REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

The state of marine pollution in the Wider Caribbean region

UNEP Regional Seas Reports and Studies No. 36

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PREFACE

The United Nations Conference on the Human Environment. which took place in Stockholm, 5-16 June 1972, adopted the Action Plan for the Human Environment, including the General Principles for Assessment and Control of Marine Pollution. In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and co-ordination within the United Nations system" (General Assembly resolution 2997(XXVII) of 15 December 1972). The organizations of the United Nations system were invited "to adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems", and the "intergovernmental and non-governmental organizations that have an interest in the field of the environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination". Subsequently, the Governing Council of UNEP chose "Oceans" as one of the priority areas in which it would focus efforts to fulfil its catalytic and co-ordinating role.

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes eleven regions 1/ and has over 120 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental degradation and encompassing a comprehensive approach to combating environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of the marine and coastal environment. The action plans promote the parallel development of regional legal agreements and of action-oriented programme activities.

By decision 8(II) of 29 March 1974, the Governing Council of UNEP decided that priority should be given, in the fields of oceans, to regional activities and stressed the importance of the Caribbean region.

After a preparatory process, which included a number of expert meetings, missions and preparation of sectorial studies on resources and environmental problems of the Caribbean region, the Intergovernmental Meeting on the Action Plan for the Caribbean Environment Programme (Montego Bay, Jamaica, 6 - 8 April 1981), attended by representatives of Governments from 22 States of the region, adopted the Action Plan for the Caribbean Environment Programme and three resolutions dealing with (a) programme implementation, (b) institutional arrangements, and (c) financial arrangements related to the implementation of the Action Plan 2/.

1/ Mediterranean, Kuwait Action Plan region, West and Central Africa, Wider Caribbean, East Asian Seas, South-East Pacific, South Pacific, Red Sea and Gulf of Aden, East Africa, South-West Atlantic and South Asian Seas.

2/ UNEP: Action Plan for the Caribbean Environment Programme. UNEP Regional Seas Reports and Studies No. 26. UNEP, 1983.

The present document (issued as UNEP/CEPAL/WG.48/Inf.4) served as one of the documents prepared to facilitate the negotiations which led to the adoption of the Action Plan.

CONTENTS

1. DESCRIPTION OF THE REGION

1.1 Definition of the Region

The Wider Caribbean is defined for the purpose of this overview as the coastal and open waters of the Caribbean Sea proper, the Gulf of Mexico and adjacent waters of the Atlantic Ocean. The coastal areas included are those of East Mexico, Central America, Panama, the Bahamas and Antillian Archipelago, South America from Columbia to French Guiana and the Southern United States (figure 1).

1.2 Hydrography

The Wider Caribbean is a semi-enclosed body of water consisting of several deep basins separated by major sills (figure 2). The deepest point, 7,100 metres, is in the Cayman Trench; the average depth is approximately 2,200 metres. The two major basins are the Caribbean Sea and the Gulf of Mexico. Jointly, these two basins have been called by some the "American Mediterranean" (R. Holgson, 1973). The total sea surface of the area is approximately 4.24×10^6 km^2 (1.60×10^6 km^2 for the Gulf of Mexico and 2.64×10^6 km^2 for the Caribbean proper - J. L. Harding and W. D. Nowlin, 1966). Therefore, the total volume of water is approximately 9.3×10^{18} litres. By comparison, the Mediterranean Sea is about 3.0×10^{18} litres.

The dynamics of the water masses and related phenomena have been summarized in the supplement to the Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions (UNESCO, 1977) as follows:

> "The most striking hydrographic feature in the region is the continuous flow of water through the area from east to west in the Caribbean Sea proper, followed by a movement from south-east to north-east in the Yucatan Basin, and finally, in the Gulf of Mexico, a strong flow to the east again through the Straits of Florida, after an anticyclonic movement of most of this water in the western area of the Gulf.
>
> "Approximately 3.0×10^7 cubic metres of water per second (9.4×10^{17} l/year) pass through the various passages between the islands of the Lesser Antilles, transported to them by the combined equatorial currents. The general movement of The general movement of this water, which is stable all the year round, although some seasonal changes can be found in the velocities, is shown schematically in figure 3 in which an area of continuous flow is indicated by a dotted line. The velocities given are mean velocities during the year. Seasonal changes can be expected however, and much higher velocities will be found, especially where the water is forced through narrow passages, such as the Yucatan Channel or the Straits of Florida; velocities up to 3.5 and 4.5 km, respectively, are observed in the current core in these two areas.
>
> "Outside the dotted line, currents are weaker and also unstable. During certain months, large vortices are formed off the coast of Costa Rica, Panama and Colombia, and similarly in some parts of the Gulf of Mexico. The main circulation in the latter, as already pointed out, forms an anticyclonic movement flowing through the western part of the area and, eventually, combines its flow in the Straits of Florida with the water masses which turn after passing through the Yucatan Channel immediately to the east, the latter movement being more pronounced during the northern hemisphere winter months.

