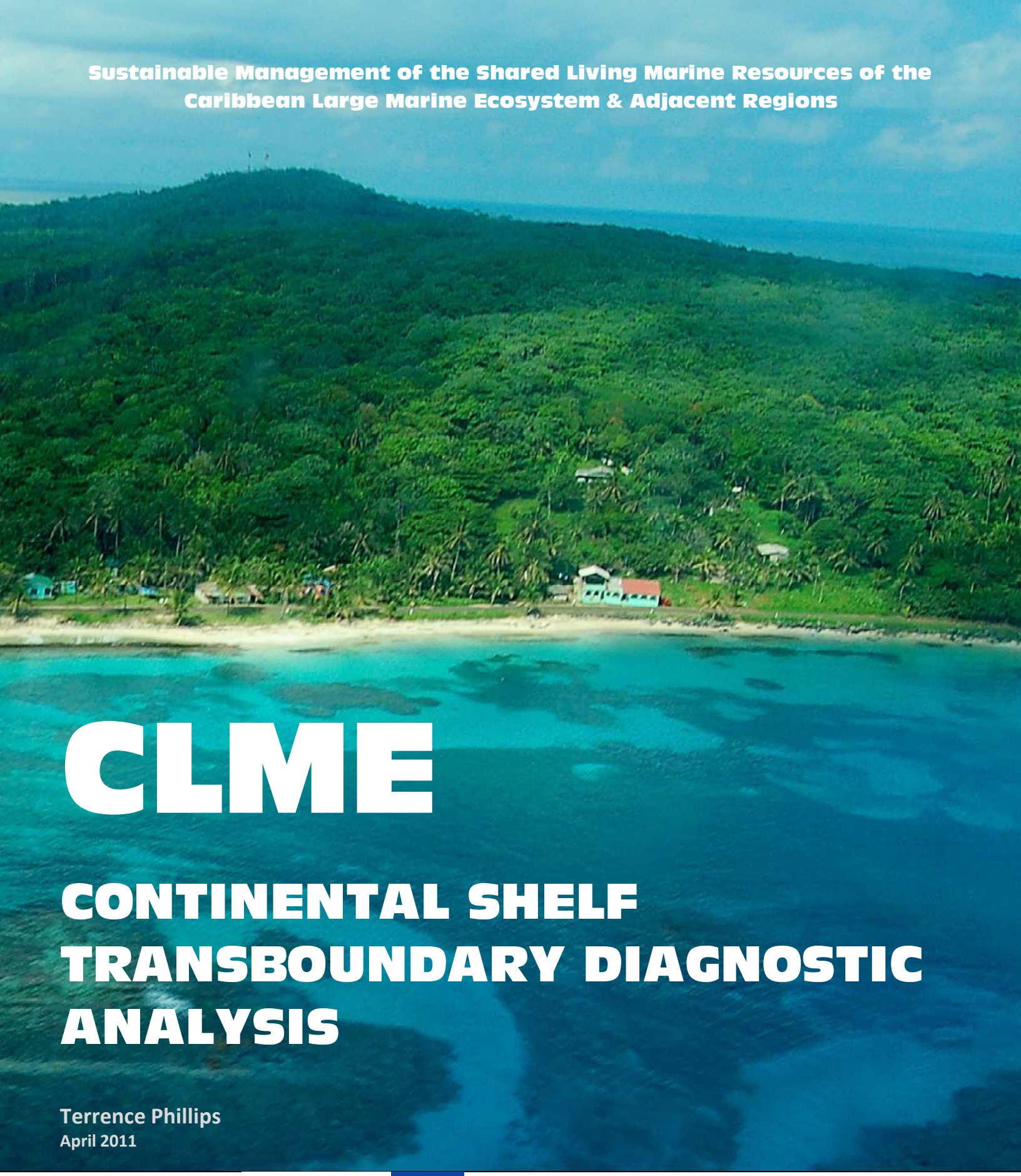
Sustainable Management of the Shared Living Marine Resources of the Caribbean Large Marine Ecosystem & Adjacent Regions



CLME

CONTINENTAL SHELF TRANSBOUNDARY DIAGNOSTIC ANALYSIS

Terrence Phillips

April 2011

Caribbean LME Project
www.clmeproject.org
GLOBAL ENVIRONMENT FACILITY 20 YEARS INVESTING IN OUR PLANET
UNDP
UNESCO United Nations Educational, Scientific and Cultural Organization
Intergovernmental Oceanographic Commission
UNOPS

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

Consultancy to deliver the CLME Project Causal Chain Analysis (CCA) revision, CCA gap analysis and the update of the Continental Shelf Ecosystem Transboundary Diagnostic Analysis (TDA)

- REVISED DRAFT -

Prepared for

The Caribbean Large Marine Ecosystem and Adjacent Areas (CLME) Project
Cartagena Colombia

By

Terrence Phillips
April 08, 2011

Table of Contents

List of Tables

List of Acronyms and Abbreviations

BW	Ballast Water
CARICOM	Caribbean Community
CBD	Convention on Biological Diversity
CC	Climate Change
CCA	Causal Chain Analysis
CEPNOR	Centro de Pesquisa e Extensao Pesqueira do Norte do Brasil
CFRAMP	CARICOM Fisheries Resource Assessment and Management Programme
CLME	Caribbean Sea Large Marine Ecosystem
COPESCAL	Commission for Inland Fisheries of Latin America
CRFM	Caribbean Regional Fisheries Mechanism
CSE	Continental Shelf Ecosystem
DOF	Department of Fisheries
EAF	Ecosystem Approach to Fisheries
EEZ	Exclusive Economic Zone
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FONAIAP	Fondo Nacional de Investigaciones Agropecuarias
GBP	GloBallast Partnerships Project
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIWA	Global International Waters Assessment
GOG	Government of Guyana
HDI	Human Development Index
IAS	Invasive Alien Species
IBAMA	Instituto Brasiliero do Meio Ambiente e dos Recursos Naturais Renovaveis
IFREMER	Institute Français pour l'exploitation de la mer
IMO	International Maritime Organization
INAPESCA	National Fisheries and Aquaculture Institute
INSOPESCA	Socialist Institute for Fishing and Aquaculture
IUCN	International Union for the Conservation of Nature and Natural Resources (The World Conservation Union)
IUU	Illegal, Unregulated and Unreported
IWRM	Integrated Water Resources Management
LCDS	Low Carbon Development Strategy
LME	Large Marine Ecosystem
LMR	Large Marine ecosystem Resources
LNG	Liquefied Natural Gas
MARPOL	The International Convention for the Prevention of Pollution of Ships
MAS	Maritime Authority Suriname
MAT	Ministry of Agriculture and Land (Venezuela)
MCB	Marine Catchment Basin
MCS	Monitoring, Control and Surveillance

MEA	Millennium Ecosystems Assessment
MIS	Marine Invasive Species
MOU	Memorandum of Understanding
MSY	Maximum Sustainable Yield
NBC	North Brazil Current
NBSLME	North Brazil Shelf Large Marine Ecosystem
SAP	Strategic Action Plan
SEAP	Special Secretariat of Aquaculture and Fisheries
SPAW	Specially Protected Areas and Wildlife
SPF	Specific Pathogen Free
TDA	Transboundary Diagnostic Analysis
TED	Turtle Excluder Device
UK	United Kingdom
UN	United Nations
UNCED	United Nations Convention on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNIDO	United Nations Industrial Development Organization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USD	United States Dollar
WCR	Wider Caribbean Region
WECAFC	Western Central Atlantic Fishery Commission

1. Executive Summary

This report reviews and reformulates the Thematic Report for the Guianas-Brazil Sub-region into the Continental Shelf Ecosystem Transboundary Diagnostic Analysis with an ecosystem approach to fisheries (EAF). The first section covers the Executive Summary while the second highlights the importance of the CSE to the shrimp and ground fish fisheries occurring within. It also gives an update on the status of these fisheries and identifies the focus of the TDA as being on the ecosystem services being provided by the living marine resources found within the CSE.

The third section provides the global, regional significance and overall objective of the CLME Project, and the purpose of the Transboundary Diagnostic Analysis while setting out the geographic scope of the continental shelf ecosystem as the North Brazil Shelf Large Marine Ecosystem (NBSLME). This 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 $km^{2.}$ For the purpose of this report the use of the term North Brazil Shelf Large Marine Ecosystem includes the adjacent area of the Gulf of Paria.

Section four of the report provides an overview of the major socio-economic activities taking place within the CSE and the bordering countries of Brazil, French Guiana, Suriname, Guyana, Venezuela and Trinidad and Tobago. These include fisheries and aquaculture, offshore energy operations, and marine transportation. In the area of fisheries, it also provides an overview of other shrimp and groundfish fisheries to be found within the CLME and gives some indication of the status of these fisheries and the issues affecting their sustainability.

In addition section four gives an analysis of the current issues in relation to fish and fisheries, pollution and ecosystem health and habitat and community modification and examines the implications for the NBSLME. It identifies the major knowledge gaps in baseline information; the socio-economic features of the countries in the region and gives an overview of the governance arrangements in place for the fisheries and other sectors.

In the area of fisheries, this CSE supports one of the major export oriented shrimp fisheries in the world, with the demersal fin-fish fisheries being of significance for commercial and social reasons. There are lesser fisheries for shelf-based schooling pelagic resources such as mackerels and jacks and for sharks. 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. Aquaculture development in the region has been significant over the years and is seen as a major growth area by many of the countries bordering the LME.

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. Effluents from industries are released, sometimes untreated, into the water bodies.

Contamination by mercury and 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. Contaminants in river effluents, particularly those of the Amazon, could be transported across national boundaries and EEZs.

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. 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.

Growth of the local human population and pressures associated with urban and industrial development will continue to threaten the environmental health of this region. The problems are potentially reversible, considering that there is greater public and governmental awareness about environmental issues. Additionally, several measures at national and regional levels are already being taken to address some of these problems.

In terms of the knowledge gaps, there is need to determine the possible links between the recruitment of young shrimp and the environment and its likely effects on the shrimp fishery. Also, more 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. With regards to the groundfish fisheries, management is seriously hindered by a lack of comprehensive and reliable information on many important species such as the red snapper. Since the scope of the TDA has 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.

The vulnerability of the fisheries sector to climate change and its implications for sustainable development are recognized. As such, it has been recommended that in relation to mainstreaming climate change considerations into ongoing fisheries management programmes, there is need to design at the very minimum, an adaptation package that would reflect the status of the science, and be flexible in order to benefit from new research findings. It should also

exploit the knowledge base of key actors i.e. the fishers, while being cost-effective, and socially and culturally acceptable to stakeholders.

Agriculture is very important to many economies in the region, such as Suriname and Guyana, but not much is known about its impact when extended into areas included in the broader marine environment, and the effluents carrying chemicals used in agriculture if they are drained in

sufficient concentration to the sea. Little information is available on the effects of mercury from artisanal gold mining on the riverain, estuarine and marine ecosystems. Additional research is required to improve 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.

In the NBSLME, socio-economic activities include subsistence agriculture (rice, corn, cassava and beans), fisheries (mostly artisanal and focused on shrimp), and the exploitation of gold in the Amazon Basin. Logging and mining are also taking place in the Amazon basin. There is coastal exploitation of clay and sand, and limited ecotourism. 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. In general, unsustainable overexploitation of living resources as well as environmental degradation may result in threats to food security and loss of employment, as well as loss of foreign exchange to the countries bordering this region.

Five countries (Brazil, Suriname, Guyana, Venezuela, and Trinidad and Tobago) and one dependency (French Guiana) border this CSE, and would need to address the key transboundary living marine resources issues existing in it. The fragmented nature of coastal and marine resource management is a legacy of the colonial past. The languages and cultures of the foreign occupiers (Portugal, France, the Netherlands, Great Britain and Spain) were 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 the Ramsar Convention on Wetlands. However, there is currently a lack of coordinated support among them for ecosystem monitoring and management.

UNCLOS and recent international initiatives in fisheries have made it necessary for the countries in the area to revise their policies and legal frameworks for fisheries management and development. To this effect, Brazil, French Guiana and Guyana have put the necessary legislation in place, while Suriname, Trinidad and Tobago and Venezuela were in the process of doing so. In general, the legislation in place or being put in place promotes the ecosystems based approach to management and calls for the development, implementation and regular evaluation of fisheries management and development plans, based on the best available scientific and socio-economic information, in consultation with the stakeholders involved in the various fisheries.

In most instances, fisheries administration and research fall under the umbrella of the Ministry of Agriculture of the countries of the NBSLME, except in Brazil, where fisheries administration is shared between the Ministry of Agriculture and IBAMA, with research being delegated to CEPNOR and, in Venezuela, where research has been delegated to FONAIAP. In general, MCS is delegated to the navy, air force, army, coast guard or police. In many of these countries some level of institutional reform is taking place to better enable the fisheries administrations to carry out their mandates. Many countries are faced with problems such as insufficient staff to fulfill essential functions, poor communication between different levels and interest groups, and no

clear decision-making procedures and responsibilities which mainly stem from insufficient funding.

Regional and sub-regional organizations such as the FAO/WECAFC and CRFM have been actively promoting fisheries management and development in the NBSLME. 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 CSE, the countries may need to strengthen and/or develop mechanisms for regional collaboration and cooperation in areas such as assessment and management, harmonized legislation, a regional database for fisheries and related data, established mechanisms for strengthening MCS at the national and regional levels, involvement of the various stakeholders in the management process and building of public awareness.

The legal and institutional arrangements on integrated coastal management and environmental management at the national and regional levels should have been reviewed, but such information was not readily available. A similar situation applies to the offshore energy and marine transportation sectors for some of the countries involved.

Section five of the report reviews the major perceived governance and water related environmental issues and problems within the context of the Millennium Ecosystems Approach to ecosystem goods and services. It identifies and analyses the transboundary issues under fish and fisheries such as unsustainable fishing (overexploitation of the shrimp and groundfish fisheries, excessive by-catch and discards, IUU fishing); pollution and ecosystem health (chemical pollution by fertilizers and pesticides from agriculture, and heavy metal pollution by mercury from the gold mining industry); and habitat and community modification (modification or loss of ecosystems (mangroves) and ecotones). In each instance it addresses the likely environmental impacts, socio-economic consequences, causal chain analysis (CCA) and linkages with other transboundary problems. It also recognizes that due to the migratory nature of the fishery resources which are found in the pelagic ecosystem and the importance of these resources, especially the coastal pelagics and sharks, to the livelihoods of fishers, their communities and other stakeholders in the countries bordering the CSE, it will be necessary to address the transboundary issues identified for these two ecosystems in a holistic rather than an isolated manner. Likewise, the lessons learned from addressing the transboundary issues in the coral reef ecosystem may be beneficial in dealing with the problems affecting coral reef ecosystems in the NBSLME.

In section six of the report which looks at the root causes of the CCA, it is recognized that while the immediate and underlying causes of the negative 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. Section seven identifies the interventions required to

address the transboundary issues, with the focus being mainly on providing solutions at the level of the underlying and root causes.

Section eight of the report examines the most suitable means of introducing an ecosystems approach to fisheries (EAF) in this CSE. It recognises that most of the countries are already party to several international environmental agreements which show 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; and
- governance should ensure both human and ecosystem well-being and equity (FAO 2003).

It also acknowledges that the ecosystem approach will not be an instant replacement for traditional fisheries management, and should be seen as an evolution of the existing fisheries management systems. As such, progress towards EAF is likely to be achieved in an incremental way rather than overnight.

In section nine, the report concludes that the living marine resources of this CSE hold significant economic, environmental, cultural and spiritual value. Due to the shared nature of these resources, the major transboundary areas of concern identified require urgent attention at the overall regional and NBSLME levels that can be implemented at the national and local levels.

Sustainable fisheries development in the NBSLME should take account of the full range of ecosystems goods and services, and should not threaten the sustained delivery of these goods and services to society. It is only realistic to expect that fisheries, being a human activity, will lead to human well-being and equity for all relevant stakeholders and should be developed in the context of the policies and goals of the other sectors.

Implementing EAF would require robust, participatory decision-making mechanisms at all levels, which would lead to more effective adoption of management advice based on the best available scientific information. In addition, fisheries management should not be seen in isolation from the management of the coastal zone, but over time should become better integrated with other social and economic sectors of coastal management.

2. Introduction

The NBSLME supports the major shrimp and groundfish fisheries of the Guianas–Brazil region. There are also lesser fisheries in this LME for shelf-based schooling pelagic resources such as mackerels and jacks and for sharks. There are interactions among the resources that are exploited and also among the various commercial and small-scale fisheries that exploit them. Key ecosystem interactions are with coastal wetlands that serve as nursery habitats. At the human level, interactions with other marine sector users such as offshore energy, marine transportation and marine-related tourism could potentially increase and contribute to threatening the sustainability of the continental shelf ecosystem goods and services. This ecosystem is probably intermediate in complexity between the pelagic and reef ecosystems (Mahon *et a*l, 2010).

The shrimp resources in the CSE 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.

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 CSE 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).

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, with declining catch rates and a decrease in the size of this species. Recent trends in catch per unit effort and other analyses indicate that the corvina is now overexploited in some areas, with the low stock levels of this species being commensurate with exploitation levels beyond the MSY level. Similarly, lane snappers (***L. synagris***), bangamary (***Macrodon ancylodon***) and sharks are also showing signs of overexploitation (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. The trends in fishing mortality were not high enough to have created the very conspicuous decline in abundance, which implies that environmental factors (seasonal river run-off and rainfall) may be more significant than fishing in determining recruitment in these species (Heilemen, 2008). In the case of the seabob shrimp fisheries of Suriname and Guyana, preliminary analyses have indicated that there is no evidence

from the catch and effort data that the stock is overfished and/or that overfishing is occurring (CRFM, 2009). Table 1 gives some indication of the number of fishers, size of the industrial and artisanal fleets, the annual production in terms of weight and value for the shrimp and groundfish fisheries of the countries bordering this CSE. It also gives some information on the overall employment in the fisheries sectors of Brazil, Guyana, Trinidad and Tobago and Venezuela, but in the cases of Brazil, Trinidad and Tobago and Venezuela the employment may go beyond those employed in the shrimp and groundfish fisheries of the NBSLME.

Table 1*: Fishers, Fleet, Annual Production for the Shrimp and Groundfish Fisheries, and Overall Fishery Sector Employment of the Countries in the NBSLME*

	Number of Fishers		Number of Vessels		Annual Production		Value of Landings		Overall Fishery Sector Employment
	Industrial	Artisanal	Industrial	Artisanal	Shrimp (mt)	Groundfish (mt)	Shrimp US$ m	G/fish US$ m	
Brazil			243[1]		3,533[1]				800,000
French Guiana	68[1]	60[1]			4344[1]	1,527[1]			
Guyana		5000[2]	147[2]	1200[2]	16,640[2]	24,726[2]			10,000
Suriname			96[3]	936[3]	9013[3]				
Trinidad & Tobago			78[2]	1492[2]	799[4]	815[4]	2.97[4]	0.6[4]	10,000
Venezuela	888[5]	1300[5]	111[5]	30[5]	1,055[6]	9,021[6]			56,800

Information Sources: FAO Fisheries Reports #600, 628& 651; FAO Country Profiles (Venezuela); Heileman (2008); CRFM Fishery Reports 2007, 2008 & 2009

[1] 1996 estimates
[2] 2008 estimates
[3] 2007 estimates
[4] 2004 estimates
[5] 2000 estimates
[6] 1999 estimates

The focus of the TDA is on the ecosystem services being provided by the living marine resources found within the CSE. In this case, the main living marine resources found over the continental shelf are the shrimp and groundfish resources which are of considerable socio-economic importance as it relates to food security, poverty alleviation, foreign exchange earnings and the development of coastal communities.

