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Science and Research Serving Effective Ocean Governance in the Wider Caribbean Region

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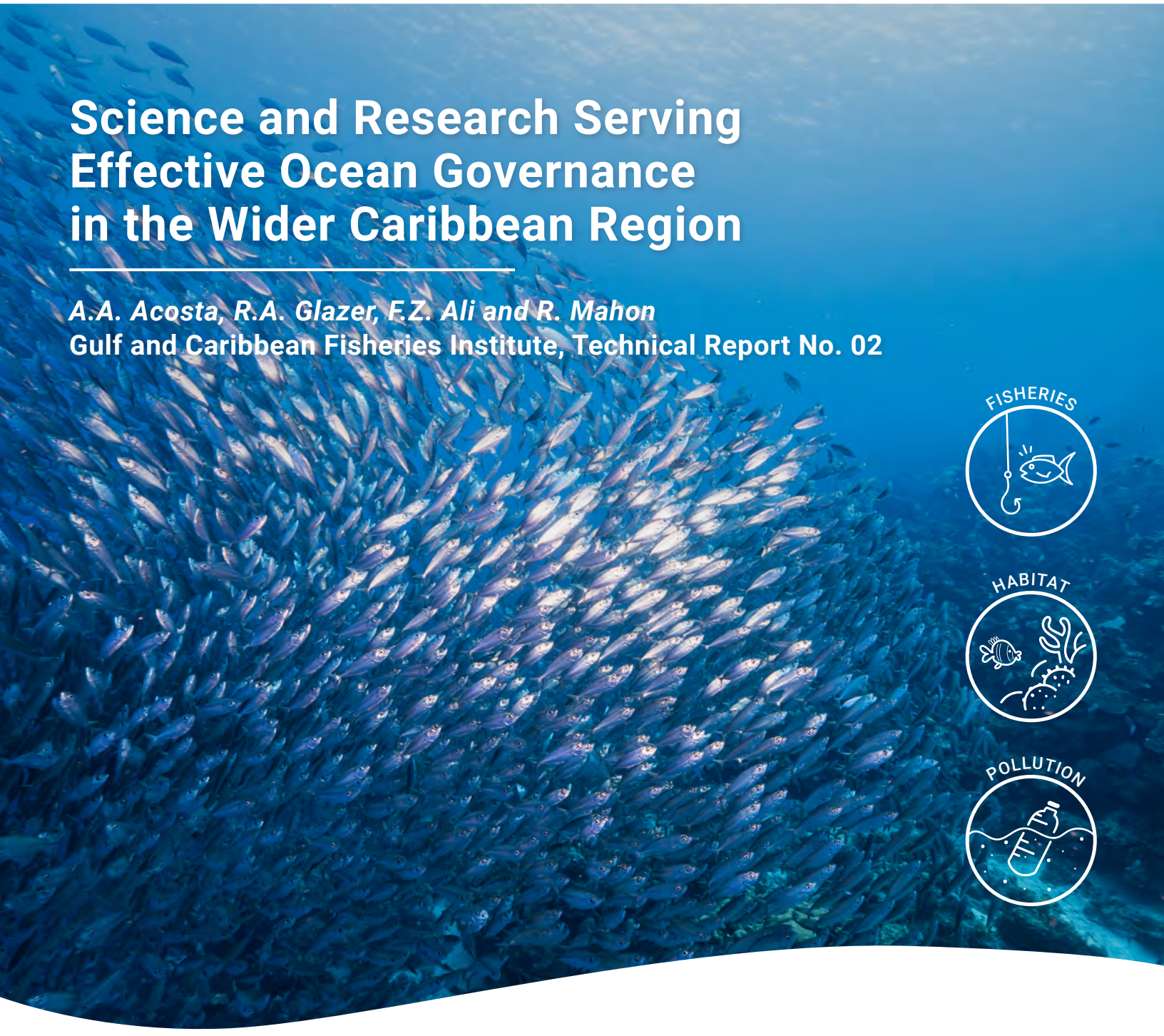

Catalyzing implementation of the Strategic Action Programme for the Caribbean and North Brazil Shelf LME's (2015-2020)

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Science and Research Serving Effective Ocean Governance in the Wider Caribbean Region

Alejandro A. Acosta, Robert A. Glazer, Fadilah Z. Ali and Robin Mahon

List of Acronyms

Acronym	Description
ACS	Association of Caribbean States
ALDFG	Abandoned, Lost or Otherwise Discarded Fishing Gear
AMLC	Association of Marine Laboratories in the Caribbean
ARPEL	Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean
BASE	Best Available Scientific Evidence
BRD	Bycatch Reduction Devices
CaMPAM	Caribbean Marine Protected Area Management
CARICOM	Caribbean Community
CARPHA	Caribbean Regional Public Health Agency
CBD	Convention on Biological Diversity
CCA	Causal Chain Analysis
CCAD	Central American Commission on Environment and Development
CERMES	Centre for Resource Management and Environmental Studies
CFMC	Caribbean Fisheries Management Council
CFRAMP	CARICOM Fisheries Resource Assessment and Management Program
CLME	Caribbean Large Marine Ecosystem and Adjacent Regions
CLME+	Caribbean and North Brazil Shelf Large Marine Ecosystems
CMOU	Caribbean Memorandum of Understanding on Port State Control
CRFM	Caribbean Regional Fisheries Mechanism
CSA	Caribbean Shipping Association
CTO	Caribbean Tourism Organisation
CWWA	Caribbean Water and Wastewater Association
DPSIR	Driver-Pressure-State-Impact-Response
EAF	Ecosystem Approach to Fisheries
EBM	Ecosystem Based Management
EBFM	Ecosystem Based Fisheries Management
ECLAC	Economic Commission for Latin America and the Caribbean
ECROP	Eastern Caribbean Regional Ocean Policy
EEZ	Exclusive Economic Zone
FACs	Fisheries Advisory Committees
FAD	Fish Aggregating Device

Acronym	Description
FAO	Food and Agriculture Organization of the United Nations
FCCA	Florida-Caribbean Cruise Association
FIRMS	Fisheries and Resources Monitoring System
GCFI	Gulf and Caribbean Fisheries Institute
GDP	Gross Domestic Product
GEAF	Governance Effectiveness Assessment Framework
GEF	Global Environment Facility
GF	Governance Framework
GMFC	Gulf of Mexico Fisheries Council
GPA	Global Programme of Action
GPML	Global Partnership on Marine Litter
GPML-Caribe	Global Partnership on Marine Litter - Caribbean Node
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICZM	Integrated Coastal Zone Management
IGOs	Inter-Governmental Organizations
IMO	International Maritime Organization
IOCARIBE	Intergovernmental Oceanographic Commission, United Nations Educational, Scientific and Cultural Organization
IUU	Illegal, Unreported and Unregulated fishing
LAC	Latin America and the Caribbean
LBS	Land-Based Sources
LME	Large Marine Ecosystem
LMR	Living Marine Resource
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MR	Marine Reserve
MSC	Marine Stewardship Council
MSP	Marine Spatial Planning
NBSLME	North Brazil Shelf Large Marine Ecosystem
NICs	National Intersectoral Committees
NOAA	National Oceanic and Atmospheric Administration
NPAs	National Programmes of Action
OA	Ocean Acidification
OAS	Organisation of American States

Acronym	Description
OECS	Organisation of Eastern Caribbean States
OSPESCA	Organisation of the Fisheries and Aquaculture Sector of the Central American Isthmus
PaV1	*Panulirus argus* Virus 1
PMAC	Port Management Association of the Caribbean
PoWPA	Programme of Work on Protected Areas
RAPMaLi	Regional Action Plan on Marine Litter
RFBs	Regional Fisheries Bodies
RFMOs	Regional Fisheries Management Organizations
RGF	Regional Ocean Governance Framework
RNRS	Regional Nutrient Reduction Strategy
ROLAC	Regional Office for Latin America and the Caribbean
SAFMC	South Atlantic Fisheries Management Council
SCRS	Standing Committee Research and Statistics
SAP	Strategic Action Programme
SDG	Sustainable Development Goal
SICA	Central American Integration System
SIDS	Small Island Developing States
SOCAR	State of the Cartagena Convention Area Report
SOMEE	State of the Marine Environment and associated Economies
SPAW	Specially Protected Areas and Wildlife
TDAs	Transboundary Diagnostic Analyses
TED	Turtle Excluder Device
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNEP - CEP	United Nations Environment Programme - Caribbean Environment Programme
UWI	University of the West Indies
VMS	Vessel Monitoring System
WCA	Western Central Atlantic
WCR	Wider Caribbean Region
WECAFC	Western Central Atlantic Fishery Commission

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Executive Summary

The Caribbean and North Brazil Shelf region (collectively the CLME+ region) is one of the most heavily exploited coastal zones in the world and is threatened by a diversity of stressors from local, regional, and global sources. These originate from both natural and anthropogenic sources and may include marine and land-based sources of pollution, discharges from maritime commercial activities, unsustainable fishing practices including overexploitation of fish stocks, and invasions of invasive species. All of these stressors are further influenced by a changing climate. Yet, even in the face of climate change, increasingly more coastal communities are looking at the ocean as the next frontier for economic development.

This project identified priority research topics from the perspective of decision makers who are charged with implementing policies because they must have timely and relevant information to effectively create policies that contribute to the sustainability of natural resources. This report represents the results of a project conducted by the Gulf and Caribbean Fisheries Institute (GCFI) designed to identify priority research topics at the nexus of science and policy. Three research agendas served as the focus for this study: 1) unsustainable fisheries of Spiny lobster, Flyingfish, and shrimp and groundfish, 2) habitat degradation, and 3) pollution.

Five crosscutting themes served as the framework for identifying gaps in knowledge for each agenda. Lists of existing gaps in knowledge were created from online research, and from interviews and workshops with experts. The items in the lists represented the research topics. The five crosscutting themes were:

Science: research topics with a general focus on organismal, ecological, or natural science

Governance: research topics that focused on priority information needed to develop strong governance structures

Monitoring: research topics necessary to ensure that monitoring projects focused on the optimal targets and provided the relevant long-term information for decision makers

Economic: research topics that support resilient societies with respect to social and economic sustainability

Communications: research to identify the most effective communication approaches to inform and influence internal and external stakeholders

The lists of the research topics were presented to the focal points responsible for developing polices for each agenda, and these individuals identified the highest research priorities from the perspective of decision makers. Using online surveys in English, Spanish, and French, the research topics within each theme were scored by the focal points and the highest scoring topics were identified as high-priority topics.

Priority topics for the fisheries agenda were mostly technical and originated from the Science theme. In general, the decision makers managing the fisheries examined in this report felt that the most important gaps to address related to scientific issues including developing stock assessments, identifying gaps in life-history characteristics, elucidating recruitment and population dynamics, understanding migratory patterns, and developing fisheries-relevant climate-based management tools. Furthermore, the decision makers felt that a priority was identifying best approaches to engage disparate components of the fishery-management community. The fisheries decision makers also recognized the importance of increasing the understanding of the effects of pollution on population abundance and structure of the key fisheries.

The priority topics for the habitat agenda were mostly related to assessing impacts to ecosystems and developing approaches for their restoration. The decision makers who reviewed the habitat agenda identified the importance of developing adaptation approaches that address climate-change by providing options to prevent declines in populations or extinction of vulnerable species. Another priority focused on addressing coral diseases by developing coordinated research, monitoring, and planning at the regional level. Examining the ecological effect of ocean acidification on benthic habitats and species also scored high. They further recognized the need to quantify the value of the loss of ecosystem services as a result of changing conditions.

Restoration was also a key topic for decision makers addressing the habitat agenda. They felt that it was important to evaluate the effectiveness of habitat restoration programs and to identify ways to scale up projects. As was true with all the other agendas, identifying existing and potential funding sources for monitoring programs was a high priority.

The pollution agenda research priorities in general focused on societal approaches for dealing with pollution including policy development as well as identifying the most effective advocacy approaches. For example, the decision makers felt that identifying approaches that increase the integration of policy across government sectors, incentivize the participation of the private sector, and implement evidence-based planning were high priorities. They felt that research was needed to ensure that the expansion of tourism is accompanied by smart waste management, and the development of effective advocacy approaches.

With respect to the science theme, the respondents concluded that the identification of pollution hotspots was critical. They further felt that addressing the transboundary issues of pollution were important by assessing the major sources and transport mechanisms of pollutants.

Other critical themes emerged in the development of this report.

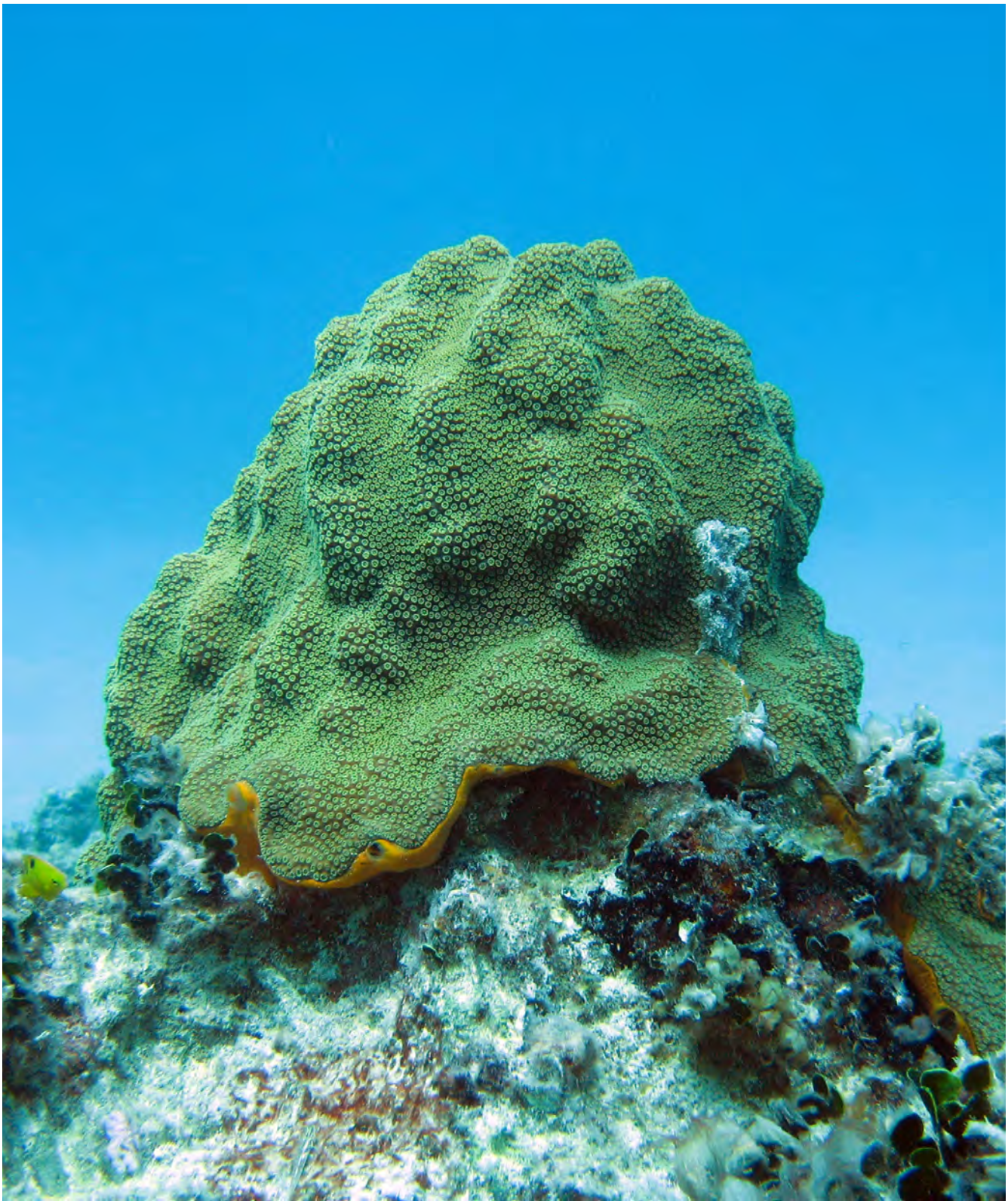
The transboundary nature of economic, social, and living marine resources throughout the region necessitates regional and sub-regional cooperative mechanisms. Most of the challenges that marine and coastal resources in the CLME+ region are facing are of a transboundary nature and cannot be addressed at national levels. Yet, most of the activities related to marine resources are conducted at national levels.

Therefore, both research and policy needs to be coordinated within the region. Ocean research and governance mechanisms across the CLME+ countries are, in general, highly fragmented. The CLME+ program aims at reducing this level of fragmentation by enhancing governance, increasing the coordination and development of common agendas, and maximizing efficiency of existing capacities. All of these serve to create synergies between research, technology, innovation, and governance. The complexity of the challenges, and the capacities needed to respond to the issues addressed in this report, go beyond the capabilities of any single country

Climate change will have an enormous impact future activities and economic stability of society. How societies adapt to these changing conditions with respect to the shifting distribution of key fisheries and habitats will impact their resilience.

This report serves as an important step towards charting a path that supports sustainable growth based on conservation values. At the same time, this report attempts to better understand the gaps and priority research needs particular to the nations of the CLME+ region. The research topics within each research agenda will produce a new body of knowledge and help develop research paradigms about marine ecosystem function. Inevitably, they will lead to better understanding of how the seas are impacting local and regional economies, what drives human behavior, and the values that drive the development of society. These societal values will all be dynamic under a changing climate and it will be critical to anticipate these changes.

The impacts resulting from addressing these research priorities will depend on the promotion, endorsement, and widespread dissemination of this report by the CLME+ program, the focal points associated with addressing each agenda, and all stakeholders in the region. The CLME+ program has already had a major impact in the Caribbean relative to marine policy, governance, and scientific research. If the research priorities are addressed, the impacts will be consequential on the science, governance, technology, conservation, environment, societal resilience, economies, gender equality, social justice, and human health. Ultimately the authors hope that addressing the priority research topics in this report will form the basis for new governance structures, approaches for creating employment opportunities, appropriate and enforceable regulations, and ways for increasing conservation awareness of stakeholders in the region.



Chapter 1

Introduction

1.1 The CLME+ and Ecosystem-Based Management

The concept of Large Marine Ecosystems (LMEs) has emerged as a mechanism for the promotion of an ecosystem-based approach to large-scale ocean management. This approach is now being promoted through several regional initiatives, strongly supported by the United Nations and its agencies and partners, particularly the World Bank and the Global Environment Facility's (GEF) International Waters (IW) Portfolio (Vousden 2015). Ecosystem-Based Management (EBM) represents an integrated approach to environmental decision-making and requires a broad understanding of all the components and functions of the ecosystems. Although it is not possible to understand all the components of each ecosystem, we can prioritize our monitoring, analysis, and research so that in the short term we 1) focus on activities that will inform our understanding of the most critical and influential components and functions of the ecosystem and 2) help us to understand how these are affected by human actions. Furthermore, we can concentrate efforts on those components and activities that have a direct influence on decisions that are most important to society as well as natural resources.

The marine biodiversity of the Caribbean Sea is inextricably linked to human activities and the environment (Fig. 1.1) and it is changing rapidly in response to both natural and anthropogenic pressures. Climate change, pollution, maritime traffic, overexploitation of fish stocks, and invasions of alien species are among the stressors placing the region's ecosystems at risk. Despite these external stressors, these ecosystems are still expected to provide for growing economic activities such as fisheries and tourism.