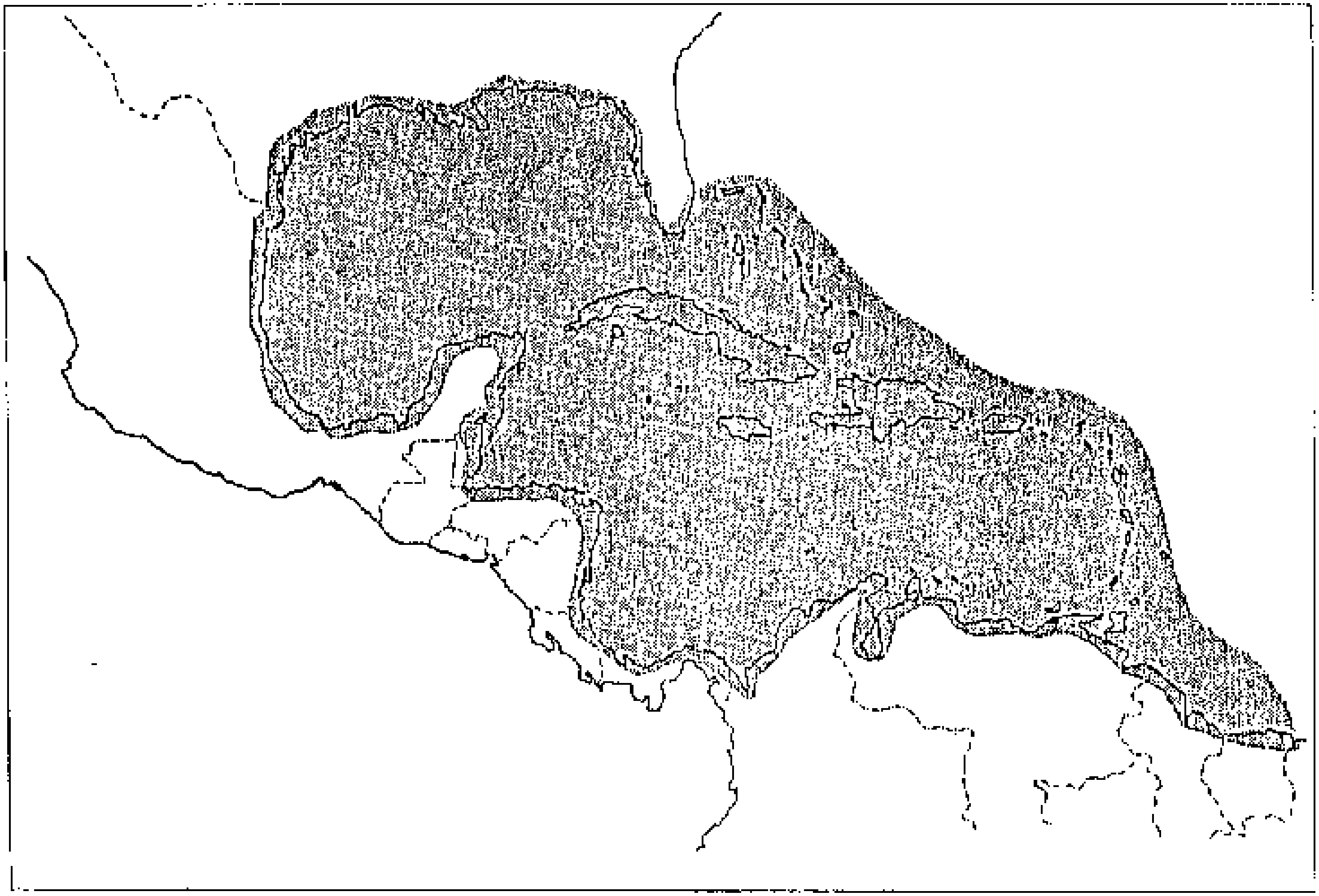


Figure 1: Wider Caribbean Regional Sea

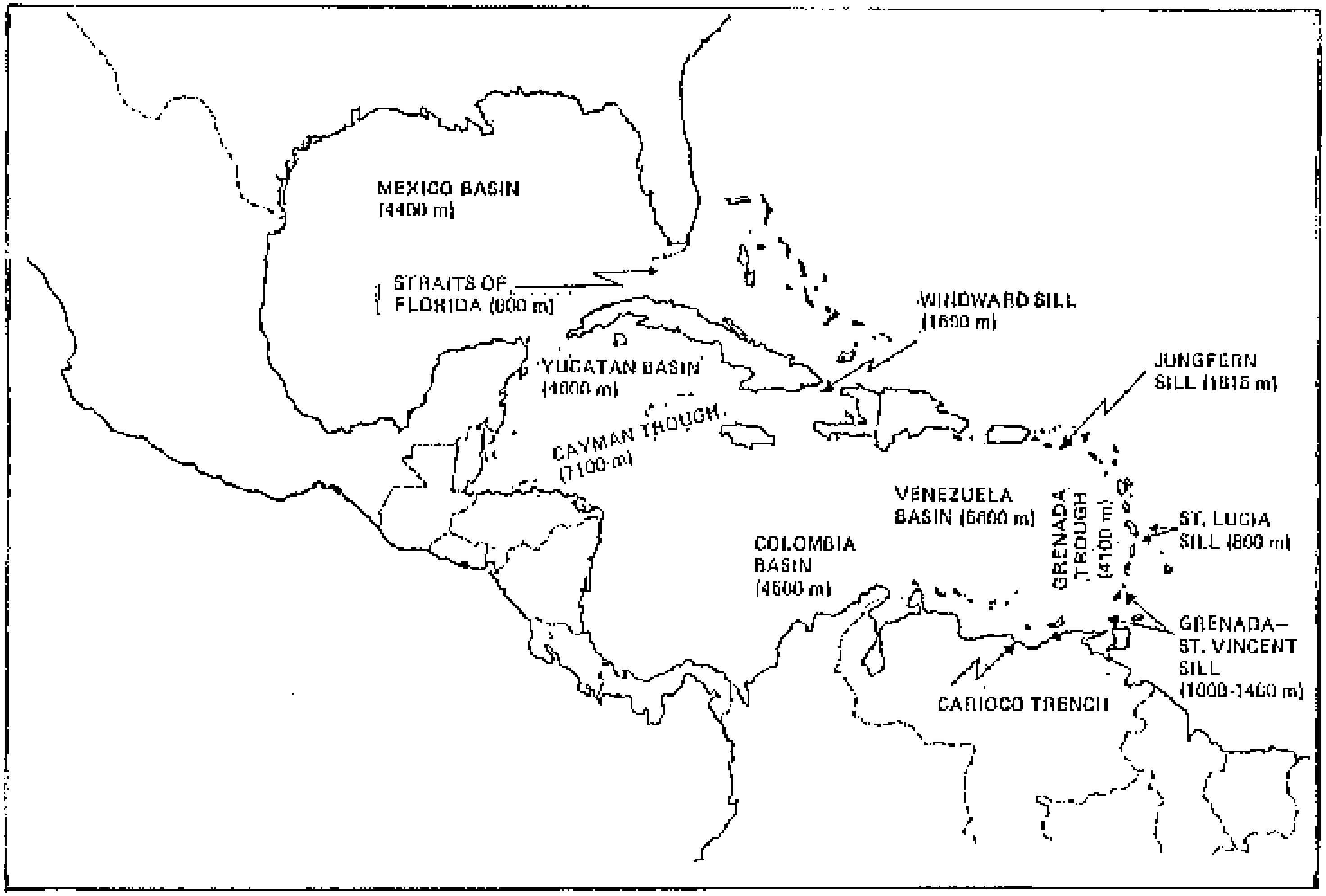


Figure 2: Major basins and sills of the Wider Caribbean

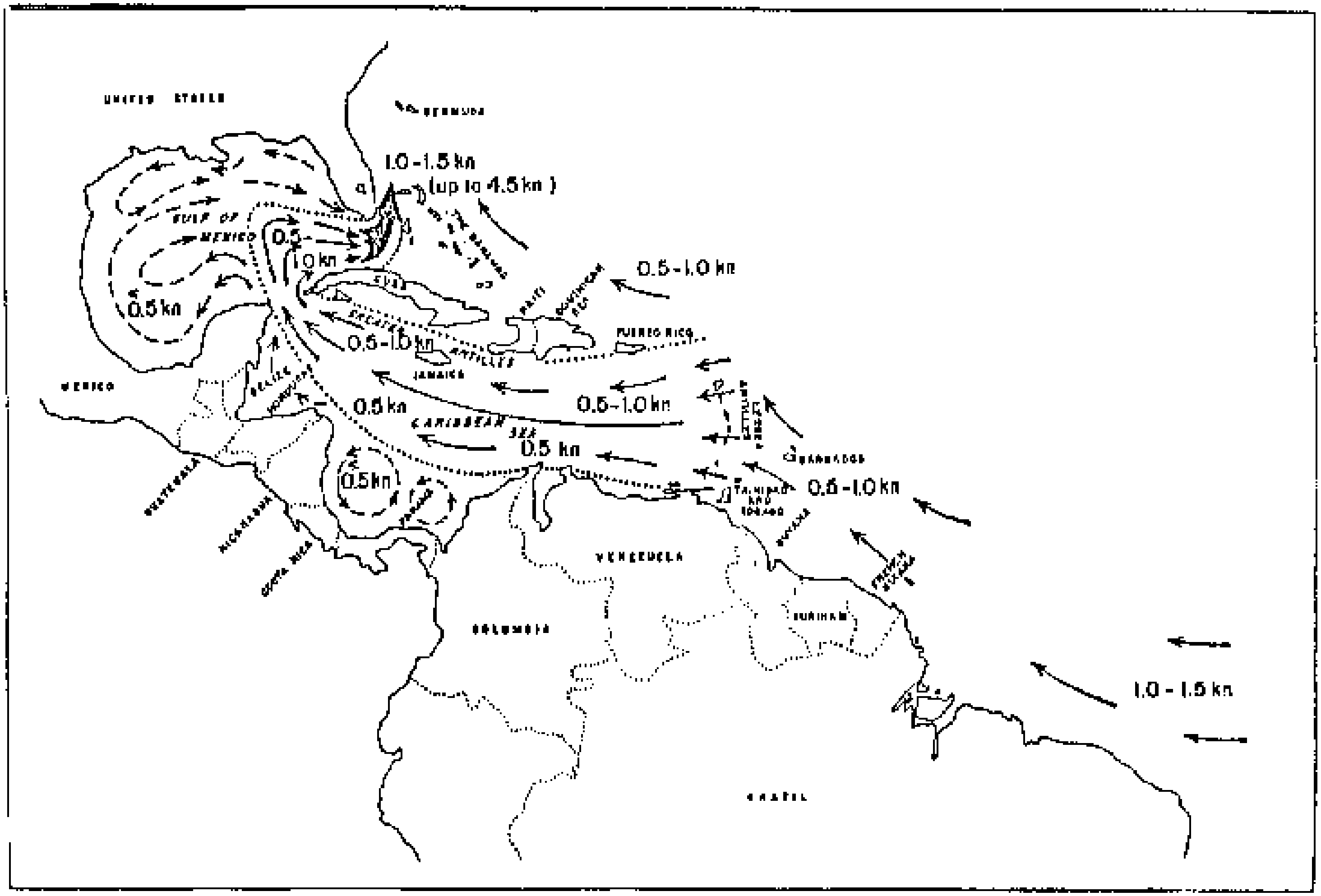


Figure 3: Prevailing currents of the Wider Caribbean (UNESCO, 1977)

"The surface temperature in the tropical parts of the region has an average value of about 27°C and does not vary considerably during the year. The seasonal fluctuations do not exceed 3°C. The same holds true for the southernmost part of the Gulf of Mexico. However, its northern part shows extreme seasonal changes in temperature, from about 16 C in winter to 28°C in summer, so that during the winter months there is a strong latitudinal temperature gradient.

"The cooling of surface waters in the northern and central part of the Gulf of Mexico during winter months also affects the vertical temperature distribution. Whereas in the whole Caribbean area and adjacent seas the temperature decreases by 10-15°C during the first 200 m beyond which depth there is only very slow further decrease, a thermocline layer is formed during the winter in parts of the Gulf of Mexico at depths that may sometimes reach 100 m.

"Although this will have some influence on the mixture of any potential pollutant in the area, more important in this connection seems to be the development of upwelling which takes place, particularly along the north coast of the Yucatan Peninsula from May to October, with a peak in June, and off the north-eastern Venezuelan coast where upwelling is strongest between December and April."

There is a distinct seasonal variation in the surface salinity of the Caribbean (figures 4 and 5). The relatively high salinities between January and May (with maxima > 36.5 $^{0}/_{00}$ in February and March) are regularly followed by lower salinities between June and December (with minimal < 34.5 $^{0}/_{00}$ in October and November). The cause of these variations is the inflow of low salinity water from the south-east in late autumn which arises from input by the Orinoco and Amazon Rivers or by tropical convergence (G. Wust, 1964; D. K. Atwood, 1977).

The deepest of the sills (Windward sill, 1,600 m) are much shallower than the shallowest basins: therefore most of the water in the Caribbean is below sill depth. This raises the question of how much exchange or renewal of this water takes place across the sills. D. K. Atwood (1977), after analysing available data on oxygen, temperature and silicates, concludes that "apparently very little renewal or flushing occurs" in the deeper zones of the Caribbean and therefore "pollutants" that find their way into these waters will not be easily flushed out." The lack of flushing is also illustrated by the example of the deep Venezuelan Basin where, according to V. Worthington (1955), natural processes caused dissolved oxygen to be depleted by 6 per cent in about 20 years. This being the case, it is not unreasonable to expect that the addition of large amounts of oxygen-consuming waste into the depths of this basin could increase the rate of oxygen depletion and possibly lead to anoxic conditions. Unfortunately, present knowledge about the fragility of the Caribbean deep-water system does not permit a reliable estimate of its waste assimilation capacity.

The current systems shown in figure 3 are only yearly averages. Smaller currents or eddies develop seasonally such as the Gulf of Panama and the Gulf of Mexico loop currents (D. K. Atwood, 1977). Therefore, a general estimate of the transport of material, including pollutants, by currents should be made only cautiously, because the large spatial and temporal variability which has been observed in the Caribbean may lead to serious errors if only prevailing current systems are taken into account. As an example, the westerly inflow of water through the island passages of the Lesser Antilles barrier is disturbed in its passage. This results in the generation of turbulent wakes and eddies of large diameter which concentrate nutrients (T. D. Leming, 1971) because of the associated current patterns. The same concentration effect could apply to pollutants.

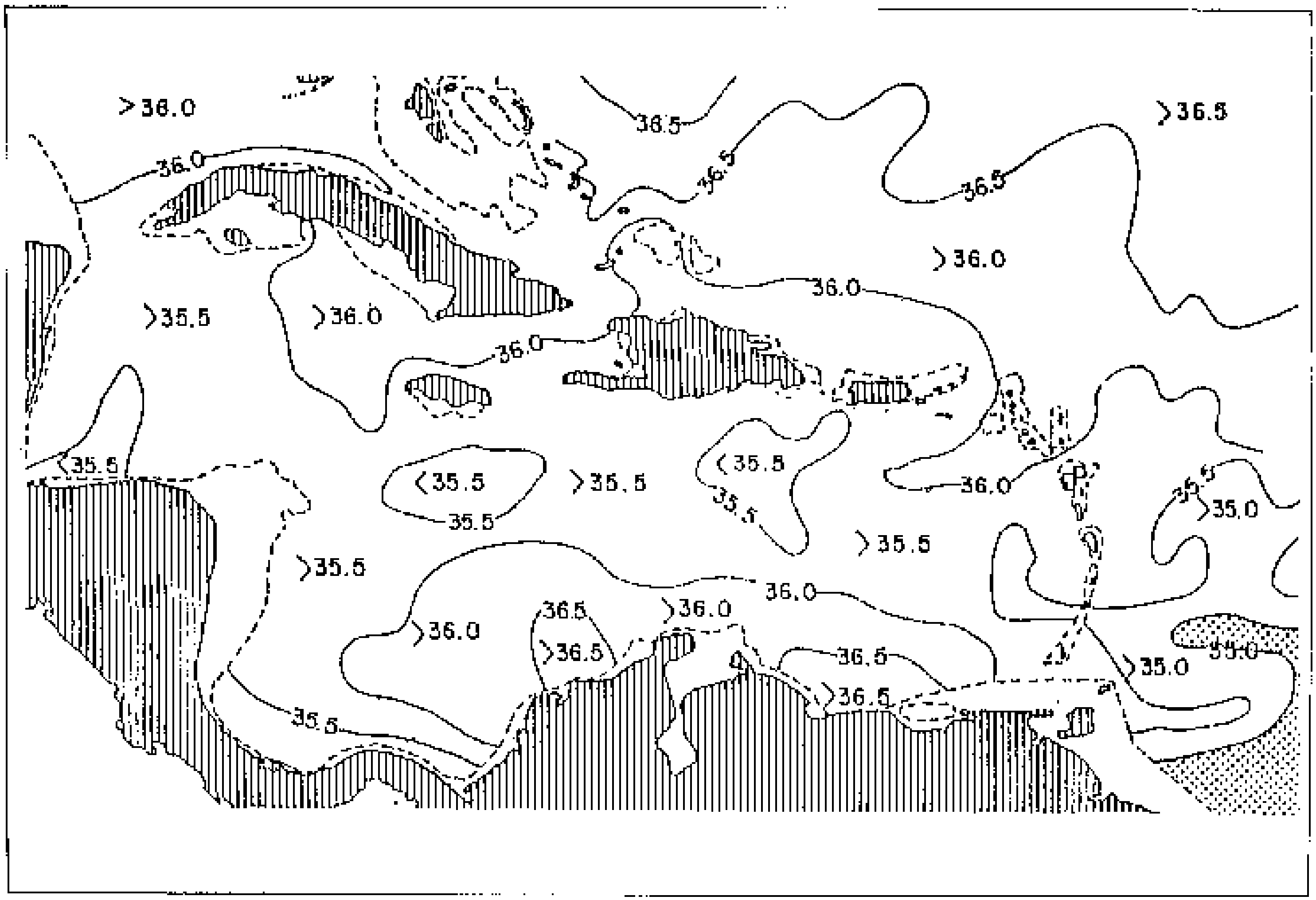


Figure 4: Surface salinity during December to May (Atkins 1977)

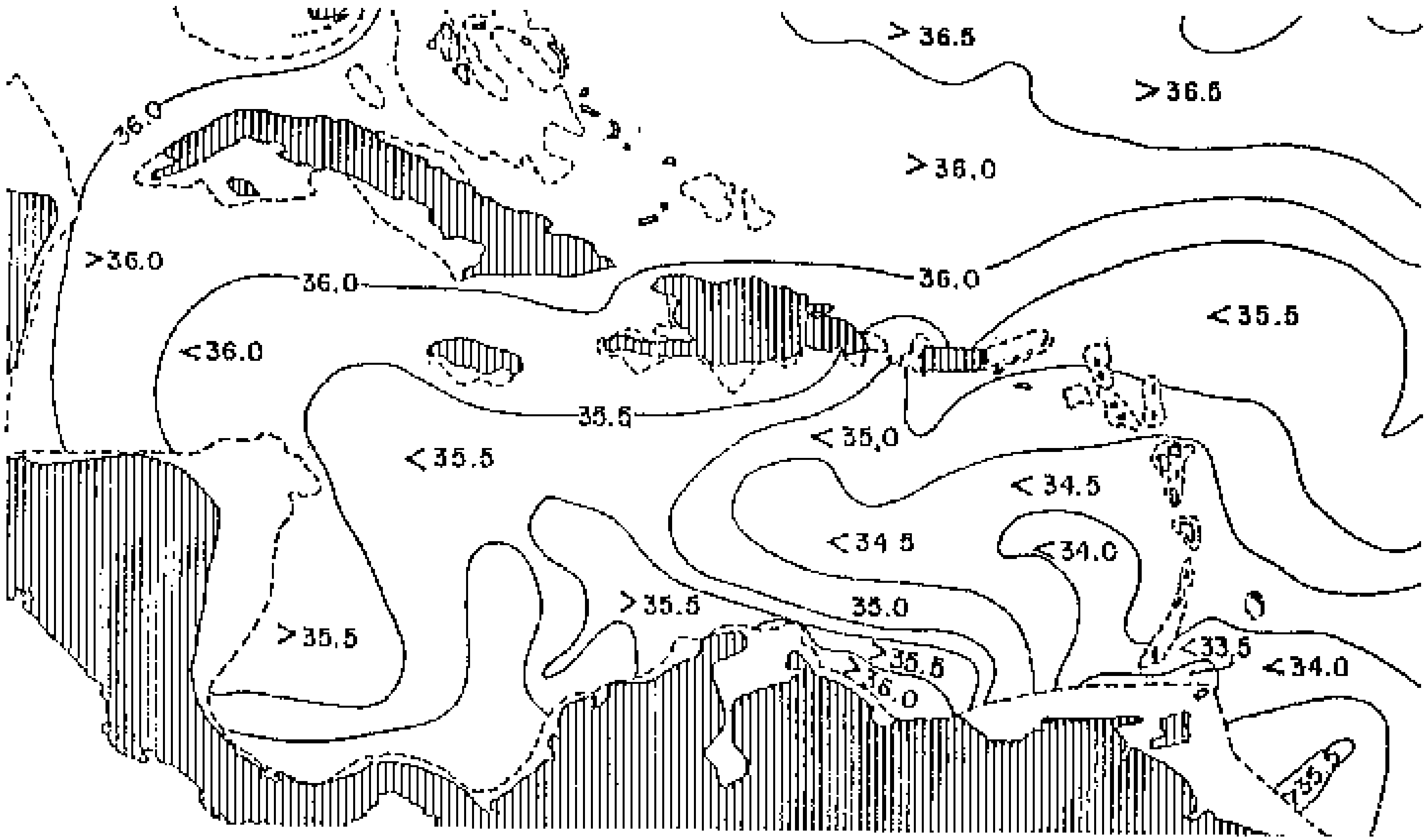


Figure 5: Surface salinity during June to November (Atkins 1977)

The drainage area of the Wider Caribbean Region (J. M. Martin and M. Meybeck, 1977) is about 7.5×10^6 km^2. This includes drainage basins of two of the world's largest rivers, the Mississippi and the Orinoco. The largest is the Mississippi basin, 3.25×10^6 km^2, with an inflow of about 1.8×10^4 m^3/sec while the Orinoco basin discharges about 3.0×10^4 m^3/sec from an area of 0.95×10^6 km^2. Although the Orinoco is geographically outside the Caribbean proper, it has also been taken into consideration because the major current flowing north-west along the Venezuelan coast carries with it most of the Orinoco outflow into the Caribbean Sea. On the other hand, because their influence has not been quantified, outflow from rivers south of the Orinoco (e.g. the Amazon discharges 4 - 5 times more than the Orinoco) have not been taken into account, although their contribution to the Caribbean hydrography must be very significant (G. Wust, 1964).

