. Organic Matter

Figure 7 shows the changes in inflows of organic matter, represented by BOD_5, contained in sewage discharged by sub-region in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and in this updated report.

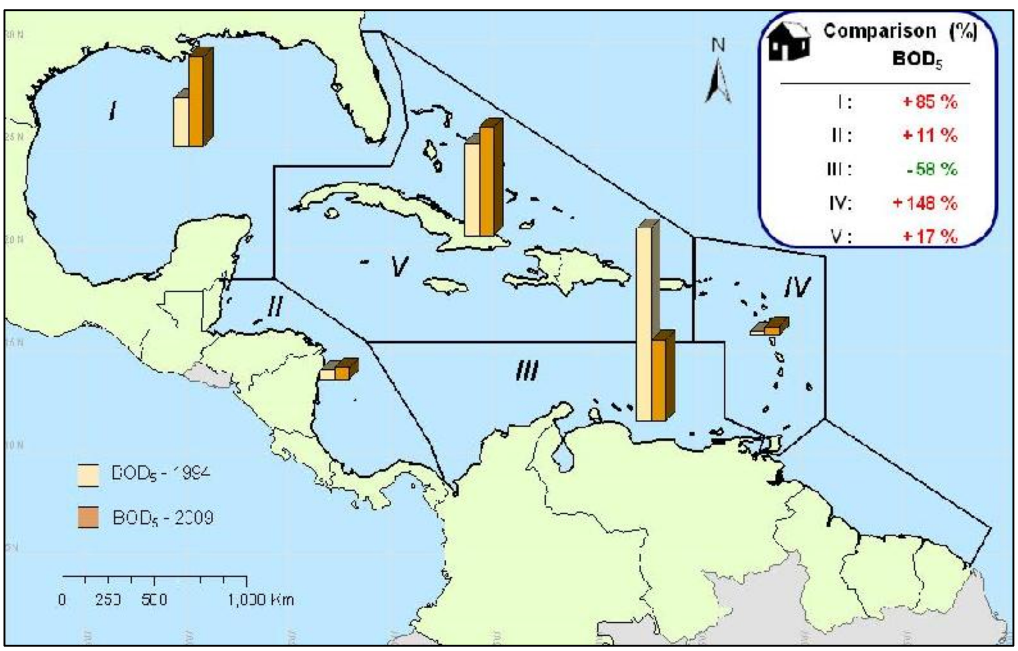

Figure 7. Comparative levels of the organic matter (DBO_5) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

Sub-region III (Southern Caribbean) shows a strong reduction in the organic pollutant load discharged in WCR. The rest of the sub-regions I, II, IV and V show an increase in the organic pollutant load, typical of the gradual population growth.

3.5.2. Total Suspended Solids

Figure 8 shows the changes of total suspended solids (TSS) levels contained in domestic wastewater discharged by sub-region in the WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and in this updated report. As in organics matter, Sub-region III (Southern Caribbean) shows a strong reduction in the suspended solids pollutant load discharged in WCR. Sub-region V (North-eastern and Central Caribbean) shows a slight decrease. The rest of the sub-regions I, II and IV show increases in the suspended solids pollutant load.

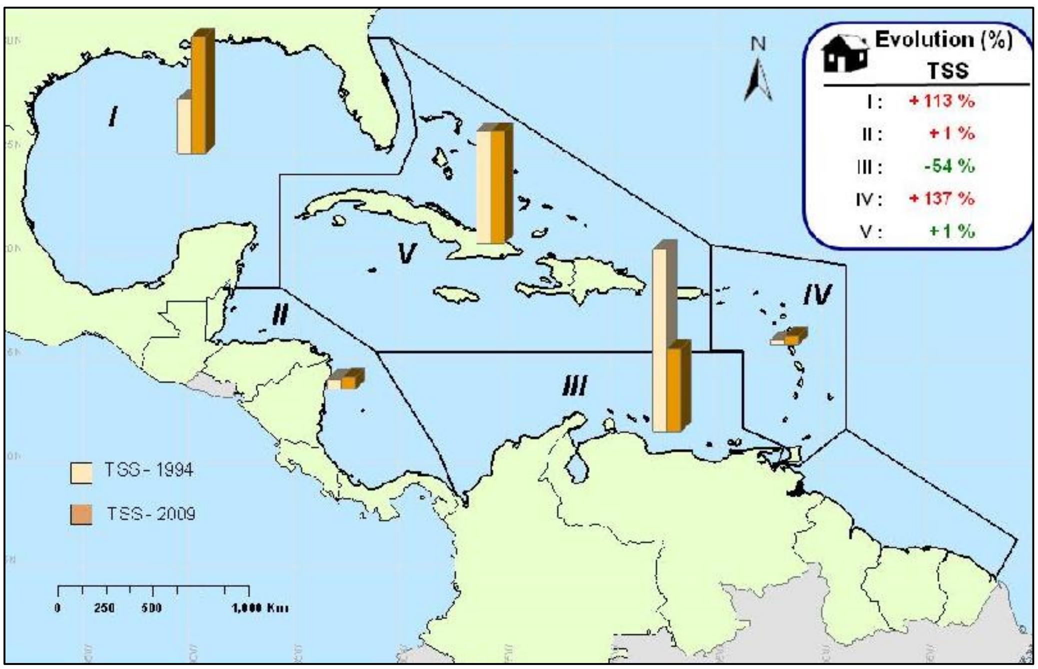

Figure 8. Comparative levels of the suspended solids (TSS) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

3.5.3. Nutrients

Figure 9 shows the TN change contained in sewage discharged by sub-region in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and in this updated report. A reduction in the nitrogen pollutant load discharged in sub-regions I (Gulf of Mexico) and III (Southern Caribbean) is observed. Sub-region II (Western Caribbean) doesn't present variations in the pollutant load whereas sub-regions IV and V show increases.

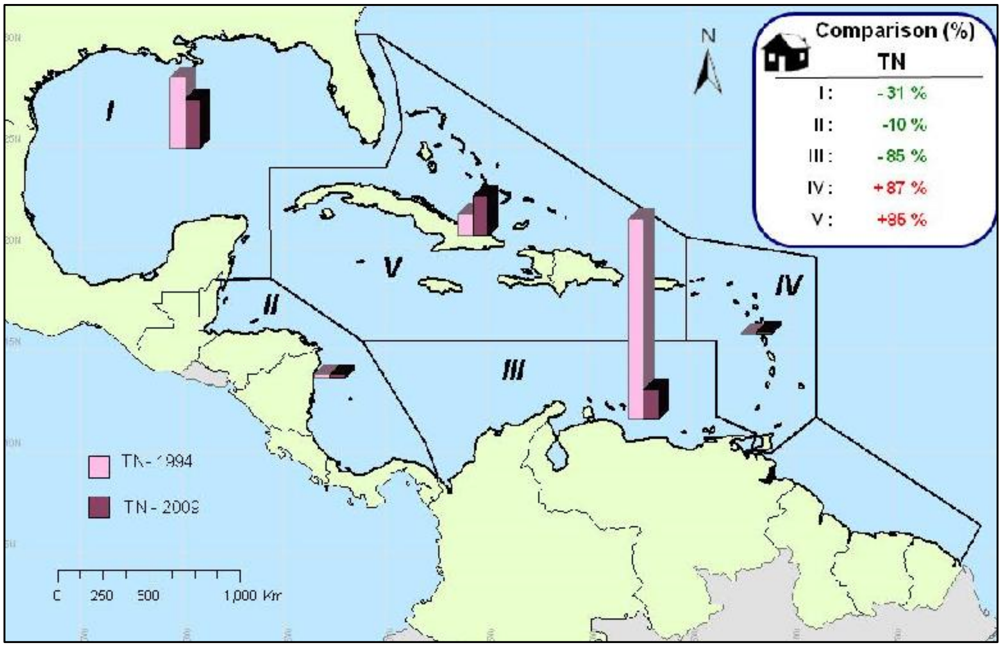

Figure 9. Comparative levels of the nitrogen (TN) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

Figure 10 shows the change of total phosphorous (TP) contributions contained in sewage discharged by sub-region in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and in this updated report. A reduction in the phosphorous pollutant load discharged in all the sub-regions of WCR is observed.

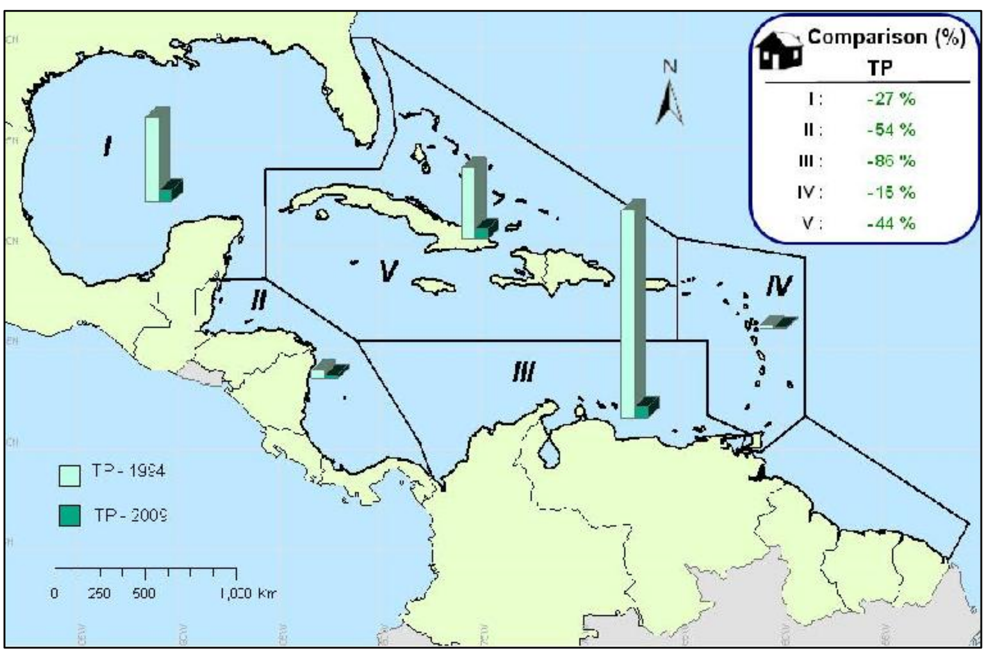

Figure 10. Comparative levels of the phosphorus (TP) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

4. INDUSTRIAL POLLUTANT LOADS. UPDATE

4.1. Industrial pollutant loads discharged in WCR

Industrial wastewater discharged in WCR, like domestic wastewater, is a source of marine pollution and represents a threat to sustainable development [26]. The information related to the polluting contributions of industrial origin to WCR is showed in National Technical Reports of 15 countries and other reports [8].

The methodology take into account the indicators analysis to evaluate organic matter, expressed as COD and BOD_5, suspended total solids (SST), nitrogen (NT) and phosphorous (PT) as well as grease and fatty (G and F). The pesticides, heavy metals and bacteria loads indicators are conditioned to the readiness of resources in each country. Direct methods include the taking of samples, the flow determination and analytic methods normalized for laboratory tests, according to Standard Methods (APHA, 1998). Indirect methods include the production indicators and consumption, the emission factors estimate, extrapolation, balance of materials and others of quick evaluation.

The main industrial activities in the countries and territories of the region, by sub-region, appear in table 6 in broad categories in order to identify the sub-regions with high industrial pollutant loads (1997-2008).

Table 6. Main industrial activities in WCR countries [8]

Countries and territories	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sub-region I															
United States of America	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mexico	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Sub-region II															
Belize		x	x	x									x		
Guatemala															
Honduras	x	x	x	x	x	x			x						x
Nicaragua															
Costa Rica	x		x	x				x							x
Panama	x			x		x							x		x
Sub-region III															
Colombia	x	x	x	x	x	x	x	x	x		x	x	x		x
Venezuela	x	x	x	x	x	x	x	x	x		x	x	x	x	x
Guyana			x	x									x		
French Guiana			x						x	x			x		x
Suriname		x	x												
Aruba	NA														
Netherlands Antilles	x		x	x				x							x

Countries and territories	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sub-region IV															
Anguilla	NA														
Antigua and Barbuda		x		x									x	x	
Barbados	x	x	x	x			x		x		x	x			x
British Virgin Islands				x									x		
Dominica		x		x									x	x	
Grenada		x	x	x									x		x
Guadeloupe		x	x												
Martinique		x													
Montserrat	NA														
St. Martin	NA														
St. Bartholomi	NA														
St. Lucia		x	x	x					x				x		x
St. Kitts and Nevis		x	x	x			x				x		x	x	
St V. and the Grenadines		x	x	x											
US Virgin Islands		x											x		
Trinidad & Tobago	x	x	x	x	x	x	x	x	x		x	x	x	x	
Sub-region V															
Bahamas	NA														
Cayman Islands	NA														
Cuba	x	x	x	x	x	x	x	x	x		x		x	x	x
Dominican Republic	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Jamaica	x	x	x	x		x			x	x	x		x		x
Puerto Rico	x			x		x							x		x
Turks and Caicos Islands	NA														

NA: Not Available
A: Oil refinery
B: Sugar factories, refinery and distillery
C: Drinks and spirits
D: Food processing plants
E: Pulp and paper
F: Chemical industries
G: Textiles
H: Basic industry (iron, steel, machinery, non ferrous metals)
I: Soaps and perfumes
J: Mining
K: Plastics
L; Lathe operations
M: Power stations
N: Galvanisation
O: Other

The water quality indicators selected in the methodology for estimating land-based pollutant loads to the region as a result of the workshops in Caracas and Havana in 2005 and 2006, respectively, are biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solids (TSS), total nitrogen (TN), total phosphorous (TP) and grease and fats (G and F) [9,10].

