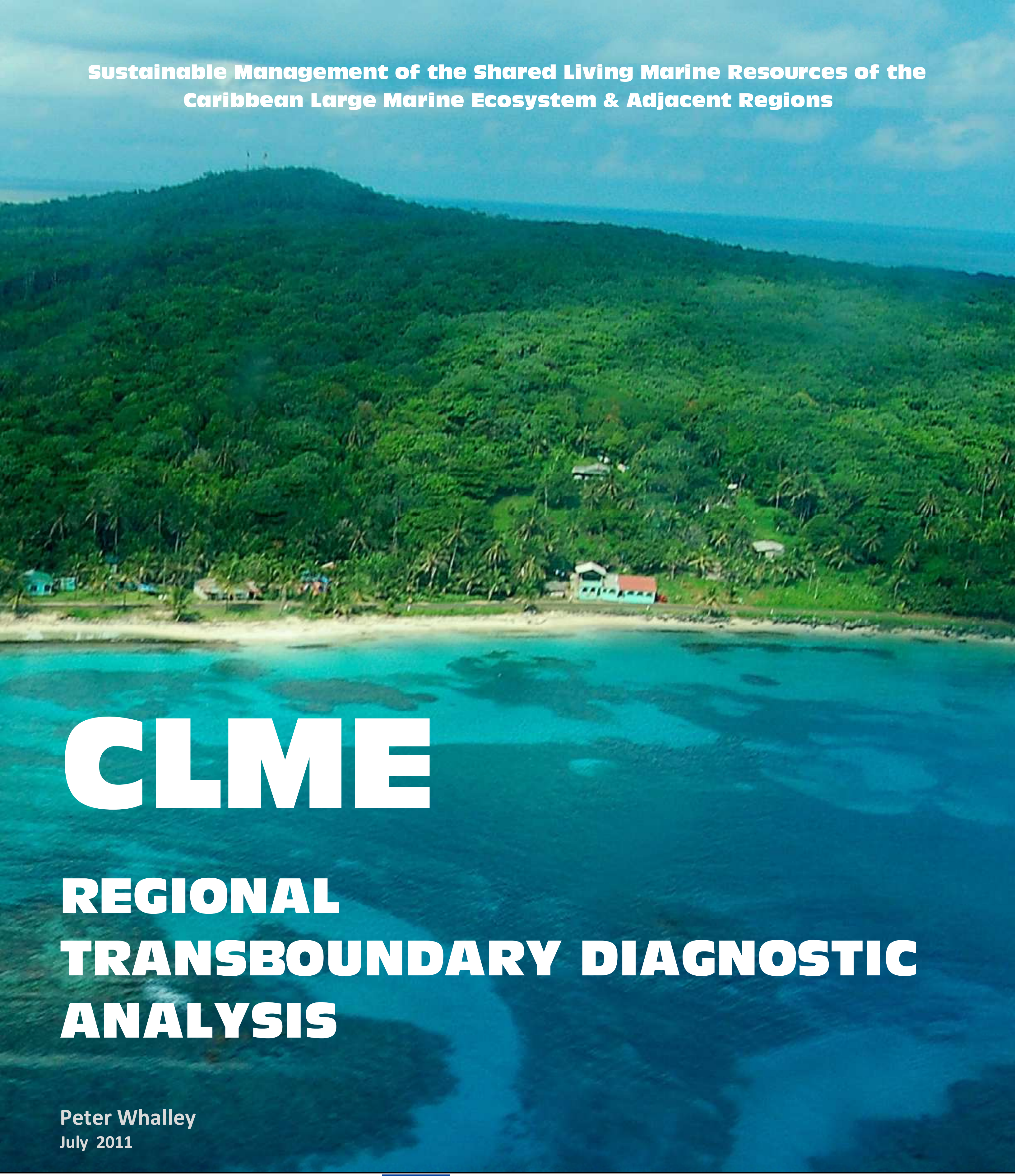

Sustainable Management of the Shared Living Marine Resources of the Caribbean Large Marine Ecosystem & Adjacent Regions

CLME

REGIONAL TRANSBOUNDARY DIAGNOSTIC ANALYSIS

Peter Whalley

July 2011

Caribbean LME Project

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Sustainable Management of the Shared Living Marine Resources of the Caribbean Sea Large Marine Ecosystem (CLME) and Adjacent Regions

Caribbean Large Marine Ecosystem Regional Transboundary Diagnostic Analysis

Prepared by the UNDP/GEF CLME Project

July 2011

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Abbreviations

BOD	Biological Oxygen Demand
BPoA	Barbados Programme of Action for the Sustainable Development of SIDs
CARICOM	Caribbean Community and Common Market
CBD	Convention on Biological Diversity
CCA	Causal Chain Analysis
CEHI	Caribbean Environmental Health Institute
CEP	Caribbean Environment Programme
CITES	Convention on International Trade of Endangered Species
CLME	Caribbean Large Marine Ecosystem
COD	Chemical Oxygen Demand
CPUE	Catch per unit effort
CRFM	CARICOM Regional Fisheries Mechanism
CSME	CARICOM Single Market and Economy
DIN	Dissolved inorganic nitrogen
EAF	Ecosystem Approach to Fisheries
EBM	Ecosystem-based Management
EEZ	Exclusive Economic Zone
EU	European Union
FSP	GEF Full-Sized Project
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIWA	Global International Waters Assessment
GPA	Global Programme of Action for Protection of the Marine Environment from Land-based Activities
HABS	Harmful Algal Blooms
HDI	Human Development Index
HMS & SS	Highly Migratory and Straddling Stocks
IAS	Invasive Alien Species
ICCAT	International Commission for Conservation of Atlantic Tunas
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission of UNESCO
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for the Conservation of Nature
IUU	Illegal, Unregulated and Unreported (fishing)
IWCAM	Integrated Watershed and Coastal Area Management
LAC	Latin America and Caribbean
LBS	Protocol Concerning Marine Pollution from Land-Based Sources and Activities (Cartagena Convention)
LME	Large Marine Ecosystem
LMR	Living Marine Resources
LNG	Liquefied Natural Gas

LOSC	Law of the Sea Convention
MARPOL	Convention on the Prevention of Marine Pollution from Ships
MEA	Multinational Environmental Agreements
MEA	Millennium Ecosystems Assessment
MIS	Marine Invasive Species
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
MTI	Marine Trophic Index
NBC	North Brazil Current
NBSLME	North Brazil Shelf Large Marine Ecosystem
NGO	Non-Governmental Organization
OECS	Organization of Eastern Caribbean States
OLDEPESCA	Fishing Development Latin American Organization
OSPESCA	Organization of the Fishing and Aquaculture Sector of the Central American Isthmus
PDF-B	GEF Project Development fund
PCU	Project Coordination Unit
POPs	Persistent Organic Pesticides
SAP	Strategic Action Programme
SCUBA	Self Contained Underwater Breathing Apparatus
SICA	Central American Integration System (OSPESCA)
SPAW	Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region
SST	Sea Surface Temperatures
STAG	Stakeholder Advisory Group
TDA	Transboundary Diagnostic Analysis
TED	Turtle Excluder Device
TN	Total Nitrogen
TNC	The Nature Conservancy
TP	Total Phosphorous
TSS	Total Suspended Solids
TTT	Technical Task Team
TWAP	GEF Transboundary Waters Assessment Project
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
UNGA	UN General Assembly
UNIDO	United Nations Industrial Development Organization
UNOPS	United Nations Office for Programme Services
USA	United States of America
USD	United States Dollar

WB	World Bank
WCR	Wider Caribbean Region
WECAFC	Western Central Atlantic Fishery Commission
WSSD	World Summit on Sustainable Development

1. Executive Summary

The Caribbean Large Marine Ecosystem and Adjacent Project (the CLME Project) addresses two Large Marine Ecosystems (LMEs): the Caribbean LME and North Brazil Shelf LME. The Caribbean LME is a semi-enclosed tropical sea of about 3 million km^2 bounded to the north by the Bahamas and the Florida Keys, to the west by Central America, to the south by South America and to the east by the Lesser and Greater Antilles Island chain. The CLME is also bordered by the Gulf of Mexico LME to the north and the North Brazil Shelf LME to the south. The North Brazil Shelf LME extends along the north eastern South American coast from the Parniba River in Brazil to the boundary of the Caribbean. The focus of the UNDP/GEF CLME Project is on assisting the Caribbean countries to improve the management of their shared living marine resources, most of which are experiencing overexploitation and degradation, through an ecosystem based approach.

A number of unique features make the CLME of special global and regional significance. The region is the most geopolitically diverse and complex in the world. With 22 independent states and 17 dependent territories (USA, UK, France, and the Netherlands) the CLME has the highest number of maritime boundaries of any other LME. This presents a considerable challenge for the effective management of the region's living marine resources, especially as many of them are shared.

An important component of the CLME project has been to undertake a Transboundary Diagnostic Analysis (TDA). A TDA is a widely-used tool within GEF International Waters Projects to provide a scientifically objective assessment of the causes of the main problems affecting transboundary and shared systems. In the project development phase (PDF-B) a preliminary TDA identified three priority transboundary problems that affect the CLME: unsustainable exploitation of fish and other living resources, habitat degradation and community modification, and pollution associated with three geographical areas (Insular Caribbean, Central/South America and Guianas/Brazil) within the Wider Caribbean Region (WCR). The PDF-B phase also highlighted the importance of having an effective governance regime to address the sustainability of the living marine resources of the WCR and the need to develop a specific framework targeted at interventions needed to bring about change in regional fisheries governance.

This report is the revised and updated Regional TDA based on TDAs of three fisheries ecosystems of regional significance: the reef, pelagic and continental shelf fisheries ecosystems. This Regional TDA (supported by the three fisheries TDAs and a regional governance analysis) will serve as the science basis for development of an agreed program of interventions including fisheries management reforms, conservation measures and pollution control. A Strategic Action Programme (SAP) with a shared vision for the CLME will be developed, and required priority interventions, reforms and investments to address the main transboundary problems agreed to. To assist this process, the project will create an integrated information management system bringing together congruent fisheries, biological, pollution and socio-economic data and information as a powerful management tool. Similarly, a monitoring and evaluation framework within a Regional Monitoring Environmental Programme will be developed. Pilot projects and case studies on specific transboundary fisheries (spiny lobster, reef, flyingfish, large pelagic and, shrimp and groundfish fisheries) will trial governance models at the local, national and sub-regional levels and provide additional knowledge on means of applying ecosystem based approaches to fisheries management and determining the fisheries' socio-economic importance and sensitivities.

The WCR ecosystem

The CLME region has considerable ecosystem resources that both contribute to the socio-economic growth of the region and offer ecological and biodiversity value. The WCR contains significant ecological features including:

- Over 12,000 species reported by the Census of Marine Life,;
- About 118 marine invasive species;
- Over 185 species of water birds and over 350 species of North American migratory birds during the winter months;

There is considerable spatial and seasonal heterogeneity in productivity throughout the WCR through interactions of open-ocean, coastal and ocean process and significant riverine inflows. High productivity is found in a range of coastal habitats such as coral reefs, mangrove forests and seagrass beds as well at ocean fronts and upwellings, and continental shelf influenced by river outflow.

The WCR provides valuable ecosystem 'services' (benefits derived from ecosystems), including through fisheries, tourism, coastal defences, and biodiversity support. These valuable systems are under growing threat from direct and indirect human activities, including climate change and variability. Marine ecosystems in the WCR have been treated in a fragmented manner, with individual habitats or fish stocks assessed and managed separately, with little consideration to preserving the overall health of the ecosystem. The focus of this TDA (this Regional TDA, and the detailed fisheries ecosystem TDAs) is to assess specific fisheries ecosystems and to identify the causes for their degradation that will lead to coherent management actions for the protection and sustainable exploitation of the living resources through the planned SAP.

The marine resources of the Caribbean Sea are largely shared resources, and the effectiveness of any management initiative will depend on collaborative and cooperative actions at the regional level, or other appropriate scale, depending on the issue and the resource. A number of regional initiatives and organizations already exist, and the establishment of an appropriate governance mechanism or framework for management of Caribbean transboundary living marine resources should be urgently pursued.

Approach to developing this Regional TDA

> This Regional TDA is based on the outputs of three fishery ecosystem TDAs and a detailed governance analysis. These source documents should be referred to for further detail and are available on the project website[1].

At a meeting of the Technical Task Team (TTT) and the Stakeholder Advisory Group (STAG) assembled to discuss the development of this TDA in Cartagena (January 2010), it was agreed to refocus the preliminary TDA undertaken in the PDF-B phase from three geographical sub-regions (Insular Caribbean, Central/South America and Guianas/Brazil) to three ecosystems representing the key types of fisheries of the CLME (reef, pelagic and continental shelf fisheries ecosystems). The reorientation towards fishery ecosystems represents a significant and innovative advance for the CLME Project. Most coastal and marine fisheries in the WCR take place in one of these three ecosystem types. These ecosystems are also the basis for a variety of other non-fishing activities such as recreation, tourism and transportation. The three ecosystems TDAs form the basis of this regional TDA and will lead to specific management plans and interventions within the SAP. The TTT/STAG meeting also adopted the Ecosystem Based Management (EBM) approach to developing the TDA consistent with FAO's Ecosystem Approach to Fisheries. In the perspective on the Ecosystem Approach that appears to be preferred by the countries of the WCR, the full range of human uses and the tradeoffs among them must be considered.

At the TTT/STAG meeting the Causal Chain Analysis (CCA) was also reviewed and updated for each of the three previously identified priority transboundary issues (unsustainable exploitation of fish and other living resources, habitat degradation and community modification, and pollution) for each fisheries ecosystem. The TTT/STAG meeting recommended the appointment of three international experts to develop detailed reports on the fisheries ecosystems and on regional governance that have been summarised by a forth expert into this Regional TDA. Over 600 pages of detailed assessments and information are available in reports on Reef & Pelagic Fisheries ecosystems, Continental Shelf fisheries ecosystem and Regional Governance. These in-depth reports (available on the project website) will be a prime reference for the subsequent development of SAPs for the three fisheries ecosystems including the regional governance of these ecosystems.[1]

This Regional TDA summarises regional information on the socio-economic features and activities of the CLME, provides the key findings from the three fisheries ecosystems reports (including the CCAs) and the governance analysis and summarises the main recommendations to be further developed in the SAP. The TDAs utilizes existing information available from the previous TDA and available literature.

Regional Socio-Economic Background

The WCR countries range from the most to the least developed, and includes the poorest country in the western hemisphere as well as a number of SIDs and low lying coastal countries such as Belize and Guyana. Caribbean countries are considered middle- and high-income, except Haiti,

[1] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

which is classified as low-income. About 25% of the Caribbean population can be considered as poor, with more women than men living in poverty. The WCR countries have a high degree of vulnerability to climate change and associated phenomena. In the last decade, the region suffered from several large natural disasters (mainly hurricanes and earthquakes) that caused significant damage and economic losses, and a great number of human fatalities.

The WCR is intensively used for fishing, tourism, shipping, and petroleum exploitation. It is noted for its maritime industry, with the Panama Canal the world's leading maritime hub. Tourism and fisheries are heavily dependent on the living resources and are of considerable socio-economic importance in the region. Relative to its size, the Insular Caribbean is the most tourism-driven region in the world, with the economies of many of the islands very dependent on tourism. Almost 25 million tourists travelled to the Caribbean during the year 2000. Although marine fisheries make only a small contribution to GDP, they represent a very important source of food, livelihoods, employment, income, and foreign exchange earnings in all the countries. In the 1970s and 1980s, many Caribbean countries embarked on large fisheries expansion programmes, mostly targeting offshore resources. Nevertheless, the fisheries remain predominantly small scale, with numerous artisanal fishers in coastal areas. It was estimated that over 5 million people are dependent on marine fisheries for their livelihoods in the region. In 2006, the value of the total fisheries landings from the WCR is estimated at more than US$500 million.

The Fisheries Ecosystems

The CLME Project has defined three fisheries ecosystems on which to prepare detailed TDAs that will form the scientific basis for the development of a SAP.

- ***Reef Fisheries Ecosystem:*** is considered to include shallow water coral reefs as well as mangroves, seagrass beds, lagoons, estuaries and beaches, as well as coral banks and rocky outcrops in deep waters that support valuable fisheries resources. There is high connectivity among these different components, making it necessary to consider them as one large, interdependent marine ecosystem with shared biodiversity. The coral reef-mangrove-seagrass complex is one of the most biologically diverse and productive systems in the world. They serve as habitat, feeding and nursery grounds for numerous commercially important fish and invertebrate species, including many with transboundary distribution. Among the major reef associated species that are exploited in the CLME are spiny lobster, queen conch, snappers and groupers, in addition to an immense variety of other reef fish species.

  Mangroves and seagrass are important carbon sinks, which is pertinent to the issue of concentration of greenhouse gases and global warming. Coral reefs contribute to the region's tourism industry and support important fisheries throughout the region. The annual value of ecosystem services provided by Caribbean coral reefs has been estimated at between US$3.1 billion and US$4.6 billion, with degradation by 2015 potentially costing between US$350 million and US$870 million per year.

- ***Pelagic Fisheries Ecosystem:*** considered as the epipelagic zone of the ocean, extending from the surface to a depth of about 200m. Areas of high productivity within the pelagic zone include coastal upwelling and ocean fronts.

The pelagic realm provides important habitats for adult and early life history stages of living marine resources as well as lower trophic levels (phyto and zooplankton) that are important in ocean food webs. The fish communities in the pelagic system include a wide range of small coastal pelagic species that are important components of the pelagic food web as well as large pelagic species such as mackerels, tunas, sharks and billfishes, and eggs and larvae of reef organisms.

For the purposes of the pelagic ecosystem TDA, the focus is on the large pelagic fish stocks, which comprise two groups: large coastal pelagics (e.g. small tunas and mackerels); and the more widely distributed and highly migratory large oceanic species (e.g. yellowfin and skipjack tunas, swordfish and marlins). Many of these fisheries resources are transboundary as they are shared between countries with some even extending into international waters, and there is likely wide dispersal of larval stages across EEZs. Over the last 15 - 20 years, the region's capacity for exploiting large pelagic resources has expanded considerably, especially through the development of longlining for oceanic pelagic species. The countries with well-developed fisheries for large pelagic resources include Barbados, Grenada, St. Lucia, Trinidad and Tobago, and Venezuela.

- ***Continental Shelf Fisheries Ecosystem:*** The North Brazil Shelf Large Marine Ecosystem owes its definition to the influence of the North Brazil Current (NBC), which flows parallel to Brazil's coast. The hydrodynamics of this region is dominated by the North Brazil Current, which is an extension of the South Equatorial Current and its prolongation, the Guyana Current. The shrimp resources in the Continental Shelf Fishery Ecosystem supports one of the most important export oriented shrimp fisheries in the world while the groundfish resources are important for commercial and social reasons, with the red snapper being probably the most important groundfish in the region because of its wide distribution range and export value. There are lesser fisheries for shelf-based schooling pelagic resources such as mackerels and jacks and for sharks.

  Human activities along the coastlands have led to severe habitat modification in thes Continental Shelf Fishery Ecosystem, with mangroves, which dominate a major part of the shoreline, having been seriously depleted in some areas. Unsustainable fishing of the shrimp and groundfish resources of the Continental Shelf Fishery Ecosystem could result in considerable socio-economic consequences as these fisheries make significant contributions to food security, poverty alleviation, foreign exchange earnings and the development of coastal communities.

Regional Fisheries Governance

In addition to identifying the priority issues within the CLME region, the PDF-B phase highlighted the need to develop a WCR-tailored framework targeted at the interventions needed to bring about changes in regional governance. An assessment of the regional and fisheries ecosystem-specific stakeholders has been undertaken.

In reviewing advances in ocean governance thinking since the PDF-B phase this TDA analysis summarises: key legal and policy-level advances at the international level, a growing awareness of ecosystem-based management, climate change impacts and specific projects focused on regional governance. There have also been a number of global ocean governance initiatives contributing to an increased understanding of factors affecting governance and resilience thinking. Given the increasing recognition of the need to take an ecosystem approach to managing transboundary living resources and the cross-cutting effects of climate change, new players have been identified. Among these new players, representatives of the tourism and conservation sectors are prominent.

Priority Transboundary Issues

The three agreed key transboundary issues (unsustainable fisheries, habitat degradation and pollution) have been analysed with specific reference to each of the three fisheries ecosystems. Inevitably, due to the physical and ecological linkages between these ecosystems many of the causes of the transboundary issues are common to all three fisheries ecosystems. In addition, there are links between the three transboundary issues (for example, pollution is addressed as a key transboundary issue but is also a cause of the habitat degradation). In addition the biological (demographic) linkages between the three fisheries ecosystems (for example between fish spawning, juveniles etc.) have to be considered. The fisheries ecosystem reports identify the uncertainty, and concerns, that climate change and variability could have in the CLME region and acknowledges the cross-cutting nature of climate impacts and the need for more data and assessments to understand the vulnerability and potential means to adapt to climate change.

The three identified transboundary issues that have an impact on the overall health and functioning of all three fisheries ecosystems. These impacts have a negative effect on the socio-economic development and sustainability of the WCR reducing the benefits available from the ecosystem services. As these issues are of ‘transboundary’ significance their impacts affect the WCR as a whole leading to the recommendation of a need for a coherent marine governance structure to protect and allow for sustainable development in the region. There are common aspects to the root causes of the three transboundary issues, for example; poor or inadequate governance, poverty, inadequate data and lack of public and governmental interest. The planned SAP will need to review the details of these causes and assess the potential options to address these.

The three transboundary issues are:

- ***Unsustainable Fisheries:*** applies to all three fisheries ecosystems with considerable similarity to the causes. There is significant evidence that overfishing or fishing close to maximum sustainable yields is impacting stock levels reflected in declining landings and collapsed stocks. Fishing is also having impacts at the ecosystem level, as evident in progressively declining mean trophic level of the catch, which signifies that larger predators are being depleted. illegal, unregulated and unreported (IUU) fishing is a regional problem and fishery regulations, where they exist, are poorly monitored and enforced. This is especially so in the offshore pelagic fisheries mainly because of the high costs and complexity of monitoring vessels in the exclusive economic zones. In addition, vessels under flags of convenience contribute to the unsustainable exploitation of the region’s fisheries. High bycatch levels are a common concern in all three fisheries ecosystems, particularly the Continental Shelf Fishery Ecosystem.

Over-fishing threatens more than 70% of Caribbean reefs. Large pelagic resources are also being exploited beyond sustainable levels, including dolphinfish, wahoo, blue and white marlin, sailfish and yellowfin tuna. The number of overexploited and collapsed stocks of large pelagic resources increased markedly from the late 1970s, with the proportion of collapsed stocks reaching almost 40% in 2006. In this year, about 60% of the pelagic stocks were overexploited and collapsed and about 10% rebuilding. These trends confirm the widespread reports of overexploited and collapsed stocks in the CLME, and are consistent with the unregulated expansion of fishing in previous decades. Many of the demersal fisheries in the area are either fully or overexploited, with by-catch and discards being of concern throughout the area, especially for the trawl fisheries. IUU fishing poses a significant threat to fisheries management in the region.

In general, all the shrimp species in the Continental Shelf Fishery Ecosystem are subjected to increasing trends in fishing mortality and the fisheries are generally overcapitalized. Despite the relatively stable catches, overexploitation was found to be severe, with there being evidence that some of the groundfish fisheries in this area may be fully or overexploited.

Unsustainable exploitation leads to reduced stocks and reduced opportunities to sustain livelihoods in the WCR. The root causes identified by the CCA for unsustainable fisheries include: poor governance, unsustainable development models, inadequate knowledge and public awareness, lack of alternative food sources and employment.

- ***Habitat degradation:*** The CLME habitats and their associated living resources are responsible for the valuable fisheries and tourism in the CLME. There are common concerns leading to habitat degradation across the fisheries ecosystems, e.g. shipping (and ship pollution), alien species introduction, climate change (including: acidification, increase storm damage, water temperature increases, pollution from land-based sources). Coastal habitats within the reef and continental shelf ecosystems are subject to impacts from destructive fishing methods, coastal development, watershed and marine pollution. Coastal environments are also more impacted from increasing sediment loads (for example from inappropriate land use in river basins, including forest clearance and agriculture) that can result in increased turbidity and choking of sensitive reef environments. Due to their proximity to the land-based sources (e.g. wastewater, industry, mining, agriculture) pollution can be more significant with regards to habitat degradation (e.g. through eutrophic conditions) within the reef and continental shelf ecosystems. The threats to these coastal environments from the loss of reefs and mangroves (for example) are potentially very significant given the important 'ecosystem services' these provide, for example, in supporting commercially important species and providing coastal defences against extreme weather events.

  Unsustainable exploitation has led to deterioration of reef condition in the Caribbean, as seen in the overgrowth of reefs by algae when the abundance of herbivorous fish (such as the Caribbean parrotfish) is reduced through overexploitation. This is of particular concern in areas where reefs have already been affected by the mass mortality of the spiny sea urchin, another important herbivore on coral reef. Valuable catches (for example, conch and lobster) have declined. Impairment of ecosystem functioning by fishing is evident by the decline in trophic level and Fishing in Balance (FIB) indices.

The root causes for habitat degradation include: poor governance, weak and ineffective legal and institutional frameworks, inadequate knowledge and public awareness.

- ***Pollution:*** affects all three fisheries ecosystems with coastal environments being potentially more impacted, although all ecosystems are subjected to marine discharges. Land-based sources (from tourism activities, wastewater, industry, agriculture, forestry, mining, oil exploration, etc.) leads to localized and dispersed pollution from nutrients, micro-biological species, persistent organic pesticides (POPs), hydrocarbons, heavy metals, for example. Soil erosion from forest clearances or agriculture can lead to greater sediment loads being discharged from the rivers to the CLME region. In addition to the habitat degradation concerns indicated above, sediments can have associated pollutants which can be slowly released. A global problem from land-based sources containing nutrients (e.g. from wastewater and agriculture) is eutrophication that result in oxygen depletion affecting mainly coastal areas that can further impact sensitive habitats. Land-based sources in the WCR are under the Cartagena Convention LBS Protocol, which has recently (2010) come in to force.

  The root causes identified by the CCA for pollution include: poor governance, weak and ineffective legal and institutional frameworks, inadequate environmental quality standards, inadequate data, and limited financial resources.

Towards the Strategic Action Programme

The development of the SAP will be based on the root, underlying and immediate causes identified for the three fisheries ecosystem TDAs and Governance Analysis reports. The SAP will also be informed by the results of the pilot projects and case studies on specific fisheries that will provide practical experiences to guide the SAP. In the course of the preparation of the fisheries ecosystem TDA reports, potential regional actions that could offer solutions to the main Transboundary issues have been identified and over 60 are summarised, *as examples*, in this Regional TDA. These potential actions, together with additional options, will be the subject of a detailed assessment and evaluation by the SAP formulation team.

2. Introduction

The Sustainable Management of the Shared Living Marine Resources of the Caribbean Large Marine Ecosystem and Adjacent Areas Project (the CLME Project) covers two Large Marine Ecosystems (LMEs): the North Brazilian Shelf LME and the Caribbean Sea LME. Together these correspond to the geopolitical entity known as the Wider Caribbean Region.

2.1. Background to the CLME Region

2.1.1. Global and regional significance of the CLME

The CLME is a semi-enclosed tropical sea bounded to the north by the Bahamas and the Florida Keys, to the west and south by Central and South America, and to the east by the Lesser and Greater Antilles Island chain (Figure 1). It is bordered by the Gulf of Mexico LME to the northwest and the North Brazil Shelf LME to the southeast. This distinct ecological region covers an area of about 3.3 million km^2 (Sea Around Us Project 2010), making it the second largest sea in the world.

The North Brazil Shelf LME extends along northeastern South America from the Parnaíba River estuary in Brazil to the boundary with the Caribbean Sea and has a surface area of about 1.1 million km^2.

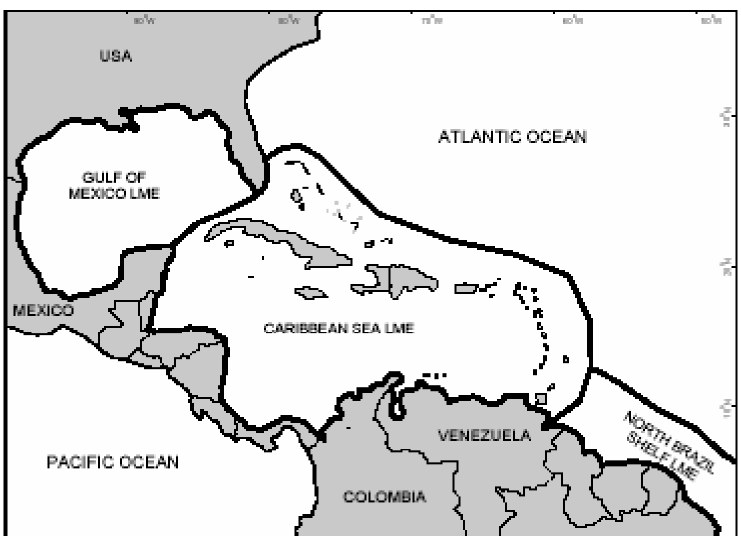

Figure 1. Map of the CLME

A number of unique features make the CLME of special global and regional significance. The region is the most geopolitically diverse and complex in the world. The 26 independent states and 17 dependent territories (USA, UK, France, and the Netherlands) mean that the CLME has the highest number of maritime boundaries of any other LME. This presents a considerable challenge for the effective management of the region's living marine resources, especially as many of them are transboundary.

These countries and territories range from the largest to the smallest in the world, and from the most developed – USA and European countries– to the least developed –Haiti. Another unique feature of the CLME is the number (over 20) of Small Island Developing States[2] (SIDS), the largest number of SIDS in any of the world's LMEs.

Box 1. States and Overseas Dependent Territories of the Caribbean Large Marine Ecosystem and Adjacent Areas Project (CLME Project)

Continental States	Independent Island States	Overseas dependent territories (metropolitan countries)
Belize*	Antigua & Barbuda*	Anguilla (U.K.)*
Brazil	Bahamas*	Aruba (Netherlands)*
Colombia	Barbados*	British Virgin Islands (U.K.)*
Costa Rica	Cuba*	Cayman Islands (U.K.)
Guatemala	Curaçao[1*]	French Guiana (France)
Guyana*	Dominica*	Guadeloupe (France)
Honduras	Dominican Republic*	Montserrat (U.K.)*
Panama	Grenada*	Martinique (France)
Mexico	Haiti*	Puerto Rico (U.S.A.)*
Nicaragua	Jamaica*	Netherlands Antilles (Netherlands): Bonaire, St. Eustatius, Saba*
Suriname	St. Kitts & Nevis*	St. Barthélemy (France)
Venezuela	St. Lucia*	St. Martin (France)
USA	St. Maarten[1*]	Turks and Caicos (U.K.)
	St. Vincent & the Grenadines*	U.S. Virgin Islands (U.S.A.)*
	Trinidad & Tobago*	

[1]Previously Dutch territories, became independent on 10 October 2010

*SIDS and low-lying coastal countries

The importance of the Caribbean Sea for sustainable development is recognized in a number of international (UN) declarations. Among these are

- The series of UN General Assembly (UNGA) resolutions based on the Caribbean Sea Initiative of the Association of Caribbean States beginning with Resolution 54/225 "Promoting an integrated management approach to the Caribbean Sea area in the context of sustainable development", which was adopted by the 54th Session of the UN General Assembly in February 2000 and continuing with subsequent updated resolutions at regular intervals the most recent being Resolution 65/155 "Towards the sustainable development of the Caribbean Sea for present and future generations" adopted in December 2010;

[2] Included in the UN list of SIDS

- Barbados Programme of Action for the Sustainable Development of SIDS (BPoA), which resulted from the UN Global Conference on the Sustainable Development of SIDS held in Barbados in 1994. This is accompanied by the Barbados Declaration, a statement of political will underpinning the agreements contained in the BPoA, which identifies actions required at the national, regional, and international levels for sustainable development in these countries and for reducing their vulnerability. The BPoA has been recently (2005) supplemented by the Mauritius Initiative[3]
- Cartagena Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region, which was adopted in 1983. Unique to the region, the Cartagena Convention and its three protocols (Protocol Concerning Cooperation in Combating Oil Spills in the Wider Caribbean Region; Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region; and Protocol Concerning Marine Pollution from Land-Based Sources and Activities) constitute the first regional framework convention for the protection of the region's marine and coastal areas and wildlife.
- MARPOL Special Area: From 1st May 2011 the Caribbean Sea will be designated a "Special Area" under provisions of the International Convention for the Prevention of Pollution from Ships (MARPOL)".

2.1.2. Purpose of the Transboundary Diagnostic Analysis

A Transboundary Diagnostic Analysis (TDA) is an objective assessment using best available verified scientific information to examine the state of the environment and the root causes for its degradation. The TDA provides the technical and scientific basis for the logical development of a Strategic Action Programme (SAP) that is based on a reasoned, holistic and multi-sectoral consideration of the problems associated with the state of and threats to transboundary water systems and resources. The SAP embodies specific actions (policy, legal, institutional reforms or investments) that can be adopted nationally, usually within a harmonized multinational context, to address the major priority transboundary concern(s), and over the longer term restore or protect a specific body of water or transboundary ecosystem.

A TDA is also a valuable process for multilateral exchanges of perspectives and stakeholder consultation as a precursor to the eventual formulation of a SAP. The analysis is carried out in a cross-sectoral manner, focusing on transboundary issues without ignoring national concerns and priorities.

2.2. Structure of Regional TDA

The purpose of this Regional Transboundary Analysis is to provide an overview of the three priority transboundary issues (unsustainable fisheries, habitat degradation and pollution) and their environmental and socio-economic impacts and causes in the three fisheries ecosystems, providing sufficient levels of detail to give confidence in the analyses and recommendations for the future Strategic Action Programme. The Regional TDA has been prepared from information

[3] Mauritius Strategy for the further Implementation of the Programme of Action for the Sustainable Development of Small Island Developing States. January 2005. http://www.un.org/special-rep/ohrlls/sid/MIM/A-conf.207-crp.7-Mauritius%20Strategy%20paper.pdf

in the three fisheries ecosystems reports and the governance assessment of the CLME region. These extensive and detailed reports provide the basis for the summary conclusions presented in the Regional TDA and **are the main sources of reference for more information, and especially for developing the SAP**. [4]

The Regional TDA is provided in the following format:

- Section 3 - Methodology: provides an explanation of the approach adopted to collecting information, analysing it and assessing the situation in the three fisheries ecosystems including governance and stakeholder analysis within the CLME fisheries.
- Section 4 – Regional Analysis: provides a summary of the common features across the three fisheries ecosystems, including climate, ecological features and socio-economic background to the WCR. An assessment of the regional ocean governance arrangements in the WCR is also included.
- Section 5- The CLME Fisheries Ecosystems: the three fisheries ecosystems are described and analysed with an assessment of the current situation, impacts of the three transboundary concerns and governance specific issues. A summary of the key knowledge gaps is presented that will be a focus in the SAP development and pilot projects. Finally a synthesis of common and cross-cutting issues is presented, including climate change considerations.
- Section 6 – Analysis of Root Causes: provides a summary of the detailed Causal Chain Analysis undertaken in the fisheries ecosystems reports and summarises the main root cause of the three transboundary issues impacting the fisheries ecosystems.
- Section 7 – Priority Actions: summarises the key actions identified to be incorporated in the development of fisheries ecosystem specific SAPs.
- Annex 1 - Detailed CCA diagrams from three fishery ecosystems and each priority transboundary issue.
- Annex 2 - References and bibliography: an extensive list of publications is included providing further details and evidence of the conclusions summarised here based on the three fisheries ecosystems and governance reports.

[4] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

3. Methodology

3.1. Introduction

An important activity of the CLME Project has included a Transboundary Diagnostic Analysis (TDA) to assess the sustainable use of transboundary living marine resources in the Wider Caribbean Region (WCR) that will lead to a Strategic Action Programme (SAP) for the sustainable use and management of these resources. A preliminary TDA was prepared during the preparation phase (2007) of this project and has been used for the basis of this updated TDA.

3.2. Summary of the Preliminary TDA (2007)

During the preparatory phase of the CLME project, a preliminary TDA was developed for three sub-regions (Insular Caribbean, Central/South America and Guianas/Brazil). The preliminary TDA identified and analysed three priority transboundary environmental problems

- Unsustainable exploitation of living resources;
- Habitat degradation and community modification, and;
- Pollution.

These priority transboundary issues are interlinked, not only because of their synergistic impacts on living marine resources, but also because in general they have the same underlying and socio-economic, legal, and political root causes. Some of these underlying and root causes are also manifested at the regional level, for example, deficiencies in institutional, policy and legislative frameworks for transboundary management of the living marine resources of the CLME.

The socio-economic dependence of the countries, particularly the SIDS, on the living and non-living marine resources presents a considerable challenge for LME level governance that would result in sustainable management of the region's shared living marine resources. Sectoral decision-making at the national governmental level that seeks to enhance economic gain in one sector can often conflict with the achievement of economic, social and environmental goals set in other sectors.

The marine resources of the Caribbean Sea are largely shared resources, and the effectiveness of any management initiative will depend on collaborative and cooperative actions at the regional level, or other appropriate scale, depending on the issue and the resource. A number of regional initiatives and organizations already exist, and the establishment of an appropriate governance mechanism or framework for management of Caribbean transboundary living marine resources should be urgently pursued by implementing a range of policy options that focus on:

- Strengthening national capacity to participate in regional management processes;
- Strengthening existing and emerging regional arrangements and organizations to play the role of 'competent organizations' as defined by the UN Fish Stocks Agreement; and,
- Developing linkages among these arrangements and organizations.