Other significant, although much smaller, drainage systems within the Wider Caribbean Region are in the Yucatan Peninsula, the State of Florida and Cuba.

Data and estimates relevant to the river inputs into the region are summarized in tables 1 and 6.

Rivers, and in particular their sediments, are potential carriers of a considerable pollution load (J. M. Martin and M. Meybeck, 1977). The Caribbean region is no exception. In view of the size of the river basins drained into the region and their contribution to the Caribbean hydrography (0.5×10^7 m^3/year compared with 3×10^7 m^3/year mentioned earlier as entering the Caribbean through the passages between the islands of the Lesser Antilles), riverborne pollutants should receive special attention.

The total sediment delivery by rivers (table 6) into the Wider Caribbean Region is estimated at about 1×10^9 tons per year (J.-M. Martin and M. Meybeck, 1977).

1.3 Ecosystem distribution

It is commonly accepted that the tropics are much richer in diversity of species than colder regions. This is also true of the edges of tropical seas. A large number of genera, families and systematic groups of a higher order are wholly, or almost entirely, confined to the warm oceans and constitute the basic elements of their ecosystems. Two of the most important systems are coral reefs and coastal mangrove swamps. Another system of importance, even though much less understood, is the sea-grass areas. These are typical of the Wider Caribbean Region but are also probably the most vulnerable ecosystems in the Region. Coral reefs and mangroves are important as land-builders and for the protection of shores from erosion. Sea-grass also may be important in these respects. The mangroves in particular have a high economic value as the irreplaceable habitat for many commercially important species (figures 6, 7 and 8).

Although these coastal areas offer a wide species diversity, certain factors limit not only the ecology of the offshore seas but also the fisheries potential of the Region more substantially than that of temperate seas such as, for example, the North Atlantic or the Norwegian Sea. First, the Caribbean region lacks an extensive, shallow continental shelf. Four-fifths of the waters of the Wider Caribbean Region are deeper than 1,800 m and half are deeper than 3,600 m. Secondly, water temperatures do not fluctuate over a wide range so that there is a relatively stable thermocline which indicates a lack of mixing of surface and deep waters. Although there are significant upwelling areas, they are not a dominant featrue. The result is a restricted nutrient supply which is reflected in the limited fishery in offshore areas. Nevertheless, certain areas, namely the Gulf Coast of the United

Table 1 : Provisional List of Major Rivers Affecting the Greater Caribbean Region[1/]

River	Area (km^2)	Water discharge ($m^3 sec^{-1}$)
USA		
Apalachiocola (Flo)	44,000	620
Mobile (Ala)	97,000	1,500
Mississippi (La)	3,263,000	18,400
Brazos (Tex)	114,000	160
Colorado (Tex)	107,000	79
USA - MEXICO		
Rio Grande (Tex)	467,000	23
MEXICO		
Panuco	66,300	549
Grijalva	36,300	723
Usumacinta	47,700	1,763
GUATEMALA - HONDURAS		
Matagua	16,600	252
HONDURAS		
Ulua	22,500	526
Patuca	25,600	325
HONDURAS - NICARAGUA		
Coco	26,700	950
NICARAGUA		
Rio Grande de Matagalpa	19,700	762
NICARAGUA - COSTA RICA		
San Juan	38,900	1,620
PANAMA		
Changuinola	2,745	204
COLOMBIA		
Magdalena	235,000	7,500
VENEZUELA		
Orinoco	950,000	30,000

1/ Criteria of choice: water discharge more than 200 $m^3 sec^{-1}$ or drainage area more than 100,000 km^2

SOURCE: Martin and Meybeck, 1977.

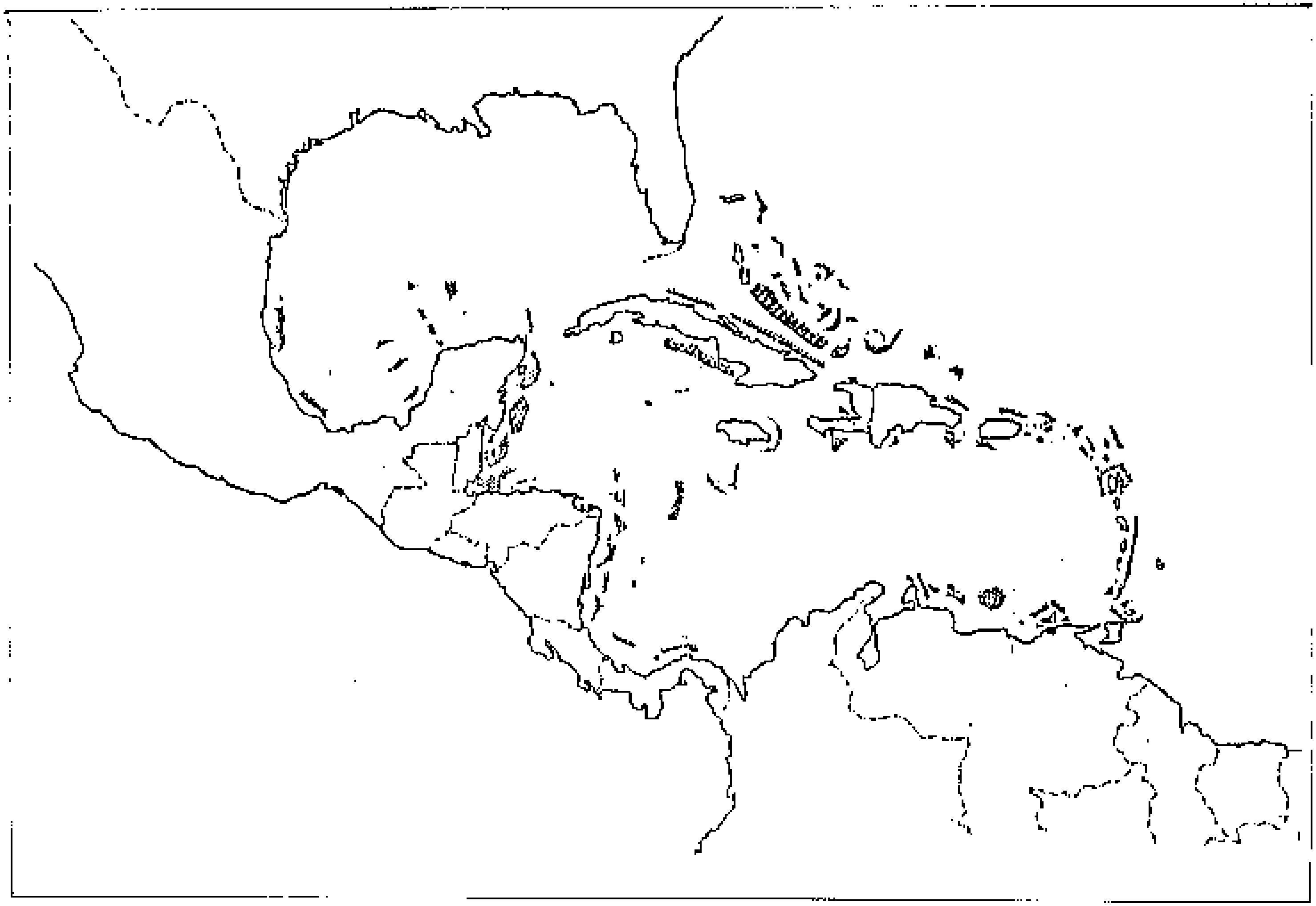


Figure 6: Areas where living coral reefs exist (Sources: Ray, 1979)

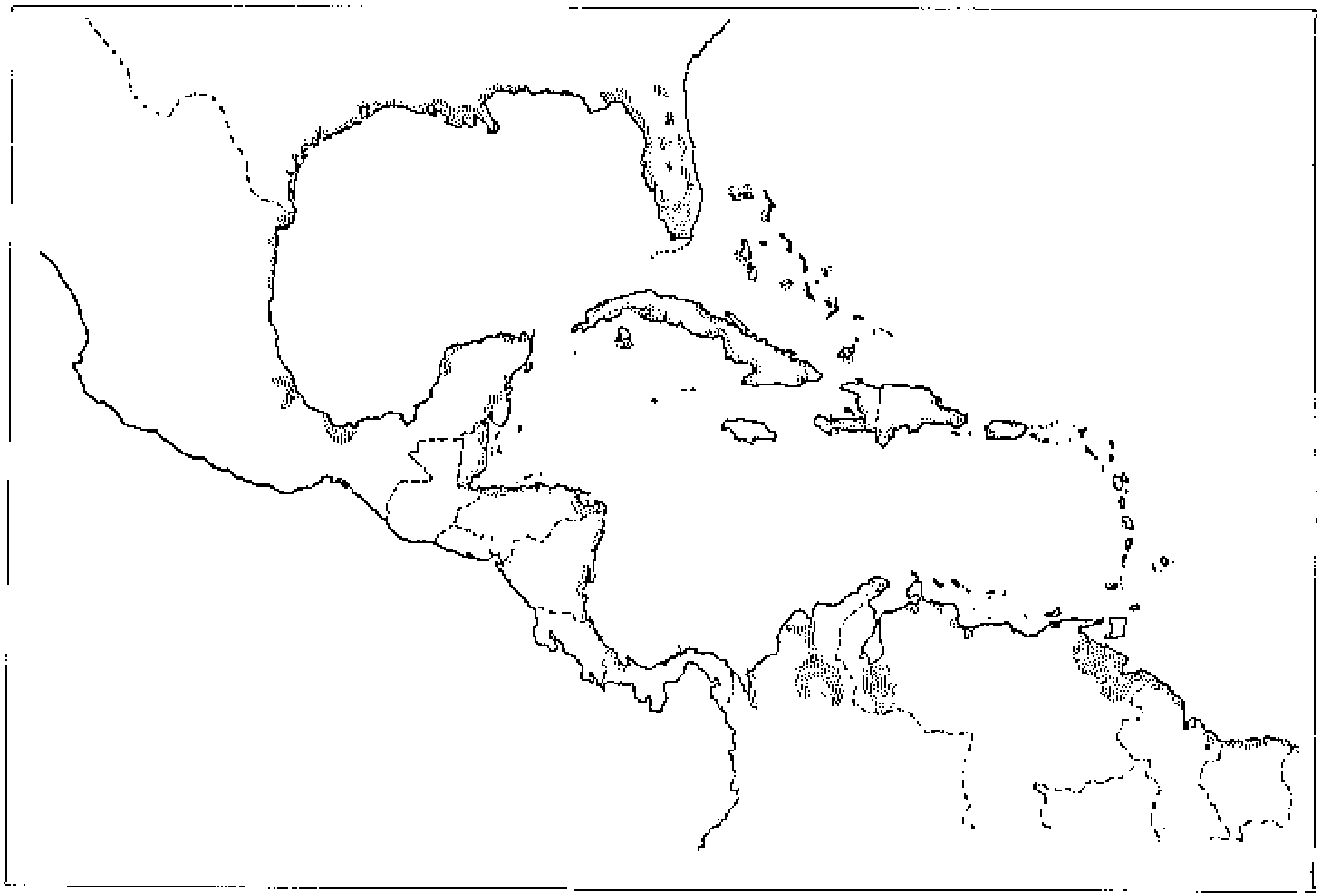


Figure 7: Areas where mangroves exist (Sources: Ray, 1979)