It should be noted that while this TDA focuses mainly on the transboundary issues - unsustainable fishing, pollution and habitat and community modification - affecting the important shrimp and groundfish fisheries within the NBSLME, there are other shrimp and groundfish fisheries within the CLME (in the waters of Jamaica, Panama, Nicaragua and Belize) which may be facing similar problems. As such, the lessons learnt from addressing these transboundary issues in the NBSLME may be applied to other CSEs within the CLME at the national and regional levels.

This CSE TDA, along with the TDAs for the reef and pelagic ecosystems and the regional governance framework, will serve to inform the development of the regional TDA for the CLME.

3. Background

3.1 Global and regional significance of the CLME

The Caribbean Sea Large Marine Ecosystem (CLME) is a semi-enclosed tropical sea bounded by North America (South Florida), Central and South America and the Lesser Antilles Chain of Islands (Figure 1). The Caribbean Sea and adjacent regions include a wide variety of tropical ecosystems, associated natural resources and biodiversity. The region includes 26 countries and 19 dependent territories of the USA, UK, France and the Netherlands, with countries ranging from some of the largest (e.g. Brazil and the USA) to some of the smallest (e.g. Barbados, St. Kitts and Nevis) in the world, and from the most to the least developed. Throughout the region, there is a high dependence on marine resources for livelihoods, particularly from fishing and tourism. As such, the sustainability of its living resources is of considerable importance to an appreciable portion of the countries in the region.

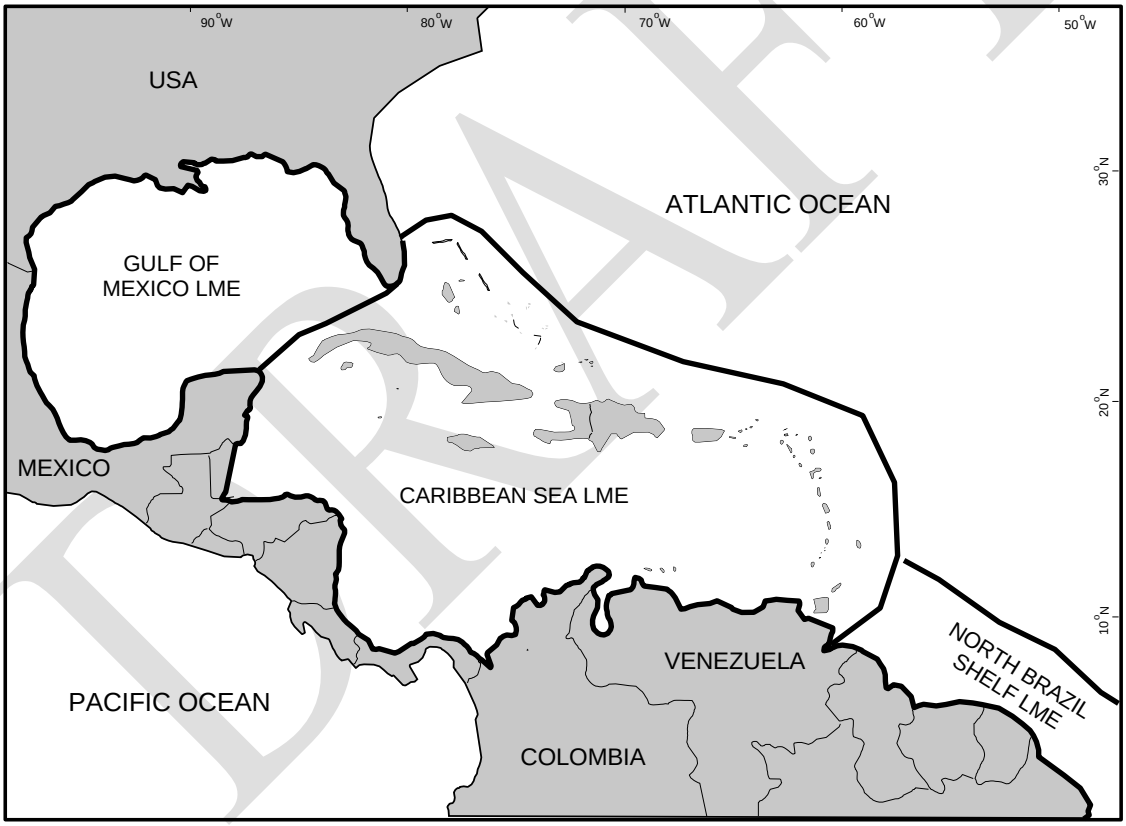


Figure 1. The Caribbean and Adjacent Large Marine Ecosystems

The overall objective of the CLME Project is the sustainable management of the shared living marine resources of the Caribbean LME and adjacent regions through an integrated management approach. It is expected that this project will provide an opportunity for the implementation of

management reforms that will permit sustainable development and management of the shared LMRs of the Caribbean Large Marine Ecosystem and adjacent regions. Since most LMRs are shared in some way, these reforms can be expected to lead to improved food security and enhanced livelihoods in coastal communities that rely on fisheries and tourism (CLME Project Coordinating Office, 2006).

3.2 Purpose of the Transboundary Diagnostic Analysis (TDA)

Transboundary Diagnostic Analyses are science-based analyses of transboundary water-related concerns and opportunities that exist in multi-country surface water, ground water, and coastal/marine water systems. These analyses are used to identify priorities for joint action, root causes and scope for the concerns or opportunities, and serve as the basis for reforms and investments which are included in the strategic action programmes (SAPs)[1].

This TDA Report will review and reformulate the Thematic Report for the Guianas-Brazil Sub-region into the Continental Shelf Ecosystem TDA with an ecosystem approach to fisheries (EAF) focus. It will also include a revised causal chain analysis (CCA), gap analysis and the update of the CSE TDA with recommended interventions for inclusion in the SAP.

3.3 Geographic scope

The North Brazil Shelf Large Marine Ecosystem (Figure 2) is characterized by its tropical climate and 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 (Figure 3).

As described by Bischof, Mariano and Ryan, the NBC plays a dual role in that it first closes the wind-driven equatorial gyre circulation and feeds a system of zonal countercurrents, and second, provides a conduit for cross-equatorial transport of upper-ocean waters as part of the Atlantic meridional overturning cell. Large anticyclonic rings shed by the current swirl northwestwards along the South American coast, often reaching the eastern edges of the Lesser Antilles, where they eventually become absorbed into the Caribbean and Florida Currents.

The NBC appears as a surface-intensified flow with maximum speeds located above the 24.5 isopyncnal surface on the southern edge of all sections. Maximum speeds are typically found in the southern portion. Peak speeds of 110 cm s^{-1} have been recorded, although generally the current flows between 60-100 cm s^{-1} (Arnault *et al*, 1999; Bourles, *et al*, 1999). At about 5°S and 35°W, a salinity maximum of 37.1 was measured declining to 36.7 at the equator. However, salinity on average ranges anywhere from 35 to 36.75 (Bourles *et al*, 1999). Average temperatures of the NBC range from 22°C to 29°C. Near surface waters in this region show enhanced nutrient content (phosphate, silicate and nitrate) and their distribution confirm meanders of the NBC deduced from drifter experiments. These meanders are generated by the retroflection of the NBC in the western area, which then feeds the North Equatorial Countercurrent. (Oudot *et al*, 1998).

[1] (http://www.iwlearn.net/publications/TDA)

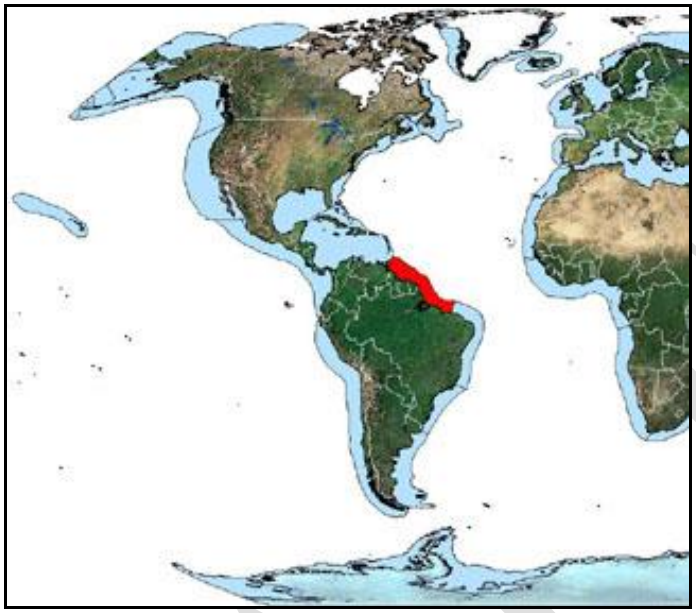


Figure 2. North Brazil Shelf LME (LME #17: North Brazil Shelf)

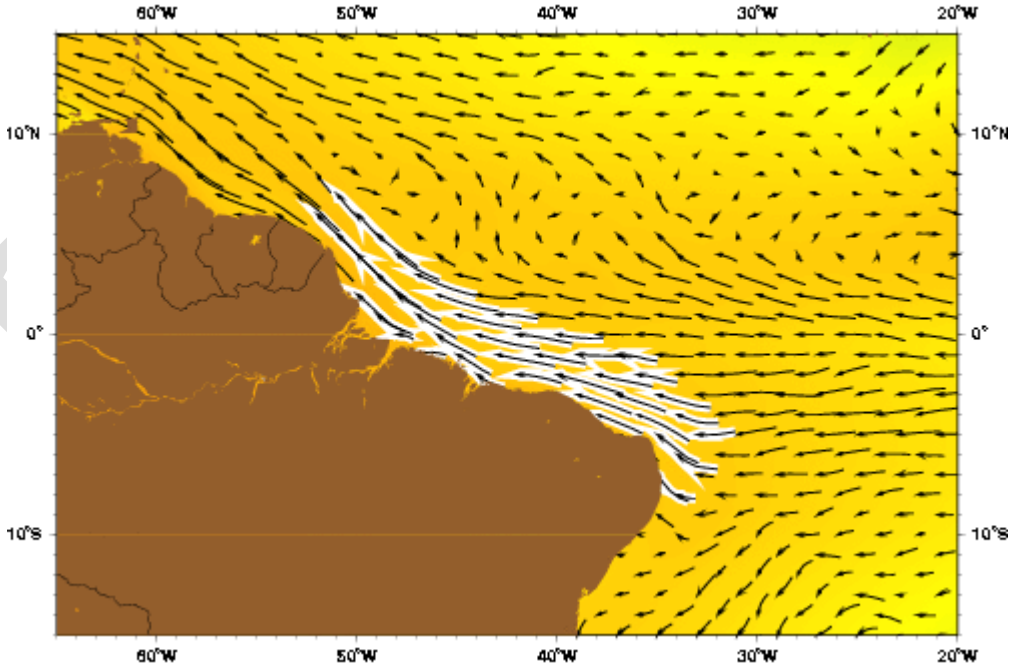


***Figure 3. North Brazil Current as represented by the Mariano Global Surface Velocity Analysis** (MGSVA). Source: http://oceancurrents.rsmas.miami.edu/atlantic/north-brazil.html*

The vertical circulation structure of the NBC is a well-studied and well-understood phenomenon and clearly summarized by Bourles *et al* (1999). The NBC rings are a significant contributor to transporting water across current gyres and between hemispheres in the tropical Atlantic. On average, NBC rings form 5-6 times per year, propagate at 14 km/day with a range of 8-30 km/day, and have a radius on the order of 100-200 km (Bourles *et al*, 1999).

Defined and influenced by the NBC, 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. It contains 0.01% of the world's coral reefs and 0.06% of the world's sea mounts. Shelf topography and external sources of material, particularly the Amazon River with its average discharge of 180, 000 $m3s^{-1}$, exert a significant influence on the marine ecosystem, with this being complemented by discharge from other rivers such as Tocantins, Maroni, Corentyne, and Essequibo. A wide continental shelf, macrotides and upwellings along the shelf edge are some other features of this LME (Heileman, 2008, 2010 and LME 17: North Brazil Shelf).

The Gulf of Paria, a 7800 km^2 inlet of the Caribbean Sea, lies between the Venezuelan coast (including the mountainous Paria Peninsula) and Trinidad. It extends about 160 km east-west and 65 km north-south, and is linked with the Caribbean to the north by a strait called the Dragon's Mouths and with the Atlantic to the south by the Serpent's Mouth (both roughly 16 km wide)[2] .

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 (Figure 4). 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 $gCm^{-2}day^{-1}$. 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[3].

Major fronts within the North Brazil Shelf LME are associated with outflow from the Amazon River and, to a lesser extent, the Orinoco River. The Amazon plume initially turns north-westward and flows along the Brazil coast as the North Brazil Current. Off the Guiana coast, between 5°N and 7°N, the North Brazil Current retroflects and flows eastward. This retroflection develops seasonally and produces anticyclonic rings of warm, low-salinity water that propagate north-westward toward Barbados, the Lesser Antilles Islands and eventually to the Caribbean Sea. The second major source of fresh water is the Orinoco River plume. Most thermal fronts are associated with salinity fronts related to freshwater lenses and plumes originated at the Amazon

[2] (http://www.britannica.com/eb/article-9058456/Gulf-of-Paria)
[3] (http://en.wikipedia.org/wiki/Gulf_of_Paria).

and Orinoco estuaries. Such fronts are relatively shallow, sometimes only a few meters deep. However, these fronts are important to many species whose ecology is related to the upper mixed layer. Fresh lenses generated by the Amazon and Orinoco outflows persist for months, largely owing to the sharp density contrasts across TS-fronts that form their boundaries (in case of fresh, warm tropical lenses, the temperature and salinity contributions to the density differential reinforce each other) (Heileman, 2008, 2010).

Figure 4. Amazon Plume estimated at 380 kilometres wide on September 8, 2000
(Source: NASA)

For the purposes of this report the use of the term North Brazil Shelf LME (NBSLME) includes the adjacent area, the Gulf of Paria.

4. Continental Shelf Ecosystem and Socio-economic Settings

The NBSLME supports the major shrimp and groundfish fisheries of the Guianas–Brazil region. There are also lesser fisheries in this CSE for shelf-based schooling pelagic resources such as mackerels and jacks and for sharks. There are interactions among the resources that are exploited and also among the various commercial and small-scale fisheries that exploit them. Key ecosystem interactions are with coastal wetlands that serve as nursery habitats. At the human level, interactions with other marine sector users such as offshore energy and marine transportation could potentially increase and contribute to threatening the sustainability of the continental shelf ecosystem goods and services. Examples of such interactions with the habitat and living resources of the ecosystem include accidental spills of noxious substances from transiting ships and from possible hydrocarbon production and distribution infrastructure, disposal of garbage at sea and ballast water discharges, which increase the threat of alien invasive species (Mahon *et al*, 2010). Besides this CSE, there are other areas in the CLME with shrimp and groundfish fisheries e.g Jamaica, Panama, Belize and Nicaragua.

4.1 Fisheries and aquaculture

4.1.1 Description of the current fisheries

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).

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 CSE 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[4]. 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[5]. The artisanal multigear fleet of Trinidad and Tobago target pelagic or demersal species. Among the pelagic species caught are mackerels (***Scomberomorus brasiliensis, S. cavalla***), with 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***)[6].

The semi-industrial multigear vessels operating within the territorial waters and the exclusive economic zone (EEZ) also target king mackerel, dolphinfish, swordfish (***Xiphias gladius***) and tunas (***Thunnus albacares, T. obesus***). Marlins (***Makaira nigricans, Tetrapturus albidus***), wahoo, dolphinfish and sharks are caught as bycatch[7].

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 stabilized (Figure 5). The value of the annual landings peaked at over 900 million US$ in 1986 (Figure 6). Brazil followed by Venezuela, Guyana and Suriname, account for most of the catch from this area (Figure 7).