The grease and fats indicator was not assessed in this updated report because of a lack of reliable data. Pesticides, heavy metals and bacteria loads were not assessed either because require more substantial technical resources and capacity at the national level.

Table 7 shows the estimated industrial pollutant load, in tons per year, discharged by sub-region in WCR. The most available recent data for each country was taken, which span the period between 1997 and 2008.

Table 7. Industrial pollutant load ($t.yr^{-1}$) discharged by sub-region in WCR (1997-2008) [8]

Industrial pollutant load discharged in WCR ($t.yr^{-1}$)					
Countries and territories	**BOD_5**	**COD**	**TSS**	**TN**	**TP**
Sub-region I					
United States of America	112,600	198,410	295,340	6,060	974
Mexico	83,649	175,662	209, 122	7,350	1,470
Subtotal	*196,249*	*374,072*	*504,462*	*13,410*	*2,444*
Sub-region II					
Belize	870	1, 827	218	290	80
Guatemala	7,362	15, 460	2, 408	24	5
Honduras	410	856	100	115	70
Nicaragua	312	733	39	78	36
Costa Rica	801	2 ,034	1, 305	135	62
Panama	199	897	1, 913	17	10
Subtotal	*9, 954*	*21,807*	*5,983*	*659*	*263*
Sub-region III					
Colombia	4, 000	6, 000	80, 000	1, 000	100
Venezuela	28, 559	59, 974	6 ,155	9, 605	475
Guyana	87	183	26	8	5
French Guiana	51	214	28	10	6
Suriname	102	214	28	10	6
Aruba	NA				
Netherlands Antilles	1, 489	3, 127	438	145	88
Subtotal	*34,288*	*69,498*	*86,647*	*10,768*	*674*

Industrial pollutant load discharged in WCR ($t.yr^{-1}$)					
Countries and territories	**BOD_5**	**COD**	**TSS**	**TN**	**TP**
Sub-region IV					
Anguilla	NA				
Antigua and Barbuda	45	95	9	4	2
Barbados	1, 650	4, 116	15	58	7
British Virgin Islands	5	11	2	1	1
Dominica	636	1, 336	120	24	18
Grenada	365	767	185	21	17
Guadeloupe	538	1, 026	123	32	18
Martinique	734	2, 378	770	NA	NA
Montserrat	NA				
St. Lucia	190	399	895	38	34
St. Martin	NA				
St. Bartholomi	NA				
St. Kitts and Nevis	183	384	100	8	5
US Virgin Islands	44	2, 331	800	6	2
Trinidad & Tobago	192, 337	340, 336	39, 138	1, 125	523
S.V. and the Grenadines	335	704	225	9	4
Subtotal	*197,062*	*353, 883*	*42,382*	*1,326*	*631*
Sub-region V					
Bahamas	NA				
Cayman Islands	NA				
Cuba	44, 340	93, 083	NA	1, 697	1, 194
Dominican Republic	587	1, 190	69	32	14
Haiti	521	1, 051	58	27	12
Puerto Rico	1, 491	3, 131	5, 610	1	5
Jamaica	5, 178	10, 873	2, 788	158	62
Turks and Caicos Islands	NA				
Subtotal	*52, 117*	*109, 328*	*8,525*	*1, 915*	*1,287*
Total	**489,000**	**928,000**	**648,000**	**28,000**	**5,000**

NA: Not available

In general, the largest industrial pollutant loads discharged in WCR come from sub-region I (Gulf of Mexico). The smallest industrial pollutant loads come from sub-region II (Western Caribbean) associated with growth in industrial development tending to occur in the central and coastal regions of the Pacific coast. These results are linked with the industrial development of the upstream coastal zone as well as the levels and specific features of the industrial wastewaters treatment and reuse.

4.2. Organic matter of industrial origin

Figure 11 shows the organic matter inflow, represented by BOD_5 and COD, contained in the industrial wastewatesr discharged by sub-region in WCR. Sub-region I (Gulf of Mexico) and sub-region IV (Eastern Caribbean) contribute the largest.

Such a large amount of organic matter in sub-region IV, which is made up of the small islands of the Lesser Antilles which have little development and industrial diversity, is due to the high contribution from Trinidad and Tobago with increasing industrial development reinforced by the oil industry. This information dates from 1997 and it is included in National Technical Report presented by Trinidad and Tobago [8].

Sub-region II (Western Caribbean) shows the lower contribution associated with growth in industrial development tending to occur in the Pacific coast.

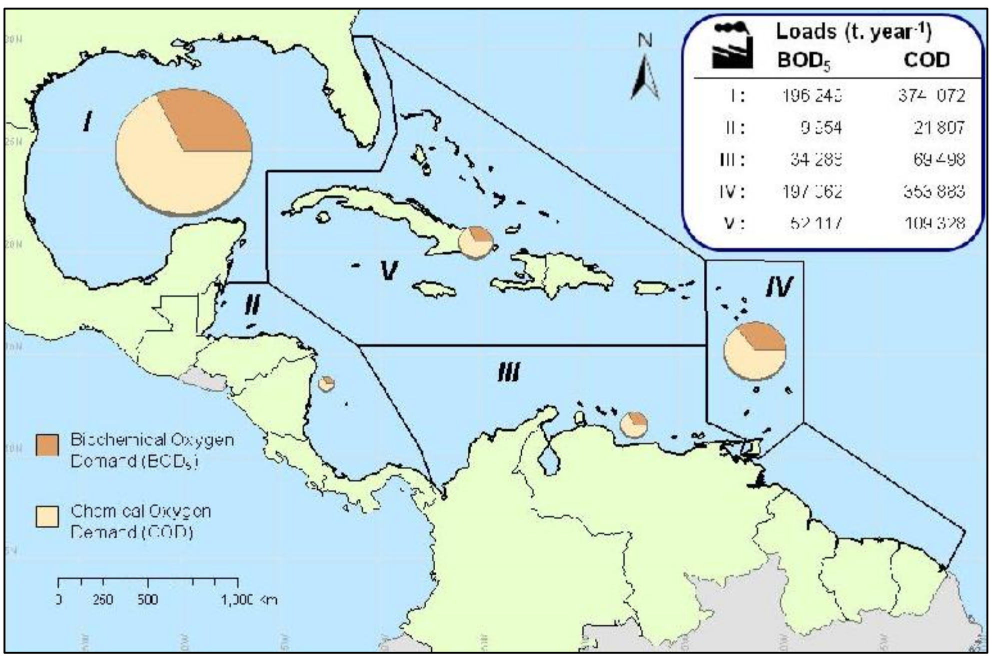

Figure 11. Organic matter (BOD_5 and COD) inflow of industrial origin by sub-region in WCR ($t.yr^{-1}$)

4.3. Suspended Solids of industrial origin

Figure 12 shows the total suspended solids (TSS) contribution contained in industrial wastewaters discharged in WCR.

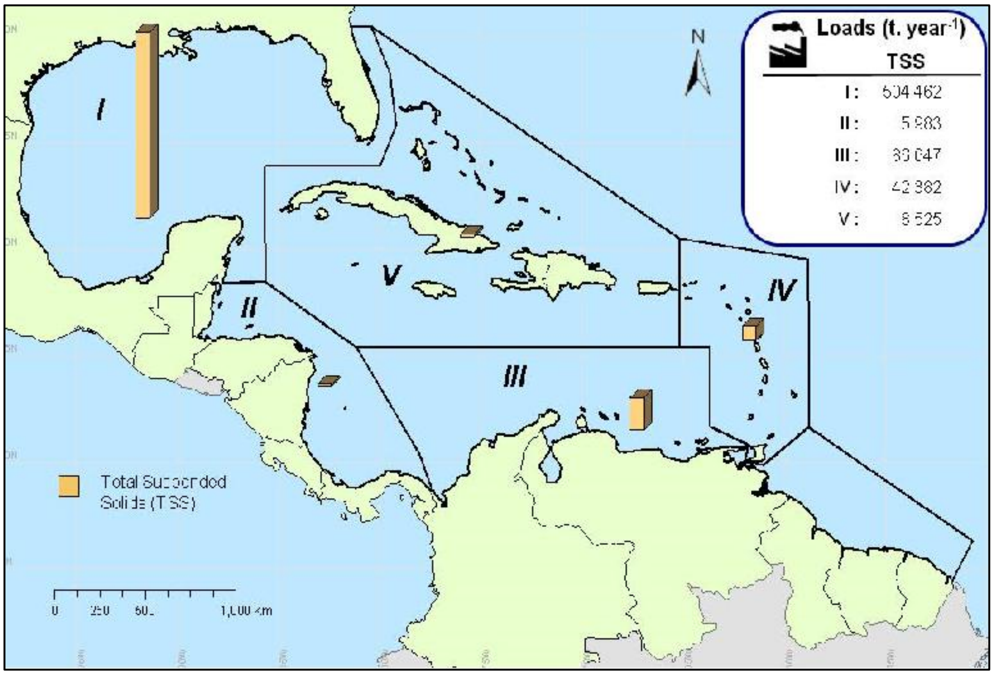

Figure 12. Total suspended solids (TSS) inflow of industrial origin by sub-region in WCR ($t.yr^{-1}$)

The larger TSS contributions come from sub-region I (Gulf of Mexico) linked with the discharge of more than 4,000 industries and sub-region III (Southern Caribbean). As with organic matter, the least significant contribution of total suspended solids of industrial origin discharged in WCR comes from sub-region II (Western Caribbean) for reasons previously cited in sections 4.1 and 4.2.

4.4. Nutrients of industrial origin

Eutrophication problems detected in WCR which seriously affect coastal ecosystems are linked mainly to nutrients (TN and TP) [27]. The relationship between these two indicators on industrial activity is different from urban activity because their presence is governed by the raw materials used in technological processes and can generate larger amounts of nitrogen compared to a decrease of phosphorous or vice versa.

Figure 13 shows the nutrients loadings (TN and TP) contained in industrial wastewaters discharged by sub-region. The larger TN contributions come from sub-region I (Gulf of Mexico) and sub-region III (Southern Caribbean), whereas the larger TP contributions come from sub-region I (Gulf of Mexico) and sub-region V (North-eastern and Central Caribbean). The lower nitrogen and phosphorous contribution come from sub-region II (Western Caribbean).

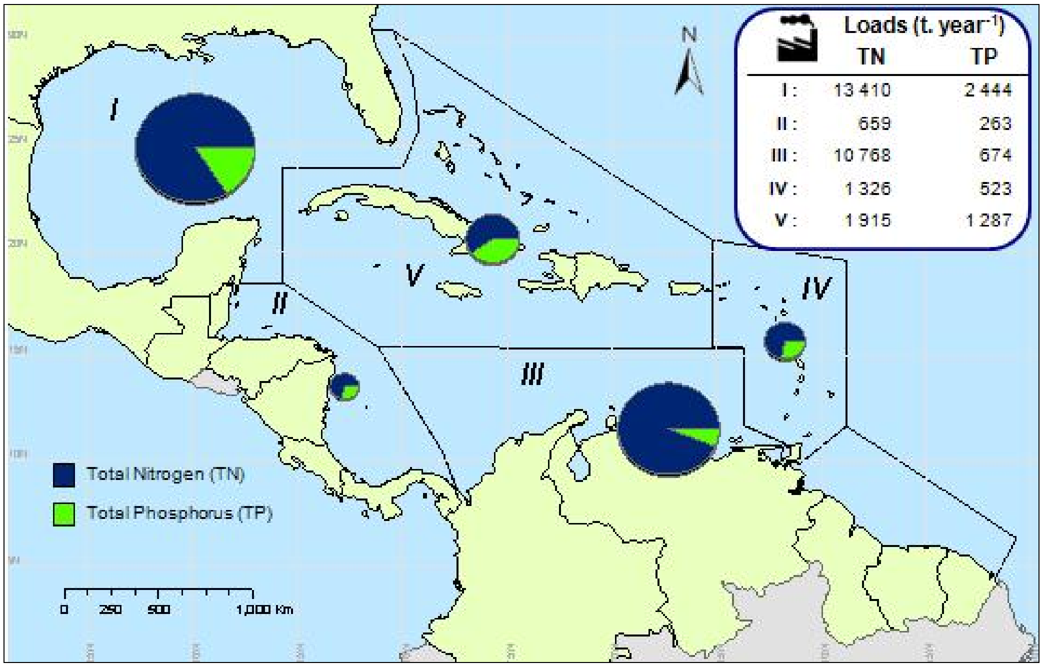

Figure 13. Nutrients (TN and TP) inflow of industrial origin by sub-region in WCR (t.yr^{-1})

4.5. Comparison with original CEP Technical Report No. 33

Table 8 shows the comparative levels of industrial pollutant loads, except COD, discharged by sub-region in WCR in tons per year, reported in CEP Technical Report No. 33 (1994) and in this updated report.

These results should only be taken as reference for future regional projects due to the available scarce information for the execution of the report and probably, differences among methodologies used in both reports.