Nevertheless, many of the challenges to developing effective marine resource policies in the region are difficult to address at national levels because of limited scientific capacity to address timely issues with the possible exception of the larger countries (e.g., United States, Mexico, Brazil). This is compounded by the multidimensional complexities of the challenges coupled to funding limitations.

The issues are expansive. These may relate, for example, to anthropogenic impacts on the marine environment and its biodiversity (e.g., overfishing, aquaculture, maritime transport, energy production), the impacts of climate change on marine ecosystems and coastal habitats (e.g., ocean acidification, sea level rise, increasing sea surface temperatures), the impacts on the marine environment by pollution, and perhaps most critically, the limitations of effective regional governance frameworks. When these issues are considered together with society's interest in promoting a blue economy, the necessity of developing integrated regional approaches becomes clear.

The Caribbean and North Brazil Shelf Large Marine Ecosystem (CLME+) project was borne under this environment. The CLME+ is one of the most biophysically and geopolitically diverse and complex marine regions in the world (Mahon et al. 2010). Together, it consists of 26 countries and 18 overseas territories. Debels et al. (2017) reported that unsustainable fisheries, habitat degradation, and pollution are three key threats to CLME+ marine ecosystems, and their effects are being exacerbated by climate change. Among the root causes of the threats are weak governance, pollution from both land-based sources (e.g., agricultural run-off, liquid waste discharges) as well as offshore origins (e.g., shipping, mining, oil and gas exploration), and over-exploitation of living marine resources, particularly in areas where there is no legal control or enforcement.

Debels et al. (2017) further concluded that better EBM approaches within the CLME+ were needed for the relevant countries to avoid these threats and to achieve the goals of sustainable use and development. They also concluded that any integration principles that were adopted should be ecologically-relevant, transparent, and well documented, thus, ensuring comparability across disparate geographic regions.

The vision for clean, healthy, biodiverse, and productive oceans and seas with sustainable resource use requires bridging the gap between policy and science. To accomplish this, the status of marine ecosystems needs to be assessed by enhancing the existing scientific knowledge of marine ecosystems. However, this information must be management-relevant for effective policies to be crafted.

Implicit in this approach is recognizing that humans are an integral part of the ecosystem and understanding their role in shaping how ecosystems function is critically important to developing effective management strategies (Borja et al. 2017). Without recognizing the human capacity to alter ecosystems and formally including this dimension in developing management approaches, failure to develop sustainable management practices is almost a certainty.

Many of the threats to the Caribbean's marine resources requires cooperation and collective action by numerous stakeholders for effective management. It is within this context that the CLME+ integrated research priorities framework, which aims to provide a coherent approach for integrated governance of the marine environment, has been developed. This requires an approach that engages scientists, policy-makers, and the public to achieve a shared understanding of the value of the marine resources and importantly informed decision-making based on sound scientific knowledge.

Figure 1.1 |Sustainable marine resources that benefit society require healthy ecosystems free from the pressures of overfishing and pollution.

1.2 The structure of this report

This report is intended to identify priority research topics and information gaps from the perspective of decision makers. Ultimately, the goal is that this information will be useful for identifying those areas of research which provide the greatest value in developing effective and implementable policy.

Within this framework, the report is organized into three sections. The first section is intended to provide background information and the pertinent issues that will be addressed in future sections. This section includes chapters that provide the introduction to the report (Chapter 1), the background to regional complexities (Chapter 2), an overview of the information transfer at the science/policy interface in the context of research (Chapter 3) and an overview of previous efforts to develop research strategies (Chapter 4). The second section of the report focuses on the methodology behind the development of specific research topics (Chapter 5). Chapters 6, 7 and 8 provide an overview of the fisheries, habitat and pollution issues in the region, respectively and identify the themes, goals, and research topics for each. Each chapter also identifies the priority research topics identified by the decision makers. The third section includes recommendations for implementation (Chapter 9), the research agenda in the anthropocene (Chapter 10) and final reflections (Chapter 11).

A hierarchical approach was employed to develop research topics. First, specific themes were identified that encompass a wide range of activities. These themes go beyond the focus of many research agendas in that they do not deal solely with the natural sciences; other themes were considered that are needed for effective policy development and implementation (e.g., communications, governance, economics). The themes are further subdivided into goals where research topics fall under (Fig. 1.2). This provided a holistic approach that addressed the gaps in information from the wide range of activities that decision makers must consider.

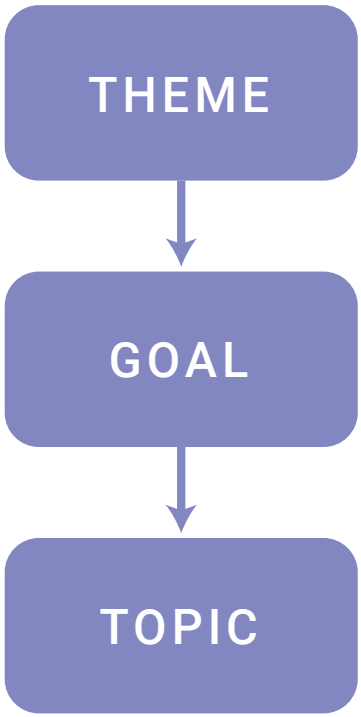


Figure 1.2 | The relationship between themes, goals, and research topics for each research agenda in this report. The themes represent broad areas of commonality for each research agenda (i.e., pollution, fisheries, and habitat). The goals are specific outcomes that are associated with each theme. Research topics represent specific and actionable areas of research that provide the focus for potential programs that may assist decision makers to identify effective policies.

Photo credit: Jerry Corsaut

Chapter 2

The Regional Context

2.1 The Need for Policy-Guided Research

The Caribbean and North Brazil Shelf Large Marine Ecosystem (CLME+) is a politically diverse and environmentally complex region. Altogether, it encompasses over 4.4 million km^2 comprising 35 states and territories. The region is characterized by a complex mosaic of intertwined ecological, social, economic, and governance processes.

Yet, the CLME+ region is plagued by many of the same issues affecting marine environments elsewhere. Overfishing, habitat degradation, and pollution have become pernicious threats to the sustainability of the resources and economies of the region. Added to this is the overarching threat of climate change. Taken together, it is clear that a great deal of work is needed to ensure that the living marine resources continue to provide benefits to the communities that rely on them.

Given the diverse political structure in the region, it is not surprising that ocean governance has been recognized as a weak link in implementing sustainable, region-wide policies and agreements. Ineffective or poorly developed governance arrangements are also due, in part, to the region's cultural complexities. However, local and regional governmental authorities are also often paralyzed by the lack of clear and substantive science which contributes to implementing effective policies. Science must be responsive to the needs of policy to achieve effective and efficient governance arrangements and, therefore, must involve the interactions between policy-makers and science providers. This interface between information providers and information users forms the basis of this report.

The CLME+ GEF-funded project was developed to address the sustainable management of the region's living marine resources using an Ecosystem-Based Management (EBM) approach. To accomplish this, a Strategic Action Programme (SAP) was developed and as of 3 June 2019, formally endorsed by 25 countries and six overseas territories (Fig 2.1).

Figure 2.1 | The status of endorsements of the CLME+ Strategic Action Programme as of 3 June 2019.

The SAP was built on the Governance Effectiveness Assessment Framework (GEAF; Fig. 2.2) which demonstrates how the effectiveness of polices can be evaluated and ultimately lead to the improvement of the condition of individuals in a society. It has been argued that this framework should form the basis for developing policies.

Governance Effectiveness Assessment Framework

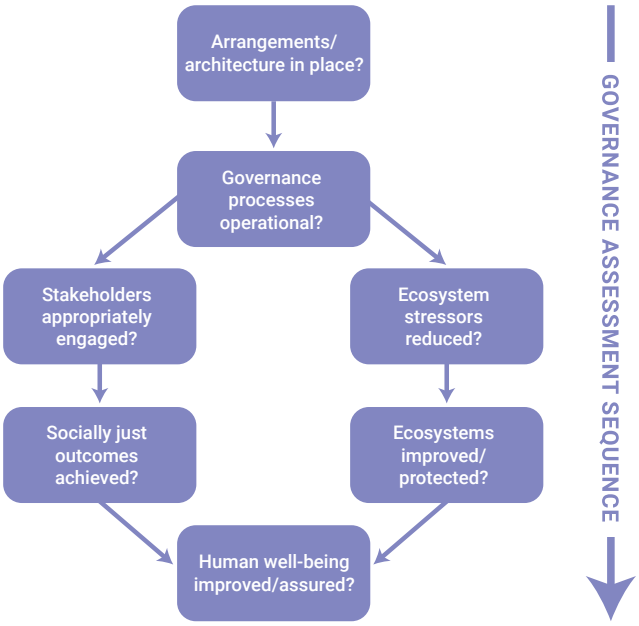


Figure 2.2 | The Governance Effectiveness Assessment Framework (GEAF) adopted by the CLME+ project.

This report represents the results of a project conducted by the Gulf and Caribbean Fisheries Institute (GCFI) designed to identify research priorities at the nexus of science and policy. Under the lens of the GEAF Framework, this project focuses on three of the most important issues affecting coastal societies and Small Island Developing States (SIDS): unsustainable fisheries, habitat degradation, and pollution. The three associated research agendas as identified in section O2.6 in the CLME+ SAP:

1. Expand the knowledge base required for implementation of Ecosystem Approach of Key Fisheries including Flyingfish, Spiny Lobster, and shrimp and groundfish in the CLME+ region,

2. Expand the knowledge base to support habitat protection and restoration in the CLME+ region,

3. Expand the knowledge base required for the efficient and cost-effective reduction of pollution from Land-Based Sources and Activities (LBS) in the CLME+.

Taken together, the three agendas provide an overview of three key issues impacting living marine resources in the CLME+ region and the research needs driving the development of effective policy.

This report considered the impacts from climate change as an overarching driver and, thus, its effects are embedded within the research priorities for each agenda. How living resources respond to the changing conditions and how the changing climate exacerbates already impacted systems will have a bearing on how fish populations and healthy marine habitats persist and thrive and how impacted populations and habitats recover.

Management decisions for the region's living marine resources must arise from a solid, scientific base. This is where well-designed and comprehensive monitoring programs are needed. Policy and management responses require a clear understanding of the underlying causes and effects of change and their consequences in the marine environment. Elucidating these responses can be achieved by ensuring that monitoring programs address the gaps in the underlying existing state of knowledge. In addition, monitoring programs need to be prioritized by policy makers so that they can assess the efficacy of implemented management actions, thus, ensuring that adaptive approaches use the best information to respond to changing conditions.

Governance frameworks that address each of the research agendas are further complicated by the transboundary nature of the distribution and connectivity of the living marine resources and pollutants including marine debris. Due to the complex oceanographic and ecological linkages within the Wider Caribbean Region (WCR) (Fig 2.3), coupled with the fact that many marine resources are shared by multiple jurisdictions, there is a recognized need for effective governance arrangements at a regional scale (Spalding and Kramer 2004; Chakalall et al. 2007). The current, fragmented approach to governance within the CLME+ region is regarded as being inadequate and ineffective (Parsons 2007). However, it is clear that there is no one-size-fits-all approach for governance of transboundary resources. Rather, there needs to be careful, in-depth consideration of multiple arrangements which address the complexities of the region and which also account for the identified needs and concerns of all countries and stakeholders (Chakalall et al. 2007). In this sense, effective regional governance must recognize this connectivity and address its complexity through mechanisms that include robust intergovernmental arrangements.

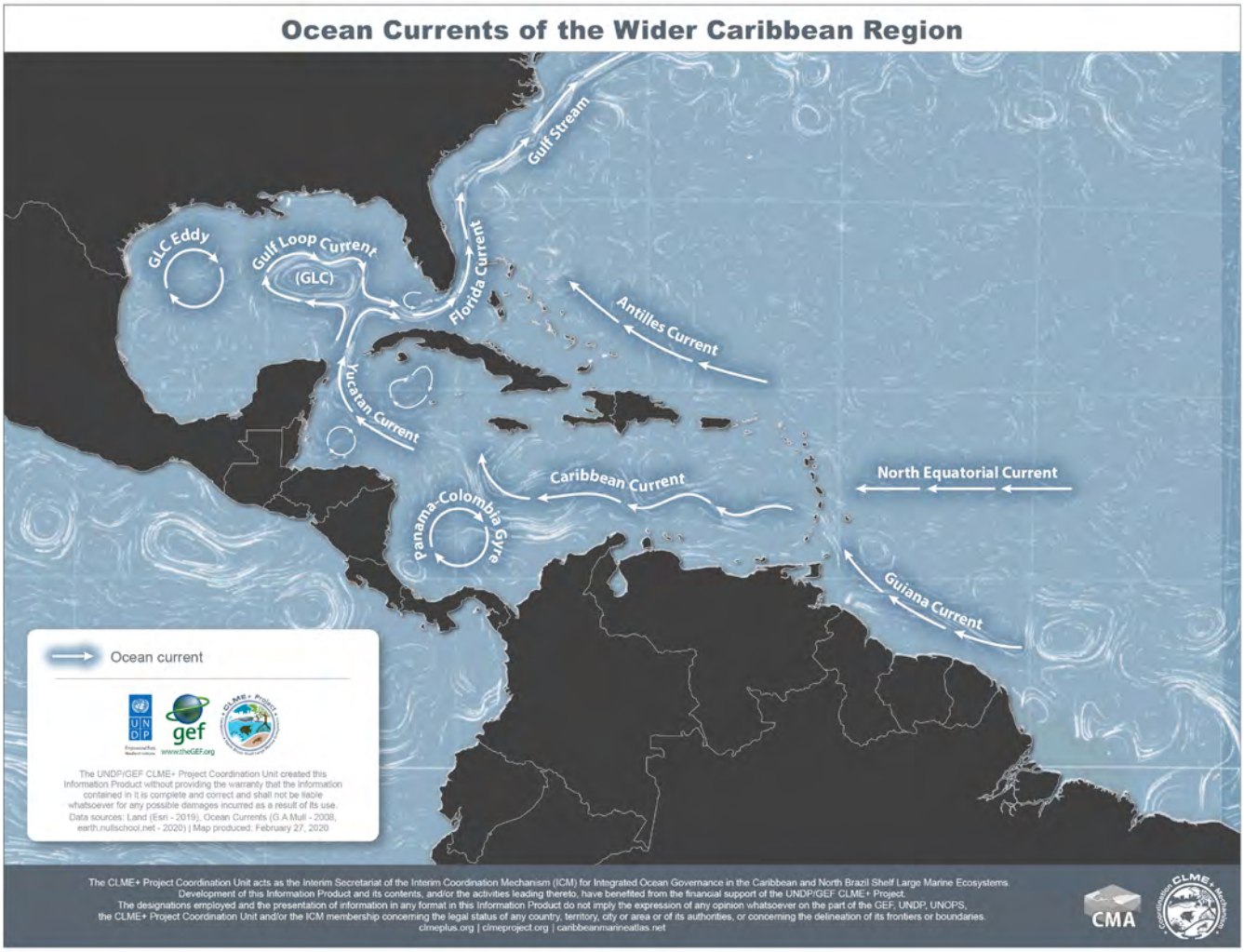


Fig 2.3 | The major hydrographic processes that affect the dispersal and retention of living marine resources and pollutants in the WCR and CLME+ region. A number of mesoscale features serve to facilitate long-distance transport as well as retention in localized areas.

2.2 Addressing the CLME+ regional complexity

Addressing the following priorities is essential to effectively addressing the region's social, political, economic, and environmental complexities.

2.2.1 Capacity-building

Well-crafted capacity building programs focused on technical and governance-based skills are critical to ensure that policy makers are able to operate with confidence that the policies they develop have a high probability of success. The information provided to them must be based on the best available science in forms that are understandable, relevant, and timely. To achieve this objective, new and focused skills must become priorities in the region's universities and training programs to ensure a degree of self-sufficiency. Furthermore, initiatives need to attract and target the development of young professionals. There is also a need to acknowledge that marine research must be viewed as multi-disciplinary and thus an additional focus must be placed on addressing this. This is extremely critical as the need increases for new approaches that address policy-relevant goals spanning science and governance. The lack of capacity related to effective management is a critical bottleneck that impedes both the growth of a sustainable blue economy and the development of policies that are both achievable and effective. Capacity-building programs are needed to ensure that a critical mass of workforce is available that has both the adequate skills and competence to face the new and emerging needs of multiple sectors and the resources to create relevant policies that address the complexity of diverse tropical marine ecosystems.

2.2.2 Communications

Ensuring effective and efficient communications is a theme that runs throughout this report. How these national and regional communication networks are constructed, and the information they convey, will ultimately define the effectiveness of management decisions. Communications pervades all themes, especially when decision makers need the best science and approaches to address their priorities. Without efficient communication of relevant and timely information among users, information providers, and decision makers, the value of the information and the robustness of the decisions originating from that information may be compromised.

2.2.3 Integration

The development of effective regional policies often requires cross-disciplinary frameworks and interactions. This topical priority category ensures the closer integration of knowledge, research networking and information exchange thus reinforcing excellence in science. By promoting integration and improving knowledge transfer in existing and emerging areas such as fisheries, energy, aquaculture, climate change, and blue technologies, achieving successful integration will help to achieve the goal of sustainable, and more efficient use of, marine resources.

2.2.4 **Synergies**

This report is meant as a guide to decision makers by providing the information they need to make well-informed decisions focused on sustainably managing their living marine resources including the conservation and protection of the marine environment and its biodiversity against human impacts (e.g., pollution, habitat degradation and loss, overexploitation). In that spirit, addressing research priorities from a diverse suite of activities provides more value than addressing, for example, a single science-based research topic. Thus, the diversity of topics in multiple disciplines represents synergistic opportunities. From this well of diversity springs synergies; between many related topics in multiple goals and this should be considered together when developing an overall research strategy. Simultaneously, adaptive approaches must be developed that ensure strong linkages between socio-ecological conditions and institutional arrangements (Galaz et al 2010; Young, 2011; Young 2012).

In many instances, existing research is duplicative with existing or previous efforts. The overlapping nature of these efforts could be a reason for poor implementation and lack of cooperation among stakeholders (Agard et al. 2007) as well as leading to confusion. The often-contradictory nature of duplicative activities may result in inaction or, worse, using conflicting information to make uninformed decisions. More coordinated research outputs are needed to reduce duplication and take advantage of synergistic opportunities. Furthermore, a comprehensive understanding of how to structure interconnected governance systems is necessary to ensure resilient management frameworks and ecosystems.

There are several regional and government agencies working directly or indirectly on biodiversity, fisheries, and socio-economic issues. The priorities of these agencies should be linked to research projects and these agencies should strive to work together in synergistic partnerships. Similarly, it may be more resource-efficient to strengthen and support current initiatives rather than develop new ones. In this regard, the CLME+ project provides opportunities for identifying potential strategic alliances among initiatives of different stakeholders including those representing civil society and for creating synergies among them.