This strengthening must span the full range of activities required for collaborative management of shared living marine resources, including: information gathering and sharing, analysis and interpretation, provision of advice, management decision-making, implementation and reviewing/assessing progress. In most cases, there is adequate information for preliminary planning that identifies the strategic approach to be adopted, the associated information needs and interim management actions that can be taken while the information/advisory base is being strengthened.

3.3. Approach adopted for the CLME TDA

3.3.1. Background

At a meeting (January 2010, Cartagena) of the TDA Technical Task Team (TTT) and the Stakeholder Advisory Group (STAG) a decision was taken to realign the approach of the CLME TDA based on specific fishery ecosystems rather than geographical sub-regions followed in the preliminary TDA. The TTT and STAG considered this approach to be more consistent with the overall goal of the project.[5] Three specific ecosystems (continental shelf, pelagic and reef ecosystems) were agreed as the focus of the revised TDA. In addition, draft Casual Chain Analyses (CCAs) for the three systems were prepared during the TDA-SAP workshop (January 2010, Cartagena) and have been reviewed, validated and prioritized using the Global International Waters Assessment (GIWA) methodology.[6]

Using the preliminary TDA (2007) as a starting point, the TTT recommended the appointment of three international regionally-experienced experts to update the TDA (and the draft CCAs developed during the TDA-SAP workshop) on the basis of the agreed fisheries ecosystems and to update the regional governance report. The outputs from these experts (http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas) provide the substantive material for the conclusions and recommendations from this Regional TDA.

At the TTT/STAG meeting the three transboundary problems were restated as:

- Unsustainable fisheries;
- Habitat degradation; and,
- Pollution.

3.3.2. Ecosystem approach to fisheries assessment and management

The decision by the TTT and the STAG to adopt an Ecosystem Based Management (EBM) approach to the development of the TDA consistent with FAO's Ecosystem Approach to Fisheries (EAF) (see Box 1) resulted in the identification of the three fishery ecosystems (reef, pelagic and continental shelf) that are subject to three transboundary problems (unsustainable fisheries, habitat degradation and pollution).

[5] The goal of the UNDP/GEF CLME Project is the sustainable provision of goods and services of the shared living marine resources in the Wider Caribbean through robust co-operative governance.

[6] www.unep,org/dewa/giwa

Box 1. Ecosystem-Based Management (EBM) and EAF [7] [8]

Ecosystem-Based Management (EBM) is a management approach that:

- Integrates ecological, social, and economic goals and recognizes humans as key components of the ecosystem.
- Considers ecological- not just political- boundaries.
- Addresses the complexity of natural processes and social systems and uses an adaptive management approach in the face of resulting uncertainties.
- Engages multiple stakeholders in a collaborative process to define problems and find solutions.
- Incorporates understanding of ecosystem processes and how ecosystems respond to environmental perturbations.
- Is concerned with the ecological integrity of coastal-marine systems and the sustainability of both human and ecological systems.

FAO Ecosystem Approach to Fisheries:

EAF's main purpose is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems.

The reorientation towards fishery ecosystems represents a significant and innovative advance for the CLME Project. Most coastal and marine fisheries in the WCR take place in one of these three ecosystem types. These ecosystems are also the basis for a variety of other non-fishing activities such as recreation, tourism and transportation. In the perspective on the Ecosystem Approach that appears to be preferred by the countries of the WCR, the full range of human uses and the tradeoffs among them must be considered.

In all three fisheries ecosystem, species interactions are among the prominent ecosystem issues. There are interactions among the resources that are exploited and also among the various commercial and small-scale fisheries that exploit them. Interactions with the marine transportation sector (including cruise ships, recreational vessels, commercial freight, etc.) also pose a concern in terms of the sustainability of ecosystem services. Examples of such interactions with the habitat and living resources of the ecosystem include disposal of garbage at sea, ballast water discharges increasing the threats of alien invasive species, accidental spills of noxious substances from transiting ships and from possible hydrocarbon production and distribution infrastructure.

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7 http://www.ebmtools.org/

8 http://www.fao.org/

The three ecosystem types are characterized briefly in the following paragraphs to provide some perspective on the range of governance issues that must be addressed by the SAP that is to be developed.

Coral reef ecosystems are clearly the most complex among those of the WCR. This stems both from its biological characteristics, the many human demands and impacts upon it. It includes coral reefs and related mangrove and seagrass habitats that are mainly coastal. It supports fisheries for reef fishes, spiny lobster and conch, which are three of the major fisheries of the region. There are also lesser fisheries for sea urchins, and small schooling coastal pelagics associated with the habitats of reef ecosystems. Coral reefs are ecologically among the most complex systems in the world owing to the variety of habitats and high biodiversity. Coastal areas with reefs are also the most popular for tourism development in the WCR owing to the white sand beaches, protected swimming and opportunities for marine recreational activities such as snorkeling and SCUBA diving. This leads to the competing economic demands and multiple marine and land-based impacts referred to above.

The off-shelf or open sea pelagic ecosystem of the WCR (considered to the epipelagic zone extending 200 m in depth) is arguably the least complex of the three fisheries ecosystems. It supports a variety of fisheries for both regional and ocean-wide large pelagics (such as dolphinfish, billfishes and tunas) as well as for flyingfish. There are lesser fisheries for cetaceans as well. At the fisheries interaction level, this ecosystem is where interactions between commercial and recreational fisheries are likely to be of greatest concern; especially regarding the relative social and economic benefits of these types of fisheries.

The continental shelf ecosystem supports the major shrimp and groundfish fisheries of the region. There are also lesser fisheries in these ecosystems for sharks, and for shelf-based schooling pelagic resources such as mackerels and jacks. Key ecosystem interactions are with coastal wetlands that serve as nursery habitats. At the human interaction level, this ecosystem is where interactions with other marine sector users such as marine transportation, offshore energy and marine-related tourism could potentially increase and contribute to threatening the sustainability of the continental shelf ecosystem services. This ecosystem is probably intermediate in complexity between the pelagic and reef ecosystems.

The implications of the EAF will be developed further in this report, however the above introduction has been provided to emphasise the point that although the term *fishery ecosystems* is being applied, there is the recognition that an ecosystem approach involves a balance among the many use and non-use services that ecosystems provide. It is also recognised that there are clear linkages and interactions between the three fishery ecosystems.

Marine ecosystems are prolific providers of ecosystem services. The concept of ecosystem services has been developed to aid our understanding of the human use and management of natural resources. Our health and wellbeing depends upon the services provided by ecosystems and their components: water, soil, nutrients and organisms. Therefore, ecosystem services are the processes by which the environment produces resources utilised by humans such as clean air, water, food and materials. Ecosystem services can be defined in various ways.

The four types of ecosystem services defined by the Millennium Ecosystem Assessment and adopted for this TDA are:

***Provisioning services*:** The products people obtain from ecosystems, such as food, fuel, fibre, fresh water, and genetic resources.

***Regulating services*:** The benefits people obtain from the regulation of ecosystem processes, including air quality maintenance, climate regulation, erosion control, regulation of human diseases, water purification, and protection from extreme events such as storms and tidal surges.

***Cultural services*:** The non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.

***Supporting services*:** Services that are necessary for the production of all other ecosystem services, such as primary production, production of oxygen, and soil formation.

3.4. Governance and Stakeholder Analysis

During the PDF-B phase, final selection and recommendation of key stakeholders was based upon their potential role(s) in contributing to the objectives of the CLME Project and position in the proposed project components' partnership diagrams/generic policy cycle. This was done based upon a review of each stakeholder's current mandate, roles and responsibilities and matching these with a list of key potential roles identified from the governance framework and key activities of the CLME Project. [9]

In an effort to further analyse the importance of the identified stakeholders in contributing to the success of the CLME project objectives, two additional refinements were made. The first refinement resulted in a categorization of the stakeholders in terms of their explicit role in each of the identified CLME project activities while the second refinement further categorized stakeholders in terms of their likelihood to be involved at a particular stage in the policy cycle for the particular CLME project activity. These were listed as focusing on shrimp and groundfish in the continental shelf ecosystem, reef fisheries and biodiversity, as well as lobster found in the reefs ecosystem, and large pelagic fishes in the open sea pelagic ecosystem.

3.5. Identification and analysis of transboundary environmental issues and root causes

Causal Chain Analysis (CCA) traces the cause-effect pathways of a problem from the environmental and socioeconomic impacts back to its root causes. Its purpose is to identify the most important causes of priority problems in international waters in order to target them by appropriate policy measures for remediation or mitigation. By understanding the linkages between issues affecting the transboundary aquatic environment and their causes, stakeholders and decision makers will be better placed to support sustainable and cost-effective interventions.

[9] See report entitled "Key Institutional Players at the Local, National, Sub-Regional, Regional and International Levels in the Caribbean Sea Large Marine Ecosystem" prepared for the CLME Project Implementation Unit by K. Parsram (2007).

The components of a CCA include:

Socio-economic impacts:	The adverse effect of an issue on human welfare (e.g. increased costs of water treatment or illnesses due to pollution).
Environmental impacts:	The adverse effects of an issue on the integrity of an aquatic ecosystem (e.g. loss of aquatic life as a result of eutrophication).
Immediate causes:	The physical, biological or chemical variables that have a direct impact on an issue; for example, enhanced nutrient inputs in the case of eutrophication.
Sector activities:	Include two components- the activities in the different economic sectors that provoke the immediate cause (e.g. in the agricultural sector, the excessive application of certain kinds of pesticides) and the decisions made by firms, farmers, fishermen, households, government officials or politicians (socio-economic agents in general) that directly or indirectly produce the negative impact (e.g. farmers´ decision to use a highly persistent pesticide).
Underlying causes:	Includes two components - Resource uses and practices; and Social, economic, legal and political causes.
Root causes:	The key factors, trends, processes or institutions that influence a situation, issue, or decision that propel the system forward, and determine a scenario's outcome (e.g. governance and culture).

The CCA presented for the three priority transboundary issues in the CLME are based on the previous thematic reports (preliminary TDA, 2007) and on the review of these by the TTT in January 2010. Full details of the CCA for each of the fisheries ecosystems are presented on the CLME project website[10] within the three fisheries ecosystems TDAs. A summary of the immediate, underlying and root causes are presented in Section 6 of this Regional TDA and the detailed CCA diagrams from the three fisheries ecosystems TDAs are presented in Annex 1

[10] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

4. Regional Analysis

4.1. CLME climate and oceanography

Meteorologically, the region is dominated by a tropical climate, with distinct wet (roughly June – November) and dry seasons (December – May), moderate air temperature ranges, and persistent trade winds. Annual rainfall varies between 50 - 1,250 mm. The seasonal variations of the meteorological conditions are caused by north-south migrations of the Intertropical Convergence Zone, which is found near the equator in winter and at about 10°N at the end of summer. The wet season is associated with a continuous series of tropical waves that move westward, some developing into depressions, tropical storms, and hurricanes. A distinctive hurricane season extends from June to November.

The North Brazil Shelf LME owes its definition to the influence of the North Brazil Current (NBC), which flows parallel to Brazil's coast. The hydrodynamics of this region is dominated by the North Brazil Current, which is an extension of the South Equatorial Current and its prolongation, the Guyana Current.

Water flows into the Caribbean Sea from the Atlantic Ocean mostly through the Grenada, St. Vincent, and St. Lucia Passages (Johns et al 2002) (Figure 2). It then continues westward as the Caribbean Current, the main surface circulation in the Caribbean Sea. The sources of the Caribbean Current are the South Equatorial current which splits at the eastern tip of Brazil into a southern branch that flows south and a northern current that becomes the NBC. The NBC then merges with the Northern Equatorial Current which is then the main source of water flowing into the Caribbean. Significant amounts of water is transported northwestward by the Caribbean Current, which turns sharply westward as it crosses the Cayman Basin and enters the Gulf of Mexico as a narrow boundary current, the Yucatan Current (Fratantoni 2001). The circulation in the Caribbean Sea experiences much variation in both space and time, some of it in the form of mesoscale eddies and meanders (Molinari et al 1981). The ocean circulation patterns in the Caribbean Sea and the transboundary nature of its living marine resources give rise to significant linkages among the region's coastal and marine areas and living marine resources.

Oceanic fronts in the region are generated by coastal wind-induced upwelling off Venezuela and Colombia (Belkin et al 2009). A front of about 100 km long dissects the Gulf of Venezuela along 70°40'W, likely caused by the brackish outflow from Lake Maracaibo combined with coastal upwelling. A 200 km-long front in the Gulf of Honduras peaks in winter, likely related to a salinity differential between the Gulf's apex and offshore waters caused by high precipitation in southern Belize (Heyman and Kjerfve 1999).

A dominant feature of the CLME is the massive quantities of fresh water and sediments entering from three great South American river systems: the Amazon, Orinoco, and Magdalena Rivers.

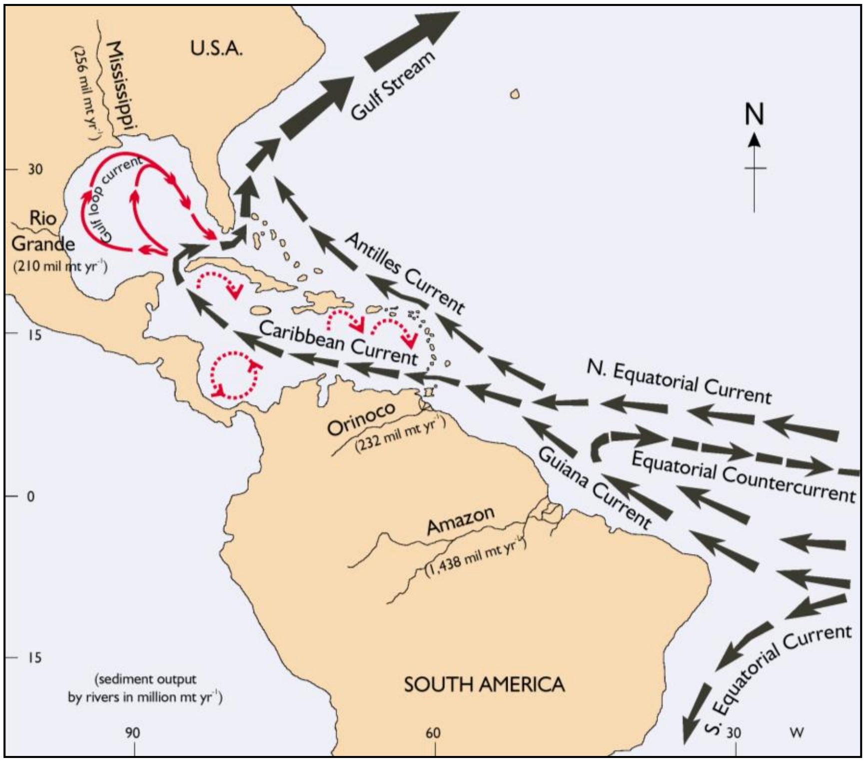


Figure 2. Caribbean Sea circulation pattern

4.2. CLME ecological features

The Caribbean Sea is generally considered oligotrophic, mostly comprised of clear, nutrient-poor waters. Based on SeaWiFS global primary productivity estimates, the Caribbean Sea is considered a low productivity ecosystem (<150 g C m^{-2} yr^{-1}) (NOAA 2003). Depending on the time of year, however, the Caribbean Sea can be better defined as mesotrophic (Gilbes and Armstrong 2004). Surface waters, enriched by upwelling and by discharges from the Orinoco River, are advected northwards into the region, especially during the rainy season. The intrusion of the Orinoco River during autumn promotes large concentrations of chlorophyll *a* in the eastern Caribbean, which can be carried as far as Puerto Rico (Müller-Karger et al 1989). Moreover, strong trade winds during winter and spring generate coastal upwelling along much of the coastline of northeast Colombia and Venezuela, bringing nutrients to the surface and increasing primary production in that area (Andrade and Barton 2000, Müller-Karger and Castro 1994).

The Caribbean Sea has been critically assessed and ranked by expert consensus as having marine ecosystems with the highest priority for conservation in the whole of Latin America and the Caribbean (Sealey and Bustamante 1999).

The North Brazil Shelf LME is considered a Class I, highly productive ecosystem (>300 gCm-2yr-1), with the Amazon River and its extensive plume being the main source of nutrients. Primary production is limited by low light penetration in turbid waters influenced by the Amazon, while it is nutrient-limited in the clearer offshore waters. Primary productivity on the continental shelf has been found to be greatest in the transition zone between these two types of waters, occasionally exceeding 8 gCm-2day-1. The North Brazil Shelf LME has a high number of amphibians, birds and reptile species. In addition to high production, the food webs in this LME are moderately diverse. Brazil's coral fauna is notable for having low species diversity yet a high degree of endemism (Heileman, 2008, 2010 and LME 17: North Brazil Shelf). The Gulf of Paria is a brackish water body, with wet season salinities being below 23 ppt. The extensive mangroves along the Venezuelan and Trinidadian coastlines are an important wildlife habitat and probably play a crucial role in regional fisheries[11].

There is a high diversity of habitat types and primary producers (e.g., coral reefs, mangroves, sea grasses, macro algae, benthic and epiphytic algae, phytoplankton). Within the CLME is found the longest barrier reef in the Western Hemisphere – the 220 km long MesoAmerican Reef (MAR) system– which extends from the Yucatan Peninsula to Honduras.

High productivity is found in these habitats, which naturally dominate the coastal margins of the CLME. These three types of habitats often exist together within a tightly-coupled ecological complex and provide important ecological services. For instance, coral reefs, mangroves, and seagrass beds function as spawning and nursery grounds for fish and invertebrates. They provide coastal protection against waves and storm surges, and coastal stabilization. Mangroves influence the productivity of coastal areas by contributing nutrients and acting as sediment traps in estuarine waters, thereby protecting coral reefs from sedimentation. Seagrass habitats are important for fishery production, and as a food source for certain threatened animal species.

The Census of Marine Life programme in the Caribbean region found at least 12,046 species have been reported to occur in the Caribbean Sea (Miloslavich et al 2010). About 45% of the fish species are considered Caribbean endemics.

At least 34 species of marine mammals (31 cetacean, 2 pinnipeds, and 1 sirenian) are known to inhabit the waters of the Caribbean Sea, seasonally or year-round (UNEP-CEP/RCU 2001). The cetacean species include seven species of baleen whales and 24 species of toothed whales. Of the two pinnipeds, the West Indian monk seal (*Monachus tropicalis*) is now generally considered extinct. For many marine mammal species, Caribbean waters are primary habitat for critical activities including feeding, mating and calving.

The Caribbean is noted for the annual aggregation of the world's biggest fish – the whale shark (*Rhincodon typus*). The WCR includes nesting and foraging grounds, as well as important migration corridors, for six of seven extant marine turtle species: leatherback (*Dermochelys coriacea*), green (*Chelonia mydas mydas*), loggerhead (*Caretta caretta*), hawksbill (*Eretmochelys imbricate*), olive ridley (*Lepidochelys olivacea*), and kemp's ridley (*L. kempii*). All six species are included in the IUCN Red List of Threatened Species.

Turtles may travel significant distances through multiple political jurisdictions during the estimated one to four decades required to reach sexual maturity. The largest green turtle nesting colonies in the WCR are found at Tortuguero, Costa Rica (the largest in the Western Hemisphere and one of the two largest remaining in the world) and Aves Island, Venezuela (Carr et al 1982, Bräutigam and Eckert 2006). The largest leatherback nesting colonies in the region are located in Trinidad and the Guianas (primarily French Guiana and Suriname). The former is the world's largest insular nesting leatherback colony. Marine turtles are popular subjects for dive and nature

[11] (http://en.wikipedia.org/wiki/Gulf_of_Paria)

tourism and, in this context, are increasingly becoming a source of revenue for coastal communities in the region, such as in Costa Rica, Grenada, St. Lucia, and Trinidad and Tobago.

Over 185 species of waterbird (seabirds, wading birds, marshbirds, waterfowl and shorebirds), including a number of endemic and globally threatened species, make their home in the Caribbean (Clay et al 2005). Millions of birds representing approximately 350 species that breed in North America migrate each year to spend the winter in Latin America and the Caribbean.

Caribbean marine biodiversity is under increasing threat from invasive species. Two well-known marine invasive species that have significant impacts in the region are: the Indo-Pacific green mussel (*Perna viridis*), which was introduced in Trinidad in 1990 and has since spread to a number of locations throughout the Caribbean Sea (Agard et al. 1992); and the red lionfish (*Pterois volitans*), which can cause severe disruption to coral reef communities.

4.3. Water quality issues in the WCR

Seawater in the WCR is impacted by a range of land and water based pollution sources. The key concerns are from nutrients (leading to eutrophic conditions), hazardous organic substances from industry and oil processing plants, oils spillage, and heavy metals from land based mining operations.

Sewage is regarded as one of the most important and widespread causes of deterioration of the coastal environment in the Caribbean. While sewage contains a number of substances, of particular concern is its high content of nutrients and microbes. Nutrients have given rise to widespread eutrophication (over-enrichment of water by nutrients such as nitrogen and phosphorus). Suspended sediments also impair water quality by blocking light penetration and introducing attached chemical compounds and pathogens. It is estimated that less than 20% of sewage is treated in the LAC region (UNEP 2003), with most of it flowing untreated to rivers and the sea (Martinelli et al 2006, PNUMA 2007).

In 2005, CLME countries used more than 1.7 million tonnes of fertilizers (UNEP-RCU/CEP 2011). Sediments, sewage, and nutrient pollution from agricultural sources constitute the largest pollution threat to critical coastal habitats. It is therefore essential for WCR countries to prevent, reduce, and control these sources of pollution under the LBS Protocol and other measures such as IWCAM in order to protect human health and living marine resources.

Notable is the increase in loads from watersheds (nutrients and sediments), which could severely affect coastal ecosystems. Estimates indicate that the CLME receives substantial DIN loads, between 750,000 to 1 million tonnes per year.

Oxygen depletion caused by eutrophication can lead to fish kills in the water column in some localized areas (UNEP 2004a, 2004b). These transboundary impacts are likely to be more pronounced during the rainy season.

Table 1 shows the total annual loads of $BOD_{5,}$ COD, TSS, TN, and TP discharged into the four sub-regions of the Caribbean Sea from urban and industrial activity and watersheds inflows according to the available information (UNEP-RCU/CEP 2010).The largest total contribution of nutrients comes from the Southern Caribbean with much of this attributed to the Magdalena River of Colombia (CARSEA 2007).

An estimated 90% of the hydrocarbon pollution in the WCR originates from land-based industrial sources and activities (UNEP-RCU/CEP 2011).

Table 1.Wastewater flow and total annual pollution loads discharged into the Caribbean Sea

Sub-region	Drainage area (km^2)	Waste-water flow [12] ($m^3.sec^-$)	Average annual load ($tonnes.yr^{-1}$) x 10^3				
			BOD_5	COD	TSS	TN	TP
Western Caribbean	291,439	3,004	427	1,851	5,819	15	5
Southern Caribbean	1, 278,743	3,364	3,364[13]	14,670[14]	202,383	644	125 [15]
Eastern Caribbean	105,242	1,004	210	389	56	3	1
North-east and Central	378,871	3,055	722	2,780	7,688	36	13

4.4. Socio-economic background

The CLME Region is the most geopolitically diverse and complex region in the world, with great cultural and economic diversity among its countries. Five hundred years of settlement by Europeans, Africans, Asians, and people from other parts of the Americas has resulted in a patchwork of independent states and colonies of governments in different regions (Box 1). This presents unique challenges to the establishment of the co-operative approaches needed to sustainably manage this ecosystem for the common good (CARSEA 2007).

The total population of the CLME countries and territories listed in Table 2for which data are available is approximately 225,000 million (including Mexico). If Mexico is excluded (most of its population is located in the Gulf of Mexico LME), this estimate is about 113.4 million, of which about 36% are located in the Insular Caribbean. Caribbean countries are considered middle- and high-income, except Haiti, which is classified as low-income. It is noteworthy that the countries with the four highest GDP/capita in the region are SIDs (Bahamas, Trinidad and Tobago, Barbados, and Antigua and Barbuda, in descending order). Among the Central/South American countries, Mexico has the highest GDP/capita, followed by Venezuela. After near-zero economic growth in 2000 and 2001, the region has been experiencing positive growth rates since 2003 (UN-ECLAC 2007). High levels of economic growth, however, mask persistent and in some cases increasing poverty. Studies carried out in 2003 showed that 25% of the Caribbean population can be considered as poor, with more women than men living in poverty (Trotz 2003). Significant variation exists among the countries with respect to poverty, with the highest proportion (65%) of population below the national poverty line being in Haiti (UNDP 2006).

12 The industrial wastewater flow is not included because of the lack of information.

13 Organic loadings and phosphorous from Rio Orinoco watersheds are not included because of the lack of information.

14 Same as previous footnote.

15 Same as previous footnote.

Additional social indicators provided by UN-ECLAC (2010) show that life expectancy at birth for Latin America is 74.6 and the Caribbean 72.4 years; for the Latin America and Caribbean (LAC) region, illiteracy rate (above 15 years old) was 8.3% in 2010; this was higher among women (8.8%) than men (7.7%); the proportion of the population with an improve drinking water source in 2008 was 93% and improved sanitation facilities 79%.

Table 2. Selected socio-economic data for the CLME region: Total population, GDP/Capita, Human Development Index), contribution of fisheries and aquaculture to national GDP, and travel and tourism to national GDP of CLME countries

(blank cells: no data available from sources consulted)

Country	Total pop [16] (000) (2011)	GDP/Capita [17] (2008 PPP US$)	HDI [18] (rank)	% Fisheries & aquaculture Contribution to GDP [19] [20]	Travel & tourism % Contribution to GDP (2010) [21]
Antigua & Barbuda	89	19,117	47	1.3	78.5
Aruba	108				
Bahamas	350	25,887	43	1.6	46.5
Barbados	257	22,794	42	8% agri GDP	48
Belize	319	6,460	78	4.15	28.2
Brazil	195,400	10,900	73	0.4	
Colombia	46,930	8,959	79	3.86	5.3
Costa Rica	4,703	11,143	62	1.38	14.0
Cuba	11,205		51	6.8	5.9
Curaçao					
Dominica	66	8,967	73		23.3
Dominican Republic	10,026	8,616	88		15.9
French Guiana	195	8,300			
Grenada	105	8,424	74	1.76	24.3
Guatemala	14,729	4,761	116	0.44	7.6
Guyana	761	6,800	104	6.0	
Haiti	10,253	1,040	145		7.0
Honduras	7,773	3,845	106	5.25	9.5
Jamaica	2,741	7,547	80	6.0 (agric GDP)	25.3

[16] UN-ECLAC 2010.
[17] UNDP International Human Development Indicators: http://hdr.undp.org/en/data/profiles/, based on UN DESA (2009).
[18] UNDP Human Development Report 2009.
[19] FIINPESCA–OSPESCA/FAO/SUECIA 2009.
[20] FAO Fishery Country profiles (http://www.fao.org/countryprofiles/default.asp?lang=en)
[21] World Travel & Tourism Council 2010 (http://www.wttc.org/eng/Tourism_Research/Economic_Data_Search_Tool/index.php)

Country	Total pop [16] (000) (2011)	GDP/Capita [17] (2008 PPP US$)	HDI [18] (rank)	% Fisheries & aquaculture Contribution to GDP [19 20]	Travel & tourism % Contribution to GDP (2010) [21]
Mexico	111,738	14,192	56	0.8	12.7
Netherlands Antilles	203				
Nicaragua	5,896	2,632	115	5.62	7.2
Panama	3,562	13,210	54	2.49	13.7
Puerto Rico & US Virgin IsI.	4,123				
St. Kitts & Nevis	53	15,092	62	3.8	30.5
St. Lucia	176	9,431	69	7.3 (agri)	35.1
St Vincent & the Grenadines	109	8,967	91	2.0	26.5
Suriname	534	9,900	94		
Trinidad & Tobago	1,349	25,162	59	0.09	36.8
Venezuela	29,499	11,820	75	4.5 (agri)	7.1
French Territories					
UK Territories	136				

- 2007- GDP in the primary sector "Agriculture, forestry, hunting and fishing" 2000 - 2007 (at current prices in millions of U.S. dollars).
- Other Sources: CIA World Factbook; Food and Agriculture Organization Website; UNDP Website; World Bank Website; CRFM Website

The LAC region is the most urbanized region in the developing world, with 77% of its population living in cities (UN Habitat 2008). About 116 million live within 100 km of the coast in the region, with nearly three-quarters of the population in coastal zones being urban inhabitants (UN Habitat 2008). The region will continue urbanizing over the next two decades, with the proportion of the urban population reaching 85%. Many of these cities are in the vulnerable, low elevation coastal zone.

Cities embody some of society's most pressing challenges, from pollution and disease to unemployment and lack of adequate shelter and sanitation. Location in the coastal zone makes these cities very vulnerable to extreme meteorological events such as storms and hurricanes. The CLME region has a long history of natural disasters caused by storms and hurricanes, floods, volcanic eruptions, landslides and earthquakes. In the last decade, the region suffered from several large natural disasters whose magnitude, in terms of fatalities and damages, has been significant. For example, between 2002 and 2009, the LAC region experienced 69 storms (29 in the Caribbean), which caused a total of 6,483 deaths (62% in the Caribbean) and affected 11.3 million people (47% in the Caribbean) (UN-ECLAC 2010)

The most notorious recent hurricane was Hurricane Ivan in 2004, which devastated nearly the entire island of Grenada and caused widespread damage in other islands such as Barbados, Jamaica, and Tobago. The 2004 hurricanes caused about US$2.8 billion in damages in Cuba, Dominican Republic, Grenada, Haiti, and Jamaica (CRED 2005).

The annual average cost associated with natural disasters between 1970 and 1999 ranged between $700 million and $3.3 billion (Charvériat 2000). Although economic damages from meteorological disasters in the Americas decreased in 2009 compared to the 2000-2008 annual average, they were still the most costly disasters compared to other disaster types in 2009[22].

This underscores the importance of the region's coastal habitats for their coastal stabilization and protective function.

Of particular concern is the effect of global warming, which is projected to lead to an increase in the frequency and severity of tropical storms (IPCC 2001). Based on global projections and studies in other regions, sea-level rise of 30 -55 cm for the Caribbean over the next 50 years is considered a reasonable projection. A rise of this magnitude is expected to have severe implications for the social and economic development of many Caribbean States (IPCC 2001). It has been suggested that land loss from sea-level rise, especially on the low limestone islands, is likely to be of a magnitude that would disrupt virtually all economic and social sectors (Leatherman 1997). This is of grave concern among the Insular Caribbean countries. The SIDS show particularly high environmental and socio-economic vulnerability to external perturbations.

The high dependence of the CLME countries on the marine environment and living marine resources, combined with their high environmental vulnerability underscores the importance of conserving this environment and sustainably exploiting these resources, especially with regard to a changing global climate over which these countries have little or no control. The main economic activities of Caribbean countries include tourism, construction (much of which is tourism-related), mining and oil extraction (Brown et al 2007). The petroleum industry is a major economic sector in Venezuela, Mexico, and Trinidad and Tobago, the region's three largest oil exporters.

4.4.1. Fishing industry in the CLME

The Caribbean fishing industry showed little expansion until the second half of 20th Century (Christy 1997). Prior to this, the fisheries were limited to subsistence and artisanal levels. In the 1970s, especially after the declaration of the Exclusive Economic Zone (EEZ) regime, several countries (e.g. Mexico, Cuba, Colombia, Nicaragua, Panama, and Venezuela) implemented government-sponsored fisheries expansion programmes.

The fisheries of the Caribbean Sea are predominantly multi-species, multi-gear, small-scale or artisanal fisheries. In Central America, for example, 90% of the fishers and 97% of the sub-regional fishing effort are artisanal. Caribbean fisheries are conducted by low-capital, labour-intensive operators, with the main exceptions being the industrial shrimp and tuna fisheries, as well as fisheries for high-value reef species such as conch, lobster, snapper, and grouper.

Table 2 shows the contribution of fisheries to GDP (for some countries this is combined with aquaculture and for others included in agricultural GDP) as well as travel and tourism to GDP. It is evident that compared to tourism fisheries do not play a very significant role in terms of

[22] CRED Americas http://cred.be/sites/default/files/ADSR_2009.pdf

national wealth generation. Despite the relatively low contribution to GDP, however, the impact of fisheries is considerable. Marine fisheries constitute an important economic sector in the region, providing foreign exchange earnings, employment, incomes, and animal protein. A significant portion of the region's population depends upon fishing for its survival and is unable to substitute fish for other sources of animal protein.

Small-scale fisheries in particular are widely recognized as an integral part of the fisheries sector in all CLME countries and play an important role in sustainable development, especially with respect to key issues such as poverty reduction, food nutrition, and livelihood security, wealth creation, foreign exchange earnings, and coastal-rural development (CARSEA 2007). The fisheries sector is primarily seen as an "economic safety net" to complement other employment activities (e.g. the construction and tourism sectors).

Data compiled for the Regional TDA (see detailed fisheries ecosystem TDAs[23])indicate at least one million persons are employed in fishing and related activities[24] . Based on the CARSEA estimate of five dependants for each person employed in this sector, the number of persons in the Caribbean who rely on fisheries for their livelihoods is at least 5 million. People engaged in fishing often have low levels of formal education, limited access to capital, and limited occupational and geographic mobility. Therefore, they will be highly impacted by declines in living marine resources.

Data compiled for these TDAs show that the region's fishing fleet consists of about 34,000 boats (excluding Mexico because of the relatively small proportion of its coastline in the CLME and unknown number of boats in this area, and a few countries for which data were unavailable). CARSEA (2007) reported a total of 31,500 boats (approximately 25,000 artisanal. In general, fish consumption per capita is higher in the Insular Caribbean compared to the continental states, which demonstrates the dependence of the islands' population on the CLME fish resources. Fish protein supply per capita exceeds the world average of 4.5 g/day in 11 of the countries, 10 of which are in the Insular Caribbean (Table 3). Fish protein as a percentage of total animal protein exceeds the world average in eight countries, all of which are in the Insular Caribbean. In addition, a high demand for fish is seen in the tourism sector, both for direct consumption and recreational fishing.

Despite the large number of countries that exploit the fisheries resources of the CLME, the catch is dominated by only a few countries, with Venezuela, Cuba, Mexico, and Jamaica accounting for nearly 80% of the total catch of about 364,000 tonnes in 2006. In 2006, the value of the total landings was about US$533 million, 65% of which was attributed to only five countries (Bahamas, Cuba, Jamaica, Nicaragua, and Venezuela). Significant proportions of high-value species such as lobster, conch, and tunas in the landings of these countries account for the relatively high value.

[23] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

[24] Some countries report only numbers of fishers, while others report a combined total of fishers and employment in processing and marketing

Table 3. Socio-economic importance of the fisheries sector in CLME countries

Country	[1,2]No. employed in fisheries	[1,2]No. vessels	[3] Fish protein supply per capita (g/day)	[3]Fish/animal protein %	[3]Fish Imports value (000 US$)	[3]Fish exports value (000 US$)
Antigua and Barbuda	1,193		14.1	24.6	7,882	327
Aruba						
Bahamas	9,300	4,000 (reef mainly)	7.7	12.6	17,806	83,367
Barbados	2,825	485 (reef, coastal); 300 (flyingfish & large pelagics); 30 longliners	11.3	22.0	18,847	899
Belize	3,843	593 (artisanal)	3.5	11.6	1,541	20,866
Brazil		243 (industrial)			297,221	238,602
Colombia	28,485 (industrial); 26,700 (aquaculture); 66,000 (smallscale marine and inland)		1.6	5.4	174,105	188,690
Costa Rica	1,210	242	2.1	6.3	44,972	107,255
Cuba	16,710	1,306	2.2	9.7	49,188	81,000
Curacao						
Dominica	2,903	>1,100 (10 tuna longliners)	8.3	16.7	1,815	6
Dominican Republic		3,752	2.8	10.3	102,195	4,937
French Guiana	128					
Grenada	2,800 ([4]2,515)	480 (pelagic); 130 (reef-fish); 50 (bait); 100 (lobsters, conch) ([4]1695 registered vessels)	11.1	22.1	4,701	4,115

Country	[1,2]No. employed in fisheries	[1,2]No. vessels	[3] Fish protein supply per capita (g/day)	[3]Fish/animal protein %	[3]Fish Imports value (000 US$)	[3]Fish exports value (000 US$)
Guatemala	1,420	465	0.7	4.7	43,852	89,640
Guyana	5000	1347			1.07	54.2
Haiti			0.8	10.1	17,014	4,879
Honduras	10,766 (artisanal)	5,383 (artisanal)	0.9	3.4	19,080	186,934
Jamaica	20,480	4,154	7.6	19.0	94,406	9,231
Mexico	268,727 (primary sector)	106,425	3.3	8.0	540,423	830,207
Nicaragua	5,676 (artisanal)	1,892 (artisanal)	1.1	6.2	6,599	96,448
Panama	2,280 (artisanal)	760 (artisanal)	3.9	10.5	24,999	362,304
St. Kitts & Nevis	600 (primary sector); >75% in reef fisheries		8.7	16.7	3,927	434
St. Lucia	2,339	690	12.6	21.4	6,810	11
St Vincent & the Grenadines	2,050 ([4]900 registered fishers)	600 ([4]745 registered vessels)	4.9	12.2	1,260	362
Suriname		1032				
Trinidad & Tobago	7,085	2,264	6.1	19.7	25,655	8,723
Venezuela	786,600	65 (tuna)	4.8	14.0	187,244	33,018
French Territories						
UK Territories						
			4.5 (World)	**15.6 (World)**		

[1]FAO Fishery Country profiles (http://www.fao.org/countryprofiles/default.asp?lang=en)
[2]FIINPESCA–OSPESCA/FAO/SUECIA 2009.
[3]FAO (2009). Yearbook of Fisheries and Aquaculture Statistics 2007. FAO, Rome.
[4]Data provided by countries in response to survey by CLME project.