Nevertheless, it is unquestionable the increase in the industrial wastewater treatment capacities and disposition, in particular in the oil industry and the increase of the environmental awareness. Also, governments have increased demands on industry as regards environmental protection in WCR in the recent years.

Table 8. Comparative levels of the industrial pollutant loads discharged by sub-region in the WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report [5,8]

Sub-region	CEP Technical Report No. 33 (1994) and updated report	BOD_5	TSS	TN	TP
I	CEP TR No. 33 (1994)	2, 142, 324	2,7 74,2 15	13, 673	16, 293
	Updated Report	196,249	504,462	13,410	2,444
II	CEP TR No. 33 (1994)	126 ,259	149, 887	40, 526	4, 519
	Updated Report	9,954	5,983	659	263
III	CEP TR No. 33 (1994)	304, 100	1, 624 768	100, 067	32, 353
	Updated Report	34, 237	86, 647	10, 768	674
IV	CEP TR No. 33(1994)	393, 707	1, 330, 270	148, 306	15, 343
	Updated Report [1]	197, 062	39, 138	1, 326	523
V	CEP TR No. 33 (1994)	460, 872	1, 073, 696	46, 532	14, 114
	Updated Report [2]	52, 117	8, 525	1, 915	1, 287
Total	**CEP TR No. 33 (1994)**	**3, 427, 000**	**31, 920, 000**	**349, 000**	**82, 000**
	Updated Report (2010)	**489,000**	**648,000**	**28,000**	**5,000**

[1] Does not include Anguilla, St. Martin, St. Barthelemi and Montserrat due to the lack of information.
[2] Does not include Bahamas, Cayman Islands, Turks and Caicos Islands nor Cuba TSS due to the lack of information.

A very strong reduction in the industrial pollutant loads dischaged in WCR is observed, despite the progressive industrial development. BOD_5 85% decrease, TSS 98% decrease, TN 92% decrease and TP 93%, showing apparently increased treatment coverage in the WCR.

4.5.1. Organic matter

Figure 14 shows the changes of organic inflow, represented by BOD_5, contained in industrial wastewater discharged by sub-regions in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and the updated report.

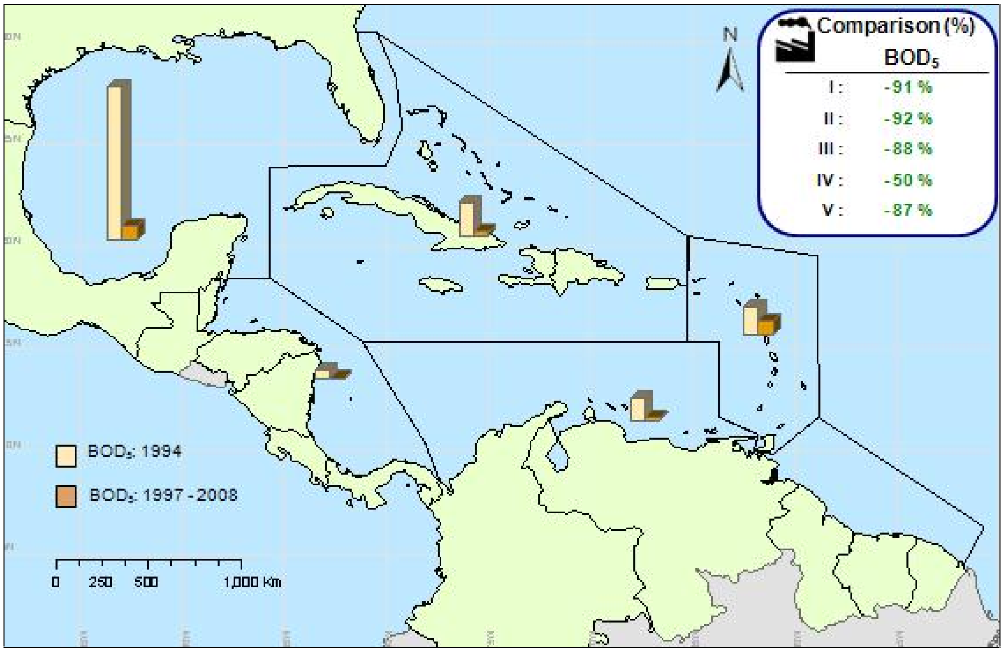

Figure 14. Comparative levels of organic matter (BOD_5) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

A strong reduction in the organic pollutant load discharged in WCR is observed despite the growing industrial development. The larger reductions are observed in sub-region II (Western Caribbean) and sub-region I (Gulf of Mexico) over 90% each, while a smallest reduction appears in sub-region IV (Eastern Caribbean) some 50%. Sub-region III (Southern Caribbean) and sub-region V (North-eastern and Central Caribbean) show similar reductions some 88%.

4.5.2. Suspended Solids

Suspended solids (TSS) inflow shows strong reductions in sub-region each, the most outstanding being sub-region V (North-eastern and Central Caribbean) some 99% decrease. Sub-regions IV (Eastern Caribbean), III (Southern Caribbean) and II (Western Caribbean) over 90% decrease while a less significant reduction appears in sub-region I (Gulf of Mexico) some 82%.

4.5.3. Nutrients

Figure 15 shows the total nitrogen (TN) inflow discharged by sub-region in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and the updated report.

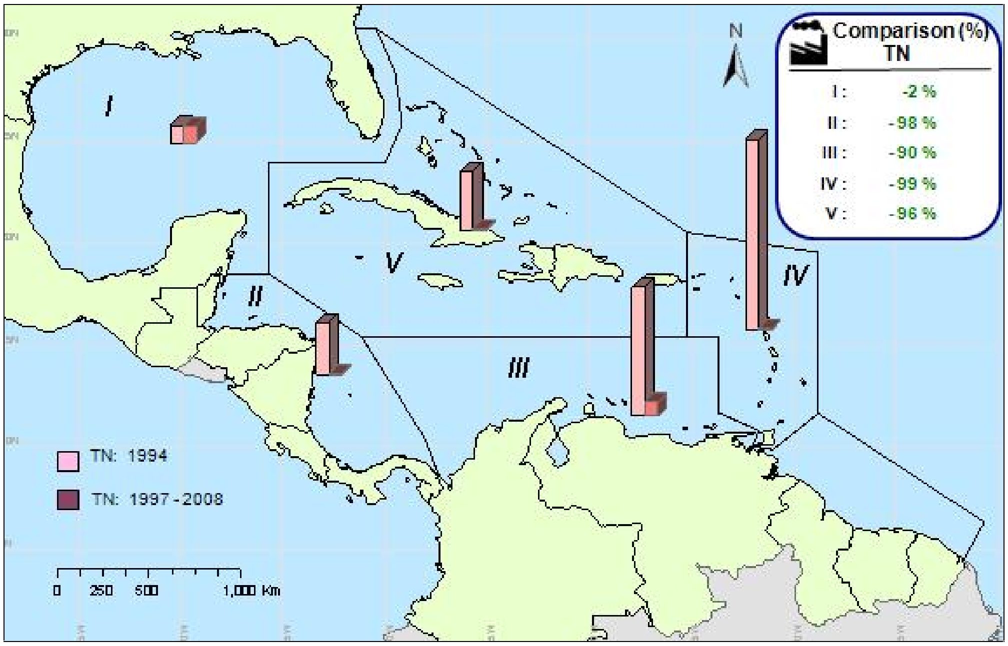

Figure 15. Comparative levels of nitrogen (NT) inflow by sub-region in WCR ($t.yr^{-1}$) reported in CEP Technical Report No. 33 (1994) and the updated report

The larger reductions are observed in the sub-regions IV (Eastern Caribbean) and II (Western Caribbean) some 99% and 98%, respectively, while the lowest reduction appears in the sub-region I (Gulf of Mexico) with only 2%.

Figure 16 shows the total phosphorous (TN) inflow discharged by sub-region in WCR (tons per year), reported in CEP Technical Report No. 33 (1994) and the updated report.

The larger reductions in total phosphorous are observed in sub-regions III (Southern Caribbean) and IV (Eastern Caribbean) some 98% and 96%, respectively, while the lowest is seen in sub-region I (Gulf of Mexico) some 85% decrease where oil industry and their support industry prevails in the coastal area.

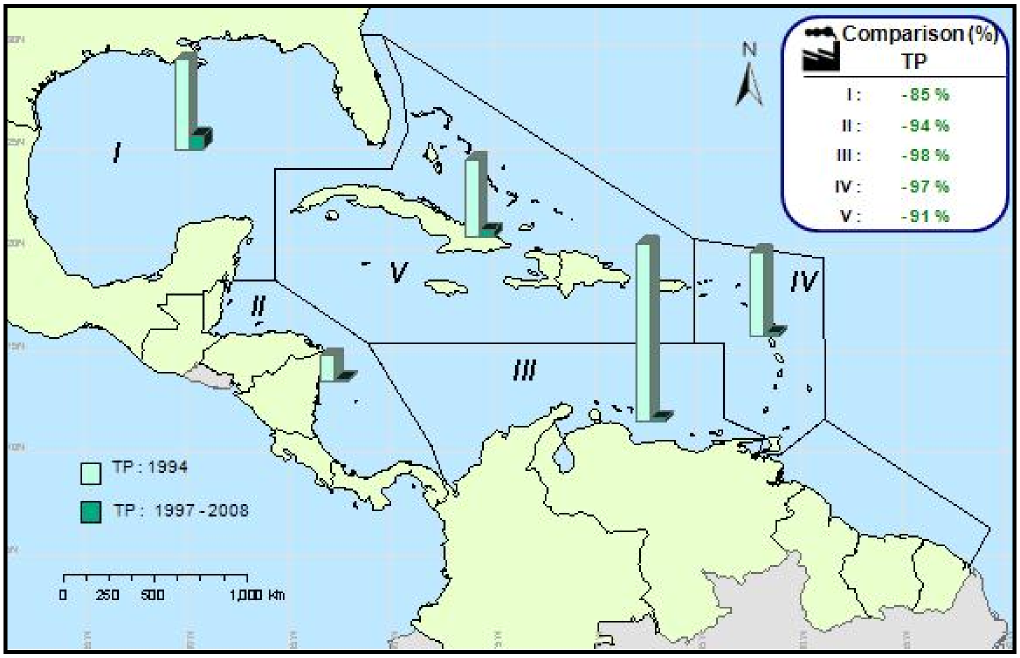

Figure 16. Total phosphorous (TN) inflows by sub-region in WCR and the comparison with CEP Technical Report No. 33 (1994) and updated report

4.5.4. General Observations Comparing 1994 Data to Current Data

In general, with the understanding of the limitations of the data available, since 1994, a strong reduction in the industrial pollutant load discharged in WCR is observed and the critical causes include:

- *Inter-relationship between good governance and environmental protection;* growing environmentalist awareness is evidenced and the shared need to access technological development to preserve the environment, is complemented by political will and good governance.

- *Implementation of organisational and legal measures by governments to reduce the improper discharge of industrial waste;* governments have increased demands on industry, and the most effective include industrial wastewater levies which has promoted the construction of numerous plants of treatment in the industrial sector, and the compulsory demand for Environmental Impact Assessments (EIAs) for new work projects and the expansion or modification of existing wastewater treatment works, which have contributed to the implementation of Cleaner Production Practices (CPPs) that improve Integrated Coastal Management Programmes (ICPM) and environmental quality in WCR.

- *Investments of transnational companies;* transnational companies have made investments in WCR and in their competition to be market leaders, they have been obliged to meet the requirements of the ISO standards family quality systems, in particular standard ISO 14001 [28] which leads to CPPs with a minimum of waste and environmental damage.

- *Saving water resources;* the increased reuse of industrial wastewater and its recirculation in productive processes have had very positive results in reducing industrial pollutant loads in WCR. In 2003, Mexican industry generated 5.4 x 10^9 $m^3.yr^{-1}$ (171 $m^3.sec^{-1}$) of industrial wastewater, and there were 1,640 treatment plants. Of these, 1,579 were operational and purified wastewater some 27.4 $m^3.sec^{-1}$. It is estimated that treated wastewater was re-used at a rate 26.3 $m^3.seg^{-1}$. Of this, 4% was re-used directly in industry, 91% indirectly and only 5% was discharged into receiving bodies of water [29].

Effluent limits established for industrial wastewaters discharged in WCR must consider the industry characteristics and wastewater, as well as the characteristics of the discharge site and/or receiving marine environment in accordance with Annex II of LBS Protocol.

4.6. The Dumping of Hydrocarbons

Oil spills in WCR have adverse effects on the ecology of coastal ecosystems, particularly coral reefs, marine feeding grounds, mangroves and fish and shellfish populations. Moreover, massive oil spills caused by accidents with maritime tankers or offshore oil platforms are particularly lethal. In addition, oil spills can affect the quality of the WCR’s beaches and may have significant negative impacts on the economies of countries relying on tourism.

Pollutant loads from the petroleum industry in the region were not quantified because the information provided by countries was piecemeal, inadequate and statistically could not be used to properly classify each sub-region. However, oil spills associated with industry, shipping and offshore operations constitute one of the greatest environmental threats to the WCR [30].

4.6.1. Industrial hydrocarbon pollution risks in WCR

An estimated 90% of the hydrocarbon pollution in the WCR originates from land-based industrial sources and activities. This pollution is particularly from oil refineries, which number over 100, although 75% are located in sub-region I (Gulf of Mexico). Similarly, a significant amount of oil produced in the region is shipped to the USA through an intricate network of distribution routes.