Chapter 3

Making science relevant: The Role of Science in the Effective Governance of the Caribbean Sea, North Brazilian shelf, and the Gulf of Mexico

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3.1 Introduction

The principle that decisions regarding conservation and management of living marine resources should be based on the 'best available scientific evidence' (BASE) is enshrined in the UN Convention on the Law of the Sea (UNCLOS) (United Nations 1982) for both EEZs and the High Seas[1]. Countries and their regional organizations are legally obligated to operationalize this principle. Consequently, it has become well established in national, regional, and global management policies and agreements. Nonetheless, there is considerable room for interpretation of the meaning of 'best' and 'available' (Wolters et al. 2016). Even with the best intentions, managers have found many challenges to developing, obtaining, and using the best available scientific evidence. These challenges range from low capacity to produce or access relevant scientific evidence, through poor communication of science to decision makers, to governance processes that are poorly structured or inadequately structured for the uptake of scientific advice.

The problem is that governance processes resort to making decisions without the BASE, or delaying them based on a lack of such information. The United Nations Environment Programme (UNEP) Foresight Process on Emerging Environmental Issues for the twenty-first century concluded that the cross-cutting issue "Broken Bridges: Reconnecting Science and Policy" was a pressing problem globally hampering efforts to achieve sustainable development (UNEP 2012). The problem of linking science and policy has been extensively discussed in the literature for decades (e.g., Rice, 2005; Chilvers and Evans, 2009) and more recently, the adoption of ecosystem based approaches to management has resulted in renewed attention to this issue (Borja et al. 2017).

Developing countries and regions, particularly those with Small Islands Developing States (SIDS) are especially affected by the challenges outlined above. The Wider Caribbean Region (WCR) is one such region, as has been noted by the GEF Transboundary Diagnostic Analyses (TDAs) (Heileman 2011; Phillips 2011; Mahon et al. 2011; CLME 2011). McConney et al. (2016) explored the challenges that the WCR faces in moving towards the use of BASE in governance of coastal and marine resources. Consequently, the Caribbean Large Marine Ecosystem Strategic Action Programme (CLME+ SAP) has identified the development and implementation of a strategy to promote the uptake of science in management as an important component of sustainable use of living marine resources in the region (Debels et al. 2017). This chapter examines the challenges to the use of BASE for LMR management in the region and recommends ways of improving its uptake for decision making.

[1] UNCLOS Article 61(2) "The coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation."

UNCLOS Article 119 (1) "In determining the allowable catch and establishing other conservation measures for the living resources in the high seas, States shall: (a) take measures which are designed, on the best scientific evidence available to the States concerned [...]."

3.2 The need for policy-guided research

In order to assess the opportunities for improving the production and uptake of science by marine resource managers, it is important to understand the processes by which this takes place and to know the actors in the processes. Broadly, research outputs are created by 'research providers'. These outputs are then taken up by 'research users' (Stojanovic et al. 2009), terms that will be used throughout this chapter. The process or mechanism by which research providers communicate research findings to research users and they, in turn indicate their needs to the research providers is the 'science-policy interface'. At the CLME Regional level, both research providers and research users are heterogenous groups and there are numerous interfaces between the two groups. Our focus in this report is on the regional and subregional processes, but linkages with national processes must also be considered as this is the level where most implementation takes place. Knowing who the providers and users are, and what their capacity to provide and consume is, will be an important aspect of developing effective uptake of science into decision making. There is also a third category of person or organization that is critical to these processes. These are science-policy facilitators.

This chapter takes a broad perspective on what constitutes scientific research in the context of providing advice to 'research users'. Research may comprise a diversity of activities that can generate new information. For example:

- Original research driven by curiosity or the scientific process (pure research)
- Original research carried out to address a specific societal problem perceived by the researcher or identified by a user (applied research)
- Review of existing research around an identified problem
- Synthesis and meta-study around an identified problem

All of these can produce valuable input to decision making depending on the nature of the problem being addressed.

3.2.1 Research providers

Ecosystem based management (EBM) of living marine resources requires a wide range of information. Providers of coastal and marine research may be from any of the relevant disciplines:

- Biogeophysical sciences (geology, biology, ecology, physics, chemistry)
- Social sciences (political, economic, social)
- Legal studies
- Management studies
- Technological studies
- Interdisciplinary studies that bring the above together to address a research problem, including information obtained from local stakeholders and communities (UNEP 2012; Weichselgartner and Marandino 2012)

The research may take place in a variety of institutional settings such as those listed below:

- Universities and colleges
- Technology institutes
- Marine laboratories (university, government, NGO, private foundations, IGO)
- National agencies
- Regional IGOs
- NGOs at all levels
- Private sector

These categories are not mutually exclusive. A marine laboratory could be national, governmental, university, or NGO. Individuals or teams from any of these settings may collaborate with others from any other setting. As governance becomes more widely accepted as including all stakeholders, there will need to be provision for the uptake of coproduced information which is generated through collaborations of scientists, users and other interested parties (Gustafsson et al. 2017).

3.2.2 Research users

Users of coastal and marine research consist of two broad types: advisors and decision-makers. For the most part, the advisors are the primary users with whom the research providers engage. On occasion, there may be the need for the providers to engage directly with decision-makers.

Advisors may be formulating advice for:

- National decision making processes
  - Cabinet
  - Ministries and individual ministers
  - Bodies such as Fisheries advisory committees (FACs), National Intersectoral Committees (NICs), technical committees supporting international and regional commitments, etc.
  - Technical advisors in UN missions.

- Regional decision making processes
  - Intergovernmental organizations' Conference of Parties (IGO CoPs)
  - Ministerial Councils (including heads of government)
  - NGO Boards

3.3 Characteristics of the science policy interface

Science policy interfaces as defined in the previous section can be found in multiple settings in the WCR. These include sectoral IGOs, multipurpose economic integration IGOs, and at the national level within government departments. This chapter focuses on interfaces that involve a regional aspect which may be either science provider or science user. These science-policy interfaces will be most effective in an institutional setting with well-defined processes. An example of a conventional science advisory process that takes place within a well-defined arrangement in an IGO is shown for the International Commission for the Conservation of Atlantic Tunas (ICCAT) (Box 3.1). In the CLME+ initiative, the policy processes for LMR governance are referred to as policy cycles as depicted in Figure 3.1. Policy processes should be iterative, and well-structured, providing for the conversion of data and information into policy advice which is then passed on to decision-makers. This is important to ensure that the processes are 'adaptive' (National Research Council 2009). In this policy cycle, the 'analysis and advice' stage is critical for effective uptake of science by policy. Few research users want, or are capable of, using unprocessed data or uncontextualized information. The role of the 'analysis and advice' stage is to process the data and information available to address specific policy questions and to package it for policy makers in a form that is understandable and policy relevant. The process also allows for feedback from policy makers to the science community regarding topics on which advice is requested or needed.

Box 3.1 Example of a conventional science policy interface (ICCAT):

- Countries provide data and information on tuna catches, effort, biology, etc.
- Species working groups analyze the information, together with any other available information from the literature, academia, fisheries laboratories, etc. and provide technical advice on stock status
- The SCRS reviews the technical advice, considers other information such as compliance and enforcement issues, and formulates management advice
- The ICCAT Commission considers the advice and makes decisions regarding what measures should be implemented. This also leads to requests for additional information and suggestions for research

The process is well known, regular, and understood by all. It involves government scientists, academia, government managers, NGOs, IGOs, industry, and the ICCAT secretariat which facilitates the process.

Figure 3.1 | The basic policy cycle used by the CLME Initiative which provides for the iterative uptake of science into policy making.

3.3.1 Characteristics

It is important that the science-policy process be based on key principles that promote credibility, including accountability, transparency, legitimacy, and participation. These should be agreed upon by the scientists and policymakers that will be engaged in the process (Fritz 2010). However, there is much more to building science-policy interfaces than simply establishing the institutional architecture and specifying the processes. It includes, for example, working with the specified processes to building and strengthen relationships between providers and users, including matters of trust, credibility, and reliability of both providers and users (Carden 2009). It may be viewed as a coevolutionary process that includes both science 'pushes' and policy 'pulls' (Watson-Wright 2005; van den Hove 2007). Ultimately, when the interface is working, neither side should have to 'push' or 'pull' too hard to elicit cooperation from the other. Rice (2005) observes that in this process, the scientists will at times be ahead of the policy makers, who may appear reluctant to respond to advice. At other times, the policy makers will be ahead of the science with demands that require both time and resources. Planning and communication can serve to minimize these situations. Ideally, the science users should be able to specify the problem that they need advice on. The providers may then need to reframe the questions of policy makers in terms that can be addressed by research. Getting this right will require interaction or dialogue between the two groups.

3.3.2 Intermediaries and the processing of advice

Connecting science and policy as described above may even require a separate kind of expertise in the form of an intermediary or broker who facilitates the exchange of information among scientists, policy-makers, and even other stakeholders (Bednarek et al. 2015). This type of expertise may be located within the analysis and advice stage of the policy process or associated with the decision-making process. As previously noted, scientific advice seldom goes directly from the science-advisor stage to the ultimate decision makers. It is usually considered first by their policy advisors who weigh the technical advice together with other factors such as feasibility, competing interests, and broader societal values to formulate the final advice. Ultimately, the decision makers will merge the advice with their own suite of factors before reaching final policy conclusions (Gudmundsson 2003). It is important for scientists to understand that their input is usually only one of several factors influencing policy decisions otherwise they are likely to develop a negative view of the process and become disinclined to participate (Singh et al. 2014)

Given the subjective application of considerations by decision makers in making their decisions, it has often been proposed that there should be a clear boundary between the provision of scientific advice and the decision-making process (Polachek 2012). That way, the nature of the advice is objective and transparent up to the point where it is provided (Lidskog and Sundqvist 2015). Adherence to this approach has been termed 'speaking truth to power' (Hass and Stevens 2011). This is an idealized situation, and the reality is that the pathways that science may take from producers to users are more varied (Keller 2009), and often more complex, than the ideal course (National Research Council 2009).

Some examples include:

- Scientists may seek to take their findings directly to decision makers and to lobby for the decisions they think are needed.
- Scientist may provide their information to lobby groups, such as NGOs, that approach decision-makers directly.
- Where decision-making processes are absent, advice may bypass that stage and be transmitted directly to implementers (for example, advice emanating from WECAFC is generally communicated to Chief Fisheries Officers who may then choose to act or not act on it).
- Decision makers may bypass advisory mechanisms and seek out scientists directly thus preferring to get their inputs 'unofficially'.

These 'work around' situations may produce results, but inevitably undermine the development and operation of transparent, accountable mechanisms.

3.4 Science policy interfaces in the WCR

There are many science policy interfaces for governance of LMR in the WCR and a strategy for improving the uptake of science into policy making must consider them all. Understanding these interfaces, how they are structured, and how they work in terms of process and timing will help the science community to work in ways that will be the most impactful in influencing policy decisions (Carden 2009).

3.4.1 The Regional Governance Framework context for science policy interfaces

The CLME+ Regional Ocean Governance Framework (RGF) is a conceptual formulation that encompasses the entire set of ocean governance issues, the governance arrangements with responsibility for ocean governance, their policy processes, and the interactions among them that are envisaged as being required for effective ocean governance in the CLME+ region (Mahon et al 2015). The CLME+ RGF takes the more general LME Governance Framework (LME GF) (Fanning et al 2007) (Figure 3.2) and applies it to the specific circumstances of the CLME+ Project region. The more general LME GF was developed for the CLME Project to communicate the overall structure needed for regional ocean governance, consisting of policy cycles at multiple levels (from local to global) with appropriate vertical and lateral linkages (Fanning et al 2007). Application of the LME GF to the CLME Region considers the ocean governance arrangements already in place for the issues identified, the completeness and strength of the policy processes associated with those arrangements, the lateral linkages among the regional/sub-regional arrangements, the upward vertical linkages between the regional/sub-regional arrangements and relevant global arrangements, and the downward vertical linkages between regional and national arrangements[2]. An appreciation of this overarching framework is important for all science providers and advisors as it is the governance context within which they will be operating.

The depiction of the RGF that is specific to the CLME+ Region is shown in Figure 3.3 which reflects its nested nature, showing how issues may be successively aggregated, both topically and geographically. For example, in fisheries, resource specific issues are first aggregated by major habitats, then under fisheries overall. Then, fisheries, together with pollution and habitat degradation/biodiversity, come together under the overarching heading of EBM at the planning and operational level. Ultimately, EBM issues come together with other ocean governance issues such as shipping and oil and gas extraction all coordinated and linked by the Permanent Coordinating Mechanism (PCM).

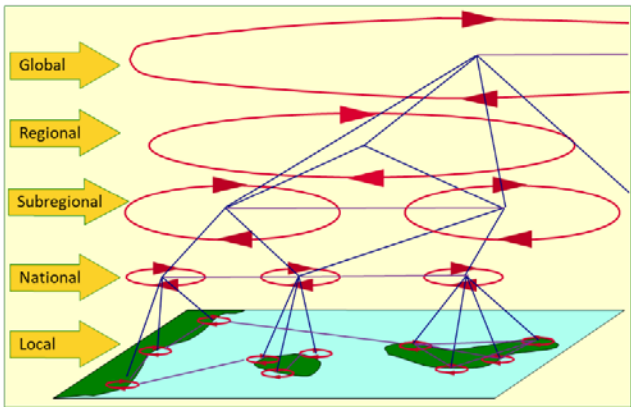
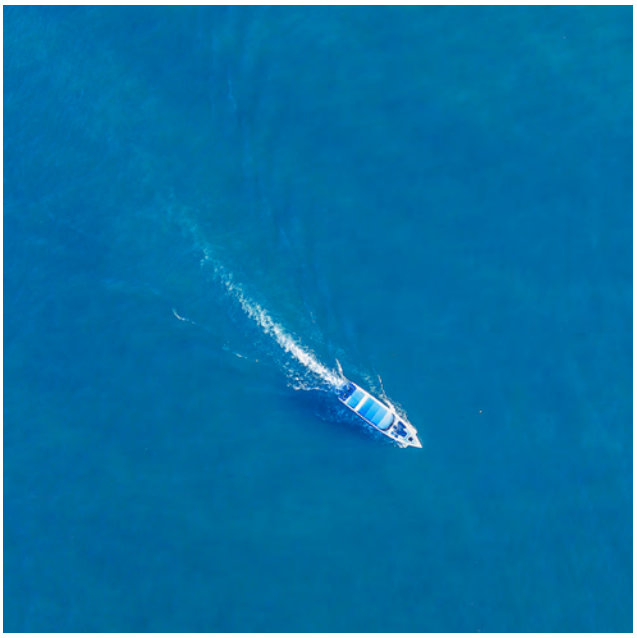


Figure 3.2 | The conceptual LME Governance Framework upon which the CLME+ RGF is based.



[2] *One could argue that a full framework would also include subnational linkages and functionality as well.*

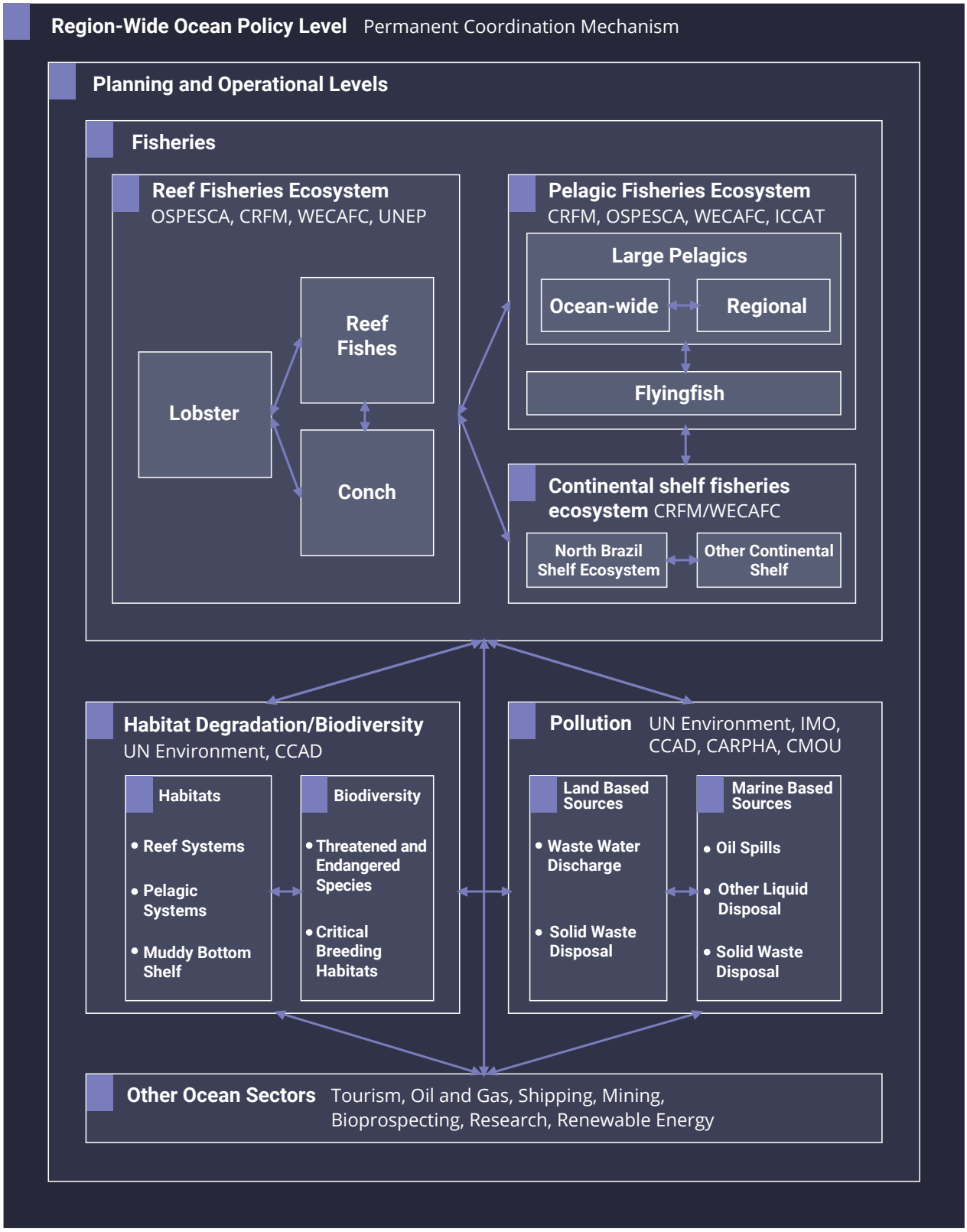


Figure 3.3 | CLME+ Regional Ocean Governance Framework – a multilevel, nested perspective. Ocean governance issues aggregate topically and geographically from the smallest boxes to the largest overarching PCM box (after Mahon et al. 2014)

The main aim of the RGF is for all stakeholders, including science providers and users, to have a clear understanding of the overall regional arrangements that are considered necessary for effective ocean governance. This allows them to see where they fit into the RGF and can engage with other RGF partners. It illustrates the many levels and arenas within which science input to policy decision making may take place. These range from the level of overarching policy setting through strategic planning to operational planning and day-to-day management. Fanning et al. (2013) provide examples of the different policy needs at different levels for marine protected areas, tuna fisheries, and Flyingfish fisheries in the WCR. It can be expected that the closer the advisory process is to day-to-day management, the fewer non-science factors must be considered in reaching a final decision.