4.4.2. Aquaculture

Overall, the aquaculture industry is well-developed in only a few countries. The industry is primarily based on the production of white shrimp (*Litopenaeus vannamei*) and Tilapia, although a number of other species are commercially farmed. In the Insular Caribbean, there is some small-scale production of tilapia and seaweeds (Gracilaria). The culture of marine fish is limited to experimental production of species such as cobia in Colombia and Cuba, and conch in Turks and Caicos.

In Central America, Panama and Honduras have the highest fisheries landings and number of boats and jobs, although the per capita fish consumption is very low in Honduras compared with Panama. In this sub-region, aquaculture production, mainly of shrimp and tilapia, surpasses fish capture production in four out of the six countries that border the CLME. This trend is most pronounced in Honduras where aquaculture production in 2007 amounted to about 17 times more than capture production. Honduras is also the sub-region's biggest aquaculture producer, followed by Costa Rica (Table 4). Aquaculture is one of the fastest growing industries in Belize and over the last five years has surpassed the earnings from lobster and conch that have been Belize's most important fisheries revenue earners. While the culture of aquatic organisms consists largely of freshwater species, this can have deleterious impacts on coastal habitats when waste and contaminated effluents are disposed of in coastal areas.

Table 4. Aquaculture production (tonnes) in Central America

Species/Country	Belize	Costa Rica	Guatemala	Honduras	Nicaragua	Panamá
Shrimp	2,472.37	5,274	13,500	30,367	11,097.5	8,263
Tilapia	165	19,489	2,900	12,820	333.7	46.6
Trout		536				

Source: FIINPESCA – OSPESCA/FAO/SUECIA 2009.

In Brazil, aquaculture began in the early twentieth century. In the 1990s, total aquaculture production increased from approximately 30,000 tonnes at the beginning of the decade to 176,531 tonnes by 2000 and 246,183 tonnes by 2002. It is predominately based on small-scale farming units, with an estimated 100 000 farms occupying an area of 80,000 hectares in 1998. In 2002, finfish species comprised 69 percent of Brazilian production with 169,858 tonnes, followed by crustaceans with 26 percent or 64,043 tonnes, molluscs 4.7 percent or 11,685 tonnes and frogs 0.2 percent or 597 tonnes.

Aquaculture in French Guiana is aimed mainly at the production of freshwater shrimp (*Macrobrachium rosenbergii)* with direct employment for 12 persons[25]. In Suriname, the main geographical area of industrial aquaculture is the Commewijne district, located in the coastal area, while the main areas of small-scale aquaculture are in Nickerie, Saramacca and Paramaribo.

[25] http://www.iim.csic.es/pesquerias/Pesca/EU/regional%20socio-economic.pdf

In Suriname, industrial production was 310 t in 2003 and 288 t in 2004, with no data being available for small-scale aquaculture production.

In Guyana, the people on the Corentyne Coast have practiced a form of fisheries enhancement that is similar to aquaculture for over 100 years. Aquaculture activities can be divided into freshwater and brackish water, almost all of which are practiced on the coastal plains. The species farmed using semi-intensive pond rearing practices are the Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*Oreochromis niloticus*), Jamaican red tilapia, giant river prawn (*Macrobrachium rosenbergii*), armoured catfish or atipa (*Hoplosternum littorale*) and the salmon shrimp (*Mesopenaeus tropicalis*).These products are mainly sold in local domestic markets situated along the coast of the country, with farmers usually selling directly to consumers.

In Venezuela, aquaculture development began relatively recently with the cultivation of shrimp (*Penaeus sp.*) in the 1980s. The main markets and consumption centres for the fish products of native species such as tambaqui, bocachico, and catfish, are located in the country's interior regions The main export species is marine shrimp, 80 percent of which is destined to the North American market, followed by exports of inland fish to the Republic of Colombia through the border town of Cúcuta.

In Trinidad and Tobago, with the coastal marine resources being viewed as heavily exploited or over-exploited, aquaculture is considered to be one of the avenues to supplementing the declining marine resources in an effort to meet the increasing demand for protein through fish and fish products. It is practiced at the subsistence and semi-commercial levels by approximately 53 farmers. There are about three aquaculture farmers of some significance. Their production of tilapia fingerlings and market size tilapia between 2000 and 2004 being estimated at 701,500 fingerlings and 45,000 kg respectively.

4.4.3. Tourism in the CLME region

Another economic sector that is highly dependent on the amenity value or cultural ecosystem services of the CLME is tourism. The dependence of tourism on coastal and marine areas and living marine resources as well as the concentration of tourism infrastructure and activities on the coast causes major environmental problems for the very living resources that support tourism. Tourism is an important sector in a number of the countries, especially in the Insular Caribbean. Tourism has become one of the principal industries and the fastest growing economic sector in the sub-region (CARICOM Secretariat 2003). The high dependence of the economies of some of the countries on tourism is evident in its contribution to GDP, which reaches nearly 79% in Antigua and Barbuda and over 30% in the Bahamas, Barbados, St. Kitts and Nevis, St. Lucia, and Trinidad and Tobago.

According to data from the Caribbean Tourism Organization in 2000 almost 25 million tourists travelled to the Caribbean. The hotel sector, however, is rivalled in bed/berth capacity by the cruise ship sector, the fastest-growing tourism segment (McElroy 2004). The total number of cruise-ship passenger arrivals in the Caribbean was 14.6 million, with the most frequent ports of call being in the Bahamas (2.5 million), U.S. Virgin Islands (1.8 million), Cozumel, Mexico (1.5 million), Puerto Rico (1.3 million), and Cayman Islands (1.0 million).

Of particular interest is that in the Caribbean Islands, travel and tourism rank first in relative contribution to national economies, with real GDP growth of 4.1% per annum over the coming 10 years. Relative to its size, the Insular Caribbean is the most tourism-driven region in the world. In terms of jobs and export income, the contribution of tourism is nearly double that of the global average, and accounts for more than a fifth of all capital investment in the region (CARSEA 2007).

For the Latin American countries, travel and tourism rank 13th in relative contribution to national economies, with real GDP growth of 5.1% per annum over the coming 10 years. In the continental countries, while tourism makes a lower contribution to GDP than in the Insular Caribbean countries, the number of jobs in this sector is at least ten times more as a result of their larger population sizes. In terms of the proportion of total employment, however, jobs in the tourism sector in the Insular Caribbean has a higher proportion of all jobs (10.8%) compared with the continental countries (6%).

The expected growth in tourism, much of which is associated with coastal and marine areas, will put increasing pressures on the Caribbean Sea ecosystem and living resources.

4.4.4. Land-based coastal activities

Pollution is a key concern within the CLME region. Sources from land-based activities (e.g. agriculture, industry, wastewater etc.), riverine discharges (including sediments), shipping (e.g. ports) are all considered to have an impact on the fisheries ecosystems.

Land-based activities represent a major source of pollution affecting all three ecosystems which has been recognised through the LBA protocol to the Cartagena Convention addressing this issue. Sources include untreated wastewater from municipalities and industry, point and diffuse agricultural inputs, erosion due to inappropriate land use, forestry, mining and accidental pollution.

Human activities in includes agriculture, aquaculture, industry (including mining and oil), and urbanisation and tourism (including issues of inadequate wastewater treatment).

4.4.5. Offshore energy operations

Much of the oil exploration, extraction, refining, and transportation activities take place in marine and coastal areas of the CLME. The CLME has major oil producing countries (Mexico, Colombia, Venezuela, USA, and Trinidad & Tobago) and important ports for oil refining. A large number of offshore oil platforms operate in the region (e.g. off Venezuela, Trinidad and Tobago, Colombia), with offshore drilling explorations in other areas such as off Cuba and Jamaica. These offshore platforms are potential sources of pollution from oil and other substances.

4.4.6. Marine transport operations

The Caribbean Sea is noted for its maritime industry, with tens of thousands of cargo vessels, cruise ships, fishing and recreational vessels plying the waters of the Caribbean Sea each year. The Panama Canal makes the Caribbean Sea, particularly in the north, an area of intense maritime cargo freight traffic between the Atlantic and Pacific Oceans. With between 10 - 15 thousand ship crossings annually, the Panama Canal is the world's leading maritime hub and accounts for about 30% of Panama's GDP. The Canal is currently undergoing a US$5.25 billion expansion that will allow it to accommodate larger ships. A total movement of about 104,000 ships and averages of over 8,500 ships per month and approximately 300 ships per day have been reported in the CLME and adjacent regions (Vila et al 2004). The three areas with the highest number of movements were all within the CLME, with the highest movement taking place on the Atlantic Coast of South America with 28,392 ships per year (Figure 3), associated mainly with the Panama Canal. Much of the ship traffic in the Caribbean Sea is related to oil transportation with the Caribbean Sea second in oil traffic only to the Persian Gulf.

Shipping accounts for the introduction of significant quantities of ballast water (see Box 3) into the Caribbean Sea. In 2005, six million tonnes of ballast water were poured into the Caribbean Sea, of which 84% came from international shipping. About 7 million barrels of oil are discharged annually from tank washings.

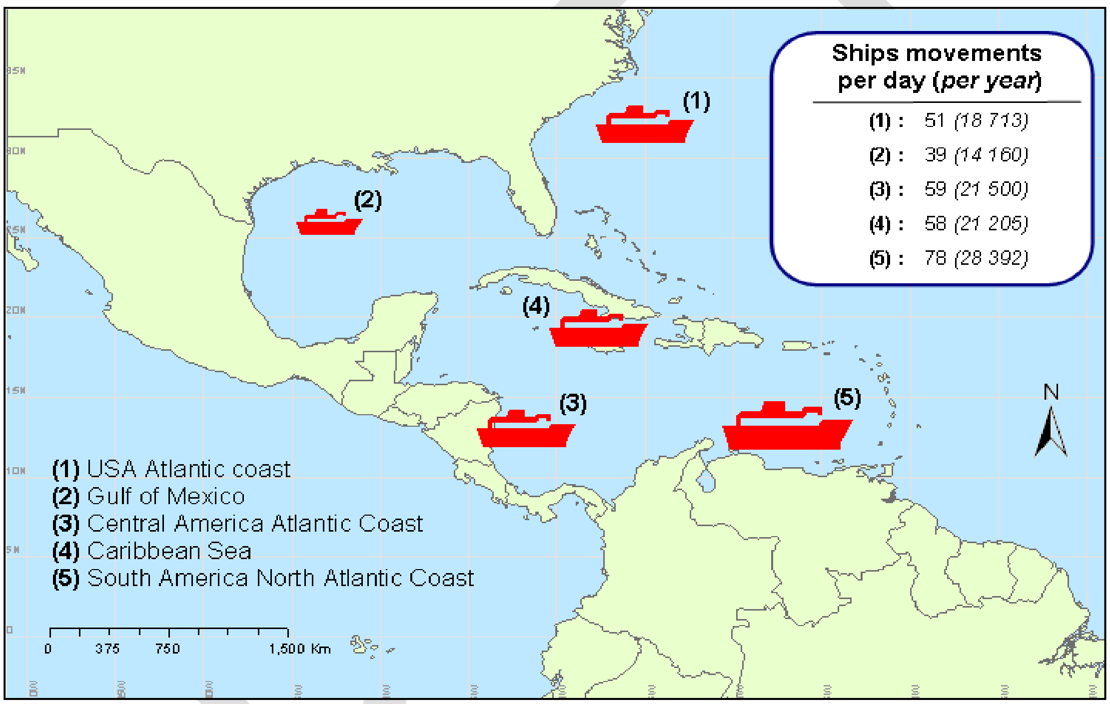


Figure 3. Daily and yearly ship movement in the five areas in the Wider Caribbean in 2003

Box 2. GloBallast Programme [26]

Based on the success of the GloBallast Programme, the IMO has once more partnered with the GEF, UNDP, member governments and the shipping industry to assist less-industrialized countries to tackle the ballast water problem under a project entitled: *Building Partnerships to Assist Developing Countries to Reduce the Transfer of Harmful Aquatic Organisms in Ships' Ballast Water*. It is also referred to as GloBallast Partnerships. The partnership effort is three-tiered, involving global, regional and country-specific partners that represent government, industry and non-governmental organizations. Private sector participation will be achieved through establishing a GloBallast Industry Alliance with partners from major maritime companies. The overall goal of the GloBallast Partnerships Project is to reduce the risks and impacts of marine bio-invasions caused by international shipping, with the specific objective being to assist vulnerable developing states and regions to implement sustainable, risk-based mechanisms for the management and control of ships' ballast water and sediments in order to minimize the adverse impacts of aquatic invasive species transferred by ships.

4.5. Governance Analysis

4.5.1. Regional Governance

A comprehensive and detailed governance analysis for the WCR has been prepared and should be referred to for more details. [27]

Given the emphasis on governance in this project a brief introduction to the term and its application in this project is included here. [27] Current thinking on governance is largely about interactions among players (actors or stakeholders), the institutions, whether formal or informal, that shape these interactions, and the visions and principles that guide these institutions and interactions [28]. This is the broad perspective taken on governance in the CLME Project.

Much of this broadening of the scope of governance has been due to the recognition that hierarchical command and control approaches have not worked well for Social-Ecological-Systems (SESs). This is considered to be due largely to the complexity, diversity, and dynamics of SESs arising from many sources, not the least the multi-scale nature of both ecosystems and governance systems in a globalizing world. Thus SESs tend to be characterised by high uncertainty and low controllability. Much of the current discussion on governance is about how to deal with these characteristics. In addition to the implications of SES complexity, there is increasing concern with a suite of principles that broaden the range of issues that is being taken

[26] http://globallast.imo.org/index.asp?page=GBPintro.html&menu=true

[27] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

[28] Hence the recent definition of governance from Kooiman et al (2005) "Governance is the whole of public as well as private interactions taken to solve societal problems and create societal opportunities. It includes the formulation and application of principles guiding those interactions and care for institutions that enable them." Similar perspectives are espoused by most groups working on governance of natural resources (Biermann et al 2009, Armitage et al 2008).

into consideration by governance of SESs. These are primarily human rights issues, such as rights of access, the right to have the opportunity to rise above poverty and the right to self-determination by participation in decisions that affect one (Kooiman et al 2005). Thus the business of governance itself has become more complex.

Key concepts emerging in response to the above circumstances relating to natural resource governance at national and local levels are the capacity to adapt to changing conditions either by buffering against them (Berkes et al 2001) - resilience - or by changing with them in the most advantageous way possible – transformation (Olsson et al 2004, Mahon et al 2008). The capacity to detect changing situations, learn from past experience and innovate is increasingly recognised as a valuable set of assets for complex, diverse and dynamic SESs (Folke et al. 2002). Enabling this type of capacity is seen as the way to deal with situations of high uncertainty and low controllability. At the regional and international levels, which are the focus of the CLME Project, attention is also focussed on enabling governance systems that also have capacity for adaptation and transformation (Bierman et al 2009, Young 2010).

The reassessment of the LMR governance situation in the WCR in the light of the orientation towards fishery ecosystems, as well as with reference to changes in the governance arrangements in the region since the PDF-B, suggests that a network approach to governance that links existing LMR governance arrangements, seeks to strengthen them and to build upon their existing strengths is still appropriate. Indeed, the above changes and advances are such that the suggested approach appears to be even more appropriate at the present. Increasing awareness of the uncertainty that will result from climate change will demand an approach that seeks to build resilience and adaptive capacity. At the same time, the increasing diversity of regional stakeholders with interests in LMR that is necessitated by adopting an ecosystem approach and by including climate change consideration speaks to the need for interaction and networking that is flexible and demand driven.

A shift towards an ecosystem approach in the WCR such as that developed by stakeholders at the 2008 EBM Symposium is highly consistent with the FAO EAF as well as the CBD principles in its recognition of the diversity of issues that must be considered in LMR governance in the WCR, including social justice issues. It is also a recognition that agreed principles and processes must underlie effective governance. In such a diverse system, functional linkages, processes and interactions are fundamental to moving forward. Solutions can no longer be assumed to be available off-the-shelf. They must be developed rapidly, as demand arises, with the best information available and with the understanding and engagement of all concerned. As circumstances arise and change, good governance will require increased attention to the roles that are essential for responsiveness and adaptation. These will include people and institutions that facilitate process, connections and information flow.

The Large Marine Ecosystem Governance Framework that was developed in the PDF-B for the WCR is an attempt to capture the essential characteristics of the current regional governance arrangements and to portray them is a way that allows for them to be broken into their component parts to facilitate interventions aimed at improving the arrangements and enhancing the overall framework. This framework is based on linked policy cycles at multiple levels, from local to international (Fanning et al 2007). The cycles have a common structure but may vary in nature at various levels and from location to location at any given level (Figure 4 and Figure 5).

However, they must be complete in order for there to be effective governance at the level or location in question. Cycles must also be linked vertically with two-way flows if they are to be effectively connected with the remainder of the framework (Figure 4). Incompleteness and disconnectedness are two common problems in WCR living marine resource governance. As such, it is also important for vertical linkages to be established among the decision-making stages of the various cycles. Linkages across policy cycles at other stages, such as the technical ones more common among scientific communities, are necessary but not sufficient for effective governance. Finally, lateral linkages are also important as they serve to promote shared learning across policy cycles occurring at the same jurisdictional or geographic level, as for example, national level cycles taking place in different countries across the region.

With reference to this framework, the long-term ocean governance goal for the CLME Project area is 'fully-functional policy cycles at all appropriate levels with the appropriate vertical and lateral linkages'. This long-term goal can be approached incrementally with targeted interventions specifically aimed at:

- Establishing or completing policy cycles,
- Building or enhancing linkages.

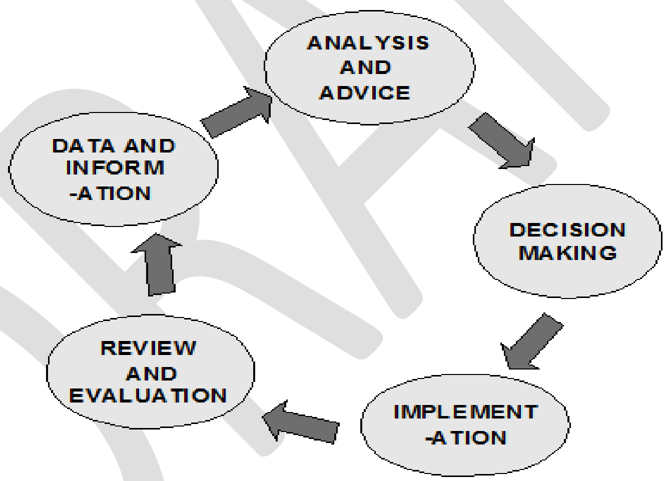


Figure 4. The generic policy cycle used as the basis for the CLME-approved LME governance framework (Fanning et al. 2007)

Figure 5 illustrates the potential for engaging stakeholders in the process of governance as is considered to be essential for an ecosystem approach

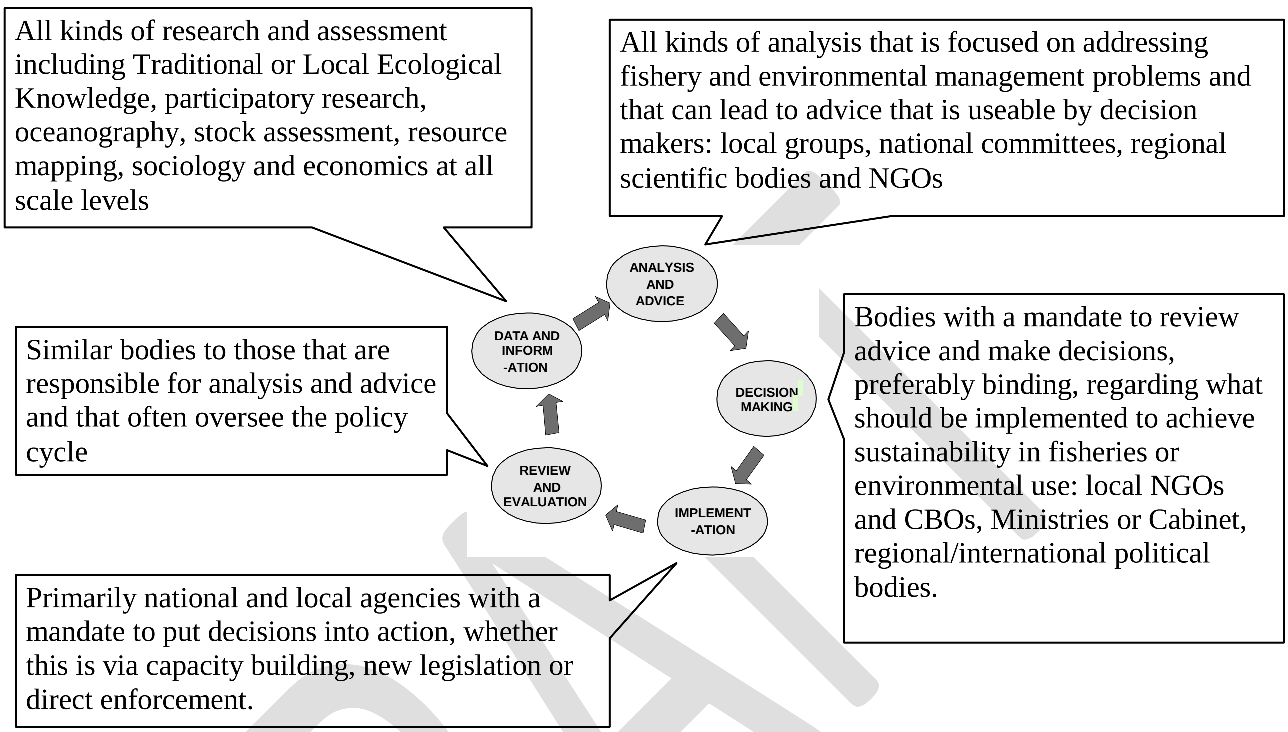


Figure 5. The diversity of stakeholders in the policy cycle depending on stage and scale level (Fanning et al. 2007)

The LME governance framework as designed for the WCR is sufficiently flexible to accommodate:

- A diversity of policy cycle arrangements and linkages that can include the full range of stakeholders (e.g. Figure 5);
- The diversity of ecosystem approaches that currently exist; and,
- Existing organizations within the region, but its adoption by these entities will require that they review and adjust their modes of operation.

The various pilot projects and case studies comprising the CLME FSP were developed explicitly to explore the CLME Governance Framework described above and to determine the best way forward with strengthening it towards achievement of the long-term goal.

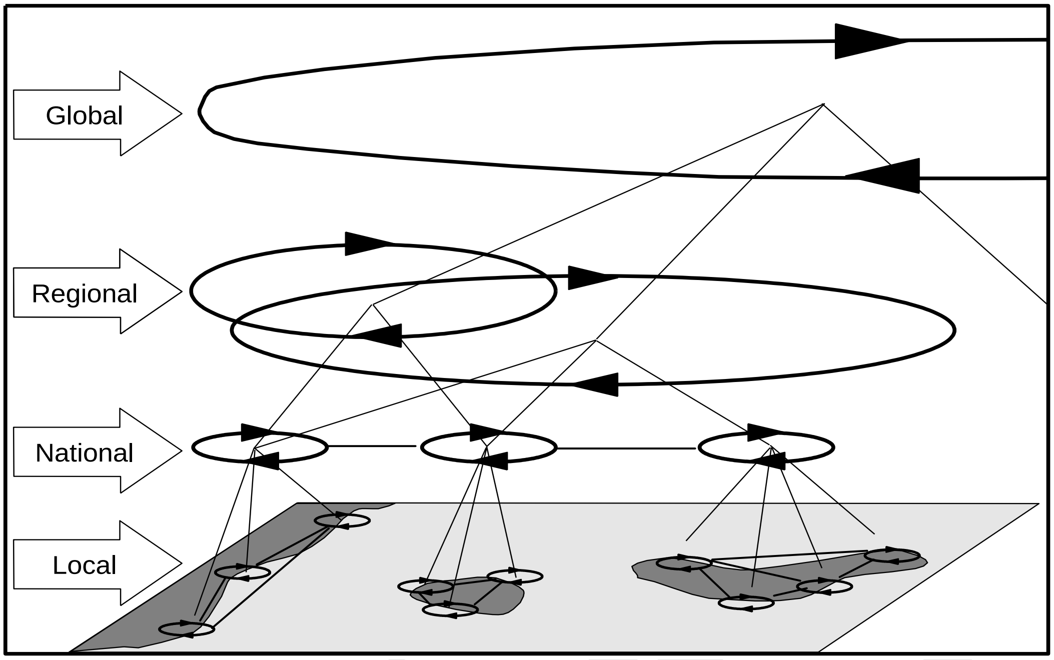


Figure 6. The conceptualized multi-scale component of the proposed LME Governance Framework with vertical and horizontal linkages among the different policy cycles (horizontal ellipses). The multi-level linkages do not necessarily imply a controlling function (Fanning et al. 2007

4.5.2. Stakeholders in governance

Stakeholder engagement and participation are recognized as a key component of an ecosystem approach. As indicated above, the development of an effective framework of governance arrangements covering key marine ecosystems and their transboundary LMRs requires knowing who the stakeholders are and how they currently fit, or should fit, into the framework. Therefore, stakeholder identification was seen as a critical step in setting the stage for stakeholder participation in the Full Project. Recognizing that the CLME project covers some 26 countries and the need for the project to identify stakeholders that will affect and be affected by the project (academic, resource users, managers, NGOs, Government, community-based organizations, donors, fishers and fishers' organization), considerable effort was expended during the PDF-B phase to identify these players.

The approach to assessment of stakeholders was to explore their actual and potential roles in the stages of the policy cycles that comprise the governance arrangements for various ecosystems and LME issues. As already indicated there is a huge diversity of organisational stakeholders that may have a variety of potential roles (Table 1). These are constantly changing. Knowing who they are and keeping them engaged is a dynamic iterative part of the governance process that must be built in as efforts at strengthening the framework proceed. There is also the need to identify the appropriate subsets for various issues.

This was done in the PDF-B for a number of different transboundary LMRs as well as other aspects of the framework. The example for the reef fishery ecosystem is shown in Figure 7 and the subcomponents for which stakeholders were identified separately in this way are listed below:

Reef fish fishery Lobster fishery	= Reef fishery ecosystem
Shrimp and groundfish	= Continental shelf ecosystem
Flyingfish fishery Large pelagic fishery	= Open ocean (offshore) ecosystem
Regional monitoring and reporting system Regional ocean/CSI	= Regional governance framework

Since the PDF-B phase, some of the stakeholders have increased in prominence while others have declined. Given the increasing recognition of the need to take an ecosystem approach to managing transboundary living resources and the cross-cutting effects of climate change, new categories of likely actors have been identified. Among these representatives of the tourism and conservation sectors are prominent.

Table 5. Selected key institutional players in the CLME project area at the local, national, sub-regional/regional and international levels identified in the PDF-B phase of the project based on their potential role in CLME Project activities (Source: Parsram (2007)

Potential Role(s) in CLME	Levels of interaction	Organizations
Technical assistance in filling knowledge gaps and sharing data and information. Participating in the TDA analysis and development of the Strategic Action Programme	Local	Fisher folk Organizations, Fish processors, MPA Authorities (e.g. SMMA, Buccoo Reef Trust, TCMP, CORALINA etc), NGOs (Environmental Awareness Group, Barbuda Council, GRENCODA, FUNDAECO, CONAP, GMTCS, NCRPS, BREEF, SMMA etc.)
	National	National Fisheries Departments and special committees, Fisheries Advisory Committees, Universities, Research Institutions (e.g. CARICOMP, Center for Marine Sciences, INVEMAR) IDO, CIP, Aquario Nacional de Cuba, CIBIMA, ECOSUR, IMA, Maritime Authorities, CZMUs, National Fisherfolk Organizations
	Sub-regional/ Regional	CARSEA, CRFM, WECAFC, CERMES, MarGov, MBRS, IOCARIBE, UNEP CAR/RCU, GCFI, OPSPESCA, OLDEPESCA, FAO LAPE, IFREMER, CANARI, INCOPESCA, SPAW/RAC, CCDC, UWI CMS, CFMC, OECS
	International	Reef Check, AGRRA, NOAA, FAO, ICAAT, ICRAN, COML, University of Miami RSMAS, CINTOO, IUCN, TNC, WWF, WRI
Potential for co-financing; Implementation of necessary institutional, legal and policy governance reforms at the national and regional levels; CLME project	Local	Primary Fisherfolk Organizations, NGOs, SMMA, Buccoo Reef Trust, TCMP, CORALINA, Environmental Awareness Group, Barbuda Council, Barbados Marine Trust, CEC, GRENCODA, ART, FUNDAECO, CONAP, GMTCS, NCRPS, NEPT, NEST, BREEF, Dive Operators, Tour Operators,

Potential Role(s) in CLME	Levels of interaction	Organizations
promotion, specifically with respect to advancing the achievement of the components of the project; Building cross-sectoral linkages and partnerships among advisory and decision-making bodies at the national, sub-regional and regional levels; Encouraging increased ratification and implementation of relevant international agreements Public education, outreach, disseminate and share project results, best practices and lessons learnt; Capacity building for and implementation of management measures and legal, policy and regulatory reforms.	National	National fisheries authorities, Fish Processors and traders, Maritime Authorities, Naval Forces/Coast Guard, Ministries of Environment, Ministries of Agriculture, Ministries of Trade and Commerce, National Trust, NGOs, CZMUs, UNIPESCA, FENICPESCA, DIGIPESCA, CONAPESCA
	Sub-regional/ Regional	CARSEA/Cropper Foundation, OECS, CRFM, CERMES, MarGov, ACS, CARICOM, SICA, CTO, CHA, OSPESCA/SICA, CFMC, WECAFC, IFREMER, UNEP-CEP, SPAW/RAC, IOCARIBE, ECLAC, OLDEPESCA, INVEMAR, Research Institutions, CaMPAM, CCA
	International	OAS, FAO, UNDOALOS, ICAAT, CTA, IDRC, OAK, Ocean Foundation, Bill Fish Foundation, IUCN, WW2BW, IOI, UNFSA, ICRAN, NOAA, TNC, WWF
Participate in developing and implement pilot projects (Flyingfish, Reef Fisheries, Lobster, Shrimp and Ground Fish)	Local	Fishermen Organizations, Fishing Companies, NGOs, CORALINA, Coral Cay Conservation, TCMP, SMMA, Bucco Reef Trust, NCRPS, Diving Associations, MPAs
	National	Fisheries Departments/Divisions/Commissions, Research Institutes, CARICOMP, UWI CMS, IMA, EMA, CZMUs, IBAMA, ACML, Naval Forces/Coast Guard, UNIPESCA, FENICPESCA, DIGIPESCA, CONAPESCA
	Sub-regional/ Regional	CRFM, WECAFC, UNEP CEP, MBRS, SICA, OSPESCA/SICA, AECI, GCFI, CONFEPESCA, OLDEPESCA, INVEMAR, CERMES, MarGov, UWI CMS, CCCCC, CFMC, CEHI, CANARI
	International	FAO, UNEP, WWF, WRI, AGRRA, Reef Check, TNC, ICRAN

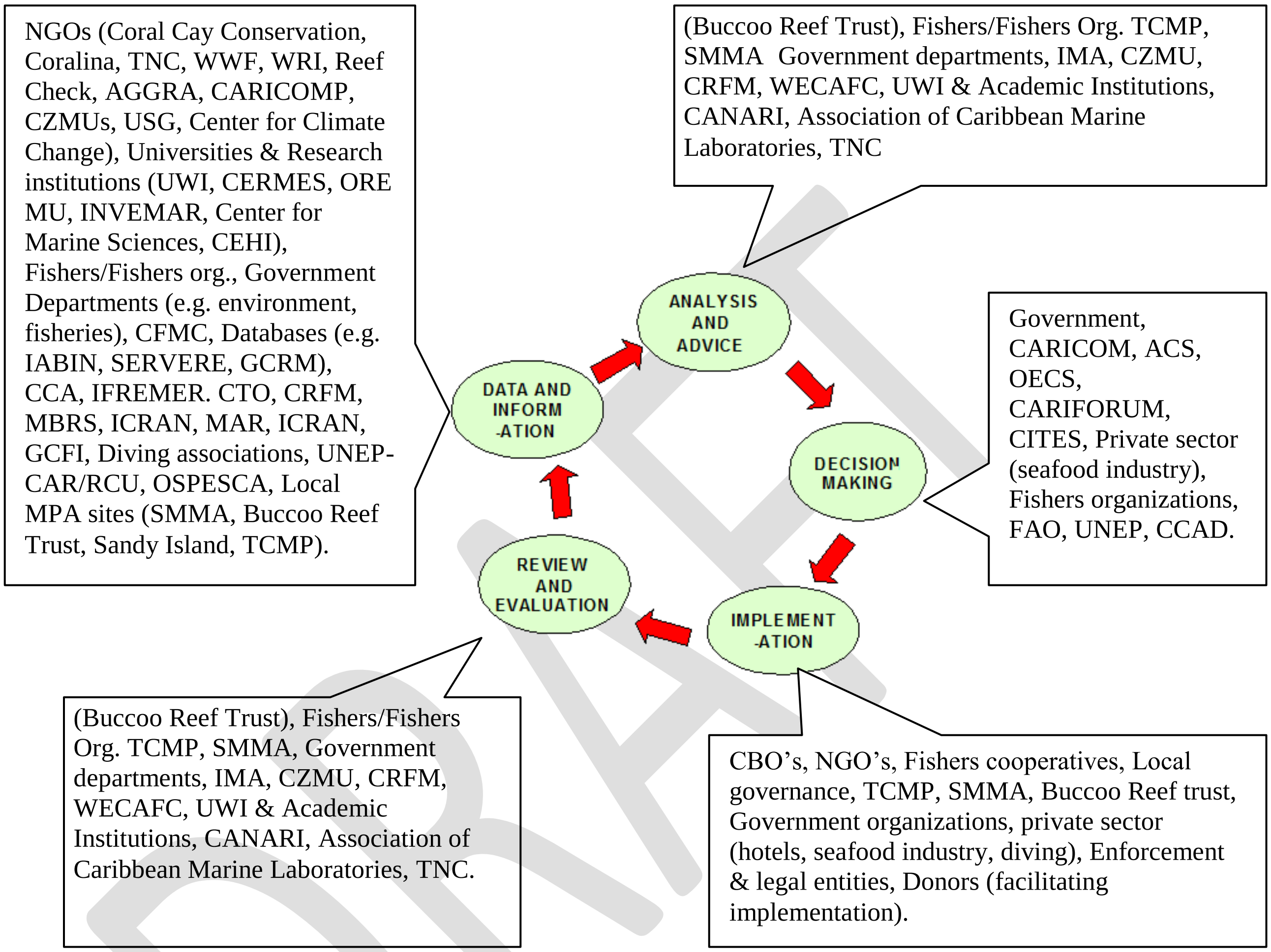


Figure 7. CLME stakeholders by policy cycle stage for the Reef Fisheries and Biodiversity pilot project as identified in the PDF-B phase of the project (Parsram 2007).

The following figure represents the many regional fisheries organisations in the WCR showing the countries party to these organisations.

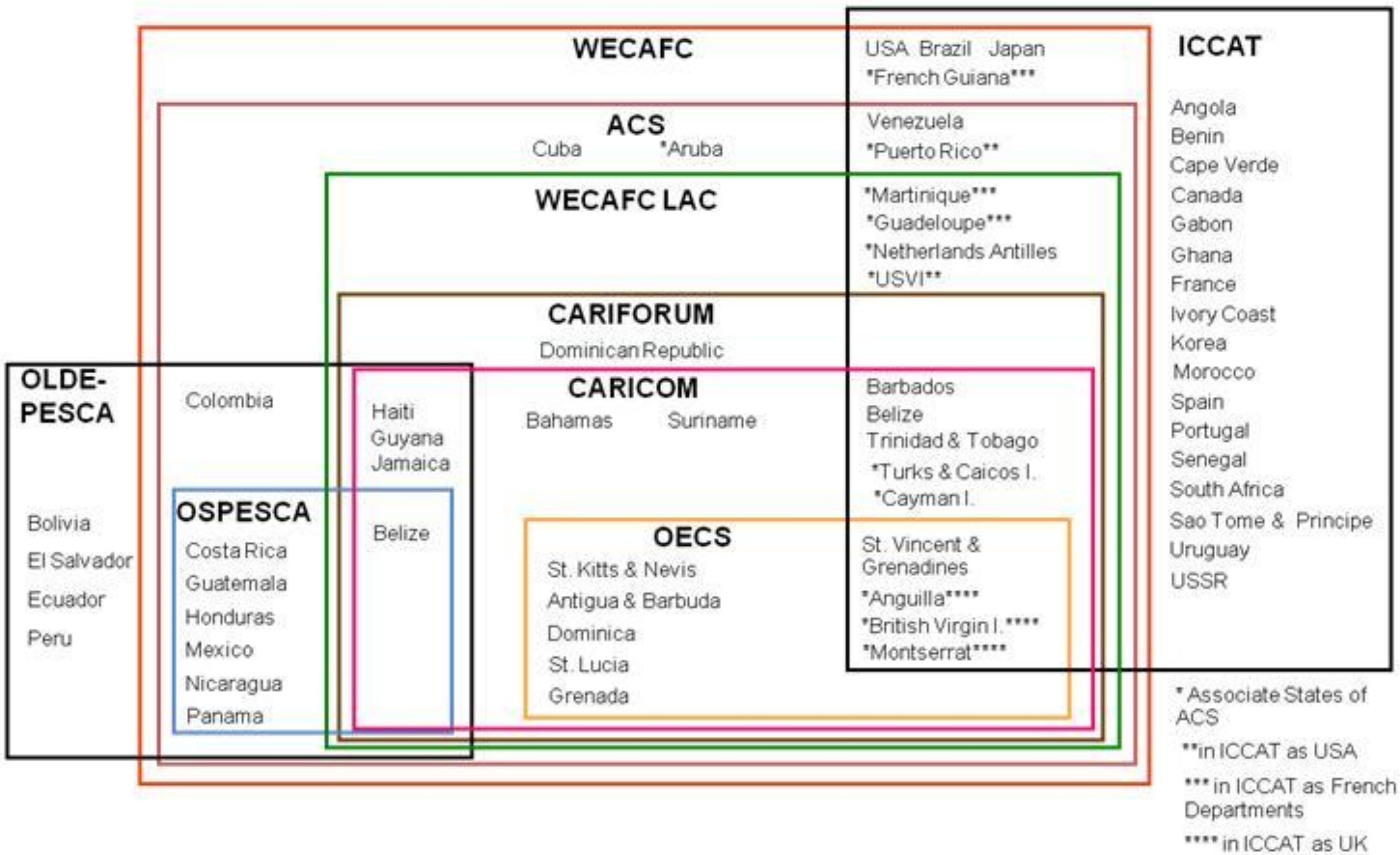


Figure 8. The overlapping and nested fisheries related organisations in the Caribbean Sea

5. The CLME Fisheries Ecosystems

Full details of the analyses for three fisheries ecosystems are presented in the detailed TDAs available on the project website.