This poses a potential danger to the WCR because of the risk of oil spills as a result of accidents and technological failures caused by the movement of tankers along, and in proximity to, restricted channels.

During the period 2003-2004, a research was conducted on the movement of ships in the region, with information supplied by Lloyd´s Maritime Information Unit (LMIU) which included five areas of study: Atlantic Coast of Central America (CAM), Atlantic Coast of the United States of America (USA), Gulf of Mexico (USG), Atlantic Coast of South America (SAA) and the Caribbean Sea (CAR) with a total movement of 103,970 ships and averages 8,664 ships per month and 285 ships per day [31].

Figure 17 shows daily and yearly ship movement in the five areas of study in the year 2003, as well as the geographical location of each area. The larger movement was located on the Atlantic Coast of South America (SAA) with 28,392 ships per year, and the least in the Gulf of Mexico (USG) with 14,160 ships per year. This movement does not identify the types of ships involved, but it provides information on the shipping traffic and the potential danger posed to the WCR by the risk of oil spills and other hazardous substances.

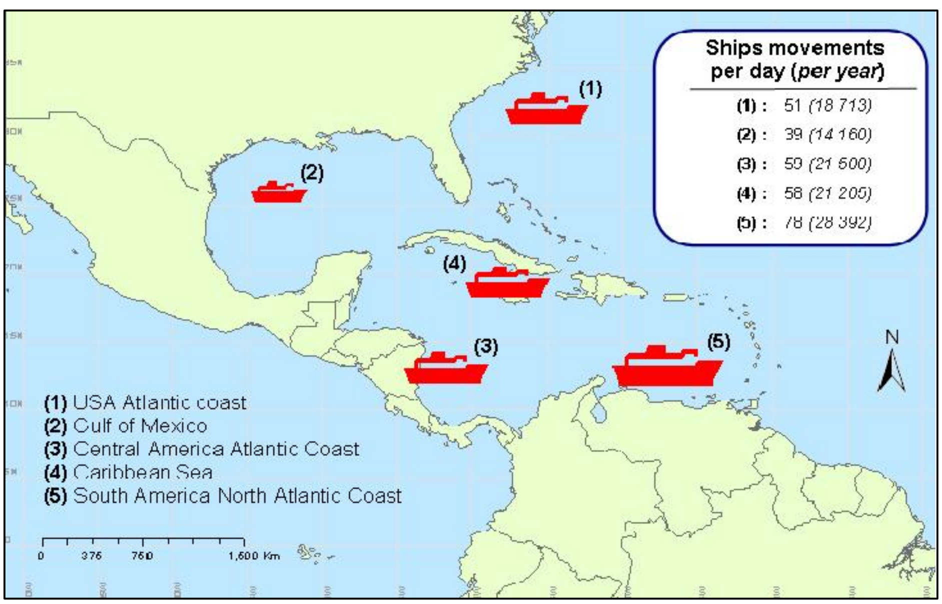

Figure 17. Daily and yearly ship movement in the five areas of study in 2003 [31]

4.6.2. Offshore platforms risks in WCR

Offshore operations increase rapidly in WCR, particularly in sub-region I (Gulf of Mexico) where a large number of oil platforms operate offshore. In sub-region III (Southern Caribbean) offshore operations take place in Lake Maracaibo, Venezuela as well as the Guajira, Colombia. In sub-region IV (Eastern Caribbean) offshore drilling-exploration take place along the east coast of Trinidad and Tobago. Likewise, research is being done for offshore drilling-exploration to the North of the west coast of Cuba and off the coast of Jamaica.

Oil spills from offshore platforms occur as a result of burst pipelines, explosions and out of control wells, fires, overflows and malfunctioning equipment. A well known oil spill catastrophe from offshore platforms occurred in the well IXTOC I in the sub-region I (Gulf of Mexico) in 1979 and 0.5×10^6 tons of light crude escaped in a period of 9 months until the well was sealed and the leak controled.

At the end of April of 2010 explosion and sinking of a platform of petroleum offshore occurred in the sub-region I (Gulf of Mexico) that allowed escaping in their first weeks up to 800,000 daily liters of petroleum. Some weeks later was the sinking of a gas platform offshore in the sub-region III (South Caribbean).

The so-called "produced water" is water released from the oil-bearing stratum during drilling, and contains oil and gas. It is another potential source of pollution because it is regularly discharged into the marine environment on occasion, and is re-injected into the oil deposit in accordance with environmental legislation of the country where they operate, and the economic assessment of the well. This water is frequently contaminated with the remains of chemicals from the hydrocarbons, substances produced in the injection process (dispersants, anticorrosives and biocide) and traces of dissolved and particulate petroleum.

Produced water discharged into the sea forms "plumes", which drift on the tides and with the winds, which carry pollutants up to many kilometres away, and can produce concentrations of hydrocarbons in filtering organisms (oysters) along the coasts up to 20 km from the offshore platform. Also, oil can form together with other suspended particles the called "tar balls", an emulsion of water in oil (70-80% water) which degrade very slowly in the marine environment and can affect coastal beaches in WCR [32]. Oil concentrations of 500 ppm or even less can inhibit the growth of phytoplankton and pelagic bacteria. Their effect also extends to the sea bed at a distance which depends on the relief of the seabed and existing oceanographic conditions. Values of up to 5 km have been measured, affecting a surface of 80-100 km^2, up to 90 km from the spill site, although the larger concentrations have been located around the platform [33,34].

Moreover, on offshore platforms, the flaring of excess gas and oil residue causes atmospheric pollution. In the largest platform in the Grand Banks off Nova Scotia, Canada known as Hibernia, 1-2 million m^3 $gas.day^{-1}$ were burnt during the period 1997-2000, forming a flare 20 m above the platform [35].

5. WATERSHEDS. UPDATE

5.1. Pollutant loads from watershed runoff discharging in the WCR

A watershed is the land area which drains rain or irrigation water towards a stream, river, lake, marsh, bay or aquifer. Pollution and sediment can be picked up by this water, transported into watercourses and eventually deptosited in the coastal environment. Coastal and marine water quality can therefore be impacted by human activities a great distance from the sea.

In WCR countries, many of the watersheds have been seriously damaged as a result of long periods of agricultural use, urban and rural development, and growing industrial development to the detriment of forest lands.

Nutrient and sediment pollution from agricultural practices is a severe problem in WCR, impacting coastal and marine waters throughout the region. Likewise, the commercial use of timber, firewood for domestic use, and the construction of roads have generated a large increase in deforestation rates in WCR, thus contributing to land erosion and an increase in the solids discharge into waterways. Additionally, urban runoff is an increasing problem in WCR due to the growth of population centers and tourism infrastruction. Clearing land for development increases the impervious cover in watersheds, thus accelerating and concentrating polluted runoff from streets, parking lots, driveways and other urban surfaces.

Runoff from mining, in particular in areas where mineral beds are not covered, is sources of toxic and hazardous pollutants that eventually end up in coastal ecosystems. Bauxite mining is particularly important for the economies of Jamaica, Suriname and Guyana and to a lesser extent, the Dominican Republic and Haiti. Bauxite extraction is a source of serious pollution in coastal areas of these countries, although in Jamaica the bauxite waste is not dumped directly in rivers or coastal areas but in special dumps. Other mining operations in the region include the bed extraction for nickel oxide production, which takes place mainly in Cuba and Dominican Republic [5,36].

Water courses draining runoff, in turn, have differing levels of pollution caused by domestic and industrial wastewaters coming from storm drains, sewerage and illegal connections. Studies conducted on the siltation of coral reefs along the coastline of sub-region II (Western Caribbean) countries confirm the negative impact caused by silts loads transported by the rivers to WCR [37].

Nutrients pollutant loads coming from watersheads inflows of USA were estimated through the SPARROW model [45]. The pollutant loads coming from Colombia and Venezuela were estimated with direct methods through of the taking of samples and registrations *in situ* with portable teams, flow mensurations and analytic methods normalized for laboratory tests. In addition, the current database in several laboratories of the region was used [8].

The quality indicators most commonly analysed in river currents for their harmful effects on the marine environment are:

- Biochemical oxygen demand (BOD_5).
- Chemical oxygen demand (COD).
- Total suspended solids (TSS).
- Total nitrogen (TN).
- Total phosphorous (TP).
- Grease and Fats (G and F).
- Total coliforms (TC).
- Heavy metals (chromium, lead and cadmium). These toxics in the marine environment were not assessed due to insufficient data.

Table 9 shows the average annual pollutant load discharged in WCR ($t.yr^{-1}$), the drainage area (km^2) and the flow ($m^3.sec^{-1}$) of the main river basins by sub-region.

Table 9. Average pollutant load in WCR ($t.year^{-1}$), drainage area (km^2) and flow ($m^3.sec^{-1}$) from river basin by sub-region (2000-2008) [8,37,38,39,40,41,42,43,44,45,46,47,48,49,50]

Watersheds	Drainage area (km^2)	Flow ($m^3.sec^{-1}$)	Average annual load ($t.yr^{-1}$) x 10^3				
			BOD_5	COD	TSS	TN	TP
Sub-region I							
Mississippi / Atchafalaya	3, 234, 000	20, 141	NA	NA	169, 290	1, 424 [1]	116 [1]
Minor basins	1, 274, 020	8, 755	NA	NA	47, 271	220	36
Subtotal	*4, 508, 020*	*28, 896*	*NA*	*NA*	*216, 562*	*1, 644*	*152*

Sub-region II							
Minor basins	291, 439	2, 783	403	1, 796	5, 800	12.7	4.3
Subtotal	*291, 439*	*2, 783*	*403*	*1, 796*	*5, 800*	*12.7*	*4.3*
Sub-region III							
Orinoco River	952, 173	32 ,321	NA	NA	105, 850	480 [2]	NA
Magdalena River / Dique canal	256, 622	7 ,576	2, 983	13, 290	96, 000	95	67
Minor basins	69, 948	5 ,209	238	1, 060	433	45	53
Subtotal	*1, 278, 743*	*45, 106*	*3, 221*	*14, 350*	*202, 283*	*620*	*120*
Sub-region IV							
Minor basins	105, 242	1, 005	1.7	8	2.6	0.2	0.04
Subtotal	*105, 242*	*1, 005*	*1.7*	*8*	*2.6*	*0.2*	*0.04*
Sub-region V							
Minor basins	378, 871	3, 618	524	2, 335	7, 540	16.5	5.6
Subtotal	*378, 871*	*3, 618*	*524*	*2, 335*	*7, 540*	*16.5*	*5.6*
Total	**6, 562, 000**	**81, 000**	**4, 000 [3]**	**18 ,000[3]**	**432, 000**	**2,300**	**300[4]**

NA: Not available
[1]SPARROW model (Alexander *et al.*, 2008).
[2] Ramirez, Rose & Bifano (1988); Lewis & Saunders (1986) ; Meybeck (1982).
[3]Does not include organic runoffs from sub-region I and the Orinoco River basin due to the lack of information.
[4]Does not include phosphorus runoff from the Orinoco River basin due to the lack of information.

Sub-region I (Gulf of Mexico) discharges high loads of suspended solids (over 200 millions tons TSS per year) and nitrogen (over 1 million tons TN per year) in the WCR, according to SPARROW model in Mississippi / Atchafalaya watersheads. Sub-region III (South Caribbean) discharges, also, high loads of suspended solids (over 200 millions tons TSS per year) in the region. WCR receives runoff from the three of most important watersheds in Latin America and the Caribbean; the Mississippi/Atchafalaya basin in USA, the Magdalena River/Dique Canal in Colombia, and the Orinoco River in Venezuela, which contribute a total fresh water flow some 60,000 $m^3.sec^{-1}$ covering a drainage area over 4 million square kilometers (Figure 18).

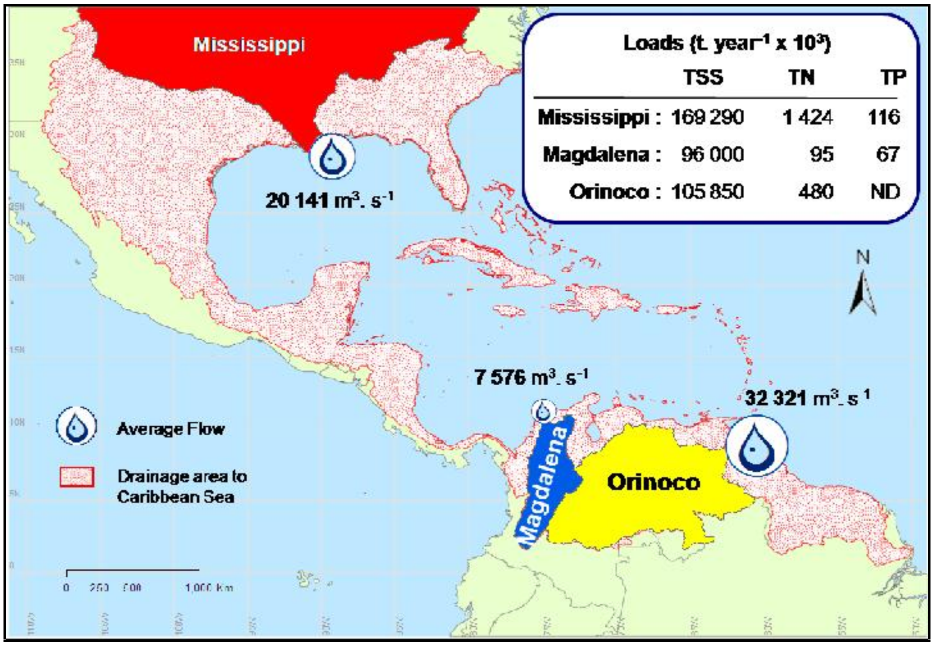

Figure 18. Flow (m.sec^{-1}) and pollutant loads (t.year^{-1}) in the main river basins of the WCR

The Mississippi/Atchafalaya basin is a source of important contamination by suspended solids and phosphorus discharging into WCR some 170 million tons per year of TSS and more than 100,000 tons of TP per year. Some 41% of the US territory drains into the Gulf of Mexico through the Mississippi river basin and its associated river systems [8].