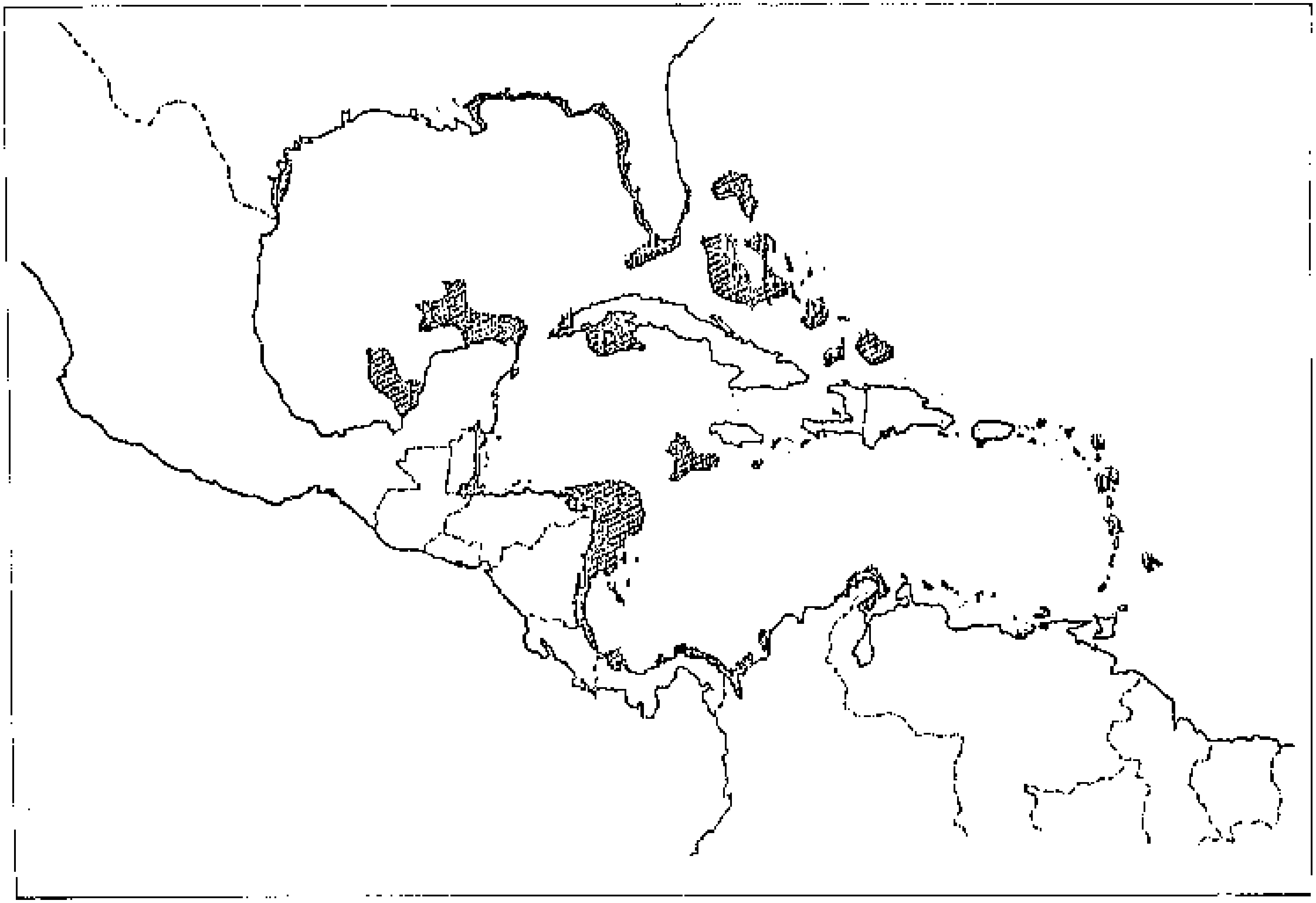


Figure 6: Areas where seagrass exists (Sources: Ray 1979)

States, the Bahia de Campeche, the Jamaican Ridge area and the North Coast of South America, have important commercial shrimp fisheries. Since these are associated with shallow areas, mangroves, estuaries and coastal lagoons, a high premium is placed on the role of coastal ecosystems of great productivity because of the vital life support they provide for the region's fisheries.

Mangroves develop in the intertidal zone of tropical, swampy sea-coast which is rich in sediment and loose mud, thus providing favourable conditions for the growth of mangrove trees (Rhizophora, Avicennia and others). Their prop roots provide a surface for the attachment of marine organisms and reduce tidal currents, thus promoting deposition of nutrient-rich mud and silt. In addition, by breaking the storm-waves and dampening the tidal currents, the sediments they trap help to build, or at least maintain, the coastline against forces of erosion. The roots penetrate into the mud layer and may play an important role in the mineral cycling necessary for maintaining the productivity exhibited by the mangrove community (Golley, 1962). Although mangroves have been generally considered to have limited economic value, they make, in fact, a substantial contribution to the food-webs which support commercial fisheries (Heald and Odum, 1970) by providing "nursery-grounds" for fish, shellfish, prawns and crabs. Mangrove leaves, as they drop and decompose, form the base of a food-web which extends to large predaceous fishes and many birds (figure 9). It is estimated, for instance, that 75 per cent of the pink-shrimp harvest in Florida are dependent on nutrients derived from the mangrove ecosystem. Moreover, mangroves provide a safe and irreplaceable wildlife habitat for a variety of other aquatic animals such as small fishes, crabs, etc., and birds such as egrets, cranes, ibis, etc., and their contribution as part of the estuarine wetland system to the mineralization of organic anthropogenic waste is of practical value. Furthermore, the use of mangroves for wood products such as timber, firewood or charcoal production, is not negligible in many parts of the Caribbean.

Nevertheless, the direct harvesting of goods produced by the mangrove ecosystem, or its destruction by pollution, is minor when compared to inappropriate and ill-conceived development programmes for marinas, harbours, recreational beaches, coastal resorts and coastal residences which, in many cases, were started by clearing out mangroves. There is an alarming rate of deliberate and accidental destruction of mangrove communities which may lead to a considerable reduction of the area covered by them today.

The coral reefs constitute a large biocoenosis which provides a habitat for a great variety of special, sometimes spectacular, fauna. Corals are animals of the phylum Coelenterata and are always associated with coral reefs. In many places, however, coralline algae such as Lithothamnion and Halimeda are as quantitatively important as the corals. Reef formations are limited to waters of less than 50 m with a mean annual temperature of 23°C and above. Temperatures falling much below this in the colder seasons prevent reef formation. These basic requirements are satisfied in many areas of the Wider Caribbean Region which explains the extensive reef systems found in the Region. They extend northwards as far as southern Florida, the northern waters of the Gulf of Mexico and Bermuda, with the two most extensive and dense being found in the Bahamas and off Belize. The reef systems of the Caribbean must be considered as one of the most important ecologically as well as being a major attraction for the multi-million dollar tourist industry.

By contrast, the off-shore waters of the Wider Caribbean Region contain less diverse and abundant species than the near-shore systems just mentioned. This is especially true with respect to commercially exploitable fishes. This situation is due, in part, to the well-developed and stable thermocline which inhibits mixing of nutrient-rich, deep waters with surface waters. Furthermore, as already mentioned, the Region lacks extensive shallow shelves as well as up-welling currents, both of

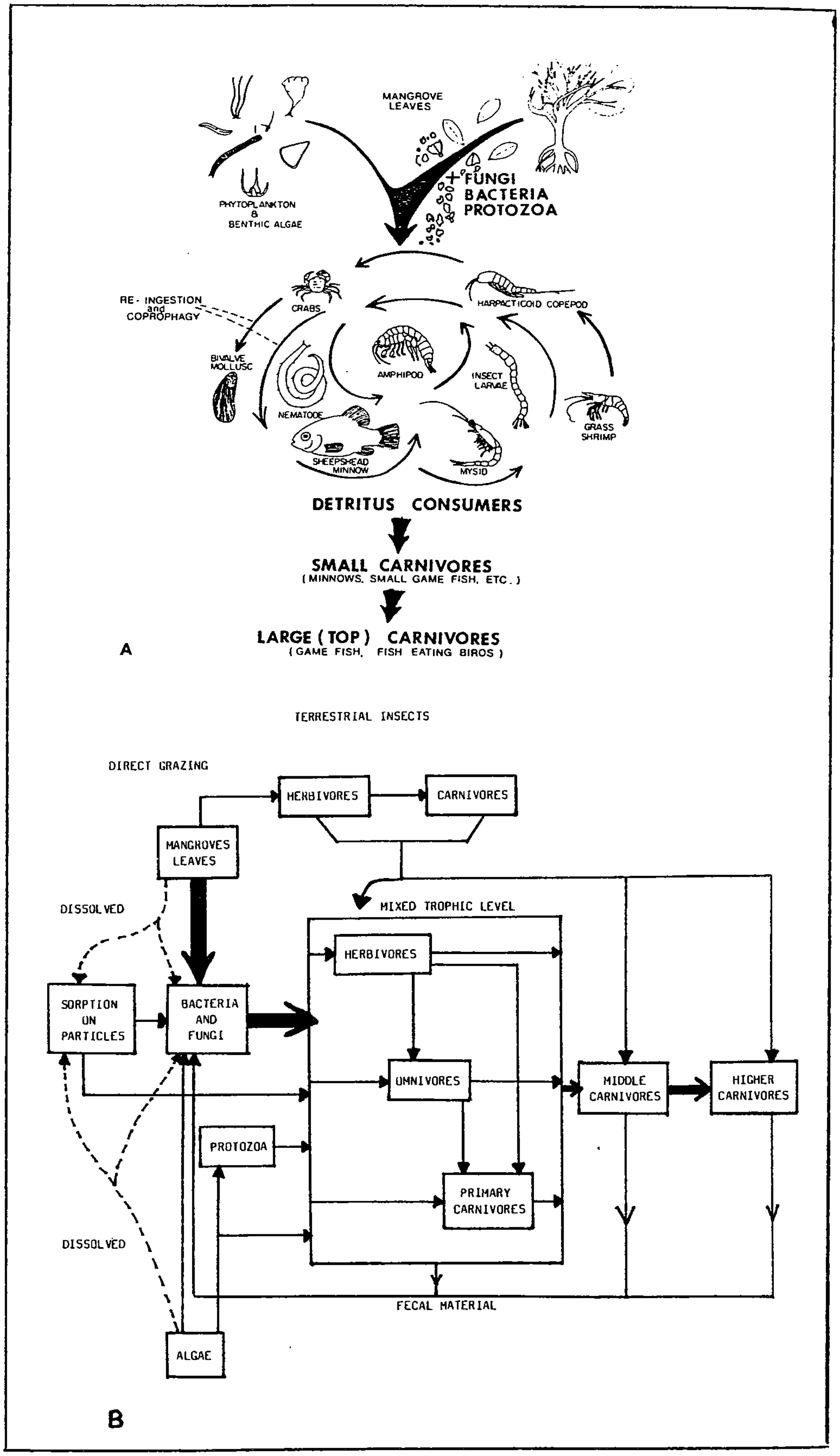


Figure 9: Food web based on mangroves (Source: Odum 1971)

which can contribute nutrients to the surface waters, although some limited up-welling occurs seasonally off northern Yucatan and north-east Venezuela. Thus the region lacks the conditions necessary to support large concentrations of phytoplankton and zooplankton at any one time, and as a consequence fish populations are smaller than in temperate seas and extensive upwelling areas.

2. TYPES, SOURCES AND LEVELS OF POLLUTANTS

Marine pollution is defined by the IMCO/FAO/UNESCO/World Meteorological Organization (WMO)/International Atomic Energy Agency (IAEA)/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution (GESAMP) as the "introduction by man directly or indirectly of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities, including fishery, impairing the quality for use of sea-water and reduction of amenities" (GESAMP, 1976).

The "substances or energy" referred to are the wastes resulting from the transformation of matter to produce goods or energy. These wastes are inherent, and practically unavoidable, in all human activities. The rate or level of consumption of energy and materials by a community is an index frequently equated with the degree of that community's socio-economic development. Not all wastes are pollutants per se, but only those resulting in "deleterious effects." Wastes from one activity may, ideally, constitute a resource for another activity. There are numerous examples of this. Pollution occurs when wastes are not utilized and, in addition, are not assimilated harmlessly by the system into which they are introduced, e.g. the sea. The waste assimilating capacity of the marine environment is very large but not unlimited. When the limit is exceeded, the system is altered, sometimes catastrophically.

The Caribbean in general is a developing region where the level of industrialization and urbanization is still relatively modest in most places. Consequently, general pollution of the marine environment caused by wastes from land-based sources has not, with the exception of oil spills mentioned previously, reached the catastrophic levels found in more industrialized regions. Nevertheless, there are, and have been for some years, localized problems of marine pollution, and there are currently planned activities which are potentially damaging in a general way.

2.1 Socio-economic development of the Region influencing, or influenced by, marine pollution

A large number of political entities with a striking diversity of cultural and historic backgrounds, natural resource endowments, political organization and degrees of socio-economic development, share as a common resource the waters of the Wider Caribbean Region.

There is an estimated population of 160 million in the riparian countries and States of the USA which border these waters (United Nations, 1978). However, only a fraction of this population is concentrated along the coasts of the Region. Coastal cities with populations of more than 100,000 are illustrated in figure 10. In the case of some islands the entire population should be considered as coastal. The level of the socio-economic development in the Region is tremendously diverse with per capita incomes ranging from $170 to $13,000 per year (United Nations, 1978).

