Conservation and Sustainable Use of the Meso-American Barrier Reef System in Mexico, Belize, Guatemala and Honduras: *Threat and Root Cause Analysis*[1]

Draft

I. BACKGROUND

The main goals of the MBRS program are to enhance protection of vulnerable and unique marine ecosystems and to assist the countries of Mexico, Belize, Guatemala and Honduras strengthen and coordinate national policies, regulations, and institutional arrangements for marine ecosystem conservation and sustainable use. The current draft Project Development Fund (PDF) proposal includes support for the following: i) promote the conservation and sustainable use of the MBRS; ii) expand environmental education and awareness; iii) develop a regionally compatible ecosystem/biodiversity monitoring program and information system; and iv) strengthen regional coordination. According to the recommendations of GEF Secretariat Review meeting of the PDF Block B Grant proposal, coastal and reef-based threats and their underlying root causes need to be identified and current national actions detailed as part of the baseline analysis of each country participating in MBRS.

II. OBJECTIVES AND GEOGRAPHICAL BOUNDARIES OF THE STUDY

The general objective of the Threat and Root Cause Analysis (TRCA) is: *Identify the real and potential threats, and their underlying root causes, to the ecological health of the Meso-American Barrier Reef System (MBRS) and assess the geographical coverage and impact of current and proposed actions at the national level aimed at treating these threats, in order to achieve greater synergy through a regional project for conservation and sustainable use of the MBRS*. Where gaps in the existing database prevent an accurate assessment of the nature, source, magnitude and significance of likely and potential threats, are to be identified and prioritized for consideration for inclusion in GEF project design. In this context, the specific objectives of the TRCA study are:

- Development of an analytical framework to facilitate a systematic treatment of the MBRS;
- Identification, through a logical and systematic approach, of existing threats to the "ecological health" of the MBRS and their root causes;
- Identification and characterization of gaps in the existing data base which prevent adequate assessment of the threats and root causes contributing to reef system degradation;
- Identification and characterization both national and regional efforts currently underway to address existing threats and their underlying causes; and
- Proposal of measures to be considered to address more effectively existing threats, causes and data gaps, complementary to, or in addition to, existing efforts and projects, and distinguishing these between national and regional efforts.

The TRCA Study also incorporates the analysis of real and potential transboundary impacts and threats, with particular relevance to several of the principal drainages into the MBRS: the Bay of Chetumal (shared by

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Mexico and Belize) and the Gulf of Honduras (shared by Belize, Guatemala and Honduras). Analyses focused primarily on point and non-point sources of contamination and conflicts in resource use (especially fisheries and tourism).

The general MBRS study area stretches from Isla de Contoy Mexico south along the coasts of Belize and Guatemala, including the barrier reef and offshore islands, to the Gulf of Honduras, and then east along the North Coast of Honduras, including the Bay Islands, to the mouth of the Aguán River. The MBRS includes adjacent marine ecosystems and coastal watersheds in Mexico, Belize, Guatemala and Honduras. The inland boundaries of the study area vary by country and specific locality, but are generally intended to encompass those land and water resources within the coastal plains and adjacent coastal watersheds. However, as numerous land and resource utilization and conservation activities are carried out in areas upstream (including agricultural, industrial and residential/urban uses, wetlands and protected areas) that affect ecological functions of the MBRS, a broader interpretation was permitted to sufficiently encompass all "significant" threats and related underlying causes that could influence reef health. The ocean extension of the study area approximates the limits defined by World Wildlife Fund (WWF) for the Meso-American Caribbean Reef Ecoregion (see map in Annex 1); varying from approximately 40 km off the northern coast of the State of Quintana Roo in Mexico, extending out some 240 km from the Gulf of Honduras, to about 50 km off the North Coast of Honduras at the mouth of the Aguan River.

III. ANALYTICAL METHODS EMPLOYED IN THE STUDY

Several methodologies, at national, regional and global scales, have been used to develop analyses of threats to coastal resources and coral reef systems. Each has served in meeting its objectives in assessing real and potential impacts of improper use of coastal and reef resources. Several of these approaches are described below. The methods used in the current TRCA study consider some of the analytical parameters employed in the studies presented below, and are coincident with many of the findings and conclusions presented therein concerning significant threats and their root causes.

A. A Review of Several Analytical Methodologies for Threat and Root Cause Analysis

Several reports have been published recently that deal with threat and root cause analysis, including a few with direct relevance to the current MBRS TRCA study. Root cause analysis is nothing new, yet has taken on added significance in recent years as a more effective mechanism for analyzing problems related to environmental protection and biodiversity conservation around the world, including coral reefs. Several of these approaches are reviewed as a basis for understanding the strategy to be employed in the MBRS TRCA study.

In the publication “Reefs at Risk: A Map-Based Indicator of Threats to the World's Coral Reefs” (Bryant, Burke and McManus, 1998), the authors have assembled a simplistic classification system of indicators of potential threat (risk), although not a measure of actual conditions. Four threats were preselected for analysis on a global scale: (i) coastal development; (ii) overexploitation and destructive fishing practices; (iii) the impact of inland pollution and erosion/sedimentation; and (iv) marine pollution. The authors used a series of “decision rules” for assigning the indicators, focusing their attention on the location, in proximity to the reef as measured in kilometers, of selected anthropogenic infrastructure (cities, ports, oil tanks and wells, etc.) and characteristics (population density, an erosion index based on modeled land use/cover, precipitation and slope). The component indicators were then qualified as to there magnitude, in terms of size of cities and infrastructure and population density, presence of ports and oil wells of refineries, and the inflow of sediments. Risk (or *threat*) was then assessed as being either “high” or “medium” should there be intersects with the qualifiers, and “low” should there be no intersects. The system was then applied using 14 distinct data sets and 800 mapped *ReefBase* sites throughout the world. Classifications and locations were reviewed with coral reef experts and scientists from around the world before production of reference maps depicting these risks at a global scale and then for each ocean region, including the Tropical Americas. The classification system presents an overview of risk at a very small and general scale with predetermined analytical parameters,

assuming that essentially the same four threats occur in relation to every reef area. The approach is best used to alert planners, policy makers and resource users and managers about potential threats of inappropriate development and resource use. As the authors admit, the study tends to over- and under-report risks in certain areas due to the restrictions of scale. For example, in cases of entire islands and coastal areas being included under a "high risk" designation where, in reality, only portions of these areas are at such high risk. Also, the approach does not consider other parameters which could represent important risks for coral reefs including: income levels and poverty (except as a static qualifier for the threat of overfishing); presence of projects and policy initiatives oriented toward reef and fisheries conservation; nor does it consider natural phenomena such as El Niño events and hurricanes.

"Root Causes of Biodiversity Loss: An Analytical Approach" (Steadman-Edwards, 1998) promotes a methodology wherein problem-specific conceptual models are developed to orient the researcher, beyond the traditional focus on the intermediate, or "proximate" causes[2], to the root causes or *the socioeconomic factors that drive people to degrade the natural environment.* The methodology promotes analysis beyond identification of the root causes of biodiversity loss at the local level, to a more systematic comprehension of the complexity of economic, social, political and cultural causes on a much broader scale including national, regional and even international levels. Finally, a root causes framework can be assembled as a basis for prioritizing and selecting and designing the most efficient project actions to achieve objectives of stemming the loss of biodiversity. There are limitations in the use of the approach as emphasis may be placed more on analysis of national and regional issues than on local concerns and realities. This can lead to over-emphasizing the inclusion of project actions oriented to structural and policy issues if their consideration is not balanced with actions at the point where the threats are manifested (at the local level). Also, the approach does not consider natural phenomena, which may contribute to biodiversity loss, such as earthquakes, hurricanes, floods, droughts and El Niño events.

In an exercise applying this analytical approach in the region, Worldwide Fund for Nature convened a "Preliminary Meeting of Experts on the Meso-American Caribbean Reef" (MACR) in Belize City on April 12-14, 1999, to begin the process of conservation planning for this ecoregion (Jorge, 1999). The workshop highlighted aspects concerning the value of the reef and its resources, especially biodiversity, and natural and anthropogenic phenomena affecting the MACR. The participants identified the inland boundary of the MACR ecoregion as the furthest inland limit of saltwater influence, including habitats of coastal lagoons, mangroves and lowland riparian forests; but also recognized the connection with the watersheds draining into the Caribbean. Applying the root causes analytical approach as outlined by Stedman-Edwards, the workshop participants analyzed regional and country-specific issues. The workshop concluded that the principal threats to the MACR ecoregion are: inappropriate land use; pollution from point and non-point land-based sources and ships; tourism and inappropriate coastal development; and unsustainable fishing practices. For each of the principal threats, workshop participants attributed certain root causes by country, identified gaps in the existing information base and addressed research needs. Several transboundary issue areas, and those common across the MACR ecoregion, were also identified. As presented, nearly all of the results of the WWF workshop, in the identification of threats and root causes coincide with the findings of the current TRCA study. The MACR conservation initiative is complementary to the efforts of preparing the MBRS regional project and an effort is being made to coordinate among both initiatives in order to reach mutual goals.