3.4.2 Science-policy interfaces in Intergovernmental Organizations (IGOs)

The regional Intergovernmental Organizations (IGOs)[3] with responsibility for ocean issues are a critical component of the RGF and provide pathways for the uptake of science in policy making. Some of these are multipurpose economic integration organizations with a broad mandate that includes oceans; namely The Caribbean Community (CARICOM), the Organisation of Eastern Caribbean States (OECS), The Central American Integration System (SICA), and the Association of Caribbean States (ACS). These high-level policy bodies will be considered in the next section. Numerous other IGOs have a sectoral focus and can be considered science users. In all cases, these IGOs have been established by a signed agreement, have a secretariat, and hold regular intergovernmental meetings (IGMs) in which member countries take decisions. These various components are referred to collectively as an intergovernmental arrangement. Most of the key IGOs that are relevant to sustainable use of LMRs in the WCR are listed below:

1. The Caribbean Environment Programme (UN Environment CEP) and the arrangements for its three protocols (Oil Spills, Land-Based Sources of Pollution (LBS) and Specially Protected Areas and Wildlife (SPAW)
2. The Western Central Atlantic Fishery Commission (WECAFC) of FAO
3. The Organisation of the Fisheries and Aquaculture Sector of the Central American Isthmus (OSPESCA) of SICA
4. The Central American Commission on Environment and Development (CCAD) of SICA
5. The Caribbean Regional Fisheries Mechanism (CRFM), of CARICOM
6. The Caribbean Regional Public Health Agency (CARPHA), of CARICOM
7. Memorandum of Understanding on Port State Control in the Caribbean Region (Caribbean MOU PSC)
8. Inter-American Convention for the Protection and Conservation of Sea Turtles (IAC)

[3] *In this report the term IGO refers to the entire arrangement.*

There are other sectors whose activities may impact LME in the WCR. Their science input needs should also be considered, for example, tourism, oil and gas, shipping, energy, and mining. Some have regional IGOs that could also play a role in regional LMR governance, such as the Caribbean Tourism Organisation (CTO), Caribbean Shipping Association (CSA), Port Management Association of the Caribbean (PMAC), Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean (ARPEL).

Most IGOs have technical meetings, the outputs of which are recommendations. These may either be taken to a decision-making level, if there is one associated with the IGO, or taken back for adoption at the national level (see below). While the members of WECAFC and IOCARIBE and the parties to the Cartagena Convention meet every two years, all other IGOs convene their regular meetings at least annually. A strategy for improving the uptake of science into policy making needs to take all of these possible pathways into consideration.

Readers may note that the above list does not include IOCARIBE, which is IOC-UNESCO's regional commission in the WCR. This is because IOCARIBE does not have a mandate for governance issue per se. Its mandate is to promote and disseminate science in the region. Consequently, one might expect to see it play a prominent role in facilitating many of the strategies and actions that will be recommended in this chapter.

3.4.3 Interfacing with high-level fora

For technical advice to have its greatest impact, it should be oriented towards the highest decision-making level needed for the respective issue. This will depend on whether the recommendation requires a policy, legislative, or operational response. Given the polycentric[4], multilevel nature of regional ocean governance in the Wider Caribbean, it may, at times, be useful to take technical and policy advice from any IGO to several decision-making bodies in order to ensure the greatest possible level of uptake. Consequently, it is useful for all stakeholders engaged in regional ocean governance to have a clear understanding of the high-level policy making fora in the Wider Caribbean and their geographical and issue coverage.

In the case of the three UN agencies (UN Environment CEP, IOCARIBE, FAO WECAFC), the highest level is a technical intergovernmental forum that develops recommendations for uptake at the national level. On occasion these recommendations may be taken by regional multipurpose bodies (CARICOM, OECS, SICA, ACS) to their ministerial committees. In the case of IGOs that are affiliated with regional multipurpose bodies namely, CRFM, OSPESCA, CCAD, OECS Commission, and the Caribbean Sea Commission, the parent bodies provide opportunities for ministerial review and adoption of advice. These bodies have meetings of ministers of environment, fisheries and agriculture, foreign affairs, health, trade, transport, etc. to which advice can be taken. Ultimately, they all have meetings of their Heads of Government as well.

[4] Polycentric means that there are several centers of activity and decision-making associated with a particular issue to be governed. Polycentricity has pros and cons; for example, it may lead to gaps and overlaps in governance. On the other hand redundancy can provide resilience if one of a suite of polycentric arrangements becomes dysfunctional (Ostrom 2010)

Navigating this polycentric system to ensure that advice reaches the appropriate forum and level requires understanding of the overall system and interaction among the IGO partners. For example, there are opportunities for outputs from the three UN IGOs, which do not have access to ministerial fora, to be taken up by the regional IGOs that do have such access and to be passed to the appropriate ministerial committees. Another route from the UN IGOs to ministerial fora of the regional multipurpose organizations is for the latter to be represented at senior technical levels by individuals who can then get the outputs of these meetings on the agendas of the appropriate ministerial meeting. Note that for maximum effectiveness, it may be useful for advice to be reviewed at several high-level fora to ensure the widest possible opportunity for uptake. Coordinating and monitoring these flows and the outcomes would be an important PCM function. Other high-level decision-making bodies in the region which offer potential for the PCM to engage with are the Caribbean Development and Cooperation Committee (a permanent subsidiary body of ECLAC) and the Forum of Ministers of the Environment of Latin America and the Caribbean (UN Environment/ROLAC).

3.4.4 Interfaces at the national level and National Intersectoral Committees (NICs)

Within the multilevel RGF, the national level is critical. It is the level where most of the implementation needed to address transboundary problems takes place. This is achieved through national policy, enabling legislation, regulation, monitoring, and enforcement. For these measures to be effective and harmonized with other countries, clear and efficient communication among national agencies and between the national and regional levels is needed. For this reason, GEF International Waters projects require participating countries to establish Inter-ministerial Coordination Mechanisms (ICMs). These are also often referred to as national intersectoral coordination committees (NICs).

The linkage between a country and a regional initiative or IGO should be well-structured and follow clear and transparent processes if regional information is to flow efficiently to national decision-making arenas. Ideally, the individual responsible for the issue being considered at the regional level would be part of, or have access to, the NIC and would use it as a consultative mechanism. Thus, information flowing from the national level to regional level would be a collective national perspective and would be widely known at the national level. Conversely, information flowing from the regional level to the national level would be shared with the NIC and become widely known by stakeholders. Clear archived documentation of these flows would be a best practice for NICs and would facilitate changeovers in responsibility at the national level, as well as providing critical institutional memory.

From its outset, the CLME initiative has been promoting and researching NICs. Two studies have indicated that while there are mechanisms in many countries, few have what could be described as a fully functioning NIC based on the guidelines developed for the CLME Project (Mahon et al. 2010; McConney et al. 2016). The conclusion is that there is considerable work to be done to develop and strengthen NICs and that this must be part of any ongoing initiative to develop the RGF.

3.4.5 The Proposed CLME+ Partnership

The CLME+ Partnership ("Global Partnership for the Sustainable Management, Use and Protection of the Caribbean and North Brazil Shelf Large Marine Ecosystems") recognizes that for the RGF to function effectively, it needs to engage with a much wider range of stakeholders at all levels than just the Intergovernmental Organizations (IGOs) and countries that are expected make up its governing structure. The CLME+ Partnership is currently being developed as a mechanism to engage the full range of stakeholders and to include them in the development and implementation of ocean governance in the wider Caribbean Region. These stakeholders will include the full range of science providers in the region and key ones outside the region. It is being designed to pay specific attention to its potential role in promoting the production and uptake of science in decision making.

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CLME+ Project
Caribbean & North Brazil Shelf Large Marine Ecosystems

3.5 Linking research, policy, and planning in a long-term relationship

There is the need for strategic and management plans at all levels to identify:

- Research needs
- Approaches to obtaining research input
- Clear processes by which research will be used

This will make it easier for research providers to understand how best to get their research outputs into the policy arena and to interact with the policy processes generating the plans.

3.5.1 The research community (research providers)

3.5.1.1 Research capacity

As previously stated, the research provider community is highly heterogeneous. There is considerable research capacity within the region among the categories of research bodies listed in Section 2.1.1. Toro (2016) reported there are 147 academic higher education institutions (universities, polytechnics, and colleges) with marine science and technology programs. There will be many more that are conducting relevant research when the full range of disciplines and types of research are considered (see Section 2. Section A). Although many of these are concentrated in a few countries, namely the USA, Mexico, Colombia, and Brazil, the remainder, distributed through 14 other countries, collectively represent considerable research capacity. A full inventory of these tertiary institutions and their research capacity has not been done and would be useful in coordinating research and especially its transfer to decision making, as will be discussed below.

Regional intergovernmental organizations may conduct research in several modes. It may be done by permanent staff pursuing syntheses of knowledge from secondary sources, or more basic research may be carried out by consultants that they engage. The

projects and other activities carried out by these IGOs generate considerable quantities of research which is accessible to varying degrees. Similarly, NGOs at local national and regional levels produce applied research outputs. As with tertiary education institutions, there is no reliable inventory of these organizations, let alone their research outputs.

National agencies often have researchers as well. As with the tertiary education institutions, they are mainly concentrated in the larger, more developed countries. Nonetheless, again, the collective amount of research generated by capacity in national departments of smaller, less developed countries is likely to be considerable when taken altogether, and worth capturing. It is also important to recognize that valuable relevant research is conducted by private sector companies or organizations, such as the as oil and gas industry, or The Florida-Caribbean Cruise Association (FCCA). Much of this may be proprietary, but still needs to be considered in reflecting upon existing research capacity and outputs.

Finally, there is the considerable amount of research that is conducted in the region by external researchers, mainly from universities. It is not uncommon for such research to be conducted unbeknownst to anyone in the WCR and to be published in journals and reports that are difficult to even know about, let alone access. In many countries, research policies require that data and reports be provided to relevant agencies in the country. However, smaller countries may not have the capacity to manage these data and reports

Overall, it can be concluded that there is considerable research capacity, but that it is widely distributed through various agencies at multiple organizational levels, as well as geographically. This makes it difficult to access either the outputs already produced, or the expertise that exists in these agencies. This is not to say that there is sufficient research, that capacity is adequate, or that topics are adequately covered (e.g., Box 3.2), only that efforts to increase the uptake of science in decision making should consider what information and expertise is already available while seeking to generate more and better research.

Box 3.2 Economic valuation of ecosystem services of marine ecosystems in the WCR

The recent inventory and analysis of over 200 economic valuation studies of ecosystem services of marine ecosystems in the WCR illustrates the unevenness of treatment of topics that can arise when research is uncoordinated. The review indicates that marine economic valuations in the WCR have focused on a limited number of benefits derived from marine ecosystems, primarily those that are relatively easy to measure and convey, such as recreation opportunities in protected areas, and benefits that are ascribed to easily measured market indicators. Values associated with reefs have received far more attention than those associated with the pelagic or shelf ecosystems. The economic impacts of overfishing remain largely unexplored. Regulating and maintenance services provided by the marine ecosystems of the WCR have been recognized as important but have not been linked to valuation. Finally, estimates of non-use values for WCR marine ecosystem goods and services are few. The review suggested that future work on valuation be coordinated among countries and agencies so that gaps can be prioritized, and valuation studies can be directed toward a more comprehensive understanding of the full value of the goods and services provided by marine ecosystems in the WCR (Schuhmann and Mahon 2015).

3.5.1.2 **Improving access to research**

3.5.1.2.1 The role of information brokers and coordinators

There are several avenues to improving access to research outputs and expertise that can be pursued as part of a strategy to increase the uptake of science in decision making. They may include better access to:

- Research outputs that already exist
- Expertise that can generate new research outputs that may be needed

In both cases there is the conventional approach of developing databases and inventories which may be centralized or distributed with access through portals, such as the portal that GCFI developed for CLME. Additionally, there is the approach of getting to information via the people who are likely to know where it is, namely the experts operating in the field (Collison and Parcell 2001). Given the rapidly changing information and actors, this latter approach may be the most effective one in which information brokers and coordinators will have a significant role to play. There are already arrangements within the WCR that can play, or that could adapt to this role, primarily GCFI, or the Association of Marine Laboratories of the Caribbean (AMLC).

The AMLC, founded in 1957, has a membership of 36 marine laboratories in 14 countries across the WCR[5]. Its goals are to: advance common interests in the marine sciences, encourage the exchange of research results, foster cooperative research projects, expose students to established scientific methods, and participate in decisions made by national and international organizations concerning the marine environment. These are all relevant to increasing the uptake of science into decision making. The last goal especially indicates a mandate to engage with science-policy processes. In order for this goal to be realized, the AMLC may have to adapt to play the role of information/expertise broker by developing an access interface which would allow a science policy process access to the extensive expertise represented by its membership as per Box 3.

Box 3.3 Assembling an ad hoc working group with input from a science expertise broker

An IGO such as WECAFC is seeking to provide advice to member countries on seagrass systems as fishery nurseries. WECAFC contacts AMLC and asks them to provide the names of persons working on this topic. The individuals named, or a subgroup, are asked to join an ad hoc working group on the topic, and also to provide the names of any international experts that might be important working group members. This working group, with membership from IGO and national scientists, compiles/conducts research and provides advice to the WECAFC Commission. It remains in place until the topic has been satisfactorily addressed.

The approach of ad hoc working groups is currently used by several IGOs, but expertise is generally not assembled through a comprehensive process.

The Gulf and Caribbean Fisheries Institute (GCFI), founded in 1947, promotes the exchange of current information on sustainable use of marine resources in the CLME+ region. From its beginning, GCFI has promoted dialogue among stakeholder groups that often operate in relative isolation from one

[5] *http://www.amlc-carib.org/index.html*

another, such as scientists, resource managers, and the private sector. It does this principally through an annual conference, the location of which moves around the region. GCFI is an independent not-for profit corporation. Similar to AMLC, GCFI could adapt by assembling teams of experts to address specific questions that are proposed by IGOs and/or national policy advisors. The GCFI egroup (GCFINET) currently provides a platform where questions can be asked and where experts can connect with each other; however, it is rare for policy advisors to come to the group for structured input to policy decision making.

Another example of an existing network that provides access to expertise, is the UWI Ocean Governance Network managed by CERMES. Established in 2013, the network has over 80 members comprised of staff and students at the four UWI Campuses in the full range of disciplines listed earlier in this chapter. The network was established primarily to provide an access point to UWI expertise for CARICOM, OECS, the ACS, their institutions, and their member countries. The most notable use of the network has been in getting a small group of UWI experts to join the advisory team for the CARICOM negotiators of the United Nations Agreement on Biodiversity Beyond National Jurisdiction that is currently being developed. Other institutions could be encouraged to develop oceans governance networks that allow access to their expertise.

The role of IOCARIBE, whose mandate has already been mentioned as being the facilitation of scientific research and the uptake of that research by policy makers, should be central in facilitating the access to research.

3.5.1.2.2 Information systems

There have been various attempts over the years to develop centralized and decentralized information systems to provide practitioners with information on expertise, projects, project outcomes, and documented results of work done in the region. So far, none seems to have gained universal acceptance. Individual IGOs and NGOs maintain information systems of their own. However, users must go searching through a wide variety of these (including obsolete versions still lingering on the web) in order to gather the information they need. The most recent attempt was through IOCARIBE, funded by the CLME Project with GCFI as implementer. It showed promise but came to a stop due to lack of financial support. For such a system to become established, used, and supported by user inputs in the region it will need a long-term home institution and financial support. It could be argued that given its mandate to promote science and science uptake into policy making in the region, IOCARIBE would be the logical choice of home institution for such a system.

3.5.1.2.3 Documentation and publication

Improving access to science information will include proper documentation of science findings, including applied research. Much of the work done in the WCR ends up in institutional reports that are difficult to find. Often these are not made discoverable on the web, if they are on the web at all. A strategy to increase uptake of science in decision making in the WCR will include establishment of report series that are properly documented, citable, and accessible on the web. Some examples are CERMES technical report series and CRFM reports. Greater attention is needed to ensuring that grey literature reports are made discoverable on the web by institutionalising them in report series and linking them to bibliographic systems that use abstract and keywords to improve discoverability. One of the advantages of establishing report series is that they become known and people go to them when in search of particular types of information, (e.g. FAO Fisheries and Aquaculture Reports).

Similarly, GCFI has produced over 72 years of annual publications resulting from research presented at their annual conference. While most of the publications are in the form of grey literature, they have recently started a publication series and have developed a partnership to publish peer-reviewed original research. The articles are indexed and discoverable in many search engines.

Much of the work published in the grey literature is, if not proprietary, publishable in journals at some level. This lends credibility to the findings and should be programmatically encouraged and supported whenever possible.

3.5.1.3 Making applied research more attractive for science producers

While mechanisms for brokering access to expertise and information such as those referred to above can improve access, they can also serve to build/strengthen communities of practice based around a research question that brings together the multidisciplinary expertise needed to address complex questions of EBM (Stojanovic et al. 2009). There are numerous questions and issues to be considered in pursuing this direction. They include incentives for scientists to participate in these processes. One disincentive is the view by many scientists that science and policy making should be at 'arm's length', leading to disinclination to get drawn into policy-making processes. In response to this it can be argued that science-policy processes, if properly structured, will have a clear demarcation between science advice and policy advice (Polachek 2012).

Access to funds for research is always an issue for researchers. It can be assumed that by working together on problems that are based on questions proposed by technical advisors, groups of science providers will increase their likelihood of accessing funding from donors (bilateral, intergovernmental, foundations, NGOs) with an interest in the issue.

Apart from this there is the need to develop a regional level research funding mechanism, similar to the national science funding mechanisms found in large countries, that can support the applied research needed to ensure the use of BASE.

3.5.1.4 Monitoring science inputs and assessing policy influence

In order to build a culture of producing science for decision making and using it in decision making, progress should be monitored, documented, and shared (Carden 2004; Kushner et al. 2012). Promoting the uptake of science into policy making should be a strategic direction for regional level planning and should be monitored and reported on. This should include specific documentation of the impact of research on decision-making, both within the Caribbean and externally for similar resource systems and socioeconomic settings.

[5] *http://www.amlc-carib.org/index.html*

3.6 The strategy for linking research and policy making

3.6.1 Strategic directions

The forgoing sections provide the context and rationale for a strategy to increase the uptake of science in decision making for sustainable use of LMRs. The strategy must include four components:

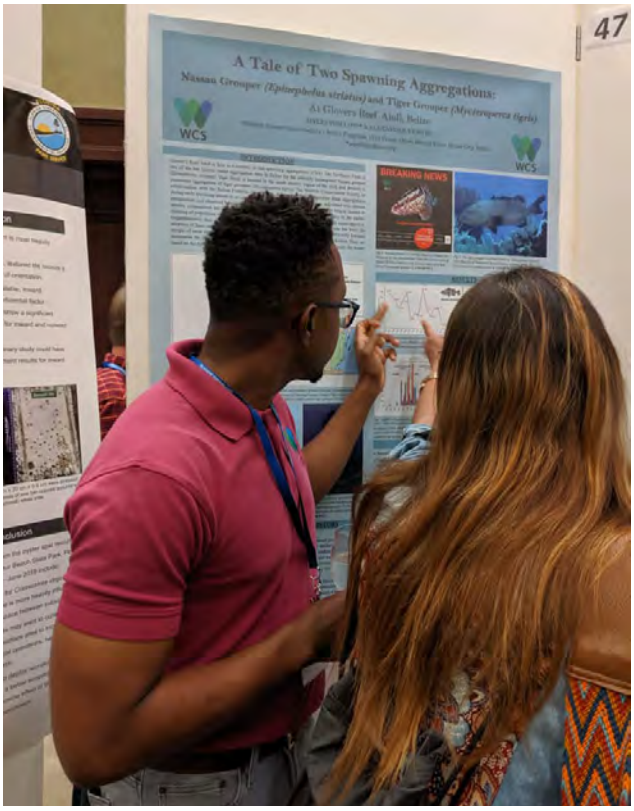
- Promoting high-quality applicable science
- Engaging research providers
- Engaging research users
- Facilitating the interaction between the two groups.