This section provides an overview of the key issues based on the main findings from the three fishery ecosystem and governance reports. [29]A common approach is taken to presenting the summarised information for the reef, pelagic and continental shelf ecosystems under the following sub-headings:

a)	Introduction	Highlighting the key features of the fishery ecosystem
b)	Services	A summary of the main services provided by the fisheries ecosystem adopted by the MEA approach (provisioning services, regulating services, cultural services and supporting services)
c)	Description of the fishery ecosystem	Summarising the important species and fisheries
d)	Analysis of the current situation	Summarising the main concerns associated with the three transboundary problems agreed by the Technical Task Team (unsustainable fisheries, habitat degradation and pollution) and the environmental and socio-economic consequences caused by the problems on the fishery ecosystems
e)	Governance	Issues related to the specific fishery ecosystem

The section concludes with a summary of the key information and knowledge gaps associated with the CLME fishery ecosystems and a cross-cutting assessment of issues common to all three ecosystems (including climate impacts) that will be addressed in a coherent way under the SAP.

The analysis in this TDA of the three fishery ecosystems rather than by region presents an innovative approach to undertaking a TDA, however the need to provide a comprehensive analysis of each fishery which are inherently linked does lead to some repetition in the observations. The advantage is that the information presented will be readily accessible and useable during the SAP formulation/implementation stages of the CLME project where it is anticipated that three specific SAPs will be prepared to address the problems identified for each ecosystem fishery.

[29] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

5.1. Reef Ecosystem

5.1.1. Introduction to the Reef Ecosystem

For the purposes of the CLME TDA, the reef ecosystem is considered to comprise the following:

- Coral reefs (shallow water)
- Estuaries and lagoons
- Mangroves
- Seagrass beds
- Beaches
- Deep water reefs and rocky outcrops along continental shelf edge and slope).

Caribbean marine ecosystems are inextricably linked through the movement of living organisms as well as pollutants, nutrients, diseases, and other stressors (Grober-Dunsmore and Keller 2008). Coral reefs, mangroves, and seagrass beds represent an integrated and interacting set of ecosystems (Mumby and Hastings 2008), with high connectivity between them. Of particular interest is demographic connectivity, defined by Mora and Sale (2002) as the demographic connection between populations due to the migration of individuals (especially larvae) between them. [30]

Connectivity considerations have great importance for the management of Caribbean coral reefs and may increase the resilience to external perturbations including climate-induced changes such as hurricane disturbance and coral bleaching. Mangroves and seagrass beds function as nursery habitats for many reef-dwelling organisms such as lobsters and reef fishes, particularly in the Caribbean (Steneck et al 2009), and are considered essential and critical fish habitats. [31]

Yet, throughout the region these habitats are often considered as separate systems although they should be considered together as one large, interdependent marine ecosystem with shared biodiversity for management purposes (e.g., in design and management of MPAs).

Caribbean coral reef habitats, seagrass beds and mangroves provide important ecosystem services both individually and through functional linkages. The health of these ecosystems is critical to maintaining the ecosystem services they produce (see following section), yet they are increasingly subjected to anthropogenic pressures from both land and sea based sources as well as to the impacts of climate change.

Deep water coral reefs also support valuable fisheries for snappers and similar species throughout the CLME. These are not independent, however, of coastal ecosystems.

- **Coral Reefs:** Estimates of the percentage of the world's coral reefs that occur in the CLME range from 7% (Burke and Maidens 2004) to 9.5 % (Sea Around Us Project 2010). The entire Caribbean region contains only two true barrier reefs. Extending 220

[30] Connectivity can be broadly defined as the exchange of materials, organisms, and genes and can be divided into: 1) genetic or evolutionary connectivity that concerns the exchange of organisms and genes, 2) demographic connectivity, which is the exchange of individuals among local groups, and 3) oceanographic connectivity, which includes flow of materials and circulation patterns and variability that underpin much of all these exchanges (Grober-Dunsmore and B.D. Keller, eds. 2008).

[31] Essential and critical habitat as been defined by U. S. Congress as those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.

km from the southern part of the Yucatan Peninsula to the Bay Islands of Honduras, the MesoAmerican Reef system is the longest barrier reef in the Western Hemisphere. A smaller barrier reef lies north of Providencia Island (Colombia). Coral reefs harbour high biological diversity and numerous commercially important fish and invertebrate species.

- **Coastal Lagoons:** Coastal lagoons play a key role in regulating coastal productivity and are favorable habitats for primary producers (phytoplankton and aquatic plants). These habitats play a critical role in the life cycle of numerous finfish and shellfish species in the Caribbean.

- **Seagrass Beds:** The two main seagrass species in the Caribbean are the turtle grass (*Thalassia testudinum*) and the manatee grass (*Syringodium filiforme*). Seagrass beds are highly productive habitats and support a considerable biomass and species diversity. Various species of fish, as well as conch, lobster, turtles, sea urchins, and manatees use seagrass habitats as feeding and nursery grounds. Seagrasses filter out sediments, stabilize the bottom sediments, and help to absorb excess nutrients from land run-off. Thus they play an important role in maintaining the health of adjacent coral reefs.

- **Mangroves**: The four dominant mangrove species in the CLME are red mangrove (*Rhizophora mangle)*, black mangrove (*Avicennia germinans)*, white mangrove (*Laguncularia racemosa)* and the buttonwood (*Conocarpus erectus).* Mangrove forests are among the world's most productive ecosystems and are key to major food webs in coastal areas. They also provide nursery grounds and refuge for commercially important marine fish and invertebrates. In the Caribbean, the presence of prolific mangroves in the vicinity of coral reefs was found to exert a profound impact on the community structure of 162 species of reef fish and greatly elevated the total adult biomass of several species, many of which are economically and/or ecologically important (Mumby et al. 2004). Mangrove forests also serve as over-wintering habitat for a number of species of neo-tropical migrant birds. These habitats also act as buffers against hurricanes and tidal surges, and filter terrestrial sediment, pollutants, and nutrients, minimizing their input into more sensitive habitats such as seagrass beds and coral reefs

- **Beaches**: Caribbean beaches are of great importance to tourism, attracting foreign visitors and local people throughout the region. Beaches are also important nesting sites for sea turtles American crocodile (*Crocodylus acutus*), as well as for birds. They also provide feeding areas for birds and other animals.

- **Deep water reefs and rocky outcrops**: The Caribbean Sea includes large expanses of deep water reefs and rocky outcrops that harbour a wide variety of deep-sea coralsand commercially important fish species (Lutz and Ginsberg 2007). Two of the more significant deep-sea coral species are *Lophelia pertusa and Oculina varicosa*, which form extensive deep-water communities that harbour commercially important fish species, making them susceptible to destructive bottom trawling practices (Reed 2002). The unique and vulnerable deepwater coral (*Oculina*) habitats off the southeastern USA have been identified as essential fish habitat for Federally managed species in the USA (Lutz and Ginsburg 2007, Ross and Nizinski 2007).

5.1.2. Reef Ecosystem services

The major ecosystem services provided by coral reef and other coastal ecosystems are listed under the four categories of services in the table below (adapted from UNEP 2005, CARSEA 2007, World Resources Institute 2009 and others)

Table 6. Ecosystem services provided by coastal ecosystems

ECOSYSTEMS	ECOSYSTEM SERVICES			
	Provisioning	**Regulating**	**Cultural**	**Supporting**
Coral reefs	• Food (fish and shellfish) • Ornamental fish and corals • Material such as seashells for use in handicraft • Construction material • Natural medicines and pharmaceutical products • Genetic resources	• Hydrodynamic barrier to wave energy (protection of shorelines from erosion, storms)	• Recreational and • tourism value • Knowledge systems • and educational value • Spiritual and inspirational value	• Habitat for fish and shellfish • Material for the formation and maintenance of sandy beaches
Mangroves	• Food (fish and shellfish stocks) • Fuelwood • Construction material • Natural medicines and pharmaceutical products	• Stabilization of coastlines (buffer between land and sea) • Protection of adjacent coral reefs from suspended solids, pollutants and drastic changes in salinity due to inflow of freshwater • Removal of contaminants from surface inflows • Nutrient retention and removal • Protection from erosion and storm surges	• Recreational and tourism value • Knowledge systems • educational value	• Habitats for a wide array of terrestrial and aquatic species • Feeding, nursery and breeding areas for fish and other species • Carbon sequestration (blue carbon) • Nutrients to other ecosystems such as coral reefs and seagrass beds

ECOSYSTEMS	ECOSYSTEM SERVICES			
	Provisioning	**Regulating**	**Cultural**	**Supporting**
Seagrass beds	• Fish and shellfish • Natural medicines and pharmaceutical products	• Settlement and binding of suspended sediments and encouragement of accretion • Nutrient cycling • Reduction of wave energy	• Recreational and tourism value • Knowledge systems • educational value	• Habitats for a wide array of aquatic species • Nursery and feeding areas and shelter for fish and crustaceans • Detritus to reef system • Food (detritus) to offshore habitats • Beach sand (from calcareous skeletons of organisms (e.g. molluscs, crustaceans, calcareous algae)
Beaches	• Construction material • Base for small-scale fisheries, tourism and recreational activities		• Recreational and tourism value • Knowledge systems • educational value	• Habitats and nesting sites for fauna such as sea turtles • Coastline protection • Stabilization of sediments

Estimates of the annual economic value of ecosystem services provided by Caribbean coral reefs are between US$3.1 billion and US$4.6 billion, with degradation by 2015 potentially costing between US$350 million and US$870 million per year (Burke and Maidens 2004). More recently, the total economic value of three key coral reef-associated services (fisheries, tourism and recreation, and shoreline protection) was estimated in Trinidad and Tobago and St. Lucia (Burke et al 2008); Belize, which also included the contribution of coastal mangroves (Cooper et al 2009); and the Dominican Republic (Wielgus et al 2010). As shown in Table 6, the annual economic contribution of coral reefs is substantial, with tourism and shoreline protection the most important.

Table 7. Annual economic contribution (million US$) of ecosystem services of coral reefs for Tobago and St. Lucia and coral reefs and mangroves for Belize

Ecosystem service	Tobago	St. Lucia	Belize
Coral Reef-associated Tourism and Recreation	$101- $130	$160- $194	$149.9 - $195.7
Coral Reef-associated Fisheries	$0.8 – $1.3	$0.5 – $0.8	$14.2 - $15.9
Shoreline Protection - Potentially Avoided Damages (annual value for 2007)	$18 -$33	$28 -$50	$231 – $347
TOTAL	**$119.8 -$164.3**	**$188.5- $244.8**	**$395 – $559**

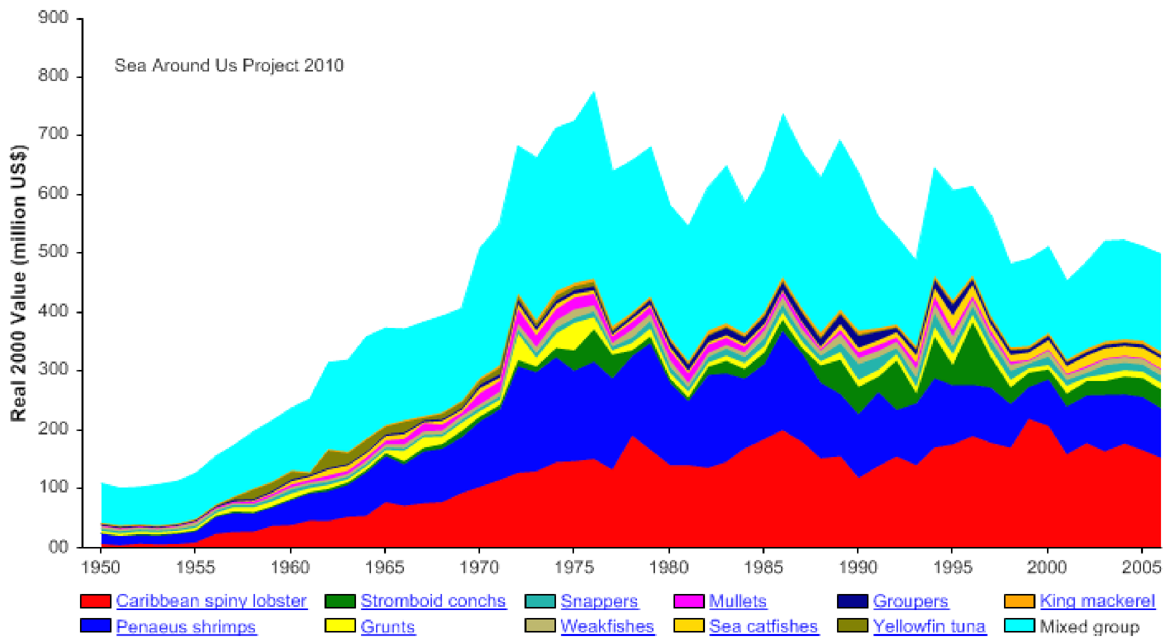
5.1.3. Description of the current reef fisheries

Caribbean fisheries are predominately dependent on nearshore coral reef ecosystems. Owing to the circulation patterns as well as the close proximity and ecological similarity among the countries, dispersal of planktonic larvae across EEZs is not unlikely. Therefore, even the coastal resources have an important transboundary component to their management.

Reef resources, which dominate the landings in many CLME countries and territories, provide an important source of food, employment, and livelihoods for coastal communities. Within the reef system, the coral reefs are the most intensely exploited by large numbers of fishers, the majority of whom are considered small-scale and artisanal, while a small proportion are industrial (commercial).

Both the artisanal and industrial fisheries target high-value reef species, although a large diversity of species can be caught. Among the dominant reef resources are Caribbean spiny lobster (*Panulirus argus*), queen conch (*Eustrombus gigas*), and several species of snappers (Lutjanidae), groupers (Serranidae), and grunts (Haemulidae). Although the landings (by weight) of reef species constitute a small fraction of the region's total landings, their economic value (particularly of lobster and conch) makes up a very substantial proportion of the value of the total landings (Figure 9). Despite their socio-economic importance, significant data and information gaps persist for the regional fisheries, even for the more valuable stocks that have been the subject of numerous studies (e.g. lobsters, conch, snappers, and groupers).

Figure 9. Value of reported annual landings of major species in the CLME



The fisheries for the major reef resources are described in the following.

- ***Spiny lobster:*** Fisheries for lobster developed from smallscale operations in the early 1960s to fully overcapitalized, export-oriented industries in the 2000s. Landings of spiny lobster rose steadily to peak in 1999 at about 25.5 thousand tonnes valued at nearly US$220 million. In the CLME, the greatest spiny lobster production comes from areas with large shallow coastal zones with suitable habitat for settlement of larvae and juvenile lobsters. The protection of shallow-water nursery habitats is therefore critical for sustaining viable lobster fisheries. A sub-regional initiative to harmonize management of lobsters in Central America has been developed by OSPESCA/SICA**.**

- ***Conch:*** Historically, the fishery for queen conch has been one of the most economically and culturally important in the Caribbean. Landings of conch rose steadily from 1950 to peak in 1994 at about 31,000 tonnes, following which it declined to about 13,000 tonnes in 2002 with slight increases thereafter). In 1992 the queen conch was listed under Appendix II of CITES, signifying that it is threatened by international trade if this is not strictly controlled.

- ***Reef Fishes:*** The most valuable reef fisheries are for snappers including queen snapper (*Etelis oculatus);* silk snapper (*Lutjanus vivanus*), blackfin snapper (*L. buccanella*), black snapper (*Apsilus dentatus*) and vermilion snapper (*Rhomboplites aurorubens*); and groupers including Nassau grouper (*Epinephelus striatus*), red grouper (*E. morio*), black grouper (*Mycteroperca bonaci*), yellowfin grouper (*M. venenosa*), and tiger grouper (*M. tigris*). Many Caribbean reef dish species form dense spawning aggregations which are heavily fished throughout the region. In addition, fisheries for mixed shallow-water reef fish are the mainstay of small-scale fisheries throughout the region and a major reason for reef degradation. These are of significant importance to sustaining the livelihoods of local fishers for food and income.

- **Marine Turtles: :** In a number of countries important exemptions to otherwise complete legal protection exist, for example, for the extraction of eggs (Guatemala), of turtles for indigenous use (Honduras), and turtles for subsistence use (Colombia) (Bräutigam and Eckert 2006). The exploitation and subsistence consumption of the green turtle is an ancient tradition in Central America, where turtle hunting (*tortuguear*) for eggs and meat play an important cultural role.

5.1.4. Analysis of the Current Situation

The Reefs at Risk Threat Index developed by Burke and Maidens (2004) showed that about two-thirds of the region's reefs were threatened by human activities. A recent update of this assessment reveals that this proportion has increased to 75% (Burke et al 2011). The updated assessment found that fishing is the most pervasive threat. Other threats include marine-based pollution, coastal development, and watershed-based pollution. These pressures work individually and synergistically to cause significant large-scale loss of coral cover and marine biodiversity.

Although some reefs have survived heavy over-fishing, the combination of this threat with coral diseases, hurricanes, pollution, and coral bleaching has been devastating for countries such as Jamaica and for many areas in the Lesser Antilles (Burke et al 2011). Climate change has become a major pervasive force affecting the region's marine habitats, especially coral reefs. Increasing sea surface temperatures (SST) cause bleaching in corals, and increasing acidification (as the concentration of carbon dioxide rises in sea water) dissolves or impairs formation of carbonate skeletons in corals and other calcareous organisms, in addition storms and hurricanes, which are predicted to become more Mangrove and seagrass habitats are increasingly being converted to other uses such as urban and tourism infrastructure and aquaculture ponds.

Throughout the region, reef fish and invertebrates have been heavily exploited, especially in nearshore areas. As a result of intense historical exploitation, the trend over the past few decades has been of declining catch accompanied by changes in fish communities towards smaller, low valued species. Also alarming is the decrease of herbivorous fish such as parrotfish in many reef areas, which has contributed to regime shifts from coral to algal dominated reef habitats that is becoming widespread in the CLME. As nearshore habitats and resources are degraded and depleted, exploitation is shifting towards offshore areas. In the absence of appropriate management interventions to recover inshore habitats and living marine resources and protect those in offshore areas, these negative trends are likely to continue.

5.1.4.1. Unsustainable fisheries

Unsustainable fisheries is of major transboundary significance owing to the shared and/or migratory nature of some of these species. Overfishing is rated as the most pervasive threat to the region's reefs, affecting almost 70% of reefs; in reality this could be even higher (Burke et al 2011).

Since the mid-1970s, annual reported landings of CLME reef resources have showed a general declining trend (Figure 10 and Figure 11)

Queen conch populations in a several countries are partially, fully, or severely overfished. Overfishing of conch, fuelled primarily by international demand for meat and conch pearls, has reduced most stocks throughout the region and has resulted in declining annual harvests (Appeldoorn et al, in press).

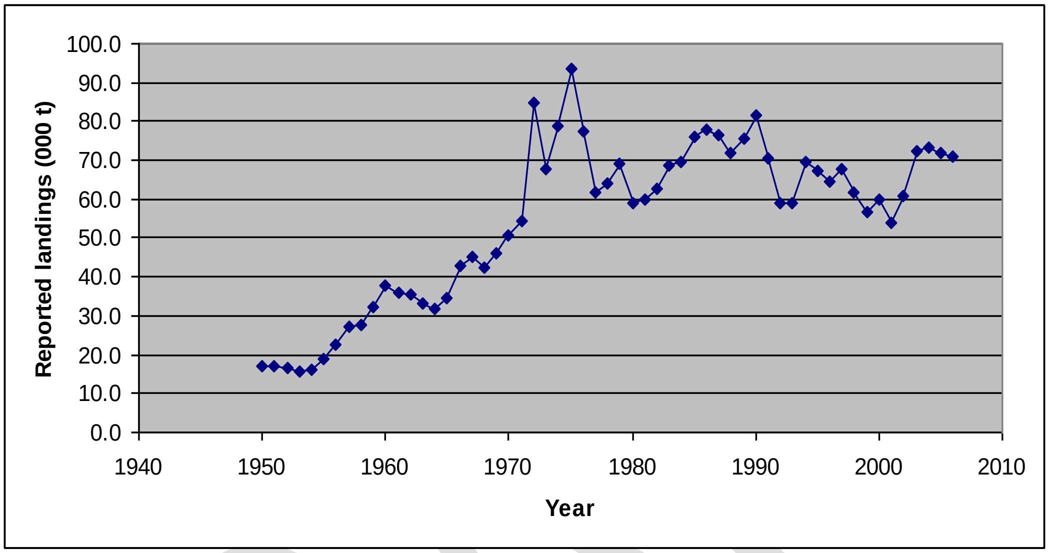


Figure 10. Annual reported landings on reef resources in the CLME

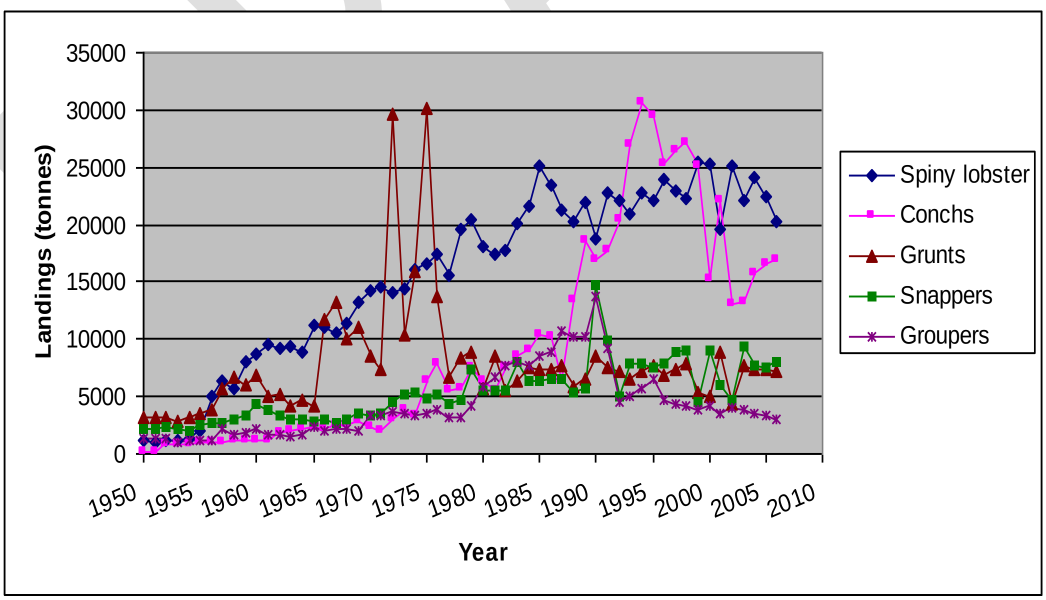


Figure 11. Trends in annual catches of major reef associated resources in the CLME from 1950 – 2006

Spawning aggregations are important for the maintenance of reef fish populations through larval connectivity (Heyman et al 2008). These aggregations have a high vulnerability to overfishing and are heavily exploited in the Caribbean, with some having become extinct in several localities.

Annual trends (from 1950 to 2006) in the overall status of reef resources in the CLME is represented by the Stock Status Plots[32] (Figure 12). These plots assess the status of stocks by number of stocks (top) and by catch biomass (3-year running average values; bottom) since 1950 (Sea Around Us Project 2011). As can be seen in the top panel, the number of overexploited stocks increased markedly from the mid-1970s and the number of collapsed stocks from the late 1980s. In 2006, about 20% of the commercially exploited reef fish stocks were overexploited and nearly 20% had collapsed (Figure 12, top). Slightly less than 20% of the catch in 2006 came from overexploited stocks (decreasing from about 40% in 2002), with negligible catches from collapsed, developing or rebuilding stocks (Figure 12, bottom). These trends are consistent with the unregulated expansion of fishing in earlier decades in the CLME.

Analyses carried out by the UBC Sea Around Us Project for the CLME project showed that the Marine Trophic Index (MTI) [33] of the annual catches of reef fish declined steadily between 1950 and 2006 (Figure 13). These analyses relied upon the global database of fish landing assembled and maintained by the FAO. The observed decline in MTI could be attributed to the progressive depletion of top predatory reef fish such as snappers and groupers.

An indicator of the ecosystem impacts of unsustainable fishing is a change in the structure of the marine food web. This is reflected in decline in the mean trophic level of the catch, as represented by the MTI. This phenomenon - 'fishing down the food web'- occurs with depletion of large predators (high trophic level species), leading to a predominance of smaller, low-trophic level species (Pauly et al. 1998). Analyses carried out by the UBC Sea Around Us Project showed that the MTI of the annual catches of reef fish declined steadily between 1950 and 2006 (Figure 13). The observed decline in MTI could be attributed to the progressive depletion of top predatory reef fish such as snappers and groupers, large individuals of which are now rare throughout the region (Burke et al 2011). Commercial fishing has also significantly depleted members of the snapper-grouper complex on deep water reefs (Koenig et al 2005).

As shown in Figure 13, the initial increasing trend in the Fishing in Balance (FiB)[34] Index for the CLME reef fisheries might have been caused by expansion of these fisheries. The decline in the FiB Index for CLME reef fish, especially from the 1980s accompanied by a steady decrease in annual landings are alarming trends that reflect the impairment of ecosystem functioning of Caribbean reefs. The results of these analyses are very useful in providing a holistic picture of the status of the reef resources. They convey strong messages about the need to reverse or prevent further declines before they become irreversible.

[32] These analyses and plots for reef and pelagic stocks were provided for the CLME project by the University of British Colombia Sea Around Us project (the analyses are usually carried out for combined stocks)

[33] The MTI is one of the eight indicators that the Conference of the Parties of the CBD identified for "immediate testing" of their ability to measure progress towards the 2010 target. The MTI is the CBD's name for the mean trophic level of fisheries landings, originally used by Pauly et al. (1998) to demonstrate that fisheries, since 1950, are increasingly relying on the smaller, short-lived fish and on the invertebrates from the lower parts of both marine and freshwater food webs.

[34] This index has the property of increasing if catches increase faster than would be predicted by TL declines, and to decrease if increasing catches fail to compensate for a decrease in TL.

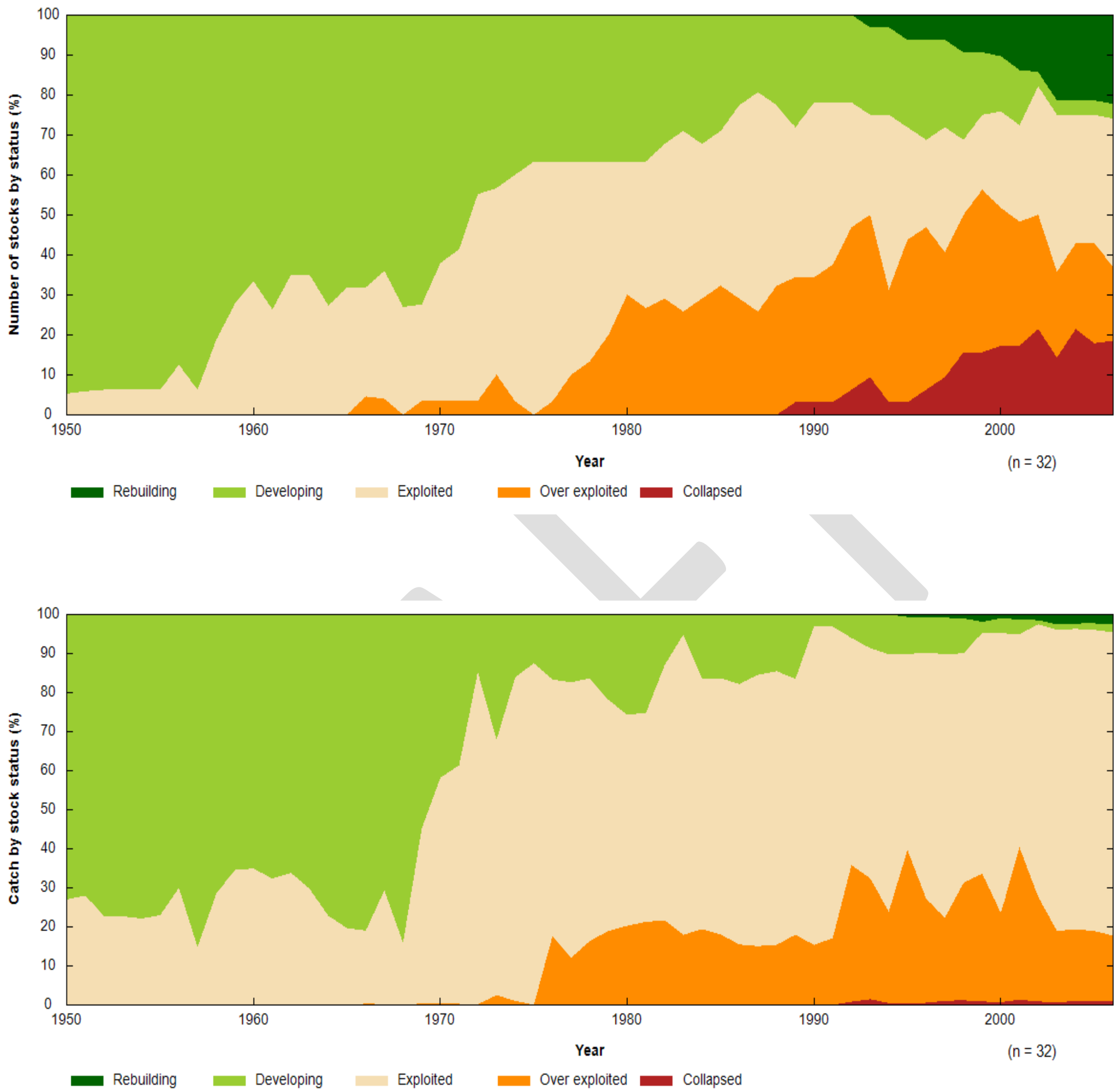


Figure 12. Stock Status Plots for reef fish in the CLME

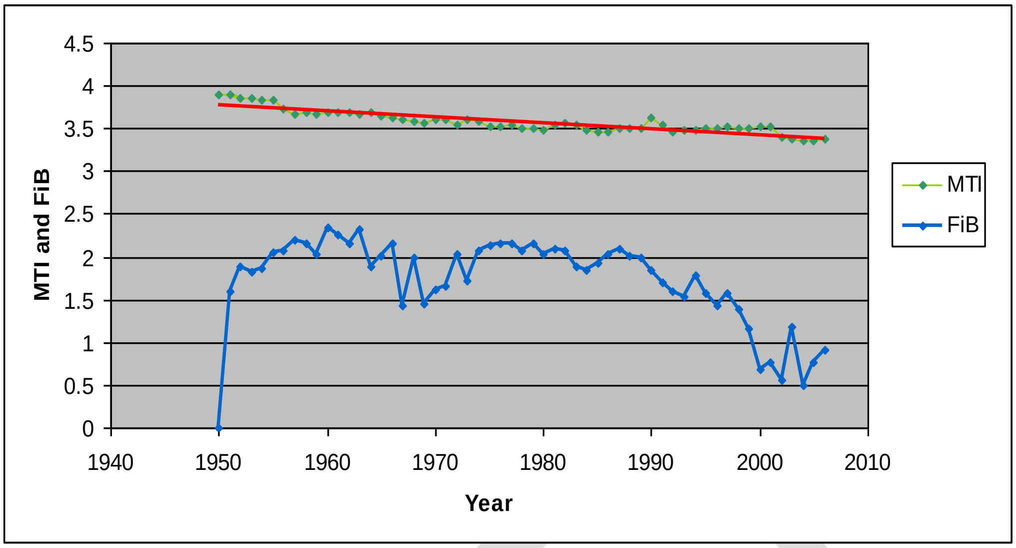


Figure 13. Marine Trophic Index (MTI) and Fishing-in-Balance Index (FiB) for reef species in the CLME

Fishing has also threatened biodiversity, with some species currently on the IUCN Red List. For example, the Nassau grouper is now included on the IUCN Red List of Endangered Species (IUCN 2007), which is attributed to an estimated decline in population abundance of 40% within its distributional range. The Goliath grouper, *Epinephelus itajara* (previously called jewfish), is listed as critically endangered and face an extremely high risk of extinction in the wild. According to the IUCN Red List of Threatened Species, persistent over-exploitation, especially of adult females on nesting beaches and the widespread collection of eggs are largely responsible for the depleted status of all six Caribbean sea turtle species. Marine mammal populations have also been affected by unsustainable fishing.

Overfishing, particularly of herbivorous species, has been identified as a key-controlling agent on Caribbean reefs, leading to shifts in species dominance (Aronson and Precht 2000). The impact of overfishing on habitats is clearly demonstrated by the effect of the reduction in the population of herbivorous fish on reef health. Feeding by large herbivores is usually responsible for reducing algal biomass and, in some cases, enhancing coral cover. The grazing function of these herbivores is particularly important in areas in which the population of the herbivorous long-spined sea urchin (*Diadema antillarum*) has been decimated during its Caribbean-wide mass mortality in 1983 (Lessios et al. 1984). The population of the Caribbean parrotfish (*S. guacamaia*), usually the most important grazer on Caribbean reefs (Steneck 1994), has declined in many areas throughout the CLME, which has serious consequences for the health of the region's coral reefs.

In summary, the major transboundary impacts from unsustainable fisheries practices include:

- ***Reduced abundance of stocks*** (as evident in decreasing total catches and catch per unit effort and collapsed stocks). All the major reef fishery resources of the CLME (spiny lobsters, conch, snappers, and groupers) are overexploited or exploited close to their maximum sustainable yield, and a number of stocks have already collapsed.

- ***Change in trophic structure of fish populations*** Excessive fishing pressure has reduced the abundance of top predators on reefs throughout the region. The decline in both the MTI and the FiB Index reveal that fishing has impaired the functioning of Caribbean reefs and their provisioning of ecosystem services.
- ***Threats to biodiversity*.** Unsustainable fishing has contributed to changes in reef biodiversity and the threatened status of a number of species including groupers, snappers, and turtles. Several of these are of transboundary importance.
- ***Degradation of habitats*.** Most of the region's reefs are threatened by overfishing and destructive fishing practices. Commercial fishing on deep water reefs has caused extensive damage to corals (Koenig et al 2005). Fishing can impact reef habitats through direct damage as well as by depletion of certain trophic groups such as herbivores, which has promoted the overgrowth of coral reefs by algae throughout the region.

The ecosystem impacts from unsustainable fisheries practices will have socio-economic consequences throughout the region, potentially including:

- Disruption of trade and reduction of foreign exchange earnings (as demonstrated by the CITES trade embargo on queen conch).
- Loss of employment and income, and reduced food security in communities that depend on fishing.
- Erosion of livelihoods and loss of employment in the fisheries sector could lead to increase in criminal activities and migration towards big cities.
- Reduced inshore resources also lead to increasing operational expenses, since fishers have to extend their fishing range offshore.
- Negative consequences for dive tourism and for recreational fishing.
- A positive outcome from unsustainable exploitation is that the ensuing unprofitability could force fishers out of this sector and encourage the development of alternate, more sustainable forms of employment such as ecotourism

5.1.4.2. Habitat degradation

Burke and Maidens (2004) integrated four major threats to Caribbean reefs (coastal development, marine-based threats, overfishing, land-based sediment and pollution) into the Reefs at Risk Threat Index, which showed that nearly two-thirds of the region's coral reefs are threatened by human activities, with overfishing being the major threat. An update of this assessment[35] (based on overfishing and destructive fishing, coastal development, watershed-based pollution and marine-based pollution and damage) has revealed an increase in the proportion of Caribbean reefs threatened by human activities to more than 75%, with more than 30% in the high and very high threat categories (Burke et al. 2011). Climate-related threats are projected to push the proportion of reefs at risk in the Caribbean to 90% in the year 2030, and up to 100%, with about 85 % at high, very high, or critical levels, by 2050.

[35] Reefs at Risk Revisited.

The Insular Caribbean is particularly threatened. From Jamaica through to the Lesser Antilles, more than 90% of all reefs are threatened, with nearly 70% classified as at high or very high threat, with coastal development and watershed-based pollution the most severe.

Coral reefs in particular are under very high threat from global climate change and unsuitable aquatic tourism practices. The overall threat is very high for coral reefs and high for the other four habitats (the Nature Conservancy's Mesoamerican Reef Programme).