In another example, PROARCA/COSTAS, the Regional Environmental Project financed by USAID, presented the results of its participatory "mini-case study" of gaps in the application of environmental protection/natural resources conservation laws and regulations for the Gulf of Honduras region (Brown, 1998). A series of interviews with representatives of locally-represented government and non-government organizations and

[2] Stedman-Edwards states that the proximate causes of biodiversity loss have been thoroughly examined in the literature, and are: habitat alteration and loss; over-harvesting; species and disease introduction; and pollution and climate change.

resource users to ascertain the levels of awareness of, adherence to, and deficiencies in the existing regulatory environments in each country as applicable to fisheries in the Gulf of Honduras. For each country, stakeholders groups, from their perspective, described the principal problems affecting fisheries, and their socioeconomic and environmental linkages, were identified. The majority of issues dealt with over-exploitation of fisheries resources (specifically lobster, conch, shrimp, sardines and finfishes) with inappropriate equipment, in inappropriate areas and during closed-season; encroachment into certain countries' fishing areas by extra-nationals; industrial/artisanal distortions of scale and their implications; and illegal manatee hunting. For each set of problematic activities (which can also be considered *threats*) indicated by the stakeholder groups, direct and indirect socioeconomic and environmental impacts were analyzed, and their causes (root and intermediate) were assessed. The results of this exercise were then put before a workshop (*Taller Regional sobre Manejo de Pesquerías en el Sistema Arrecifal del Caribe Mesoamericano*, 24-26 de Marzo 1998, Cayos del Diablo, Izabal, Guatemala) held with the representatives of each stakeholder group (government, NGO, fishers) to facilitate a consensus concerning actions necessary to resolve the issues perceived among the participants. Again, the results of this study and resulting workshop coincide with the many of the findings of the actual TRCA study.

B. Analytical Methodology Employed in the MBRS Threat and Root Cause Analysis

The analytical methodology used for the MBRS TRCA study was oriented to be as practical and geographically- focused as data would allow. The study was limited to a review and analysis of existing information. Based on a preliminary review of information sources, it was determined that there were important gaps in the information base, especially in terms of quantitative data with relevance to water quality, ecological condition of coastal and reef resources, fisheries and resource use/consumption rates. Therefore, equal weight was given to qualitative information. Information was collected and reviewed at both regional and national levels (in Mexico, Belize, Guatemala and Honduras). The bulk of the information has been analyzed and synthesized, and presented in a series of matrices by region and for each country included in the project area. Information presented in the matrices was reviewed by members of the respective national barrier reef committees to ensure its validity and comprehensiveness. The matrices were complemented, as these were made available, with data provided by the specialists responsible for the other project preparation studies underway, especially those concerning coral reef health, protected areas management and ecotourism, law and policies, sustainable fisheries and environmental monitoring. In order to guide the TRCA study, a series of terms and concepts were defined; these are defined below.

1. Definition of Terms and Concepts

For the TRCA study, the term *threat* is understood to be the agent or vehicle that represents the risk to the MBRS. Threats can be based on:

- *known or existing problems*, inasmuch as these represent an activity or phenomenon that is negatively impacting the ecological health and integrity of the MBRS, whether these are qualitatively or quantitatively substantiated and/or documented; and

- *probable or potential problems*, as represent activities or phenomena that pose negative impacts (risks) to the ecological health and integrity of the MBRS, as these are perceived based on best-available scientific judgement and the "worst-case scenario" principle.

Threats, as well as the manifestation of negative impacts, can be: temporary or permanent; direct, indirect or cumulative; localized, regional or global; and of minor, moderate or severe intensity (usually based on scientifically accepted standards/thresholds). Hence, it is important to categorize and prioritize the threats in order to give relevant technical guidance in the design of activities to be proposed under the regional project, and not get lost in numerous activities of limited impact, albeit with the good intentions of treating all threats

identified during the course of the study. Based on the review of literature and discussions with selected scientists in the four countries, the following categories were seen as the principal threats and root causes and are further disaggregated and substantiated in the study:

- *Coastal/Island Development and Unsustainable Tourism*, which includes urban, hotel and resort development and related infrastructure, together with all the direct and indirect impacts that these bring to bear on the MBRS (pollution/contamination, nutrification, sedimentation, physical reef damage, impacts to estuary and lagoons and mangrove destruction, beach erosion, habitat change, etc.);

- *Inappropriate Inland Resource and Land Use and Industrial Development*, encompassing a broad range of agricultural, urban and industrial development in inland watersheds which drain into coastal areas, contamination of wetlands, lagoons and estuaries, whether directly or indirectly impacting the MBRS (sedimentation, pollution/contamination, nutrification, habitat and species/abundance changes, mass kills of organisms, etc.);

- *Overfishing and Aquaculture Development*, in relation to activities of industrial, artisanal, subsistence and recreational fishing, and aquaculture in coastal areas and the real and potential impacts of species and abundance change, local extinction of selected species, habitat change/symbiosis imbalances, reduced subsistence and revenues from fisheries.

- *Inappropriate Port, Shipping and Navigation Practices*, including intentional and accidental contamination of waters, reefs and beaches, physical reef damage, impacts to aquatic species and fisheries (including mass kills), degradation of the tourism value of reefs and related coastal environments, and related topics

- *Natural Oceanographic and Climato-Meteorological Phenomena*, with relevance to the influence of currents and winds, El Niño/La Niña events, hurricanes and tropical storms, global warming, and earthquakes and tsunamis.

Inasmuch as information reviewed allowed, the *location and distribution* of the manifestation of the threats (what and where), and their intermediate and root causes have been identified in order to bring clarity of scale to the objectives of the study. The study avoided focusing exclusively on root causes, as these were found to be primarily of political or macroeconomic origin. Attempts have been made to assess as precise a location and range as possible (data permitting) in order to strategically distribute responsibilities of treating a threat to appropriate local, national and regional entities, as well as attribute the causes and eventually assign appropriate liabilities (actions) to the originators of the threats.

Connectedly, the *boundaries* of the TRCA were delimited with an understanding of the technical, political, institutional, logistical and financial limitations inherent in the region and the four countries involved. Hence, more emphasis was placed on gauging threats to the MBRS more directly tied, geographically and by virtue of causal relationships, to natural and anthropogenic phenomena in proximity to the coasts and reefs of the region and adjacent ocean. At the same time, it is important to point out that the results of the study are oriented to the design of the regional project objectives of conservation and sustainable use of the MBRS, and do not encompass all actions necessary to treat numerous and varying political, socioeconomic and environmental management deficiencies within each country. Consequently, based on the results of the literature review under the TRCA, decisions were made on the inclusion or exclusion of certain actions and phenomena occurring in geographical areas of great distance from the MBRS (for example, threats posed by a nuclear power plant in Cuba, transfer of atmospheric chlorinated hydrocarbons from Europe via the Trade Winds, or deforestation in the Altiplano of Guatemala and interior of Honduras at distances of 150-200 km), even when these may have represented part of the root or intermediate causes of certain threats to the barrier reef system.

2. Composition of the Matrices

The first task carried out under the methodology was a literature review in each of the four participating countries facilitated by national consultants, and at the regional/global level by the regional consultant to ascertain the existence of potential threats to the MBRS. The information has been analyzed and synthesized into a series of matrices to facilitate an understanding of the relations between threats and their root causes by country and for the MBRS region as a whole, using the following qualifiers:

(i) *how the threat is manifested on the MBRS*, that is, substantively what type of negative impact may be caused or experienced attributable to the threat;

(ii) *geographic location/distribution*, where does the threat originate and where is the MBRS being impacted;

(iii) *intermediate causes*, specifically what activity is causing the threat as manifested;

(iv) *root causes*, what agent or situation instigates or facilitates the intermediate causes of impacts manifested on the MBRS;

(v) *national laws and regulations and international and regional conventions and treaties*, which establish a legal and political framework for the sustainable use and conservation of resources within the MBRS;

(vi) *current and planned projects/programs*, what are current and planned efforts related to the treatment of the threats and their root and/or intermediate causes;

(vii) *principal transboundary issues*, that affect the ecological health of the MBRS, as a threat that may originate in one country but be manifested on another or to resources shared in common;

(viii) *knowledge base*, what and how good is the information base in discerning the threat, how it is manifested and its root cause, and what information gaps have affected the threat and root cause analysis; and

(ix) *proposed action areas*, indicative guidance to the design of actions for treating the threats and their root and/or intermediate causes at national and regional levels.

The matrices and accompanying discussion are intended to facilitate the design of the MBRS regional project and its respective component activities by providing an integral understanding of the range of threats and impacts to the ecological health of the reef system, within and among the countries included in the regional project area, and their intermediate and root causes. To this end, it is intended that the project deal with many of these threats within the regional context of actions already underway in participating countries and at the regional level. Specifically, the TRCA study provides project design perspectives concerning the following:

- ¿*What needs to be done at the national level in order to reach objectives obtainable at the regional level*? This may require government actions in areas of policy and legal/regulatory frameworks and/or the reorientation in activities of ongoing or planned projects and programs in each country.