It may appear obvious that researchers and users should be willing and eager to play their respective roles in ensuring that decisions are based upon the best available information. However, this is not always the case. Researchers may prefer to keep on doing their own thing and publishing without the added burden of having to engage with users. Similarly, users, especially decision makers, may feel that they have been doing quite well without the added burden of having to grapple with a lot of new information. Both sides may feel threatened by having to engage with the other. Therefore, incentives for both groups will be an important part of a strategy. The elements of such a strategy are outlined in the following sections.

3.6.2 Promoting high-quality applicable science

High-quality applicable science can be promoted by the following actions:

- Engage donors of all types (bilateral, private, UN) to build a practice of funding research for which there is a demand[6].
- Strengthen regional research centers, especially in gap areas.
- Develop opportunities for interaction among researchers, both conferences and small working groups.
- Develop opportunities for early career researchers to work with established ones (within and outside the region)



[6] *The aim here is not to suppress pure research or downplay its importance. However, in a developing region, there are plenty of interesting and challenging research questions with applicability (in Pasteur's Quadrant)*

3.6.3 **Engaging research providers**

Research providers should be encouraged to engage with consumers and science-policy facilitators through the following actions:

- Engage research managers such as university chancellors, deans, and/or research station directors to build mechanisms for getting science into policy, such as
  - Building internal institutional mechanisms in provider institutions to facilitate access to their expertise (e.g., UWI Ocean Governance network, see Box 3.2)
  - Giving greater recognition and career advancement to persons who:
    - Produce applicable research and engage directly in policy processes to provide science inputs.
    - Participating in policy processes at the institutional level in roles such as formulation and brokering the transfer of advice.
- Emphasizing the social responsibility of all scientists, especially in a developing region where research funding and capacity is limited, to contribute to sustainable development agendas
- Paying researchers when possible.

3.6.4 **Engaging research users**

Research users should be engaged to encourage the use of best available scientific information in decision-making through the following activities:

- Producing information based on research that clearly addresses the concerns of research users.
- Establishing clear pathways for decision makers and their advisors to access research outputs and expertise, even outside of the clear process above
- Documenting and sharing examples of good governance processes that use research outputs
- Documenting and sharing case histories of instances where use of research has resulted in improved management and even human well-being (within the region and for similar resource systems worldwide).

3.6.5 Facilitating the interaction between the two groups

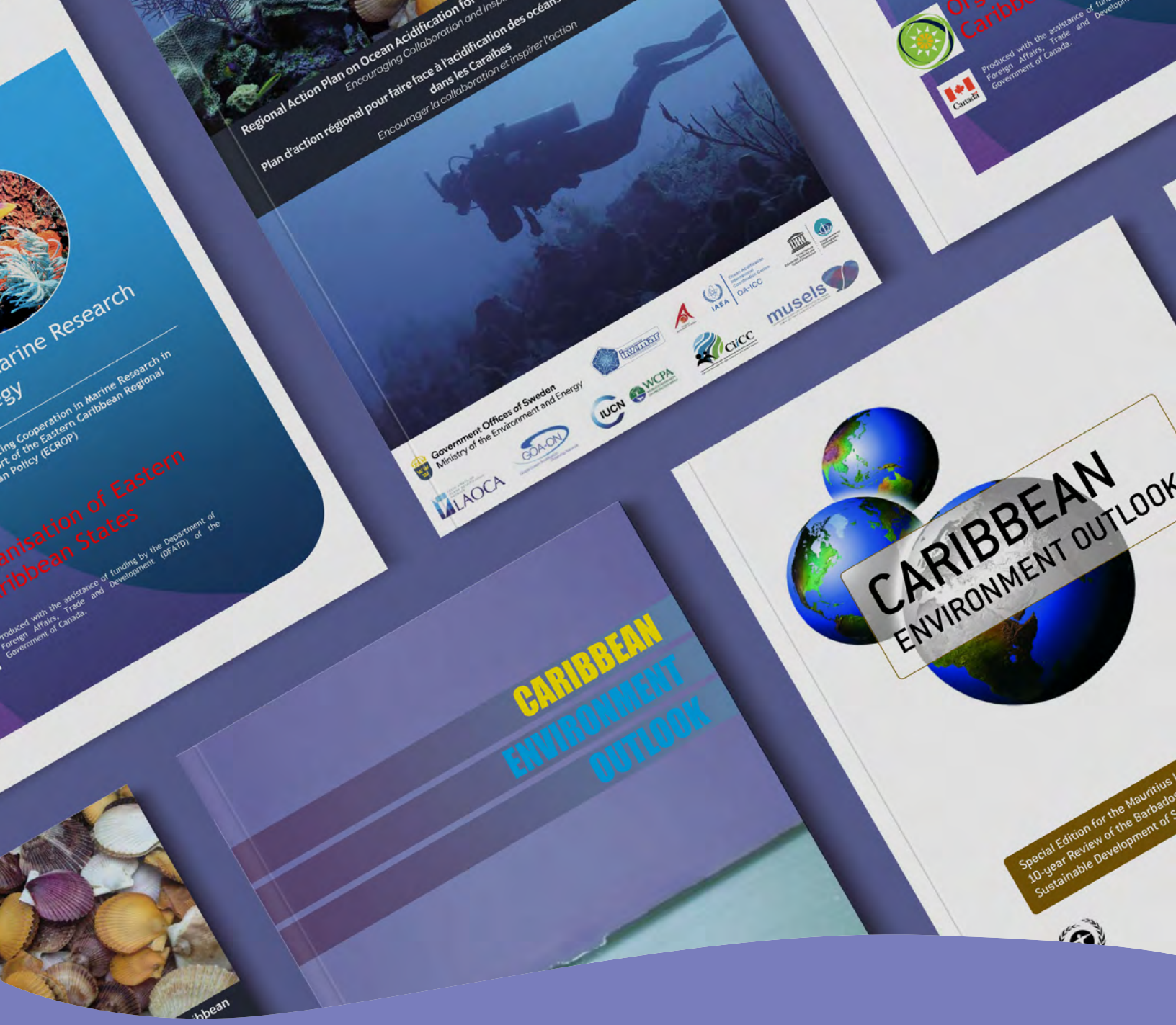
The interactions between research providers and research users should be facilitated through the following actions:

- Establish, document, and share information on policy processes that use science so that researchers can at least be aware of them and at best engage with them.
- Develop an understanding among research users of the processes and constraints (funding, time needed for results, researcher's time) associated with research.
- Expose both providers and users to best practices in other regions and institutions.
- Develop a regional interface that would allow users to find the expertise needed. This would allow users to build teams to address problems that may be of short or long duration, and to find mature expertise to engage in the development of advice. Teams could plan and carry out any of the types of research identified above depending on need and availability of funding.

3.6.6 Institutionalising the development of use of BASE in policy making

All stakeholders will need to engage for the approach outlined above to become a reality; however, that is not enough. There needs to be an agency with responsibility for pursuing this strategy. Given its mandate, IOCARIBE would appear to be the logical institutional home for the strategy. It is noted also that several functions of the CLME CM pertain to this strategy as well. Actions include:

- Designate a body to oversee and build the regional interface (ideally the Coordinating Mechanism).
- Develop a research policy making and strengthening strategy to share with both groups
- Take a programmatic approach to developing the use of BASE in policy making, with strategic and action planning



Chapter 4

Previous efforts at research strategy development in the CLME+ region

Marine research in the Caribbean region has a long and rich history; however, this research has often been guided by projects that are opportunistic by nature rather than strategic. Unfortunately, in many cases, the information provided by these studies has been difficult to translate to policy because scientists rather than decision/policy makers drove these research activities. Furthermore, multiple assessments have been conducted in the past with a focus on natural conditions without considering the links to socio-economics or factoring in governance arrangements. Having a thorough understanding of the multiple interrelated dimensions occuring in oceans as well as how these translate to human well-being including economies is essential to making informed decisions to achieve a sustainable blue economy. Because of this need, the State of the Marine Environment and associated Economies (SOMEE) supported by the UNDP/GEF CLME+ Project was developed to facilitate action and support decision-making on the governance and management of shared resources whilst building on and integrating existing mandates.

Furthermore, several regional thematic strategies have helped to contribute to research priorities even though research wasn't the primary objective when they were developed. The United Nations Caribbean Environment Programme (UNEP-CEP) has created several technical reports on marine litter, sargassum, ballast water, and oil spills. These reports are publicly available for others to use when developing focused research strategies. There are also instances of strategies that attempt to take a region-wide approach and to provide information that can be translated to policy. This document is intended to build on those previous efforts.

The earliest Caribbean regional research strategy that was identified was developed by UNESCO in 1989. This strategy focused on priorities for marine pollution monitoring, research, control, and abatement. The main subject areas included industrial pollution, pollution from agriculture and other land-use activities, domestic sources of pollutants, and marine based sources of pollution including oil discharges and marine debris (UNESCO 1989). Since then, multiple National Programmes of Action (NPAs) for the Protection of the Coastal and Marine Environment from Land-based Sources (LBS) of Pollution were developed to help the region respond to the increasing threats to the marine environment from pollution in a more integrated manner (UNEP 2006). The State of the Cartagena Convention Area Report (SOCAR) was developed as an assessment of marine pollution from LBS and activities in the Wider Caribbean Region in order to inform decision making and stimulate actions to reduce / eliminate LBS in the long term (UNEP-CEP 2020). The SOCAR builds on other efforts such as the Caribbean Environment Outlook which included state of the environment assessments in order to help identify regional environmental concerns whilst also highlighing policy priorities (UNEP 1999, 2005). Reports such as these are essential to other research strategies as they provide a quantitative baseline for monitoring and assessement in the marine environment whilst also informing the development of legislative and policy initiatives. Additionally, unlike national and regional reports which identify research needs for filling data gaps to fulfill reporting, these are essential to foster strategic decision making.

The Organisation of Eastern Caribbean States (OECS) Commission developed a Marine Research Strategy in 2016 which aimed to support the implementation of the Eastern Caribbean Regional Ocean Policy (ECROP) by creating an integrated, well-funded, and well-designed framework for marine research (OECS 2016). This Strategy was developed with the core principles of designing in accordance with international best-practices building on existing actions such as research policies from other organizations like the CRFM and FAO, embracing and developing these activities, implementing an inclusive and consultative approach that fosters local ownership, and ensuring sustainability of the outputs by addressing transition processes and planning for future

steps.The Caribbean Regional Fisheries Mechanism (CRFM) developed a Fisheries and Aquaculture Research Agenda for 2016 – 2018 which consisted of 26 high-priority research activities identified from 182 research recommendations. These high-priority research activities focused, in-part, on emerging topics such as invasive alien species and climate change. Other, more traditional research topics were also considered such as natural hazards; fisheries stock assessments; illegal, unreported and unregulated fishing (IUU fishing); reef and slope fisheries; fisheries and associated ecosystems; pelagic species; policy including governance and management; and underutilised and unutilised species.

A Regional Action Plan on Ocean Acidification for Latin America and the Caribbean was also developed in 2018 by INVEMAR in Colombia to identify the key priorities needed to address ocean acidification (OA) and support the region's response to this global challenge. This activity identified many gaps in the region's ability to cope, manage, and respond to ocean acidification. Priority actions were identified and grouped according to themes such as science, policy, funding, communications, and outreach and associated implementation strategies were developed (Laffoley et al. 2018).

A Regional Nutrient Reduction Strategy (RNRS) for the WCR is currently under development by UNEP-CEP. This strategy is intended to expand baselines; identify the most important pollution sources; identify high priority areas for further action; facilitate knowledge exchange; transfer and build capacity; support institutional policy and legal reforms. The Strategy will also include the development of regional standards, criteria, and new areas of research related to nutrient pollution.

Finally, a Regional Strategy and Action Plan for the Valuation, Protection, and/or Restoration of Key Marine Habitats in the Wider Caribbean is currently being developed for the 2021 – 2030 time frame by CANARI with a focus on the three nearshore habitats (coral reefs, mangroves, and seagrass beds). This strategy aims to advance key UN Environment agendas; complement and integrate regional strategies; align actions to meet obligations of regional and multilateral environmental agreements; operationalise priority actions related to habitats and provide a framework for multi-stakeholder and cross-sectoral achievement of mutual objectives.

Numerous regional meetings are held annually such as those of the Gulf and Caribbean Fisheries Institute (GCFI), Association of Marine Laboratories in the Caribbean (AMLC), Caribaea Initiative, and the Caribbean Water and Wastewater Association (CWWA). Hundreds of regional and international scientists attend these meetings to share the latest research; however, there are additional needs to link this research with decision-making. There has also been an increase in collaborative approaches to research within the region. For example, the GCFI and UNEP-CEP have collaborated as co-hosts to the Caribbean Node of the Global Partnership on Marine Litter. Through this collaboration they have brought together multiple stakeholders (academia/research, government, civil society, private sector, etc) to develop a regional strategy to identify priority research and management areas of focus for marine litter in the WCR. Similar partnerships are critical to leverage existing capacity. Partnerships must be developed or strengthened with a focus on developing region-wide strategic approaches to dealing with critical marine sustainability issues.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Chapter 5

Approach and Methodology

5.1 Background to the Methodology

As previously articulated, the focus of this report is on identifying research priorities in the CLME+ region at the nexus of science and policy. Thus, the perspective is meant to be from decision makers because they are the entities that will use the information to craft policy. If the information they receive is not timely or relevant, the value of that information will be limited both in terms of their willingness and ability to use the information and to develop effective policy from it.

Ultimately, this document represents the combination of a regional research framework informed by national and regional stakeholder-driven priorities. It is the adherence to recognition of the social, economic, and environmental complexities of the region that form the basis for the development of the research agendas detailed in Chapters 6-8 (i.e., fisheries, habitat, and pollution).

The research agendas were developed from numerous sources and together they served as a comprehensive roadmap to address research priorities that serve to inform decision makers. The outline is guided foremost from the vision of the Strategic Action Program (SAP) of the CLME+ project: "a healthy marine environment in the CLME+ [that] provides benefits and livelihoods for the wellbeing of the people of the region." It is the fidelity to this vision that has driven the approach, and the results, that we describe.

The approach that was employed was to 1) conduct a gap analysis to identify a wide diversity of research topics to address specific management needs, and 2) to use the results from the gap analysis to identify the highest priority research topics of decision makers. Thus, this two-step approach served as the framework from which research priorities were both identified and prioritized.

The research topics fall under overarching themes and, within those themes, specific goals (Figure 1.2). The themes are broad categories that consist of research in the areas of science, governance, monitoring, economics, and communications. The goals are driven by the needs associated with the specific agenda and associated themes.

5.2 Research Themes

This project adopted a process that used each agenda's themes to provide structure for the lists of research topics. The themes extended beyond the often-traditional views of research which tend to focus strictly on the biological and ecological sciences. Instead, the focus was broadened to provide a holistic approach to understanding the research needed to accomplish the development and implementation of policy by also addressing social, political, and economic barriers to implementing effective policies.

The research agenda is comprised of five themes which when taken together represent the full range of information decision makers would likely need to make well-informed decisions. The themes included research related to:

1. **Science** – the science theme is focused on the goals and research topics related specifically to the biological and ecological sciences.

2. **Governance** – the governance theme examined the limitations in existing governance structures and identified the research needed to overcome these limitations.

3. **Monitoring** – the monitoring theme recognizes that there are gaps in monitoring approaches and that there are specific research needs that address these gaps, especially considering that monitoring is often designed to assess the effectiveness of policy-driven management activities.

4. **Economics** – the economics theme identified the research topics that focused on economic impacts as well as economic opportunities.

5. **Communications** – the communications theme recognizes that communication to a wide suite of stakeholders is necessary to achieve the goals of effective policy implementation by both facilitating stakeholder buy-in as well as conveying clearly the needed information to the appropriate policy and decision makers in a form they can use.

5.3 Identification of Research Topics and Development of Goals – The Gap Analysis

5.3.1 Research topic questionnaire

The process of identifying gaps (i.e. research topics) was multi-dimensional. First, a questionnaire was developed and distributed to a suite of stakeholders. The individuals surveyed for this study were comprised of practitioners with extensive experience and knowledge of the marine resource issues and the conservation and management of marine resources in the CLME+ region. Potential participants were identified through the GCFI membership and registration list for the annual conference, the focal points for the various agendas (i.e., LBS protocol, SPAW protocol), and FAO fisheries experts. We further refined the pool of experts through recommendations from CLME+ members and by asking the respondents to recommend other potential experts using a 'snowball sampling procedure'. In all, the respondents represented researchers, managers, stakeholders, academicians, students, resources users, civil society members, industry, and decision makers. Each individual who was contacted had worked on the waters in the CLME+ region for two or more years with some exceptions for those in industry/civil society.

5.3.2 Consultation Workshops

GCFI conducted workshops at the 2016, 2017, and 2018 GCFI conferences and each workshop focused on one of the agendas examined in this report (e.g., Fisheries, Habitat, Pollution). The focus of the workshops was to catalogue research topics using a brainstorming format.

In all workshops, the participants were introduced to the approach of using research themes to identify research topics. Five tables were set up that corresponded to each theme. The workshop participants shuttled between the

tables and brainstormed research topics within each of the themes.

The workshops were aligned to conference-specific themes or special sessions. For example, the 69th meeting (2016) had a topical session entitled "Identifying, Understanding, and Reducing Marine Debris in the Gulf and Caribbean". Therefore, the workshop at that meeting addressed the pollution agenda. The theme for the 71st meeting (2018) spotlighted habitats so the workshop at the 71st meeting focused on the habitat agenda. In this way, the workshops benefited from the enhanced attendance at the conference by the regional experts who were there for the topical session.

Prior to each workshop, the questionnaire described in Section 5.3.1 was sent to a subset of the participants to help them prepare their input for the upcoming workshop. At the workshops, the participants were asked to provide inputs related to needs, actions, and/or tools that addressed the questions in the questionnaire. GCFI moderators and partners facilitated the discussions.

An additional focus of the workshops was to collect other information on research needs for the specific agenda thus collecting stakeholder input on:

- The most pressing issues dealing with the agenda in the CLME+ region
- Potential needs and priorities that could be addressed to achieve the goals of the project
- The instruments/tools that could be used to identify these needs and priorities.

Subsequent to the workshops, area of commonalities were identified. These served as the basis for the development of goals and to distill similar thoughts into one comprehensive topic.

5.3.3 Additional Sources

To ensure that the research topics identified for each research agenda was as complete as possible, an extensive literature review was conducted to glean those that may have been overlooked using the other methods. The principal sources that were used to ensure completeness were the State of the Cartagena Convention Area (SOCAR), The State of the Marine Environment and associated Economies (SOMEE), regional fisheries reports from the FAO, CLME Reef & Pelagic Ecosystems Transboundary Diagnostic Analysis, and the Regional Strategy and Action Plan for the Valuation, Protection and/or Restoration of Key Marine Habitats in the Wider Caribbean 2021–2030. Together with other scientific literature and reports, these primary sources of information were instrumental in adding to the information from the surveys and the workshops.