Figure 19 shows the discharge of the Mississippi river into the Gulf of Mexico. There is a permanent "jet" formed by the suspended sediments discharged.

Figure 19. Satellite imagery of the Mississippi river mouth

The Orinoco River watershed is located in high rainfall areas. It contributes the highest amount of fresh water in WCR some 32,000 $m^3.sec^{-1}$ and it is the second largest pollution source by suspended solids in the Region with more than 100 million annual tons. Likewise, it discharges 248 million nitrogen tons per year due, probably, because of lithology type drained and the intensive use of fertilizers and agrochemicals [47,48,49,50].

In sub-region I (Gulf of Mexico) the drainage areas cover the Gulf of Mexico include the Mississippi/Atchafalaya River basin, Texas Gulf Coast Rivers, and the Río Grande River, and the rivers of the U.S. South Atlantic Gulf Coast, and the East Coast of Mexico to the eastern tip of the Yucatan Peninsula.

The Mississippi/Atchafalaya River watershed covers some 50% of the total drainage area in WCR over three million of square kilometers and has six main sub basins that form the upper part of the Mississippi, Missouri, Ohio, Arkansas, Lower Mississippi, and Red Rivers (Figure 20).

Figure 20. Mississippi/Atchafalaya watershed, USA

Figure 21 shows the freshwater flow coming from watersheds inflows by sub-region in WCR. The larger freshwater come from sub-region III (Southern Caribbean) with 55% followed by sub-region I (Gulf of Mexico) 35%, while the less significant inflows coming from sub-region IV (Eastern Caribbean) some 1% and sub-region II (Western Caribbean) some 3%. In total, 81,000 $m^3.sec^{-1}$ of freshwater are discharged into the WCR with an important nutrient contribution and organic matter to the marine waters and an increase of their fertility.

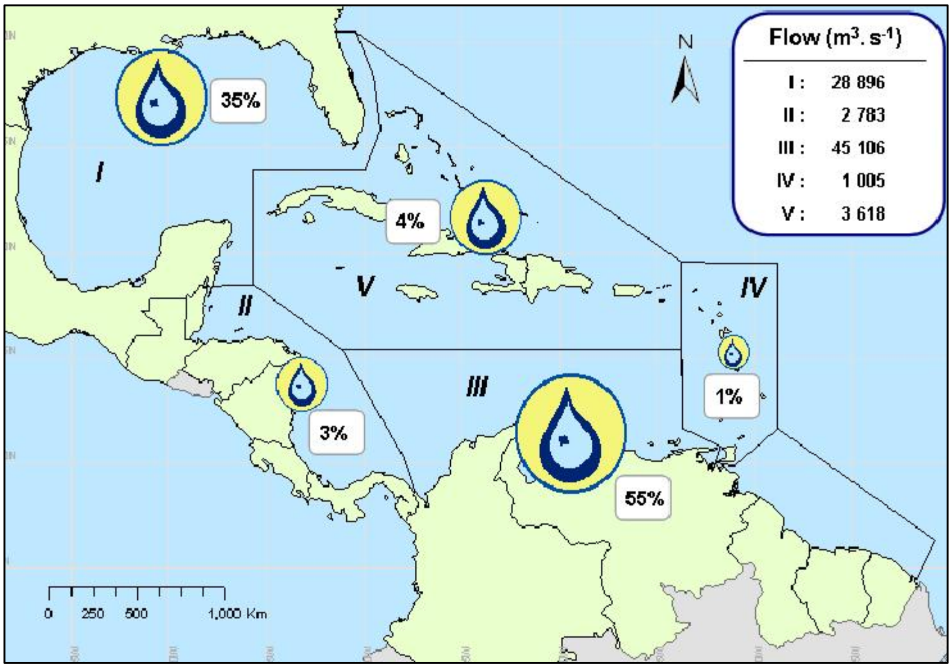

Figure 21. Fresh water inflow to the WCR (m^3.sec^{-1} and %) from river basin by sub-region

These results are related to the amount of precipitation, the size of watersheds inflows and their urban, industrial, and agricultural development. In addition, runoff is related to the environmental management procedures and practices in the upper river beds, which have evolved unevenly in the WCR's countries, and even within countries, due to a lack of coordination between the basin management institutions and stakeholders. This can cause conflicts out of competing interests, and above all, gaps in task executions. Stakeholders may try to take advantage of their location and water rights, regardless of whether they pollute downstream, and may not feel responsible for the control of urban drainages [51].

5.2. Suspended solids from watersheds

Sediment discharges to WCR are associated with the erosion of lands within watersheds due to the deforestation, urbanisation, and agricultural activities such as land clearing and incorrect use of cultivation techniques. The progressive development in the region has required changes in the traditional use of the land, particularly increasing agricultural and livestock development in detriment of the lands of forest use [5].

The larger suspended solids (TSS) contribution comes from sub-regions I (Gulf of Mexico) and III (Southern Caribbean) over 200 millions tons TSS per year. The least significant contribution of TSS come from sub-region IV (Eastern Caribbean), mainly represented some 2,600 t.yr^{-1} from

Trinidad and Tobago. Sub-region V (North Eastern and Central Caribbean) and sub-region II (Western Caribbean) contribute between 7-6 million tons TSS per year, respectively.

It is important to highlight the Rio Cobre basin in Jamaica in sub-region V (North Eastern and Central Caribbean) that contributes some 97.4% (1,400,000 t $TSS.yr^{-1}$) of the annual rate of silts discharged to the Bay of Kingston, Jamaica [41]. This load represents some 20% of the average annual load of TSS discharged into sub-region V (Table 9).

Rio Cobre was studied in GEF Project RLA/93/G4 “Planning and Environmental Management of Heavily Contaminated Bays and Coastal Areas in the Wider Caribbean” to calculate the annual rate of sedimentation in Hunts Bay due to the discharge coming from the rivers and the Sandy Gully channel.

Figure 22 shows the jet formed by Rio Cobre runoff into the region.

Figure 22. Typical behavior of the suspended solids “jet” from Río Cobre in Hunts Bay, Kingston Harbour, Jamaica

5.3. Nutrients from watersheds

The amount of nutrients from watersheds entering the WCR are over 2 million tons per year of total nitrogen (TN), and 300,000 tons per year of total phosphorus (TP), without taking into account the Orinoco River inflow due to a lack of information regarding phosphorus. Nutrients cause excessive growth of marine algae which decay and lead to low oxygen levels in coastal waters, ultimately causing death of marine organism in a process knows as “eutrophication”.

The larger contribution of TN and TP come from sub-region I (Gulf of Mexico) with 1.6 million tons per year and 152 thousand TP tons per year. However, total phosphorus inflow from Orinoco River is not included in the overall nutrient loading assessment due to a lack of information. The smallest nutrient loading contribution come from sub-region IV (Eastern Caribbean) with only 200 t TN .yr^{-1} and 40 t TP .yr^{-1} due to the smaller area and smaller size of the Sub-region’s watersheds. The most significant source of TP pollutant loading are agricultural activities, whereas TP loadings are also affected by atmospheric deposition of nitrogen.

5.4. Inflows of other pollutants to the WCR

Table 10 shows other pollutants from the three main basins of the WCR, specifically the estimated sediment load (TSed), total organic carbon (TOC), fats and grease (F and G), dissolved and dispersed petroleum hydrocarbons (DDPH) and total coliforms (TC) in most probable number per day. There are high levels of sediment loads coming from the Mississippi / Atchafalaya River basin into the WCR.

Table 10. Pollutants (TSed, TOC, F&G, DDPH, TC) from the main watersheds in WCR in tons per year [8,37,39,40,41]

Watershed	Drainage area (km^2)	Annual yearly load (t.yr^{-1})				TC (MPN.day^1)
		TSed*	TOC	F&G	DDOH	
Mississippi / Atchafalaya	3,234,000	646,800	4,537,300	NA	NA	NA
Orinoco River	952,173	190,400	NA	2,500	NA	20.4 E+17
Magdalena River / Dique Canal	256, 622	51,300	NA	16,300	676,000	401.0 E+17
Total	**4, 443, 000**	**888,500**	**4, 537,300**	**19,000**	**676,000**	**421.4 E +17**

*** Calculations based on an erosion rate of 200 t. km^{-2}.yr^{-1}**
NA: Not available

The main pollutants from watersheds in WCR are sediments load. Coastal and marine ecosystems are significantly affected by land-based sources and activities that can be located many kilometers away from the coast. Considering this, it is critical for coastal resource management to consider the impacts originating in upland areas that can be great distances from river mouths. Integrated Coastal Management (ICM) must include an understanding of watersheads management to effectively protect the coastal and marine environmental quality in WCR.

5.5. Inflows from non-point sources to the WCR

Non-point pollutant sources are those substances that enter the environment as a result of runoff, rainfall, atmospheric deposition, drainage, filtration or hydrological modifications, according to the definition of the LBS Protocol [6]. Non-point source pollution is closely linked to runoff which carries pollutants that are then discharged in lakes, rivers, coastal areas, wetlands and even drinking water aquifers. Among the most harmful pollutants that are discharged in WCR are fertilizers, herbicides, and pesticide residues from agricultural and residential areas, greases and fats, heavy metals from urban runoffs and energy production as well as sediments produced by poor management of agricultural, construction and mining activities.

Fertilizer, agro-chemical, and manure runoff from agricultural lands in upstream coastal areas of WCR countries are significant sources of nutrients to the marine environment (particularly nitrogen and phosphorus) from non-point sources. These contaminants are particularly prevalent because important crops like sugar cane, citrus fruits, bananas, grains and coffee require large amounts of fertilizers and pesticides. If proper agricultural practices are not followed, non-point source runoff may carry excess fertilizers and pesticides downstream to the ocean where effects on marine resources are likely.

5.5.1. Use of fertilizers and agrochemicals in WCR

Recent studies on the use of fertilizers in the WCR show that vegetable crops have the highest rates of fertilizer use, some 242 kg.ha^{-1}.year^{-1}followed by sugar cane 216 kg.ha^{-1}.year^{-11}, roots and tubers 212 kg.ha^{-1}.year^{-1}, and cereals and oil bearing seeds (main crops per area and total fertilizer volume applied) some 102 kg.ha^{-1}.year^{-1} and 85 kg.ha^{-1}.year^{-1}, respectively. Banana crops have a rate of 479 kg.ha^{-1}.year^{-}1, beets 254 kg.ha^{-1}.year^{-1}, citrus fruits 252 kg.ha^{-1}.year^{-1}, potatoes 243 kg.ha^{-1}.year^{-1}and vegetables 242 kilogram per hectare per year [52].

Table 11 shows fertilizer use in the region for 2005. WCR countries used, at least, more than three million tons of fertilizers in 2005, even without evaluating a significant number of countries due to lack of information. This result must be taken only as a reference, since fertilizer use in the coastal areas of continental countries and in large islands is not segregated due to a lack of information.

Table 11. Fertilizer use ($t.yr^{-1}$) by sub-region in WCR for 2005 [52]

Countries in the WCR	Fertilizer use ($t.yr^{-1}$) x 10^3
Sub region I	
United States of America	NA
Mexico	1 731
Subtotal	*1 731*
Sub region II	
Belize	5.7
Guatemala	198.5
Honduras	102.4
Nicaragua	56.2
Costa Rica	232.8
Panama	18.8
Subtotal	*614.4*
Sub region III	
Colombia	466.9
Venezuela	438.7
Guyana	7.8
French Guiana	NA
Suriname	3.0
Aruba	NA
Netherlands Antilles	NA
Subtotal	*916.4*
Sub region IV	
Anguilla	NA
Antigua and Barbuda	NA
Barbados	NA
British Virgin Islands	NA
Dominica	3.0
Granada	NA
Guadalupe	NA
Martinique	NA
Montserrat	NA
St. Lucia	1.1
St. Martin	NA
St. Bartholomi	NA
San Kitts & Nevis	0.3
US Virgin Islands	NA
Trinidad & Tobago	5.7
S.V. and the Grenadines	1.2
Subtotal	*11.3*

Sub region V	
Bahamas	0.3
Cayman Islands	NA
Cuba	69.8
Dominican Republic	79.8
Haiti	14.4
Puerto Rico	NA
Jamaica	14.1
Turks and Caicos	NA
Subtotal	*178.4*
Total	**3 451.5**

NA: Not available

WCR countries are considered an importer of large amounts of pesticides for vector control in agriculture, since it is an important economic activity in almost all countries in the region. Regularly, the main crops are sugar cane, coffee, bananas, oranges, pineapple, corn, cotton, vegetables, rice, cocoa, beans, and tubers among others.