- ¿*What should be done at the regional level in order to achieve objectives not obtainable at the national level*? This is especially related to bringing about participation of each country and regional project managers in: actions to unify research protocols, parameters, standards, analytical methods and

tools for environmental monitoring and information management; and in actions to improve knowledge, raise awareness and improve the capacity among governmental, non-governmental and resource-user organization and entities that should take part in efforts to bring about the sustainable use and conservation of the MBRS.

IV. EXISTING THREATS TO THE MBRS

The following sections provide a review of the types of activities that pose threats to the ecological health of the MBRS. Where available and relevant, information obtained from the literature is cited to provide depth to the analysis. Threats are distributed under the five major categories indicated earlier in the study. For each category, several groups of anthropogenic activities representing specific threats to the MBRS are summarily analyzed, as are their respective manifestations of impact. Matrix 1 presents a more extensive analysis of threats for each of these groups at the regional level, including their specific geographic origin, and an assessment of the actions that directly affect the ecological health of specific elements of the MBRS. Annex 2 provides an assessment of threats at the national level for each of the countries comprising the MBRS.

A. Inappropriate Coastal/Island Development and Unsustainable Tourism

Land clearing and construction activities for urban, tourism and industrial developments in coastal areas involve removal of natural vegetation, dredging, filling, channelization and draining, and sand and coral rock mining in mangrove, dune communities, wetlands, shorelines and adjacent areas. These actions can cause changes in local currents and flushing in bays, onshore and offshore erosion and sedimentation of seagrass beds, adjacent reefs and navigation channels, and result in a loss of protection from storms and hurricanes. Siltation and agricultural runoff can seriously impact the productivity of seagrasses, such as *Thalassia testudinum*, as their leaves are smothered and photosynthesis interrupted (Heyman, 1996). Coral reefs grow at slower rates in areas of high sedimentation, and species changes occur in response to such conditions, with more tolerant coral species found in more highly-sedimented areas, especially on near-shore patch reefs (Hall, 1994). Similar problems occur with the disturbance of the Zooxanthellae symbiotic algae, if light restricts their photosynthesis or impacted by herbicides (even in low concentrations), that may die or leave its host corals, resulting in bleaching or death of the latter. Construction can also result in fracturing and stress of terrestrial, riparian, coastal, estuarine and nearby reef ecosystems resulting in changes in composition of species. As the residential and tourist populations grow, increased consumption of water from surface and ground water sources (especially on islands) can induce salt intrusion and changes in ecosystem function, and decrease the availability of local and regional water supply.

Disposal or spills of untreated liquid organic and chemical wastes, whether domestic, industrial, agricultural runoff (including fertilizers and pesticides) or oil or formation waters from petroleum drilling locations, can cause nutrification and/or chemical contamination of estuaries, bays, wetlands, reefs and seagrass beds, potentially causing massive kills of, and sublethal impacts to, aquatic organisms in fresh, salt and brackish water environments, and further affect related trophic chains. Pan American Health Organization reports that only about 10% of the sewage generated in Central American and Caribbean countries is properly treated (CEPNET, 1999). The City of Chetumal, for instance, discharges 200 cubic meters of untreated sewage into the Bahía de Chetumal each day (Bezaury, 1999). Volumes of raw or poorly-treated sewage of similar or greater magnitude are discharged from urban centers directly into coastal waters of the MBRS coast from Belize City, Puerto Cortes, Tela, La Ceiba and Trujillo. Excess nutrients can result in blue-green algal blooms that compete with symbiotic and coral-building alga, and smother coral reefs. Repeated fish kills in the vicinity of Belize City are attributed to effluent from an industrial galvanizing plant (UNEP, 1992). Grease and oil contamination is reported in areas where oil palm is processed (primarily the North Coast of Honduras. Most marine organisms are extremely sensitive to even low concentrations of most pesticides, a situation exacerbated if corals and other organisms are already under stress from high water temperatures or

sedimentation (Hall, 1994). The disposal of solid wastes into coastal rivers, the sea, shorelines and estuaries, impacts fishes and reef organisms and reduces the aesthetic value of the tourism resources. The combination of nutrients and chemical contaminants is thought to exacerbate coral diseases and bleaching and/or stress their recovery.

Many tourist sites are over-saturated with visitors, beyond their carrying capacities, both from biophysical and management perspectives. Punta Nizuc Reef in Quintana Roo, for example, has an average of 1,500 snorklers per day arriving on 21 large tour boats and 650 two-seater jet skis (J. Bezaury, 1999). Improper diving, fishing and recreational activities by tourists and nearby residents has caused physical and biological damage to island environments, reefs and beaches. Many of the coastal and marine protected areas are under financed and exist more "on paper" than in reality, as monitoring and enforcement actions are deficient. Immigration induced by the growing tourism service sector and availability of employment opportunities can lead to the proliferation of poorly planned residential neighborhoods without adequate basic human services. This can lead to sanitation and human disease problems, the exacerbation of social problems, and pressure on adjacent natural resources as people of limited economic means cut mangroves for fuel and building supplies and fish for subsistence and income.

Ever-increasing cruise ship and live aboard tourism, which is predicted to add an additional 20 ships and 2,000,000 passengers to the Caribbean in the year 2000, can produce similar impacts experienced in urban areas if not regulated. Belize has an average of 3,000 cruise ship and live-aboard visitors per day (Belize Tourist Board, personal communication, 1999). Pulses of high numbers of tourists can overtax public services, reduce local food stocks, and generate vast amounts of solid and liquid wastes that must be accommodated by municipalities in the MBRS, and present challenges for police. If these ships visit offshore island and coral reef sites, waste management problems become more acute, and inexperienced and/or unsupervised divers and snorklers may present problems of coral breakage and predation and uncontrolled fishing.

B. Inappropriate Inland Resource and Land Use and Industrial Development

While industrial and agricultural development may be at a great distance from coastal areas, induced sedimentation, especially from the expansion of agricultural activities in upland watersheds, and contamination from agricultural runoff and the disposal in of liquid and solid wastes of industrial and urban origin, make there way down-river and empty into the MBRS. The threats as manifested on the resources of the MBRS, including the impacts of sedimentation and organic and inorganic pollution, are similar to those of coastal development as indicated above. Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) represent the two greatest pollutant loads entering the Wider Caribbean Region and MBRS, with TSS loads from rivers being one order of magnitude higher than loads from industrial and urban/domestic sources discharged directly into coastal waters (CEP, 1994). The most important of these rivers are: the Rio Hondo of Mexico; New River and Belize River in Belize; the Rio Motagua of Guatemala and parts of Honduras; and the Chamelecón, Ulua, Lean and Aguán Rivers on the North Coast of Honduras. It is estimated that approximately 90% of all pesticides applied in the region do not reach their targeted species, much of this lost to runoff into streams and eventually manifested in marine biota in coastal waters (CEP, 1994). Approximately 2,500 gallons of liquid wastes are discharges from sugar refining and rum distilling operations on the New River in Belize, contributing large organic loads and spent lubricants to the Bahía de Chetumal (UNEP, 1992). Of the 380 industries registered in the Sula Valley, the most industrialized area adjacent to the MBRS and drained primarily by the Río Chamelecón, 150 are reported to have environmentally problematic effluents (ESA Consultores, 1998). Some 50% of these industries have a BOD concentration of more than 1,000 mg/l and a COD in excess of 2,000 mg/l. Hurricane Mitch scoured huge quantities of sediment from rivers and sent them into suspension into the MBRS. Chemical compounds, including chlorinated hydrocarbons (DDT, aldrin), asphalt and heavy metals, buried after years of deposition in river beds of the Chamelecón and Ulua Rivers, were washed into lagoons, estuaries and out to sea, adding to the cumulative chemicals loading of coastal waters of the MBRS.

Additional impacts of deforestation related to land clearing for agricultural expansion in upland watersheds, are those of induced changes in hydrological functions as these may relate to the coast. Reduced infiltration to ground water aquifers can reduce the hydrostatic levels near coasts and indice salt intrusion on a subregional scale. Also, with less vegetative cover, surface water temperatures are increased and will contribute to warming of seawater, potentially affecting movement of currents and inducing metabolic changes in aquatic organisms in the MBRS. Construction of transport infrastructure, beyond the impacts related to land clearing and disturbance of the hydrological functions in watersheds, also may improve access to fragile coastal areas, as well as upper watersheds, induce immigration, resulting in increased anthropogenic activities and spontaneous development, including land clearing, with the aforementioned impacts of deforestation, increased erosion and sedimentation, agricultural runoff and waste disposal.