Once the list of research topics was developed for each agenda and theme, areas of commonality were identified and grouped into overarching goals (Table 5.1). These formed the structure for the tables of research topics (see Chapters 6, 7, and 8).

The research topics were intentionally developed at the strategic scale rather than identifying specific projects and/or actions. There was also an effort to minimize the number of research topics while still ensuring completeness of coverage. It was determined that this approach made prioritization easier and more manageable. In many cases, the multiple resources that were used to develop the research topics consisted of topics that had significant overlap. When this occurred, these were combined to ensure that no content was lost.

5.4 Identifying the highest priority research topics

Determining the research priorities of decision makers was the goal of this report. To identify the highest priority research topics, online surveys for each agenda were developed in SurveyMonkey (www.surveymonkey.com) and distributed electronically in English and Spanish to a broad suite of stakeholders. This approach provided a comprehensive distribution that ensured that important stakeholders were included in the survey. Each agenda-specific survey was distributed to over 1200 individuals found in databases of decision-makers encompassing a diverse set of stakeholders tailored to the specific agenda. These included, but were not limited to focal points for the LBS protocol for the pollution agenda, SPAW protocol for the habitat agenda, and FAO/CRFM for the fisheries agenda. The questionnaire was also sent to regional email distribution lists that focused loosely on the specific agenda under examination. For example, in addition to focal points, the CaMPAM-L email distribution list for MPA managers was sent the habitat agenda survey.

The highest-priority research topics were identified by examining the survey responses by the decision makers. As part of the survey, each participant was first asked to identify their role in their ministry/organization/agency. To ensure that the results addressed the priorities of decision makers, the results were filtered for those individuals who self-identified themselves in that role.

The participants were also asked to rank the importance of each research topic on a scale from 1 (not important) to 4 (very important). The results of these responses were analyzed by calculating the mean value of those responses for each topic. Those topics with the overall highest mean score represented the highest priority within that goal; those with the lowest score represented the lowest priority. The research topic that scored the highest overall for the specific agendas were also identified. In this way, decision makers could use these results to identify areas to dedicate resources that best met their priorities.

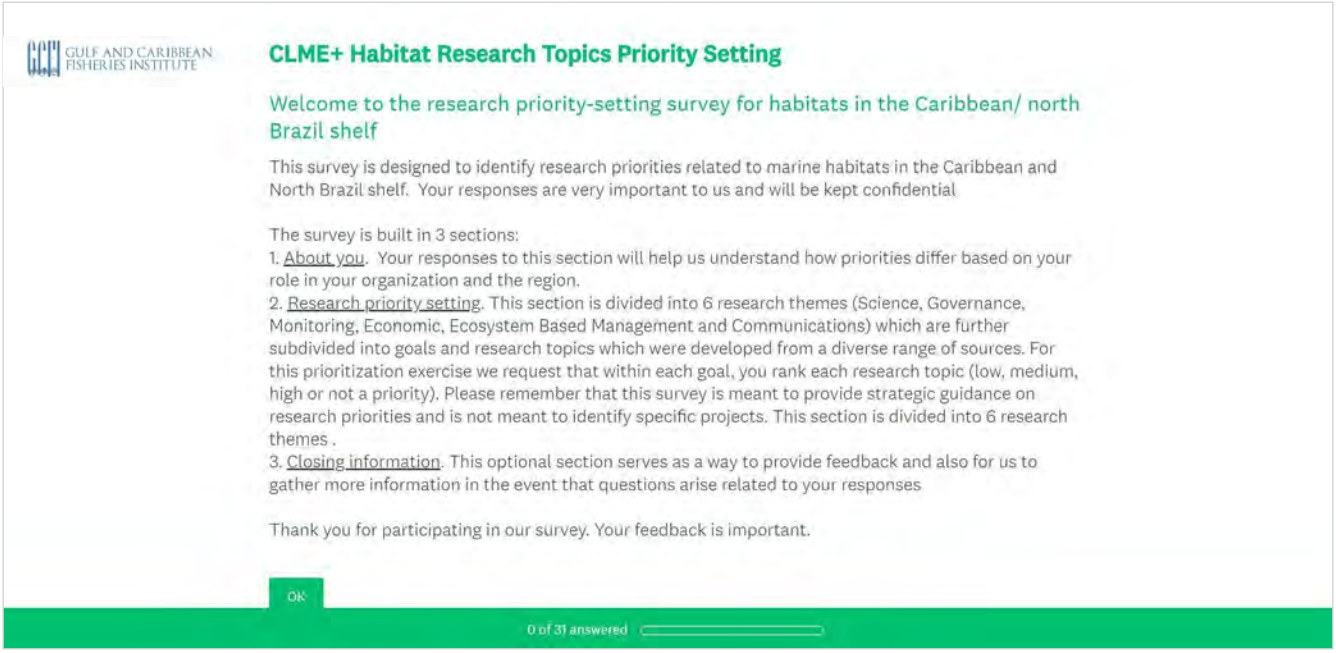


Table 5.1 | Research goals associated with research agendas and themes

Theme	Goal
Science	Investigate Caribbean Spiny Lobster population status & its role in the ecosystem
	Examine potential impacts of climate change on the Spiny Lobster fishery
	Understand Flyingfish population status
	Understand ecosystem role of the Flyingfish stocks
	Examine potential impacts of climate change on the Flyingfish fishery
	Examine potential impacts of Sargassum on the Flyingfish fishery
	Investigate shrimp and groundfish population status and its role in the ecosystem for industrial and artisanal fisheries
	Reduce the potential impacts of climate change on the shrimp and groundfish fisheries
Governance	Improve Spiny Lobster fishery governance
	Strengthen regional coordination in support of Flyingfish fishery governance
	Improve shrimp and groundfish fisheries governance
Monitoring	Improve data quality needed to understand the Caribbean Spiny Lobster's ecosystem role in the Caribbean
	Harmonize and enhance data collection systems at the local and regional level
	Understand ecosystem role of the Flyingfish stocks
	Ensure sustainable industrial and artisanal fisheries by improving data quality needed for shrimp and groundfish
Economic	Highlight the social and economic importance of the Spiny Lobster fishery
	Enhance the social and economic value of the Flyingfish fishery
	Better understand the social and economic importance of the shrimp and groundfish fisheries
Communications	Increase interest of managers/stakeholders in information and management measures of the Spiny Lobster fishery
	Enhance research cooperation in support of shared policy interests and transboundary issues of the Spiny Lobster fishery
	Increase interest of managers/stakeholders in information and management measures of the Flyingfish fishery
	Enhance research cooperation in support of shared policy interests and transboundary issues of the Flyingfishfishery
	Increase communication effectiveness for the shrimp and groundfish fisheries

Table 5.1 continued

Theme	Goal
Science	Assess ecological role and value of marine habitats
	Apply best practices to collect and share data to conduct research on marine habitats
	Assess impacts of emerging issues on marine habitats
	Assess the potential of habitat restoration for conserving marine habitats
	Identify and reduce the incidence of threats to marine habitats
	Identify which management actions are most effective for conserving marine habitats
Governance	Apply best practices to improve effectiveness of existing legislation and programs protecting marine habitats
	Strengthen capacity to improve effectiveness of existing legislations and programs protecting marine habitats
	Implement ecosystem based approaches for conserving marine habitats
Monitoring	Apply best practices to collect and share results of marine habitat monitoring
	Monitor marine habitats in deep water
	Monitor the ecological role and value of marine habitats
	Monitor anthropogenic threats to marine habitats
Economic	Investigate sustainable financing options for marine habitats
	Assess the value of marine habitats
	Promote gender equality and cultural values of marine habitats
Communications	Apply best practices to enhance communications for the sustainable management of marine habitats
	Build capacity in all facets of marine conservation and sustainable use to disseminate and apply best practices to engage communities in the sustainable management of marine habitats
	Enhance communications related to marketing, funding and education initiatives

Table 5.1 continued

Theme	Goal
Science	Reduce the risk to areas and wildlife from marine pollution
	Reduce the risk to human health from marine pollution
Governance	Create or enable policies and legislation that contribute to the reduction in marine pollution
	Engage the private sector to achieve policy and management-based solutions to pollution
	Identify and develop improved solid waste management approaches
	Reduce the risk to society from marine pollution
Monitoring	Increase monitoring and assessment activities related to marine pollution
	Enhance inputs from scientific research in monitoring activities related to marine pollution
	Increase stakeholder participation in research and monitoring activities related to marine pollution
Economic	Reduce the economic impacts from pollution
	Enhance inputs from scientific research in monitoring activities related to marine pollution
Communications	Ensure effective communication to ensure pollution mitigation and reduction

Chapter 6

Fisheries Research Agenda

6.1 Introduction

Marine fisheries and the seafood they provide play an important role in coastal Caribbean and Latin America communities by contributing to food security, providing livelihoods, and other potential economic and social benefits. Most of the fisheries production comes from marine fisheries. In 2016, Latin America and the Caribbean represented 4% of the global population engaged in the fisheries and aquaculture sectors (FAO 2018). On average, fisheries and aquaculture account for about 1% of the Gross Domestic Product (GDP) in the WECAFC area. Despite the relatively low production, fish catch in the WECAFC area focuses on high value species such as Spiny Lobster, Queen Conch, and shrimp.

In the Caribbean, many fisheries are under stress from numerous causes and these have impacts to the communities that depend upon them (Figure 6.1) Whalley (2011) provided a summary of the key issues impacting reef, pelagic, and continental shelf fishery ecosystems. Overfishing and ecosystem degradation are the most pernicious threats to many of the region's fisheries (Brown and Pomeroy 1999). This is particularly troublesome because small-scale fishers rely on these fisheries for their livelihoods. Coral reef ecosystems in the Caribbean have more recently been threatened by Sargassum outbreaks, which were first recorded in the early 1990s (Bouchon et al. 1992) and now represent a growing concern in the region (Johnson et al. 2013, Louime et al. 2017).

In the North Brazil Large Marine Ecosystem, Freire and Pauly (2010) described the overfishing as a classic "fishing down the marine food web" dynamic. This region suffered one of the worst collapses of trophic structure in the world. Unfortunately, there is some uncertainty with assessing total catches because it was shown that a critical aspect of the total fish catch (such as discards and IUU fishing) remains largely unknown (Pauly et al. 2017).

In Latin America and the Caribbean, catch reconstruction data show that discards contribute significantly to declines in annual catch; most of this is contribution comes from industrial fisheries (Zeller 2017, Pauly and Zeller 2015).

While these resources represent a rich natural capital, effective management remains challenging, especially when considering the threats from overfishing, coastal development, pollution, and climate change (Figure 6.1). Achieving effective fisheries management is complex because of the importance of harmonized governance structures that support economic vitality in a multi-dimensional transboundary environment. Furthermore, managing natural resources across such a vast expanse presents its own complexities

Well-managed commercial, recreational, and artisanal fisheries play an important role in the region's economy by serving as sustainable sources of food. For the Spiny Lobster, Flyingfish, and shrimp and groundfish fisheries, governments need to work closely with national and regional fisheries management agencies as well as local communities and other stakeholders. There are, however, major gaps in knowledge about these fisheries, and major challenges in their assessment and management.

This chapter includes three main sections. The first is an introductory section that provides an overview of general trends in the fisheries of the countries belonging to the CLME+ as well as some of the key challenges they are facing in terms of sustainability. The second component consists of sections that identify research gaps for the three key fisheries (i.e., Caribbean Spiny Lobster, Flyingfish, and shrimp and groundfish). The third section examines the complex characteristics of the regional fisheries governance structures from the management perspective and argues for a shift from conventional approaches towards a system that enables and adapts to a wider range of externalities. A review of governance in the region was presented in Chapter 3 of this report and can be found in other publications (e.g. Mahon 2019).

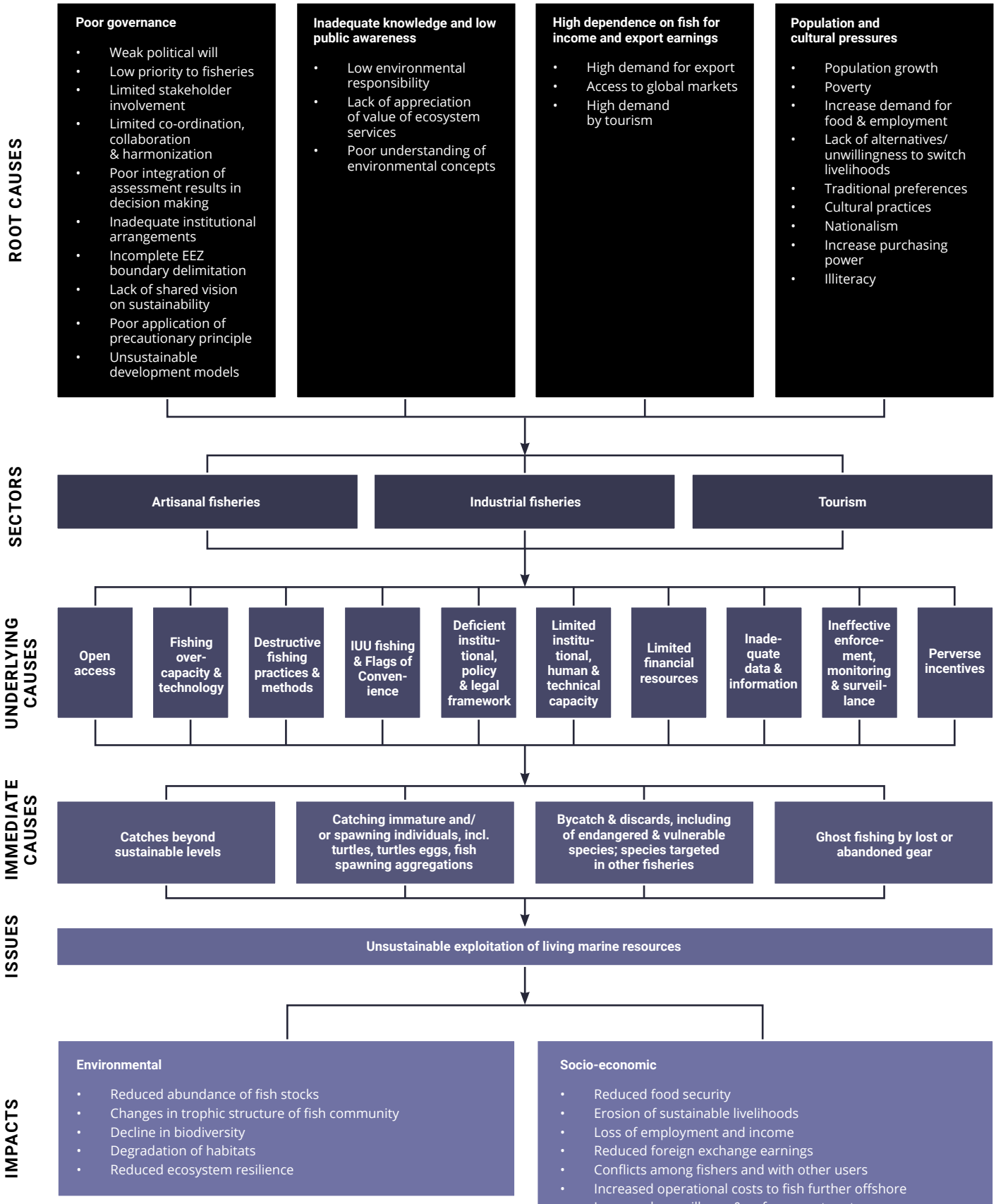


Figure 6.1 | Causal chain diagram illustrating the relationships between causes and effects of unsustainable exploitation of fisheries resources in the Caribbean.

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

6.1.1 Characterization of the Fisheries of the Caribbean and the North Brazil Shelf LME (CLME+)

The CLME+ region (Figure 6.2) is geographically one of the most complex regions in the world and is divided into several deep ocean basins separated by shallow zones of offshore banks and the continental shelf. The major island groups are The Bahamas and adjacent banks and Islands, which account for half of the islands and bank shelf areas, the Greater Antilles (Cuba, Puerto Rico, the Virgin Islands, and Hispaniola) and the lesser Antilles (Stevenson 1981).

The fisheries in the Caribbean region are primarily artisanal and use outboard-powered vessels primarily 5-12 m in length. Notable exceptions include the shrimp and groundfish fisheries of Guyana and Suriname where trawlers in the 20-30 m range are commonly used, and the tuna fishery of Venezuela which utilizes large (> 20 m) long liners and purse seiners. In some countries there has been a recent trend towards midsize vessels in the 12-15 m range, particularly for large pelagic fishes, deep slope fishes (snappers and groupers), and lobster and conch on the offshore banks (Mahon 2002). Many fishers are part-time and make their living from a variety of activities besides fishing, especially where fish resources are seasonal.

Figure 6.2 | The countries/states of the Wider Caribbean Region and the three Large Marine Ecosystems that comprise it.

The geography of the region results in very complex benthic habitats/ecosystems with a rich biodiversity (Smith et al. 2002; Roberts et al. 2002; Cochrane 2005,); at least 12,046 species including 987 are fish species reportedly occur in the Caribbean Sea (Miloslavich et al. 2010).

The Caribbean and adjacent countries are dependent to a significant degree on two inter-related economic industries: fishing and tourism (Parsons 2007). However, the latest WECAFC assessment indicated that landings have decreased from 2.4 million tons in 1984 until 2017 with landings reported at 1.6 million tons (Figure 6.3).

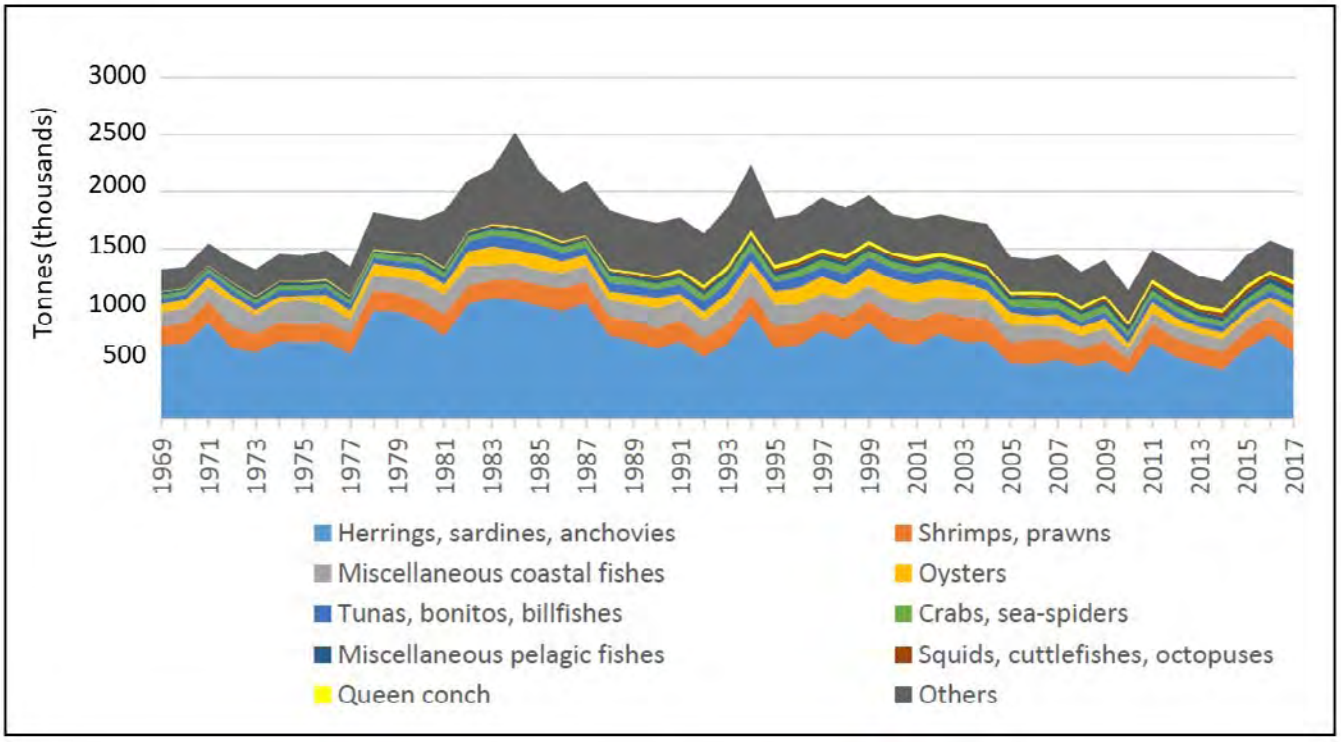


Figure 6.3 | Total reported landings (in thousand tons) by International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groups in the Western Central Atlantic (1969-2017).