Table 12 shows the agricultural areas (hectare) for the dominating crops in WCR by sub-region. Sub-region I (Gulf of Mexico), however there was a lack of information from many countries.

Table 12.. Agricultural area (ha) by sub-region in WCR [53]

Countries and Territories	Agricultural area (ha) x 10^3				
	Coffee	Sugar Cane	Banana	Corn	Cocoa
Sub region II					
Belize	NA	57.3	4.7	35.0	NA
Guatemala (1996)	380	154	13.3	576.2	NA
Honduras	NA				
Nicaragua	134.4	79.8	2.5	373.5	NA
Costa Rica (2000)	106	46	48.1	10.4	3.6
Panama	NA				
Subtotal	*620.4*	*337.1*	*68.6*	*995.1*	*3.6*
Sub region III					
Colombia (1999)	2 049.2	447.6	123.8	150.2	NA
Venezuela (1997)	171.4	155.4	NA	651.7	51.6
Guyana	NA				
French Guiana (2005)	0	0.2	0.5	0.088	0
Suriname	NA				
Aruba	NA				
Netherlands Antilles	0	0	0	0	0
Subtotal	*2 220.6*	*603*	*124.3*	*802*	*51.6*

Countries and Territories	Agricultural area (ha) x 10^3				
	Coffee	**Sugar Cane**	**Banana**	**Corn**	**Cocoa**
Sub region IV					
Anguila	NA				
Antigua & Barbuda	NA				
Barbados	NA				
British Virgin Islands	NA				
Dominica	NA				
Granada	NA	0.5	3.6	NA	4.5
Guadalupe	NA				
Martinique	NA				
Montserrat	NA				
Sta. Lucía	0.04	NA	5.3	NA	0.3
St. Martin	NA				
St. Bartholomi	NA				
St. Kitts & Nevis	NA				
US Virgin Islands	NA				
Trinidad & Tobago	NA				
S.V. and the Grenadines	NA				
Subtotal	*0.04*	*0.5*	*8.9*	*NA*	*4.8*
Sub region V					
Bahamas	NA				
Cayman Islands	NA				
Cuba	NA				
Dominican Republic	NA	NA	11.6	23.2	NA
Haiti	NA				
Puerto Rico	NA				
Jamaica	NA				
Turks and Caicos	NA				
Subtotal	*NA*	*NA*	*11.6*	*23.2*	*NA*
Total	**3,000**	**940**	**213**	**2,000**	**60**

NA: Not available

Figure 23 shows pesticide use (tons) in the year 2001 in sub-region II (Western Caribbean) excluding Guatemala.

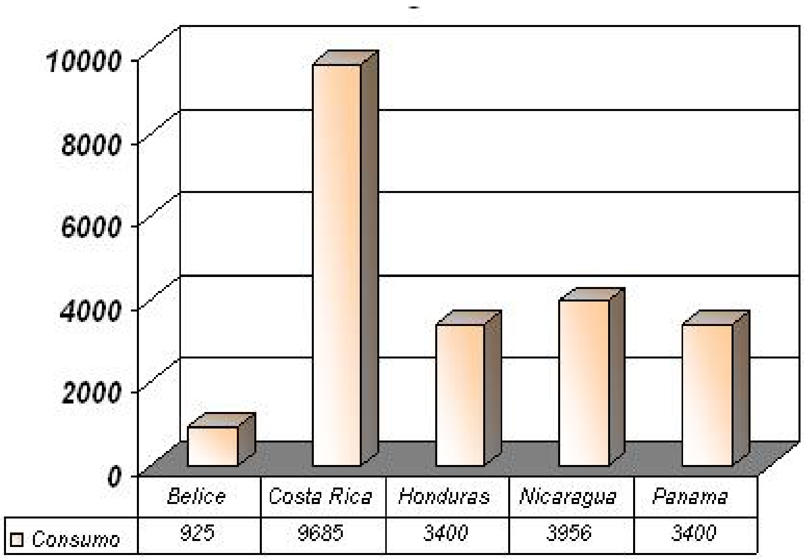

Figure 23. Pesticide use (tons) in sub-region II (Western Caribbean) in 2001 [54]

Sub-region II (Western Caribbean) used more than 21,000 tons of pesticides in 2001, excluding Guatemala. The increased use and application of fertilizers and pesticides has been documented in seven countries in WCR, thus increasing the potential risk for pollution in downstream watershed areas from runoff of excess chemicals, especially during the periods of heavy rainfall characteristic of WCR. Table 13 shows the average annual use of pesticides in very few WCR countries between 1982-1984 and 1995-2001 and the annual increase.

Table 13.. Average annual use of pesticides ($t.yr^{-1}$) in some WCR countries [5,54]

Country/Sub-region	Pesticide use ($t.yr^{-1}$) x 10^3		Increase %
	1982-1984	1995-2001	
Honduras (Sub-region II)	0.9	3.2	72
Nicaragua (Sub-region II)	2	4	50
Costa Rica (Sub-region II)	3.7	10.7	65
Panama (Sub-region II)	2.4	4.3	44
Colombia (Sub-region III)	16.1	47.6	66
Dominican Republic (Sub-region V)	3.3	4.6	28
Jamaica (Sub-region V)	1.4	2.1	33
Total	**30**	**76**	**61***

***Non weighted average value**

5.5.2. Contaminant inflows from non-point sources to the WCR

Determining the amount of fertilizer, agrochemical and other pollutant loadings in the WCR is very complex and requires taking many variables into account, as well as using mathematical models to predict their behavior, attributed mainly to sediment particles that are mobilized when agricultural nonpoint source pollution is produced during heavy rain events.

Estimations of pollutant loading from non-point sources in WCR, using mathematical models have been made in the Mesoamerican area of sub-region II (Western Caribbean), as well as sub-region IV (Eastern Caribbean) and sub-region V (North Western and Central Caribbean).

The first regional estimates of sediment loadings and the effects of pollutants from land-based sources using mathematical models was carried out in 2004 in the Reefs at Risk Project of the World Resources Institute (WRI). The project analyzed over 3,000 minor watersheds in WCR and identified coastal waters with high probabilities of having increasing loadings of sediments and pollutants (Figure 24). According to the WRI study, 9,000 km^2 of threatened coral reefs were identified using a threat indicator, representing ⅓ of the total in the region (15% with medium level threat and 20% with high level threat) [55].

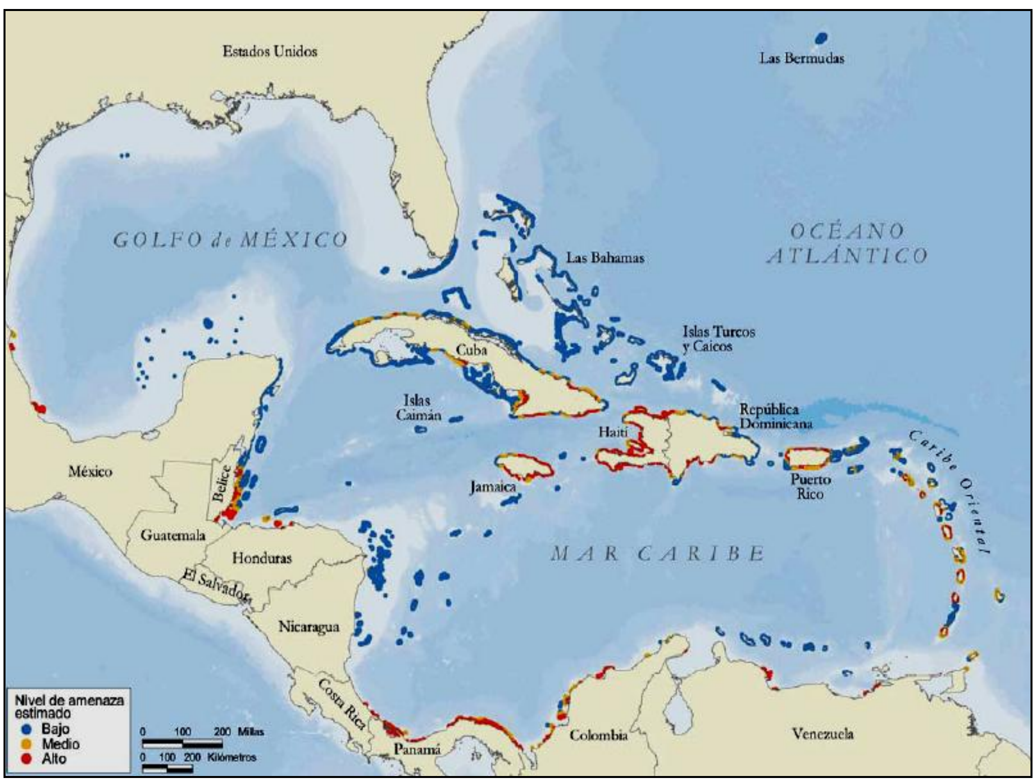

Figure 24. Coral reefs threatened by sediments and pollutants in WCR

Coral reefs are highly threatened throughout the WCR, including reefs in the Mesoamerican area (Belize, Guatemala, Honduras and a small part of Mexico), Costa Rica and Panama in sub region II (Western Caribbean), Colombia and Venezuela in sub region III (Southern Caribbean), some islands of the Lesser Antilles in sub region IV (Eastern Caribbean) and countries most of the Greater Antilles in sub region V (Northwestern and Central Caribbean).

In 2006, WRI published the findings from the Watershed Analysis in the Mesoamerican Reef. This study was a collaborative effort to evaluate the land-based threats posed to the Mesoamerican Reef from human alterations of the landscape. The analysis quantifies sediment and nutrients coming from over 400 watersheds that discharge along the Mesoamerican Reef in sub region II (Western Caribbean) by using the spatial analysis tool, the Non-point Source Pollution and Erosion Comparison Tool (N-SPECT), developed by NOAA [56]. N-SPECT is a modeling tool that provides projections and maps of surface water runoff volumes, pollutant loads, pollutant concentrations, and total sediment loads.

Figure 25 shows the results with a visual estimate of sediment discharges and nitrogen into Mesoamerican Reef.

More than 80% of sediment loads and more than 50% of nitrogen loads in the Meso-American Reef area are transported to the ocean by watersheds in northern Honduras, specifically the Ulua river basin. The model indicates that a relatively lower percentage of sediment loading comes from Belize watersheds. Sediment loads to WCR from the Meso-American region (Belize, Guatemala, Honduras and part of Mexico’s Yucatan Peninsula) area some 374 million of ton per year.

A similar approach was used to assess the sediment loadings for sub-regions IV (Eastern Caribbean) and V (Northwestern and Central) by the RAC-Cimab in 2008 using the N-SPECT model, with regional and global databases [57].

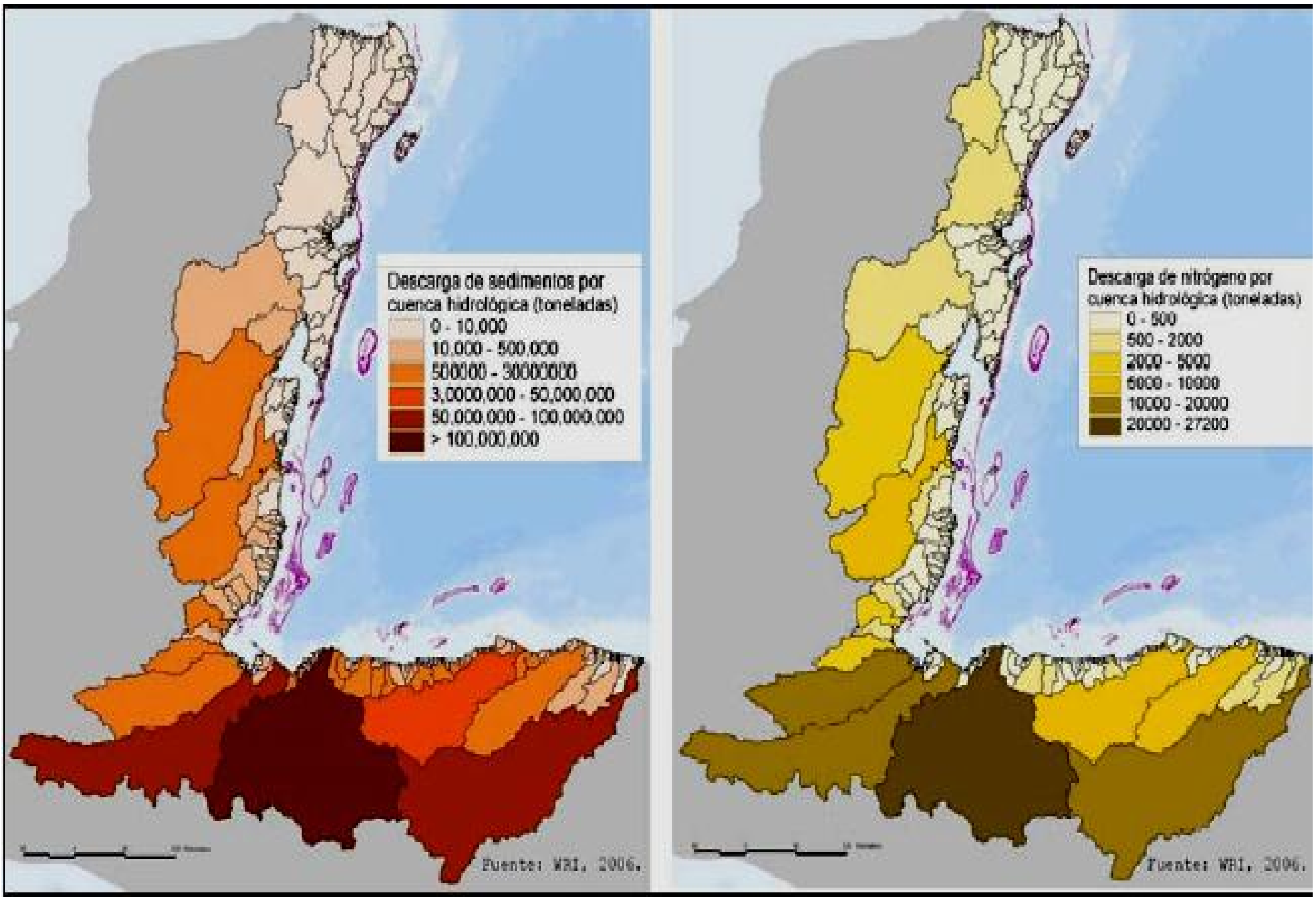

Figure 25. Sediment and nitrogen discharges by watershed into the Mesoamerican Reef area ($t.yr^{-1}$)

Table 14 shows sediment loads in tons per year by country and territory, according to the analysis of inflows by basin.