C. Overfishing and Inappropriate Aquaculture Development

Overfishing occurs when artisanal, sport and especially industrial fishers fish in disregard of regulations pertaining to closed-seasons, closed and protected areas, fishing of spawning aggregations, and with a lack of respect for size and limit/number limitations. These actions interrupt reproductive processes, gradually reducing stocks available for subsequent fisheries, with resulting reductions in fisheries revenue for local and national economies. Based on the results of FAO's 1994 of the Wider Caribbean, just over 35% of stocks in the region were regarded as over-exploited; however 70% of the pelagic stocks and 60% of the demersal stocks were considered over-exploited. The over-dimensioned fishing fleets, especially in Honduras where the number of industrial ships was 360 in 1996, places great fishing pressure on the primary commercial species, especially as these now use more advanced navigation and fish-finding equipment and some pull as many as four trawling nets.3 Species under the greatest pressure are lobster, conch, shrimp and certain species of finfish (esp. grouper and large grazers), for which overall harvests has been reduced by 60-75% based on catch-per-unit-effort, or CPUE, since 1979 in Honduras and Belize (ESA Consultores, 1998; Rodríguez and Wnndevoxhel, 1998), with similar reductions noted in the rest of the MBRS. Utilization of illegal equipment and fishing methods, including the use of SCUBA for lobster and conch fishing, has led to excessive local depredation and reduction in stocks of key commercial species. Sport fishers and divers glean "trophy" fish from reefs and lagoons, especially jewfish, groupers, kingfish and snook. By-catch of fishing activities, especially with small-sieve nets and drift-lines, of both marketable and non-marketable species is estimated in the Caribbean at 60-70% of industrial catches, resulting in important reductions in overall fisheries biomass in the MBRS. In 1986, unutilized by-catch from the shrimping industry of Honduras was estimated at 67 million pounds (Foer and Olsen, 1992). The Wider Caribbean region has the highest percentage of discards than any other major fishing area worldwide, with shrimp fishing producing the greater volume of discards (CEPNET, 1999). Shrimp trawlers also disrupt or destroy important quantities of seagrass beds and corals.

The burgeoning shrimp farming industry is gaining impetus in Belize and Guatemala. Poor siting and construction of ponds in areas exposed to storms and floods can introduce exotic species and diseases into lagoons and other habitats in coastal ecosystems. Similarly, exotic tilapia species can be accidentally or intentionally introduced in local streams, lagoons and wetland areas and compete and/or reduce indigenous fish populations. If shrimp larvae are collected from local beaches, estuaries and lagoons, this could result in reductions in nurseries of natural stocks, in turn impacting open water shrimp fisheries in the MBRS. Effluent discharged from ponds into coastal waters can induce local nutrification and introduce exotic diseases into local estuarine and reef ecosystems; or the antibiotics used to control diseases may destroy beneficial bacteria in natural settings. Finally, depending on methods of bio-prospecting and capture/harvest, certain species of interest could be over-harvested, potentially reducing their populations beyond recovery thresholds, and/or cause interruption to ecosystem functions and trophic chains in localized locations.

D. Inappropriate Port Management, Shipping and Navigation Practices

3 The Honduras fleet consists of 128 shrimp trawlers, 181 lobster boats, 14 conch fishing boats and 37 finfish boats.

More than 90% of commerce in the region is transported by ocean-going ships, making ports and navigation of high economic development value, but also a focal point for real and potential threats to the ecological health of the MBRS (Rodríguez and Windevoxhel, 1998). Oil terminals at Puerto Santo Tomás de Castilla in Guatemala (export) and Puerto Cortes and Tela Honduras (import) involve the transport of millions of gallons petroleum through the MBRS region each month. Two oil tankers carrying a total of 55,000 barrels of fuel visit Belize each month (Foer and Olsen, 1992). Ports and jetties construction and dredging associated with channel and harbor maintenance results in increased suspension of sedimentation in seagrass beds and nearby coral reefs stressing and potentially smothering these, and interrupting photosynthetic processes of corals' symbiotic and other alga. Redeposition of sediments may induce changes in coastal morphologic processes resulting in erosion of beaches, accretion of sediments in navigation channels, estuaries and coastal lagoons, and may change flows in local currents and flushing of bays and estuaries. Changes in coastal morphology may reduce defenses against storms and actually instigate more damage from storm surge and flooding.

Inadequate port management can lead to spills of organic, inorganic and toxic cargoes, including fuel, lubricants and bilge waters, which can contaminate coastal waters, potentially impacting nearby reefs, beaches, bays and estuaries and their resident living organisms. With the operation of oil terminals (Puerto Santo Tomás de Castilla in Guatemala, Tela and Puerto Cortes in Honduras), improper transfer of cargoes lead to contamination. Where these involve offshore transfer docks (Tela), conduits lying on the sea floor may break or leak.

Inappropriate waste management practices on ships and ports, including accidental or intentional dumping of sewage, oily bilge waters, waste oil and solid wastes into open seas, harbors and bays, can result in nutrification and/or chemical contamination of estuaries, bays, wetlands, reefs and seagrass beds. Most ports have limited facilities to receive solid and liquid wastes from ships, inducing many to dump their wastes directly into the sea. Puerto Santo Tomás de Castilla in Guatemala, for instance, receives nearly 5,000 metric tons of solid wastes annually from ships, even as it has inadequate waste landfill facilities (Fernandez, 1995). Much of these wastes are dumped in the open air and some make their way back to the coastal waters and beaches. Such spills can cause fish kills as well as cause sublethal impacts to aquatic organisms residing in fresh, salt and brackish water, and their related trophic chains. As solid and liquid wastes float ashore, they foul beaches, represent human health hazards and reduce aesthetics important to the tourism industry. Finally, accidents such as collisions, groundings and founder of ships can cause physical damage to reefs, and potentially lead to complete loss overboard of cargoes and leakage of fuels and lubricants into the sea. There was a major spill of 25,000 gallons of asphalt and 6,000 gallons of bunker oil associated with the sinking of a freighter off Punta Manabique Guatemala in 1975 (CEP, 1995; personal communication, M. Basterrechea, 1999). In 1990, a minor spill occurred from an oil barge off the coast of San Pedro Belize (Foer and Olsen, 1992). Hazardous cargoes, such as of petroleum, chemicals, fertilizers, pesticides, palm oil, radioactive materials and similar toxic substances could cause local and subregional catastrophic damage to most all aspects of coastal ecosystems.

E. Natural Oceanographic and Climato-Meteorological Phenomena

Oceanographic and climato-meteorological features are permanent phenomena in nature and only represent threats inasmuch as improperly executed anthropogenic development activities expose humans and their infrastructure to greater risk. Hence, the intermediate and root causes do not apply here. Rather, if these phenomena are not considered in planning and implementing development activities, the threats and causes described above can be more acute and bring about much more negative consequences for the human and natural environments. As described in Matrix 1, predominating currents and winds tend to influence the transport and concentration of sediments and contaminants entering the MBRS. The damaging effects of tropical storms, hurricanes and El Niño/La Niña events (especially floods and storm surges) are exacerbated through improper development actions practiced in coastal areas and inland locations. The MBRS receives more than 60 tropical storms per century, with various hurricanes hitting Honduras, Belize and Quintana Roo,

including Mitch in 1998, Gilbert in 1988, Greta in 1978, Fifi in 1974 and Hattie in 1960 among the most damaging (Heyman and Kjerfve, unpublished).

Coral diseases and bleaching are believed aggravated in areas of high sedimentation and contamination brought about by antropogenic activities on shore. The bleaching event of 1997-1998 was perhaps the most damaging to date for the MBRS, with corals from the southern coast of Quintana Roo through Belize and into the Bay Islands suffering extensive mortality (Kramer, 1999). The same study found that coral diseases were also widespread in the MBRS, with the highest levels of infestation occurring in back reef areas and patch reefs in Belize and off the leeward coasts of Cayos Cochinos and the Bay Islands of Honduras. And the rising sea level brought about by global warming will have much greater impacts on infrastructure built in areas reclaimed from shorelines, wetlands, mangroves and low islands.

V. ANALYSIS OF THE ROOT AND INTERMEDIATE CAUSES

As a point of background relevant to the analysis of intermediate and root causes of threats to the MBRS, it was determined that each of the countries comprising the MBRS have fairly comprehensive legal frameworks for protecting the environment and coastal resources (see Annex 3), although their application is disparate depending on the productive subsector involved and country. Each of the countries has legislation requiring environmental impact assessments of development projects in coastal areas, whether these are urban, residential, industrial, ports or tourism projects. In isolated cases, especially for Mexico in Cozumel, Chetumal and the Cancun-Tulum Corridor, land-use planning and zoning has been carried out in coastal areas as means to guide environmentally-sound development. Compliance with these plans, however, has been irregular with developers varying from stipulations generating local pressure on coastal resources and presenting new localities of environmental damage and contamination. Land-use planning is almost non-existent in Guatemala and Honduras, although programs have been proposed for coastal Guatemala and the Bay Islands, the latter being financed under the Bay Islands Environmental Management Program by IDB.