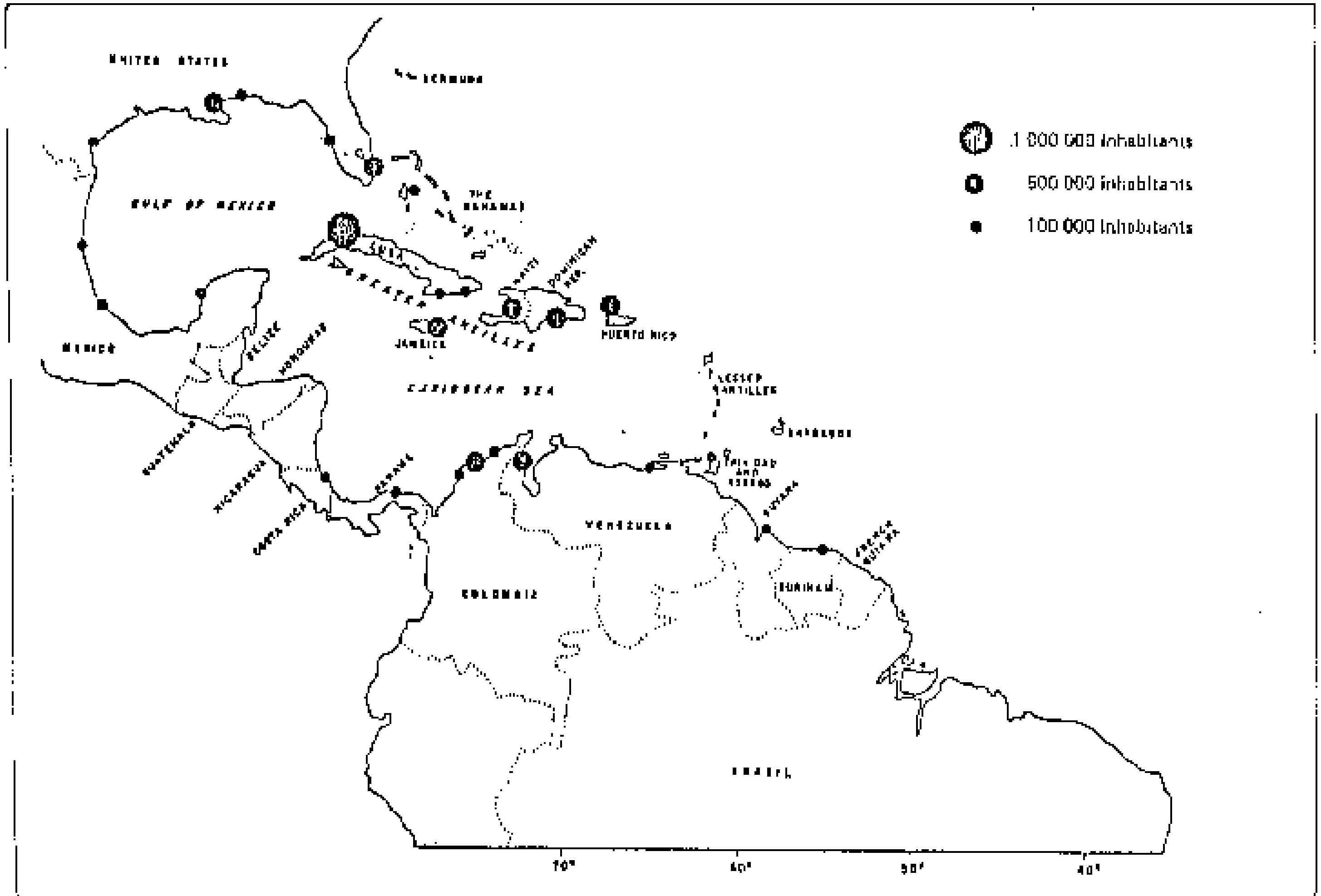


Figure 10: Coastal cities with populations of more than 100,000

Export-oriented single-crop agriculture, mainly sugar, has been the principal economic activity of most of the Caribbean States during the past century or so, with the few exceptions of mineral-rich territories that export raw ores. With post-war increase of capital investment and technology transfer, many countries have shifted towards other sectors such as manufacturing and tourism. In general, however, most of the countries of the Region still have monocultural, export-oriented economies devoted to the production of basic commodities either agricultural or mineral or both. Although shifts to industrialization have sometimes resulted in a reduction of agricultural output, in general they have encouraged energy-intensive agricultural practices. With this has come increased use of fertilizers and chemicals in some countries of the region. It is expected that the consequence of further modernization will be the increased applications of agricultural chemicals, especially pesticides. The environmental impact of these chemicals on the tropical system of the Wider Caribbean Region still needs to be determined.

Although there is not, in general, widespread industrialization in the Region, certain local areas are being intensively industrialized as processing centres for indigenous or imported raw materials. In fact, the expansion of processing indigenous raw materials, especially oil, in the case of resource-endowed countries, or the development of trans-shipment and processing facilities for imported raw materials by countries lacking natural resources seems to be a major strategy of the developing countries of the Region. In addition, another recent trend towards industrialization can be observed where attempts are being made by large trans-national corporations to capitalize on the Region's inexpensive labour and in some cases on legal concessions not available elsewhere.

Parallel to industrialization and intensification of agriculture, other sectors of the economy, such as tourism and fisheries, are being pursued with varying degrees of intensity by different countries. In fact in some of the smaller islands of the eastern Caribbean, marine-resource-oriented tourism is a major source of national income.

To summarize: because of its diversity, it is not easy to generalize on the socio-economic situation of the Region except to stress that raw materials production, intensification of agriculture and industrialization are steadily increasing. In many countries, especially the smaller eastern islands, with limited exploitable natural resources, tourism is being developed. In most cases all these activities are being superimposed on economies that have been oriented towards monocultural labour-intensive agriculture, limited natural resource exploitation or self-sustaining agrarian activities and fishing. As many of the activities are taking place in the coastal zone they threaten the marine environment through direct injection of wastes, alterations in coastal ecology, poor land-use practices, air and run-off pollution, and others.

When reading the following summary of specific marine pollution sources, it must be borne in mind that a thorough assessment of the Region's problems has not yet been undertaken and, as a result, information is either incomplete or non-existent for some countries, while in others a great deal has been accomplished. Indeed this is the major impetus for having a Caribbean Environment Programme.

2.2 Industrial waste

Apart from contamination by petroleum hydrocarbons (reviewed in section 2.6) there is no widespread marine pollution in the Wider Caribbean Region although severe, localized environmental problems do occur mainly in the vicinity of large urban or industrial areas. These problems threaten the development of certain economic activities, such as coastal tourism and fisheries, which depend on a healthy marine environment. The increasing pace of industrial development of the Region will inevitably increase the risk of environmental disruption unless adequate and timely measures are taken, including careful selection of sites for future industrial activities, application of appropriate waste treatment and disposal practices and selection of appropriate technological processes.

The largest industrial concentrations in the Region can be found along the coasts of Venezuela, Colombia, Mexico, Cuba, the Gulf States of the United States of America, Puerto Rico, Trinidad and Tobago, the Netherlands Antilles, the US Virgin Islands and Jamaica. Industrial development in the Central American States with the exception of the San Pedro Sula area on the north coast of Honduras, is mainly along or oriented towards the Pacific coast rather than the Caribbean (UN/DIESA, 1979).

Disposal of chemical wastes in the Gulf of Mexico has been taking place for some time, mainly from chemical plants situated in the coastal areas of Texas and Louisiana. A sampling of the types and quantities of material disposed of are presented in table 2. Many of the compounds listed are known to be highly toxic and therefore potentially damaging to marine life. Evidence is given by Giam et al., (1978) that two types of industrial chemicals, polychlorinated biphenyls (PCBs) and phthalate ester plasticizers are already present in a variety of marine organisms.

The mining of minerals (table 3) frequently generates wastes harmful to marine ecosystems. The marine disposal of red mud tailings from bauxite mining practised in certain countries (UN/DIESA, 1979) is potentially damaging to marine ecosystems especially coral reefs, and thereby fisheries resources. Added to this is destruction of the aesthetic quality of the beaches which reduces their use for tourism and recreation. Similarly, beach-sand mining for the construction industry, although not introducing pollutants as such into the marine environment, is widespread. Indeed, it may be the single most destructive coastal industrial activity, producing severe and irreparable beach erosion in many places (Deane et al., 1973). In addition it introduces particulate material to the water column. It might also cause, temporarily, high turbidity in the waters and blanketing of highly productive benthic communities such as coral reefs.

2.3 Domestic waste

Marine pollution caused by domestic wastes, mainly from urban areas, is generally known to be a problem common to the whole Region and is associated with all major cities in the area. In some locations sewage pollution has already resulted in potentially hazardous conditions for human health and the marine environment (Wade, 1972). Although no complete systematic survey of present waste management practices by coastal communities appears to have been carried out, data from 1974 indicate that less than 10 per cent of the sewage systems had treatment facilities. It is probable that this percentage has not changed (Butrico, 1979). Data on sewage systems in urban areas as furnished by countries of the region is presented in table 4.

Bearing in mind the few treatment facilities presently in operation and estimates that sewage generated by 30 million people is dumped untreated into the Caribbean (Butrico, 1979) it is doubtful, in the short term, that development of treatment capacity will keep pace with population and industrial growth. As a result, the assimilative capacities of natural waters, particularly coastal lagoons and estuaries, will continue to be exceeded.

Table 2 : Partial list of chemicals authorized by EPA (USA) for dumping in Gulf of Mexico during a seven month period in 1973

Description of Material	Average Concentration (wt/wt%)	Kg. Dumped/ month
Containers:		
Metallic Sodium	60	9.2×10^4
Metallic Calcium	13	1.8×10^4
Calcium Oxide	4	5.5×10^3
Sodium Oxide	13	1.9×10^4
Inert Salts	10	1.4×10^4
	4.3	1.3×10^6
Direct Discharge:		
2,5 - dichlorobenzoic acid (Na salt)	0.2	3.3×10^4
2,5 - dichloro - 6 nitro - benzoic acid (Na sait)	6.0	9.8×10^5
2,3 - dichloro - 6 - nitro-benzoic acid (Na salt)	0.7	1.1×10^5
2,5 - dichloro - 4 - nitro-benzoic acid (Na salt)	0.8	1.3×10^5
2,5 - dichloro - 3 - nitro-benzoic acid (Na salt)	0.3	4.9×10^4
Acrylonitrile	0.005	1.1×10^3
Acetonitrile	0.01	2.2×10^3
Heavy Nitriles	0.4	9.9×10^4
HCN		6.6×10^3
Sulfate as $(NH_4)_2SO_4$	4.7	1.0×10^6
Methanol	1.6	3.5×10^5
Propanol	1.6	3.5×10^5
Iso-butanol	1.6	3.5×10^5
Dinitrophinol	0.01	2.2×10^3
Benzene	0.06	1.3×10^4
Dinitrobenzene	0.001	2.2×10^2
Nitrobenzene	0.01	2.2×10^3
Aniline	0.01	2.2×10^3
Methylene Chloride	0.1	3.2×10^4
Formaldehyde	0.1	3.2×10^4
Sodium Terephthalate	7	4.8×10^5
Ethylene Glycol	7	4.8×10^5
Sodium Styrene Sulfonate	1	6.8×10^4
Trichloropropane	22	3.7×10^5
Tetrachloropropyl ether	8	1.4×10^5
Dichloroethane	10	1.7×10^5
Trichloroethane	25	4.2×10^5
Dichlorobutance	30	5.1×10^5
Other Organics (mostly Thiuram compounds)	1.0	3.2×10^5
Others consisting of:		
Dichloropropene		
Dichloropropane		
Allyl Chloride		
Dichlorohydrin		
Glycerine		
Tetrachloroethene		
Trichloroethylene		
Tetrachloroethylene		

SOURCE: NSF, 1975

Table 5

MINING PRODUCTION FOR SELECTED ORES WITHIN THE GREATER CARIBBEAN DURING 1976

Country	Bauxite	Chromium ore (Cr_2O_3 content)	Copper ore (Cu content)	Lead ore (Pb content)	Manganese ore (Mn content)	Mercury ore [3]	Nickel ore [3]	Tin concentrates (Sn content)	Zinc (Zn content)	Iron ore (Fe content)
Colombia						3 [5]				498
Costa Rica										
Cuba		10	2.9		27.9 [2]		37,103 [4]			
Dominican Republic	621						24,359			
Guatemala				0.1						
Guyana	3,203									
Haiti	739		6.6 [1]							
Honduras				20.1					20	
Jamaica	10,309									
Mexico			89	200	563	810	56	406	259	3,644
Nicaragua			0.6							
Surinam	487									
Trinidad and Tobago										50,153
United States	420		1,456	553	28	808	14,940		439	11,585
Venezuela										

Notes : (1) 1971
(2) 1966
(3) metric tons
(4) 1973 content of oxide and sulphide
(5) 1979

Source : UN Statistical Yearbook, 1977

Table 4 : Population served with sewerage systems in the Greater Caribbean Region

Country	Urban Pop. served in 1000s	%	Total Pop. served in 1000s	% Total Pop.
Antigua	0	0	0	0
Barbados	0	0	0	0
Belize	4	5	5	3
Colombia	9,958	65	10,611	41
Costa Rica	404	42	446	21
Cuba	2.788	46	2,988	31
Dominica	0	0	0	0
Dominican Republic	600	27	1,030	21
El Salvador	648	36	659	15
Grenada	10	36	10	13
Guatemala	725	31	725	11
Guyana	118	43	118	14
Haiti	0	0	0	0
Honduras	444	48	445	16
Jamaica	133	21	153	7
Mexico	16,390	41	16,483	27
Montserrat	0	0	0	0
Nicaragua	403	31	403	17
Panama	874	97	1,534	88
Suriname	85	38	85	21
St. Kitts	0	0	0	0
St. Lucia	0	0	0	0
St. Vincent	0	0	0	0
Trinidad	252	69	292	27
Venezuela	5,000	52	5,267	40

SOURCE: Reid. 1979.

In addition to the domestic sewage load from local urban centres there are additional problems caused by the numerous resort hotels present throughout the region, particularly in the insular Caribbean. Many of these hotels are equipped with "package" sewage treatment plants which are often overloaded or inadequately maintained. The result is discharge of sewage in close proximity to bathing beaches (Mood, 1977).

Finally, contamination of the marine environment by human wastes and garbage discharges from watercraft is considerable in many areas throughout the Caribbean (Mood, 1978).