The high level of international shipping traffic in the Caribbean Sea poses a potential danger to the ecosystem from exotic species. Known examples of invasive species that were introduced through shipping are the red lionfish (*Pterois volitans*), native to the Pacific Ocean, and the Indo-Pacific green mussel (*Perna viridis*). In 2004 recreational divers first reported seeing lionfish, whose range is expanding rapidly throughout the Caribbean. Due to their population explosion and aggressive behavior, this species can drastically reduce the abundance of coral reef fishes, leaving behind a devastated ecosystem. The loss of herbivorous fish through predation by lionfish promotes overgrowth of corals by algae. Potential negative impacts of the green mussel on marine living resources include competition with the oyster fishery, displacement of native mussels, and carriers of diseases and parasites harmful to native species.

In summary, the key transboundary impacts from habitat degradation include:

- ***Loss of ecosystem structure and function;*** Recent studies have revealed a trend of serious and continuing long-term decline in the health of the region's coral reefs (Wilkinson 2002, Gardner et al 2003, Kramer 2003). In some areas, up to 80% of shallow-water reefs have been destroyed and coral diseases have contributed to the extensive loss of two important reef-building corals. In some areas throughout the Caribbean, up to 100% of corals have been affected by bleaching. The widespread loss of reef rugosity is likely to have serious consequences for reef biodiversity, ecosystem functioning and associated ecosystem services. With the loss of reef herbivores such as sea urchins and parrot fish, coral reefs are increasingly being overgrown by algae, which impairs reef structure and functioning.
- ***Reduction/loss of biodiversity.*** Coastal habitats are critical for marine biodiversity, serving as essential habitats for many fish, molluscs, crustaceans, sea turtles as well as some marine mammals. Over the past two decades, a combination of anthropogenic and natural stressors has caused a reduction in marine biodiversity. Staghorn and elkhorn corals and sea fan are listed as Critically Endangered on the IUCN Red List, because of population reductions exceeding 80%, in particular due to the effects of disease as well as climate change and human-related factors. Habitat degradation and loss (along with overfishing), is also responsible for the massive decline in Caribbean populations of sea turtles and marine mammals such as the manatee. A 99.7% drop in historic Caribbean populations of the green and hawksbill sea turtles since the 17th century has been reported. This could be partly attributed to the loss of 20% of historic nesting sites due to land development and turtle exploitation, and another 50% of the remaining sites having been reduced to dangerously low populations.

- ***Reduction in fisheries productivity and other ecosystem services.*** The close association of reef fish and invertebrates with their habitat, and high dependence on suitable benthic habitat for reproduction and settling of larvae and juveniles, degradation and loss of essential fish habitat has severe consequences for fisheries productivity. Studies of corals, lobsters, and fishes suggest that population declines ranging from 50 to 100% can occur when the recruitment potential of benthic habitats is diminished.

The ecosystem impacts from habitat degradation will have socio-economic consequences throughout the region, potentially including:

- Degradation of coastal ecosystems results in a wide range of adverse socio-economic impacts linked to the tourism and fisheries sectors. Most small-scale fisheries throughout the region are reef-based, representing an important source of food, livelihood and income. Degradation of coral reefs and loss of reef fisheries will have major impacts on the hundreds of thousands of people who depend on reef fisheries. Similarly, most tourism is concentrated on the coast, a significant portion of which is directly reef-related (dive tourism). Habitat degradation and loss of ecosystem services could potentially result in a reduction in tourism and subsequent loss of employment and income from this sector.
- Loss of protective function of coastal habitats and increased exposure of coastal human communities to hurricanes and tidal surges and other such risks. Substantial costs could be incurred to address increased coastal erosion.
- Conflicts among different groups of users could also arise from habitat degradation (e.g. between fishers and tourists).
- Estimates of economic losses from coral reef degradation in the Caribbean range from US$350 million - 870 million per year by 2015 to coastal countries that currently receive benefits valued collectively at US$3 billion – 4.6 billion per year (CARSEA 2007 adapted from Burke and Maidens 2004).

5.1.4.3. <u>Pollution</u>

Most pollutants can be dispersed throughout the water column from the sea surface to the bottom environment, and their concentrations are not usually recorded separately for the environment of reef and pelagic systems. This tendency presents some difficulty in carrying out analyses of pollution for reef and pelagic systems separately.

Pollution has significant transboundary implications in the CLME, as a result of the high potential for transport across EEZs in wind and ocean currents and impacts on transboundary living marine resources and ecosystem services. Further, certain contaminants in sea water and marine organisms can directly affect human health through direct contact or consumption. The main pollution problems of the CLME region were identified as: High presence of organic matter and nutrients (phosphorus and nitrogen); elevated concentrations of organic and inorganic toxic substances (oil hydrocarbons and heavy metals), and micro-organisms coming from fecal matter above national and international quality criteria (UNEP-CEP/Cimab 2010). In terms of land-based pollution to the Caribbean Sea, Gil-Agudelo and Wells (in press) and Sweeney and Corbin (in press) reported that sewage (domestic and industrial), heavy metals, hydrocarbons, sediment loads, and agrochemicals (fertilizers and pesticides) are considered the most important.

Widespread Hg concentrations in the regions, in sediments (average 71.3 µg/l) and in coral skeletons (average 18.9 µg/l), suggests that these pollutants are being carried along the region by ocean currents, with high concentrations of this metal being found even in 'pristine' reefs (Guzmán and García 2002).

A serious but unseen threat to living marine resources is the bioaccumulation of pollutants such as POPs and heavy metals in their tissue. This is of great concern in higher trophic level animals and ultimately humans, due to the bio-magnification of these pollutants in the food chain.

In summary, the key transboundary impacts identified with the reef fishery ecosystem associated with pollution includes:

- ***Deterioration of environmental quality.*** Pollution reduces the quality of the marine environment, including in places far from the source. Pollutants that are known to cause severe degradation to reef ecosystems are nutrients, sediments, and hydrocarbons.Several coastal pollution hotspots have been identified in the region, which show poor environmental quality resulting from a range of substances (Cimab 2010). Sewage is regarded as one of the most important and widespread causes of deterioration of the coastal environment in the Caribbean. Nutrients have given rise to widespread eutrophication. Suspended sediments also impair water quality by blocking light penetration and introducing attached chemical compounds and pathogens.

- ***Threats to living marine resources.*** Coral reefs are highly threatened by pollution throughout the WCR. Pollution can kill or impede the growth of coral, mangrove and seagrass and make them more vulnerable to diseases. Sedimentation and pollution from both land and marine based sources pose high levels of threat to coral reefs in the Caribbean, with pollution from inland sources threatening about one-third of Caribbean coral reefs. High nutrient inputs have promoted hotspots of eutrophication, increased algal and bacterial growth, degradation of seagrass and coral reef habitats, changes in community structure, decreased biological diversity, fish kills, and oxygen depletion in the water column in some localized areas throughout the region (UNEP 2004a, 2004b). Smothering of coral reefs, seagrasses, and associated filter feeders and other benthic organisms by high sediment loads is of concern throughout much of the region.

The ecosystem impacts from pollution will have socio-economic consequences throughout the region, potentially including:

- The socio-economic consequences of pollution vary from slight to severe in the region, as found by GIWA. These include a decrease in the value of fisheries products through contamination, and loss of economic and aesthetic value of coastal areas.
- High bacterial counts have been detected in some bays in the region (UNEP 2004a), especially where there are large coastal populations and high concentration of boats. Microbiological pollution from sewage is also a threat to human health and in some areas downstream coastal communities have a high prevalence of gastrointestinal and dermal ailments (UNEP 2006).

- Bioaccumulation of some pollutants such as POPs and heavy metals in the tissue of marine organisms that are consumed by humans can also have serious impacts on human health.
- Pollution has also diminished the aesthetic value of some areas, impacting on recreational activities and reducing revenue from tourism (UNEP-CEP/RCU 1997).
- The economic cost of addressing pollution (e.g. clean up of oil spills, adoption of new technologies) and of medical treatment of pollution-related illnesses could be very significant.
- Data (or access to data) on the socio-economic impacts of pollution is very limited in the region.

5.1.5. Governance in the Reef Fisheries Ecosystem

At the national level, almost all the countries have established authorities and government ministries whose mandate extends to living marine resources (e.g. Ministry of Environment, Fisheries, or Agriculture, Fisheries Departments) and under whose authority resource assessment, research, management, and regulation fall. At the subregional level, in the English-speaking Caribbean, the CARICOM Regional Fisheries Mechanism (CRFM) undertakes resource assessment.

For the Spanish-speaking countries harvesting the fishery resources of the reef ecosystem, with the exception of Colombia, all the countries are members of the Latin American Organization for Fishery Development (OLDEPESCA), created in 1982 and based in Lima, Peru. The Central American countries are also members of the Fishing and Aquaculture Organization of the Central American Isthmus (OSPESCA/SICA), an inter-governmental organization created in 1995 and based in San Salvador, El Salvador.

Research and monitoring capacity also exists in national (e.g. University of Havana) and regional universities (University of the West Indies) and national (e.g. Institute of Marine Affairs, Trinidad and Tobago and INVEMAR, Colombia), and intergovernmental organizations (e.g. Caribbean Environmental Health Institute - CEHI). Most research conducted is, however, limited to resources and/or ecosystems within national borders.

Within most countries integrated living marine resource management is still in its infancy. In addition, in general there is no mechanism for communication and collaboration among relevant sectors on a national, as well as on the sub-regional and regional scales regarding transboundary issues and related governance frameworks.

While most of the countries have legislation related to the exploitation and management of living marine resources, fisheries management initiatives are partly governed by international frameworks such as the Law of the Sea Convention (LOSC), the UN Fish Stocks Agreement, and the FAO Code of Conduct for Responsible Fisheries.

Almost all the countries have established MPAs and/or national parks with marine components. However management of MPAs in the reef fisheries ecosystem across the region has been varied. The countries in the Central and South American sub-region have met with considerable success at both the national and sub-regional level (e.g. MPAs in Belize and Colombia and the joint efforts[36] targeted at managing the Meso-American Barrier Reef System (MBRS)). However, in the case of the Insular Caribbean, MPAs are generally not effectively managed because of limited human and financial resources.

In 1989 the Heads of Government of CARICOM agreed to deepen the economic component of the integration process into a CARICOM Single Market and Economy (CSME). One of the key objectives of the CSME is the development of common policies in several areas including management of fisheries. However, management of the reef ecosystem fisheries resources is complicated by factors such as the absence of delimited EEZ boundaries, multiple user conflicts arising from marine-based tourism, land and sea-based pollution, and unregulated fishing (Cadogan 2006). Competition for these resources is likely to increase with the entry into force of the CSME. Under the CSME, CARICOM States are expected to have preferential rights of access to each other's EEZs.

Common fishing zone provisions are also being pursued at the sub-regional level through the Environment and Sustainable Development Unit of the OECS. The harmonization of legislation by the OECS in the 1980s was followed by various initiatives towards the establishment of a common fisheries zone or zones and efforts at joint surveillance.

5.2. Pelagic Ecosystem

5.2.1. Introduction to the Pelagic Ecosystem

For the purposes of the CLME TDA, the pelagic ecosystem is considered to be restricted to the epipelagic zone of the ocean. This is the euphotic zone that extends from the surface to a depth of about 200 m. While it does not have the structural complexity of coral reefs and other coastal habitats, the pelagic environment is not homogenous. It can be characterized by differences in abiotic and biotic factors (temperature, oxygen, salinity, transparency, light intensity) and the presence of phytoplankton, zooplankton, prey and predators. Areas of high productivity within the pelagic zone include coastal upwelling and oceanic fronts.

The pelagic realm provides important habitats for adult and other life history stages of living marine resources (including of reef species) as well as lower trophic levels (phyto and zooplankton) that are important in ocean food webs. A total of 28 functional groups of macrofauna were identified in the Lesser Antilles Pelagic Ecosystem, comprising over 100 species among which are seabirds, small and large pelagic bony fish, pelagic sharks, marine mammals, turtles and invertebrates (squid and crustaceans) (Mohammed et al 2008).

During hydroacoustic and pelagic trawl surveys, high concentrations of juveniles of large pelagic species as well as of reef species were observed in offshore pelagic areas beyond the shelf area (Melvin et al. 2007). Therefore, the pelagic ecosystem has important trophic and ontogenetic linkages with the reef system, the deeper oceanic zones as well as with the land (e.g. through seabirds and turtles that nest in coastal areas and beaches).

[36] Mexico, Belize, Guatemala, and Honduras are participating member countries of the MBRS.

5.2.2. Pelagic ecosystem services

The major categories of ecosystem services are described in the reef ecosystem section, and are also pertinent to the pelagic ecosystem. This realm provides a range of valuable ecosystem services, some examples of which are given in Table 8. Among these, the provisioning service (especially fish resources), cultural service (recreational and tourism value) and supporting service (habitat value and transport of eggs and larvae, including of reef species) are of particular relevance to the CLME project.

A brief description of the major pelagic groups that are of commercial importance in the CLME follows.

- ***Small coastal pelagic species:*** This group consists of an enormous diversity of species, and includes jacks (*Caranx* spp., *Selar crumenophthalmus*), scads or robins (*Decapterus* sp.,), ballyhoo (*Hemirhamphus* sp.), herrings (*Harengula* spp, *Sardinella* spp.) and anchovies (*Anchoa* spp.). These species occur on the shelf areas and support important local fisheries (for bait and human consumption). Some of these species also constitute a major food source for larger pelagic species.

Table 8. Ecosystem services of the pelagic ecosystem

PELAGIC ECOSYSTEM SERVICES			
Provisioning	**Regulating**	**Cultural**	**Supporting**
• Fish for food and recreational fishing • Medium for shipping • Energy generation (waves) • Pharmaceutical products	• Climate regulation	• Recreational and tourism value (recreational fishing, sailing, etc) • Knowledge systems and educational value • Spiritual and inspirational value	• Habitat for fish, including critical habitat for eggs and larval stages of fish and shellfish • Transport of eggs and larvae to feeding and recruitment grounds • Biodiversity function: Sea turtles, seabirds, marine mammals?

- ***Large pelagic species:*** The large pelagic resources form the basis of very valuable commercial fisheries in the CLME region. They are categorized into two groups: coastal pelagic species and oceanic pelagic species. There is also a close ‘trophic’ link between the fisheries that harvest these large predators and those that harvest their prey. Additionally, fishing gears used to target large pelagic fish resources, such as longlines, can also catch other living marine resources such as sea turtles, sea birds and various other species of fish as bycatch.

- ***Marine mammals:*** Marine mammals are an integral part of the marine and coastal fauna of tropical and sub-tropical waters of the Caribbean Sea. These animals also have significant economic, aesthetic and amenity value to the peoples of the region. At least 34 species of marine mammals are known to inhabit the waters of the Caribbean Sea, seasonally or year-round (UNEP-CEP/RCU 2001). There is a limited fishery for marine mammals in the region, mainly in the Lesser Antilles.

5.2.3. Description of the current pelagic fisheries

These resources support very important and valuable fisheries in the region, contributing to food, employment, income and foreign exchange in the various countries. With the overfishing and decline of reef and inshore fisheries, the pelagic resources have become the focus of fisheries expansion in the region, particularly for large pelagic species.

Prior to the latter part of the 20th Century, Caribbean fisheries were limited to subsistence and artisanal levels. In the 1970s, especially after the declaration of the EEZ regime, several countries (e.g. Mexico, Cuba, Colombia, Nicaragua, Panama, and Venezuela) implemented government-sponsored fisheries expansion programmes, with focus on the offshore resources.

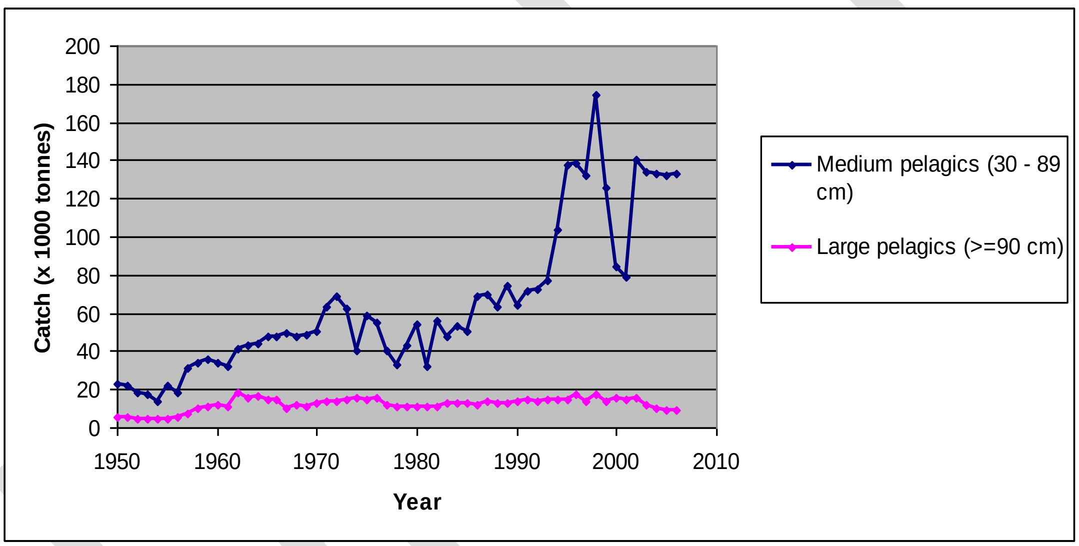


Figure 14. Trends in annual catches of large and medium pelagic fish in the CLME from 1950 – 2006

The focus of this TDA is on the large pelagic species that are of transboundary and economic significance in the CLME. These include those species regularly assessed by ICCAT (albacore, yellowfin tuna, bigeye tuna, skipjack, bluefin tuna, swordfish, blue marlin, white marlin, sailfish, blue shark and mako shark) and those species that have not been assessed by ICCAT either because of their low priority (small tunas, spearfishes, mackerels and other sharks) or because they do not fall under ICCAT's management, such as dolphinfish and carangids.

The annual reported landings of medium pelagic species in the Sea Around Us Project database showed fluctuations over the past few decades, with a marked decline between 1998 and 2001 (Figure 14). In contrast, the annual landings of large pelagics were fairly stable until 2002, following which they declined slightly.

The numbers of boats and persons employed in the pelagic fisheries are difficult to discern for the entire CLME. At the regional level, however, the majority of the boats and persons employed are found in the artisanal, inshore sector, with a smaller proportion in the large pelagic sector.

Large oceanic pelagic fisheries

- ***Large tunas:*** Apart from Venezuela (and the USA, which has some catches in the western Tropical Atlantic), the major fishing countries for large pelagic resources are in the Lesser Antilles, most of which are members of the CARICOM Regional Fisheries Mechanism (CRFM): Barbados, Grenada, St. Lucia, and Trinidad and Tobago. Substantial catches of large pelagic species are also taken by Martinique and Guadeloupe.

  Caribbean governments and fishing industry have spent considerable effort over the last 15 - 20 years to build the region's capacity for exploiting large pelagic resources, especially through the development of longlining for oceanic pelagic species. Several countries now operate significant numbers of medium (7–15 m) and large (>15 m) longliners.

  Of the species regularly assessed by ICCAT, those with the largest landings in the CRFM countries are yellowfin tuna, albacore tuna, skipjack and sailfish. [37]

  With the exception of Venezuela, the Central-South American large pelagic fisheries can be considered modest and are underexploited, especially in the Central American countries. The Central American countries capture mainly dolphinfish, swordfish, sailfishes, marlin, jacks, and sharks in the Caribbean Sea.

- ***Pelagic sharks:*** Pelagic sharks are caught in the Caribbean (as well as Atlantic and Gulf of Mexico) with a variety of gears, including longlines, gillnets, handlines, rod and reel, trawls, trolls and harpoons. However, they are mostly caught as bycatch in pelagic longline fisheries targeting swordfish and tunas. Sharks are in very high demand including on the international market where they fetch a very high price. The high demand for shark fins in the Asian market has been cause for concern, as this has promoted intense fishing pressure for these resources including in the CLME. Because of their life history strategy (low reproductive rate and live-bearers), sharks are very vulnerable to overfishing and a number of species are already threatened. The lack of data on sharks in the CLME region is a major constraint to their management.

- ***Marine mammals:*** Whaling has traditionally been carried out by St. Vincent and the Grenadines and St. Lucia, with the primary target species being blackfish (pilot whale) *Globicephala macrorhynchus*. Average annual catch of marine mammals in the LAPE area between 2001 and 2005 was 5.95 tonnes of killer whales (*Orcinus orca*, *Pseudorca crassidens* and *Feresa attenuatae*) and 16.77 tonnes of shallow-diving small cetaceans (Mohammed et al 2008).

[37] Anguilla, Antigua and Barbuda, Barbados, Bahamas, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St.Kitts and Nevis, Suriname, St. Vincent and Grenadines, St. Lucia, Trinidad and Tobago, Turks and Caicos, UK Virgin islands

Large coastal pelagics

The large coastal pelagics are considered as small tunas by ICCAT. Five species account for about 88% of the total reported catch by weight in the Atlantic region (ICCAT): Atlantic bonito *(Sarda sarda)*, frigate tuna *(Auxis thazard)*, which may include some catches of bullet tuna *(Auxis rochei)*, little tunny *(Euthynnus alletteratus)*, king mackerel *(Scomberomorus cavalla)*, and Atlantic Spanish mackerel *(Scomberomorus maculatus)*.

Most of the large coastal pelagic species have been conventionally fished throughout the region and have a high socio-economic relevance for most of the countries and for many local communities as a main source of food and livelihoods. The increasing importance of fish aggregating devices in the eastern Caribbean and in other areas has improved the efficiency of artisanal fisheries in catching these resources.

Recreational fishing for large pelagic species can be a significant component of the harvest sub-sector in many places. Mahon (2004) made a rough valuation of recreational fisheries for charter vessels based on about 85 charter boats in CARICOM countries. The total annual revenue for all boats was estimated at about US$6.6 million, equivalent to about 9% of the value of commercial fisheries.

For the CLME project, the following species are of particular interest, with case studies being conducted: flyingfish, dolphinfish, wahoo, mackerels (cero and king mackerel), blackfin tuna and bullet tuna. Flyingfish is included as this is a commercially important, shared resource in the Eastern Caribbean, and has close ecological and fisheries interactions with large pelagics such as dolphinfish and wahoo.

A brief description of the fisheries for these species is given below.

- ***Flyingfish:*** The fisheries for flyingfish are concentrated in the southern part of the Lesser Antilles, with significant small-scale commercial fisheries in Barbados, Grenada, Dominica, Martinique, St. Lucia, and Tobago (Oxenford et al 2007). In this sub-region, the fourwing flyingfish contributes 95% of the catches (Mohammed et al 2008).

  The directed flyingfish fishery is part of a multi-species, multi-gear pelagic fishery. Fishers use either trolled or stationary hook and line gear (baited with flyingfish) to catch regional large pelagic species, primarily dolphinfish, but also wahoo and ocean triggerfish (*Canthidermis* spp.). These two activities are largely inseparable as neither is likely to be economically viable alone, and the major flyingfish catch comes from this troll/gillnet sector (Fanning and Oxenford, in press).

  The flyingfish provides a good example of a species for which EAF management is highly appropriate (Fanning and Oxenford, in press). Tagging studies indicated considerable movements of the fourwing flyingfish between the countries in the Eastern Caribbean, which suggest that the minimum appropriate management unit for this species should be the combined EEZs of these countries (Oxenford et al. 1993).

- ***Dolphinfish:*** The dolphinfish is a highly migratory pelagic species that is targeted by both commercial and recreational fishers throughout its geographic range. An assessment of the dolphinfish stock in eastern Caribbean waters suggested that fishing mortality is much greater than that required for MSY, and as a result, catches from the stock are much lower than MSY (Parker et al 2000). Given the lack of any concrete signs of a decline in catch rates over this period, it was concluded that catches of dolphinfish are sustainable at current levels of harvest. Because of the importance of this species to most eastern Caribbean countries greater efforts should be made to collect the data needed for stock analyses in the future.

- ***Wahoo:*** Wahoo is particularly important in the Caribbean in both commercial and recreational fisheries. George et al (2000) assessed the wahoo stock in eastern Caribbean waters using a combination of length-based models. Their results suggest that fishing mortality is much greater than that required for MSY and that, as a result, catches from the stock are much lower than MSY. These results are highly uncertain and dependent on growth parameters not yet well estimated (George et al 2000). Based on observations it was inferred that the local abundance of the stock was sustainable at these levels of harvest at least in the short term. Therefore, a precautionary approach should be adopted in managing and further developing this fishery until the stock dynamics are better understood. Management of the wahoo fishery should be based on collaborative arrangements between the CRFM and major non-CRFM fishing nations in the region (CRFM 2007).
- ***Mackerels: :*** Mackerels, particularly king mackerel and serra Spanish mackerels, are commercially important in a number of CLME countries and territories. They are considered part of a multi-species complex of coastal pelagic species taken by a combination of gears and fleets. Landings in CRFM countries between 1990 – 2006 were dominated by the Spanish mackerel (40,432 tonnes), followed by king mackerel with 14,089 tonnes (CRFM 2008). Information on cero mackerel (*S. regalis*) is limited in the CLME region.
- ***Blackfin tuna:*** In the Western Atlantic, the highest quantities are landed by Venezuelan fleets. Among the Eastern Caribbean countries, by far the largest recorded quantities of blackfin tuna are traditionally landed in Martinique and Guadeloupe followed by Grenada..
- ***Bullet tuna:*** Unknown quantities of bullet tuna are landing and recorded as frigate tuna (*Auxis thazard*) in the Atlantic (ICCAT 2006), where catches of *Auxis* species are usually not identified to species.

5.2.4. Analysis of the current issues

The pelagic ecosystem provides enormous social and economic benefits to the countries and people of the region, particularly the large pelagic fisheries resources that are shared among the countries within as well as with countries outside the region. While the pelagic realm is often seen as a vast expanse of ocean with unlimited living resources, heavy and in many cases non-selective fishing, land and marine-based pollution, and climate change are leading to decline in these valuable resources and degradation of the pelagic habitat. This has implications, not only for the pelagic resources themselves, but also for the reef ecosystem owing to the high connectivity between these two systems (e.g. transport of pelagic eggs and larvae of reef organisms from spawning grounds to settlement and recruitment areas), and for the entire CLME.

5.2.4.1. Unsustainable fisheries

A major concern is the unsustainable exploitation of large pelagic fisheries resources. Their high economic value and demand globally drive intense fishing pressure for these resources throughout their range. As a consequence, a number of these stocks are already showing signs of overfishing and collapse. The high incidence of bycatch in pelagic fisheries, particularly of endangered or threatened species with already small population sizes, is a leading conservation concern. The issue of Illegal, Unreported, and Unregulated (IUU) fishing is an enormous problem with respect to the pelagic resources as most countries do not have the capacity for surveillance and enforcement in their respective EEZs. Related to IUU is another issue of concern – Flags of Convenience (FOC) –especially for vessels fishing on the high seas (Box 10). An analysis of information available from the Lloyd's Register of Ships between 1999 and 2005 on fishing vessels registered to the top 14 countries that operate open registries or 'Flags of Convenience' for large-scale fishing vessels was undertaken under the auspices of the World Wildlife Fund International and others (Gianni and Simpson 2005). Four CLME countries (Belize, Honduras, Panama, and St. Vincent and the Grenadines) have consistently topped the list of FOC countries with the largest number of large-scale fishing vessels (>24m) registered to fly their flag.

Some of the highly migratory and straddling stock are already considered to be overfished throughout the Atlantic Ocean (Die 2004). These include the Atlantic swordfish (ICCAT 2001a) and Atlantic blue marlin and white marlin (ICCAT 2001b). The abundance of Western Atlantic sailfish fell dramatically in the 1960s and has not increased much since. Current catches seem sustainable (ICCAT 2001b), but it is not known how far the current levels are from MSY. In spite of fisheries regulations, the oceanic fishing industry continues to decline, with almost 70% of the stocks fully exploited or overfished. More recent assessments by ICCAT found that a number of these species are still overexploited, with catches continuing to decline. Among these are blue and white marlin, sailfish and yellowfin tuna.

Calculation of catch per unit effort (CPUE) trends in four of the Windward Islands (Mohammed 2003) show that increases in offshore catches between 1980 and 1999 (36% to 143%) were far outweighed by the corresponding increases in fishing effort to produce such catches (339% to 598%).

CPUE declined substantially in the offshore fisheries of each of the four countries (by a range of between 52% and 69%), despite increasing fishing effort. These trends are also evident in the CLME, as discussed below.

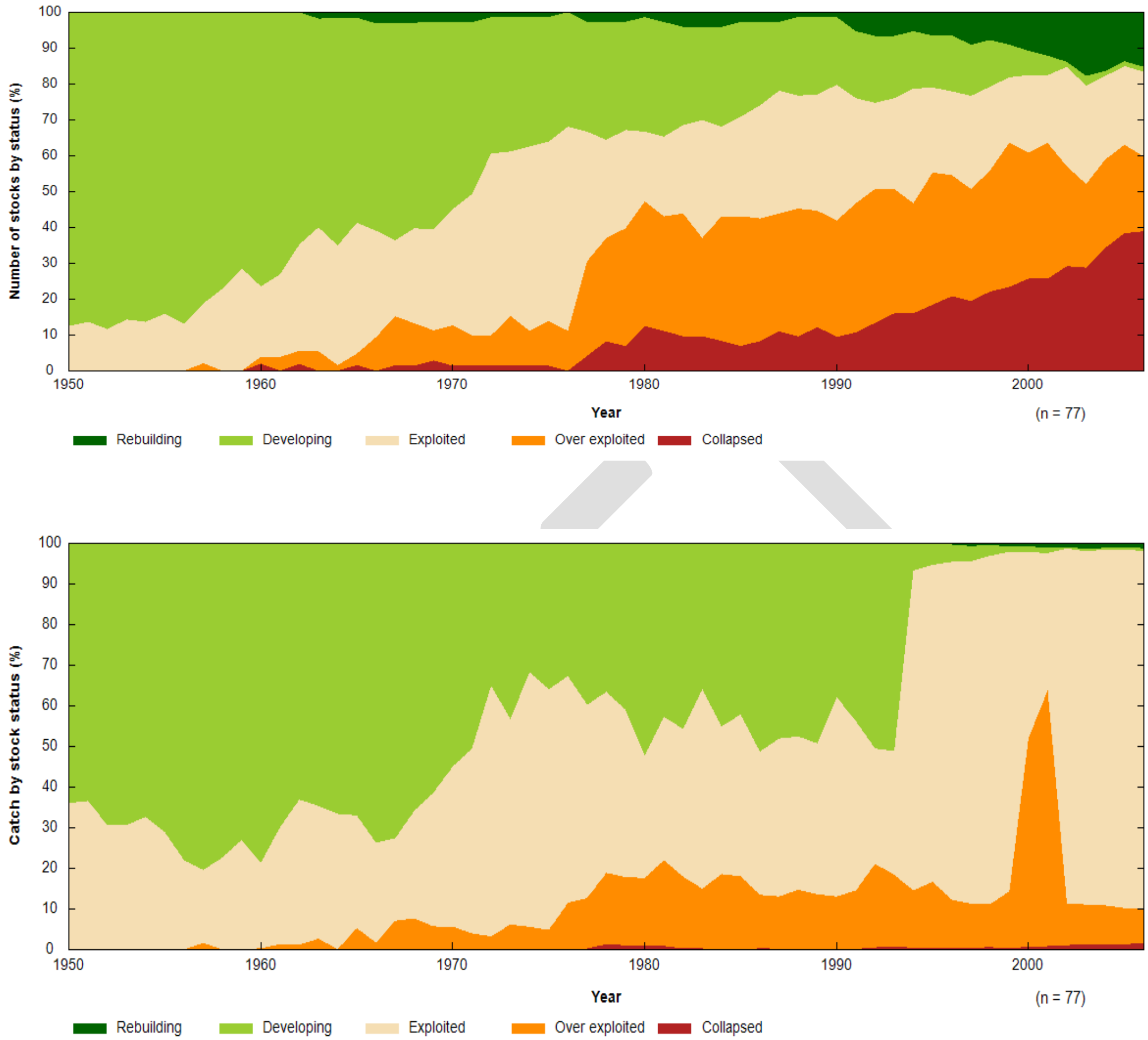


Figure 15. Stock Status Plots for pelagic fish stocks in the CLME

As shown by the stock-status analysis the number of overexploited and collapsed stocks increased markedly from the late 1970s (Figure 15, top panel). While the former stabilized and even declined in recent years, the proportion of collapsed stocks continued to steadily increase to almost 40% in 2006. In 2006, about 60% of the pelagic stocks were overexploited and collapsed and about 10% rebuilding. In 2006 about 10% of the catch came from overexploited stocks (decreasing from nearly 70% in 2000 - 2002), with negligible catches from collapsed, developing or rebuilding stocks (Figure 15, bottom). As for reef fish stocks, these trends confirm the widespread reports of overexploited and collapsed stocks in the CLME, and are consistent with the unregulated expansion of fishing in previous decades.The results of these analyses are very useful in providing a holistic picture of the status of the pelagic resources and conveying strong messages to policy makers about the need to reverse or prevent further declines.

Fishing for marine mammals has traditionally been carried out in a number of the islands such as Dominica, St. Lucia, and St. Vincent and the Grenadines. The Caribbean monk seal is now considered extinct by the IUCN, largely through over-hunting (Rice 1973). The West Indian manatee once occurred along the nearshore coastal waters of Tobago during the 18th Century. This species is now extinct from around Tobago as a result of local and regional hunting (Khan 2002). The baleen whale, sperm whale, and West Indian manatee are all listed as Vulnerable to extinction on IUCN Red List of Threatened Species.

Analyses carried out by the UBC Sea Around Us Project for the CLME project showed that the MTI of the landings of pelagic species in the CLME declined steadily between 1950 and 2006 (Figure 16). The decline in MTI could be attributed to the progressive depletion of top predatory pelagic fish in the CLME, which is consistent with the observed global trend of reduction in large predators in marine ecosystems (Pauly et al 1998, Myers and Worm 2003).

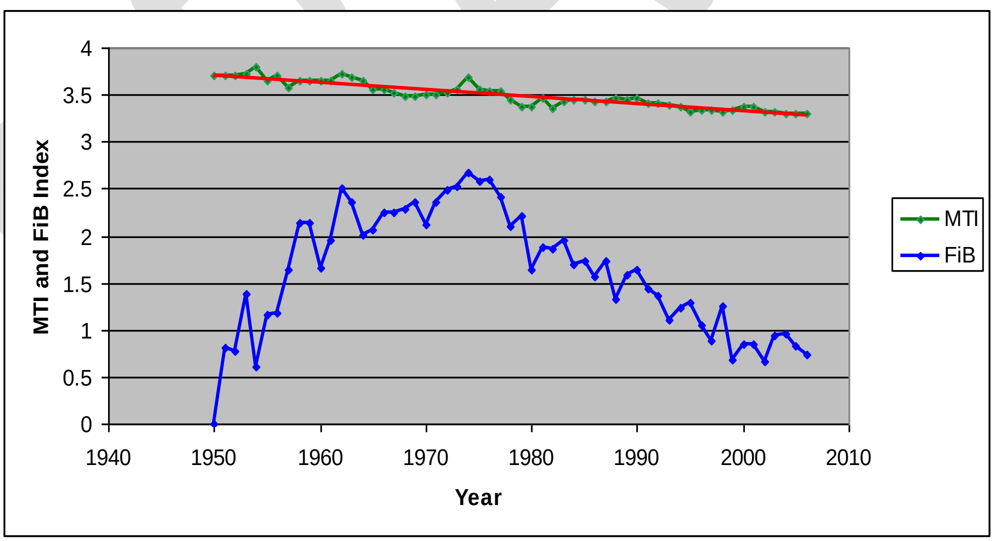


Figure 16. Marine Trophic Index (MTI) and Fishing-in-Balance Index (FiB) for pelagic species in the CLME

The FiB index increases where geographic expansion of the fisheries is known to have occurred. As shown in Figure 16, the FiB Index for the CLME pelagic resources increased initially, which is consistent with the expansion of these fisheries during this period. As discussed in the reef ecosystem section, the FiB will decrease if discarding occurs that is not considered in the 'catches', or if the functioning of the ecosystem is impaired by fishing (Sea Around Us Project 2010). The marked decline in the FiB Index for CLME pelagic resources, especially from the 1980s accompanied by a steady decrease in annual landings, may reflect the impairment of ecosystem functioning of the pelagic system, as has also occurred for the reef ecosystem.

In summary, the major transboundary impact from unsustainable fishery practices includes:

- ***Reduced abundance of fish stocks*** (as evident in declines in total catch and catch per unit effort and collapsed stocks). Reduced abundance is reflected in reduced catches and declines in CPUE, which is evident for many of the pelagic stocks. Some of the highly migratory and straddling stocks are already considered to be overfished throughout the Atlantic Ocean (Die 2004). In spite of fisheries regulations, the oceanic fishing industry continues to decline, with almost 70% of the stocks fully exploited or overfished. More recent assessments by ICCAT found that a number of these species are still overexploited including blue and white marlin, sailfish and yellowfin tuna.

- ***Changes in trophic structure of fish populations*** . Large pelagic fish species are among the top predators in the ocean.The populations of some of these species have been reduced by fishing, with changes in the trophic structure of the pelagic communities towards smaller, less valuable species at lower trophic levels in the food chain.

- ***Threats to biodiversity***. The incidence of large quantities of bycatch in pelagic fisheries is of concern globally, especially as this bycatch often includes threatened, endangered and /or protected species such as marine mammals, marine turtles and sharks as well as seabirds (e.g. Arocha et al 2002, Zollett 2009).