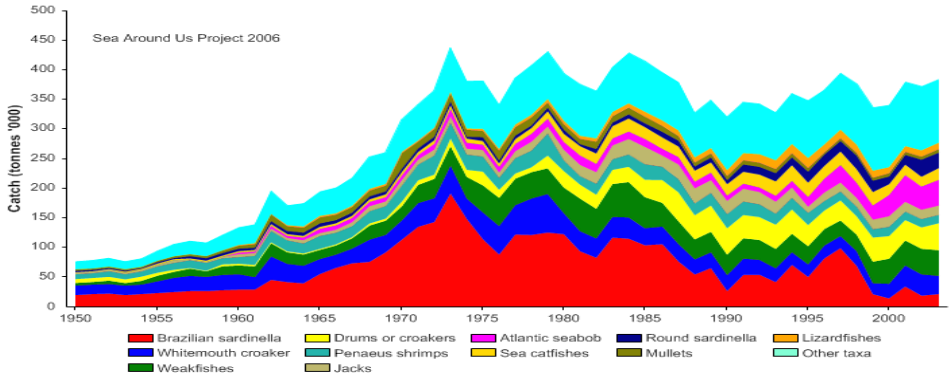


Figure 5. Annual fish landings in the North Brazil Shelf LME (Sea Around Us 2006)

[4] (http://www.eoearth.org/article/North_Brazil_Shelf_large_marine_ecosystem#gen2)
[5] (http://www.fao.org/fishery/countrysector/FI-CP_GY/en)
[6] (http://www.caricom-fisheries.com/LinkClick.aspx?fileticket=7%2B1B5CpxGDw%3D&tabid=86).
[7] (http://www.caricom-fisheries.com/ LinkClick.aspx?fileticket=7%2B1B5CpxGDw%3D&tabid=86)

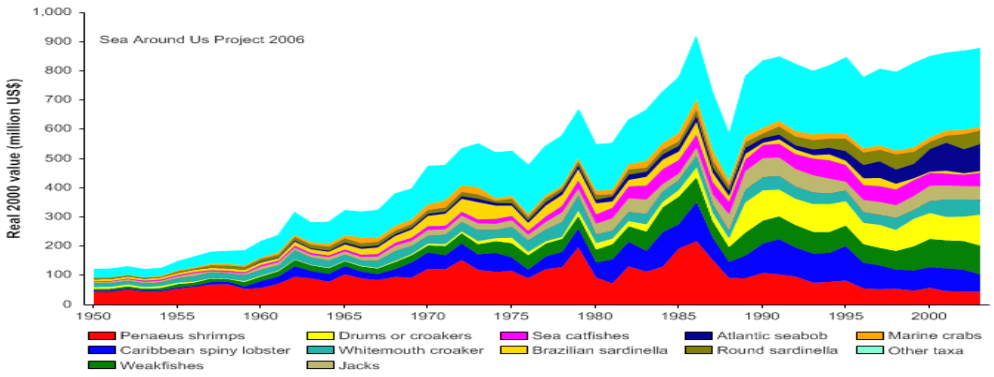


Figure 6. Value of fish landings in the North Brazil Shelf LME (Sea Around Us 2006)

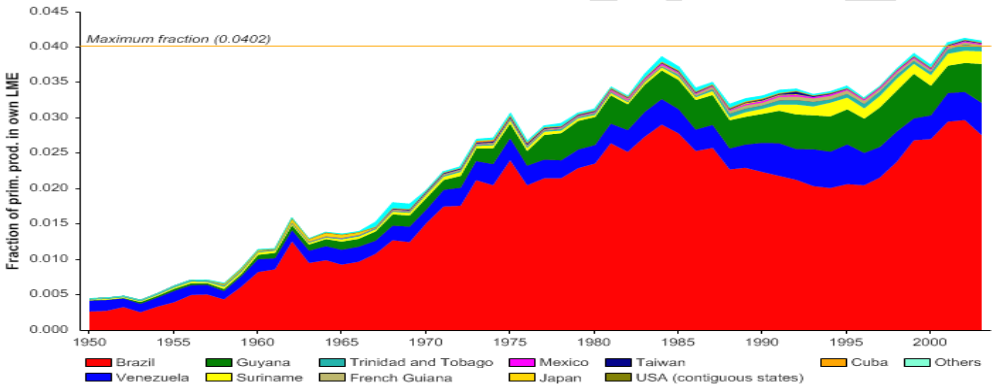
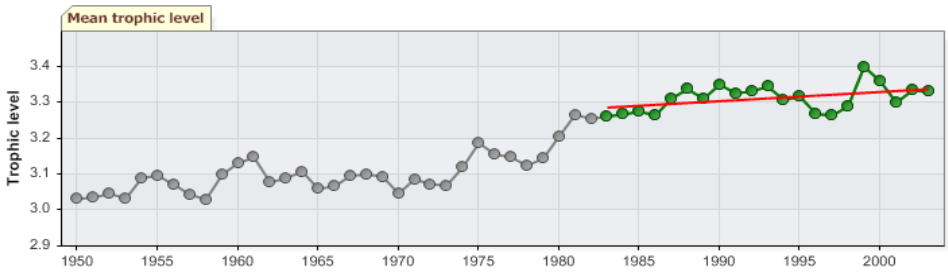


Figure 7. Primary production required by the catches by countries in the North Brazil shelf LME (Sea Around Us 2006)

Between 1983 and 2003, the Marine Trophic Index showed a slightly increasing trend (Figure 8 top), while the Fishing in Balance Index remained relatively constant (Figure 8 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).



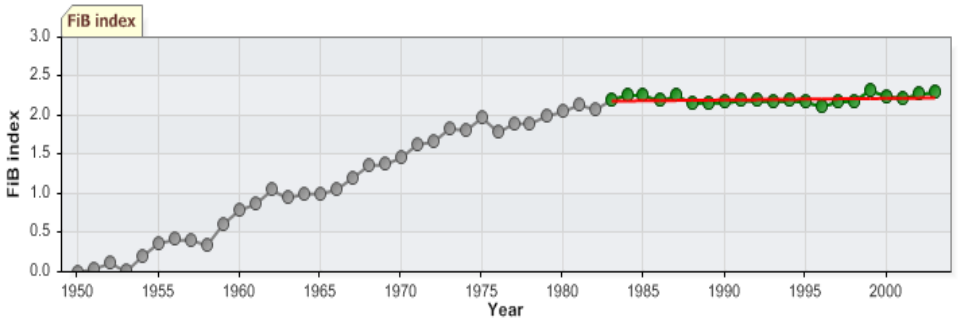


Figure 8. Marine Trophic Index (top) and Fishing in Balance Index (bottom) in the North Brazil Shelf LME (Sea Around Us 2006)

4.1.2 Description of shrimp fisheries in Jamaica, Panama, Nicaragua and Belize

Even though this TDA focuses mainly on the transboundary issues - unsustainable fishing, pollution and habitat and community modification - 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.

4.1.2.1 Jamaica

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. During 1999 and 2000, a trend of falling market prices had been observed, with it being reported that the shrimp were discoloured, possibly due to pollution in the Kingston harbor area, and that hotels and restaurants were switching to imported shrimp. The fishers involved are predominantly from low-income communities.[8]

4.1.2.2 Panama

According to the FAO country profile for 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.

[8] (http://www.fao.org/docrep/003/y1715e/y1715e06.htm#bm6.7).

There are 232 "Florida-type" trawlers with licences to operate in the shrimp fishery which catch several shrimp species such as the fidel, cabezón, carabalí, rojo and the titi. For the period 1996 – 2000, the total catches (tonnes) for all the shrimp species were 8,304; 8,979; 6,112; 5,441; and5 328.

A regulation, put in place in 1998, does not allow for the replacement of the shrimp vessels in order to reduce progressively the fishing capacity. As such, the vessels are quite old (more than 20 years)[9]. This information would appear to be for fishing in both the Pacific Ocean and Caribbean Sea.

4.1.2.3 Nicaragua

Pearl Lagoon is one of the biggest lagoons in the Caribbean and the biggest in Central America and is the home of the most abundant penaeid shrimp ***(Litopenaeus schmitti)*** fishery in the lagoon environment in Nicaragua. There are 10 communities in the area, representing 7 different ethnic groups, which for many years have dedicated themselves fundamentally to fishing activities as a means of subsistence and for sale outside the community. 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. The shrimp are caught mainly by hand nets (mosquito gear), with there being only about 4 to 7 artisanal trawling vessels in the Bar Point area. The fishermen in the area have been expressing growing concern about the shrimps stocks, with it becoming clear over the past years that the fish and shrimp stocks are becoming overexploited and with landings showing a serious decline. The once abundant shrimp fishery in the lagoon is disappearing *(*Colindres, 2006*).*

The regulations in Nicaragua strictly prohibit trawling within the lagoons, with the mesh sizes for trawls being restricted to ¾ inches for small shrimps in the coastal zone. However, it would appear that this regulation is not being fully implemented with fishers using smaller mesh sizes, especially when using the hand net, since the regulation does not include the use of hand net and they are also practicing trawling in the lagoon and close to the coast *(*Colindres, 2006*).*

4.1.2.4 Belize

The industrial shrimp trawl fishery has been an important fishery in Belize over the last six decades, with shrimp tails landings reaching a peak of over 145 MT in the late 1980s. Although landings dropped significantly to approximately 74 MT in 2004 with only four local trawlers and others fishing through joint venture agreements with local cooperatives, the fishery valued at Bze $948 thousand in 2004 was considered to be significant to the two main fishermen's cooperatives[10]. 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

[9] (http://www.fao.org/fi/oldsite/FCP/en/PAN/profile.htm)
[10] (http://www.fao.org/fishery/countrysector/FI-CP_BZ/en)

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.[11]

4.1.3 Description of coastal aquaculture

4.1.3.1 Brazil

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. In the north and northeast regions, native species and tilapia are the main cultured species, while polyculture farms utilizing carp are present in almost every state. Carp is currently the major fish species farmed in Brazil.[12]

With the creation of the Special Secretariat of Aquaculture and Fisheries (SEAP) in 2003, the aquaculture sector is experiencing a unique period of improved organization and development. Many investors are now looking to aquaculture as a promising option for investment and this is expected to result in increased production and job generation in coming years. There is enormous potential for aquaculture on the north and northeast coasts, especially with seaweed and native oyster production which is a predominantly female activity in many fishing communities.[13]

4.1.3.2 French Guiana

Aquaculture in French Guiana is aimed mainly at the production of freshwater shrimp (***Macrobrachium rosenbergii***) with direct employment for 12 persons.[14]

4.1.3.3 Suriname

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. The species contributing to most of the industrial aquaculture production is ***Litopenaeus vannamei***. In small-scale aquaculture the species being utilized are kwie-kwie (***Hoplosternum littorale***) and Mozambique (black) tilapia (***Oreochromis mossambicus***). These species are endemic to Suriname and can be found in fresh and brackish water bodies throughout the country, with fingerling being caught in the wild and introduced into controlled environments such as the backyards of local farmers. The industry makes no use of genetically improved or modified species.[15]

[11] (http://na.oceana.org/en/blog/2010/12/victory-belize-bans-trawling).
[12] (http://www.fao.org/fishery/countrysector/naso_brazil/en#tcNA002A).
[13] (http://www.fao.org/fishery/countrysector/naso_brazil/en).
[14] (http://www.iim.csic.es/pesquerias/Pesca/EU/regional%20socio-economic.pdf).
[15] (http://www.fao.org/fishery/countrysector/FI-CP_SR/en).

In Suriname, industrial production was 310 t in 2003 and 288 t in 2004, with no data being available for small-scale aquaculture production. The average farm-gate price was US$ 4.03/kg. Industrial aquaculture contributes to the economy by creating jobs and earning foreign exchange while small-scale aquaculture operations contribute to national food security and protein supply. Aquaculture, especially small-scale aquaculture, has had a positive impact on the livelihood of poor rural households by generating income, increasing fish consumption and improving family nutrition. Integrated rice-fish farming provides small-scale farmers with a better income and supports food security. The implementation of aquaculture in rice operations requires an environment free of chemical substances, which promotes food safety at the national and international levels.[16]

4.1.3.4 Guyana

In Guyana, the people on the Corentyne Coast have practiced a form of fisheries enhancement that is similar to aquaculture for over 100 years. Several attempts have been made over the years to develop freshwater and brackish water aquaculture especially since local consumer demand for freshwater fish is high; this is reflected in the per capita consumption of fish in Guyana (54 kg in 2008). Because of declines in the marine capture fisheries as well as marketing difficulties with traditional crops there has been a renewal of interest in aquaculture. 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. Aquaculture is still in its developmental stages and because of its almost insignificant contribution to the economy it is not recorded separately. The government's policy towards aquaculture focuses mainly on private sector driven growth with the government acting as a facilitator. Aquaculture is seen as a means of promoting agriculture diversification, improving food security, increasing the availability of high value protein food and improving environmental benefits.[17]

4.1.3.5 Venezuela

In Venezuela, the first steps or attempts in aquaculture date back to the first decree issued by General José Antonio Páez to stock "marine" fish in Lake Valencia, State of Carabobo, in 1830. Exotic commercial species were introduced and culture techniques for native species that could adapt to captivity were implemented. However, real aquaculture development began relatively recently with the cultivation of shrimp (***Penaeus sp.***) in the 1980s. By the end of 2004, the fish farming industry was adversely affected by the Taura syndrome viral disease that caused a significant drop in the production of shrimp; which constitutes 90.8 percent of the total national aquaculture production. In 2005, the introduction of Specific Pathogen Free (SPF) ***Penaeus vannamei***, which resists the Taura syndrome virus, was approved solely for reproductive

[16] (http://www.fao.org/fishery/countrysector/FI-CP_SR/en).
[17] (http://www.fao.org/fishery/countrysector/naso_guyana/en).

purposes. In addition to shrimp farming, tilapia (***Oreochromis sp***.) and trout (***Oncorhynchus mykiss***) cultivation follow in importance, but their cultivation has been hindered in recent years because of the genetic degradation of broodstock and inadequate fingerling supply. Estimated aquaculture production in 2003 was 15, 712 tonnes valued at USD 51, 088, 000.

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 (States of Táchira, Barinas, Apure, Cojedes, Carabobo, Bolívar, Monagas and Anzoátegui), with a marked growth in sales and consumption in the country's central area (Aragua, Caracas and Miranda) which are constituted by popular markets, self-service stores, fish shops, etc. 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.

The location of the main aquaculture production areas in the country correspond to those which present the best physical, natural, economic, and accessibility conditions for the installation of aquatic production units, either small-scale or rural, and commercial or industrial. At the same time, this approach takes into consideration the need to protect natural areas that are comprised of fragile ecosystems such as mangroves which may be affected by the development of aquaculture.[18] The impact of aquaculture during the last six years on the country's economy has been significant, especially in the agricultural sector and in geographic areas where the environmental conditions have favoured the establishment of aquaculture farming units. For example, in the South-western region of the country factors such as river pollution, over fishing, and population increases have encouraged agricultural producers to switch to aquaculture as an alternative for socio-economic development. The shrimp farming industry has had a significant impact on coastal regions where the conditions are favourable, such as Lake Maracaibo, the western coast of the state of Falcón, and the northeastern coasts. The thriving shrimp farms have promoted socio-economic development through the construction of access ways, the absorption of labour, and the implementation of services, in addition to the significant generation of foreign currency which contributes to the national economy within the extensive international processing and marketing chain.

The National Fisheries and Aquaculture Institute (INAPESCA) have included a project related to the genetic improvement of high biological and commercial value cultured species (which is supported by the national research sector) in its programmes. Tambaqui (***Colossoma macropomum***) cultivation is being developed in the country's rural areas (mostly integrated to other agricultural activities). In order to promote aquaculture development, INAPESCA has been promoting the establishment of a concentrated fish feed manufacturing plant adapted to the sector's needs as well as a financing programme with governmental banks to grant credit to the small and medium-sized aquaculture producers.[19]

[18] (http://www.fao.org/fishery/countrysector/naso_venezuela/en#tcNA002A).
[19] (http://www.fao.org/fishery/countrysector/naso_venezuela/en#tcNA002A).

4.1.3.6 Trinidad and Tobago

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. The stated vision for aquaculture is *"*to promote the development of an aquaculture industry that is sustainable and market driven in support of food and nutrition security, employment generation and rural development, creation of investment opportunities and foreign exchange*."* Despite such a vision, there are still significant constraints to aquaculture development such as the relatively high input costs of land, water, infrastructure and finance; availability of suitable and adequate land and the associated user conflicts; availability of an adequate water supply of acceptable quality; the need for the control of environmental degradation and pollution; availability of appropriate food fish species and the adequate production of fingerlings and the adoption of appropriate technologies.[20]

Aquaculture is practised at the subsistence and semi-commercial levels by approximately fifty-three (53) farmers. Information on the total acreage is not available. There are about three (3) aquaculture farmers of some significance. Their production of tilapia fingerlings and market size tilapia between 2000 and 2004 were estimated at 701 500 fingerlings and 45 000 kg respectively. The primary species being produced are the tilapia species (***Oreochromos nilotica)*** and the red hybrid tilapia. Other food fishes which are cultivated include ***Oreochromos mossambica***, ***Haplosternum littorale***, ***Hypostomus robinni*** and ***Macrobrachium rosenbergii***. There are numerous other species, both indigenous and introduced, which have demonstrated the potential for successful cultivation.[21]

4.1.4 Description of the offshore energy operations

4.1.4.1 Suriname

In Suriname, oil production began in 1985 at a rate of 1,000 barrels per day (bpd). In 2009, the output was 15,190 bpd, an increase of 60.9% from 2005 level, with oil consumption being 14,000 bpd (up from 12,578 bpd in 2005), and exports 1,190 bpd. Suriname is a small net exporter of oil. The proven oil reserves are 80 million barrels, which can give 14.4 years of production at the 2009 extraction rate. Oil refinery capacity is 7,000 bpd, but steps are in train to increase it to 15,000 bpd. Most of the oil that is produced is from onshore fields. All oil exploitation is reserved for Staatsolie which explores for, produces and refines oil and operates a 28 megawatt (MW) diesel-generated power plant. It is also exploring the possibilities of producing biofuels from sugarcane. Other private companies can only participate in oil exploration through production sharing agreements with Staatsolie (Standards Forum, 2010).

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

4.1.4.2 Trinidad and Tobago

In Trinidad and Tobago, petroleum has dominated the economy since the 1950s when offshore production began. In 1999, there were 18 international companies involved in oil and gas exploration and production, while the state-owned Petroleum Company of Trinidad and Tobago (Petrotrin) was involved in extraction and refining at its refinery at Pointe-á-Pierre. The oil and gas sectors are divided between foreign and national companies, with the former paying the government a royalty on all oil and gas produced. In the 1990s, production of refined petroleum averaged 125,000 barrels per day, this increased in 1999-2000 when world crude oil prices rose from US$11.64 per barrel in early 1999 to US$17.37 6 months later. In 1998, total oil-related exports, including crude oil, refined petrol, and gas, earned just over $1 billion, but this was expected to rise from 1999 onwards.

In 1999, Trinidad and Tobago had proven reserves of oil standing at 605 million barrels in (with possible reserves estimated at 2.6 billion barrels) and gas reserves standing at 22.9 billion cubic feet, enough to last 51 years at current rates of extraction. Recent findings have suggested that there may be even greater reserves of gas and oil off the shores of Trinidad.[22]

The country has made a transition from an oil-based economy to one based on natural gas; natural gas production over the period October 2007 through April 2008 was 115.2 million cubic meters per day, up from 111.9 million cubic meters per day over the same period in 2006-2007. About half of the country's natural gas production is converted into liquefied natural gas (LNG) at the Atlantic LNG facility in Trinidad and exported under long-term contracts and on the spot market. Trinidad and Tobago is the fifth-largest exporter of LNG in the world and the single largest supplier of LNG to the U.S., providing two-thirds of all LNG imported into the U.S. since 2002. Natural gas production continues to expand and should meet the needs of new industrial plants coming on stream over the next few years, including iron, aluminum, ethylene, and propylene. The petrochemical sector includes plants producing methanol, ammonia, urea, and natural gas liquids. After steady growth in recent years, this sector experienced the impact of a global economic slowdown which began in late 2008. A number of plants responded with temporary shutdowns.[23]

It should be noted that information on the offshore energy sectors for Brazil, French Guiana, Guyana and Venezuela was not readily available.

4.1.5 Description of marine transport operations

4.1.5.1 Suriname

In Suriname, the largest port Nieuwe Haven Seaport in Paramaribo and the second largest port Nieuw Nickerie, are owned by NV Havenbeheer Suriname (Suriname Ports), a government entity. In 2010, the terminals at Nieuwe Haven Seaport will be managed by three privately-owned Surinamese companies; Integra Marine and Freight Services; Continental Shipping Company, and VSH United. The port handles about 90% of all general import and export

[22] (http://www.nationsencyclopedia.com/economies/Americas/Trinidad-and-Tobago.html).
[23] (http://www.state.gov/r/pa/ei/bgn/35638.htm).

cargoes. From 2000 to 2008, container traffic grew from 19,000 teu (twenty-foot equivalent unit) to 56,000 teu. In 2008, Nieuw Haven received about 790 vessel calls (Standards Forum, 2010).

The Nieuwe Haven Seaport was rehabilitated in 2010 while the port at Nieuw Nickerie is being expanded and modernized. There is also a port at Paranam, located 42 nautical miles up the Suriname River, which is owned and operated by SURALCO, the aluminum company that is owned by Alcoa and is used to export bauxite (Standards Forum, 2010).

It should be noted that information on the maritime transport sectors of Brazil, French Guiana, Guyana, Trinidad and Tobago and Venezuela was not readily available.