2.4 Agricultural waste

Sources of pollution of the marine environment from agricultural activities can be categorized broadly in terms of (i) inorganic fertilizers; (ii) pesticides; (iii) liquid effluents containing high organic loads (from industries such as sugar refineries and rum distilleries); and (iv) high silt content run-off resulting from poor soil management practices (the latter is dealt with in section 2.5). Although data on the importance of these sources are fairly scarce there are indications that pollution stemming from agricultural activities has occurred and may have already become serious.

The inorganic fertilizers utilized in the Wider Caribbean Region are mainly nitrogen or phosphorus-based compounds or potash. Consumption figures for two representative periods are presented in table 5 (United Nations, 1978). Leaching of these by rain produces run-off with high nutrient content. This in turn leads to eutrophication of rivers and estuaries when the elevated nutrient levels lead to rapid proliferation of algae or "algal blooms" followed by high biological oxygen demand (BOD) when the bloom dies and decay processes occur. Although not substantiated by analytical measurements, there is evidence that such problems exist in some countries of the region (Gajraj, 1977).

Analysis for the DDT and DDE in the tissues of reef-dwelling groupers in the Gulf of Mexico and Grand Bahamas showed that these compounds are present (Giam, 1974). Of the three reef systems analysed, those in the Gulf of Mexico had a higher level concentration of the residues. Another study of plankton and a variety of shrimp and fish from the Gulf and Northern Caribbean showed that DDTs were widely distributed although the levels were generally low. The samples with the highest concentrations were coastal areas. In addition to input from local use, these compounds may be carried to the Caribbean from outside the Region. Evidence has been presented, for example, that the trade wind system of the Atlantic region deposits chlorinated hydrocarbons in amounts comparable to those transported to the sea by major rivers (Bidleman and Olney, 1973; Windom and Duce, 1976). Thus a clockwise circulation around the high pressure centre of the Azores is said to result in transport of such compounds in aerosols from Europe and North America to the lower latitudes of the Atlantic and the Caribbean.

One major study of pesticide residue distribution through the ecosystem is under-way in Colombia although not in the coastal area. Other studies have been carried out in relation to the application of pesticides to cotton and other crops in Central America but none has dealt with the concentration level and impact of these substances on the marine environment (Davies et al., 1975).

As an increase in the use of pesticides is expected in the Wider Caribbean Region, steps should be taken to develop pilot monitoring programmes in areas of potential contamination to assess the concentration levels and their bioaccumulation in the

Table 5 : Fertilizer Consumption in the Wider Caribbean Region in 1976/1977
(Thousand metric tons)

COUNTRY	Potash (K_2O)	Phosphate (P_2O_5)	Nitrogenous (N)
Bahamas	0.5	0.4	
Barbados	1.5	1.9	0.4
Belize	-	1.2	0.6
Colombia	34.5	54.3	69.9
Costa Rica	16.8	40.0	10.4
Cuba	116.0	175.6	57.5
Dominican Republic	19.4	15.0	21.4
El Salvador	8.7	-	-
Guadeloupe	3.2	1.8	3.0
Guatemala	19.0	19.4	26.3
Haiti	0.1	0.2	-
Honduras	5.4	13.0	9.0
Jamaica	5.7	10.0	1.3
Martinique	4.1	5.3	6.4
Mexico	50.0	392.2	223.6
Nicaragua	8.8	17.0	14.0
Panama	7.5	14.3	4.2
St. Kitts-Nevis-Anguilla	1.2	0.2	0.5
St. Lucia	1.2	1.0	1.3
St. Vincent	1.0	1.2	0.4
Trinidad and Tobago	2.4	5.0	0.2
U.S. Virgin Islands	-	0.2	0.2
Venezuela	40.0	22.1	46.3

SOURCE: United Nations Statistical Handbook, 1977.

trophic chains in the marine and coastal communities.

One of the major crops in the Caribbean is sugar cane from which sugar and rum are produced. On some typical islands, 30 per cent of the arable land is under sugar cane cultivation. On at least one island, Barbados, over 50 per cent of the total area of the island at any one time is under sugar cane. In addition to the usual potential pollutants associated with agriculture, the sugar industry produces large volumes of water with high BOD and solid wastes, i.e. filter press cakes and bagasse (Gajraj, 1978).

2.5 Pollutants carried by rivers

The total amount of river water discharged to the Wider Caribbean Sea is approximately 2.8×10^3 km^3/year (2.8×10^{15} litres per year - Martin and Meybeck, 1977). This includes two of the world's largest rivers, the Mississippi Mississippi and the Orinoco. Some rivers in Colombia, Mexico, Guatemala and the United States are currently being monitored for various pollutants or pollutant-related parameters. However, the number involved to date is still quite limited (WHO/UNEP, 1979).

Monitoring and control of pollutant discharges in rivers flowing into mangroves, coastal lagoons, estuaries and coral reefs are of particular importance because these areas are the primary source of biological productivity for the Wider Caribbean Region. For example, increased sediment loads of many small rivers resulting from soil erosion have been reported as fatal to coral reefs and other communities subjected to the influence of such river flows (Johannes, 1970).

A summary of data concerning some of the more important rivers of the region is presented in table 6.

2.6 Oil pollution

Contamination by petroleum hydrocarbons seems to be the most serious marine pollution problem of the region and is reviewed in detail in a separate report (IMCO, 1979).

The production, conversion and transportation of petroleum and petroleum products are the most significant economic activities in the Wider Caribbean Region.

2.6.1 Production

The Wider Caribbean Region is potentially one of the largest oil producing areas in the world. Existing and projected production areas onshore and offshore are located along the coast of Venezuela, Trinidad and Tobago and in the Gulf of Mexico. For the entire region nearly one-third of the total oil production or 3.1×10^6 B.P.D. (in 1978) was from offshore (IMCO, 1979). Significant expansion is expected; in just two countries there are planned, and under construction, no less than 38 offshore platforms scheduled for installation within the next 18 months (Ocean Industry, 1979).

Based on past experience, an estimated 6.7 per cent of the total offshore production spills into the marine environment as a consequence of pipeline accidents, blow-outs, platform fires, overflows and malfunctions and other minor occurrences. These sources accounted for the release into the Wider Caribbean waters of an estimated 76.6 million barrels of oil during 1978 (IMCO, 1979). Figure 11 illustrates oil spill high-risk zones associated with offshore production.

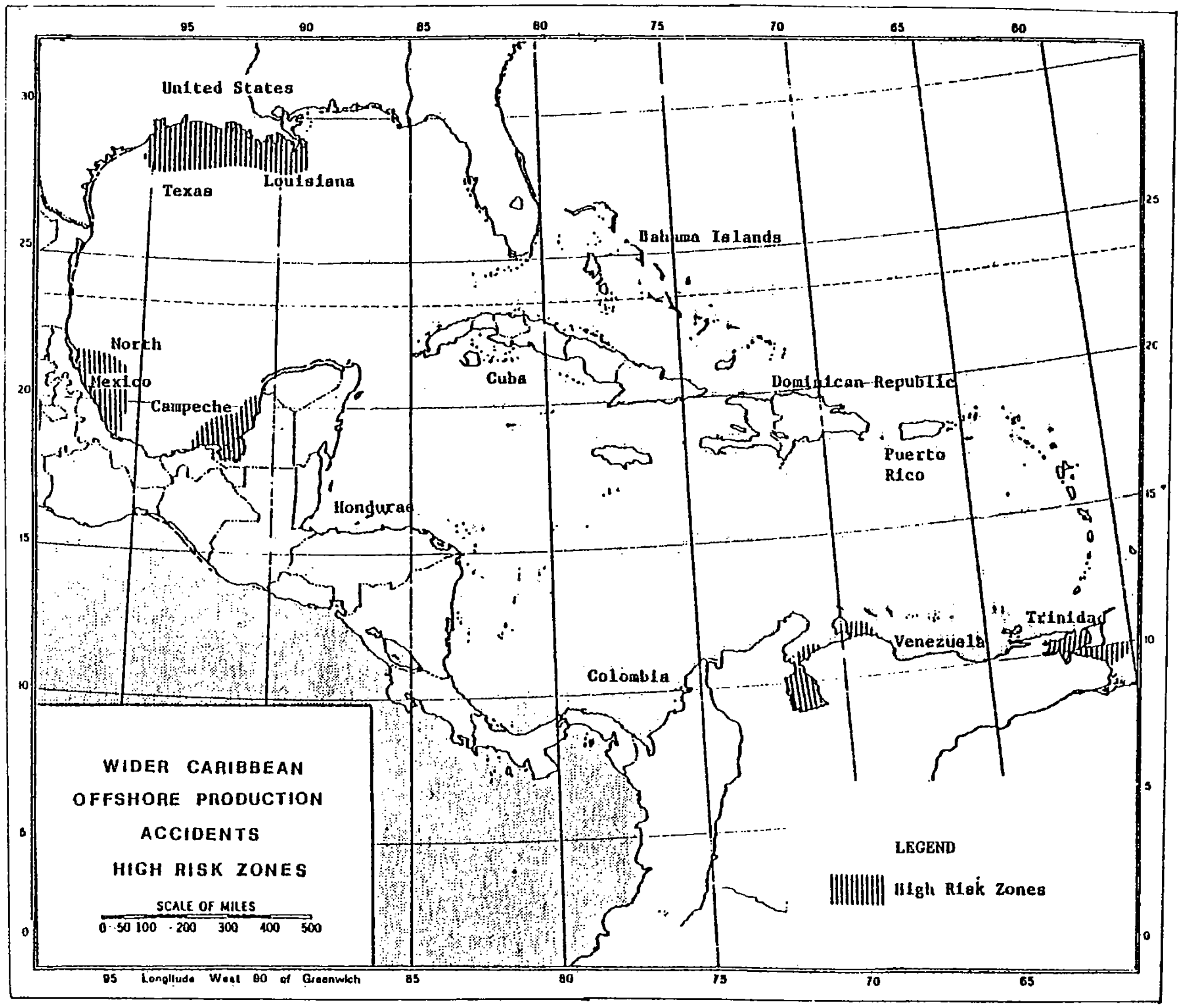
Table 6 : Partial List of Sediment Discharge by Rivers into the Gulf of Mexico and the Caribbean Sea

River	Drainage area at the station (10^3 km^2)	Sediment discharge (10^6t.per year)	Specific transport ($t.km^{-2}$ per year)	Mean turbidity ($mg.l.^{-1}$)
<u>USA</u>				
Mississippi	2,923	222	76	380
Apalachicola	44	0.16	6.8	15
Mobile	95	4.5	42	95
Brazos (Tex)	114	15.9	139	3,200
Colorado (Tex)	106	1.9 1/	17.9	
Rio Grande	467	very low 1/		
<u>COLOMBIA</u>				
Magdalena	235	234	1,000	1,000
<u>VENEZUELA</u>				
Orinoco	950	85.0	91	90
<u>EL SALVADOR</u>				
Rio Grande at Moscoco	2,350	0.5	214	
<u>HONDURAS</u>				
Choluteca	1,510		246	
<u>COSTA RICA</u>				
Reventazon	1,367	3.5	2,600	
Grande	638		126	
<u>NICARAGUA</u>				
Viejo	854		35.9	
<u>PANAMA</u>				
Barjano	3,218		811	

1/ Low values due to dams

SOURCE: Martin and Meybeck, 1977.

Figure 11


United States
Texas
Louisiana
Bahama Islands
North
Mexico
Campeche
Cuba
Dominican Republic
Puerto
Rico
Honduras
Trinidad
Venezuela
Colombia
WIDER CARIBBEAN
OFFSHORE PRODUCTION
ACCIDENTS
HIGH RISK ZONES
SCALE OF MILES
0 50 100 200 300 400 500
LEGEND
High Risk Zones
Longitude West 80 of Greenwich

2.6.2 Refining

Besides the offshore production areas, another source of oil pollution in the region is associated with oil refineries and related facilities. The present refining capacity in the Wider Caribbean Region is estimated to be 12.1×10^6 B.P.D. distributed in 73 refineries (IMCO, 1979). Although there are no estimates for the Caribbean on the amount of waste oil reaching the marine environment from coastal refineries, an extrapolation of data from other regions can be made. For example: in a recent study of one small coastal refinery in the Middle East, it was found that approximately 7.5 barrels of oil per day were routinely pumped back into the sea with the used refinery process waters (Cramer and Warner, 1975). Data from nine years of terminal operations at Milford Haven, U.K., indicate spill rates of 1.1 barrel for every million barrels throughput, which is considered to be a very low rate (IMCO, 1979). Similar rates of release for the Caribbean would imply that operational spillages resulting from refineries are only of localized significance.

2.6.3 Transportation

The Wider Caribbean now serves three major oil transportation activities:

a) The pathway for the transportation of Middle Eastern, West African, and North African crude oil to the United States usually by supertanker with a stop for refining, trans-shipping or lightering and subsequent transport by smaller vessels to the U.S. coast.

b) The pathway for shipping either crude or refined products from Venezuela and/or Aruba, Curaçao and others to various world markets.

c) The shipping of Alaskan crude oil through the Panama Canal to the U.S. Gulf Coast, the Virgin Islands or U.S. east coast refineries.

In the future the transport of crude oil or refined products from Mexico may become another major pathway.

In addition to the major pathways, the Caribbean serves for the transport of both crude oil and refined products to the many user countries in the Wider Caribbean area.

About 5 million barrels of oil are transported through the Wider Caribbean waters every day. To transport this oil, a relatively intensive tanker traffic is generated within the region. Tanker movements through restricted channels and in the vicinity of some ports increase the possibility of shipping accidents in those areas. Figures 12 and 13 illustrate these high-risk zones, and table 7 shows the likely points of impact of spills resulting from accidents within the high-risk zones.