The ecosystem impacts from unsustainable fishing practices will have socio-economic consequences throughout the region, potentially including:

- Pelagic fisheries, like reef fisheries, represent a significant source of employment, income and protein for the CLME countries
- Socio-economic impacts of unsustainable fishing of pelagic resources include loss of employment, reduced food security in communities that depend on fishing, and reduced income and foreign exchange earnings.
- Erosion of livelihoods and employment opportunities in the fishing sector could lead to increase criminal activities and migration towards big cities.
- Reduction in the abundance of pelagic fish could also have negative consequences for tourism and recreational fishing, which is growing in the region, and lead to conflicts between fishers and even countries that exploit the same stocks.
- The fishing industry has made significant investments to exploit the region's large pelagic resources. Decline of these resources represents a major economic loss to these investors.

5.2.4.2. *Habitat degradation*

Previous assessments in the CLME region have focused on degradation of coastal habitats such as coral reefs, mangroves, seagrass beds, and beaches, with no explicit mention of pelagic habitats. The pelagic ecosystem is also subjected to a range of environmental stresses including large-scale processes such as climate change and ocean acidification as well as localized pollution.

In summary, the major transboundary impact from habitat degradation includes:

- ***Loss of ecosystem structure and function and loss of biodiversity.*** The impacts of global warming and acidification on the structure and function of the pelagic ecosystem are expected to be severe. A general declining trend in primary productivity with ocean warming was reported by Richardson and Schoeman (2004) and Behrenfeld et al (2006). The impacts of climate change on biodiversity could cause ecological disturbances and potentially disrupt ecosystem services in the CLME. While mobile pelagic species are able to avoid localized degraded areas, less mobile species and early life history stages might not have this ability. These problems can result in loss of ecosystem structure, reduction of biodiversity and reduction in fishery productivity.

- ***Reduction in fisheries productivity***. The pelagic ecosystem is an important habitat for both adults and early life history stages of commercially important species, including reef-associated species. Degradation or changes in this ecosystem is therefore likely to reduce fisheries productivity. For example, the alteration of ocean conditions including water temperature, ocean currents, and coastal upwelling, as a result of climate change can affect fisheries (IPCC 2007, Diaz and Rosenberg 2008) through impacts on primary productivity, species distribution, and community and foodweb structure. Rising sea water temperatures may have a significant impact on the distribution of maximum catch potential (a proxy for potential fisheries productivity) of pelagic and demersal species by 2055 (Cheung et al 2009a). Such a redistribution of catch potential is driven by projected shifts in species' distribution ranges and by the change in total primary production within the species' exploited ranges..

The ecosystem impacts from degradation of the pelagic habitat will have socio-economic consequences throughout the region, potentially including:

- Pelagic habitat degradation and community modification are likely to have severe socio-economic consequences for those nations and communities that depend heavily on commercial and recreational fishing and tourism for their social and economic viability.
- Tourism revenues are often directly impacted by habitat degradation because of the loss of amenity value for activities such as recreational fishing, swimming, and dive tourism. Habitat degradation represents a loss of income and employment opportunities in the fisheries and tourism sectors in the medium and long-term.
- With limited opportunities for economic diversification in the small islands, habitat degradation can have severe socio-economic consequences for the Insular Caribbean (UNEP 2004a, 2004b).

5.2.4.3. Pollution

Pollutants include nutrients, sediment bound pollutants, hydrocarbons and other hazardous substances pose a significant threat to the pelagic system. The high ship traffic and oil and gas operations present a high risk of pollution of the pelagic environment from these substances.

In the pelagic ecosystem, pollution reduces environmental quality of the water column and can have severe impacts on phytoplankton and zooplankton production that forms the base of pelagic food webs, and on planktonic early life history stages of fish and invertebrates.

Within the past 50 years, eutrophication has emerged as one of the leading causes of water quality impairment. Two of the most acute and commonly recognized symptoms of eutrophication are harmful algal blooms and hypoxia (low oxygen concentration), which are common throughout the region.

Oil concentrations of 500 ppm or even less can inhibit the growth of phytoplankton and pelagic bacteria. Previous oil spills have caused significant mortality of aquatic and avian species with many contaminated carcasses observed on beaches in the Venezuela/Colombia area (UNEP 2006).

Contaminants such as mercury can move through and accumulate in higher levels of marine food chains, including in humans who are at the top of some of these chains. This is of concern in large pelagic species, which are among the top predators in the ocean. Widespread mercury concentrations along the Caribbean coast of Central America suggest that this pollutant is being carried through the region by ocean currents (Gil-Agudelo and Wells, in press).

The main transboundary impacts from pollution includes:

- ***Deterioration of environmental quality:*** Pollution reduces the environmental quality of the water column and can have severe impacts on phytoplankton and zooplankton production that forms the base of pelagic food webs, and on planktonic early life history stages of fish and invertebrates. Within the past 50 years, eutrophication has emerged as one of the leading causes of water quality impairment. Oil pollution can have major impacts on the pelagic environment, particularly in cases of major oil spills. Coastal areas near to industrial centres show significant petroleum and heavy metal concentrations in water and sediment.
- ***Threats to living marine resources:*** Oxygen depletion caused by eutrophication can lead to fish kills in the water column in some localized areas. Transbounday impacts are likely to be more pronounced during the rainy season. Contaminants such as mercury can move through and accumulate in higher levels of marine food chains, including in humans who are at the top of some of these chains. Litter, mainly composed of plastic, accumulates in beaches and shallow waters, and can cause considerable harm to fish, turtles, birds, and marine mammals by entanglement (particularly in fishing gear), smothering, and ingestion.

The ecosystem impacts from pollution will have socio-economic consequences throughout the region, potentially including:

- Chemical and organic compounds released into the environment by industrial and agricultural activities present a permanent threat to human health.
- Harmful algal booms are frequently the cause of very serious human illness when the biotoxins produced are ingested in contaminated seafood.
- Microbiological pollution from sewage is a threat to human health; in some areas downstream coastal communities have a high prevalence of gastrointestinal and dermal ailments (UNEP 2006).
- Bioaccumulation of some pollutants such as POPs and heavy metals in the tissue of marine organisms that are consumed by humans can also have serious impacts on human health. Some of these species such as tunas are known to have high levels of mercury in their flesh.
- Pollution has also diminished the aesthetic value of some areas, impacting on recreational activities and reducing revenue from tourism (UNEP/CEP 1997).
- The economic cost of addressing pollution (e.g. clean up of oil spills, adoption of new technologies) and of medical treatment of pollution-related illnesses could be very significant. Data (or access to data) on the socio-economic impacts of pollution is very limited in the region.

5.2.5. Governance in the Pelagic Fisheries Ecosystem

While most of the countries have legislation related to the exploitation and management of living marine resources, few have provisions specifically related to large pelagic fish species (Mahon and McConney 2004). For this ecosystem, fisheries management initiatives are partly governed by international frameworks such as the Law of the Sea Convention (LOSC), the UN Fish Stocks Agreement, and the FAO Code of Conduct for Responsible Fisheries.

The best established fisheries management organization with relevance to the pelagic resources of the WCR is ICCAT, which has the mandate to manage all tuna and tuna-like species in the Atlantic. Currently, however, only three Insular Caribbean countries (Barbados, Trinidad and Tobago, St. Vincent and the Grenadines) and six continental countries (Belize, Guatemala Honduras, Mexico, ,Panama , and Venezuela) are contracting parties to ICCAT. Colombia and Guyana have the status of a cooperating, non-contracting member. In addition to ICCAT, the International Whaling Commission is an important body affecting the governance of the open sea fisheries ecosystem in the region.

In addition to the work undertaken by FAO and its WECAFC, a relevant project for this ecosystem in the CLME project area was identified as the 'Scientific Basis for Ecosystem-Based Management in the Lesser Antilles including Interactions with Marine Mammals and other Top Predators' . The LAPE project is of particular relevance to transboundary living resources in that it focuses on an ecosystem approach to management of pelagic fisheries, particularly the large migratory pelagics.

A strategy for establishing a management regime for large pelagic fishes in the WCR was developed for CARICOM by Mahon and McConney (2004). The approach involved two thrusts, addressing each group of large pelagics: oceanic and coastal. For oceanic species, the need for and modes of direct involvement in ICCAT were identified and explored. For coastal large pelagic species, largely within the western central Atlantic, the need for a regional arrangement emerged. This was seen as possibly being a subsidiary of ICCAT or a separate entity with close collaboration if ICCAT is willing to delegate its responsibility for coastal species.

5.3. Continental Shelf Ecosystem

5.3.1. <u>Introduction to the Continental Shelf Ecosystem</u>

The shrimp resources in the NBSLME support one of the most important export oriented shrimp fisheries in the world. These resources include four of the larger penaeids (southern brown shrimp *Farfantepenaeus subtilis,* pink spotted shrimp *F. brasiliensis,* southern pink shrimp *F. notialis* and southern white shrimp *Litopenaeus schmitti*) and the smaller seabob shrimp (*Xiphopenaeus kroyeri*), with their general distribution and abundance differing markedly among the countries in the region. In general, the brown shrimp, *F. subtilis*, is more abundant in the eastern (Brazil through Suriname) than in the western (Guyana through Venezuela) regions of the shelf, while the pink spotted shrimp, *F. brasiliensis*, is far more important in Guyana and Suriname than in the remaining countries. The species is not caught in the Brazilian fishery and usually very large individuals are caught off the Venezuelan coast, but the species is secondary to *F. subtilis* in the inshore areas of the Gulf of Paria (Ehrhardt, 2001).

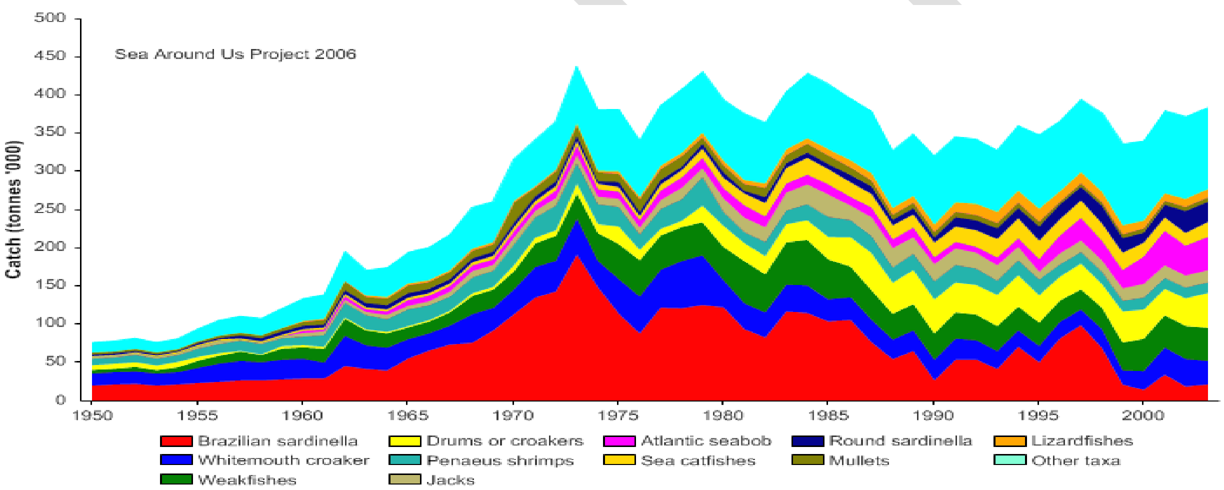


Figure 17. Annual fish landings in the North Brazil Shelf LME (Sea Around Us 2006)

The groundfish resources such as red snapper (*Lutjanus purpureus*), weakfish (*Cynoscion sp*.), whitemouth croaker or corvina (*Micropogonias furnieri*) and sea catfish (*Arius sp*.) in the Continental Shelf Fishery Ecosystem are important for commercial and social reasons, with the red snapper probably being the most important groundfish in the region because of its wide distribution range and export value. The fisheries are multigear, multispecies and multinational, using fishing methods that can be classified as industrial or artisanal depending on the level of mechanization (Booth *et al*, 2001). Sardine (*Sardinella sp*.) and tuna are also exploited, and although the volume of the tuna catch is relatively small, the value is significant (Heileman, 2008).

A high catch percentage of coastal and pelagic fishes, as well as catches of herrings, sardines and anchovies are caught in Brazil. However, information on the exploitation of Brazilian fish stocks is unavailable for all areas and species[38]. The pelagic resources are lightly exploited in Guyana, mainly as incidental catch by artisanal fishermen using various fishing gear, but there is a directed fishery for sharks[39]. The artisanal multigear fleet of Trinidad and Tobago target demersal or pelagic species, with the pelagic species being caught includingmackerels (*Scomberomorus brasiliensis, S. cavalla*), and the non-target species including a diversity of small coastal pelagics (*Selene vomer, S. spixii, Oligoplites saurus, Caranx hippos, C. crysos*) and demersal species. They also catch sharks (*Sphyrna tudes, Rhizoprionodon lalandii, Carcharhinus porosus, C. limbatus*)[40].

The total annual fish landings in this area showed a steady increase to 438,000 tonnes in 1973, following which they were relatively stable for about a decade, declined slightly, and then stabilised (Figure 17). The value of the annual landings peaked at over 900 million US$ in 1986 (Figure 18). Brazil followed by Venezuela, Guyana and Suriname, account for most of the catch from this area.

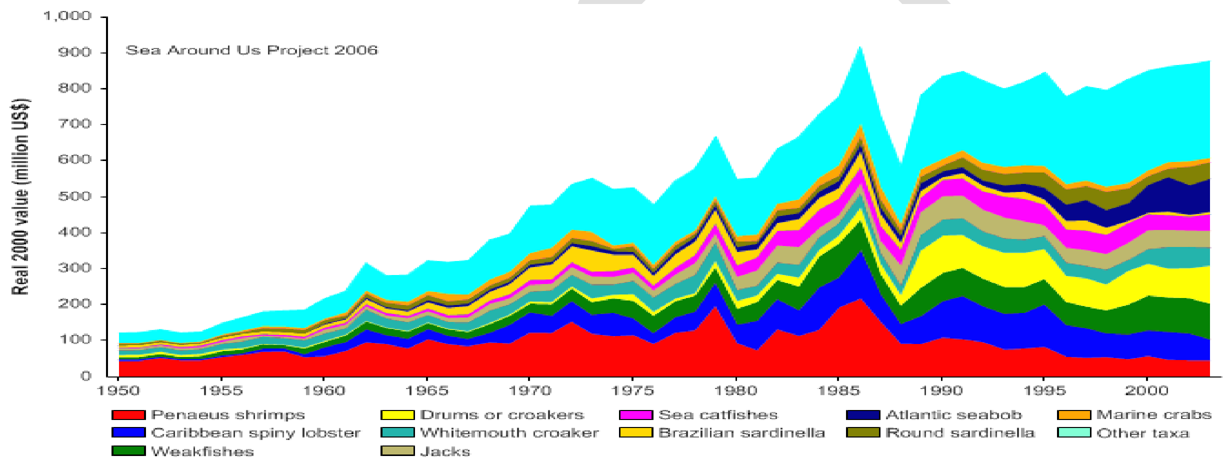


Figure 18. Value of fish landings in the North Brazil Shelf LME (Sea Around Us 2006)

Between 1983 and 2003, the Marine Trophic Index showed a slightly increasing trend (Figure 20 top), while the Fishing in Balance Index remained relatively constant (Figure 20 bottom). These trends reflect the targeting of higher trophic level species and stable catches over this period, and suggest some degree of fisheries sustainability (Heileman, 2008).

38 (http://www.eoearth.org/article/North_Brazil_Shelf_large_marine_ecosystem#gen2)

39 (http://www.fao.org/fishery/countrysector/FI-CP_GY/en)

40 (http://www.caricom-fisheries.com/LinkClick.aspx?fileticket=7%2B1B5CpxGDw%3D&tabid=86).

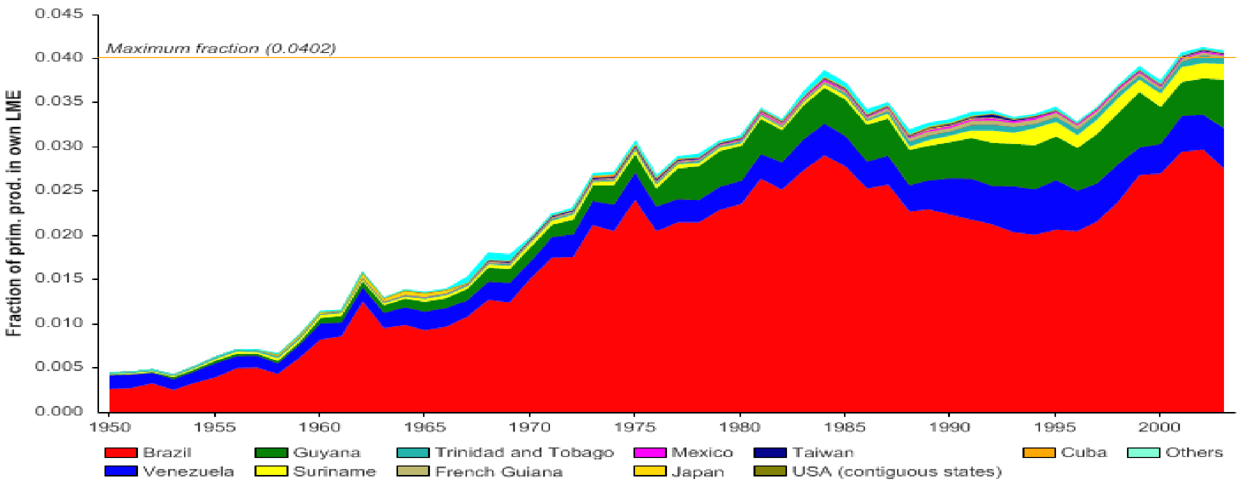


Figure 19. Primary production required by the catches by countries in the North Brazil shelf LME (Sea Around Us 2006)

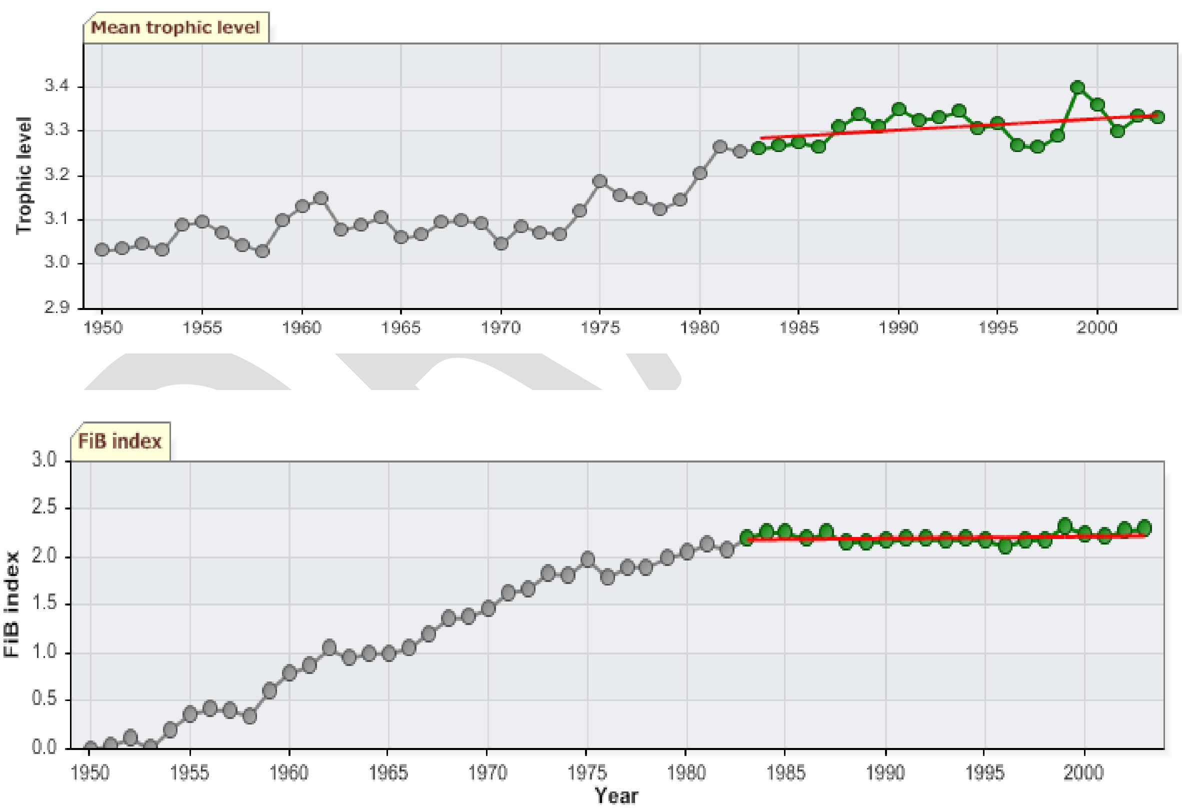


Figure 20. Marine Trophic Index (top) and Fishing in Balance Index (bottom) in the North Brazil Shelf LME (Sea Around Us 2006)

5.3.2. Services provided by coastal ecosystems in the Continental Shelf Fishery Ecosystem

ECOSYSTEMS	ECOSYSTEM SERVICES			
	Provisioning	**Regulating**	**Cultural**	**Supporting**
Mangroves	• Food (fish and shellfish stocks) • Fuelwood • Construction material	• Stabilization of coastlines (buffer between land and sea) • Protection of adjacent coral reefs from suspended solids, pollutants and drastic changes in salinity due to inflow of freshwater • Removal of contaminants from surface inflows • Nutrient retention and removal • Protection from erosion and storm surges	• Recreational and tourism value • Knowledge systems educational value	• Habitats for a wide array of terrestrial and aquatic species • Feeding, nursery and breeding areas for fish and other species • Carbon sequestration (blue carbon) • Nutrients to other ecosystems such as coral reefs and seagrass beds
Seagrass beds	• Fish and shellfish	• Settlement and binding of suspended sediments and encouragement of accretion • Nutrient cycling • Reduction of wave energy	Recreational and tourism value Knowledge systems educational value	• Habitats for a wide array of aquatic species • Nursery and feeding areas and shelter for fish and crustaceans • Detritus to reef system • Food (detritus) to offshore habitats • Beach sand (from calcareous skeletons of organisms (e.g. molluscs, crustaceans, calcareous algae)

ECOSYSTEMS	ECOSYSTEM SERVICES (Cont')			
	Provisioning	**Regulating**	**Cultural**	**Supporting**
Coral reefs	• Food (fish and shellfish) • Ornamental fish and corals • Material such as seashells for use in handicraft • Construction material • Natural medicines and pharmaceutical products • Genetic resources	• Hydrodynamic barrier to wave energy (protection of shorelines from erosion, storms)	• Recreational and tourism value • Knowledge systems and educational value • Spiritual and inspirational value	• Habitat for fish and shellfish • Material for the formation and maintenance of sandy beaches
Beaches	• Construction material • Base for small-scale fisheries, tourism and recreational activities		• Recreational and tourism value • Knowledge systems • Educational value	• Habitats and nesting sites for fauna such as sea turtles • Coastline protection • Stabilization of sediments

5.3.3. Description of shrimp fisheries in Jamaica, Panama, Nicaragua and Belize

Even though this TDA focuses mainly on the transboundary issues - unsustainable fishing, habitat degradation and pollution- affecting the important shrimp and groundfish fisheries within the NBSLME, it should be noted that there are other shrimp and groundfish fisheries within the CLME such as in the waters of Jamaica, Panama, Nicaragua and Belize which may be facing similar problems.

In Jamaica, the open access penaeid shrimp fisheries occur mainly in the Kingston Harbour, with the predominant species being the white shrimp *Penaeus schmitti*, while *P. notialis* and *P. brasiliensis* are also present in very low proportions. The white shrimp are exploited by fishers in wooden canoes using mono-filament nylon gill nets and others in fibre glass boats that use hand operated trawls. In 1999, the estimated landings were 4.5 tonnes. Combined assessments for the period 1996-2000 showed that there was no evidence that the fishery was over-exploited, with the recommendation that any further expansion of fishing effort should be cautiously implemented.

In Panama, production in the white shrimp fishery has fluctuated between 906 to 1529 tonnes, with the increase in fishing vessels, the use of illegal fishing gear in nursery areas and the destruction of mangroves for coastal aquaculture being given as likely reasons for falling catches. The MSY for the white shrimp fishery has been estimated between 4 and 5 million pounds of shrimp tails, corresponding to 200 vessels.

In Nicaragua, Pearl Lagoon, one of the biggest lagoons in the Caribbean and the biggest in Central America, is the home of the most abundant penaeid shrimp *(Litopenaeus schmitti)* fishery in the lagoon environment. . In 2004, the capture of shrimp tails and total shrimps from the Caribbean region was 3,127, 000 and 776,000 pounds, which showed a reduction of 17% and 19% with respect to 2003 when the capture was 4,274,000 and 997, 000 pounds.

In Belize, the industrial shrimp trawl fishery has been an important fishery over the last six decades, with shrimp tails landings reaching a peak of over 145 MT in the late 1980s. The fishery valued at Bze $948 thousand in 2004 was considered to be significant to the two main fishermen's cooperatives[41]. However, it should be noted that it was reported on December 8, 2010 that the authorities in Belize would be placing a ban on all forms of trawling in their waters due to the risk that such activities could pose to the health of the Belize Barrier Reef. The ban should have gone into effect from December 31, 2010.[42]

5.3.4. Analysis of the current issues situation

The shrimp resources in the Continental Shelf Fishery Ecosystem support one of the most important export oriented shrimp fisheries in the world while the groundfish resources are important for commercial and social reasons, with the red snapper being probably the most important groundfish in the region because of its wide distribution range and export value. In general, all the shrimp species in the region are subjected to increasing trends in fishing mortality and the fisheries are generally overcapitalized. Despite the relatively stable catches, overexploitation was found to be severe, with there being evidence that some of the groundfish fisheries in this area may be fully or overexploited (Heileman, 2008).

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41 (http://www.fao.org/fishery/countrysector/FI-CP_BZ/en)

42 (http://na.oceana.org/en/blog/2010/12/victory-belize-bans-trawling).

Overall, pollution was found to be moderate, but severe in localised hotspots near urban areas. Most of the pollution is concentrated in densely populated and industrialised coastal basins and not widespread across the region. Water quality in the coastal areas is threatened by human activities that give rise to contamination from sewage and other organic material, agrochemicals, industrial effluents, solid wastes and suspended solids (Heileman, 2008). Due to the coastal hydrodynamics in this area, the potential for transboundary pollution impact is significant (Charlier, 2001; Heileman, 2008). Human activities along the coastlands have led to severe habitat modification in this Continental Shelf Fishery Ecosystem, with mangroves, which dominate a major part of the shoreline, having been seriously depleted in some areas.

Unsustainable fishing of the shrimp and groundfish resources of the Continental Shelf Fishery Ecosystem could result in considerable socio-economic consequences as these fisheries make significant contributions to food security, poverty alleviation, foreign exchange earnings and the development of coastal communities.

5.3.4.1. Unsustainable fisheries

Despite the relatively stable catches, overexploitation was found to be severe, with there being evidence that some of the fisheries in this area may be fully or overexploited, particularly some of the groundfish stocks. In cases where assessments have been undertaken, there are clear signs of overexploitation of the southern red snapper (*Lutjanus purpureus*) resource; other analyses indicate that the corvina is now overexploited in some areas; and lane snappers (*L. synagris*), bangamary (*Macrodon ancylodon*) and sharks are also showing signs of overexploitation. A decrease in the average size of some groundfish species has raised sustainability issues. The increasing capture of small individuals is potentially compromising recruitment to the spawning stock. Some deep slope demersal and pelagic species are underexploited and still have potential for development (Heileman, 2008).

In general, all the shrimp species in the region are subjected to increasing trends in fishing mortality and the fishery is generally overcapitalized. Stocks of brown and pink spotted shrimp may be close to being fully exploited, with the latter being overexploited in some areas. There has been a general downward trend in the abundance of brown and pink shrimps, particularly during the late 1980s and throughout the 1990s.

Excessive by-catch and discards and destructive fishing practices are severe, and are of concern throughout the area, with the shrimp by-catch situation being well know for the region (Heileman, 2008).

Although, the information on the status of the coastal pelagic fish being caught directly or indirectly in this Continental Shelf Fishery Ecosystem appears to be limited, it should be noted that Trinidad and Tobago considers the pelagic fish being targeted by the artisanal fleet to be fully exploited and in many cases overexploited.[43]

Sea turtles occurring in the area include the leatherback (*Dermochelys coriacea*), green turtle (*Chelonia mydas*), olive ridley (*Lepidochelys olivacea*), hawksbill (*Eretmochelys imbricata*) and loggerhead (*Caretta caretta*). At the regional level, the leatherback colony in the Guianas was considered to be very volatile, but presently appears to be stable.

Most uses of sea turtles, whether consumptive or non-consumptive, are regulated and/or monitored in some way. The offshore drowning of sea turtles associated with incidental

[43] (http://www.fao.org/fishery/countrysector/FI-CP_TT/en).

capture by fisheries, especially by shrimp trawlers in the Continental Shelf Fishery Ecosystem, posed a serious management issue. This is being addressed by the nets of such trawlers having to be outfitted with turtle excluder devices (TEDs), more so if the operators are exporting their product to the USA. Because of the potential threat of incidental capture by fishing gear in offshore waters, sea turtles should be included in any regional and national fisheries management plans.

IUU fishing poses one of the biggest threats to fisheries management for developing states, with the problem being compounded by a number of factors, such as the large area of marine space to be policed, close proximity of the states leading to situations of stocks straddling the borders of neighbouring states, migratory nature of some fisheries resources and the fishing fleets that follow them, inadequate financial and technical resources for surveillance and enforcement, and insufficient skilled manpower for maintaining adequate management systems (CRFM, 2005).

The key transboundary impact identified associated with unsustainable fishery practices includes:

- Overexploitation of the shrimp and groundfish stocks in the NBSLME with inadequate fisheries management could adversely affect income, employment, food supply, and foreign exchange earnings in the countries of the region.
- Excessive by-catch and destructive fishing practices could result in reduced fish populations of non-target species as well as affect biodiversity.
- IUU fishing could lead to major losses in revenue in an area where dependency on fisheries for food, livelihoods and revenues is high.

5.3.4.2. Habitat degradation

Human activities along the coastlands have led to severe habitat modification in the NBSLME area. Mangroves, which dominate a major part of the shoreline, have been seriously depleted in some areas. For example, in Guyana, mangrove swamps have been drained and replaced by a complex coastal protection system, while on the Brazilian coast, there has been significant reduction in the original mangrove area because of cutting for charcoal production and timber, evaporation of ponds for salt, and draining and filling for agricultural, industrial or residential uses, and the development of tourist facilities. In Brazil, erosion also threatens coastal habitats and some coastal lagoons have been cut off from the sea (Heileman, 2008).

At present, the tropical forests of the NBSLME region would appear to be relatively unexploited and face few threats. In the future, increases in the impact of large scale logging, artisanal and industrial gold mining, agricultural operations and the growing populations in some of the forested areas may to lead to environmental degradation.

Trawlers often operate without restriction in the shallower areas of the shelf, over ecologically sensitive areas inhabited by shrimp in its early life stages. The environmental impact of such activities is likely to be high, considering the intensity of shrimp trawling operations in these areas. Evidence from other regions suggests that precautionary measures should be undertaken in environmentally sensitive areas of the continental shelf. Trawlers also catch significant quantities of finfish as by-catch and dumping at sea is still a widespread practice in the region.

Invasive alien species are increasingly being viewed as a threat to indigenous biodiversity because of their impact on natural habitats and ecosystems. Little is known about marine invasive species compared to terrestrial species. However, the ballast water from ships is considered to be a major invasion pathway.

The issue of invasive species as an environmental and sustainable development threat has been recognised by a number of treaties, including the Convention on Biological Diversity (CBD) and the Specially Protected Areas and Wildlife (SPAW) Protocol. In 2004, the International Convention for the Control and Management of Ships Ballast Water and Sediments was adopted to control and manage the release of ballast water by ships in order to reduce the threat of IAS in waters near ballast water release sites. The Convention is awaiting ratification (Lopez and Krauss, 2006).

The key transboundary impact identified associated with habitat degradation includes:

- In this region, there are clear indications that the entire shallow, brackish-water stretch along the seashore (0-10 m depth) plays a key role in the mobilization of nutrients and energy transfer in the lower levels of trophic webs, and serves as nursery ground for many marine fish and shrimp species.

  The existence and capacity of this near-coastal zone to fulfil its role is highly dependent on inputs from the neighbouring mangrove and associated habitats. The mangrove is very well represented in the region, where it dominates a major part of the shore, but it is possible that not all portions of the coast would have the same importance, as some processes may be concentrated in certain areas, possibly in estuaries.

  Fishing gears can alter, in a more or less persistent way, the habitats of fish populations. It is not generally known what the different species exactly require in order to complete successfully the different steps of their life cycle. It is known that habitats have to fulfil different functions such as providing shelter (hiding from predators), foraging area for food, breeding area, and nursery area. The capacity to fulfil one or more of these functions can be impaired by damage provoked by fishing gear action, with the damage being on the seabed, the benthos, or on the water quality (Charlier, 2001).

  The continued degradation of "critical" zones or habitats and the unsustainable exploitation of fisheries and other living resources in the region could lead to unemployment and reduced incomes and consequent deterioration in the quality of life in coastal communities.

5.3.4.3. Pollution

Overall, pollution was found to be moderate, but severe in localised hotspots near urban areas. Most of the pollution is concentrated in densely populated and industrialised coastal basins and not widespread across the region. Water quality in the coastal areas is threatened by human activities that give rise to contamination from sewage and other organic material, agrochemicals, industrial effluents, solid wastes and suspended solids (Heileman, 2008).

Effluents from industries are released, sometimes untreated, into the water bodies. Contamination by mercury as well as by agro-chemical wastes is the main source of chemical pollution in the Amazon Basin. Gold is exploited in all the countries of the region and mercury from mainly artisanal and small scale gold mining operations is dispersed into the air. For the most part, this mercury ends up in rivers, transforms into methyl-mercury and other chemical compounds and concentrates along the food chain. In the long term, mercury contamination could become a hazard for the coastal marine ecosystem and for human health if suitable measures to limit its use are not implemented. There is also the potential risk of pollution from oil extraction, both in the coastal plain and the sea.

Agricultural development is concentrated along the coast and includes intensive cultivation of sugarcane, bananas and other crops. This involves the application of large quantities of fertilisers and pesticides, which eventually end up in the coastal environment. Sugarcane plantations along the coast are also suspected to contribute persistent organic contaminants, which are widely used in pest control, to the coastal habitats (Heileman, 2008 and LME 17: North Brazil; Shelf.).

As a result of the coastal hydrodynamics in this area, the potential for transboundary pollution impact is significant.

The key transboundary impact identified associated with pollution and ecosystem health includes:

- Agriculture is very important to many economies in the region. It can have a direct impact on the marine environment when it involves areas included in the "broader marine ecosystem" (including brackish zones connected with the sea). Such areas are generally not suitable for agriculture, due to their salt content. For example, Suriname has a policy that does not allow agricultural projects within a certain distance from the coastline for technical and environmental reasons. Exceptions have been tolerated and there have been encroachments on the mangrove and associated brackish-water biota, for rice (as well as in French Guiana) and livestock development, but the areas concerned seem to remain modest.

  Agricultural development is very modest in terms of area used. On the other hand, farmed areas are concentrated in a coastal stretch of a few tens of kilometres breadth, the cultures are water-intensive (rice) as well as agrochemicals-intensive (sugar cane, bananas), and the drainage is directly to the sea, without treatment or monitoring of the effluents. Local effects could therefore be observed, particularly if input of an additional nutrient charge from agriculture would combine, for example, with re-suspension of organic matter trapped in sediment.

  Areas within the coastal brackish-water belt have been identified as suitable for aquaculture, particularly for marine shrimp, and a few projects have been undertaken in Suriname. These projects did not cover any significant part of the available area (Charlier, 2001). However, aquaculture seems to have been identified as a major area for development by most of the countries bordering the Continental Shelf Fishery Ecosystem and as such more coastal areas, including the brackish-water belt, could be affected in the future.

  Effluents carrying chemicals used in agriculture or residues can also be expected to have impacts if they are drained in sufficient concentration to the sea. They can be pesticides, deleterious for some marine organisms, or fertilizers that may alter the nutrient balance in the sea (Charlier, 2001).

- Gold is being exploited by mainly small-scale operations in all countries of the region. The main technology used to separate and amalgamate gold is the least expensive available and involves the application of mercury. This mercury is dispersed into the air and it is assumed that the largest part ends up in rivers, transforms into methyl-mercury and other chemical compounds, and concentrates along the food chain. According to the IUCN, high concentrations of mercury were detected in fish as far as 800 km downstream from gold mining areas in Brazil.

Larger scale gold mines also present in the region use cyanide to separate gold. Errors can have disastrous consequences for aquatic life, as happened in 1995 in Guyana with the accidental release of cyanide into the Omai and Essequibo rivers (Charlier, 2001).

The value of fisheries products could decrease due to contamination by mercury and cyanide from artisanal and large-scale gold mining respectively and pesticides and other chemicals from agriculture. Also, the occurrence of mercury in fish species and the environment could pose problems for human health.

5.3.5. Governance in the Continental Shelf Fisheries Ecosystem

The fragmented nature of coastal and marine resource management by these countries is a legacy of their colonial past. The languages and cultures of the colonizers (Portugal, France, the Netherlands, Great Britain and Spain) were each different, as were the management systems and laws they passed on to these territories, five of which are now independent democracies. These countries are party to several international environmental agreements, for example CBD, UNFCCC, UNCLOS, MARPOL and Ramsar Convention on Wetlands. However, there is presently a lack of coordinated support among them for marine ecosystem monitoring and management.