4.2 Analysis of the current issues and the implications for the NBSLME

4.2.1 Fish and 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, with declining catch rates and a decrease in the size of this species. Recent trends in catch per unit effort and other analyses indicate that the corvina is now overexploited in some areas, with the low stock levels of this species being commensurate with exploitation levels beyond the MSY level. Similarly, 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. For instance, in Brazil, immature southern red snappers comprise over 60% of the catch of this species. Trawl and Chinese seines harvest bangamary at ages far below the age at maturity. 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. The trends in fishing mortality were not high enough to have created the very conspicuous decline in abundance, which implies that environmental factors (seasonal river run-off and rainfall) may be more significant than fishing in determining recruitment in these species (Heilemen, 2008). In the case of the seabob shrimp fisheries of Suriname and Guyana, preliminary analyses have indicated that there is no evidence from the catch and effort data that the stock is overfished and/or that overfishing is occurring (CRFM, 2009).

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 (Heilemen, 2008). Analysis of the species and sizes composition of shrimp by-catch has indicated that many commercial species are included, with only a small part being utilized, and that undersized individuals generally predominate. It is also felt that the species composition has changed over the years and that several species have practically disappeared from the by-catch

(Charlier, 2001). In 1998, a study showed that by-catch from the shrimp fishery in northern Brazil was about 7.2 kg of by-catch per kg of shrimp, with 4.4 kg of by-catch being useful for human consumption. It is possible that the above rates have not changed significantly since then. For the same period, in Venezuela, the by-catch amounted to 93% of the total catch in the nets, with 33 % being sold in the local markets and about 60% being returned, mostly dead to the sea (FAO/WECAFC, 2002.). Artisanal fishing gears such as "Chinese seines" and pin seines also catch large numbers of undersized fish, which results in inefficient utilization and contributes to overexploitation (FAO/WECAFC, 2001).

Although, the information on the status of the coastal pelagic fish being caught directly or indirectly in this CSE 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.[24] The Socialist Institute for Fishing and Aquaculture (INSOPESCA) of Venezuela had indicated that the government had intended to take actions to regulate shark fishing,[25] but no information appears to be available to determine whether such action had been taken.

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. However, continued monitoring for accurate determination of their overall status is required. Based on the limited data available, green turtles do not seem to be particularly threatened in Suriname or in French Guiana, but ongoing capture on the beaches of Guyana could constitute a serious threat to the sub-population nesting in the region. With regards to the olive ridley, it has been pointed out that the apparent declines in both Suriname and Guyana may be due to a shift to new nesting sites in French Guiana. Due to their relatively low numbers in the Guianas, little is known about the status of hawksbills or their relationship to other sub-populations in the Wider Caribbean Region. In the Western Atlantic, loggerheads nest mainly in the USA and Brazil, with rare occurrences on the beaches of the Guianas. Little is known about the abundance, distribution and behaviour of these turtles in nearshore and offshore waters (Kelle *et al*, 2000).

All sea turtles nesting and/or foraging in the Guianas may belong to shared populations, as evidenced by uniquely tagged females nesting on either side of an international border; post-nesting adults migrating between nations, and by juveniles exploiting habitats extending over multiple political jurisdictions. The IUCN has classified sea turtles as critically endangered or endangered and all locally occurring sea turtle species are protected by the national laws of the Guianas (Kelle *et al*, 2000).

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 capture by fisheries, especially by shrimp trawlers in the CSE, posed a serious management issue. This is being addressed by the nets of such trawlers having to be outfitted with turtle excluder devices

[24] (http://www.fao.org/fishery/countrysector/FI-CP_TT/en).
[25] (http://www.pretoma.org/venezuela-to-regulate-shark-fishingregulan-pesca-de-tiburon-en-venezuela/),

(TEDs), more so if the operators are exporting their product to the USA (which conducts an annual inspection and certification programme). 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). It is known that such activities occur within the NBSLME, especially in the shrimp and red snapper fisheries, with Brazil, Suriname, Guyana, Venezuela and Trinidad & Tobago having identified illegal fishing as a key management issue that needs to be addressed (Chakalall *et al*, 2002).

It should be noted that for the shrimp and groundfish fisheries of Jamaica, Panama, Nicaragua and Belize, the fisheries would appear to be fully or overexploited due to issues of IUU fishing, overcapacity, pollution and habitat degradation.

4.2.2 Pollution and ecosystem health

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.).

4.2.2.1. Analysis of the current issues and their implications

As a result of the coastal hydrodynamics in this area, the potential for transboundary pollution impact is significant. River outflow is deflected towards the northwest and influences the coastal environment in an area situated west of each estuary. It has been estimated that 40-50% of the annual Amazon run-off transits along the Guyana coast. In fact, Amazon waters can be detected

as far away as the island of Barbados. As a result, most of the coastal area of the NBSLME region has been described as an 'attenuated delta of the Amazon'. This implies that contaminants in river effluents, particularly those of the Amazon, could be transported across national boundaries and EEZs (Figure 9) (Charlier, 2001; Heileman, 2008).

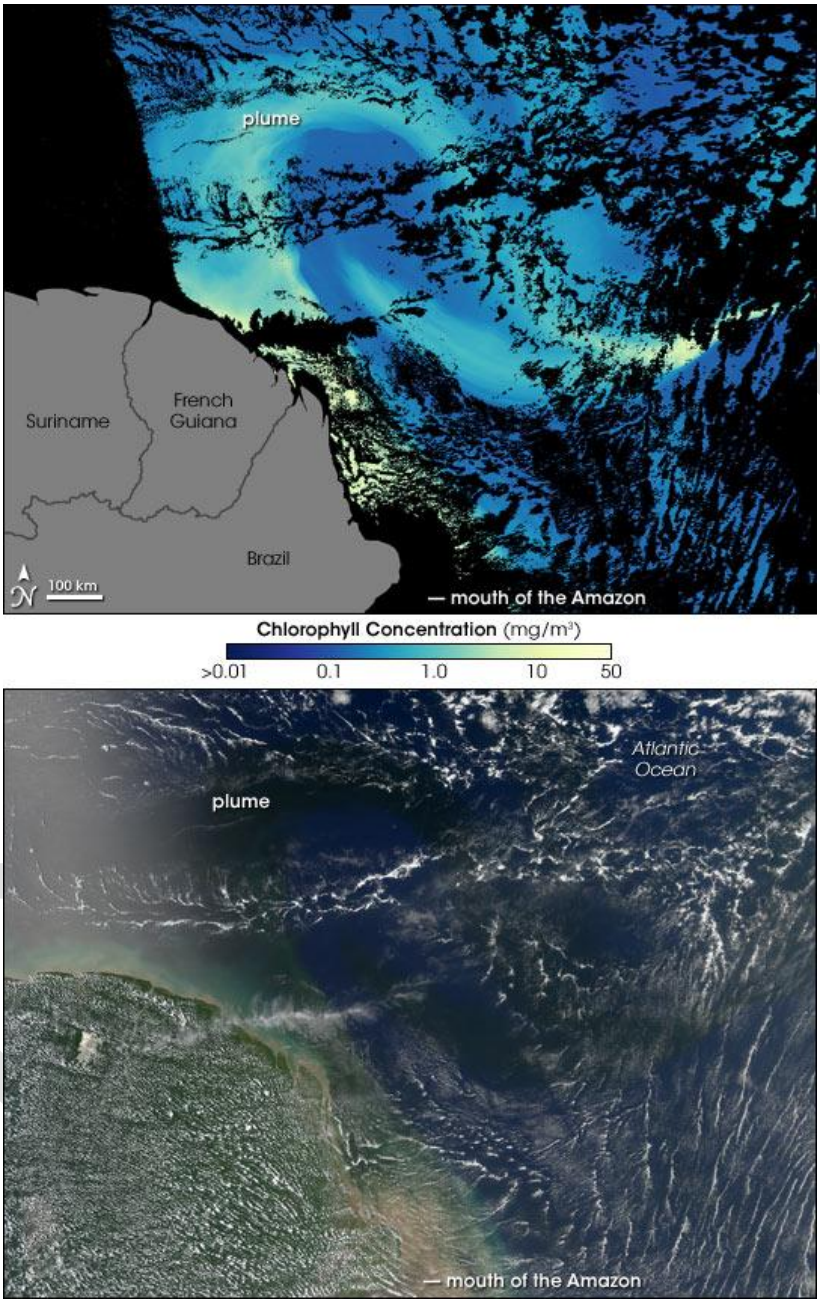


Figure 9. Transboundary Nature of Amazon Plume in the Guianas-Brazil Sub-region
(Source: http://earthobservatory.nasa.gov/Newsroom/NewImages/images.php3?img_id=17426)

4.2.3 Habitat and community modification

4.2.3.1 Brazil

Brazil holds about one-third of the world's remaining rainforests, including a majority of the Amazon rainforest, and is also overwhelmingly the most biodiverse country on Earth, with more than 56,000 described species of plants, 1,700 species of birds, 695 amphibians, 578 mammals, and 651 reptiles. Due to the vastness of the Amazon rainforest, Brazil's average loss of 34,660 square kilometers of primary forest per year between 2000 and 2005 represents only about 0.8 percent of its forest cover. However, deforestation in Brazil is one of the most important global environmental issues today. The increase in Amazon deforestation in the early 1970s coincided with the construction of the Trans-Amazonian Highway, which opened large forest areas to development by settlers and commercial interests. In recent years, growing populations in the Amazon region combined with increased viability of agricultural operations have caused a further rise in deforestation rates.[26]

4.2.3.2 French Guiana

The rainforests of French Guiana are still largely unexploited and sparsely populated, with the majority of the population living on the Atlantic coastal zone. For the immediate future, the forests of French Guiana face relatively few threats, although timber extraction is increasing and a relatively high population growth rate of displaced Lao farmers and other local groups may pressure coastal forest regions with subsistence agriculture. Gold potential in the interior regions is attracting foreign development interest, and there are some concerns over a potential road project.[27]

4.2.3.3 Suriname

Suriname's extensive forest cover and low population, about 400,000 concentrated in the capital and coastal cities, with 5 percent living in the rainforest, give it one of the lowest deforestation rates in the world. In past years there has been increasing concern over the developing mining sector, as Suriname is known to have rich deposits of gold and bauxite. Also, its inexpensive power costs make it attractive to the energy-intensive aluminum business. Such developments suggest that deforestation is likely to increase.[28]

4.2.3.4 Guyana

Guyana, a small, lightly populated country, is about three-quarters forested; approximately 60 percent of the forested area is classified as primary forest. In the past, these extensive forests have been lightly exploited, largely due to obsolete equipment and lack of capital. In the early 1990s, a large logging concession was granted to a foreign logging firm, and there was a rush from other firms to obtain similar concessions, but this was curtailed. Today, the level of harvesting in Guyana is very low.[29]

[26] (http://rainforests.mongabay.com/20brazil.htm)
[27] (http://rainforests.mongabay.com/20frenchg.htm)
[28] (http://rainforests.mongabay.com/20suriname.htm)
[29] (http://rainforests.mongabay.com/20guyana.htm).

It should be noted that the Government of Guyana (GOG) has embarked on a major Low Carbon Development Strategy (LCDS) to transform the country's economy. Under the LCDS, the country is now committed to a development path that emits low amounts of carbon, in exchange for financial compensation from the international community. Guyana's forests have been estimated to have a high economic value, so by pursuing a low carbon emission development path under the LCDS, the country can potentially gain approximately US$580 million per year. The governments of Norway and Guyana signed a memorandum of understanding in 2009 to demonstrate that a low-carbon development strategy could be a model for forested nations. Under the MOU, Guyana stands to receive substantial revenue flows totaling about US$250 million.[30]

4.2.3.5 Venezuela

Venezuela is one of the ten most biodiverse countries on Earth, with extensive rainforests that are increasingly threatened by development. Each year, roughly 287,600 hectares of forest are permanently destroyed, while other areas are degraded by logging, mining, and oil extraction. Between 1990 and 2005, it was reported that Venezuela lost 8.3 percent of its forest cover, or around 4,313,000 hectares.[31]

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.

4.2.3.6 Analysis of the current issues and their implications

Human activities along the coastlands have led to severe habitat modification in this CSE. 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).

In the past, coral reefs were mined for construction material. Currently, they are exposed to increased sedimentation due to poor land use practices and coastal erosion, chemical pollution from domestic sewage and agricultural pesticides, overfishing, tourism and development of oil and gas terminals. Additionally, there has been some coral bleaching associated with climate variation (Heileman, 2008 and LME 17: North Brazil Shelf).

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

[30] http://undp.org.gy/index.php?option=com_content&view=article&id=164&Itemid=101
[31] (http://rainforests.mongabay.com/20venezuela.htm).

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. In Suriname, small-scale fishers have reported the incidence of 'dead waters', in shallow areas, following fishing activity by trawlers. These dead waters were scattered with dead fish in larger amounts than could have been discarded by the trawlers. Vast areas were devoid of live fish, as they had apparently died or moved out of the area. Such mortality could be the result of local oxygen depletion, caused by the re-suspension of anoxic sediment combined with the presence of organic matter dumped from the vessels (Charlier, 2001).

Invasive alien species (IAS) 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 (MIS) compared to terrestrial species. However, the ballast water (BW) from ships is considered to be a major invasion pathway. Information compiled from various sources during a recent study of marine invasive species in the Wider Caribbean Region (WCR), which stretches from as far north as Florida (USA) to as far south as French Guiana in South America, revealed that the total number of MIS recorded so far was 118, with fishes forming the largest group (39) and arthropods (31) and molluscs (15) coming after. The green mussel (***Perna viridis***), an invasive species from the Indian and Pacific oceans, was found in Trinidad and Tobago (Lopez and Krauss, 2006).

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 BW release sites. The Convention is awaiting ratification (Lopez and Krauss, 2006). With regards to BW, the IMO is collaborating with the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), member governments and the shipping industry to assist less-industrialized countries to tackle the ballast water problem under the Global Ballast Water Management Programme, or GloBallast. The overall objectives of the programme are to assist developing countries to reduce the transfer of harmful organisms from ships' ballast water; implement the IMO ballast water guidelines; and prepare for implementation of the Convention.[32] Brazil was involved as one of the six pilot countries in the first phase (2000-2004) of the project (Lopez and Krauss, 2006).

Based on the success of the GloBallast Programme, the IMO has once more partnered with the Global Environment Facility, the United Nations Development Programme, 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

[32] (http://globallast.imo.org/index.asp?page=gef_interw_project.htm)

organizations. Private sector participation will be achieved through establishing a GloBallast Industry Alliance with partners from major maritime companies.[33]

The overall goal of the GloBallast Partnerships Project (GBP) 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. Thirteen countries, from six high priority regions, have agreed to take a lead partnering role focusing especially on legal, policy and institutional reform. A total of seventy countries in fourteen regions around the globe will participate, including the six pilot countries whose expertise and capacities will be drawn on for this global scaling-up effort.[34]

Trinidad and Tobago and Venezuela are listed among the thirteen countries that have agreed to take a lead partnering role in the partnership arrangements.[35]

Growth of the local human population and pressures associated with urban and industrial development will continue to threaten the environmental health of this region. The problems are potentially reversible, considering that there is a greater public and governmental awareness about environmental issues. Additionally, several measures at national and regional levels are being taken to address some of these problems (Heileman, 2008).

4.3 Identification of the major knowledge/data gaps in baseline information

4.3.1 Fish and fisheries

Recent work on the brown shrimp and pink-spotted shrimp show a consistent decrease in biomass in recent years, with the decline being attributed to such factors as fishing mortality, increasing fishing close to shore where immature shrimp are caught, and environmental factors possibly linked to rainfall and river outflow. However, there is still 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. Similarly, there is need to determine the possible links between recruitment of young shrimp and the environment and its likely effects on the fishery. Also, more bio-economic data and 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. In addition, there is 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 regards to the groundfish fisheries, the results of assessments of a limited number of species indicate high levels of exploitation with most stocks being fully exploited and frequently overexploited; but despite a desire for sustainable utilization, management was seriously

[33] (http://globallast.imo.org/index.asp?page=GBPintro.html&menu=true)
[34] (http://globallast.imo.org/index.asp?page=GBPintro.html&menu=true)
[35] (http://globallast.imo.org/index.asp?page=GBP-contacts.html).

hindered by a lack of comprehensive and reliable information on many important species (FAO/WECAFC, 2001). For example, even though the red snapper fishery, which started in 1940, is one of the most important fisheries in the region between eastern Venezuela and northern Brazil, not much is known about the stock structure and fishing effort being applied. The identification of the structure and fishing effort would contribute significantly to more effective management (Charuau, *et a*l, 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. Also, there is need to develop a better understanding of the oceanographic factors that influence these resources as well as the socio-economic and governance arrangements. Not much is known about the impacts of nearshore fishing gear such as the "Chinese seines," some nearshore gillnets, and pin seines on the resources and habitats.

The extent of IUU fishing in the CSE is unknown, but it is recognized that such activities can be detrimental to the management of the fisheries in the region, in terms of its impact on the assessment of the resources, management and economic returns.

The vulnerability of any sector to climate change is a function of (a) the degree of exposure to the threat, (b) the sector's sensitivity to the risk and (c) the capacity of the sector to cope with or adapt to the threat. An assessment of fisheries in the Caribbean region (and adjacent areas) may conclude that exposure and sensitivity capacity is low, with some of the reasons being observed and projected negative impacts (direct and indirect) on the sector, e.g. through habitat and ecosystem damage; linkage between ocean warming as a triggering mechanism in the proliferation of harmful algal blooms and various diseases; dependence of fisherfolk on the sector for employment, revenue generation and human well-being; and many fisherfolk tend to reside in vulnerable, low-lying coastal areas which exposes their physical assets (e.g. boats, gear, homes) to climate-related events such as storm surge and sea-level rise. While the sector has demonstrated considerable resilience to climate variability in the past, factors such as lack of consistent governance, access to capital on reasonable terms, weak fisherfolk organizations and consequently low bargaining power will compromise adaptation capacity in the future; and lack of insurance and other institutional support to enable the sector to rebound in the aftermath of extreme events e.g. severe storms, which are projected to become more frequent and/ or intense in the future. Since it is widely anticipated that climate change will amplify these challenges, appropriate and timely interventions will be required in order to minimize the adverse effects on stakeholders. As such, there is the need for stakeholders to accelerate the process of 'mainstreaming' climate change considerations into ongoing fisheries management programmes (Nurse, 2008).

This should be comprised of a set of practical measures aimed, inter alia, at building resilience in the sector, exploiting available opportunities, and minimizing the economic and social dislocation of fishers. At the very minimum, an adaptation package should be designed that would reflect the status of the science, and be flexible in order to benefit from new research findings. It should also exploit the knowledge base of key actors i.e. the fishers, while at the same time being cost-effective, and socially and culturally acceptable to stakeholders (Nurse, 2008).

4.3.2 Pollution and ecosystem health

Agriculture is very important to many economies in the region, such as Suriname and Guyana, but not much is known about its impact when extended into areas included in the broader marine environment, and the effluents carrying chemicals used in agriculture if they are drained in sufficient concentration to the sea. Little information is available on the effects of mercury from artisanal gold mining on the riverain, estuarine and marine ecosystems.