In addition to major oil spills resulting from tanker accidents, significant discharges of oil into local Caribbean ports occur as a consequence of ballasting, ship cleaning, tank washings and docking and undocking operations. Discharges of tank washings into the Atlantic, as well as the Caribbean, amount to the greatest continual tanker-related dose of oil pollution to the marine environment and are believed to be responsible for the tar spots and tar balls which often appear on Caribbean and Gulf of Mexico beaches.

It has been estimated that oily discharges from tank washings within the Wider Caribbean waters could be as high as 7 million barrels in one year (IMCO, 1979).

Figure 12


United States
Mexico
Cuba
Bahama Islands
Dominican Republic
Puerto Rico
Honduras
Colombia
Venezuela
Trinidad
HIGH RISK SHIPPING ZONES
WIDER CARIBBEAN AREA
SCALE OF MILES
0 50 100 200 300 400 500
Longitude West 90 of Greenwich
1. Trinidad-Tobago Channel
2. Anegado Passage
3. Mona Passage
4. Windward Passage
5. Jamaica Channel
6. Yucatan Channel
7. Straits of Florida
8. Panama Canal Approach
9. Lake Maracaibo, Netherlands Antilles
10. Caribbean N.S.-E.S. Intersection
11. Bahama Island Passages
12. Cayman Island Lighting
13. Texas Gulf Coast Lighting
14. Louisiana Coast Lighting

Figure 13

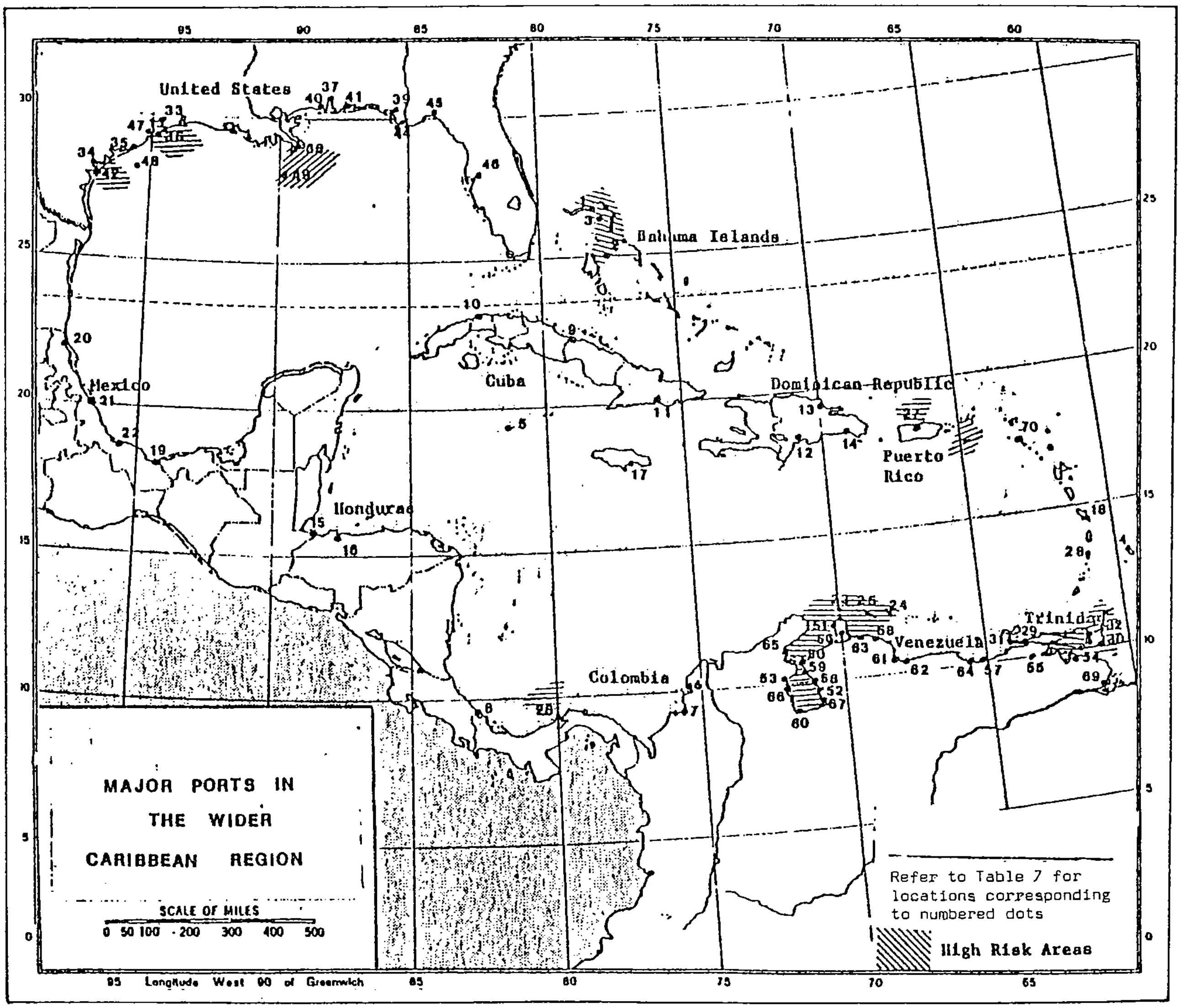

MAJOR PORTS IN
THE WIDER
CARIBBEAN REGION
SCALE OF MILES
0 50 100 200 300 400 500
United States
Bahama Islands
Mexico
Cuba
Dominican Republic
Puerto Rico
Honduras
Colombia
Venezuela
Trinidad
Longitude West 90 of Greenwich
Refer to Table 7 for locations corresponding to numbered dots
High Risk Areas

Table 7 : Zones of high risk from oil spills and likely points of impact

High Risk Zone	Likely Zone of Impact
<u>Offshore Production Accidents</u>	
Texas	Texas coastline
Louisiana	Louisiana and Texas coastline
Mexico (North)	Northern Mexico and Texas
Mexico (Campeche)	Southern Gulf Coast, Northern Mexico or Texas
Trinidad & Tobago	Trinidad & Tobago, Grenada, Venezuela
Venezuela	Venezuela, Colombia
<u>Through Shipping</u>	
Anageda Passage	Virgin Islands, Puerto Rico, Hispaniola
Bahama Island Passages	Bahamas, Florida, Cuba, Haiti
Cayman Island Lightering	Cayman Islands
Florida Straits	Florida, north Cuban shore, Bahamas
Jamaica Channel	Haiti, Cuba, Jamaica
Lake Maracaibo	Venezuela
Mona Passage	Hispaniola
Netherlands Antilles	Aruba, Curacao, Bonaire, Venezuela
Panama Canal Approach	Costa Rica, Nicaragua
St. Lucia (north and south)	St. Lucia, St. Vincent, Martinique, West Indies
Texas	Texas
Louisiana Gulf Coast Lightering	Texas, Louisiana
Tobago-Trinidad Channels	Trinidad, Tobago, Grenada, Venezuela
Windward Passage	Cuba, Jamaica, Caymans
Yucatan - east	Yucatan Peninsula, Florida, Cuba
Yucatan - west	Yucatan Peninsula, Mexican Gulf, Texas, Louisiana
<u>Port Approaches</u>	
(refer to figure 13 for numbered locations)	
<u>Bahamas</u>	
Freeport (1)	Bahamas, Florida
Nassau (2)	Bahamas, Florida
South Riding Point (3)	Bahamas, Florida

Table 7 Continued.

High Risk Zone	Likely Zone of Impact
Barbados (4)	Barbados, Martinique, St. Vincent
Cuba	
Caibarien (9)	Cuba, Mexico, Yucatan Peninsula
Havana (10)	Cuba, Florida, Dominican Republic, Haiti,
Santiago de Cuba (11)	Cuba, Dominican Republic, Haiti
Dominican Reoublic	
Bani (12)	Cuba, Dominican Republic, Puerto Rico, Haiti
Santo Domingo (14)	
Jamaica	
Kingston (17)	Haiti, Cayman Islands, Cuba
Mexico	
Coatzacoalcos (19). Tampico (20), Tuxpan (21), Veracruz (22)	Southern and western Gulf of Mexico
Netherland Antilles	
Aruba (23)	Aruba, Venezuela
Bonaire (24)	Aruba, Bonaire, Curaçao, Venezuela
Curacao (25)	Aruba, Curacao, Venezuela
Panama	
Colon (26)	Colombia, Costa Rica, Nicaragua
Puerto Rico (27)	
Guayanilla, Los Mareas, Port Yacuboa, San Juan	Dominican Republic, Puerto Rico, Virgin Islands,
St. Lucia (28)	Martinique, St. Lucia, St. Vincent
Trinidad	
Brighton (29), Galeota Point (30) Point Fortin (31) Point-à-Pierre (32)	Trinidad, Tobago, Venezuela

Table 7 Continued.

High Risk Zone	Likely Zone of Impact
U.S.A.	
Corpus Christi, Texas (34), Port Aransas (42)	Texas
New Orleans, Louisiana (38)	Louisiana
Venezuela	
Altagracia (50), Amuay (51), Bachaquero (52), Bajo Grande (53)	Venezuela, Colombia
Capure (54), Carpito (55)	Trinidad, Venezuela
Virgin Islands	
St. Croix (70)	Antigua, Dominican Republic, Puerto Rico
Tank Washings, Oily Ballast Discharge	
Tank washings from U.S. destination tankers, offshore lightering and harbours	Texas, Louisiana
Tank washings from tankers returning from Caribbean offshore lightering and harbours	Venezuela, Texas, Louisiana, Mexico
Tank washings from tankers returning from the U.S. east coast and from Europe	West Indies, Venezuela, Trinidad, Tobago, Netherlands Antilles

SOURCE: IMCO, 1979.

3. EFFECTS OF POLLUTANTS ON THE MARINE ENVIRONMENT OF THE REGION

The Wider Caribbean Region will experience many developmental activities in the future. More than half of the countries in the area are island countries, and are, therefore, closely affected by marine resources and environment. This applies to the larger, non-island countries surrounding the Wider Caribbean Region, although to a lesser degree.

Countries with extensive petroleum resources plan to develop energy-intensive heavy industries such as petrochemical processing, iron, steel and aluminium smelting, caustic soda and chlorine production. Some countries without natural resources are trying to attract non-resource-based refineries, pharmaceutical industries, as well as light industries and tourism. For a variety of reasons such as ease of trans-shipment, easy waste disposal, availability of cooling water etc., much of the development will take place in the coastal zone. Almost all of the Wider Caribbean tourist development has, and will be, oriented towards the coast. Concomitant with coastal development is coastal urbanization.

These development trends will carry the risks of increased pollution of the Wider Caribbean waters and, as a result, threaten the delicate coastal marine ecosystems upon which most of the marine biological productivity of the Region depends. The point has already been made concerning the importance of the various coastal ecosystems in providing nutrients for the Region's limited fishery. At present there is a marked paucity of data concerning the environmental impact of the existing and planned development processes in the marine environment of the Region. The lack of information on possible environmental impacts of development activities helps to aggravate the problem of marine pollution because, without information to verify possible environmental consequences, there is no motivation to control or alter a development activity. For example, an island endowed with extensive mangrove may, as a consequence, have a shrimp fishery. Without knowing that the shrimp fishery depends on the existence of a healthy mangrove, a decision may be made to destroy the mangrove to construct harbours or tourist centres etc., or even to harvest the mangrove for its peat-like material for fuel, as has been proposed in some countries. The consequence may be a ruined shrimp fishery. Some generalizations about effects are elaborated below.

3.1 Effects on human health

The main effects of marine pollution on human health are derived either from direct exposure to contaminated water or indirectly through consumption of organisms that have become contaminated by their exposure to polluted water.

Outbreaks of bacterial and viral infections have long been known to be associated with consumption of raw or partially-cooked molluscs taken from polluted coastal waters (Lumsden et al., 1925). Studies conducted on the shores of the Mediterranean Sea and the USA indicate that bathing in sewage-polluted waters gives rise to enteric disorders, vomiting, diarrhoea and that even low-level pollution by sewage can constitute a measureable and determinable hazard to the health of bathers (Mason and Mclean, 1962).

In addition to pathogenic illnesses, detrimental health effects may come about from exposure to, or consumption of, organisms exposed to water contaminated with chemical substances. Well-publicized incidences outside the Wider Caribbean have involved marine organisms contaminated by pesticides, polychlorinated biphenyls, mercury or cadmium.

Information concerning the extent of coastal water pollution by sewage in the Caribbean is very limited. A few reports have been published on evidence of levels of sewage pollution potentially dangerous to human health in several embayments in the region. For example, in Kingston harbour, high bacterial levels were found along the entire northern shore of the harbour and fish kills have been associated with high bacteria concentrations (Wade, 1972-75). Epidemiological data suggesting a relationship between quality of bathing waters and health of bathers in the Caribbean are entirely lacking although some active studies are under way in Cuba, Colombia, Venezuela and other countries.

There have been general reports on shellfish and fish poisoning within the region, some of which have been associated with pesticide applications (Ali, 1978). Concern about high levels of heavy metals however has been aroused in certain localities and it is thought that high levels are present in some areas. However, there is little information on the chronic levels of such substances, with the exception of a few studies reporting analysis of fish and other marine organisms from the Gulf of Mexico (Giam et al., 1971, 1973; Giam 1974; Baird et al., 1975).