Also, each of the countries is signatory to many of the international and regional conventions and treaties which were ratified to encourage and facilitate the countries' adherence to international standards of environmental protection of marine and coastal resources (see Matrix 2). The lack of action of the countries comprising the MBRS on many, if not most, of these conventions and treaties complicates regional efforts to conserve and promote sustainable use of the MBRS. Both the international conventions and national legal/regulatory frameworks provide a basis for qualifying many of the root and intermediate causes. That is, the lack of compliance with existing international and regional protocols, and national and municipal regulations, norms and standards is, in itself, an intermediate cause of many of the impacts manifested in the MBRS by the specific anthropogenic actions associated with the threats.

The following subsections provide an analysis of the intermediate and root causes of the threats posed by each of the groups of anthpogenic actions presented in the preceding section. Matrix 1 provides an annotated list of intermediate and root causes for each group of threats. The following discussion is provided as an integral overview of these causes.

A. Inappropriate Coastal/Island Development and Unsustainable Tourism

Land-based sources contribute nearly 77% of the total pollution load to the oceans, with 44% from improperly-treated discharges of wastes and runoff and 33% from deposited from atmospheric sources (UNEP, 1992). The intermediate causes of threats inappropriate coastal development and unsustainable tourism are linked primarily to the inability, or lack of will, to enforce compliance of existing laws and regulations regarding environmental impact assessment and land-use zoning. In some cases, laws do not have clear regulations that would provide guidance to developers, and land-use plans are non-existent. There is a notable lack of land-use/integrated coastal management plans and zoning related to basic environmental and

engineering principles. With the exception of Mexico, the absence of environmental codes & standards for land development, buildings, resource utilization, and waste treatment and disposal limits developers' guidance in meeting environmental protection standards, and the ability of government authorities to enforce the same. In addition, the technical professional capability in the countries to prepare EIAs is grossly deficient, especially for sector-specific industries and industrial scale agricultural operations (banana, sugarcane, citrus, African oil palm). The absence or poor quality of baseline information on natural resources and ecological interactions, especially in island settings, needed to prepare land-use plans, EIAs, and follow-up environmental monitoring complicates these efforts. Tourism development is increasing at an ever-greater pace. In the Bay Islands alone, 16 new hotels are under construction, while the Cancún-Tulum Corridor is experiencing a continuing boom, with large full-service resorts.

Another intermediate cause of the threats is the failure to control of settlement and inappropriate land use in marginal areas not environmentally fit for habitation, especially national & municipal properties including mangroves, beaches, wetlands and near lagoons. The burgeoning immigration to coastal areas and tourism centers from other parts of the country, by peoples in search of economic opportunity and improved social services, overstrains municipal authorities' ability to control development and exerts pressure on the local and subregional resources base. The desire of developers to institute the high-value, cosmopolitan, full-service resort tourism model, not environmentally adaptable in the certain locations, also tends to complicate land-use planning and environmental protection efforts. The ever-increasing volume of cruise ship tourists has outpaced the countries' regulatory framework, and tourism and environmental protection authorities are racing to accommodate this tourism sector with infrastructure and waste management facilities. Many of the coastal and marine protected areas are, in reality, under-protected since meager investments by governments and the failure of police and judicial authorities to enforce regulations, even when these are denounced by protected areas managers.

Behind these intermediate causes stands a series of structural root causes of political and economic origin. First and foremost would be the lack of education and awareness of the impacts of development actions in the coastal environment at all levels, from local resource users up to national government policy makers. In many cases there is a strong political lobby from vested economic interests, especially the industrialists and land developers, to avoid encumbering their development activities with the costs of environmental protection, which are seen as a low priority and "unbearable cost that reduces international competitiveness". These premises are supported by the non-sustainable economic development model promoted by most national and local governments, which is fraught with economic distortions, including subsidies to favored sectors and "friends". Large-scale industrial, agricultural and tourism developers have long enjoyed numerous subsidies which encourage overuse of resources and avoidance of incorporating environmental mitigation into their projects. The recent Agricultural Modernization Law in Honduras provides subsidies for the expansion of export-oriented crops, such as banana and cultivated shrimp, and requires EIAs for such agricultural ventures but does not provide investments for improving the capacity in the country to prepare or enforce compliance on these. These include: reduced tariffs on water and electricity, tax exemptions on investments and exports, subsidized prices on imported fertilizers and pesticides, construction of transport and communication infrastructure to facilitate development, and open access to the nations' natural resources for private gains. This non-incorporation of the environmental costs of development into national accounts actually promotes environmental degradation and coastal resources depredation.

These same distortions tend to place the rural poor at a disadvantage. Weak land tenure policies favor large land owners and restrict access of the poor to land needed, in most cases, for subsistence agriculture. This is complicated by the levels of poverty in rural areas due to the lack of employment opportunities, the failing natural resource base, and lack of investments in rural areas for basic social services (clean water, education, transport, healthcare). As these conditions worsen, the rural poor set out in search of other opportunities, with an increasing number heading to coastal areas.

Finally, with the exception of Belize and the State of Quintana Roo, there is an absence of an integrated coastal resources management policy and related laws and regulations. The lack of national investments in investigation and monitoring of coastal environmental processes and the impacts of development complicates the development of regulatory frameworks. Also, the authority for enforcing existing coastal resources and environmental management regulations is scattered among numerous government institutions, leading to low priorities and investments in the enforcement of existing regulations.

B. Inappropriate Inland Resource and Land Use and Industrial Development

The intermediate causes of the threats associated with inappropriate resources and land use and industrial development in areas inland from the coasts can be distributed into two principal groups. On one hand, similar to the situation with the threats of uncontrolled coastal development, is the lack of land-use and watershed management plans to guide environmentally-sound development, compounded by the limited regulations and local capacity to assess the environmental impacts of development projects, especially industrial enterprises and transport infrastructure, and subsidies favoring the industrial development without investments in environmental protection. This group of causes is further complicated by the lack of reliable baseline information on natural resources and ecological interactions that would facilitate preparation of needed land-use and watershed management plans. On the other hand, which lack of secure access to land, basic human services and technical assistance to facilitate their practicing of appropriate land and resource-use techniques, the rural poor are left to deforest upland watersheds and other areas incapable of supporting agricultural uses, much of this on public lands, while large land owners, for the most part, occupy productive bottom lands with extensively grazed cattle and fast-growing tree plantations. Deforestation in Guatemala since 1960, for example, has reduced forest cover by 70% (UNEP, 1992).

Root causes are found in the economic development models of the countries in the region, which are biased to the subsidizing of urban and industrial areas and away from rural areas and the rural poor; the lack of equitable land tenure policies being just one example. These policies close the rural dwellers in a cycle of poverty and unmet human services, instigating them to continue their destructive land uses to the point of failure in the resource base and/or migrate to urban and coastal areas. Added to these are the politico-economic lobby, which permeates the status quo, and the convoluted distribution of management authority responsible for watersheds, forests and environmental management, which results in inaction and finger-pointing on the part of all involved. Finally, the failure to incorporate the real environmental costs of development into national accounts results in the compounding of economic losses to such cataclysms as Hurricane Mitch.

C. Overfishing and Inappropriate Aquaculture Development

The intermediate causes of the threats associated with overfishing can be found in large part in the lack of compliance with existing national fisheries regulations and standards upheld in international conventions and treaties. This can be attributed in part to the lack of awareness of the impacts of overfishing and of the content of the law bay many artisanal fishers, and the zeal to increase catch and revenue of industrial fleets. The deficient number and capability of government staff responsible for enforcement of fisheries regulations is another intermediate cause of overfishing, including sport and aquarium fisheries. The industrial and artisanal fishing fleets are over-dimensioned, especially in Honduras where there are some 350 industrial ships. As respective countries' fleets have reduced fish stocks in their territorial waters, many turn to poaching in extra-territorial waters of neighboring countries, with Belize receiving the bulk of this fishing pressure.

The lack of valid data concerning the abundance, reproduction habits, and landings/harvest of species of fishes, mollusks and crustaceans, especially those species under pressure (lobster, conch, shrimp, grouper), restricts the development of management plans and complicates the enforcement of regulations. The failure to include spawning aggregation sites under protective status for certain species and seasons puts even greater pressure on fish stocks that struggle to recover. Also, the lack of organization and training of artisanal fishers and sport fishing guides, and the limited knowledge and/or disregard of SCUBA divers of fisheries regulations contributes to default open-access and uncontrolled fisheries.

For threats of inappropriate aquaculture, the intermediate causes are primarily those resulting in poor siting, construction and operation of ponds, due to the lack of capacity of local professionals to execute EIAs for the sector and recommend appropriate mitigating measures. Also, there are few regulations that have been promulgated for to ensure environmentally-sound operation of aquaculture operations, especially concerning aspects of larval harvests in mangroves, beaches and estuaries, and effluent disposal. Similarly for bio-prospecting, even as this activity is increasing in popularity, there are little or no regulations in MBRS countries for its regulation.

For all threats associated with overfishing and inappropriate aquaculture, the most important root cause is the lack of integrated fisheries policies and management plans at the national level, and the MBRS region as a whole. The continuation of economic distortions that provide subsidies for incrementing and/or maintaining the over-dimensioned industrial fishing fleet and strong political lobby of industrial fishing companies maintains the pressure of overfishing, even as stocks have declined precipitously by 60-75% in the last two decades. This cause is further compounded by the inherent poverty of most artisanal fishers and lack of other opportunities which drives them to overfishing; a situation exacerbated since incentives similar to those offered to industrial fishers and technical assistance are not made readily available to artisanal fishers.