The sediment load from sub-region V (Northwestern and Central Caribbean) is much greater than that of sub-region IV, particularly due to the sedimentary loads from Haiti, Dominican Republic and Cuba although seven countries were not assessed due to the lack of information. The sediment load from sub-region IV (Eastern Caribbean) comes particularly from Martinique, St. Kitts and Nevis, Dominica and Guadalupe.

However, the required pollutants coefficients are very variable for the insular regions and a study detailed case to case is required together to a more extensive database to obtain reliable data. Thus, these results should only be taken as reference for future regional projects, in particular those results linked to the small islands.

Table 14. Estimated sediment loads ($t.yr^{-1}$) discharged into the WCR (sub-regions IV and V) from non-point sources [57]

Countries and Territories	Sediment loads ($t.yr^{-1}$) x 10^3
Sub-region IV	
Anguila	0.006
Antigua and Barbuda	8
Barbados	NA
British Virgin Islands	10
Dominica	549
Granada	15
Guadalupe	911
Martinique	1,423
Montserrat	83
St. Lucia	232
St. Martin	NA
St. Bartholomi	NA
St. Kitts and Nevis	619
US Virgin Islands	26
Trinidad and Tobago	527
S.V. and the Grenadines	NA
Subtotal	*4,407*
Sub-region V	
Bahamas	NA
Cayman Islands	NA
Cuba	24,178
Dominican Republic	29,360
Haiti	54,697
Puerto Rico	7,708
Jamaica	13,849
Turks and Caicos	NA
Subtotal	*129,793*
Total	**134, 200**

NA: Not available

Figure 26 shows, also, the results of the N-SPECT model carried out by RAC-Cimab for sub regions IV (Eastern Caribbean) and V (Northwestern and Central Caribbean) with respect to the sediment loads to WCR.

It was not possible to obtain valid estimates of the nutrient loadings (nitrogen and phosphorus) because the pollution coefficients vary greatly in this island region, a detailed case by case study would be required, and a wider and more reliable database needs to be developed.

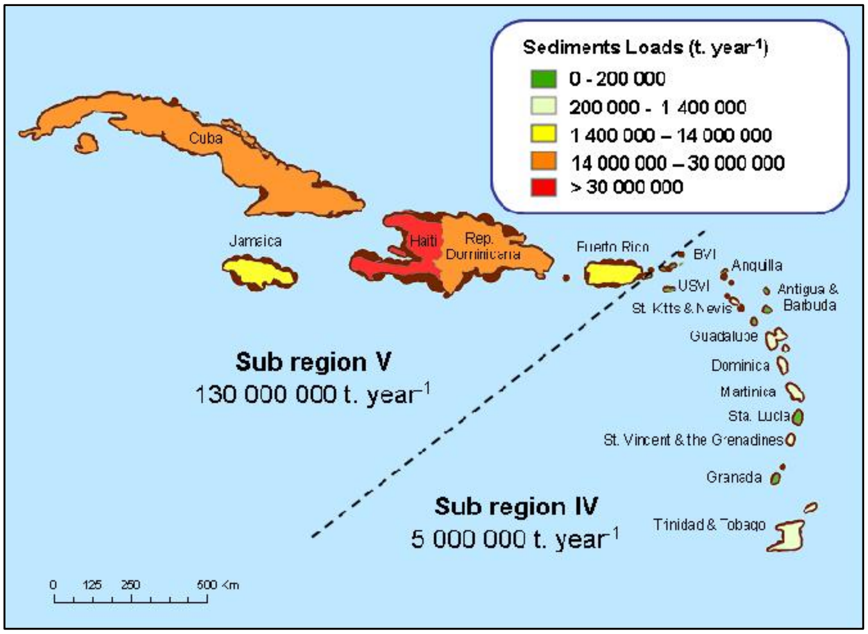

Figure 26. Relative sediment loads (t.yr-1) from non-point sources into sub-regions IV and V as a result of N-SPECT modeling 57

The practical difficulty that WCR countries have in determining sediment and nutrient loads from non-point sources is well known. Therefore, the use of models is a powerful tool that can be applied at regional level to meet the need for information, in order to comply with LBS Protocol, since its Annex 4 provides a time frame of 5 years, after it enters into force, for countries to evaluate non-point sources of agricultural pollution that may have negative effects in the zone of application of the Cartagena Convention.

This assessment includes pollutant loads estimate (nutrients and solids), the impacts identification on the environment and on public health, as well as the discharges monitoring into the marine environment.

5.6. Comparison with original CEP Technical Report No. 33

Table 15 shows a comparison of estimated total sediment loads, include both suspended sediments and bottom sediments, in tons per year discharged by the region's three main watersheds and other minor watersheds in WCR, between the CEP technical report No. 33 (1994) and the updated report.

According to the available scarce information for this updated report and that these are the results of modelling which has limited accuracy, an increase is observed in sediment loads coming from watersheds in WCR, probably as a result of the growing urban-industrial and agricultural development although several minor watersheds were not assessed due to the lack of information. Watersheds inflows from sub-region I (Gulf of Mexico) and sub-region III (Southern Caribbean) show increases in average annual sediment loads of 46% and 15%, respectively.

Table 15. Estimated total sediment loads ($t.yr^{-1}$) from watersheds into the WCR: A comparison between the CEP Technical Report No. 33 (1994) and the updated report [5,8,40,42,43,44]

Main watersheds/minor watersheds	Average annual total sediment loads [1] ($t.yr^{-1}$) x 10^3	
	CEP TR No. 33 (1994)	Updated Report
Mississippi/Atchafalaya (Sub-region I)	320,000	646,800
Orinoco River (Sub-region III)	85, 000	190,440
Magdalena River (Sub-region III)	235, 000	51 ,330
Minor watersheds (Sub-region I)	121, 000	181, 880
Minor watersheds (Sub-region III)	50, 000	197, 500
Minor watersheds (Sub-regions II, IV y V)	300, 000	511,511 [2]
Total	**1, 111 000**	**1, 877,000**

*** Calculation based on an erosion rate of 200 $t.km^{-2}.yr^{-1}$**
† Does not include Nicaragua and Panama from sub-region II due to the lack of information

6. PREDICTED CHANGES OF DOMESTIC POLLUTANT LOADS, 2015 AND 2020 SCENARIOS

6.1. Predicted changes of sanitation coverage

Since the approval of the Punta del Este Letter in 1961, WCR countries have made vast efforts to expand the sanitation coverage [58]. Table 16 shows the predicted changes of sanitation coverage with and without connection to sewer systems in the region, not including USA, among 1960-2000.

Table 16. Predicted changes of sanitation coverage with and without connection to sewer systems in WCR, among 1960-2000. USA is not included [59]

Year	Sewer system		Latrines and septic tanks	
	Population x 10^6	%	Population x 10^6	%
1960	29	14	NA	NA
1971	59	21	NA	NA
1980	95	28	105	31
1990	168	39	116	21
2000	241	49	152	31

NA: Not available

In the 1980s, sanitation services expanded significantly in the Region, coinciding with the "International Drinking Water Supply and Sanitation Decade" (1981-1990), proclaimed by the UN General Assembly in November 1980. In the 1980s and 1990s, there were significant increases in the number of persons connected to sewers and in the 1990s to the year 2000, household wastewater treatment systems, such as latrines and septic tanks, also increased [59].

Most of the people without access to sanitation services are in low income groups concentrated primarily in suburban zones, and it has been very difficult to provide these marginalized areas with acceptable services. The main problems faced by countries in the Region for sanitation coverage and expansion to marginalized populations are related to [60]:

- High levels of poverty.
- High construction and operation costs.
- Distance from existing sewage networks.
- Difficult topographies where pipes and collection systems cannot be easily constructed.

Available information on the changes in sewage treatment in WCR countries is very limited. In 1962, only 10% of sewers systems had treatment plants in the developed countries [61]. Since then, the situation has not changed significantly in the region due to high capital costs and lack of financing in the sanitation sector. Some of the countries that have expanded the sewage treatment are Colombia, USA, Mexico and Venezuela.

Sewage treatment is even more serious in WCR when considering that a large number of treatment plants are abandoned or working poorly. As a result, many ecosystems near urban areas are seen like open sewers and in general, the watercourses crossing the large cities of the region transport a high sewage load.

Nowadays, 85% (60 million of inhabitants) of the WCR population has sanitation coverage although several countries were not assessed due to the lack of information. The contribution daily per capita reaches a half value of 209 liter of domestic wastewater discharged per inhabitant per day in WCR.

The appropriate low-cost technologies can be used for WCR according to the characteristics of the place and they are associated to the wastewater collection and transfer. Many towns of WCR use not-improved on-site local systems, which although they are an alternate system for rural areas, they are not the most appropriate technological solution for urban areas, mostly because of the groundwater pollution caused by these practices in some cities [62].

6.2. Scenario 2015

In September 2000, the Millennium Declaration was adopted, which defines issues linked to peace, security and development, including areas like the environment, human rights, and governance, as the main concerns for human development. UN recommended to take into account national development priorities, and established the UN Millennium Development Goals Declaration [7]. The aim of No. 7 “Ensure Environmental Sustainability” includes four targets:

i. Target 7.A: Integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources.
ii. Target 7.B: Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss.
iii. Target 7.C: Halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation (this is a global goal, not a specific goal for the WCR).
iv. Target 7.D: By 2020, to have achieved a significant improvement in the lives of at least 100 million slum dwellers.

WCR countries, with the exception of Haiti, are complying with the goal of ensuring access to sanitation services for 50% of the population. A large part of this coverage, which has not been quantified due to a lack of information, does not include access to improved sanitation, that is, connections from homes to a public sewage network, connections to septic tanks, latrines with water flushing systems, dry latrines, and hole latrines [63]. Regarding treatment coverage in the WCR, only 28% of the countries comply with the goal to have 50% of the population with access to waste water treatment or final disposal systems (Table 2).

6.2.1. Domestic pollutant loads discharged in WCR for 2015

Table 17 shows an estimate of upstream coastal populations for 2015 (size of the population that lives up to 25 km from the coast in continental countries and large islands, and the whole population of small islands) according to the behavior of the population's growth presented in the Statistical Annual of Latin America and Caribbean (2006) [64] and the Database of Population from Latin America and Caribbean (2005) [65].

The table includes domestic wastewater flow discharged in WCR with only 35% of the population with access to wastewater treatment and disposal, given that reaching 50% of the population with improved sanitation for 2015 is a very difficult goal to achieve in the region due the economic world depression.

Table 17. Upstream coastal population and domestic wastewater flows discharged ($m^3.sec^{-1}$) in WCR for 2015 [8,11,12,59,62,63,64,65]

Countries and territories	Upstream coastal population x 10^3	Flow discharged in WCR ($m^3.sec^{-1}$)
Sub-region I		
United States of America	18,048	102
Mexico	6 ,937	15
Subtotal	*24 ,985*	*117*
Sub-region II		
Belize	161	1
Guatemala	500	2
Honduras	1,585	10
Nicaragua	325	3
Costa Rica	327	1
Panama	966	1
Subtotal	*3, 864*	*18*

Countries and territories	Upstream coastal population x 10^3	Flow discharged in WCR ($m^3.sec^{-1}$)
Sub-region III		
Colombia	5, 607	39
Venezuela	10, 768	45
Guyana	600	1
French Guiana	250	0.06
Suriname	386	2
Aruba	NA	NA
Netherlands Antilles	198	1
Subtotal	*17,809*	*88*
Sub-region IV		
Anguilla	13	0.01
Antigua y Barbuda	69	0.08
Barbados	281	0.6
British Virgin Islands	24	0.6
Dominica	69	0.1
Grenada	90	0.2
Guadeloupe	421	1
Martinique	439	1
Montserrat	91	0.006
St. Lucia	170	0.2
St. Martin	NA	NA
St. Bartholomi	NA	NA
St. Kitts and Nevis	39	0.1
US Virgin Islands	111	0.2
Trinidad & Tobago	1,077	1.3
S.V. and the Grenadines	119	0.1
Subtotal	*3, 014*	*6*
Sub-region V		
Bahamas	311	0.6
Cayman Islands	11	0.2
Cuba	7, 813	27
Dominican Republic	5, 811	2
Haiti	7, 172	11
Puerto Rico	3, 982	3
Jamaica	2, 787	3
Turks and Caicos	18	0.03
Subtotal	*27, 900*	*47*
Total	**77, 000**	**277**

NA: Not available

For 2015, the upstream coastal population in WCR is some 77 million inhabitants. Sub-region V (Northwestern and Central Caribbean) will *have* the largest upstream population coastal with 28 million inhabitants, followed by sub-region I (Gulf of Mexico) with 25 million inhabitants, whereas sub-region IV (Eastern Caribbean) with 3 million inhabitants and sub-region II (Western Caribbean) with 4 million inhabitants will be the least populated.