Residents living downstream from artisanal gold mining sites in the Amazon region are exposed to methyl-mercury through fish in streams and rivers polluted by small-scale gold mining operations. However, public health specialists have long been concerned about more direct exposures to mercury by the miners themselves, who inhale vapors when they burn off mercury that has been used to amalgamate gold during the recovery of the precious metal. They also can absorb mercury through their skin as they knead it into the soil sediment to amalgamate the gold. A team of researchers from John Hopkins University, doing scientific surveys with artisanal miners in Brazil, has shown that mercury can alter immune system response in artisanal gold miners. This study is viewed as just a snapshot and would have to be expanded into a larger-scale longitudinal study.[36]

4.3.3 Habitat and community modification

Additional research is required to improve 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. The impact of trawling on the nearshore habitats and benthic communities needs to be determined.

4.3.4 Socio-economic features

The coastal zone in the region has not been an area of spectacular economic or industrial development, with the largest part of the coast being virtually untouched by human activities. Urban development is concentrated near river mouths and on riverbanks close to sea, with human impact being probably the highest at both extremities of the region: on the right bank of the Amazon-Para estuarine system, and along the Gulf of Paria, on the Trinidadian side (Charlier, 2001).

Table 2 provides some socio-economic statistics for the countries in the NBSLME. The most populated country is Brazil, followed by Venezuela and Trinidad and Tobago, with the least populated being French Guiana. Of the six countries, Trinidad and Tobago has the highest per capita GDP and Guyana the lowest, with the others averaging US$10,425.00. In 2009, the infant mortality rate ranged from 15.3 to 31.10 for Venezuela, Brazil. Suriname, Guyana and Trinidad & Tobago, while French Guiana had an infant mortality rate of 12.07 in 2005. The per capita consumption of fish protein is significantly higher than the global average in Guyana, while for the other countries it ranges from 9.03 to 18.1 kg. The level of human development, as reflected

[36] (http://www.wellsphere.com/health-education-article/mercury-alters-immune-system-response-in-artisanal-gold-miners/1192310).

by the UN Development Index (HDI), is high for Brazil, Trinidad & Tobago and Venezuela and medium for Guyana and Suriname.

Table 2*: Selected Socio-Economic Statistics for the Countries in the CSE*

Country	Population (x 1000)	Infant mortality rate	GDP/cap (USD)	HDI level	Per capita fish consumption (kg)
Brazil	195,400[1]	17.30[3]	10,900.[1]	H (73)[1]	9.03[3]
French Guiana	195[2]	12.07[2]	8,300.[3]	Na	na
Guyana	761.4[1]	29.90[3]	6,800.[1]	M (104)[1]	54[5]
Suriname	524[1]	23.60[3]	9,900.[1]	M (94)[1]	16.9[6]
Trinidad and Tobago	1,300[1]	31.10[3]	22,100.[1]	H (59)[1]	14.0[5]
Venezuela	29,000[1]	15.30[3]	12,600.[1]	H (75)[1]	18.1[7]

Sources: CIA World Factbook; Food and Agriculture Organization Website; UNDP Website; World Bank Website; CRFM Website

[1] 2010 estimate [2] 2005 estimate
[3] 2009 estimate [4] 2007 estimate
[5] 2008 estimate [6] 1998 estimate
[7] 2001 estimate

Human activities include subsistence agriculture (rice, corn, cassava and beans), fisheries (mostly artisanal and focused on shrimp), and the exploitation of gold in the Amazon Basin. Logging and mining are also taking place in the Amazon basin. There is coastal exploitation of clay and sand, and limited ecotourism. (LME 17: North Brazil Shelf and Heileman, 2008). In Guyana and Suriname, agriculture (crops cultivated in the coastal areas), fisheries, and natural resources such as gold and bauxite are among the main economic activities.

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. In Brazil, while fisheries activities do not make a significant contribution to the GDP (about 0.4 %), it makes an important contribution to the livelihoods of the population living along the extensive coast, lakes, rivers and weirs, and has created about 800,000 jobs directly, with about 4 million persons depending indirectly on fisheries and fish farming.[37]

In Guyana, the fishery sector is of critical importance to the economy and to social well-being, with its economic contribution having grown dramatically in recent years. The sector contributes about 6% to GDP and employs about 10,000 persons directly (Heileman, 2008). In Trinidad and Tobago, the economy is dominated by oil, natural gas and petroleum exploration and export, so the contribution of the fisheries sector to the Gross Domestic Product (GDP) is small, and is estimated to be about 0.3%, which represents about 13 % of the total contribution of agriculture to GDP. However, it is estimated that the fishing industry employs over 10, 000 individuals

[37] (http://www.fao.org/fi/fcp/en/BRA/profile.htm).

directly, with another 50, 000 or so engaged in ancillary and support services. As such, these workers represent approximately 10% of the agriculture labour force.[38]

In general, unsustainable overexploitation of living resources as well as environmental degradation may result in threats to food security and loss of employment, as well as loss of foreign exchange to the countries bordering this region. (Heileman, 2008).

4.4 Analysis of economic, legal, administrative, and political context and constraints to action

Five countries (Brazil, Suriname, Guyana, Venezuela, and Trinidad and Tobago) and one dependency (French Guiana) border this CSE, and need to address the key transboundary living marine resources issues existing in it. The fragmented nature of coastal and marine resource management is a legacy of the colonial past. The languages and cultures of the foreign occupiers (Portugal, France, the Netherlands, Great Britain and Spain) were 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 the Ramsar Convention on Wetlands. However, there is currently a lack of coordinated support among these countries for 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, Agenda 21 of the United Nations Conference on Environment and Development (UNCED) 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 these countries to revise their legislation.

For example, in Brazil, Article 187 of the Federal Constitution of Brazil provides for the definition of an agriculture policy and explicitly includes agro-industrial activities, agriculture and livestock, fisheries and forestry, while Article 225 identifies a number of principles that concerns the environment. Included among these principles, are the protection of fauna and the ecological management of species and ecosystems, with both these principles implicitly including fisheries. The responsibility for the application of these principles lies with the "Poder Publico" (the Government). French Guiana, an overseas department of France, is covered by the common fisheries policy of the European Union, which came into effect in January 1983. Among other things, the policy calls for common rules for fishing in the maritime waters and co-ordination of structural policies of Member States to promote harmonious and balanced development of the fishing industry (Council Regulation (EEC) No. 101/76) (Chakalall *et al*, 2002).

[38] (http://www.fao.org/fi/fcp/en/TTO/BODY.HTM).

In Guyana, the fisheries are being regulated by the Fisheries Act 2002 (replaced the 1959 Fisheries Act and portions of the 1977 Marine Boundaries Act), which includes a number of new provisions, such as authorizing the Minister to promote the development and management of fisheries to ensure the optimum utilization of fisheries resources; mandating the Chief Fisheries Officer to prepare and keep under review a plan for the management and development of fisheries, including consultations with fishermen and others stakeholders and the creation of a Fisheries Advisory Committee (DOF, 2006). In Suriname, fisheries are regulated by the Decree on Marine Fishery, Decree C-14, in force since 1st January 1981. This legislation has been revised and a new fisheries law was drafted in 1992, which, when it comes into force would stipulate the elaboration of annual management plans for the fishery types, in which all regulatory measures will be established. This approach should allow fisheries managers to adapt to the changing conditions of exploitation.

In Trinidad and Tobago, the existing legislation, the Fisheries Act of 1916, was found to be inadequate as a legal basis upon which a modern fisheries management system can be structured. In June of 1995, a draft Fisheries Management Act and Policy Directions for Marine Fisheries in Trinidad and Tobago in the 1990s were prepared. The Act provides the framework for the management of both local and foreign fishing activity in the waters under the jurisdiction of Trinidad and Tobago. One of the major objectives as outlined in the draft National Marine Fisheries Policy is to provide for a move from a system of uncontrolled, free access to the fisheries resources towards a system of controlled access. The Policy would be dependent upon the preparation of Fishery Management Plans based on the best available scientific and socio-economic information, and the revised legislation would take into consideration the Government's participation in international agreements and national responsibilities for management of the resources of the Exclusive Economic Zone.

In Venezuela, trawl fisheries have been regulated by the joint resolutions of the Ministry of Agriculture (MAC/DGSPA/No. 46) and Ministry of the Environment (MARNR/DAA/No. 103) from 30th January 1980. The fishing areas for the trawling fleet and the ones reserved to the artisanal fishers are specified, both in the coastal zone and in the island territories. A second resolution (MAC/DGSPA/No. 391) from 13th December 1990 (Annex III) regulates the activity of the trawling fleet in the Gulf of Venezuela. All of these resolutions are under study, in order to establish up-to-date norms for this fishery (Chakalall, *et al* 2002).

It should be noted that under Article 23 of the Fishing and Agriculture Law, Venezuela banned industrial fish trawling in 2009.[39] However, there does not appear to be any literature indicating the likely effects of this action on the recovery of the resources or on the livelihoods of small-scale fishers.

For the countries bordering this CSE, fisheries administration is under the Ministry of Agriculture in all these countries with the exception of Brazil, where the responsibility is shared between the Ministry of Agriculture, responsible for development, issuing of licences and for the

[39] (http://venezuelanalysis.com/news/4302).

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. In Brazil CEPNOR (Centro de Pesquisa e Extensão Pesqueira do Norte do Brasil) is responsible for research in the North of Brazil (Atlantic Ocean and Amazon Basin), while in Venezuela FONAIAP (Fondo Nacional de Investigaciones Agropecuarias), a specialised research agency under the Ministry of Agriculture has the responsibility for fisheries research. In French Guiana, IFREMER (Institute Français pour l' exploitation de la mer) is responsible for research and it provides scientific advice on all aspects of fisheries to the French Ministry of Agriculture, which is responsible for conservation and management, including monitoring control and surveillance.

In most countries, the navy, air force, army, coast guard or police have been delegated the responsibility for monitoring, control and surveillance. This is done in collaboration with the national fisheries administrations, through agreements with the appropriate line agencies, which is the Ministry of Agriculture in most countries and IBAMA in Brazil (Chakalall, *et al* 2002).

Following the decisions taken at the 1996 Fourth Meeting of WECAFC Ad Hoc Shrimp and Groundfish Working Group of the Guianas–Brazil Shelf and CFRAMP Shrimp and Groundfish Subproject Specification Workshop, WECAFC in partnership with CFRAMP (now CRFM) conducted a series of workshops on the assessment and management of shrimp and groundfish fisheries on the Guianas–Brazil Shelf from 1997 to 2000 for the countries bordering the sub-region. This series of workshops culminated in a meeting of fisheries managers and ministers of the sub-region in 2001, and the First Regional Conference on the Sustainability of Fisheries Resources in the Brazil–Guianas Shelf in 2002, which sought to involve both resource managers and users. This approach to promoting fisheries resource assessment and management in the sub-region was viewed as an effective one, despite some shortcomings, and its continuation was recommended (FAO/WECAFC 2001).

UNCLOS and recent international initiatives in fisheries have made it necessary for the countries in the area to revise their policies and legal frameworks for fisheries management and development. To this effect, Brazil, French Guiana and Guyana have put the necessary legislation in place, while Suriname, Trinidad and Tobago and Venezuela were in the process of doing so. In general, the legislation in place or being put in place promotes the ecosystems based approach to management and calls for the development, implementation and regular evaluation of fisheries management and development plans, based on the best available scientific and socio-economic information, in consultation with the stakeholders involved in the various fisheries.

In most instances, fisheries administration and research fall under the umbrella of the Ministry of Agriculture of the countries of the NBSLME, except in Brazil, where fisheries administration is shared between the Ministry of Agriculture and IBAMA, with research being delegated to CEPNOR and, in Venezuela, where research has been delegated to FONAIAP. In general, MCS is delegated to the navy, air force, army, coast guard or police. In many of these countries some level of institutional reform is taking place to better enable the fisheries administrations to carry out their mandates. Many countries are faced with problems such as insufficient staff to fulfill essential functions, poor communication between different levels and interest groups, and no

clear decision-making procedures and responsibilities which mainly stem from insufficient funding (FAO/WECAFC, 2001).

Regional and sub-regional organizations such as the FAO/WECAFC and CRFM have been actively promoting fisheries management and development in the NBSLME. 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 the NBSLME, the countries may need to strengthen and/or develop mechanisms for regional collaboration and cooperation in areas such as assessment and management, harmonized legislation, a regional database for fisheries and related data, established mechanisms for strengthening MCS at the national and regional levels, involvement of the various stakeholders in the management process and building of public awareness.

In the case of aquaculture, administration, research and development fall under the fisheries authorities in Guyana and Suriname and the National Fisheries and Aquaculture Institute (INAPESCA) in Venezuela. Guyana and Suriname are in the process of drafting aquaculture legislation. In Suriname, the sector complies with the fisheries legislation pertaining to licensing, food safety, environment, harvest and post-harvest handling.[40]

INAPESCA was created through Decree No. 1 524 of 3 November 2001, published in the Official Journal of the Bolivarian Republic of Venezuela No. 37 391 of 13 November 2001, and is ascribed to the Ministry of Agriculture and Land (MAT). It is an autonomous institute with judicial personality, constituting the institutional executive arm of the Law of Fisheries and Aquaculture, based on the principles of responsible fishing and aquaculture and sustainable development, including social balance.[41]

At the regional level, the general objective of the Commission for Inland Fisheries of Latin America (COPESCAL) is the promotion of programmes of research and development leading to the rational utilization of inland fisheries resources, assisting member governments in the region in establishing the scientific basis for regulatory and other measures for the conservation and improvement of inland fishery resources, supporting the development of aquaculture, and encouraging education and training to reach these objectives.[42]

In the offshore energy sector, the state owned oil company Staatsolie Maatschappij Suriname N.V., which was founded on December 13, 1980, acts as the agent for the State. It actively promotes the development of the hydrocarbon potential of Suriname, and monitors petroleum agreements on behalf of the State (Staatsolie, 2008).

In relation to maritime transportation, the Maritime Authority Suriname (MAS) which was established in 1998 is the statutory body that enforces maritime and shipping legislation in

[40](http://www.fao.org/fishery/countrysector/naso_guyana/en);http://www.fao.org/fishery/countrysector/FI-CP_SR/en, http://www.fao.org/fishery/countrysector/naso_venezuela/en#tcNA002A).
[41] (http://www.fao.org/fishery/countrysector/naso_venezuela/en#tcNA002A).
[42] (http://www.fao.org/fishery/rfb/copescal/en).

Suriname. It is responsible for ensuring safe navigation in the maritime area and the internal waterways, which includes pilotage, maritime administration and casualty investigation (Maritieme Autoriteit Suriname, 2010).

The legal and institutional arrangements on integrated coastal management and environmental management at the national and regional levels should have been reviewed, but such information was not readily available. A similar situation applies to the offshore energy and marine transportation sectors for some of the countries involved.

5. Major Perceived Governance and Water-related Environmental Issues and Problems

The Millennium Ecosystems Assessment (MEA) has shown that all people depend on nature and ecosystem services to provide the conditions for a decent, healthy, and secure life. Also, in the last half-century, people have made unprecedented changes to the planet's ecosystems in order to meet the rising demands for food, fresh water, fiber, and energy. Such changes have improved the lives of many of the world's people, but they have been done at the expense of others, by weakening nature's ability to deliver key services, such as clean air and water and protection from floods, disease, and other disasters. Such losses disproportionately affect the poor.

The MEA has demonstrated that about 60 percent of the ecosystem services examined, including fisheries and fresh water, is being degraded or used in ways that cannot be sustained. There is growing evidence that many ecosystems could reach the "tipping point," at which sudden and irreversible changes can have grave implications for human well-being. Examples include the emergence of deadly diseases, the creation of "dead zones" in coastal waters, the collapse of fisheries, and shifts in regional climate.[43]

Classifications of ecosystem goods and services are mostly based on the Millennium Assessment approach which identifies four classes of ecosystem services:

- Provisioning services: the products obtained from ecosystems, including genetic resources, food and fibre, and fresh water
- Regulating services: the benefits obtained from the regulation of ecosystem processes, including the regulation of climate, water, and some human diseases
- Supporting services: these are necessary for the production of all other ecosystem services, including biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat
- Cultural services: the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experience as well as knowledge systems, social relations, and aesthetic values.[44] A major reason for the continued loss and degradation of continental shelf ecosystems is that the value of such ecosystems to human welfare is still underestimated in most economic development decisions as the benefits of their services are not captured in conventional market economics. Also, there is inadequate data for the process of decision making with most decisions in which trade-offs in ecosystem services are involved being based on incomplete information, leading to non-sustainable development. In many instances, the economic and social costs of non-sustainable ecosystem use are only realized when values are lost that can often only be restored at high costs. As such, ecosystem services are often given too little weight in policy decisions because they are not fully accounted

[43] (http://islandpress.org/assets/library/27_matoolkit.pdf)
[44] (http://openlandscapes.zalf.de/openLandscapesWIKI_Glossaries/Ecosystem%20Goods%20and%20Services.aspx).

for in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital.[45]

Data gaps regarding the value of the services being provided by the CSE contribute to the under-valuation of such services and as such should be addressed.

Table 3 shows the types of ecosystem services that can be obtained from coastal ecosystems (Adapted from Heileman, 2010). The CSE provides services which are critical to the socioeconomic development and wellbeing of the people in bordering countries.

The focus of the TDA is on the ecosystem services being provided by the living marine resources found within the CSE. In this case, the main living marine resources found over the continental shelf are the shrimp and groundfish resources which are of considerable socio-economic importance as it relates to food security, poverty alleviation, foreign exchange earnings and the development of coastal communities.

Following on literature review and consultations with the stakeholders (Table 4), the priority transboundary issues identified in the Preliminary TDA were overfishing (unsustainable fishing), pollution and habitat degradation and community modification. These were further confirmed at a meeting of the CLME TDA Technical Task Team in January 2010. This section includes the key transboundary living marine resources issues which have been identified for the CSE.

Within the context of the LME Modules (productivity, fish/fisheries, pollution/ecosystem health, socio-economics and governance (Duda and Sherman, 2002), the key transboundary issues in the NBSLME that would need to be addressed are set out below.

A. Fish and Fisheries

The key transboundary issue identified within the NBSLME is unsustainable fishing, including:

(i) Overexploitation of the shrimp and groundfish fisheries.
(ii) Excessive by-catch and discards and destructive fishing practices.
(iii) Illegal, Unreported and Unregulated (IUU) fishing.

B. Pollution and Ecosystems Health

With regard to pollution and ecosystem health the key transboundary issues identified are:

(i) Chemical pollution by fertilisers and pesticides from agriculture.
(ii) Heavy metal pollution by mercury from the gold mining industry.

C. **Habitat and Community Modification**

Under habitat and community modification, the key transboundary issue identified is:

(i) Modification or loss of ecosystems (mangroves/corals) and ecotones.