As fisheries represent a miniscule contribution to the four countries gross domestic product and export earnings, governments are now investing little in fisheries investigation and monitoring, or in the provision of sufficient budget for staffing, training and equipping for adequate licensing, vigilance and enforcement of existing regulations for boats, equipment and fishing. Fisheries authorities disregard compliance with many of the international treaties and conventions to which their countries are signatories, and bi-national agreements to control transboundary fishing. Governments insist that their hesitance to incorporate the environmental costs of maintaining sustainable fisheries into national and local accounts is because such costs are believed erroneously to reduce competitiveness in the sector.

D. Inappropriate Port Management, Shipping and Navigation Practices

As in the case of industrial development, intermediate causes of threats in this sector were found to be the lack of awareness of the impacts of ports, deficient regulations and limited local capacity to assess the environmental impacts of port projects. This is compounded by the lack of even baseline information on coastal resources and currents which together, restrict adequate siting, construction and maintenance of port facilities and result in inadequate investments in environmental mitigation and management, and poor

enforcement of compliance with existing regulations. For threats to ports operation and shipping, the intermediate causes are the lack of updated navigation charts and bathymetric and currents data, inadequate or obsolete port infrastructure and communications equipment in ports and/or aboard ships which, together, endanger shipping. The lack of overall integrated coastal management and port-specific management plans, replete with contingency plans for rapid responses to shipping emergencies and spills and equipment to handle them also poses threats to both shipping and the environment. The lack of facilities in ports for acceptance and management of wastes from ships relegates ships to disposal at sea.

At the root of the causes of threats in this sector are the lack of institutional capacity to properly manage ports operations and shipping, as the authority for application of environmental compliance and contingencies is distributed among various agencies (ports authorities, environmental authorities, merchant marine, municipalities and the navy), and too little investment is provided to maintain and/or upgrade port facilities and train port personnel. As with other development sectors, governments in the MBRS have not incorporated the environmental costs of port operation into the national and local accounts. Finally, the countries' failure to ratify and/or abide by or enforce international conventions and treaties (MARPOL, Law of the Sea, Cartagena Convention, etc.) to which countries are signatories is seen as a root cause of the threats to proper port management and shipping and navigation practices.

E. Natural Oceanographic and Climato-Meteorological Phenomena

Oceanographic and climato-meteorological features are natural phenomena that may be affected by anthropogenic activities in terms of inducing global warming which, in turn, would instigate changes in oceanographic and climato-meteorological phenomena such as the frequency and severity of tropical storms and hurricanes, El Niño/La Niña events, and seasonal changes in ocean currents and wind patterns. Again however, as these phenomena are considered natural, they would represent threats inasmuch as improperly executed anthropogenic development activities expose humans and their infrastructure to greater risk of damage from storms (see discussion in section on threats). Hence, an analysis of intermediate and root causes is not required.

VI. CURRENT AND PLANNED REGIONAL AND NATIONAL PROJECTS AND PROGRAMS RELEVANT TO THE CONSERVATION AND SUSTAINABLE USE OF THE MBRS

Each of the countries comprising the MBRS are implementing, or are proposing to implement, a number of projects and programs aimed at treating one or more of the threats to the ecological health of the MBRS. Several of these projects were designed specifically to remedy problems affecting coastal and reef resources, while others include actions that indirectly treat the threats and root causes. At the regional level, bilateral and multilateral development assistance and aid institutions are supporting numerous projects and programs to promote conservation and sustainable use of marine and coastal resources in the Wider Caribbean, including the MBRS.

A. Regional Projects and Programs

Of direct importance to the current MBRS project design are several initiatives dealing with the MBRS and coastal and reef resources (see Matrix 3 for the full list of regional activities). The coastal resources management component of the Regional Environmental Project for Central America, *PROARCA-COSTAS*, is co-financed by USAID with matching funds provided by international NGOs The Nature Conservancy (TNC), Worldwide Fund for Nature (WWF) and the University of Rhode Island/Coastal Resources Center (URI/CRC). The project supports capacity building and local empowerment of local communities in the development of strategies for the sustainable use of coastal resources focusing on pilot areas in Belize, Guatemala and Honduras. A new regional initiative*, Conservation of the Meso-American Caribbean Reef Ecoregion*, is being coordinated by WWF and focuses on biological assessment of the MBRS region and

determining priority interventions for treating root causes to resource degradation from a biodiversity conservation perspective. Both of these projects complement the Meso-American Biological Corridor Initiative spearheaded by CCAD. There are numerous ongoing international and regional programs providing technical assistance in coastal resources assessment, monitoring and capacity building. These include the Caribbean Coastal Marine Productivity Program (CARICOMP) and the UNEP-coordinated Caribbean Environment Program (CEP). Also, the Global Coral Reef Monitoring Network, operating through its Caribbean Sub-node is supported by various international and regional organizations with local coral reef monitoring carried out with GO and NGO staffs in all four MBRS countries. The Intergovernmental Oceanographic Commission/Subcommission for the Caribbean is coordinating support to countries in the Wider Caribbean Region to ratify and adopt actions under the protocols of the Cartagena Convention and supports scientific research, training and monitoring of oceanographic, fisheries and biological diversity parameters. There are also various projects under preparation with financing of GEF, World Bank, Inter-American Development Bank, UNDP, GTZ, USAID, DANIDA and other bi- and multilaterals directed to objectives of conservation of coastal and marine resources. There is currently a GEF Block B grant to develop the Gulf of Honduras Maritime Pollution Control Project with IDB support.

B. National Projects and Programs

At the national level, several projects stand out due to their direct relevance to the MBRS (see Annex 4 for the lists of projects and programs in each of the participating countries). There are various small projects related to protected areas (PAs) management of both marine and coastal and near-coastal PAs, supported by local and international NGOs and private entities, national and state governments, and bilateral and multilateral funding, including GEF, World Bank, IDB and USAID. Particular projects of interest are: the Southern Quintana Roo Integrated Coastal Zone Management Project (Amigos de Sian Ka'an, University of Quintana Roo, USAID); Conservation and Sustainable Use of the Barrier Reef Complex of Belize (Coastal Zone Management Authority and Institute, UNDP/GEF); the Trinational Alliance for Conservation of the Gulf of Honduras (currently developing new project initiatives); and the Bay Islands Environmental Program (Honduran Tourism Institute, IDB) and Sustainable Coastal Tourism Planning and Management Project (Honduran Tourism Institute, FUNDEMUN, GEF/World Bank, currently in design), both in Honduras.

C. Collaboration and Coordination among MBRS Initiatives

With so many national and regional initiatives, it is not surprising that the level of coordination among these projects has been very limited. In some cases, project managers do not know of the existence of other projects; while in other cases, financial aid institutions and/or project management agencies do not want to complicate their own efforts with collaborations with other projects. Coordination among bilateral and multilateral organizations, whether at the country or regional level, has been poor, resulting in various instances of duplication of activities, several with the same counterpart institutions. On the other hand, the capacity of several national government institutions in MBRS countries is extremely limited. Personnel are either too few or ill-prepared professionally to successfully execute complex integrated marine and coastal resources management projects; and they have no absorptive capacity for still more resources, even where these are needed. These same countries are also weak in their promotion of policies that favor implementation of projects promoting conservation and sustainable use of marine and coastal resources, especially where special economic interests tend to exert greater influence to maintain the status quo. While many of these national and regional projects support activities that coincide thematically with the proposed MBRS project, they do not have uniform geographical coverage throughout the MBRS region. They also differ strategically and methodologically, in some areas, from those of the MBRS initiative, especially in terms of their treatment, or no, of intermediate and root causes and in procedures and protocols for environmental monitoring and information formats.

Thus, it will be incumbent on managers of the current MBRS project to forge collaborations in order to create operational synergies and make best use of the limited resources available for financing activities to be

proposed under project components. Areas of opportunity for collaboration in MBRS activities can be found for each MBRS component, including: policy and regulatory strengthening, training, environmental education and public outreach campaigns and media development, planning responses for contingencies, and in areas of inventory, monitoring and the development of the proposed environmental information system.