The coming into force of the UNCLOS and recent international initiatives in fisheries, such as Agreement to Promote Compliance of International Conservation and Management Measures by Fishery Vessels on the High Seas (Compliance Agreement), The Code of Conduct for Responsible Fisheries and the Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement) have made it necessary for the countries of the Guianas-Brazil Subregion to revise their legislation. French Guiana as an overseas department of France is covered by the Common Fisheries Policy of the European Union, which came into effect in January 1983.

For the countries of the Guianas–Brazil sub-region, fisheries administration is under the Ministry of Agriculture in all the countries except Brazil, where the responsibility is shared between the Ministry of Agriculture, responsible for development, issuing of licenses and for the economic aspects, and IBAMA (Instituto Brasiliero do Meio Ambiente e dos Recursos Naturais Renovaveis), responsible for conservation and management and for enforcement. In most countries fisheries research is also conducted by the national fisheries administration, which is under the Ministry of Agriculture. Brazil and Venezuela have delegated fisheries research to specialised agencies.

Regional and sub-regional organizations such as the FAO/WECAFC and CRFM have been actively promoting fisheries management and development related to the continental shelf fisheries ecosystem. The Member States of FAO/WECAFC include Brazil, French Guiana (EU/France), Suriname, Guyana, Venezuela and Trinidad and Tobago, while those of the CRFM include Suriname, Guyana and Trinidad and Tobago. As they seek to address the key transboundary living marine resource issues for this ecosystem, the countries may need to strengthen and/or develop mechanisms for subregional collaboration and cooperation in areas such as assessment and management; harmonization of legislation; development of a sub-regional database for fisheries and related data; establishment of mechanisms for strengthening MCS at the national and sub-regional levels; stakeholders' involvement in the management process; and building public awareness.

5.4. Knowledge gaps in the CLME Fisheries Ecosystems

5.4.1. Unsustainable fisheries

- Basic data and information about fish stocks are required for reliable stock assessment and management.
- Move towards an ecosystems approach to living marine resources management would require more data/information on the continental shelf, living resources and the socio-economics .
- More data/infomration on the response of the WCR ecosystems and fish populations to global climate change.
- Knowledge on the connectivity among habitats, dispersal of larvae, patterns of movement during the juvenile and adult phases.
- Knowledge of the sustainable levels of total catch and corresponding fishing effort levels (including artisanal and industrial) for exploited stocks and stock for which fisheries are developing.
- Need to improve the quality of data/information as it relates to fishing capacity, including processing infrastructure, operating in the NBSLME shrimp fishery and on the intensity and effects of near shore fishing by shrimp trawlers.
- Need to determine the possible links between recruitment and environment and its likely effects on the fishery.
- Bio-economic assessments are required as previous work had shown that the current levels of exploitation were above the economic minimum, suggesting that potential revenue was being dissipated.
- Need to evaluate the effectiveness of the management tools, such as effort control, closed areas and closed seasons being used in the shrimp fisheries to determine how they can be improved. (FAO/WECAFC, 2001).
- With the scope of the TDA having been changed to cover the continental shelf ecosystem, more information is required on the status of the coastal pelagic and shark fisheries and the likely interactions between these resources and the main demersal resources.
- More data/information onthe extent of IUU fishing in the Continental Shelf Fishery Ecosystem and its impact on the assessment of the resources, management and economic returns.

5.4.2. Habitat degradation

- Ecosystem structure and function, and inventory of marine species;
- Spatial extent and distribution of habitats (habitat mapping);

- Economic value of coastal and marine ecosystems and services. Focus should be on the marginal economic value, which would allow economic changes associated with changes in ecosystems to be determined;
- Social and economic cost of degradation (including the cost of addressing habitat degradation);
- The degree of connectivity and interdependence among the habitats within the CLME as a whole; and connectivity with other areas of biological importance and with protected areas;
- Thresholds at which damage to habitats are irreversible;
- Additional knowledge of the role that the entire shallow, brackish-water stretch along the seashore (0-10 m depth) plays in the mobilization of nutrients and energy transfer in the lower levels of trophic webs, and providing nursery grounds for many marine fish and shrimp species.

5.4.3. Pollution

- Quantitative data on the transboundary dispersal of pollutants.
- Regular and long-term monitoring of pollution in the WCR, both at the source and in the coastal and marine environment, including areas that may be affected far from the source.
- Impacts of pollution on sensitive habitats, on living marine resources, and on human health.
- Establishment of clear targets and indicators, to for establishing a baseline and assessing progress in addressing transboundary issues .
- Establishment of indicators to measure economic losses caused by pollution on fisheries, the tourism industry, and other economic activities.
- Improving the understanding of agricultural impacts on the CLME ecosystems.
- Improving the understanding of agricultural, industry (including shipping and tourism) and municipal discharges on the CLME fisheries ecosystems

5.5. Common and cross-cutting issues affecting the CLME fisheries ecosystems

The three identified fisheries ecosystems are all highly linked physically and biologically dependent on each other with respect to living resources. Whilst this TDA is focused on the issues associated with each fisheries ecosystems (and the subsequent SAP will address the issues of concern in each fisheries ecosystem) it is clear that there are common and shared concerns. In addition the, three priority transboundary issues are also interlinked – the problem of pollution clearly has an impact on fisheries and habitats in the region, for example. Climate change will impact all fisheries ecosystem and are likely to exacerbate the three key transboundary issues. This section attempts to provide a synthesis of the common and cross-cutting issues affecting the CLME region.

5.5.1. Synthesis of common issues

5.5.1.1. Unsustainable fisheries

The transboundary issue of unsustainable fisheries applies to all three fisheries with considerable similarity in the causes. There is significant evidence that overfishing or fishing close to MSY is impacting stock levels as reflected in declining landings. IUU is a regional problem where monitoring and enforcement of fisheries regulations are poorly managed, especially in the pelagic fisheries where the increased costs and complexity of monitoring vessels in the EEZ are experienced. In addition, vessels under flags of convenience increase the difficulties in management of fisheries. Bycatch is a common concern in all the ecosystem fisheries.

Data on fisheries (catch, stock levels, IUU, etc.) is limited in all three fisheries and is an important aspect to be addressed under the SAP.

The common environmental and socio-economic impacts from unsustainable fisheries include:

- Loss of trade / foreign exchange earnings
- Loss of employment
- Food scarcity
- Erosion of livelihoods
- Loss of tourism
- Reduce stock
- Changes in trophic structure

5.5.1.2. Habitat degradation

The CLME fisheries are dependent to a large extent on the health of the specific ecosystems. There are common concerns leading to habitat degradation across the fisheries ecosystems, e.g. shipping (and ship pollution), alien/exotic species introduction, climate change (acidification, increase storm damage, temperature increases, pollution from land-based sources, etc). Coastal habitats within the reef and continental shelf ecosystems are subject to impacts from destructive fishing methods, coastal development, mining, watershed and marine pollution, etc.

The loss of reefs and mangroves (for example) are potentially very significant given the important ‘services’ these provide, for example, in providing food and coastal defenses. Coastal environments are also impacted from increasing sediment loads (for example from inappropriate land use in river basins, including forest clearance and agriculture) that can result in increased turbidity or choking of sensitive reef environments. Due to their proximity to the land-based activities and sources (e.g. wastewater, industry, mining, agriculture, etc.) pollution can be more significant with regards to habitat degradation (e.g. through eutrophic conditions) within the reef and continental shelf ecosystems. The pelagic system is also subject to rising SST and ocean acidification as well as pollution from both marine and land-based sources.

The common environmental and socio-economic impacts from habitat degradation include:

- Loss of tourism
- Loss of productive habitats
- Conflicts between 'users'
- Loss of livelihoods

5.5.1.3. *Pollution*

As indicated above, pollution affects all three fisheries ecosystems with coastal environments being potentially more impacted, although all ecosystems are subjected to marine discharges. Land-based sources (from tourism activities, wastewater, industry, agriculture, forestry, mining, oil exploration, etc.) leads to localized and dispersed pollution from nutrients, micro-biological species, POPs, hydrocarbons, heavy metals and other toxic substances. Soil erosion from forest clearances or agriculture can lead to greater sediment loads being discharged from the rivers to the CLME region. In addition to the habitat degradation concerns indicated above, sediments can have associated pollutants which can be slowly released. A global problem from land-based sources containing nutrients (e.g. from wastewater and agriculture) is eutrophication that result in oxygen depletion affecting mainly coastal areas that can further impact sensitive habitats. Land-based sources in the Caribbean are the subject of the GEF IWCAM project and are under the Cartagena Convention protocol which has recently come in to force. The SAP should further encourage endorsement and enforcement of this convention within the CLME region. In all fisheries ecosystems, bio-accumulation of hazardous substances (e.g. POPs, heavy metals such as mercury) is also a concern to human and aquatic life.

The common environmental and socio-economic impacts from pollution include:

- Loss of habitat
- Potential health issues from contaminated food
- Deterioration of environmental health
- Threats to marine resources

5.5.2. Cross-cutting issues

5.5.2.1. *Climate Change*

The implications of climate change for fisheries are steadily becoming better elaborated and the types of governance responses that will be required better understood. According to Cheung et al (2009) the WCR is likely to experience reduced abundance of fishery resources. Many other impacts on the marine ecosystems of the WCR are predicted. A key message is that marine EBM has to address additional uncertainty from climate change in both the system being governed and the governance systems. Case studies by McIlgorm et al (2010) indicate that governance adaptation will involve more flexible fishery management regimes, schemes for capacity adjustment, catch limitation and alternative fishing livelihoods for fishers. Where fishery governance systems have been less developed, fisheries will be less able to adapt to climate change impacts. Badjeck et al (2010) emphasise the importance of adaptive capacity for fishery livelihoods and the need for approaches that build livelihoods assets and reduce vulnerability. Adaptation involves addressing some of the most intractable issues that fisheries management has been grappling with for decades.

Just as EBM is considered to be an integral part of, or context for, governance arrangements and responses in all three major marine ecosystems in the WCR, climate change must be integrate in all three cases. Indeed, the FAO considers climate change to be one of many aspects that must be taken up in its Ecosystem Approach to Fisheries.

Trends in mean SST and SST anomalies for the CLME show a steady warming trend since 1982 (Figure 21; Belkin et al 2009).

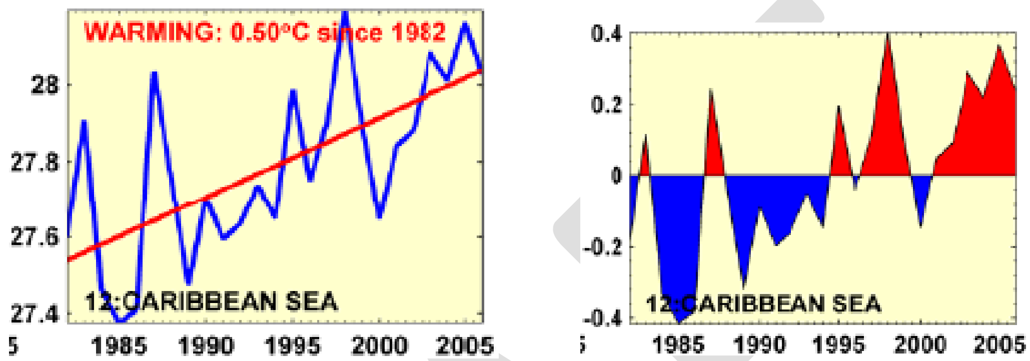


Figure 21. SST anomalies and mean annual SST for the CLME 1982 – 2006

Rising sea water temperatures may have a large impact on the distribution of maximum catch potential (a proxy for potential fisheries productivity) of pelagic and demersal species by 2055 (Cheung et al 2009). Such a redistribution of catch potential is driven by projected shifts in species' distribution ranges and by the change in total primary production within the species' exploited ranges. The catch potential in the CLME decreases considerably under the high range scenario (Figure 22).

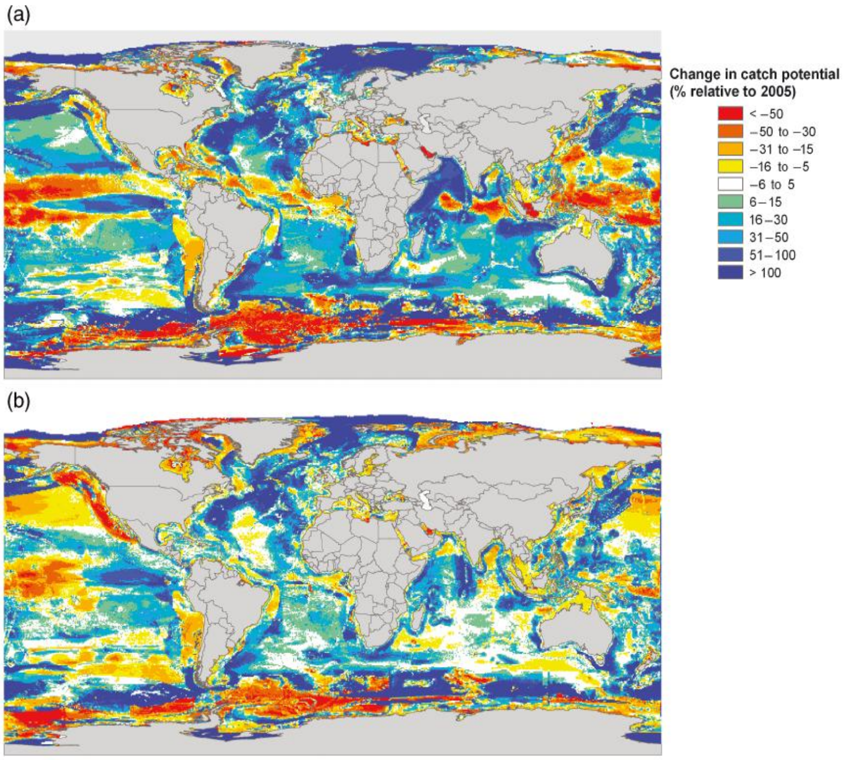


Figure 22. Change in maximum catch potential (10-year average) from 2005 to 2055 under two climate change scenarios

(a) High range (b) Low range. (Cheung et al 2009)

However, changes in availability to the local fishing fleet are more likely to occur than are large scale changes in abundance (Mahon 2002). Ocean currents are also related to upwelling that enhances nutrient enrichment and hence primary and secondary production that may support fish stocks. In the Caribbean, upwelling areas off the Guianas-Brazil Shelf, downstream of island passages, and off Venezuela are known to influence fishery production and may also be affected by climate change (Mahon 2002).

Coral bleaching is set to become one of the most serious and widespread threats to the region’s reefs. The most extreme coral bleaching and mortality event to hit the Wider Caribbean (including Atlantic) coral reefs in 2005 has been documented by Wilkinson and Souter (2008) and clearly illustrates the severe impact that climate change could have on the region’s reefs. In some areas up to 100% of corals have been affected by bleaching.

Increased prevalence of disease following bleaching was also reported from many islands of the Lesser Antilles, particularly the French West Indies. Further, hurricanes in 2005 exacerbated the damage to coral reefs caused by bleaching and disease, although the effects were not all bad. Some hurricanes reduced thermal stress by mixing deeper cooler waters into surface waters. None of these hurricanes, however, passed through the Lesser Antilles to cool the waters, where the largest sea surface temperatures hotspot persisted.

In addition to bleaching, corals and other organisms with calcareous structures are subjected to increasing stress from ocean acidification resulting from rising atmospheric carbon dioxide concentrations. A recent study (UNEP- CAR/RCU 2011) confirmed significant ocean acidification across much of the Caribbean and Gulf of Mexico. Among the impacts of ocean acidification is impairment of the formation of the carbonate skeletons of organisms such as corals.

In addition to the impacts of global warming on coral reefs, an increase in the frequency and magnitude of storms and hurricanes as well as sea level rise are serious concerns for the region. These would increase the risk of flooding, including of mangrove habitats, and accelerate existing rates of beach erosion. Changes in rainfall patterns could also alter the flow of freshwater to coastal habitats that are dependent on inputs of freshwater and nutrients from terrestrial areas.

5.5.2.2. Governance

The conclusion reached in the assessment of regional ocean governance in the WCR during the PDF-B was that complexity, diversity and dynamics are major factors affecting arrangements for transboundary living marine resources. These may be more prominent in the WCR than in many other LMEs due largely to its geopolitical complexity. This results in there being large number of stakeholders at multiple geographical and institutional scale levels. Key transboundary issues requiring governance arrangements occur at a diversity of scales and thus require matching governance arrangements. Therefore it was concluded that an approach that sought to network the stakeholders in transparent arrangements that included clear governance process and linkages among them would be the best way to approach regional governance in the WCR. This approach was seen as providing for the need to have issue specific governance arrangements at appropriate scale levels but with opportunities for harmonisation and learning among arrangements. This approach can be best described as the enabling of a network or complex of ocean governance entities within the WCR.

6. Analysis of Root Causes of concerns and issues

The Global International Waters Assessment (GIWA) developed a priority setting mechanism for actions in international waters (Belausteguigoitia 2004). Establishing priorities for actions implies not only an assessment of the severity of the problems but also an analysis of what can be done to solve or mitigate these problems. Understanding the root causes of these problems is particularly relevant for the further analysis of actions. Causal Chain Analysis (CCA) traces the cause-effect pathways of a problem from the environmental and socioeconomic impacts back to its root causes. A causal chain is a series of statements that link the causes of a problem with its effects. Its purpose is to identify the most important causes of priority problems in international waters in order to target them by appropriate policy measures for remediation or mitigation. By understanding the linkages between issues affecting the transboundary aquatic environment and their causes, stakeholders and decision makers will be better placed to support sustainable and cost-effective interventions.

While the immediate and underlying causes of these impacts may be sector-specific, in certain cases, the priority interventions for addressing them simultaneously speak in many instances to common socio-economic, legal and political root causes. Given the multiple, long-term benefits which can be accomplished by focusing on the sources of these problems, as opposed to just their symptoms, the design and implementation of actions aimed at the sustainable management of these shared living marine resources through regional, LME-wide collaboration as proposed in the CLME Project is urgently required.

The preliminary CCAthat was undertaken in the PDF-B stage (2007) using three geographical sub-regions (Insular Caribbean, Central/South America and Guianas/Brazil), this was reviewed by the CLME TDA Technical Task Team in January 2010 in-line with the agreement to re-focus the TDA on the 'fisheries ecosystem' approach. Full details of the CCAs for reef, pelagic and continental shelf fishery ecosystems are presented in Annex 1. These figures were adapted from the causal chain diagrams in the GIWA Regional Assessments (UNEP, 2006).

The causes of the transboundary concerns will be addressed in more detail during the SAP formulation where appropriate means to address these causes will be developed and, where possible, tested through the pilot demonstration projects.

For each fisheries ecosystem (reef, pelagic and continental shelf ecosystems) a detailed CCA was developed for each of the three agreed transboundary issues (unsustainable fisheries, habitat degradation and pollution). Inevitably due to the obvious linkages between the three fisheries ecosystems and the intra-dependency of the three transboundary issues there is considerable overlap and/or repletion within the CCAs. The detailed fisheries ecosystem reports (see http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas) present comprehensive analysis and assessments of the CCAs for each transboundary issue (giving a total of nine CCA assessments – see Annex 1)

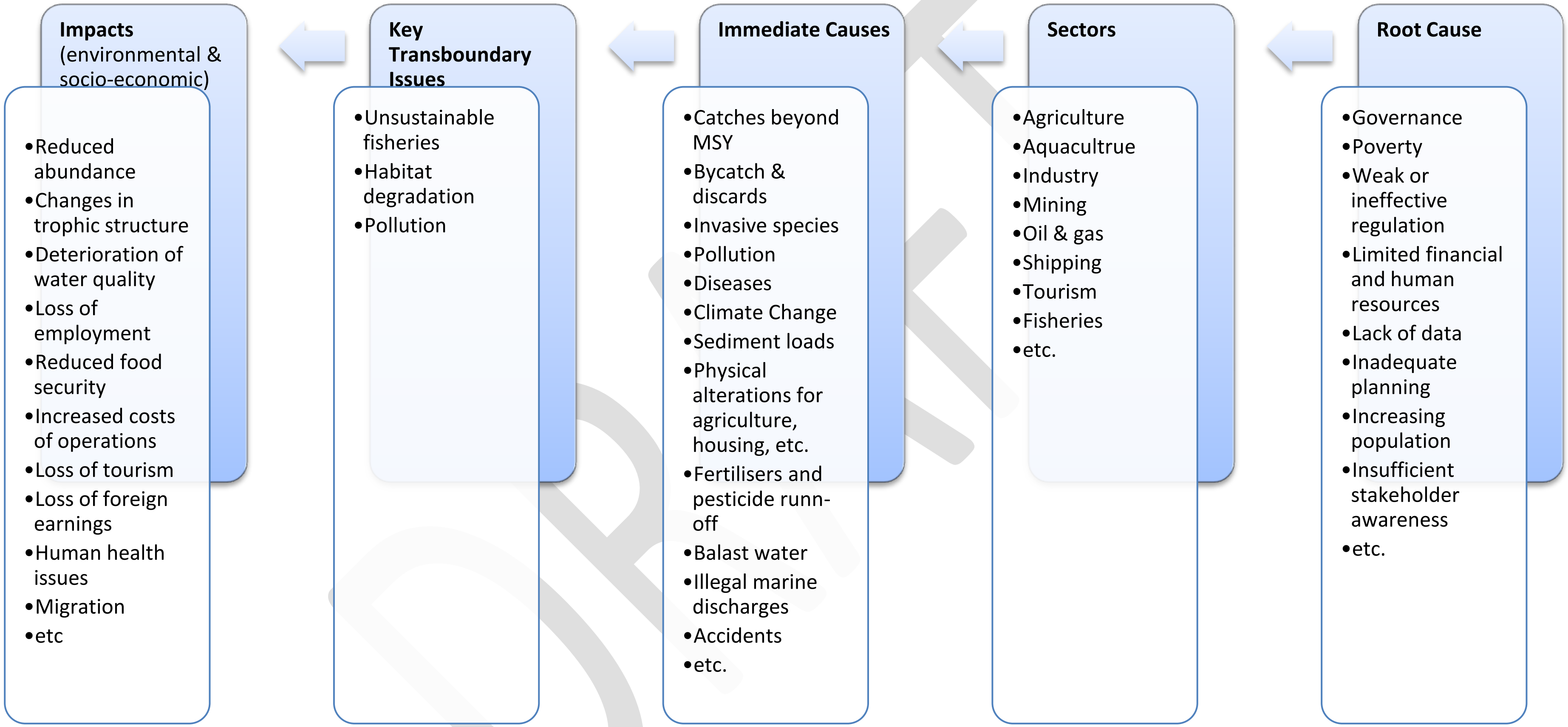
At this Regional TDA level a summary of the key elements of the CCA is presented (as an illustration) in Figure 23 with a summary of the main/common **Root Causes** from this analysis across all fishery ecosystems for each of the transboundary issues. This focus on the root causes will help to guide the development of the SAP by emphasizing the common or shared root causes (between both transboundary issues and fishery ecosystems) to ensure these receive priority attention. The recommended actions based on the CCA from each of the fishery ecosystems are presented in the next section.

The three fisheries ecosystems TDAs provide a detailed assessment of the CCAs for each Transboundary concern. While there are many commonalities in the root causes the priority associated with each fishery ecosystem and each transboundary concern do differ. It is also expected that the priority of the causes will also be different from each national perspective. This Regional TDA does not attempt to prioritise the concerns but presents a summary of the main causes associated with all the transboundary concerns.

Full details are of the CCA for each fishery ecosystem and each Transboundary concern are presented on the CLME Project website[44].

[44] http://www.clmeproject.org/documents/projectdocuments/fishery-ecosystems-tdas

Figure 23. Simplified Casual Chain Analysis for the CLME



The above is an indicative summary of all the main causes etc. from the three fisheries ecosystems and the three Transboundary problems. Full details are presented in the Fisheries Ecosystems TDAs

6.1. Key Transboundary Issue I: Unsustainable fisheries

The following summary presents the main root causes leading to the Transboundary issue of Unsustainable Fisheries. These are not presented in priority order.

- ***Poor Governance:*** Poor or inadequate governance is often cited as one of the root causes of fisheries overexploitation. Efforts have been made to protect and preserve the coastal and marine resources of the Caribbean Sea through a number of regional and international conventions and subsequent legislative frameworks. However, at the national level, the administration of the relevant legislation (where it exists) is often scattered across several governmental agencies with weak institutional provisions for the coordination of environmental initiatives across the various sectors. In most countries, stakeholder consultation and participation in governance remain fragmented and weak, despite efforts to address this problem and recognition of its potential role in effecting new and more successful ways of managing fisheries systems (Mahon et al 2008).

  These issues are even more pronounced at the regional level. Transboundary living marine resources require coordinated and harmonized governance structures that operate at the appropriate geographic scales. Reef, shrimp and groundfish fisheries are not currently served by a working international governance mechanism (such as ICCAT for the oceanic large pelagic fisheries), although specially protected reef associated species come under the SPAW Protocol. Relevant technical bodies at the regional level are WECAFC and in the case of conch, the Caribbean Fisheries Management Council. However neither have decision-making capacity, leaving it up to countries to follow agreed management procedures of not. At the sub-regional level CARICOM/CFRM, OECS/ESDU and OSPESCA/SICA also have programmes related to the assessment and management of specific resources. The latter organisation in particular has made significant progress in coordinating fisheries management in the Subregion. Some countries have difficulty taking part in these processes to the extent required for successful management.

  At the sub-regional levels, some measures are in place for harmonized management of shared resources (e.g. OSPESCA/SICA harmonized management plan for tunas and lobster in Central America; Caribbean Fisheries Management Council management of Atlantic highly migratory species). Large pelagic fisheries are currently served by a working international governance mechanism (ICCAT). However, Caribbean participation in ICCAT is weak, particularly by the small developing states (Mahon and McConney 2004). A problem with ICCAT is that it focuses on large pelagics that range ocean-wide and are important to commercial fleets. Many large pelagic species that are distributed mainly within the WCR and which support small-scale fisheries receive no attention at all. A regional mechanism for their management is needed (Mahon and McConney 2004)

  There is limited co-ordination, collaboration and harmonization among the numerous organisations and programmes in the WCR for management of transboundary living marine resources. This is clearly demonstrated in the regime for management of sea turtles, which shows enormous variation from country to country in the quality of management regimes, data collection, population monitoring and controls on exploitation (Bräutigam and Eckert 2006).

- ***Inadequate knowledge and low public awareness:*** There is general poor understanding of environmental concepts and low public awareness about the importance of marine ecosystems in providing essential ecosystem services and the economic value of these services, particularly the non-tangible services. Fish catches are still seen as disconnected from the marine ecosystems from which they come and there is low awareness about the finite nature of living marine resources. This is changing in the region, however, with an upsurge in environmental education and awareness programmes. These are necessary to change perceptions and attitudes towards conservation and environmental responsibility. This can be a cause of low political will as decision makers usually respond to the concerns of their constituents.

  While scientific knowledge is often available, it is usually poorly communicated to, and understood by policy-makers and the public. The uptake by policy makers is low and decisions are often based on other priorities.

- ***High dependence on fish for income and export earnings:*** Large pelagic resources are highly sought after for food, export and recreational fishing in WCR. Government policy in many countries is to expand fisheries as a means of generating jobs, income and foreign exchange, most often without adequate knowledge about the resources. The large pelagic resources are of high value and expansion of the lucrative fisheries for these species has been largely export-driven.

  Rising demand and increasing access to global markets promote heavy exploitation of some of the region's fisheries. According to FAO statistics fish exports from the CARICOM region amounted to around 200,000 tonnes, worth US$1.2 billion in 2000. Exports are dominated by high-value products such as spiny lobster, shrimp, snappers, groupers, and queen conch, which command premium prices on the international market. Tunas command premium prices on the international market and are among the dominant fish products exported by Caribbean countries. The high demand for shark fins in the Asian market also drives intense fishing pressure on vulnerable shark species. Although some countries such as Costa Rica have regulations that prohibit the transport, possession, and landing of shark fins, this illegal practice continues.

- ***Population and cultural pressures:*** Fish has historically been an important part of the diet of coastal communities, who depend heavily on reef fisheries as a source of food and livelihoods. In some countries, exploitation of certain reef associated species is a cultural tradition (e.g. exploitation of turtles by indigenous peoples in Central and South America). Growing demand for fish and fishery products, resulting from population growth, increasing purchasing power, and improved awareness of the nutritional value of fish, has resulted in excessive pressure on the region's fisheries resources. Increasing demand for employment by growing human populations will also put more pressures on reef resources due to limited opportunities in other sectors.

  The relatively high poverty levels in some of the countries mean greater pressures on the fish stocks from people who have little alternatives for food and employment. Despite generally favourable social development rankings, poverty remains a concern across the region. The coastal zone is particularly important for the livelihoods of the poor, who exploit common pool resources such as fish (Brown et al 2007).

Illiteracy, lack of other skills and unwillingness of some fishers to consider alternative employment and/or lack of other economic options continue to drive increased fishing pressure in some countries. High levels of unemployment in some areas force large numbers of persons to enter and remain in fisheries, which act as a safety net.

6.2. Key Transboundary Issue II: Habitat degradation

The following summary presents the main root causes leading to the Transboundary issue of Habitat Degradation. These are not presented in priority order.

- ***Poor governance:*** Efforts to protect marine ecosystems and resources have been fragmented and largely inadequate. For example, in the MAR countries, Belize has 2% of its marine territory in fully protected zones, followed by Mexico and Honduras with less than 1%, and none in Guatemala. Where protected areas exist, surveillance and enforcement are usually limited or non-existent. There is poor integration of environmental considerations into development planning in the region. Further, the marine governance of the WCR is characterized by uncoordinated efforts without any holistic integrated management plan. Management is organized primarily at the level of individual countries or political blocs, while what is required is to deal with marine environmental problems of the CLME at the scale of the entire ecosystem. The environment is given low priority on political agendas relative to short-term economic development. Stakeholder involvement in the management of marine habitats and living resources is still relatively low, although there are many examples of this in the region.
- ***Weak and ineffective legal and institutional frameworks:*** At the national level, legal and institutional frameworks are often weak and ineffective, due to a number of factors including fragmentation of responsibilities among various departments and limited coordination among them, limited cross-sectoral approaches in development panning, and inadequate human and financial resources. Where measures are in place to conserve reef habitats (e.g. MPAs), there is often poor management, surveillance and enforcement. The relevant MEAs such as the SPAW Protocol, CBD, CCD, RAMSAR, etc. are still to be ratified by many of the Caribbean countries. The SPAW protocol has been ratified so far by only 13 Caribbean States (Annex 8). Moreover, in countries that have already ratified these MEAs, there is often poor implementation and enforcement at the national level. There are inadequate unified and harmonized frameworks for transboundary habitat issues at the regional level.
- ***Trade and external dependency:*** The high dependence on international tourism and agricultural exports and in some cases limited opportunities for economic development in the countries (especially in the Insular Caribbean countries that have a very narrow natural resource base and opportunities for diversification) causes intense pressures on the region's living marine resources and environment. Capital investment in Caribbean tourism is the highest in the world relative to its size, with a proportional demand for coastal infrastructure at the expense of coastal ecosystems.

- ***Lack of economic valuation of ecosystems and their services:*** Apart from the value of tangible services such as fish catch, the economic value of ecosystems and their services is little known and goes largely unrecognized. For example, mangroves and seagrass beds are often seen as wasteland to be reclaimed or used for disposal of waste The lack of appreciation for values is a primary reason for the low political will for sustainable use of marine ecosystems.
- ***Limited knowledge and public awareness:*** There is limited knowledge, public awareness and appreciation about the importance of marine ecosystems and their services to food security and socio-economic development in the region, as well as of the connectedness among habitats and their vulnerability. There is also low awareness about sustainable practices in all sectors. This situation is changing, however, with increasing educational and public awareness programmes in the region. This condition is another reason for the low political will for sustainable use of marine ecosystems; the public do not demand it.
- ***Population and cultural pressures:*** Increasing human population throughout the region is accompanied by rising demand for living marine resources as a source of food and income, which will intensify the pressures on reef and continental shelf ecosystems. Higher populations also mean greater demand for food crops and livestock and associated requirements for agricultural land, for housing and infrastructure, and other services that could increase the pressures on coastal habitats (e.g. from land-based pollution). The relatively high poverty levels in some of the countries mean greater pressures on coastal habitats from people who have little alternatives for food and employment. Mangroves are often harvested for charcoal. Many poor communities also engage in agriculture and livestock farming, which could contribute to degradation of coastal habitats (e.g. from excessive sediments and nutrients).

6.3. Key Transboundary Issue III: Pollution

The following summary presents the main root causes leading to the Transboundary issue of Pollution. These are not presented in priority order.

- ***Poor governance:*** Efforts to protect marine ecosystems and resources have been fragmented and largely insignificant. There is poor integration of environmental considerations into development planning in the region. Further, the marine governance of the WCR is characterized by uncoordinated efforts without any holistic integrated management plan. Management is organized primarily at the level of individual countries or political blocs, while what is required is to deal with marine environmental problems of the CLME at the scale of the entire ecosystem (CARSEA 2007). The environment is given low priority on political agendas and over short-term economic development. There is limited investment in pollution control and waste treatment facilities. Stakeholder involvement in the management of marine habitats and living resources is still relatively low, although there are many examples of successful stakeholder involvement in the region. Despite the existence of regional and international policy frameworks related to pollution, a harmonized governance mechanism at the regional level to address transboundary pollution is lacking. A number of the following causes are also related to governance.

- ***Weak and ineffective legal and institutional frameworks:*** At the national level, legal and institutional frameworks to address pollution are often weak and ineffective, despite the existence of a number of relevant laws and regulations. The relevant MEAs such as the LBS (ratified in 2010) and Oil Spill Protocols, MARPOL, and Ballast Water Convention are still to be ratified by many of the Caribbean countries. Moreover, in countries that have already ratified these MEAs, there is often poor implementation, compliance and enforcement at the national level. Monitoring and enforcement of the implementation of these MEAs are the responsibility of national governments, which often lack the capacity and the political will to fulfil their obligations.

- ***Inadequate environmental quality standards and legislation***: Most of the WCR countries do not possess national environmental quality norms for coastal areas or in other cases they exist but are incomplete (UNEP-RCU/CEP/Cimab 2010). Where these exist, there is often poor compliance, monitoring and enforcement. National programmes do not usually address regional concerns and focus on addressing domestic impacts, rather than those occurring outside of territorial limits or in international waters.

- ***Inadequate data and information:*** Because of limited financial and human resources (see below) and other factors, pollution monitoring, control, and assessment activities are weak and inadequate. While numerous studies have been conducted in localized areas, most are sporadic and limited in scope. There are no systematic regional monitoring and data sharing programmes (apart from the monitoring of dust) that specifically focus on transboundary pollution and its impacts. Moreover, methodologies are often not standardized and harmonized, even the national level, which makes it difficult to compare status and trends. In general the quality of regional environmental data is low, as few countries have the necessary systems in place to collect quality-assured environmental data on a regular basis. This is being addressed however, as demonstrated by recent reports on pollution from UNEP-RCU/Car and Cimab. These studies have pointed out a number of data and information gaps both with respect to particular substances and coverage among the countries. Collection of data and information on the impacts of pollution on marine habitats and their living resources, as well as socio-economic impacts and costs need to be improved.

- ***Limited financial and human resources:*** Many of the CLME countries lack the necessary financial resources for construction and/or maintenance of sewage treatment plants and industrial and other waste treatment infrastructure. Inadequate financial and human resources also contribute to inadequate monitoring, surveillance, and pollution assessment activities. Attempts to implement the 'polluter pays' principle can be fraught with considerable difficulties.

- ***Low awareness of the value of the environment:*** The sea is generally seen as a receptacle for waste, with unlimited capacity to absorb the wide range of substances and materials that are disposed in coastal and marine areas. It is a common practice in the region's coastal towns to discharge domestic wastewater (treated or otherwise) into the nearest or most convenient body of water, in many cases because of lack of knowledge and indifference to the damage this causes to the environment and to public health. Awareness of the socio-economic and ecological value of marine and habitats and living marine resources is limited. In general, there low public awareness about the relationship between development and environmental protection, and between overall ecosystem health and the production of ecosystem services. This contributes to the low priority given to the environment on the political agenda.

7. Priority Actions for the Strategic Action Programme

> The Regional TDA is intended to highlight the transboundary issues and to identify the causes of these. In the process of developing the TDA, *potential* actions have been identified that could address the transboundary issues and are presented as indicative regional actions. Further work on assessing the cost / benefits and alternative solutions are required in formulating the SAP. Furthermore, the CLME Project is undertaking a number of pilot projects that will provide concrete experiences and new data to further guide the SAP development

The three transboundary concerns identified in the PDF-B stage have been re-evaluated and aligned with the current fishery ecosystem approach. The concerns have been assessed as still valid for the development of a Strategic Action Programme (SAP) for the CLME region following the fishery ecosystem approach.

The conclusion reached in the assessment of regional ocean governance in the WCR during the PDF-B was that complexity, diversity and dynamics are major factors affecting arrangements for transboundary living marine resources. These may be more prominent in the WCR than in many other LMEs due largely to its geopolitical complexity. This results in there being large number of stakeholders at multiple geographical and institutional scale levels. Key transboundary issues requiring governance arrangements occur at a diversity of scales and thus require matching governance arrangements. Therefore it was concluded that an approach that sought to network the stakeholders in transparent arrangements that included clear governance process and linkages among them would be the best way to approach regional governance in the WCR. This approach was seen as providing for the need to have issue specific governance arrangements at appropriate scale levels but with opportunities for harmonisation and learning among arrangements. This approach can be best described as the enabling of a network or complex of ocean governance entities within the WCR.