Many of the fisheries are either overfished or fully exploited. FAO analyzed the catch statistics of 33 species and species groups through 2015 (FAO 2017) and estimated that 12% of species/species groups were overfished, 42% of fisheries were considered between overfished and fully fished (depending on stocks or geographical location), and 36% of species/species groups were estimated to be fully fished. In some cases (e.g., penaeid shrimps excluding Atlantic seabob), landings have been low and the resource appears to be depleted (Figure 6.4). Other sources (e.g., www.onesharedocean.org) suggest that 60% of commercially-exploited fishery stocks in the CLME and Gulf of Mexico Large Marine Ecosystem (GoM-LME) and half the stocks in the North Brazil Shelf Large Marine Ecosystem (NBSLME) are either overexploited or have collapsed.

Red snapper (*Lutjanus campechanus*) is caught alongside other species in a variety of gears including traps and trawl. Catches of vermillion snapper (*Rhomboplites aurorubens*), lane snapper (*L. synagris*), mutton snapper (*L. analis*), and silk snapper (*L. vivanus*) are landed together making the assessment of these species difficult (Figure 6.5). Nevertheless, in the case of the snapper fisheries, the data are sparse.

The pressures on the region's fisheries are considerable. Subsistence fishing, commercial and recreational fisheries, collection for the hobby trades, and, significantly, IUU fishing all contribute to the catch which, in many cases, leads to unsustainability. The unsustainable nature of fishing practices is further compounded by poor regulation and enforcement coupled with a lack of political will to overcome these deficiencies. Additionally, the use of inappropriate and damaging fishing gear results in excessive bycatch and habitat degradation leading to deleterious impacts to non-target species and associated biodiversity (Singh-Renton and McIvor 2015; Debels et al. 2017).

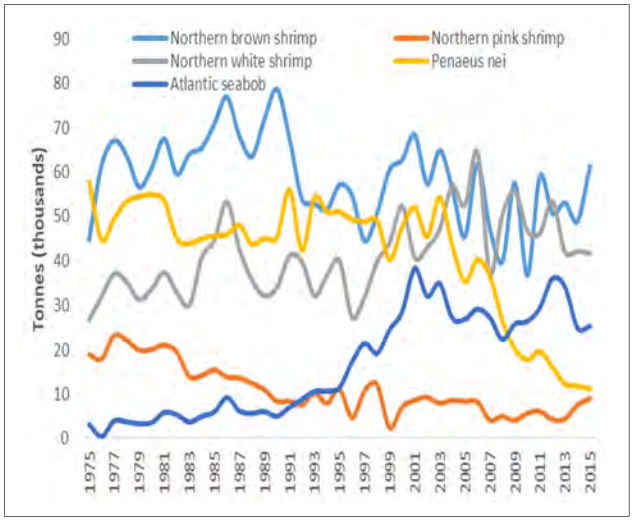


Figure 6.4 | Total reported landings (in thousand tons) by International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groups in the Western Central Atlantic (1975-2015) for (penaeid shrimps) and Atlantic seabob. (WECAFC 2017).

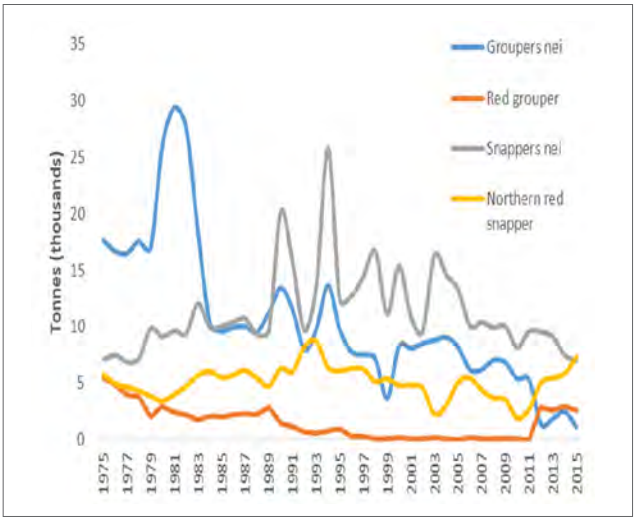


Figure 6.5 | Total reported landings (in thousand tons) by International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) groups in theWestern Central Atlantic (1975-2015) for snappers and groupers, shrimps and Atlantic seabob (WECAFC 2017).

Effective management of the region's fisheries is challenging and complicated by numerous factors. These include the diversity of the fishing fleets, the differences in fishing effort among and within countries, the lack of government support for managing many of the fisheries, the open-access nature of many resources, and the lack of appropriate frameworks for fisheries management (Chuenpagdee et al. 2011). Furthermore, fishery research institutes in the region often lack the technical capacity to assess their associated fisheries as identified within the GCFI 2017 workshop ("Identifying Research Priorities for Three Focal Fisheries in the CLME+ Region with an Emphasis at the Management/Research Interface") as well as literature reviews (, Salas et al 2007; Chuenpagdee et al 2011). Yet, data collection is common in all countries of the Latin America and Caribbean (LAC) region (Chuenpagdee et al. 2011; Salas et al. 2019). However, not all countries collect the full suite of information required for overall evaluations of the coastal communities and their associated fisheries (Figure 6.6).

6.2 Fisheries agenda

In recent years, biological and socio-economic monitoring of fisheries in the Caribbean has become an important component of marine management. Reviews and needs assessments of fisheries activities in the Caribbean have highlighted the challenge for coordinated monitoring and assessments often due to the different management objectives of multiple agencies. Additionally, the resources they have available are highly variable in quality and often limited, and often employ a wide range of sampling strategies and data collection techniques (FAO 2016; 2017). Data integration and synthesis suffer and may result in a spatially and temporally disjointed perspective on ecosystem health including the status of fisheries. In addition, limited flow of information takes place between agencies. Numerous reviews of Caribbean fisheries strategies have been conducted (e.g., Parsons 2007; Salas et al. 2007a; Salas et al. 2007b; Fanning et al. 2011; Salas 2011; Pittman et al 2012; UPR Sea Grant College Program 2014; Payne and McLanahan 2014; NOAA 2016; Debels et al 2017; Muñoz and Bail 2017; WECAFC 2017; FAO 2018; Salas2019).

The fisheries agenda, as in all other agendas within this report, is structured to address the wide suite of issues confronted by society. As described in Chapter 5, each fishery in the Fisheries Research Agenda is divided into five themes, each with one or more goals and a specific set of research topics focused on that goal.

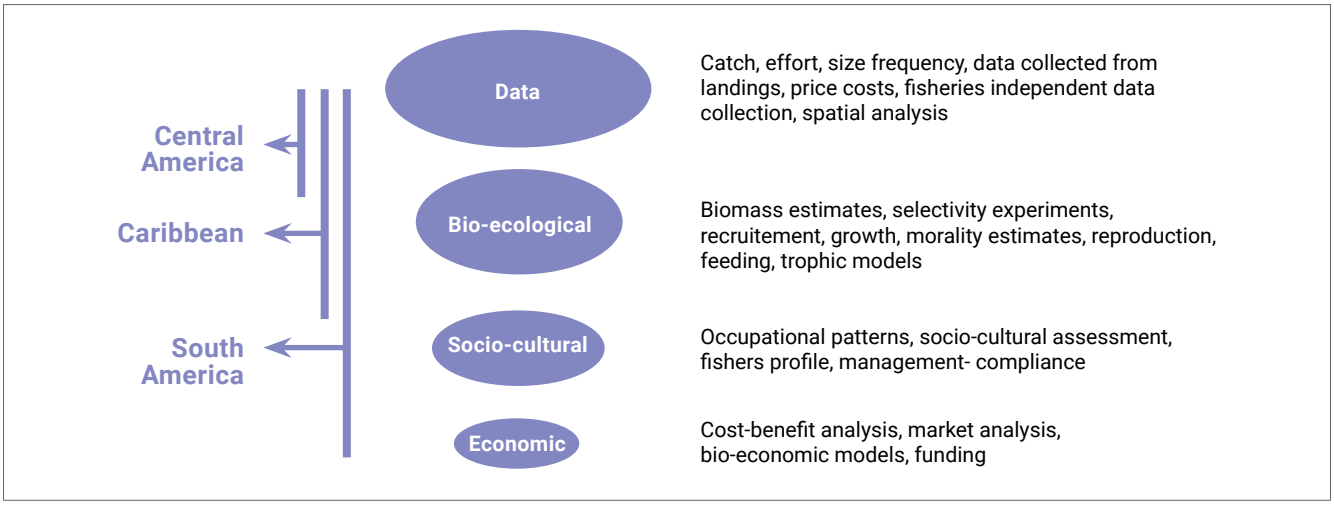


Figure 6.6 | The range of assessment tools employed in the Latin American and Caribbean region (from Chuenpagdee et al. 2011).

6.3 Caribbean Spiny Lobster fishery

6.3.1 Introduction

The Caribbean Spiny Lobster (*Panulirus argus*) is an important fishery resource throughout its range (Figure 6.7). The Caribbean fishery alone employs approximately 60,000 people, and in 2017 the volume of the lobster extraction from the region was more than 40,000 metric tons valued at US$1 billion (WECAFC 2018). FAO (2018) reported that stocks from 27 coastal and island nations or territories from Area 31 appear to be sustainably fished at maximum catch rates. The major producers include The Bahamas, Cuba, Honduras, Nicaragua, Brazil, and the United States of America (Figures 6.8 and 6.9).

Overall fishery landings peaked in 1999 at 35,787 tons. Since then, landings have decreased to a minimum around 24,000 tons in 2009. In recent years, landings showed an increasing trend with total landings reaching 30,300 tons in 2017 (FAO 2014; WECAFC 2019). The Spiny Lobster fishery is considered fully exploited in The Bahamas, Saint Vincent and the Grenadines, Antigua and Barbuda, Belize, and Anguilla and overexploited in Grenada, Haiti, Jamaica, and Saint Lucia. In The Bahamas, the Spiny Lobster fishery is currently under a certification process by the Marine Stewardship Council (MSC); a recent fishery assessment indicated the resource is not overexploited. A market for live lobster exports to China is under development (FAO 2019).

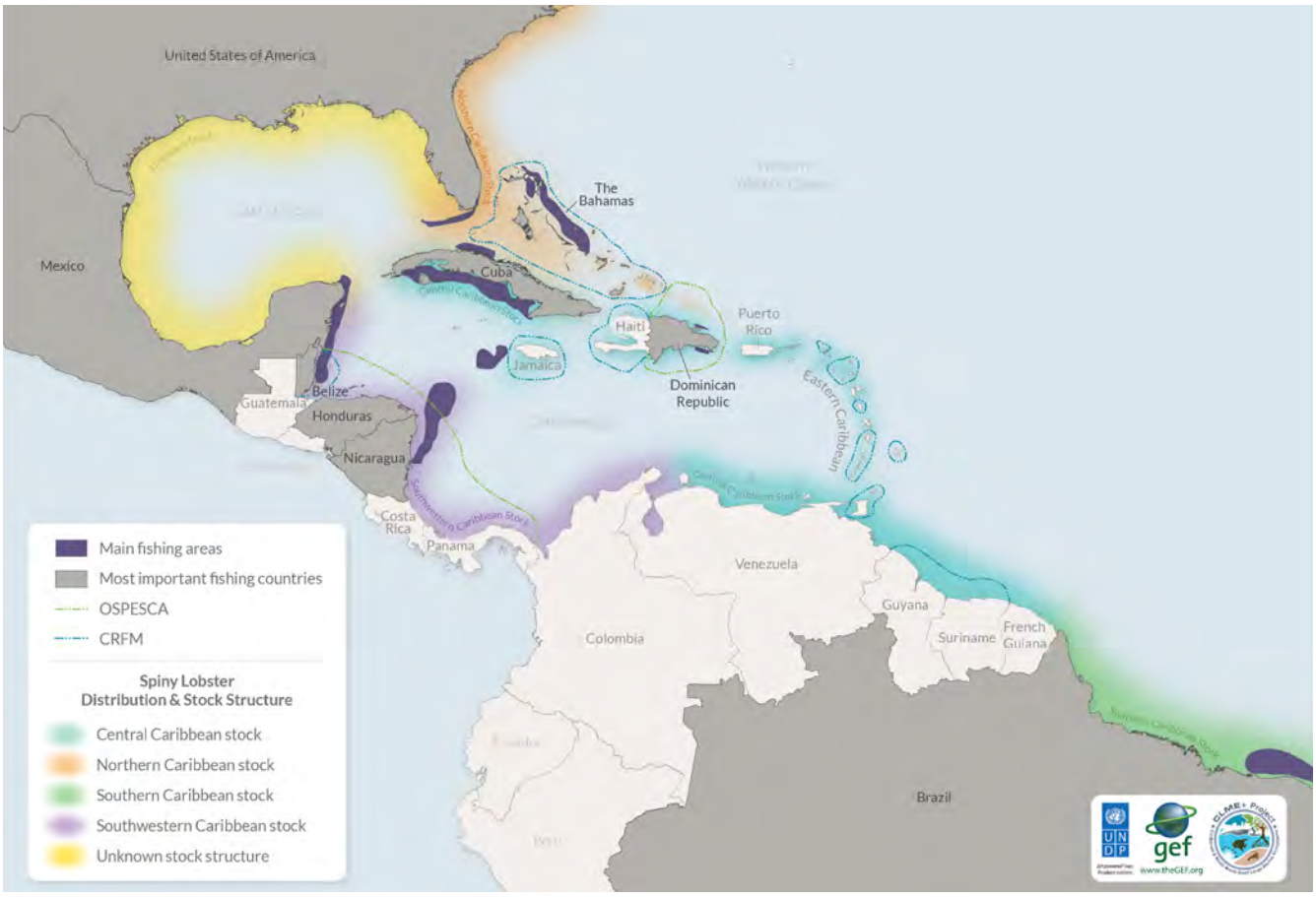


Figure 6.7 | Geographical distribution of the main commercial Spiny Lobster fisheries in the Western Central Atlantic Ocean.

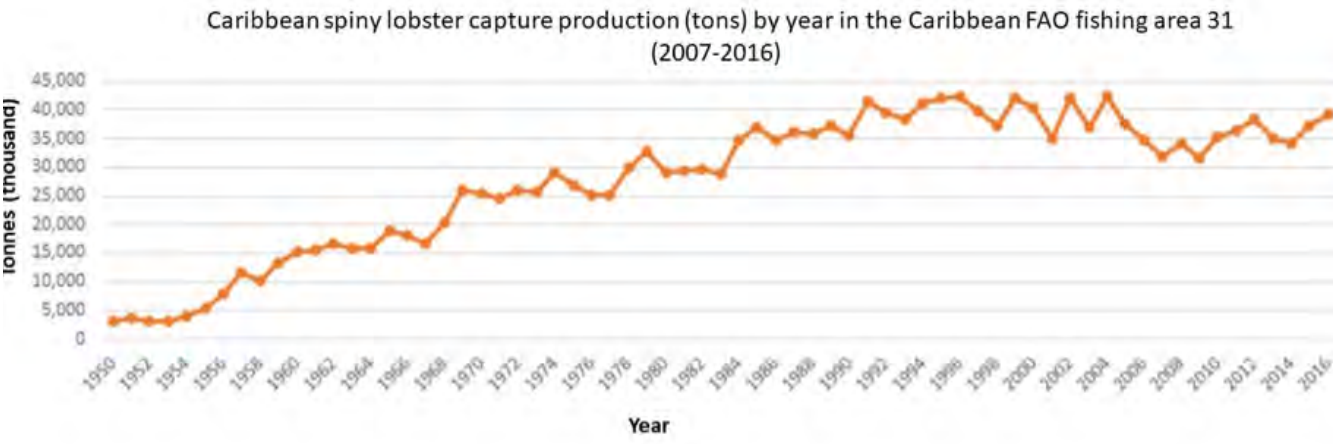


Figure 6.8 | Caribbean Spiny Lobster capture production (tons) by year in the Caribbean FAO fishing area 31 (2007-2016) (FAO 2017).

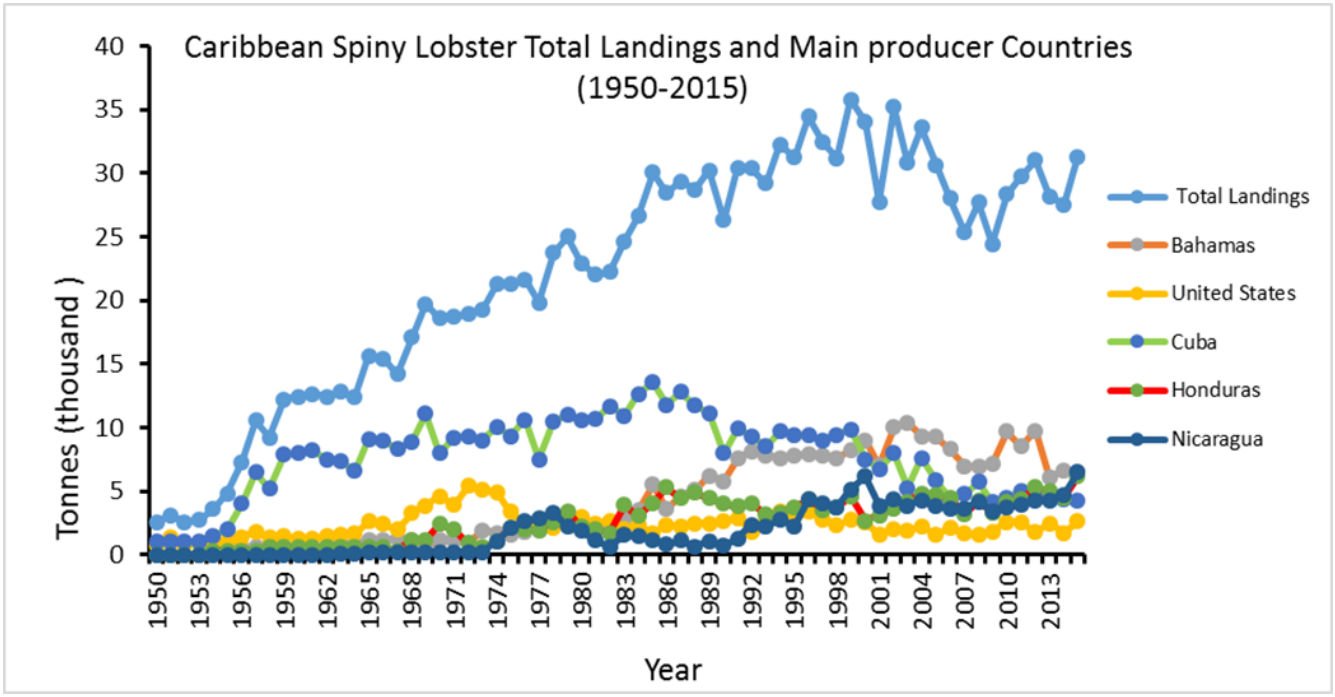


Figure 6.9 | Historic overall landings as reported to FAO by 27 coastal and island nations from Area 31, among which The Bahamas, Cuba, Honduras, Nicaragua, and the United States of America are the major producers (FAO 2017).