VII. PRINCIPAL TRANSBOUNDARY ISSUES

The TRCA study yielded an analysis of the principal transboundary issues affecting the ecological health of the MBRS (see description in Matrix 4), due primarily to predominating currents and winds found in the Western Caribbean. There are two major ocean current features affecting the MBRS.. The gyre is strongest during the dry-season months of January to April. The principal southeasterly-to-northwesterly Caribbean current generally moves waters off the northeast coast of Honduras toward the Yucatan Straights east of the counterclockwise-rotating gyre that roughly encompasses the Gulf of Honduras, from the Bay Islands to Glover Reef in Belize. The Caribbean current then bifurcates near the Mexico-Belize border, with one branch flowing swiftly on toward the Yucatan Straights and influencing the Mexican section of the MBRS. The other branch trends south just off the coast of Belize back toward the Gulf of Honduras, where part of its waters get picked up in the gyre and others flow southwesterly into the Gulf of Honduras. Seasonal close-shore currents move east to west off the North Coast of Honduras and the Bay Islands and in to the Gulf of Honduras, until they meet currents flowing south along Belizean Coast and tend to mix in the Gulf. The Bahia de Amatique, located at the westernmost extreme of the Gulf of Honduras, has a semi-closed clockwise circulation influenced by the meeting of the coastal currents from Honduras and Belize. The Bahia de Chetumal drains into the border area of Belize and Mexico and near the bifurcation of the Caribbean current, where it mixes with the current flowing south along the Belizean Coast. At the local level, bays, river mouths, headlands, islands and reef structures influence currents. Easterly trade winds predominate in the MBRS region, tending to push surface currents into the Gulf of Honduras and into the coast of Belize.

Hence, the Gulf of Honduras and Bahia de Chetumal are the regional foci for the collection of contaminants entering the MBRS. Coastal drainages from the inland and coastal watersheds of the North Coast of Honduras generally appear to flow toward the Gulf bringing any suspended sediments and contaminants (and for that matter floating solid wastes). A similar phenomenon occurs with drainages from the interior and coasts, including drainage from the Bahia de Chetumal, shared by Mexico and Belize, wherein contaminants flow alongshore into the coral lagoon leeward of the barrier reefs and islands of Belize, picking up drainage from the resort town of San Pedro, then on toward Belize City. Of particular concern is the Bahia de Amatique wherein sediments and pollutants have a greater residence time and can adversely affect aquatic organisms.

Another transboundary problem is that of uncontrolled cross-border fishing by industrial and artisanal fishers in restricted areas, during closed season, in spawning aggregation, and with destructive fishing equipment and practices. The species most at risk are ocean and lagoon shrimp, lobster, conch and selected finfishes (especially grouper), but depredation also occurs with manatee and sea turtles.

The lack of control of dumping of liquid and solid wastes by ships at sea and at port facilities has led to degradation of open waters, reefs, beaches seagrass beds, estuaries and tidal wetlands. The impacts of these activities are especially noticeable on the leeward sides of the barrier islands of Belize and Bay Islands of Honduras, as well as the Gulf of Honduras.

Finally, uncontrolled coastal development and the lack of contingency planning on the part of all governments in the MBRS region has increased the damage inflicted by tropical storms and hurricanes, with Hurricane Mitch being the most emphatic lesson. These storms destroy coastal infrastructure and buildings, spilling into the sea vast quantities of solid and liquid wastes, including hazardous chemicals, and organic materials and sediments, contaminating resources throughout the MBRS. The increased exposure and vulnerability of the coasts due to inappropriate land clearing, dredging and filling has resulted in important losses in the natural

coastal defenses that offered better protection against such storms. Also, the rapid deforestation of inland watersheds has led to increased erosion, flash flooding and sedimentation.

VIII. ASSESSMENT OF THE INFORMATION DEFICIENCIES AND GAPS

The analysis of threats and their root causes was restricted by the lack of information across a range of themes (see Matrix 5). The lack of quantitative information reduces the validity of several of the analyses, especially in pinpointing the origin of certain threats and their manifestations on MBRS resources. The most glaring gaps are those of regarding water quality for principal drainages into rivers, bays, estuaries, lagoons and coastal wetlands that make up the MBRS. Without accurate data on water quality, it is difficult to detect which point- and non-point sources are contaminating certain geographical sectors of the MBRS, whether with nutrients, chemicals and/or suspended sediments. There have been isolated programs for water quality monitoring in coastal areas in Mexico and Belize, but these have restricted geographical range and are subject to interruptions depending on the availability of "soft" money from projects. Another program is proposed for the Bay Islands as part of the Environmental Management Program financed by the IDB. Also, while the general location of industries, ports, industrial agricultural areas, petroleum exploitation areas and terminals, aquaculture operations, solid waste disposal sites and sanitary sewage discharge outfalls are known, little is understood about the volume and nature of their wastes and contamination potential.

It is also difficult to assess the static levels of contamination (baseline) to understand if the Caribbean is becoming more contaminated or less with time, if contamination levels are seasonal, and how these relate to the ecological health of varying elements of the MBRS (for example coral diseases and bleaching, fisheries productivity and recruitment, algal infestations). The ecological composition and condition of the principal estuaries, mangroves and lagoons—which are the first-line repositories and buffers of contamination entering the MBRS—are poorly understood. The same situation applies to the ecological status of reefs and seagrass beds in proximity to principal drainage outlets to the MBRS. Again, the capacity of coastal wetland features, estuaries, lagoons and mangroves, as well as fringing, patch and barrier reefs, to absorb sediments and contaminants needs to be correlated with the volume of inputs of these, as can be associated with data on water quality.

While general information is available on currents and winds in the MBRS, these are based on scanty sampling and several discontinuous studies. As currents and winds are determinants in the movement of sediments and organic and inorganic contaminants in the Caribbean, improved data collection and computer modeling would enhance the predictive capacity for assessing the movement and impacts of contaminants entering the MBRS. Their correlation with water quality data is a critical need.

Several land-use studies have been prepared for specific areas in the MBRS, and at the national level in several of the countries in the region. These, however, are outdated and are not continuously monitored to gauge changes—especially in regards to land clearing on shorelines and in mangroves, and the dynamics of deforestation in coastal and inland watersheds. The lack of a land-capability classification and zoning for terrestrial and coastal-marine areas of concern in the MBRS restricts an assessment of land-use conflicts in sensitive areas, inasmuch as their degradation may have an important influence on the health of the MBRS resources. There are few instances of monitoring the number by sites of tourists using the MBRS. While gross numbers may exist based on headcounts at airports, these are only useful at a macro-planning scale and have little use in determining carrying capacities and points of over-saturation and stress on sensitive sites in the MBRS.

The location of spawning aggregations and migratory and reproduction habits are poorly known, as is the status of fish stocks in coastal and open-ocean waters of the MBRS, whether territorial or international. Similarly, data on industrial, artisanal and sport fisheries catches are disparate, discontinuous and of questionable validity, since in few cases do they include fishing locations. Also, the number of fishing boats

of all sizes can only be estimated, since the permit/licensing process used in most countries is poorly controlled. Consequently, the status and tendencies of fisheries productivity is poorly understood, and only quantified in reduced harvests for selected species, especially lobster, conch, shrimp and selected finfishes (especially grouper).

For each of these information gaps, Matrix 5 provides a mechanism for addressing data needs. The most important need, at present, is to develop a permanent regional water quality monitoring program implemented at the local level with uniform parameters in strategically-selected sites throughout the MBRS. The program should place emphasis on the transboundary areas of the Bahia de Chetumal and Gulf of Honduras. Of similar priority is the need to develop improved data collection and modeling of currents and winds and their influence on coastal loading of sediments and contaminants. Water quality data can then be correlated with these data and for other parameters for which baselines should be generated under the inventory initiatives recommended in Matrix 5 and then permanently monitored. Water quality and current and wind data can then be correlated to determine the ecological status and dynamics of reefs, estuaries, lagoons and mangroves, and to qualify the inventory of point- and non-point sources of contamination to the MBRS.

IX. RECOMMENDATIONS FOR TREATING THREATS TO THE MBRS AND THEIR INTERMEDIATE AND ROOT CAUSES

As indicated in section VI, there are projects and programs under implementation (or in planning stages) in each of the countries that comprise the MBRS and at the regional and international level, that are designed to treat many of the intermediate and root causes of threats to the MBRS, whether directly or indirectly. Some of these, especially those dealing with regulatory reform and strengthening of the operational capacity of national and local government authorities responsible for environmental protection and coastal resources management, and investments in waste treatment, should contribute to improvements in the policy and institutional setting so as to favor investments in efforts to conserve and promote sustainable use of the MBRS. Still other actions can only be carried out by the national governments after they have made substantive changes in their economic development models, wherein they incorporate the costs of environmental protection and conservation into national accounts. This is especially the case for sector-specific productive activities including: domestic and industrial uses of water resources, agriculture, fisheries, industrial development, sanitation, energy and transport development, and tourism and coastal development. Similar policy changes are required for implementing socially-equitable land tenure reform, in order to stem migrations to coastal and urban areas, and expansion of the agricultural frontier into upland watersheds. Regional efforts can and should include a unified approach by the international community to lobby national governments to incorporate environmental costs into national accounts—including conditioning financial assistance to more environmentally-friendly policies--and to ratify and comply with international and regional conventions and treaties aimed at preventing and reducing pollution and conservation of MBRS resources.