This section is designed to bridge the work of the TDA with the SAP development. It provides preliminary ideas for inclusion in the SAP but clearly it is the expectation that the SAP formulation will undertake detailed reviews and assessments of alternatives for further action. The expected actions will address short, medium and long-term requirements to address the causes of the transboundary problems identified in this TDA. It also should be emphasised that this Regional TDA provides a summary of the details included in the three fisheries ecosystem TDAs and these latter documents (together with the Governance Analysis report) will be the main sources of reference for formulating the SAP.

7.1. Cross-cutting governance actions

7.1.1. General issues

There is a wide array of global and regional legal instruments, agreements, arrangements and action plans that are directly relevant to the management of the living marine resources of the Caribbean Sea. These cover diverse issues such as the dumping of garbage, land-based pollution and oil spills, shipment of toxic wastes, the conservation of biodiversity, and sustainable fisheries, which are all very pertinent to the three transboundary issues identified in the CLME. Application of these instruments, nationally and sub-regionally, and implementation of their provisions, is rudimentary and they are often not reflected in national legislation (CARSEA 2007). Where these are incorporated at the national level, often they are not effectively implemented and enforced due to a number of reasons including limited capacities and financial resources of the countries. There should be greater focus on improved implementation of existing, rather than development of more policies, strategies, and action plans accompanied by strategic planning and financing strategies. While actions at the national level will also benefit transboundary living marine resources and issues, to be more effective in addressing transboundary issues requires that these be undertaken within a broader framework - sub-regional and/or regional, depending on the geographical distribution of the resources or the scale of the issue.

Where possible, consideration of transboundary issues should be incorporated within a collaborative and harmonized framework. The need for improved regional collaboration and cooperation, and appropriate institutional, legislative, and policy frameworks at the appropriate scale for shared resources has been extensively discussed.

Developing these multi-scale frameworks and their effective functioning would need to be underpinned by credible data and information at the appropriate scale. This underscores the need for an improved mechanism for collecting data in a harmonized manner and for sharing data and information throughout the region. Addressing transboundary issues will also need further strengthening of the appropriate human capacity, much of which already exists in the Caribbean. A mechanism is needed to share existing human capacity, as well as experiences and best practices at the regional level and to pool financial resources, to help make existing and planned initiatives and their outcomes more sustainable.

EBM/EAF approaches are increasingly being accepted as the most appropriate frameworks to manage living marine resources, including shared resources. The nature of the CLME and its shared resources as well as its shared and common problems makes it an ideal candidate for EBM/EAF approaches, which puts emphasis on, among other aspects, maintaining the overall health of the ecosystem in order to maintain the production of ecosystem services as well as on the role of humans as a vital part of the ecosystem. The Regional Symposium (Towards Marine Ecosystem-Based Management in the Wider Caribbean) that was held in Barbados in 2008 provided valuable information and a vast range of recommendations on implementing EBM/EAF approaches in the management of the CLME and its living resources. These recommendations, which are all endorsed in this TDA, would provide much needed guidance in developing interventions during preparation of the SAP. Similarly, the results of ecological modelling carried out by the LAPE project, despite some uncertainties, provide an important basis for moving forward with EBM/EAF for the pelagic ecosystem (Mohammed et al 2008).

The review of the governance aspects of the PDF-B and of advances in living marine resource governance in the WCR since the completion of the PDF-B point to certain key activities as being of value in furthering understanding of regional governance and in developing options for a Regional Governance Framework for consideration in the Strategic Action Programme. These include:

- Developing linkages with the major IGOs to determine the most useful and desirable inputs for policy making (in collaboration with the relevant fishery bodies).
- Liaising with the Monitoring and Reporting component to develop those inputs and deliver to IGOs
- Using TWAP methodology to assess fishery ecosystem governance arrangements in all three ecosystems (in collaboration with the pilot projects)
- Assessing the relationships among the regional organizations that are engaged in LMR governance
- To use the above information to propose appropriate governance options for SAP

7.1.2. Advances in ocean governance to be considered

There have been advances in ocean governance concepts and practices both with the Wider Caribbean and globally in recent years (even since the PDF-B phase) that are relevant to the promotion of improved marine Ecosystem-Based Management by the CLME Project. Key among these are legal and policy-level advances at the international level, a growing awareness of ecosystem-based management, climate change impacts and specific projects focused on regional governance. There have also been a number of global ocean governance initiatives contributing to an increased understanding of factors affecting governance.

Regional and sub-regional intergovernmental organizations have been moving forward with various aspects of ocean governance. The OECS is pursuing an integrated ocean governance approach for its countries as well as a range of activities oriented towards improving ocean governance such as in a Marine Protected Areas. CARICOM's CRFM has been pursuing a Common Fisheries Policy that includes the ecosystem approach. OSPESCA/SICA has made advances in a number of sub-regional fisheries initiatives, also within an ecosystem context, for example, common lobster regulations in the Central American Caribbean. The ACS has been vigorously pursuing the Caribbean Sea Initiative and the establishment and implementation of the related Caribbean Sea Commission. This has the potential to serve as a regional oceans policy body. Each of these bodies has an important role to play in the development of an effective ocean governance framework for the Wider Caribbean Region, and sustainability of their progress will be an important factor in achieving this.

There is continuing progress also with the implementation of the Cartagena Convention and its Protocols. The LBS Protocol is now in force and augers well for progress with reduction of impacts from land-based sources on marine ecosystems.

At the global level, the establishment of the Regular Process by the UNGA in 2009 provides a point of connection for the proposed Regional Monitoring and Reporting System. Similarly, with the GEF IW Programme the development of assessment methodology, especially for IW system governance through the TWAP, provides an opportunity for the governance focus of the CLME Project to be linked with contribute to this global assessment.

There have been recent advances in thinking and practice relating to ecosystem based management. Indeed there has been a recent symposium on Principled Ocean Governance and the ecosystem approach for the Wider Caribbean that provides considerable guidance for the CLME Project in how to proceed in this area. New concepts and approaches are being actively developed in the governance arena and should be taken up in the CLME Project as appropriate. These include emerging ideas on how to promote resilience and transformation in Social Ecological Systems, as well as appropriate characteristics for international governance arrangements such as are being developed by the Earth System Governance Project. The implications of these for the CLME Project and transboundary LMR governance in the Caribbean are developed below.

7.2. Potential regional actions to protect Reef and Pelagic Fishery Ecosystem

7.2.1. Unsustainable fisheries

- Improved implementation of existing policy frameworks to address unsustainable exploitation of living marine resources;
- Reduction in fishing effort for overexploited stocks. This has complex socio-economic implications, and must be accompanied by creation of alternative employment opportunities as well as the interim provision of alternative sources of protein for the communities that depend on these resources for food;
- Establish economic measures and incentives to achieve compliance with regulations and promote sustainable practices;
- Co-operation in management among the key sectors (small-scale and commercial harvesting, processing and marketing sectors), as well as the relevant institutions in the countries, indigenous communities and regional and non-governmental organizations;
- Use of the best available scientific information, with a conservative precautionary and adaptive approach to management. Filling knowledge gaps needs a significant investment in targeted research, mainly in the context of adaptive management. This will require the development of strong collaborations among the scientific, management, and stakeholder communities, including at the sub-regional and regional levels;
- Harmonization at the regional level of the collection of data and information required for stock assessment and management (e.g. fishing effort, total landings by species, origin of catches), and identification of the stock structure of transboundary species;
- Implementation of ecosystem based approaches, at the appropriate geographical scales. The Ecosystem Approach to Fisheries management is increasingly being seen as the most effective approach to management and conservation of living marine resources;

- Establishment/strengthening and effective management of a sub-regional/regional network of marine parks and protected areas, including no-take reserves that provide tangible economic, social and environmental benefits to coastal communities, based on sound science (see below on options for habitat degradation);
- Protection of fish spawning aggregations and other vulnerable populations and species;
- Maintenance of connectivity in reef and pelagic ecosystems. The collaborative design and implementation of networks of marine reserves that include multi-species spawning aggregation sites, critical nursery habitat, and their connectivity, are likely to provide an important contribution to reversing the decline in fisheries in the Caribbean. Resource managers should identify and protect multi-species spawning aggregations and critical nursery grounds for fishes;

7.2.2. Habitat degradation

Several of the policy frameworks and options to address unsustainable exploitation (as well as pollution) are also relevant to habitat degradation and community modification. Options for addressing habitat degradation and community modification include:

- Improved implementation of existing policy frameworks to address habitat degradation;
- Restoration of degraded habitats and protection of healthy ones;
- Preservation and restoration of mangroves and seagrass beds that capture and cycle nutrients, sediments and other pollutants;
- Reduction of threats from both marine and land-based sources, including domestic and industrial wastewater and agricultural run-off;
- Adoption of integrated watershed and coastal area management;
- Promotion of sustainable fisheries, agriculture and tourism practices;
- Incorporation of the economic value of ecosystem services in development planning;
- Develop comprehensive regional strategies and policy alternatives that address current and emerging threats to island and coastal resources and communities;

7.2.3. Pollution

- Wider ratification and better implementation of the Cartagena Convention, particularly the oil spills and LBS Protocols, and MARPOL Convention, as well as the GPA and other relevant policy frameworks. Implementation could be improved by ensuring that existing policies, strategies, and action plans are realistic and accompanied by a strategic planning and financing strategy;
- Adoption and enforcement of environmental standards and better implementation and enforcement of the 'polluter pays' principle at national and regional levels;
- Improved monitoring, including of transboundary movements of pollutants, using standard indicators and methodologies; and development of collaborative efforts to address transboundary pollution at the source;

- Adoption of a cross-sectoral approach in dealing with pollution, and a move towards an integrated, ecosystem approach where feasible.

7.3. Potential regional actions to protect Continental Shelf Fishery Ecosystem

Most of the countries are already party to several international environmental agreements which shows a wide acceptance of the need for EAF. Some preliminary work towards EAF has started at the regional and national levels through the WECAFC ad hoc Working Group on Shrimp and Groundfish in the Brazil–Guianas Shelf. However, to apply this approach, the following principles and concepts need to be translated into policy, goals, and objectives that can be achieved by applying appropriate management strategies over the medium to long term:

- Fisheries should be managed to limit their impact on the ecosystem to the extent possible
- Ecological relationships between harvested, dependent, and associated species should be maintained
- Management measures should be compatible across the entire distribution of the resource
- The precautionary approach should be applied because the knowledge on ecosystems is incomplete
- Governance should ensure both human and ecosystem well-being and equity (FAO 2003).

For the Continental Shelf Fishery Ecosystem, initial steps towards EAF should include the following:

- Agreement on policy, goals, and management objectives for the services provided by the ecosystem. In support, the required legislative and institutional framework should then be put in place.
- Identification and involvement of all stakeholder groups in the application of EAF.
- Development and implementation of national and regional EAF fisheries management plans that include sustainability indicators (including reference points, targets, and limits) and the accompanying monitoring and evaluation procedures.
- Review of the fisheries administrative and management institutional arrangements at the national level in the first instance, and the implementation of the necessary changes to support the institutional requirements for the delivery of EAF.
- Decentralised regional approach to fisheries management in the Continental Shelf Fishery Ecosystem, enabling management measures to be taken that are appropriate to biologically distinct areas and jurisdictional levels. Management measures could include technical measures, spatial management, effort related controls, and systems of access rights.
- Tailoring of research and information provision to support the ecosystem approach, including the documentation and use of traditional knowledge.
- Application of adaptive management and the precautionary approach given the degree of uncertainty and dynamics of the ecosystem.
- Development of an effective monitoring, control and surveillance capability.

7.3.1. Unsustainable fisheries

Overexploitation of the shrimp and groundfish resources combined with excessive by-catch and discards and destructive fishing practices and IUU fishing due to inadequate fisheries management and enforcement could lead to further loss of income, employment, food supply and foreign exchange in the region and should be urgently addressed. Among the interventions required are:

- Identification of the stakeholders in the shrimp and groundfish fisheries, and the development of mechanisms for improved stakeholder participation in the management process.
- Determination of the level of poverty in the fishing communities and the identification of alternative livelihood programmes.
- Institutional strengthening of the fisheries administrations and research institutions at the national and regional levels.
- Harmonization of fisheries and related legislation in the NBSLME.
- Strengthening of the existing mechanisms for regional collaboration in resource assessment and management.
- Development of mechanisms for conflict resolution.
- Development of a regional database for fisheries and related data/information.
- Evaluation of the tools being used for fisheries management in the sub-region.
- Continued assessment, including bio-economic assessments, of the shrimp and groundfish resources.
- Determination of the extent of IUU fishing in the region and the development of mechanisms to combat it at the national and regional levels.
- Determination of the environmental factors that may be influencing recruitment of young shrimp to the shrimp fishery.

7.3.2. Habitat degradation

The continued degradation of “critical” zones or habitats (mangroves, corals) and the unsustainable exploitation of fisheries and other living resources could lead to a deterioration of the quality of life in coastal communities, and, as such, needs to be addressed. Among the interventions required are:

- Strengthening of the institutional framework for integrated coastal management.
- Improved land use policies.
- Improved knowledge of the role that the entire shallow, brackish-water stretch along the seashore plays in the mobilization of nutrients and energy transfer in the lower levels of trophic webs, and providing nursery grounds for many marine fish and shrimp species and the impacts on these areas by human activities.
- Creation of reserves to protect ecologically sensitive coastal ecosystems (e.g. mangroves).

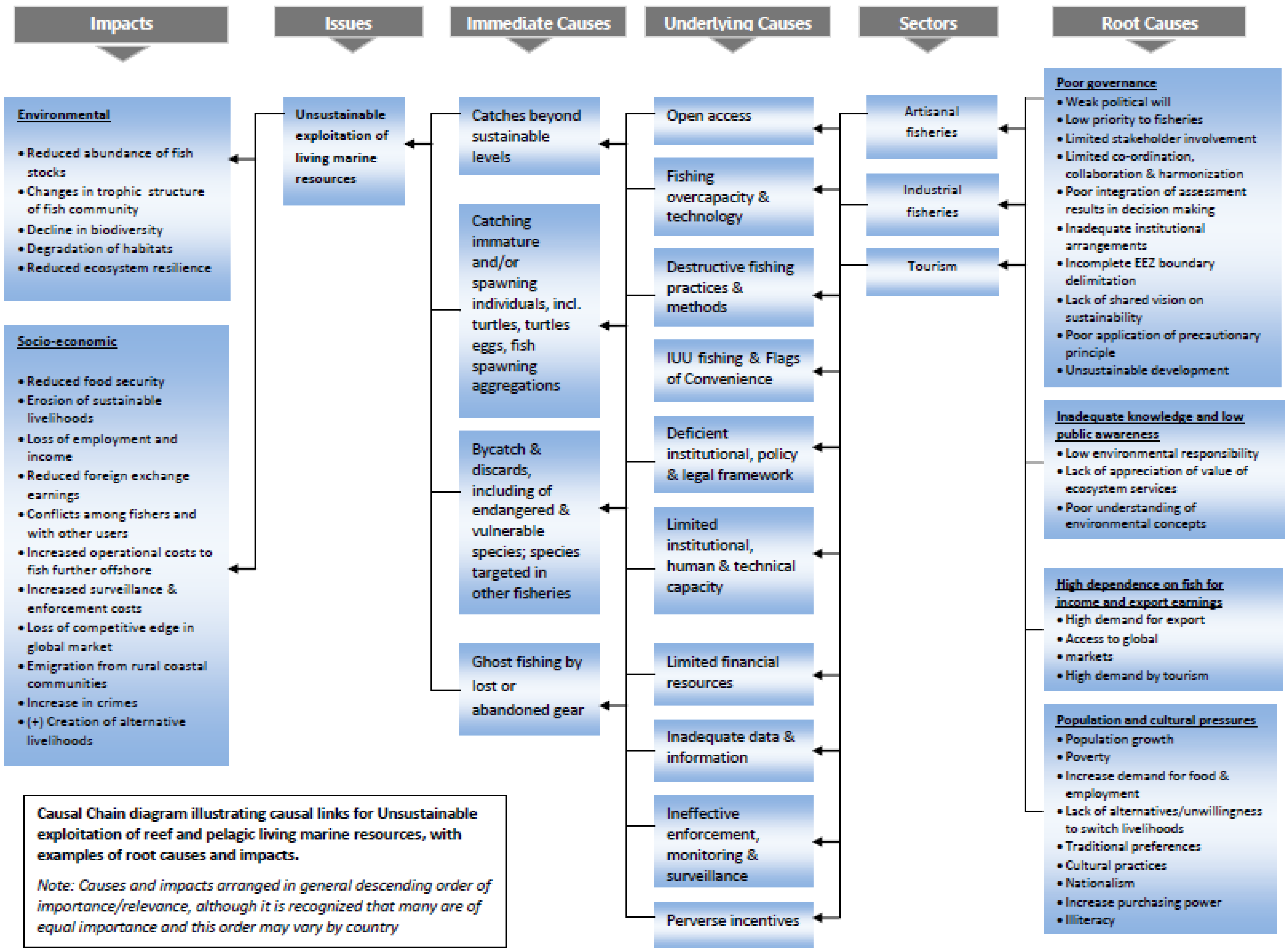
7.3.3. Pollution

Heavy metal pollution from mining and agro-chemical pollution, if not effectively managed, could lead to degradation of the coastal marine ecosystems. In the case of mercury, it could affect the health of miners, as well as the health of other members of the community should it enter the food chain. Among the interventions required are:

- Strengthening of the institutional framework for integrated coastal management.
- Improved land use and mining policies.
- Determination of the level of poverty in the mining areas and the identification of alternative livelihood programmes.
- Development and implementation of adult education and public awareness programmes.
- Strengthening of the institutional mechanisms for monitoring and enforcement in the mining industry.
- Improved knowledge of the effects of agro-chemicals and heavy metals on coastal ecosystems.

ANNEX 1:

CCA Diagrams for Reef, Pelagic and Continental Shelf Fisheries



Causal Chain diagram illustrating causal links for Unsustainable exploitation of reef and pelagic living marine resources, with examples of root causes and impacts.

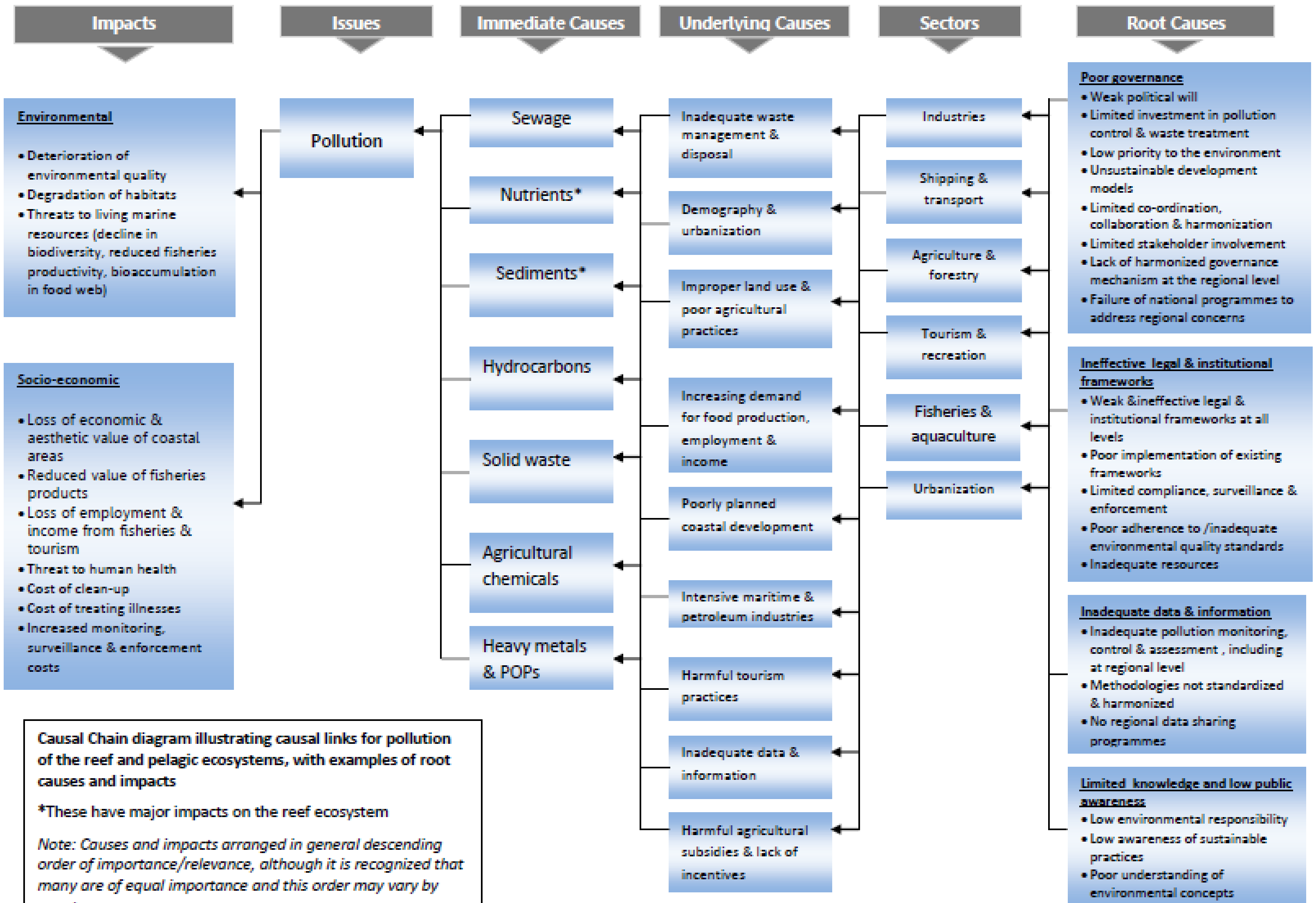
Note: Causes and impacts arranged in general descending order of importance/relevance, although it is recognized that many are of equal importance and this order may vary by country

Caribbean LME Project

GEF UNDP UNESCO UNOPS

ANNEX 1:

CCA Diagrams for Reef, Pelagic and Continental Shelf Fisheries



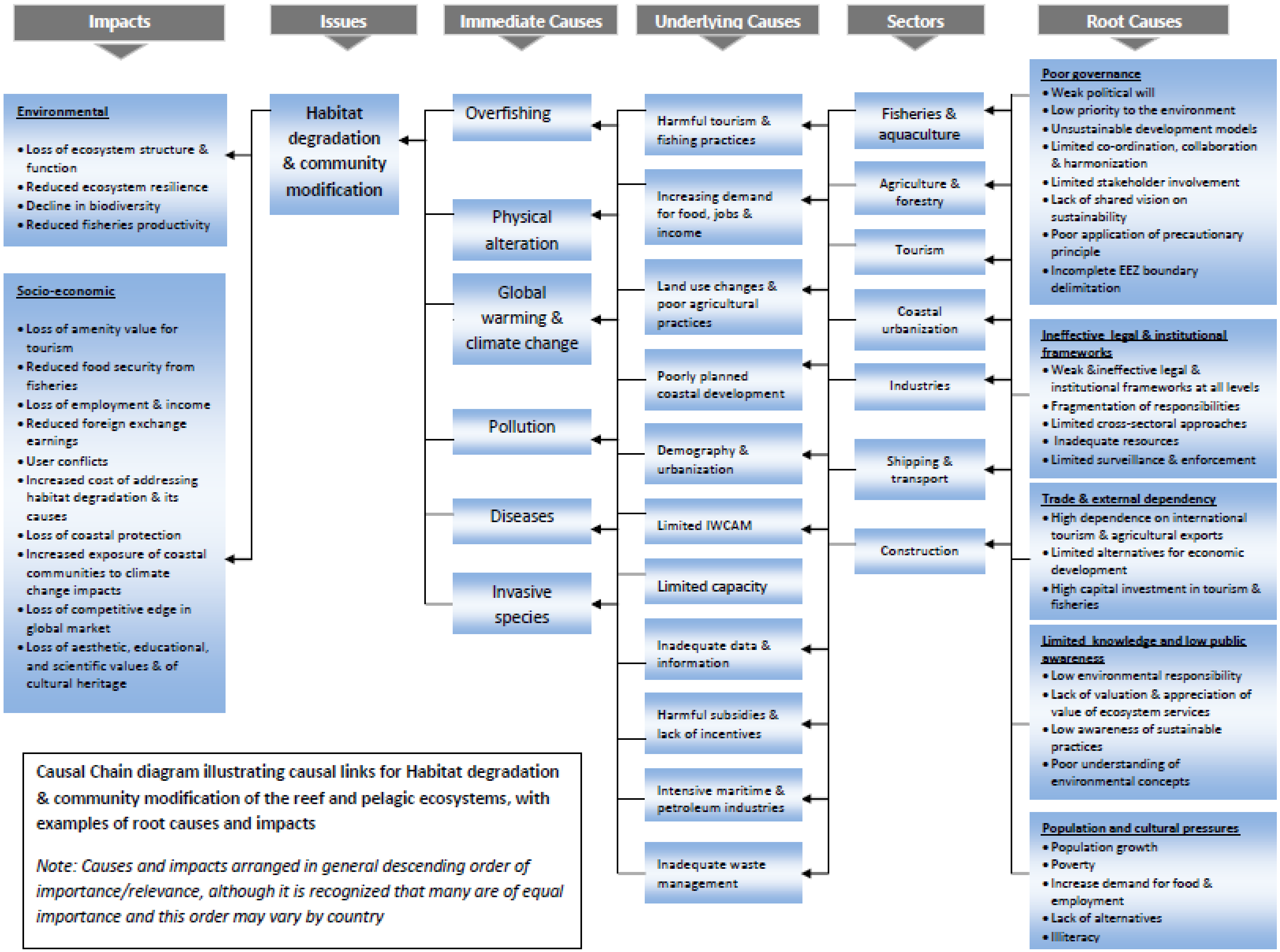
Causal Chain diagram illustrating causal links for pollution of the reef and pelagic ecosystems, with examples of root causes and impacts

*These have major impacts on the reef ecosystem

Note: Causes and impacts arranged in general descending order of importance/relevance, although it is recognized that many are of equal importance and this order may vary by country.

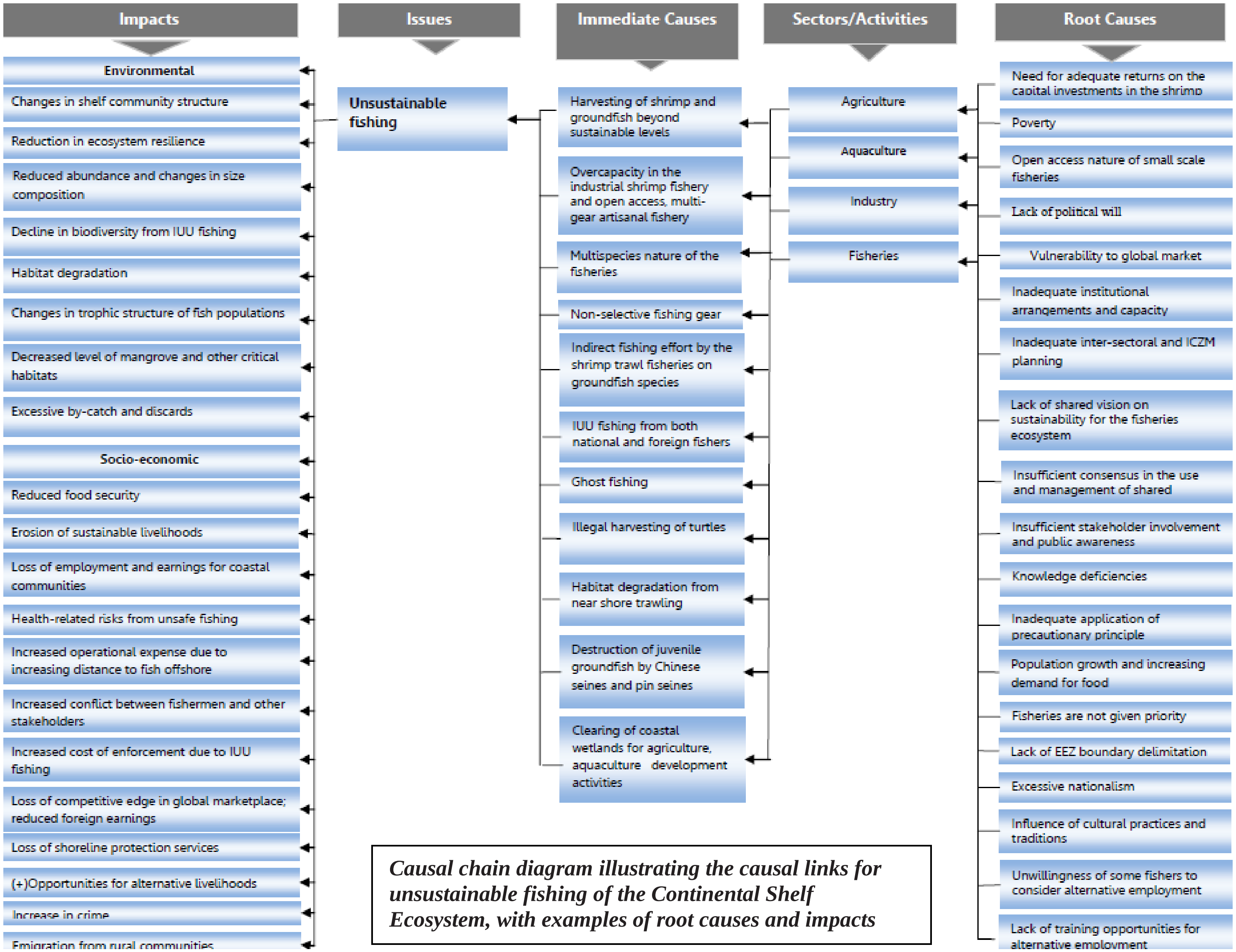
ANNEX 1:

CCA Diagrams for Reef, Pelagic and Continental Shelf Fisheries

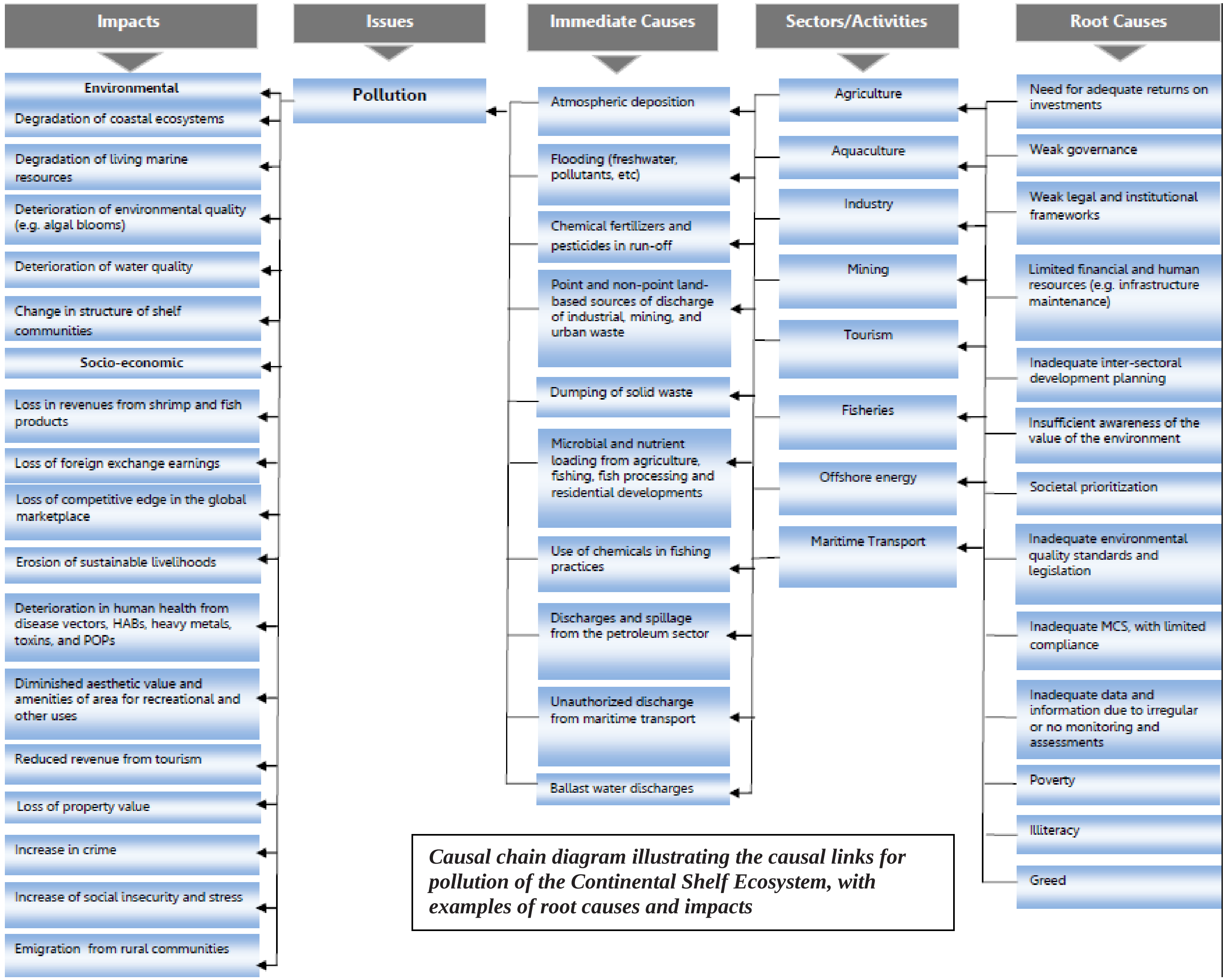


Causal Chain diagram illustrating causal links for Habitat degradation & community modification of the reef and pelagic ecosystems, with examples of root causes and impacts

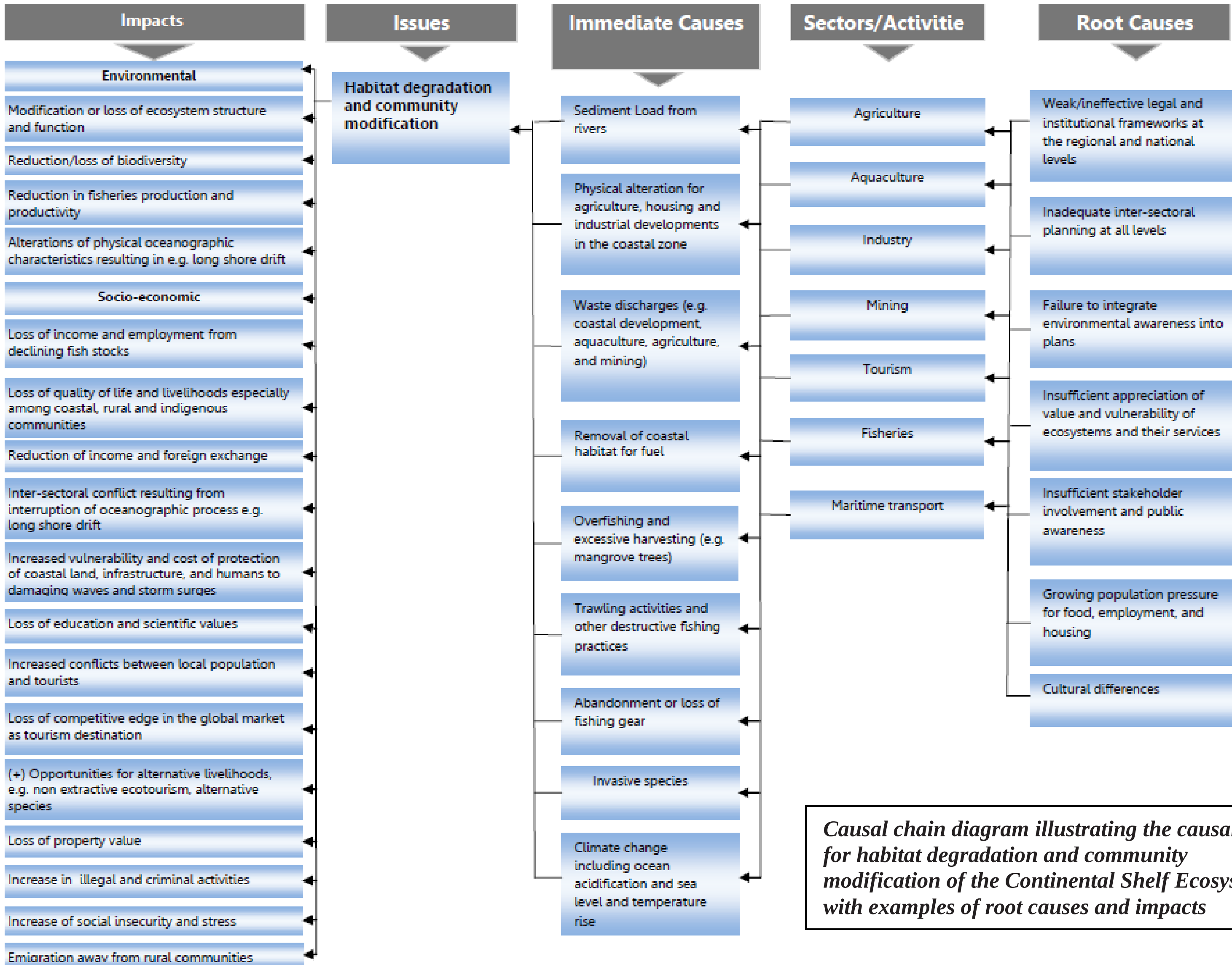
Note: Causes and impacts arranged in general descending order of importance/relevance, although it is recognized that many are of equal importance and this order may vary by country



Causal chain diagram illustrating the causal links for unsustainable fishing of the Continental Shelf Ecosystem, with examples of root causes and impacts



Causal chain diagram illustrating the causal links for pollution of the Continental Shelf Ecosystem, with examples of root causes and impacts



Causal chain diagram illustrating the causal links for habitat degradation and community modification of the Continental Shelf Ecosystem, with examples of root causes and impacts

Annex 2

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