[45] http://openlandscapes.zalf.de/openLandscapesWIKI_Glossaries/Ecosystem%20Goods%20and%20Services.aspx.

Table 3*: Ecosystem services provided by coastal ecosystems*

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

Table 4. ***Areas of Interventions based on the Completed Questionnaires by Brazil, Guyana and Suriname***

Area of Intervention	Brazil			Guyana			Suriname			
	Over-Fishing	Pollution & Contamination	Habitat Degradation	Over-fishing	Pollution & Contamination	Habitat Degradation	Over-fishing	Pollution & Contamination	Habitat Degradation	Illegal Fishing
More data and information	3	2	3	3	3	3	3	3		2
More monitoring and enforcement	3	3	2	3	2	3	3	3		3
More laws	1	1	1	1	2	3	2	1		2
More inter-ministerial level decision-making	2	2	2	2	2	3	3	1		3
More private and NGO involvement	3	2	2	3	2	3	2	3		3
Better implementation of decisions	3	3	3	3	2	3	2	3		3
Collaborative effort with neighbouring /other countries	2	1	1	3	2	3	3	3		3

Key:
0: not important; 1: somewhat important: 2. very important; 3: absolutely necessary; 9: don't know

5.1 Fish and fisheries

5.1.1 Environmental Impacts

5.1.1.1 Overexploitation of the shrimp and groundfish resources

The effects of fisheries activities on the environment are considerable in the NBSLME region and can affect fisheries productivity, with the intensity of these impacts depending on local conditions, particularly the type of substrate and benthic cover, and the natural variability of the environment. They may be more marked, as far as the benthic environment is concerned, in the outer part of the shelf (beyond 20 m depth) than in the shallow, coastal, soft-bottom zone. But the impact on the structure of the fish communities themselves (species and size composition) is real both on the inshore and offshore components of the ecosystem. However, at present, the interactions between the fisheries and environment are difficult to define and quantify, as understanding these interactions requires a detailed knowledge of the mechanisms of the ecosystem, including its natural variability, which is not currently available (Charlier, 2001).

5.1.1.2 Excessive by-catch and discards and destructive fishing practices

Practically all fishing gear catch non-target species that, for the most part, cannot be returned alive to the sea. This unintended fishing mortality has drastically reduced several fish populations around the world, particularly demersal species in areas where there is an intensive shrimp trawl fishery. Fish populations can even be reduced outside the fishing grounds. The shrimp by-catch issue is well known in the region, where studies in many countries have attempted to quantify the impact on several commercial species. Analysis of the species and size composition of the by-catch reveals that many commercial species are included, that only a small part is utilized, and that undersized individuals generally predominate.

It is also felt that the species composition has changed over the years and that several species have practically disappeared from the by-catch, indicating a dramatic shrinking of their populations, notably in the case of sharks (Charlier, 2001). "Chinese seines" and pin seines also catch large numbers of undersized fish. Destructive fishing practices, such as the use of explosives and poisons on the reefs and mangroves to capture octopus and crabs respectively, and the use of nets to catch lobsters also contribute to habitat degradation.

5.1.1.3 Illegal, Unregulated and Unreported Fishing

Illegal, Unregulated and Unreported (IUU) fishing does not pay heed to national boundaries or regional/international attempts to manage fisheries resources, so it can place unsustainable pressure on fish stocks, marine wildlife and habitats.[46]

5.1.2 Socioeconomic consequences

Overexploitation of the shrimp and groundfish stocks in the NBSLME with inadequate fisheries management could adversely affect income, employment, food supply, and foreign exchange

[46] (http://www.illegal-fishing.info/).

earnings in the countries of the region. IUU fishing can lead to major losses in revenue in an area where dependency on fisheries for food, livelihoods and revenues is high.

5.1.3 Causal Chain Analysis

The Causal Chain Analysis (immediate, underlying and root causes) that was done in the Thematic Report for the Guianas–Brazil Sub-region (Phillips, 2007) was reviewed by the CLME TDA Technical Task Team in January 2010. The results are shown in Table 5.

Table 5 was further reviewed and refined, especially as it relates to Sector/Activities, with the results being provided in Figure 10. This figure was adapted from the causal chain diagrams in the GIWA Regional Assessments (UNEP, 2006).

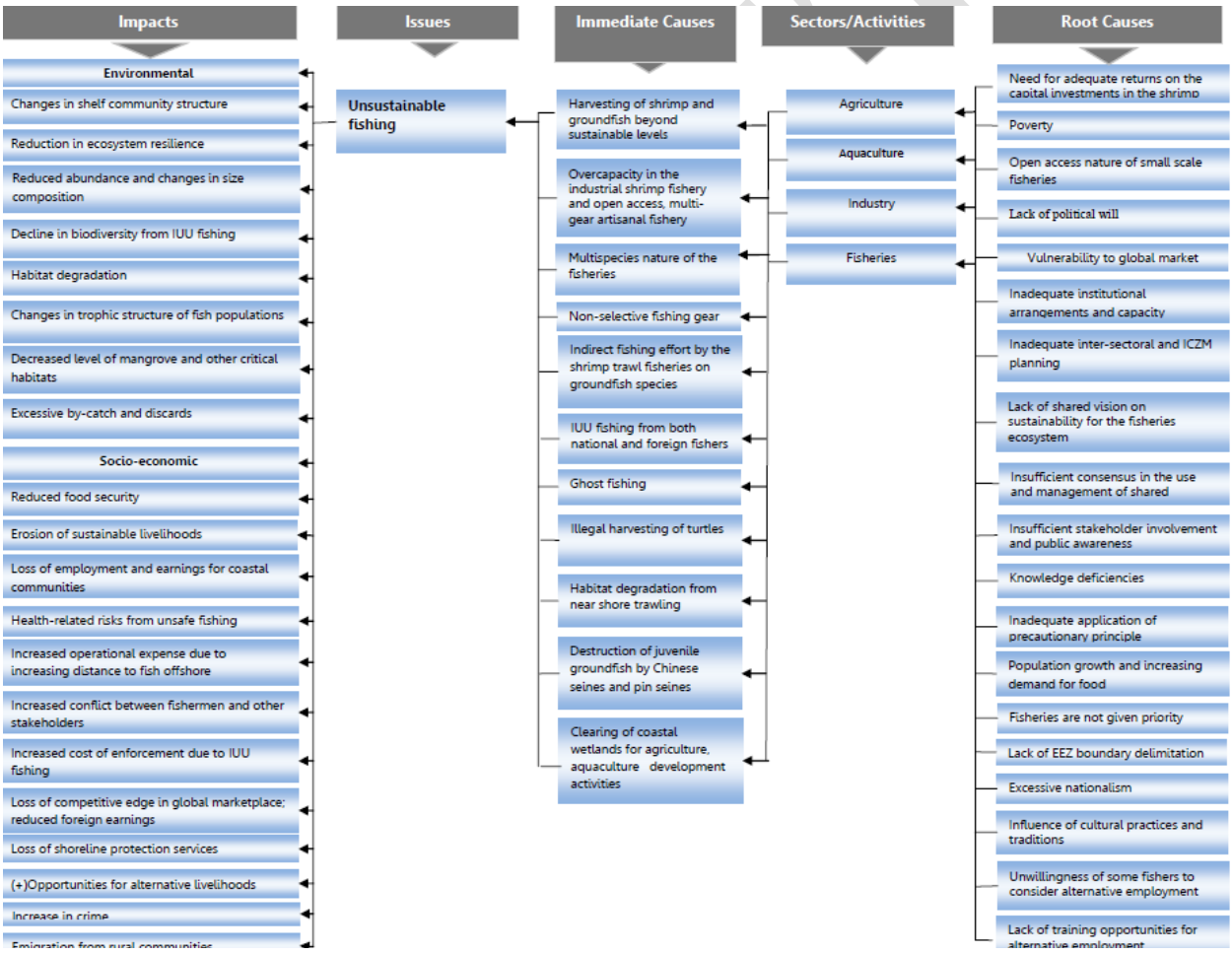


Figure 10: Causal chain diagram illustrating the causal links for unsustainable fishing

5.1.4 Linkages with other transboundary problems

In addition to overcapacity in the fishing operations, unsustainable fishing may be linked to environmental factors, which may be more significant than fishing in determining recruitment in some of these species. Shrimp and fin-fish trawls by legal and illegal operators can contribute to habitat and community modification.

5.2 Pollution and ecosystem health

5.2.1 Environmental Impacts

In general, pollution was found to be moderate, with most of it being concentrated in densely populated and industrialised coastal basins and not widespread across the region. However, contamination by mercury from gold mining and agro-chemical wastes were identified as the main sources of heavy metal and chemical pollution, with it being pointed out that mercury contamination could, on the longer-term, become a hazard for the coastal marine ecosystem and for human health, if suitable measures to limit its use were not implemented (Heileman, 2008).

Impacts on marine ecosystems generated by land-based human activities are called Marine Catchment Basin (MCB) effects. Such effects are particularly crucial in enclosed or semi-enclosed seas, but they are also important in the case of ecosystems that are strongly influenced by river run-off, as in the shallow areas of the Guianas-Brazil shelf (Charlier, 2001).

Urban development is concentrated near river mouths and on riverbanks close to sea, with human impact being probably the highest at both extremities of the region: on the right bank of the Amazon-Para estuarine system, and along the Gulf of Paria, on the Trinidadian side. Due to the hydrodynamics of the region, the central, largest part of the area may remain basically unaffected. Effluents from the relatively industrialized and populated Belém region, situated on the East bank of Pará River, are barred from this region by the outflow of the Amazon and Pará rivers. Effluents from the west coast of Trinidad reach the Gulf of Paria and, given the Northwards current through the Columbus Channel, cannot impact any region to the south. Some land-based human activities could have an impact on the marine environment and on fisheries in the region (Charlier, 2001).

(i). Chemical pollution by fertilisers and pesticides from agriculture

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, as can be seen from the review of coastal aquaculture in 2.1.2, seems to have been identified as a major area for development by most of the countries bordering the CSE 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).

(ii). Heavy metal pollution by mercury from the gold mining industry

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.

Investigations in Suriname indicate that mercury concentrations in fish may approach maximum norm (0.5 mg/kg) in piscivorous fish from the upper course of rivers, close to gold mines, and decreases towards the middle and lower course. 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).

5.2.2 Socio-economic consequences

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.

5.2.3 Causal Chain Analysis

The Causal Chain Analysis (immediate, underlying and root causes) which was done in the *Thematic Report for the Guianas–Brazil Sub-region* (Phillips, 2007) was reviewed by the CLME TDA Technical Task Team in January 2010. The results are shown in Table 6.

Table 6 was further reviewed and refined especially as it relates to Sector/Activities, with the results being provided in Figure 11. This figure was adapted from the causal chain diagrams in the GIWA Regional Assessments (UNEP, 2006).

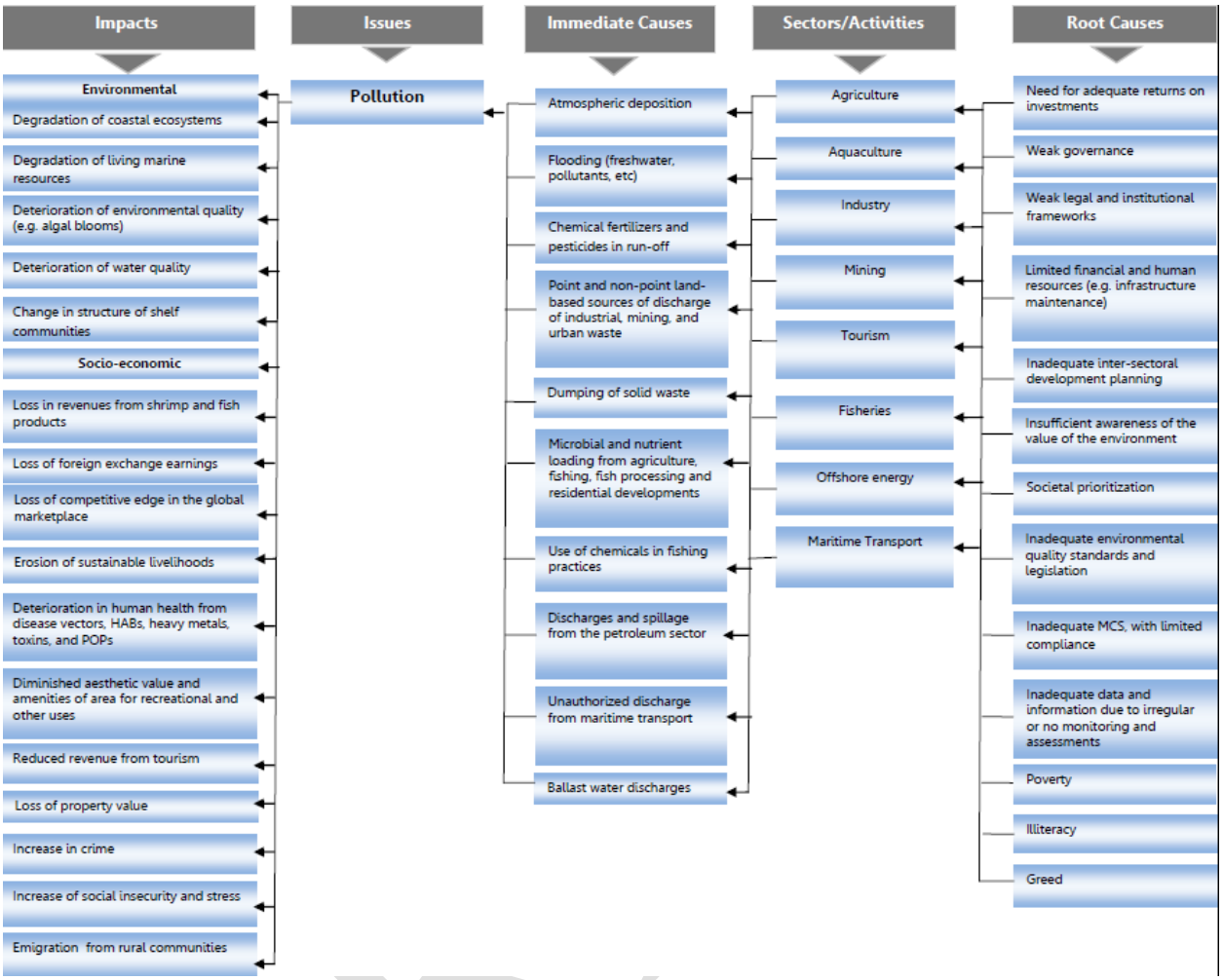


Figure 11: Causal chain diagram illustrating the causal links for pollution

5.2.4 Linkages with other transboundary problems

If not checked, the hazards posed to the coastal marine ecosystem by contamination from some chemicals being used in agriculture and gold mining could lead to the decline in fish stocks and other marine organisms.

5.3 Habitat and community modification

5.3.1 Environmental impacts

5.3.1.1 Modification or loss of ecosystems and ecotones

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. However, additional research is needed to improve understanding and quantify this role.

The existence and capacity of this near-coastal zone to fulfill 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. Ecological research is needed to identify such "critical" zones with a view to their conservation. There seem to be other particularly valuable areas, with a high primary production, like the "lixeira," in front of the Amazon estuary. Research on the processes taking place in these areas is required for the elaboration of an appropriate management strategy.

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 fulfill different functions such as providing shelter (hiding from predators), foraging area for food, breeding area, nursery area. The capacity to fulfill 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).

5.3.2 Socioeconomic consequences

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.

5.3.3 Causal Chain Analysis

The Causal Chain Analysis (immediate, underlying and root causes) which was done in the *Thematic Report for the Guianas–Brazil Sub-region* (Phillips, 2007) was reviewed by the CLME TDA Technical Task Team in January 2010. The results are shown in Table 7.

Table 7 was further reviewed and refined, especially as it relates to Sector/Activities, with the results being provided in Figure 12. This figure was adapted from the causal chain diagrams in the GIWA Regional Assessments (UNEP, 2006).

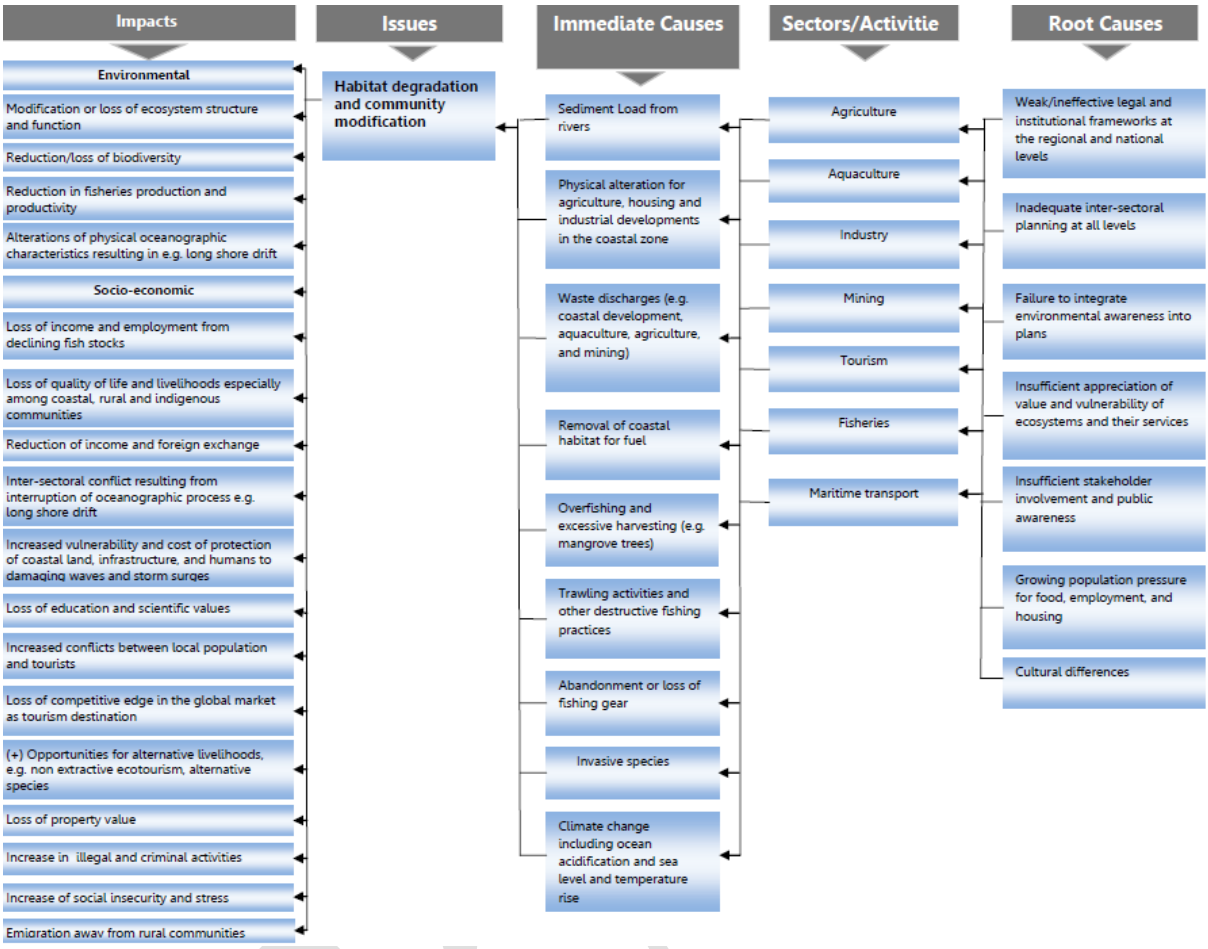


Figure 12: Causal chain diagram illustrating the causal links for habitat and community modification

5.3.4 Linkages with other transboundary problems

The removal of mangroves and associated habitats as well as the degradation of nearshore areas by trawls and other destructive fishing gear could lead to changes in composition and decline in fish populations.