Matrix 6 provides a series of proposed actions to treat the intermediate and root causes of each of the threats to the ecological health of the MBRS, as analyzed. As certain actions are required at the national level, especially those dealing with improved policy frameworks and enforcement of environmental protection and resource utilization regulations, these are indicated in a separate column. Actions are also recommended at the regional level, many of which having relevance to the design of the current MBRS project. The discussion provided in the following sections focuses on several of those actions at the regional level considered of higher priority to the objectives of the MBRS project under design, and emphasize action areas not currently considered under actual projects and programs in the region. It should be noted here that, many of the recommended actions are outside of the scope of the MBRS project.

A. Inappropriate Coastal/Island Development and Unsustainable Tourism

In order to improve the capability of professionals in all four countries to assess the real and potential environmental impacts of urban, residential, industrial, agricultural and tourism development in coastal areas, it is necessary to provide sector-specific training and guidance to staffs of GOs, NGOs, consultants and private-sector developers in environmental impact assessment. A regional program to train professionals in environmental assessment techniques for coastal regions should include sector-specific, practical guidelines for the preparation of EIAs, including guidance on land-use zoning, siting of infrastructure, norms and standards for buildings and public infrastructure, best practices for environmental mitigation, and compliance monitoring and enforcement. In order to facilitate land-use planning, site selection for developments, assessments of environmental impacts and specification of mitigation measures, it is necessary to carry out, or otherwise update, inventories and understand the condition and trends of coastal resources (see discussion on information deficiencies and gaps in section VIII).

Tourism development can be made more sustainable if developers and operators followed a set of best practices. As the number of tourist operators is too large to attempt training to all interested, it is recommended that several sub-regional training-of-trainers courses be directed to selected staffs of tourism authorities, tourism association representatives and NGOs. Also, best practices guides should be distributed to all known operators and developers, presenting practical guidance in siting and construction in coastal areas, "green" tourism operations, and ISO 14000 standards. Such training and publication of best practices guides should consider cruise ship/live-aboard tourism, diving operations and full service resorts. Wider application of economic and fiscal incentives, including lending policies of multilateral development banks, linking environmental accounting should be promoted. The use of environment-friendly products, such as paper instead of plastics and returnable and recyclable beverage containers, should be promoted by government and private sectors alike. Finally, tourism will be considered more sustainable where local communities are more fully involved in the operation of, and revenues from, tourism activities that are practiced in or near their communities. Case studies of successful community-based tourism models should be distributed to developers, tourism authorities and associations to engender interest in developing similar efforts.

B. Inappropriate Inland Resource and Land Use and Industrial Development

Many of the actions proposed to treat threats of inappropriate land use and industrial development in inland areas, outside of the direct sphere if influence of coastal areas, are similar to those proposed for inappropriate coastal development. However, it is difficult to justify project resources for treating these problems, as they are so geographically removed from the coast and deal primarily with non-coastal problems. Inasmuch as the manifestation of impacts of these threats are felt in the MBRS, coastal resources managers and users can lobby their respective governments to deal treat the problems. Many such initiatives are underway in each of the countries, especially in Honduras in the aftermath of Hurricane Mitch, where hundreds of millions of dollars are proposed for investments in watershed management projects for the Chamelecón, Lean, Aguán and selected coastal rivers on the North Coast. There are also proposals for the binational watershed of the Motagua River shared by Honduras and Guatemala.

Again, there is a need to incorporate training at the national level to improve the capability of professionals in all four countries to assess the real and potential environmental impacts of upland agricultural and industrial developments, institute land-use planning and zoning, as well as educate farmers on in appropriate land and resource use practices. Several of the actions proposed for coastal areas would also be useful in inland areas, especially for industrial development. These include the practical guidelines for the preparation of EIAs, siting of infrastructure, norms and standards for buildings and public infrastructure, best practices for sanitation and environmental mitigation, and compliance monitoring and enforcement. Also, the introduction of ISO 9000 and 14000 standards for industry would facilitate improved environmental management. Again, these recommendations are offered to those GOs and development assistance institutions for treatment of the intermediate and root causes of inappropriate land and resource use and industrial development in inland areas, but are *not* proposed for consideration in the MBRS initiative.

C. Overfishing and Inappropriate Aquaculture Development

Overfishing affects all on the MBRS and is by nature considered a transboundary threat. This is especially true in the case of migratory species and because much of the overfishing is actually poaching out-of-season, in closed areas, with illegal equipment and by illicit cross-border fishing. A regional program should be instituted to facilitate the harmonization of fisheries policies and regulations among all four countries in the MBRS, and in the priority transboundary subregions of Bahia de Chetumal (between Mexico and Belize) and the Gulf of Honduras (among Belize, Guatemala and Honduras). Such regulations should consider uniform closed seasons for selected species, closed areas, size and catch limits, no-take rules on threatened and endangered species, and uniform equipment restrictions. Regional awareness should be raised on the need to reduce industrial fleets (especially Honduras) and the promotion of incentives to do so. To facilitate the establishment of such regulations, it will be necessary to improve the knowledge base on fishing stocks and their dynamics. For this reason, a regional effort should be initiated to assess the status and tendencies of fisheries productivity in the MBRS, including assessment of stocks, location of spawning migrations, and monitoring of harvests for selected species, especially lobster, conch, shrimp and selected finfishes. As all four countries are signatories of conventions and treaties that promote conservation and sustainable use of fisheries in the Caribbean, including the SPAW Protocol of the Cartagena Convention, and those dealing with protection of biodiversity, lobbying for their compliance should provide greater impetus to fisheries management in the MBRS.

As part of the environmental education component, copies of fisheries regulations and best practices guides should be distributed to industrial fishers and artisanal fishers cooperatives in all countries. Where appropriate, programs should be instituted for retraining of artisanal fishers to become ecotourism, diving and sport fishing guides. The regional project can provide uniform training materials and train trainers in each of the countries to facilitate such retraining and certification, with emphasis placed on priority transboundary areas. The formation of binational (Mexico and Belize) and trinational (Belize, Guatemala and Honduras) fishers' associations comprised of representatives of artisanal fisheries cooperatives and industrial fishers, should be promoted as fora for resolution of transboundary conflicts and to impact information and training in appropriate fishing practices needed to sustain fisheries in the MBRS. The establishment and expansion of the coastal section of the Meso-American Biological Corridor should be actively promoted under the MBRS project. Linking strategic marine protected areas can be an effective mechanism to conserve species diversity, allow recuperation of depressed populations of species under pressure, protect spawning aggregation sites and serve as recruitment areas.

In terms of aquaculture development, there is a need to promote the use of best practices in siting and construction, and in proper effluent disposal and contingency planning in the case of disease, floods and hurricanes. Such guides can be distributed throughout the region by the project. The possibilities of using aquaculture to replenish depressed stocks of native species in local lagoons and estuaries should also be analyzed. For bio-prospecting, there is a need to provide guidance in setting uniform policies and regulations to be applied by all four countries in the MBRS, both to facilitate bio-prospecting and ensure protection of reef elements from depredation.

D. Inappropriate Port Management, Shipping and Navigation Practices

There is a need to facilitate improved capacity in the region to evaluate and mitigate the environmental impacts of ports construction and operation, including aspects of port and navigation channel siting, proper maintenance, improved navigation aids and communication, and management of liquid and solid wastes. There is an acute need for the development of contingency plans at every port to respond to accidents, toxic spills, collisions at sea and other similar occurrences. A regional effort should be initiated to train port authorities, merchant marine, navies and environmental protection authorities in these aspects and provide practical guidelines for the preparation of EIAs, mitigation measures, contingency plans and in mechanisms and

approaches for enforcement of regulations. Where regulations are outdated or lacking, technical assistance should be provided for their improvement.

As all of the countries are signatories to MARPOL and other conventions and treaties dealing with appropriate navigation, shipping and waste management on the high seas and in ports, international organizations should lobby national governments to ratify and/or comply with protocols aimed at protection of MBRS resources. Where needed regional assistance and best practices guides should be provided to appropriate government authorities and shippers enabling them to comply with these provisions.

E. Natural Oceanographic and Climato-Meteorological Phenomena

In order to better prepare for contingencies related to such phenomena as tropical storms, hurricanes, El Niño-La Niña events, global warming and to better understand the correlations of the impacts of anthropogenic activities to the ecological health of the MBRS, better information is required. The regional project should facilitate development of a regional coastal zone monitoring system with uniform parameters, data collection and analytical methods, networked throughout the MBRS, with links to international organizations already active in these activities (CARICOMP, NOAA, IOC/IOCARIBE, WMO, FAO, OAS, CPACC, UNEP, ITSU, U.S. Hurricane Forecast Center, universities, etc.). Such a system would include the standardization of parameters and methods for coral reef (composition, condition/growth characteristics, bleaching, diseases), and water quality monitoring for the MBRS region. This regional effort should include financial and technical assistance to achieve regional efficiencies of scale for permanent monitoring programs, including provision of equipment, training and technical assistance. As with the treatment of other threats as described in previous sections, the project should facilitate preparation of regional guidelines for land-use planning and disaster preparedness, sector-specific contingency plans (industry, tourism, aquaculture, ports, etc.), and provide technical assistance for their preparation at the national and subregional (transboundary) levels.

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