At the recent Regional Workshop on Marine Pollution, it was stressed that health criteria for coastal waters, as well as monitoring programmes to ascertain water quality and potential health hazards, are still much needed in the Wider Caribbean Region (UNESCO, 1977).

Other deleterious pollutants such as heavy metals, PCBs and chlorinated hydrocarbons, might be present in the marine environment particularly near coastal industrial concentrations. Information on the levels of these pollutants, on their potential bio-accumulation in organisms consumed by man, and on incidences of actual public health impairment, is not generally available, although there is one report of high mercury levels in Cartagena Bay, Colombia (FAO, 1979).

3.2 Effects on marine and coastal ecosystems

Although not abundant, reports concerning the impact of pollutants on marine and coastal ecosystems of the Region are gradually becoming available.

High organic load effluents from primary-treated sewage and industrial waste discharges are responsible for increasing abiotic conditions and the general deterioration of Kingston Harbour (Wade et al., 1972). Inadequate secondary-treated sewage discharges coupled with dredging resulted in severe environmental degradation of a coastal lagoon system near San Juan, Puerto Rico (Cintron and Rodriguez, 1972).

Oil pollution from a major spill in 1973 resulted in extensive mortality to marine organisms and general disruption of the marine environment in communities associated with mangroves and Thallasia in Cabo Rojo, Puerto Rico (Bergquist and Nadeav, 1977). Likewise an oil spill in 1975 in the Florida Bay caused extensive damage to marine communities. In the Gulf of Paria the incidence of oil spills has been increasing. In 1976 a spill involving several thousand gallons of diesel and black oil took place (Gajraj, 1978), although damage to marine communities by the oil or the chemical used to disperse it in clean-up operations was not estimated. Damage caused by the blow-out of the Ixtoc oil well in the Bahia de Campeche and from the double tanker collision off Tobago, both of which took place in mid-1979, is still to be determined.

Thousands of fish died in the Gulf of Paria over a period of five weeks between early November and mid-December 1976 (Gajraj, 1977). The cause appears to be connected with a ship laden with various undisclosed chemicals which sank in the area in 1974. Other massive fish kills have been reported throughout the Region in bays and coastal lagoons adjacent to large urban or industrial centres, suggesting a definite impact of high BOD discharges or chemical waste which, in some cases, seems to be made worse by changes in weather patterns (Cintron and Rodriguez, 1972).

The information on effects of pollutants on marine organisms and ecosystems in the Wider Caribbean Region is too limited to make a substantive argument about the seriousness of the pollution problem there. However, the few reports cited above show that stress conditions exist around many urban and industrial sites in the Region and indicate that pollution is affecting the marine ecosystems. The degree of this stress has to be assessed and the effects on public health and marine resources need to be quantified in order to provide a substantive case for managing development activities in an environmentally-sound fashion.

3.3 Effects on socio-economic activities

The two most important socio-economic activities in the Wider Caribbean Region that rely on a healthy marine environment are fisheries and tourism.

There is a fairly high dependence on fish protein sources which is likely to be maintained and increased. This is especially true of smaller islands which lack facilities for livestock production. Although, for mainly historical reasons, much of the fish requirement is imported, Caribbean fisheries have been developing and expanding.

As already mentioned, the Caribbean fisheries are closely linked to coastal ecosystem productivity due to the limited upwellings and shallows in the Region. No statistics relating to reduction of fish landings with mangrove reduction exist although it has been implied that a dwindling of the mangroves in Puerto Rico might be responsible for a slump in coastal fisheries. On the other hand, there is substantial evidence that mangrove swamps, coral reefs, Thallasia beds and coastal lagoons contribute to the life cycle of a great majority of the commercial species of fish and shellfish captured in the Region. Thus, degradation of these ecosystems resulting from pollution, or from physical disruption of coastal areas, has a far more severe effect than if the fishery was linked to productivity in open waters, where the effects of coastal pollution or other activities would be dampened.

Marine-oriented tourism is particularly important for the insular Caribbean, much of which has no other source of foreign exchange. Deteriorating conditions of beaches by domestic sewage or industrial waste reduce their desirability for tourists. Of major concern in this respect is oil pollution, directly in the form of tar on beaches and indirectly from the effects it has on the coastal ecosystems which constitute the major tourist attraction. The increased oil tanker traffic through the Region including very large crude-carriers, as well as extensive production activities, increases the probability of spills. The damages of a massive oil spill to the beaches of tourist areas could cause economic chaos, especially in the case of small tourist-oriented islands. Definitely these types of pollution are a major threat to the fragile economies of the small island States of the Region.

4. ADMINISTRATIVE AND LEGAL TOOLS FOR CONTROL OF MARINE POLLUTION

4.1 Policies and management practices relevant to the control of marine pollution

Many Caribbean countries have not fully developed the managerial and custodial ethics or the policies needed to protect adequately or to use wisely the assets of the sea. The most important reasons for this situation are that: (a) national economic problems often overshadow environmental considerations so that costs or, alternatively, loss of potential revenue are perceived as outweighing benefits; (b) marine pollution has not been identified as a major problem in the Caribbean area which, in turn, is partly due to the lack of systematic studies on environmental quality; and (c) there is a lack of awareness of the potential damage to marine ecosystems by coastal development activities.

Therefore, one of the problems confronting the Wider Caribbean Region is the general lack of policy concerning marine pollution, especially on a regional basis. Environmental management is seldom articulated at the highest level of decision-making in many of the countries in the Region, nor do environmental considerations always enter, as a rule, into development planning. In recent years this situation has been changing gradually. Some examples of national programmes, policies or laws related to marine pollution which have been formulated in recent years are: the Barbados Territorial Waters Act of 1977 which has provisions for prevention and control of marine pollution; the Grenada Territoral Waters Act of 1978 with similar provisions; the adoption of a national oil spill clean-up plan adopted in 1977 by Trinidad and Tobago; several laws adopted by Jamaica concerning territorial seas, beaches, harbours and other aspects, as well as a proposed "Clean Seas Act"; a large joint programme with the Cuban Government and the United Nations Development Programme (UNDP)/UNEP to clean up the harbour of Havana started in 1979; the Marine Protection, Research and Sanctuaries Act of 1972 by the United States; and an integrated study of the effluents from Lake Maracaibo, Venezuela. Some other Caribbean Governments are formulating policies or programmes concerning marine pollution, notably Haiti and the Dominican Republic.

4.2 Infrastructure (institutional framework) used for assessment of marine pollution

The basic institutional structure of significance in the field of marine pollution control is that of marine laboratories. There are, scattered throughout the Caribbean, many small marine laboratories which have been conducting studies on the marine environment. In general, they are attached to local universities, are outposts of universities external to the Region (particularly from Canada and the USA) or in some cases are joint ventures of overseas universities with local universities. A cadre of competent local scientists is being developed at these institutions. In most cases however, their scientific research has been focused on basic marine research rather than pollution assessment and effects. Moreover, research funds for the most part are in the form of grants which are generally made on a project basis. Usually these projects concern subjects of interest to a particular individual or institution rather than the information and data needed for better management of the Caribbean marine environment. This is particularly true in the case of laboratories associated with overseas universities where, more often than not, research is unrelated to problems of local interest.

A real need exists to co-ordinate the efforts of these laboratories and to encourage the incorporation of marine pollution assessment components in their workplans.

Further, they should be encouraged to adopt a regional approach and create a data system which incorporates clearly defined and consistently recognizable retrieval identifiers and which is available to all those conducting research in the Region. As a first step in identifying needs and encouraging data exchange, a directory of regional institutions involved in marine sciences for the Caribbean and adjacent regions has been produced by UNEP in co-operation with IOC. This directory is available as document number E/CEPAL/PROY.3/L.INF.8.

Several international organizations operating within the Wider Caribbean Region are trying to promote regional co-operation in the field of marine science and marine pollution control. In 1976, with the collaboration of IOC and FAO, a UNEP-sponsored workshop was organized (UNESCO, 1977). At this workshop, several co-operative projects were identified and recommended for implementation. IOCARIBE, a regional association sponsored by IOC, brings together representatives of about 20 Caribbean States in order to develop a regional programme of activities in marine affairs.

Other international organizations, both governmental and non-governmental, which have marine-related activities in the Caribbean are;

- UNDP: financing projects for pollution control and marine resource management.

- UNEP: sponsoring projects on marine pollution control and environmental management.

- IMCO: advising countries on maritime matters and abatement and control of ship-borne pollution.

- FAO: promoting projects related to fisheries development.

- IUCN: identifying critical marine habitats and developing strategies for their protection.

- Organization of American States: preparation of emergency action plan for coastal pollution and oil spill control for Barbados, Dominican Republic, Grenada, Haiti, Jamaica, Trinidad and Tobago.

4.3 International legal instruments relevant to the control of marine pollution

Several regional and global treaties are relevant to the control of marine pollution in the Wider Caribbean Region. They are reviewed in a separate overview (UNEP, 1979).

5. CONCLUSIONS AND RECOMMENDATIONS

The position of the delegation of Barbados at the January 1978 Commonwealth Caribbean meeting on the Law of the Sea summarizes, in an excellent way, the Region's growing concern about the protection of its marine resources:

> "The pollution problems of the Caribbean Sea may not have reached the magnitude of those in the Baltic and the Mediterranean.... but the similarity of land-locked configuration of the Caribbean with the potential for retention of pollutants from a developing Region warrants

early preventive action. If the countries of these regions are to benefit from the expoitation and sharing of the resources of the Caribbean Sea it becomes imperative that immediate action is taken to arrest the trend towards destruction of marine life which is so essential to the maintenance of the marine ecological balance and to the sustenance of our people."

This statement is fully supported by the major findings of this overview which could be listed as:

5.1 There is a paucity of data on the major sources of marine pollution in the Wider Caribbean Region, on the amounts of pollutants entering the marine environment, on the present levels of pollutants in the various components of this environment and on the effects of pollutants on marine ecosystems, human health and coastal amenities.

5.2 Although the Caribbean can still be considered as an unpolluted Region, there are severely polluted areas in coastal waters and embayments adjacent to urban and industrial developments.

5.3 There is a general lack of adequate treatment and marine disposal of industrial and domestic waste causing damage to human health and to highly productive marine ecosystems, such as mangroves and coral reefs.

5.4 Oil pollution from operation and accidental sources is a growing threat to the region's ecological and economic resources.

5.5 Untreated or partially treated sewage discharges in waters adjacent to bathing beaches frequented by tourists and local inhabitants present a potential public health problem and may lead to considerable economic losses.

5.6 In most instances there are no water quality or seafood standards for toxic materials which are suitable for tropical warm waters.

5.7 The region's national policies on marine pollution control and marine resource protection are either of very recent creation or non-existent.

5.8 Although there are several marine laboratories scattered throughout the Region, they are, in most cases, involved in basic marine research unrelated to the pressing needs of the Region for a better understanding of the problems connected with the threats posed by marine pollution.

5.9 There is no effective regional co-ordination for data gathering, exchange and integrated marine pollution monitoring and research programmes.

5.10 There are few effective linkages between the basic research and monitoring activities of national marine laboratories and the national institutions charged with the promotion and enforcement of environmental pollution control measures.

5.11 Several countries of the Region have expressed interest in developing regional and sub-regional arrangements relevant to marine pollution control and to emergency measures for prevention and abatement of accidental oil spills.

Based on these findings, the following recommendations are proposed:

5.12 Regional pollution monitoring programmes should be developed in order to assess the sources, levels and effects of major pollutants such as heavy metals, toxic organic chemicals, petroleum hydrocarbons and inorganic and organic nutrient loads from agricultural and domestic waste-waters. Examples of such programmes are described in the report of the "IOC/FAO/UNEP Workshop on Marine Pollution in the Caribbean and Adjacent Regions" and its supplement.

5.13 To implement these programmes, networks of co-operating national institutions should be created. This would require, to a certain degree, upgrading equipment and personnel facilities in existing institutions. Furthermore, methodologies providing comparable data should be adopted and the intercalibration services for the more sophisticated analytical methods should be organized.

5.14 A data reporting programme should be organized and charged with the evaluation of the results obtained and their dissemination to all users.

5.15 Pilot programmes for pollution abatement, monitoring and control such as the one currently being developed for Havana Bay by UNDP/UNEP should be promoted. Results of the exercise should be made available to other countries in the Region which face similar pollution problems by means of regional workshops and training seminars.

5.16 An inventory of major land-based pollution sources in the Region should be prepared and used by national authorities to assess the waste receiving capacity of recipient coastal waters when issuing authorizations for waste discharges from proposed facilities and revising authorizations for existing installations.

5.17 A programme to determine suitable environmental quality criteria applicable to tropical waters should be developed and used as the scientific basis for national pollution control legislation.

5.18 An assessment of the quality of bathing beaches in the Caribbean through in-depth sanitary surveys and collection of data concerning microbiological quality of their waters should be initiated, particularly in areas where hazards to public health are considered real.

5.19 Management programmes to control oil pollution from tanker and ship operations should be developed through assistance and training of competent national port authorities, formulation of contingency plans and development of regional and sub-regional arrangements which could be used in emergencies.

5.20 The creation of a regional oil pollution abatement centre should be considered in order to provide meaningful responses to the growing oil pollution threat, particularly in the case of a major accidental oil spill.

5.21 Treatment of industrial and domestic effluents should be promoted through national pollution control policies whenever such treatment is essential for safeguarding the long-term ecological and economic interests of a given country, the Region as a whole or parts of it.

5.22 An inventory of national marine resource protection legislation and policies should be undertaken in order to assist the Region in harmonizing the approach to marine pollution control on a regional and sub-regional level.

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