5.4 Linkages with Other TDAs

Due to the migratory nature of the fishery resources which are found in the pelagic ecosystem and the importance of these resources, especially the coastal pelagics and sharks, to the livelihoods of fishers, their communities and other stakeholders in the countries bordering the CSE, it will be necessary to address the transboundary issues identified for these two ecosystems in a holistic rather than an isolated manner. Also, there is need to develop a better understanding of the oceanographic factors that influence these resources as well as the socio-economic and governance arrangements. Likewise, the lessons learned from addressing the transboundary issues in the coral reef ecosystem may be beneficial in dealing with the problems affecting any coral reef ecosystems in the CSE.

6. Analysis of Root Causes of the Identified Concerns and Issues

In January 2010, the CLME TDA Technical Task Team reviewed the Causal Chain Analyses that had been done for Fish and Fisheries, Pollution and Ecosystem Health, and Habitat and Community Modification in the Thematic Report for the Guianas-Brazil Sub-region and refined them as set out in Tables 5, 6 and 7. These CCAs were further reviewed and refined as set out in Figures 10, 11 and 12.

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.

7. Priority Areas for Future Interventions

7.1 Fish and 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:

(i) Identification of the stakeholders in the shrimp and groundfish fisheries, and the development of mechanisms for improved stakeholder participation in the management process.

(ii) Determination of the level of poverty in the fishing communities and the identification of alternative livelihood programmes.

(iii) Institutional strengthening of the fisheries administrations and research institutions at the national and regional levels.

(iv) Harmonization of fisheries and related legislation in the NBSLME.

(v) Strengthening of the existing mechanisms for regional collaboration in resource assessment and management.

(vi) Development of mechanisms for conflict resolution.

(vii) Development of a regional database for fisheries and related data/information.

(viii) Evaluation of the tools being used for fisheries management in the sub-region.

(ix) Continued assessment, including bio-economic assessments, of the shrimp and groundfish resources.

(x) Review and determination of the most suitable methods for by-catch utilization and reduction. In this instance, the information from the GEF Reduction of Environmental Impact from Tropical Shrimp Trawling through the Introduction of By-Catch Reduction Technologies and Change of Management, in which Venezuela and Trinidad and Tobago were involved, could be reviewed and utilized.[47]

(xi) Determination of the extent of IUU fishing in the region and the development of mechanisms to combat it at the national and regional levels.

(xii) Determination of the environmental factors that may be influencing recruitment of young shrimp to the shrimp fishery.

7.2 Pollution and ecosystem health

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:

[47] http://www.fao.org/figis/servlet/static?xml=gef shrimp.xml&dom=org&xp nav=14)

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

If the GEF/ UNIDO project to formulate a global action plan for countries that pollute their waters with mercury used as part of the process of artisanal gold mining is still being developed and/or implemented, then, in addition to Brazil, the countries bordering the region should seek to become involved in it (LME 17: North Brazil Shelf).

7.3 Habitat and community modification

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:

(i) Strengthening of the institutional framework for integrated coastal management.
(ii) Improved land use policies.
(iii) 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.
(iv) Creation of reserves to protect ecologically sensitive coastal ecosystems (e.g. mangroves).

It should be noted that Brazil, Guyana, Suriname and Venezuela, along with Bolivia, Colombia, Ecuador and Peru, were developing a project for support by GEF, entitled *Integrated and Sustainable Management of Transboundary Water Resources in the Amazon River Basin*. The overall objective of the project is to strengthen the institutional framework for planning and executing activities for the protection and sustainable management of land and water resources of the Amazon River Basin in a coordinated and coherent manner. The project recognizes the close linkages between integrated water resource management and the protection of marine habitats. Also, Brazil is seeking GEF support for the biodiversity project: *Strengthening the Effective Conservation and Sustainable use of Mangrove Ecosystems in Brazil* through its *National System of Conservation Units*. This project aims to develop conservation and sustainable management of mangrove ecosystems in Brazil to conserve globally significant biodiversity and key environmental services and functions important for national development and well-being of traditional and marginalized coastal communities (Heileman, 2008).

The project Integrated and Sustainable Management of Transboundary Water Resources in the Amazon River Basin Considering Climate Variability and Change was endorsed by GEF in 2009 and its objective is to contribute to the effective protection and sustainable use of the water and land resources of the Amazon Basin based upon the principles of integrated water resources management (IWRM) and managing the effects of climate change (CC) within Amazonian communities in a coordinated and coherent way. The eight signatory countries are Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, Suriname and Venezuela.[48]

[48] (http://iwlearn.net/iw-projects/Fsp_112799471058).

8. CSE: Ecosystems approach to fisheries

In the NBSLME, the inadequacies can be seen in terms of the absence of well-defined decision-making mechanisms at the national and regional levels that would lead to more effective adoption of management advice based on the best available scientific information. Also, the fisheries management advice was based mainly on the traditional single species management, without adequate consideration given to all the interactions that the target fish stocks had with predators, competitors, and prey species; the interactions between fish and habitat; the effects of fishing on species and habitat; pollution and ecosystem health; socio-economic effects; and governance arrangements. Therefore, well-defined and effective national and regional decision-making mechanisms, with the necessary administrative and management support, are essential for ecosystem approach to fisheries management in the CSE (Phillips *et al*, 2008).

According to the FAO, an ecosystem approach to fisheries (EAF) strives to balance diverse societal objectives by taking account of the knowledge and uncertainties of biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. The purpose of this approach to fisheries is to plan, develop, and manage fisheries in a way that addresses the multiple needs and desires of societies, without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems (FAO 2003).

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).

It should be acknowledged that the ecosystem approach will not be an instant replacement for traditional fisheries management, and should be seen as an evolution of the existing fisheries management systems. As such, progress towards EAF is likely to be achieved in an incremental way rather than overnight (JNCC 2010).

For the CSE, initial steps towards EAF should include the following:

1. Agreement on policy, goals, and management objectives for the goods and services provided by the ecosystem. In support, the required legislative and institutional framework should then be put in place.
2. Identification and involvement of all stakeholder groups in the application of EAF.

3. 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.
4. 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.
5. Decentralised regional approach to fisheries management in the NBSLME, 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.
6. Tailoring of research and information provision to support the ecosystem approach, including the documentation and use of traditional knowledge.
7. Application of adaptive management and the precautionary approach given the degree of uncertainty and dynamics of the ecosystem.
8. Development of an effective MCS capability.

In addition, fisheries management should not be seen in isolation from the management of the coastal zone, but over time should become better integrated with other social and economic sectors of coastal management. As such, even though the focus of the programme will be on improving the governance and management mechanisms for the fisheries in the NBSLME, attention should still be paid to such unfolding plans/projects as the LCD in Guyana, GEF *Integrated and Sustainable Management of Transboundary Water Resources in the Amazon River Basin Considering Climate Variability and Change*, GEF *Strengthening the Effective Conservation and Sustainable use of Mangrove Ecosystems in Brazil* and GloBallast Partnerships Project, the results of which may contribute to addressing the transboundary and other issues affecting the NBSLME.

The FAO Code of Conduct for Responsible Fisheries could serve as a valuable tool for applying EAF. It sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective conservation, management, and development of living aquatic resources with due respect for the ecosystem and biodiversity (FAO 1995).

In reference to a decentralised regional approach (see 5 above), the proposed CLME governance framework comprising complete policy cycles at multiple jurisdictional levels that are networked through both vertical and lateral linkages (Figures 13 and 14) would apply. The foundation for the proposed framework is a generic policy cycle (Figure 13), an iterative process that should lead to incremental improvement in management, with the different stages in the cycle (data and information, synthesis and provision of advice, decision making, implementation, and review and evaluation) requiring different inputs and actors, although there is overlap. The 'data and information' stage can be regarded as the primary area where the LME technical modules of productivity, fish and fisheries, pollution, and socio-economics make their contribution to the governance process.

The framework accommodates the diversity of policy cycle arrangements and linkage types that are likely to be required for comprehensive governance and is sufficiently flexible to incorporate the diversity of ecosystem-based management approaches identified by Christie *et al.* (2007).

The goal of interventions would be to establish and enhance cycles and linkages that are context specific and appropriate to purpose, capacity and complexity. This long-term goal can be approached incrementally by targeted interventions that focus on specific subcomponents of the framework (Fanning *et al*. 2007).

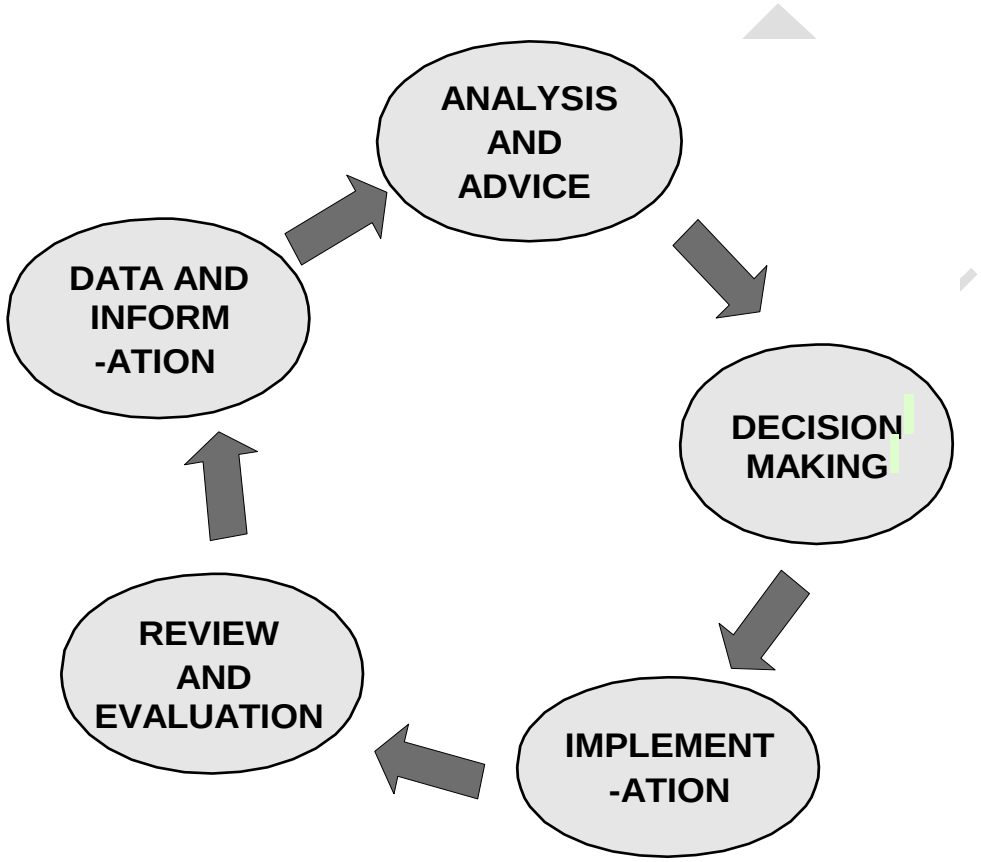


Figure 13. A generic policy cycle as used for the proposed governance framework (Fanning et al. 2007).

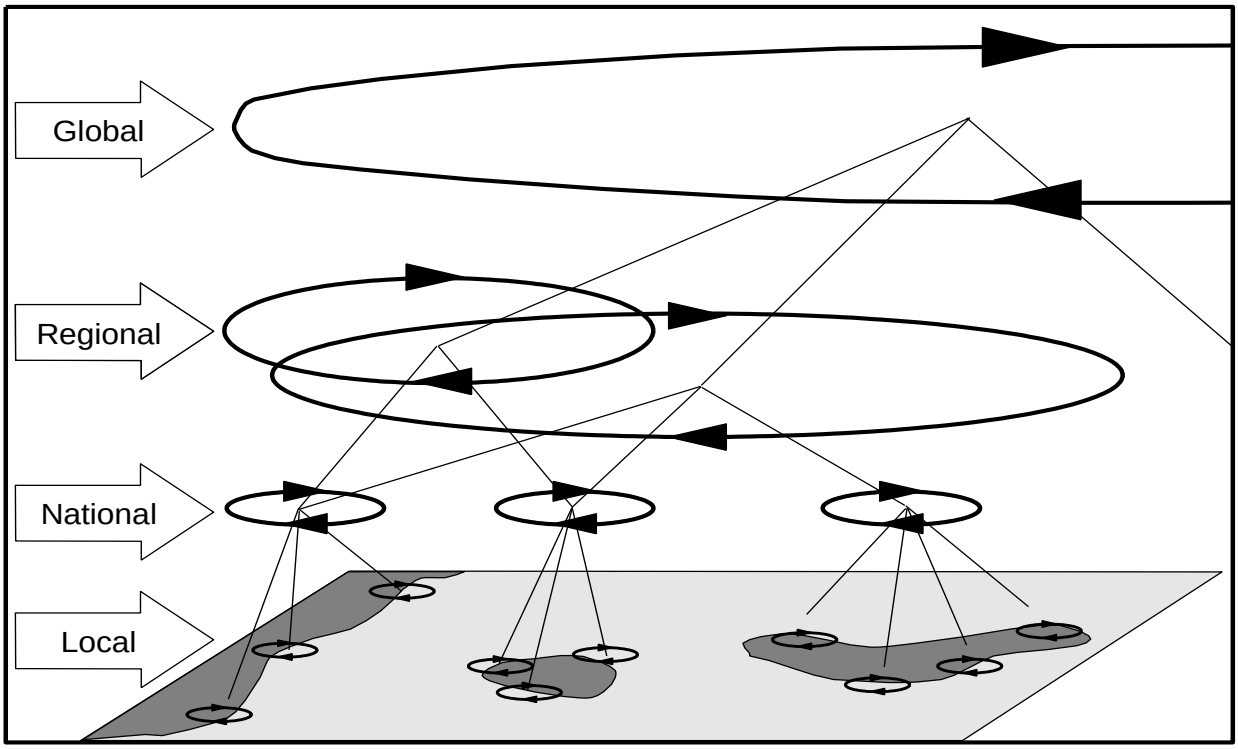


Figure 14. The multi-scale component of the proposed governance framework with vertical and horizontal linkages among the different policy cycles. The multilevel linkages do not necessarily imply a controlling function (Fanning et al. 2007).

9. Summary and Conclusions

The living marine resources of the NBSLME hold significant economic, environmental, cultural and spiritual value. Due to the shared nature of these resources, the major transboundary areas of concern identified in this report require urgent attention at the overall regional and NBSLME levels that can be implemented at the national and local levels.

As described above, unsustainable fishing could lead to further loss of income, employment, food supply and foreign exchange in the region. As such, interventions focusing on an enhancement of the all stages of the policy cycle -- ranging from the filling of critical information gaps to shared decision-making -- should be urgently addressed.

Heavy metal pollution from mining and agro-chemical pollution, if not effectively managed, could lead to degradation of the coastal marine ecosystems and in the case of mercury, could affect the health of miners and other members of the community should it enter the food chain. This issue, when coupled with the high dependence of the countries in the area on fish as a protein source poses a significant challenge to this region and within the Insular Caribbean as well, given the extensive range of dispersal of sediments from the major rivers in the NBSLME (Phillips, 2007).

Sustainable fisheries development in this CSE should take account of the full range of ecosystems goods and services, and should not threaten the sustained delivery of these goods and services to society. It is only realistic to expect that fisheries, being a human activity, will lead to human well-being and equity for all relevant stakeholders and should be developed in the context of the policies and goals of the other sectors.

Most of the countries bordering the NBSLME are already party to several international environmental agreements which shows a wide acceptance of the need for the implementation of EAF. Some preliminary work towards EAF has been initiated at the regional and national levels through WECAFC and CRFM. However, to apply this approach, EAF principles and concepts need to be translated into policy, goals, and objectives that can be achieved by applying appropriate management measures across jurisdictions over the short, medium, and long terms. A decentralised regional approach to fisheries management that incorporates the proposed multi-scale CLME governance framework would be required to achieve the goals and objectives of the ecosystem approach, with the recognition that the national level serves as the pivot around which the local and regional levels revolve.

Implementing EAF would require robust, participatory decision-making mechanisms at all levels, which would lead to more effective adoption of management advice based on the best available scientific information. In addition, fisheries management should not be seen in isolation from the management of the coastal zone, but over time should become better integrated with other social and economic sectors of coastal management (Phillips *et al*, 2008).

10. References

Arnault, S., B. Bourles, Y. Gouriou and R. Chuchla, 1999: Intercomparison of upper layer circulation of the western equatorial Atlantic Ocean: In situ and satellite data. *Journal of Geophysical Research*, **104**(C9), pp. 21,171-21,194.

Booth, A., A. Charuau, K. Cochrane, D. Die, A. Hackett, A. Lárez, D. Maison, L. A. Marcano, T. Phillips, S. Soomai, R. Souza, S. Wiggins, and M. Yspol. 2001. Regional assessment of the Brazil-Guianas groundfish fisheries. *FAO Fisheries Report* **651**:22-36.

Bischog, B., Mariano and Ryan. 2007. The North Brazil Current. Available at http://oceancurrents.rsmas.miami.edu/atlantic/north-brazil.htmlBourles, B., Y Gouriou and R. Chuchla, 1999: On the circulation and upper layer of the western equatorial Atlantic. *Journal of Geophysical Research*, **104**(C9), pp. 21151-21170.

Bourlès, B., Y Gouriou and R. Chuchla, 1999: On the circulation and upper layer of the western equatorial Atlantic. *Journal of Geophysical Research*, **104**(C9), pp. 21151 - 21170.

CIA World Factbook. https://www.cia.gov/cia/publications/factbbook/geos/gy.html

Chakalall, B., K. Cochrane and T. Phillips, 2002. Regional Conference on the Sustainability of Fisheries in the Brazil – Guianas Shelf, Paramaribo, Suriname, 5 – 7 March 2002: Existing Approaches to Fisheries Management in the Brazil – Guianas Shelf. WECAFC/B-G/1/4. 20 p.

Charlier, P., 2001. Review of environmental considerations in management of the Brazil Guianas shrimp and groundfish fisheries. *FAO Fisheries Report* **651**:37-57.

Charuau, A., K. Cochrane, D. Die, A. Lárez, L. A. Marcano, T. Phillips, S. Soomai, R. Souza, S. Wiggins, and M. Yspol. 2001. Regional Assessment of red snapper, *Lutjanus purpureus*. *FAO Fisheries Report* **651**:15-21.