For 2015, the domestic wastewater flow discharged in WCR is some 277 $m^3.sec^{-1}$. The largest amounts will come from sub-region I (Gulf of Mexico) some 117 $m^3.sec^{-1}$ (42%) followed by sub-region III (Southern Caribbean) some 88 $m^3.sec^{-1}$ (32%), whereas the less significant amounts will come from sub-region IV (Eastern Caribbean) some 5 $m^3.sec^{-1}$ (2%) and sub-region II (Western Caribbean) some 19 $m^3.sec^{-1}$(7%).

Table 18 shows an estimate of domestic pollutant loads discharged in WCR for 2015 and their comparison with this updated report, considering 50% of the population with access to improved sanitation and 35% of the population with access to wastewater treatment or final disposal.

Table 18.. Estimated domestic pollutant loads ($t.yr^{-1}$) discharged in WCR for the 2015 scenario compared to the updated report [8,11,12,63,64,65]

Sub-region	Updated Report vs 2015 Scenario	BOD_5	COD	TSS	TN	TP
I	Updated report	121,586	295,616	146,531	20,978	9,820
	2015 scenario	90,289	215,811	148,372	6,695	2,411
II	Updated report	16,239	37,009	14,953	1,812	619
	2015 scenario	38,125	92,121	61,489	1,752	701
III	Updated report	109,224	250,702	103,895	12,901	4,662
	2015 scenario	161,957	346,045	225,411	6,103	2,061
IV	Updated report	11,919	27,158	10,964	1,328	452
	2015 scenario	11,499	27,476	17,788	883	240
V	Updated report	146,375	336,413	140,055	17,465	6,370
	2015 scenario	110,309	229,615	156,769	4,376	1,764
Total	**Updated report**	**405,000**	**947,000**	**416,000**	**54,000**	**22,000**
	2015 scenario	**412,000**	**911,000**	**610,000**	**20,000**	**7,000**

Important reductions are observed in PT and NT followed by slight reductions for DQO, despite the progressive increase in population, if the objectives layouts in UN Millennium Development Goals are fulfilled. SST shows an increment characteristic of the populational progressive increase while DBO_5 shows only very slight increments, proving the importance of compliance with the UN Millennium Goals regarding the sewage treatment. However, an important financing for the sanitation coverage expansion is required, included the treatment facilities. Last aspect, this can be facilitated, when the FTCM Protocol enters in force.

6.3. Scenario 2020

6.3.1. Domestic pollutant loads discharged in WCR for 2020

Table 19 shows an estimate of upstream coastal populations for 2020 (size of the population that lives up to 25 km from the coast in continental countries and large islands, and the whole population of small islands) according to the behavior of the population's growth presented in the Statistical Annual of Latin America and Caribbean (2006) [64] and the Database of Population from Latin America and Caribbean (2005) [65].

The table includes domestic wastewaters flow discharged into the WCR, considering that 50% of the population has access to improved sanitation and 50% of the population has access to wastewater treatment or final disposal systems.

Table 19. Upstream coastal population and domestic wastewater flow discharged ($m^3.sec^{-1}$) in WCR for 2020 [8,11,12,63,64,65]

Countries and territories	Upstream coastal population x 10^3	Flow discharged ($m^3.sec^{-1}$)
Sub-region I		
United States o America	19,741	111
Mexico	8, 055	18
Subtotal	*27, 796*	*129*
Sub region II		
Belize	164	1
Guatemala	768	3
Honduras	1, 743	11
Nicaragua	452	4
Costa Rica	426	3
Panama	1, 012	1
Subtotal	*4, 565*	*23*
Sub-region III		
Colombia	6, 335	44
Venezuela	11, 244	47
Guyana	600	1
French Guaina	300	0.07
Suriname	387	2
Aruba	NA	NA
Netherlands Antilles	201	1
Subtotal	*19,067*	*95*

Countries and territories	Upstream coastal population x 10^3	Flow discharged ($m^3.sec^{-1}$)
Sub-region IV		
Anguilla	13	0.01
Antigua y Barbuda	69	0.1
Barbados	281	0.6
British Virgin Islands	24	0.6
Dominica	69	0.1
Grenada	90	0.1
Guadeloupe	424	1
Martinique	441	1
Montserrat	91	0.006
Sta. Lucía	171	0.2
St. Martin	NA	NA
St. Bartholomi	NA	NA
San Kitts and Nevis	39	0.1
US Virgin Islands	112	0.2
Trinidad & Tobago	1,085	1
S.V. and the Grenadines	119	0.1
Subtotal	*3 ,032*	*6*
Sub-region V		
Bahamas	316	0.6
Cayman Islands	11	0.2
Cuba	7,871	28
Dominican Republic	5,944	2
Haiti	7 ,297	11
Puerto Rico	4 021	3
Jamaica	2 ,807	3
Turks and Caicos Island	18	0.03
Subtotal	*28 ,287*	*48*
Total	**82 ,500**	**300**

NA: Not available

For 2020, the upstream coastal population in WCR is estimated in 82.5 million inhabitants. Sub-region V (Northwestern and Central Caribbean) and sub-region I (Gulf of Mexico) will have the largest upstream coastal population some 28 million inhabitants, whereas sub-region IV (Eastern Caribbean) some three million inhabitants will be the least populous.

For 2020, the domestic wastewaters flow discharged in WCR is some 300 $m^3.sec^{-1}$. The largest flow will come from sub-region I (Gulf of Mexico) some 43% followed by sub-region III (Southern Caribbean) some 31%, whereas the lowest flow discharged in WCR will come from sub-region IV (Eastern Caribbean) some 2%.

Table 20 shows an estimate of domestic pollutant loads discharged into the WCR for 2020 and their comparison with this updated report, considering that 50% of the population has access to improved sanitation, and 50% of the population has access to sewage treatment or disposal systems.

Table 20. Estimated domestic pollutant loads ($t.yr^{-1}$) discharged in WCR for 2020 compared to the updated report [8,11,12,63,64,65]

Sub-region	Updated Report vs 2020 Scenario	BOD $_5$	COD	TSS	TN	TP
I	Updated report	121,586	295,616	146,531	20,978	9,820
	2020 Scenario	99,741	238,406	163,907	7,395	2,662
II	Updated report	16,239	37,009	14,953	1,812	619
	2020 Scenario	41,244	99,658	66,520	1,895	759
III	Updated report	109,224	250,702	103,895	12,901	4,662
	2020 Scenario	162,616	347,468	226,330	6,127	2,070
IV	Updated report	11,919	27,158	10,964	1,328	452
	2020 Scenario	11,947	28,546	18,481	918	248
V	Updated report	146,375	336,413	140,055	17,465	6,370
	2020 Scenario	98,586	229,098	156,416	4,366	1,760
Total	**Updated report**	**405,000**	**947,000**	**416,000**	**54,000**	**22,000**
	2020 Scenario	**414,000**	**943,000**	**631,000**	**21,000**	**8,000**

Important reductions are observed in PT and NT followed by very slight reductions for DQO, despite the progressive increase in population, if the objectives layouts in UN Millennium Development Goals are fulfilled. SST shows an increment characteristic of the populational progressive increase while DBO5 shows only very slight increments, proving the importance of compliance with the UN Millennium Goals regarding the sewage treatment.

Just as in the 2015 scenario, the 2020 scenario shows the importance of sewage treatment to reduce the loads discharged into the region although a significant funding for wastewater treatment facilities in WCR is required.

It is important to highlight the importance that the countries joint efforts to comply with the UN Millennium Development Goals has for the environmental protection of WCR, regarding the sewage treatment which would involve a significant reduction in pollutant loads discharged into the region, regardless of population progressive increases. The enter in force of LBS Protocol at the Region, will be an important tool to achieve a decrease of the polluting loads coming from land-based pollution sources that inputs to RGC, due to the collaboration and funding system that could be developed inside the framework of this juridical instrument.

CONCLUSIONS

- Since the 1994 Report, sanitation coverage in the WCR has increased and reaches 85% of the upsteam coastal population, facilitated by the extended use low-costc appropriate technologies.

- Since the 1994 Report, the domestic pollutant loads discharged in the WCR show reductions, in particular decreasing nutrient loading. However, further reduction and control in pollution is required through the political will of governments at different levels (national, regional and local) to promote institutional capacity building and environmental awareness, as well as greater investments and technical support in the sanitation sector.

- Since the 1994 Report, the industrial pollutant loads discharged in the WCR have decreased appreciably, in particular decreasing nutrient loading. However, further reduction and control of pollution is required through the influence of relevant authorities on waste disposal compliance approved and established in countries of the region in order to enhance institutional capacities and environmental awareness of the commercial sector, as well as greater investments and technical support in the industrial sector with the target of promoting the implementation of the standard ISO 14001:2004 "Environmental management systems-Requirements with guidance for use".

- Sediment loading is the main pollutant contribution from watersheds in the WCR. Best management practices to improve the control of runoff from agriculture and impervious surfaces are required for effective sediment control and nutrient reductions.

- Data reported suggest that the highest runoff discharge rates and average annual loads of TSS and TP drain from sub-region I (Gulf of Mexico) and sub-region III (Southern Caribbean). However, the data reported display relatively lower average annual loads of BOD_5, COD and TN draining from sub-region I (Gulf of Mexico), which is surprising given that it displays the greatest flows of domestic wastewater to the WCR (49%). Perhaps this is due to sub-region I exhibiting enhanced management of domestic wastewaters, On the other hand, the relatively higher discharge rates and average annual loads reported for sub-region III (Southern Caribbean) may be a result of far greater runoff rates generated per square area (0.035 $m^3.sec^{-1}.km^{-2}$) when compared to the other sub-regions (range: 0.006 - 0.010 $m^3.sec^{-1}.km^{-2}$) causing increased erosion and pollutant transport.

- The enter in force of LBS Protocol at the Region, constitutes the main tool for the WCR countries to achieve a decrease of the polluting loads currently coming from land-based sources of marine pollution, derived from the collaboration and funding mechanism of the sub regional, regional or worldwide that could be developed inside the context of this important juridical instrument.

RECOMMENDATIONS

- To promote the ratification of LBS Protocol by the countries forming parties of the Cartagena Convention, due to the importance of this juridical instrument for working in the decrease of polluting loads that inputs to the WCR, coming from activities and land-based sources of marine pollution.

- To further advance the use of mathematical models and other evaluation techniques, such as Geographical Information Systems (GIS), to calculate pollutant loads coming from non-point pollution sources to the WCR and to facilitate the fulfillment of the Annex IV of the LBS Protocol, referring to the evaluation of the non point sources of agricultural pollution.

- To continue national and regional efforts in the standardization of methodologies, data analysis and interpretation, data sharing, and capacity building for continued monitoring and assessment of pollutant loads discharging to the marine environment, thus ensuring that the carrying capacity of coastal and marine ecosystems are not exceeded.

- Given limitations on available resources and the complexity of assessing pollutant loading directly, especially from non-point sources, consideration should be given to further identification and use of alternative indicators of pollutant loadings and their impacts on the marine environment.

- The 2015 and 2020 scenarios' display of slight increments in domestic pollutant loading despite the estimated upsteam coastal population increase, illustrate the importance of expanding sanitation coverage and treatment facilities in the WCR countries in compliance with the UN Millennium Development Goals and satisfying the effluent limits established in LBS Protocol of the Cartagena Convention.

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This Technical Report is a mandate from the Eleventh Inter-Governmental Meeting of the Caribbean Action Plan and the Eighth Meeting of the Conference of the Contracting Parties to the Cartagena Convention held in October 2004, at which the decision was taken to Update CEP Technical Report No. 33, with financial assistance from Swedish International Development Cooperation Agency (SIDA), starting from National Technical Reports that should be presented by the WCR countries, as well as reports and UN Agencies publications.

Update CEP Technical Report No. 33 was carried out during the period 2005-2010 in two phases. First phase involved the hosting of two workshops in Caracas and Havana in 2005 and 2006, respectively, dealing with Methodologies for Estimating Domestic and Industrial Pollutant Loads from land-based sources in WCR, where the environmental quality indicators and the methodologies settled down according to the technical and financial capacities of WCR countries.

Second phase entailed the assessment and analysis of National Technical Reports presented by a group of countries in addition to other information available up to 2009. The rest of loads pollutants discharged in WCR were estimated starting from the discussed methodologies and approved in the workshops taken place in Caracas and Havana.

This updated report is grouped into six chapters and provides an update on the domestic and industrial pollutant loads discharged in WCR, sanitation coverage expansion and treatment, as well as the pollutant loading from watersheds inflows according to the available information in the WCR countries. Likewise, it presents the projected changes of pollutant loads for the years 2015 and 2020 in fulfilling UN Millennium Development Goals.

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