Christie, P., D. L. Fluharty, A. T. White, L. Eisma-Osorio, and W. Jatulan. 2007. Assessing the feasibility of ecosystem-based fisheries management in tropical contexts. *Marine Policy* 31(3): 239–250.

CLME Project Coordinating Office, 2006. Caribbean Sea Large Marine Ecosystem: Sustainable Management of the Shared Marine Resources of the Caribbean Large Marine Ecosystem and Adjacent Regions (The CLME Project). 4 p.

Colindres, Clarence Oliver Gonzales. 2006. Description and analysis of the white shrimp (***Litopenaeus schmitti***) fisheries in Pearl Lagoon, Atlantic Coast of Nicaragua, with focus on the gear selectivity in the artesanal fleets. The Department of Aquactic Biosciences, The Norwegian College of Fishery Science, University of Tromsö. 28pp.

CRFM, 2005. A Review of the Current Situation on IUU Fishing and MCS in the Fisheries Sector of the CARICOM/CARIFORUM Region. A Strategy for Enhancing the Effectiveness of MCS and a Proposal for a Project to Enhance the Effectiveness of MCS. 55 p. Unpubl.

CRFM, 2009. Report of Fifth Annual Scientific Meeting – Kingstown, St. Vincent and the Grenadines, 09-18 June 2009. *CRFM Fishery Report* – 2009, Volume 1.

CRFM, 2009. Report of Fifth Annual Scientific Meeting, Kingstown, St. Vincent and the Grenadines, 09-18 June 2009. *CRFM Fishery Report – 2009*, Volume 1, Suppl. 1 – National Reports

CRFM. 2008. Report of the Fourth Annual Scientific Meeting, Kingstown, St. Vincent and the Grenadines, 10 - 20 June 2008. *CRFM Fishery Report – 2008*, Volume 1, Suppl. 1. 76p.

CRFM. 2007. Report of Third Annual Scientific Meeting, Kingstown, St. Vincent and the Grenadines, 17-26 July 2007. CRFM Fishery Report – 2007, Volume 1, Suppl. 1. 62p.

DOF, Guyana, 2006. Draft Fisheries Management Plan for the Fisheries of Guyana. Unpubl.

Duda, A. M., and K. Sherman, 2002. A New Imperative for Improving Management of Large Marine Ecosystems. Ocean and Coastal Management 45 (2002) 797 – 833.

Ehrhardt, N.M., 2001. Comparative regional stock assessment analysis of the shrimp resources from northern Brazil to Venezuela. *FAO Fisheries Report* **651**:1-14.

Fanning, L., R. Mahon, P. McConney, J. Angulo, F. Burrows, B. Chakalall, D. Gil, M. Haughton, S. Heileman, S. Martinez, L. Ostine, A. Oviedo, T. Phillips, C. Santizo, B. Simmons, and C. Toro. 2007. A large marine ecosystem governance framework. *Marine Policy* 31: 434–443.

Food and Agriculture Organization of the United Nations (FAO). 1995. Code of Conduct for Responsible Fisheries. Rome: FAO.

FAO, 1999. National reports presented and stock assessment reports prepared at the CFRAMP/ FAO/DANIDA Stock Assessment Workshop on the Shrimp and Groundfish Fisheries on the Guiana-Brazil Shelf. Port-of-Spain, Trinidad and Tobago, 7- 18 April 1997. *FAO Fisheries Report*. No. 600. Rome, FAO. 1999. 200p.

FAO, 2000. Information on Fisheries Management in the Republic of Trinidad & Tobago. http://www.fao.org/fi/fcp/en/TTO/BODY.HTM

FAO, 2000. Report of the third Workshop on the Assessment of Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf. Belém, Brazil, 24 May - 10 June 1999. *FAO Fisheries Report.* No. 628. Rome, FAO. 2000. 206p.

FAO, 2001. Fishery Country Profile. The Federative Republic of Brazil. http://www.fao.org/fi/fcp/en/BRA/profile.htm.

FAO/WECAFC, 2001. Report of the Meeting of Fisheries Managers and Ministers of the WECAFC Ad Hoc Working Group on Shrimp and Groundfish Resources in the Brazil – Guianas Shelf. Port of Spain, Trinidad and Tobago, 26-29 March 2001. FAO Fisheries Report. No. 650. Rome, FAO. 2001. 61 p.

FAO, 2001. Regional reviews and national management reports. Fourth Workshop on the Assessment and Management of Shrimp and Groundfish Fisheries on the Brazil-Guianas Shelf. Cumaná, Venezuela, 2-13 October 2000. *FAO Fisheries Report*. No. 651. Rome, FAO. 2001. 152p.

FAO/WECAFC, 2002. Regional Conference on the Sustainability of Fisheries in the Brazil – Guianas Shelf, Paramaribo, Suriname, 5 – 7 March 2002: Background to Shrimp and Groundfish Fisheries of the Region (Brazil – Guianas Shelf). WECAFC/B-G/1/5. 6p.

Food and Agriculture Organization of the United Nations (FAO). 2003. *The Ecosystem Approach to Fisheries*. FAO Technical Guidelines for Responsible Fisheries No. 4, Suppl. 2. Rome: FAO.

Gulf of Paria. http://en.wikipedia.org/wiki/Gulf_of_Paria

Gulf of Paria. http://www.britannica.com/eb/article-9058456/Gulf-of-Paria

Heileman, S. 2010. Consultancy to deliver the CLME Project Causal Chain Analysis (CCA) revision, CCA gap analysis and the update of the reef and Pelagic Ecosystems Transboundary Diagnostic Analysis (TDA). (In prep.)

Heileman, S. 2010. LME 17: North Brazil Shelf. Available http://www.lme.noaa.gov/index.php?option=com_content&view=article&id=63:lme17&catid=41:briefs&Itemid=72 (accessed 5 January 2010).

Heileman, S. 2008. 52. North Brazil Shelf LME. In: K. Sherman and G. Hempel (Eds). *The UNEP Large Marine Ecosystems Report: A Perspective on Changing Conditions in LMEs of the World's Regional Seas.* UNEP Regional Seas Report and Studies No. 182. Pp. 701–710. Nairobi: United Nations Environment Programme.

Kelle, L., S. Lochon, J. Therese and X. Desbois (Editors), 2000. 3rd Meeting on Sea Turtles of the Guianas. Proceedings. Programme de conservation des tortues marines de Guyane. Publication Nº 1.

Joint Nature Conservation Committee (JNCC). 2010. The ecosystem based approach. Available: http://www.jncc.gov.uk/page-1576 (accessed 5 January 2010).

LME 12: Caribbean Sea. http://na.nefsc.noaa.gov/lme/text/lme12.htm#governance

LME 17: North Brazil Shelf. http://na.nefsc.noaa.gov/lme/text/lme17.htm

LME #17: North Brazil Shelf. http://www.edc.uri.edu/lme/text/north-brazil.htm

Lopez, V. and U. Krauss, 2006. Final Report: National and Regional Capacities and Experiences on Marine Invasive Species, Including Ballast Waters, Management Programme in the Wider Caribbean Region – a Compilation of Current Information. 103p.

Mahon, Robin, Lucia Fanning and Patrick McConney, 2010. CLME TDA Update for Fisheries Ecosystems: Governance Issues - Progress report. 125 p.

Maritieme Autoriteit Suriname, 2010. Country Report - 11th Meeting of the Meso American and Caribbean Sea Hydrographic Commission (MACHC), 8 - 12 November 2010, Paramaribo, Suriname. 8p.

Nurse, Leonard, A., 2008. Incorporating Climate Change Projections into Caribbean Fisheries Management. In: Proceedings of the 61st Gulf and Caribbean Fisheries Institute,10-14 November 2008, Gosier, Guadeloupe Vol. **61**, pp. 130-138.

Oudot, Claude, Pascal Morin, Francois Baurand, Mohideen Wafar, Pierre Le Corre, 1998: Northern and southern water masses in the equatorial Atlantic: distribution of nutrients on the WOCE A6 and A7 lines. *Deep-Sea Research I,* **45**, pp. 873-902.

Pauly, D., 2005. The Marine Trophic Index. http://www.seaaroundus.org/doc/saup_manual.htm#19

Phillips, T. 2007. *Thematic Report for the Guianas–Brazil Sub-region. Prepared for the CLME Project*. Cave Hill Campus, Barbados: CLME Project Implementation Unit, Centre for Resource Management and Environmental Studies, University of the West Indies.

Phillips, Terrence, Bisessar Chakalall and Les Romahlo (2008). Management of the Shrimp and Groundfish Fisheries of the North Brazil Shelf LME: Ecosystem approach. In *Towards Marine Ecosystems-Based Management in the Wider-Caribbean* (in press).

Standards Forum, 2010. Country Brief Suriname, October 2010. 28 p.

Staatsolie, 2008. Company Profile Staatsolie Maatschappij Suriname N.V. 2p.

UNEP, 2006. Marine and coastal ecosystems and human wellbeing: A synthesis report based on the findings of the Millennium Ecosystem Assessment. UNEP. 76pp.

UNEP, 2006. Isaza, C.F.A., Sierra-Correa, P.C., Bernal-Velasquez, M., Londono, L.M. and W. Troncoso. Caribbean Sea/Colombia & Venezuela, Caribbean Sea/Central America & Mexico, GIWA Regional assessment 3b, 3c. University of Kalmar, Kalmar, Sweden.

11. Annexes

Table 5*: NBSLME CCA: Unsustainable fishing*

ITEM	Issue: Unsustainable fishing
Environmental Impacts	1. Changes in shelf community structure 2. Reduction in ecosystem resistance and resilience (e.g. Increase of susceptibility to natural disasters and the impacts of climate change) 3. Reduced abundance and changes in size composition due to irresponsible fishing practices 4. Decline in biodiversity from Illegal, Unreported and Unregulated (IUU) and other forms of irresponsible fishing 5. Habitat degradation 6. Changes in trophic structure of fish populations, with a trend towards small, low trophic level species 7. Decrease abundance of mangrove and other critical habitats 8. Excessive by-catch and discards of demersal species in shrimp fishery
Socio-economic Impacts	1. Loss of employment and financial gain accruing to coastal communities 2. Health-related injuries and death from fishing practices (i.e. increase risk taking) 3. Reduced food security (artisanal and industrial) 4. Erosion of sustainable livelihoods 5. Increase in operational expenses due to increasing distance to fish offshore 6. Increased conflicts between fishermen, and fishermen and other stakeholders. 7. Increased costs to ensure compliance due to poaching and illegal fishing 8. Loss of competitive edge in global marketplace (needs rewording) 9. Loss of foreign exchange earnings 10. Loss of shoreline protection service 11. Destabilization of coastal communities 12. (+) Opportunities for alternative livelihoods (e.g. non extractive ecotourism, alternative species) 13. Increase of criminal activities 14. Migration away from rural communities 15. Increase of social insecurity and stress
Immediate Causes	1. Harvesting of fish beyond sustainable levels + Catching of large quantities of immature and/or spawning individuals, particularly shrimp and groundfish 2. Non-selective fishing gear 3. Ghost fishing 4. The multispecies nature of these fisheries; 5. Destruction of habitats and loss of biodiversity 6. By catch 7. Illegal and irresponsible harvesting of turtles and other protected species 8. IUU fishing from both national and foreign fishers 9. Habitat loss or degradation from near shore trawling and deforestation of mangrove forests 10. Destructive fishing methods 11. Overcapacity (fishing effort and processing infrastructure) in the mainly industrial shrimp fishery and in the mainly open access, multigear groundfish artisanal fishery 12. Indirect fishing effort by the shrimp trawl fisheries on groundfish species 13. Destruction of juvenile groundfish by “Chinese seines” and pin seines; 14. Clearing for agriculture (rice), aquaculture (shrimp culture) and other development activities.
Sectors/Activities	1. Tourism 2. Agriculture 3. Industry 4. Mining 5. Gas

ITEM	Issue: Unsustainable fishing
Underlying causes	1. Inadequate knowledge of artisanal fishing effort 2. Lack of alternative food source 3. Foreign markets' demand for high value species 4. Inadequate institutional, policy and legal frameworks for fisheries and coastal zone management 5. Insufficient technical and financial capacity 6. Inadequate and insufficient information on the biology, economic and social status of each of the major fisheries 7. Lack of harmonization of policies & laws between sectors at local, national and regional levels. 8. Limited research, monitoring, enforcement and surveillance 9. Government subsidies 10. Need for foreign exchange 11. Easy access to foreign markets 12. Improvements in technology 13. Growing demand local and foreign 14. High level of investment in fishing and fishing infrastructure 15. Lack of incentives for sustainable fisheries 16. Lucrative nature of high value fishery 17. Opportunistic approach to fishing 18. Lack of data and information (unknown unknowns) 19. Foreign markets demand for shrimp and groundfish 20. High level of investment in a shrimp fishery 21. Local demand for groundfish as a source of food 22. Need for foreign exchange 23. Dependence on the groundfish fishery as a source of employment and income in many rural communities 24. Increasing cost of maintaining and operating aging industrial fleet
Root causes	1. Poverty 2. Illiteracy 3. Lack of political will 4. Ancestral memory and traditional knowledge 5. Lack of integrated governance structures and weak governance where it exists (structural and functional) 6. Failure to integrate environmental considerations in development plans 7. Open access nature of small scale fisheries 8. Lack of consensus in the use and management of shared resources 9. Lack of EEZ delimitation 10. Lack of priority for the fisheries by governments 11. Cultural practices 12. Excessive nationalism 13. Growing population pressure for food and employment 14. Limited resources (financial and human) and institutional capacity 15. Insufficient stakeholder involvement and public awareness 16. Inadequate planning at all levels 17. Vulnerability to global market forces 18. Food preferences 19. High level of uncertainty (e.g. lack of application of the precautionary principle) 20. Lack of a shared vision on sustainability for the fisheries ecosystem 21. Unwillingness of some fishers to consider alternative employment 22. Lack of training opportunities for alternative employment 23. The need by the shrimp & groundfish industry to obtain adequate returns on their capital investment

Table 6*: NBSLME CCA: Pollution and ecosystem health*

ITEM	Issue: Pollution
Environmental Impacts	1. Deterioration of environmental quality (e.g. algal blooms) 2. Deterioration of water quality 3. Degradation of coastal ecosystems 4. Degradation of living marine resources 5. Changes in structure of shelf communities.
Socio-economic Impacts	1. Diminished aesthetic value and amenity of area for recreational and other uses 2. Reduced revenues from tourism 3. Deterioration in human health from disease vectors, HABs, heavy metals, toxins and POPs 4. Loss in revenues from fish products 5. Erosion of sustainable livelihoods 6. Loss of competitive edge in global marketplace (needs rewording) 7. Loss of foreign exchange earnings 8. Loss of property value 9. Increase of criminal activities 10. Migration away from rural communities 11. Increase of social insecurity and stress
Immediate Causes	1. Atmospheric deposition 2. Flooding (freshwater, pollutants, etc) 3. Chemical fertilizers and pesticides in run-off 4. Microbial and nutrient loading from agriculture, fishing, fish processing and residential developments 5. Ballast water discharges 6. Use of chemicals in fishing practices 7. Discharges and spillages from the petroleum sector 8. Point and non-point land-based sources of discharge of industrial, mining and urban waste 9. Dumping of solid waste 10. Unauthorized discharge from maritime transport
Sectors/Activities	1. Tourism 2. Agriculture 3. Industry 4. Mining 5. Gas
Underlying causes	1. Poor agricultural practices (e.g. including excessive use of fertilizers and pesticides) 2. Unsustainable tourism practices 3. Poorly planned coastal development 4. Inadequate waste management and disposal 5. Deficient information 6. Limited application of national and international standards 7. Inadequate construction and maintenance of storage facilities for the waste containing cyanide and others from large scale mining operations 8. Increasing demand to produce crops for food (nutrition) and export 9. The demand for gold and other minerals in the world market 10. Lack of treatment of point sources of discharge 11. Limited cleaner production technologies in industry 12. Growth of aquaculture
Root Causes	1. Weak and ineffective legal, regulatory, and institutional frameworks 2. General lack of environmental quality standards and legislation 3. Limited financial and human resources (e.g. infrastructure maintenance) 4. Poor surveillance and enforcement, and limited compliance

ITEM	Issue: Pollution
	5. Lack of adequate data and information due to irregular or no monitoring and assessment 6. Inadequate integrated development planning 7. Poverty 8. Illiteracy 9. Need for adequate returns on investment 10. Weak governance. 11. Insufficient awareness of the value of the environment 12. Societal prioritization 13. Greed

Table 7*: NBSLME CCA: Habitat and community modification*

ITEM	Issue: Habitat and Community Modification
Environmental Impacts	1. Modification or loss of ecosystem structure and function 2. Reduction/loss of biodiversity 3. Reduction in fisheries production and productivity 4. Alterations of physical oceanographic characteristics resulting in e.g. long shore drift
Socio-economic Impacts	1. Loss of income and employment from declining fish stocks 2. Increased of illegal activities 3. (+) Opportunities for alternative livelihoods (e.g. non extractive ecotourism, alternative species) 4. Deterioration in quality of life among coastal communities 5. Increased conflicts between local population and tourists 6. Loss of quality of life and livelihoods especially among rural and indigenous communities 7. Reduction of income and foreign exchange 8. Loss of competitive edge in the global market as a tourism destination 9. Increased the vulnerability and cost of protection of coastal land, infrastructure, and humans to damaging waves and storm surges. 10. Loss of property value 11. Loss of educational and scientific values 12. Inter-sectoral conflicts resulting from interruption of oceanographic processes (e.g. long shore drift) 13. Increase of criminal activities 14. Migration away from rural communities 15. Increase of social insecurity and stress
Immediate Causes	1. Removal of coastal habitat for fuel 2. Trawling activities and other destructive fishing practices 3. Sediment load from rivers 4. Waste discharges (e.g. coastal development, aquaculture, agriculture and mining) 5. Physical alteration for agriculture, housing and industrial developments in the coastal zone 6. Abandonment or loss of fishing gear 7. Overfishing and excessive harvesting (e.g. of mangrove trees); 8. Invasive species 9. Climate change including ocean acidification and sea level and temperature rise
Sector/Activities	1. Tourism 2. Agriculture 3. Industry 4. Mining 5. Gas
Underlying causes	1. Resistance to change to less destructive fishing gear (e.g. Turtle Exclusion Device - TED) 2. Inadequate standards with limited application 3. Poor law enforcement 4. Unsustainable tourism practices 5. Improper land use and poor agricultural practices 6. Poorly planned and/or implemented coastal development 7. Inadequate waste management 8. Increasing demand for food, employment and income

ITEM	Issue: Habitat and Community Modification
Root Causes	1. Inadequate planning at all levels 2. Poor legal framework at the regional and national levels 3. Weak and ineffective regulatory and institutional frameworks 4. Failure to integrate environmental considerations in development plans 5. Cultural differences 6. Growing population pressure for food, employment and housing 7. Insufficient stakeholder involvement and public awareness 8. Lack of appreciation of value and vulnerability of ecosystems and their services