6.3.2 **Governance**

Recently, the Spiny Lobster fisheries in the Caribbean have taken important steps towards regional integrated management through the ratification of several agreements.

- The Strategic Action Program (SAP) of the CLME+ project included a specific strategy for Caribbean Spiny Lobster and was approved at the highest political level in most countries of the region. This provided a recognition of the importance of regional frameworks for managing this resource.

- The Central America Fisheries and Aquaculture Organization (OSPESCA) and the Caribbean Regional Fisheries Mechanism (CRFM) developed a MOU focused on its Joint Action Plan.

- The CLME+ interim coordination mechanism (ICM) includes a specific strategy for the Caribbean Spiny Lobster Fisheries Regional Management Plan (MARPLESCA) which was addressed partly within an MOU between the CRFM, FAO/WECAFC, and OSPESCA. It is currently being implemented (FAO 2018).

- The St George's Declaration on the Conservation, Management and Sustainable Use of Caribbean Lobster (*Panulirus argus*) was adopted in 2015 by 17 CRFM member countries.

The Regional Fisheries Bodies (RFBs) associated with these efforts play a key role in capacity building and strengthening of regional monitoring and scientific knowledge of Caribbean Spiny Lobster; however, there are still gaps related to science and socio-economic issues.

Several efforts have examined and assessed the governance structures for the evaluation of the Caribbean Spiny Lobster fisheries (Fanning 2012; Fanning et al. 2012, Fanning et al. 2015; CERMES 2018). In the U.S., the fishery management councils (i.e., South Atlantic Fisheries Management Council [SAFMC], Gulf of Mexico Fisheries Council [GMFC], and Caribbean Fisheries Management Council [CFMC]) have responsibility for Spiny Lobster fisheries management in their jurisdictions, but have not put forward regulations influencing regulations outside of the US.

6.3.3 **Fisheries Assessments and EBFM**

Despite the economic importance of the lobster fishery both regionally and for local communities, limited information exists on the fishery's population dynamics and exploitation rates. Gaps in monitoring catch and effort data still persist in most countries due to limitations in data collection, particularly from artisanal fisheries, and the lack of fisheries independent data. One effort to address this issue is the Ecolobster+ (Eco-langosta) sub-project of the CLME+. This project is promoting the development and adoption of a traceability system for fishery products with emphasis on Caribbean lobster, as well as the harmonization of data collection and fishery stock assessment methodologies.

Lobsters sustain significant fisheries in tropical and temperate seas worldwide and using spatial planning approaches (i.e., Marine Protected Areas [MPAs] or Marine Reserves [MRs]) have been advocated for their conservation. In the Florida Keys, it has been demonstrated that MRs protect critical lobster habitat, facilitate the increase in abundance of legal-sized lobsters, and increase the per capita reproductive output (Bertelsen and Matthews 2001; Bertelsen et al. 2004; Cox and Hunt 2005). Similar results have been reported in other regions of the world (Shears et al. 2006). However, as with most species, positive benefits will depend upon the location and size of the MPA/MR, and importantly, the presence or absence of fishing. Shears et al. (2006) argued that the absence of fishing is more important than habitat quality and availability for legal and sublegal lobster and that this effect is manifested at a large spatial scales (kilometers). Small-scale movements and detailed habitat usage patterns for Spiny Lobster are not well documented for most of the existing MPAs in the Caribbean region, and understanding movements

is critical when evaluating and designing MPAs and MRs (Glazer and Kidney 2004; Glazer and Delgado 2006).

Ehrhardt et al. (2011) identified natural and anthropogenic issues that preclude the implementation of EBFM for Spiny Lobster. These gaps include:

1. **The difficulty of defining units of stock** due to the long planktonic lifespan of the larvae, which disperse over very wide areas in the open ocean before settling in a suitable juvenile habitat,

2. **The need to identify nursery habitat.** Those regions with the greatest fishery production for Spiny Lobster in the Caribbean are those with expansive, shallow coastal zones. Habitats suitable for nurturing juvenile lobsters need to be identified and mapped,

3. **The variability of the stock-recruitment relationships** as a function of parent stock density and changes to the suitability of nursery habitat, and

4. **The relationship between Spiny Lobster population dynamics and the identification of appropriate coral reef habitat.** It is not known if the condition of the lobster spawning stock depends on the coral reef habitat for food and shelter.

6.3.4 Transboundary and Connectivity Issues for Spiny Lobster populations

In the Caribbean region, each country manages its own fishery stocks. However, most local fisheries exist in greater metapopulations that span national boundaries. This presents difficulties for managing Spiny Lobster fisheries, especially considering that larval lobsters may remain planktonic for 6 months or more (Goldstein et al. 2008) thus, facilitating long-distance transport (CLME+ report 2019) (Figure 6.10). The extended larval duration, and therefore the stock connectivity, is a significant issue for the effective assessment and management of Caribbean Spiny Lobster because the drift of larvae across political boundaries creates a strong linkage among the countries that share this transboundary resource. Segura et al. (2019) conducted a regional genetic analysis and identified strong larval connectivity between Dominican

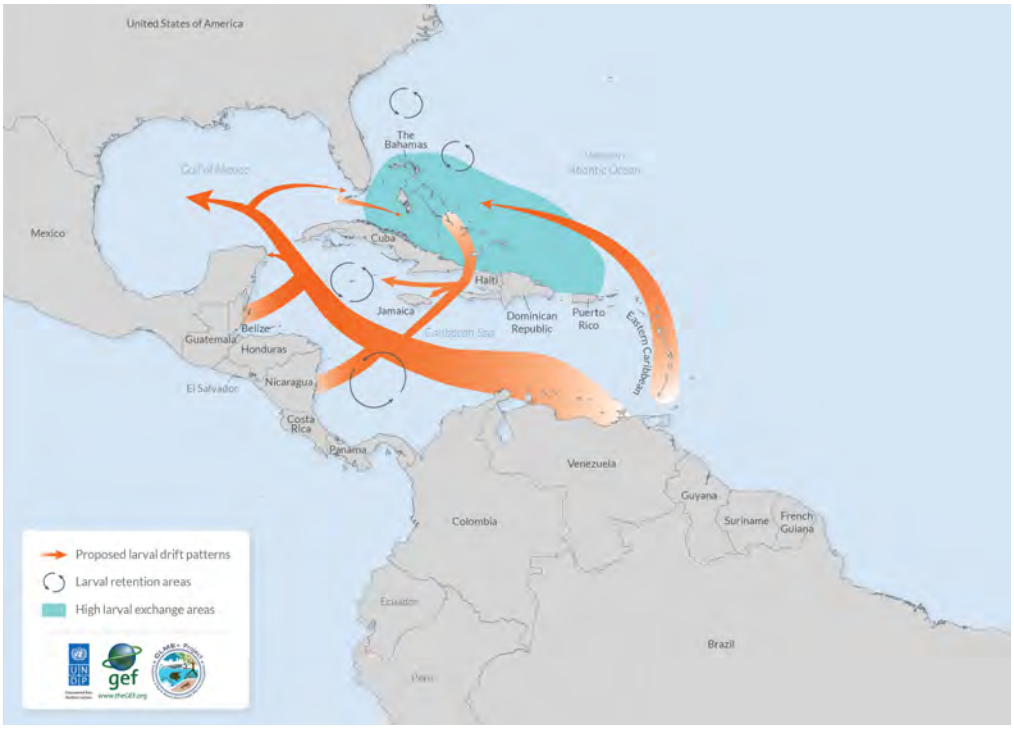


Figure 6.10 | Caribbean Spiny Lobster larval dispersal patterns and larval retention areas (CLME+ 2019).

Republic, Belize, Nicaragua, the Florida Keys, and West-Florida. These results are consistent with the larval model proposed by Kough et al. (2013) in which they used a biophysical larval dispersal model, to identify "source" and "sink" populations of Spiny Lobster in the Caribbean region and developed management recommendations based in their model.

The dispersive and retentive pattern of lobster larvae further compounds the difficulties in assessing the status of the stocks. For example, in the most recent stock assessment of the fisheries of the United States, it was not possible to clearly establish stock status due to uncertainty in recruitment sources (SEDAR 2010). Management plans presume that individual subpopulations are largely resupplied by larvae from elsewhere in the region complicating the determination of optimal harvests (e.g., SEDAR 2010).

Chollett et al (2017) analyzed the Spiny Lobster populations of Eastern Honduras. Their results indicated that it is possible to successfully manage those fisheries at a country level, however, to be effective, a transboundary cooperation approach is needed.

6.3.5 Research Agenda for Caribbean Spiny Lobster

The Spiny Lobster research agenda focuses on the biology and science that impact assessments, (i.e., changes to populations, changes to ecosystems that indicate longer-term impacts on populations, recruitment dynamics, and temperature changes), strengthening governance frameworks, reducing impacts to society, and developing effective ways to communicate to stakeholders including decision makers. Taken as a whole, the information derived from addressing the research topics is critical for the use in designing effective management systems, annual limits on catch, and fishing practices.

The approach and scope employed to develop the research topics and identify the priority research topics was described in Chapter 5.

6.3.5.1 **Spiny Lobster Science Theme**

Table 6.1 | Goals and research topics associated with the Spiny Lobster Science Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Investigate Caribbean Spiny Lobster population status & its role in the ecosystem	Score
Conduct Spiny Lobster stock assessments to determine national lobster population status based on length and weight information	3.87
Determine optimal catch quotas by countries and by regions (for example, utilizing the precautionary approach)	3.73
Investigate innovative approaches and technologies for improving fisheries data collection and oceanographic and environmental monitoring	3.57
Evaluate best approaches for implementing alternative livelihood programs in response to potential regional reduction in Spiny Lobster stocks	3.71
Quantify Spiny Lobster connectivity patterns at subregional level	3.27
Investigate the potential use of aquaculture alternatives as a way to promote the stocks' recovery and increase family income including involving fishers' networks	3.20
Develop pilot projects aimed to understand risks associated to use of low-quality data utilized in Spiny Lobster stock assessments	2.93
Design and conduct field work at sufficient intervals (i.e., every five years) to study changes in lobster abundance, and changes in fishing effort at national level	3.53
Collect and analyze data leading to the elimination of harmful fishing gear to improve ecosystem health	3.27
Study interactions of the Spiny Lobster with other coral-reef associated fisheries including the impacts of invasive species	3.27
Improve Spiny Lobster habitat map across the Wider Caribbean region	3.60
Estimate the level and impact of lobster ghost fishing at the national and regional levels persists.	3.53
Goal 2: Examine potential impacts of climate change on the Spiny Lobster fishery	**Score**
Assess the impacts of climate change on the Spiny Lobster populations, including ocean acidification, coral bleaching, sea level rise, ocean warming, changes in precipitation (including runoff), and extreme events	3.53
Identify Caribbean-specific needs and risks related to climate change and variability on the Spiny Lobster populations by building on existing vulnerability assessments	3.47
Develop decision support tools and ecosystem modelling with a broad group of stakeholders aimed to maintain/increase Spiny Lobster population conservation	3.40

6.3.5.2 **Spiny Lobster Governance Theme**

Table 6.2 | Goals and research topics associated with the Spiny Lobster Governance Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

GOVERNANCE RESEARCH THEME

Goal 1: Improve Spiny Lobster fishery governance	Score
Identify best approaches for developing regional agreements to enhance control and surveillance protocols to be followed by stakeholders' networks counteracting subregional IUU in the spiny lobster fishery	3.60
Identify ways to overcome legal concerns about issues of sharing countries' VMS information needed by authorities to counteract IUU lobster fishing	3.40
Identify capacity gaps including preparing national adaptation plans and establishing a monitoring and evaluation system in the Spiny Lobster fishery	3.53
Determine how to better engage bottom-up stakeholder' groups in governance participating in the Spiny Lobster fishery at subregional level	3.64
Identify best approaches for timely dissemination of diverse types of data and information	3.50
Identify most effective psychologic tools to counteract IUU fishing	3.33
Identify approaches that facilitate effective implementation of recommendations by existing regional lobster management entities	3.47
Identify the best structure for a regional observer program for improving monitoring of the Spiny Lobster fishing activities	3.60

6.3.5.3 **Spiny Lobster Monitoring Theme**

Table 6.3 | Goals and research topics associated with the Spiny Lobster Monitoring Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

MONITORING RESEARCH THEME

Goal 1: Improve data quality needed to understand the Caribbean Spiny Lobster's ecosystem role in the Caribbean	Score
Develop conversion factors for estimation of standardized weight / individuals for all lobster products in trade, preferably using international metric	3.50
Review and update historical information on total lobster production by vessel / fisher utilizing standardized weight units	3.78
Construction and validation of standardized fishing effort by various fishing methods/gears.	3.56

Table 6.3 continued

Goal 1: Improve data quality needed to understand the Caribbean Spiny Lobster's ecosystem role in the Caribbean	Score
Develop a digitized municipal registry of artisanal fishing vessels	3.21
Design and implement a strategy to develop a lobster fishing logbook program (traps and divers), at industrial and artisanal levels	3.33
Identify best approaches on how to update protocols of collecting fishery dependent data with stakeholder participation	3.33
Study the Spiny Lobster reproductive behavior to update variability in breeding season, size at sexual maturity and other relevant life history parameters	3.53
Review and update information on Spiny Lobster natural mortality stocks across the wider Caribbean region	3.26
Study changes in Spiny Lobster subregional recruitment patterns	3.36
Identify nursery areas, reproductive stocks and Spiny Lobster migration patterns,	3.67
Utilize marine ecosystem monitoring programs to better understand relationship between Spiny Lobster populations dynamics and coral reef ecosystem health	3.47
Study impacts of Spiny Lobster diseases on populations including the virus PaV1	2.93
Increase understanding of pollution on the Spiny Lobster population abundance and structure	3.27
Increase understanding of coastal erosion on the Spiny Lobster population abundance and structure	2.80
Evaluate the value of MPAs as lobster stock replenishment and as value to fishing-related livelihoods	3.67
Evaluate the impact of lobster fishing on Marine Protected Areas	3.33
Design a harmonized data collection program at processing plants in all countries participating in the lobster fishery	3.73
Conduct a census on fishers and other stakeholders to assess socioeconomic aspects every five years	3.40
Develop standards to verify that lobster products in trade have been legally caught, are properly labelled, and can be safely consumed	3.40
Develop best approaches and practices for Spiny Lobster market networks at national and subregional level	3.27
Determine how to better harmonize social and economic data collection programs to ensure Spiny Lobster fishery is included	3.40

6.3.5.4 **Spiny Lobster Economics Theme**

Table 6.4 | Goals and research topics associated with the Spiny Lobster Economics Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Highlight the social and economic importance of the Spiny Lobster fishery	Score
Identify the best regional approach to progressively allow lobster products in trade to be certified promoting the access to more specialized markets	3.60
Update socioeconomic valuation of the fishery	3.67
Develop a regional catch and health certification along with a cost-efficient traceability program	3.23

6.3.5.5 **Spiny Lobster Communications Theme**

Table 6.5 | Goals and research topics associated with the Spiny Lobster Communications Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Increase interest of managers/stakeholders in information and management measures	Score
Identify ways to improve the access to market intelligence information by working collaboratively with regional unions to counteract IUU lobster fishing	3.21
Identify, best practices and appropriate technology aimed to and facilitate the transfer of knowledge and understand the importance of data collection, scientific analysis, research, training, and capacity building to manage the transboundary Spiny Lobster fishery	3.57
Identify best approaches to communicate with regional domestic consumers	3.07
Identify sources, and compile /update education and outreach materials needed for better Spiny Lobster fishery management	3.29
Identify effective approaches that will actively educate the community about fishing rules and conservation through a range of educational resources, online content, social media and targeted communication campaigns for specific issues	3.50
Identify most effective options for enhancing communication among RFB and local fishers' associations	3.29
Goal 2: Enhance research cooperation in support of shared policy interests and transboundary issues	**Score**
Evaluate trainer of trainer's programs to develop training program to build the region's skilled human resources	3.73
Examine existing monitoring programs that collect fishery dependent data at sea, at landings sites and at processing facilities	3.80
Identify optimal fisheries independent sampling program including optimal sampling time intervals.	3.64
Identify best approaches for a regional capacity program that will consist of local scientists, managers, practitioners and stakeholders in addressing fishery management needs and risks	3.57
Develop a fishery monitoring and research program that will include identifying optimal standards for data collection, identify data needs, and include an implementation strategy	3.79
Identify best new technologies to improve fishers' digital reporting	3.57
Identify best practices related to cooperative approaches in support of shared policy interests and transboundary issues	2.93

6.3.6 Analysis of priority-setting results for Spiny Lobster Research Topics

Of the 41 people who responded to the Spiny Lobster survey, a total of fifteen individuals self-identified as decision-makers. Their responses are reported below. In some cases, respondents did not score a particular topic and when this occurred, no score for that respondent was used in the calculations for that topic.

Of the 60 research topics that were considered, the overall highest score in the entire survey originated in the Science Theme and focused on developing a stock assessment for Spiny Lobsters (Table 6.6). This topic received a score of 3.867 out of 4.0. This emphasized the importance of basic science to help inform sound fisheries policy. It also emphasized the gap in the fundamental knowledge of Spiny Lobster populations since these assessments are critical to effective sustainable management. Because stock assessments form the backbone for effective Caribbean Spiny Lobster management, well-developed, robust scientific information is a core requirement and this analysis recognizes this priority. This is consistent with the conclusions of Ehrhardt and Fitchett (2010) in which they noted that comprehensive fundamental research on Spiny Lobsters needs to be conducted in order to develop and apply models that could be adopted for EBFM.

The second highest scoring research topic was in the communications theme and focused on assessing existing fishery-monitoring programs.

Table 6.6 | The topic that ranked highest for the Spiny Lobster research priorities. This topic points out the need for good basic fisheries science that can be used to help inform decisions on Spiny Lobster management.

Overall highest Spiny Lobster research priority

Theme/Goal	Priority Topic
SCIENCE/GOAL: Investigate Caribbean Spiny Lobster population status and its role in the ecosystem	Conduct Spiny Lobster stock assessment to determine national lobster population status based on length and weight information

6.4 **Flyingfish fishery**

6.4.1 **Introduction**

The stock of the Caribbean Flyingfish (*Hirundichthys affinis*) is recognized as the single most important small pelagic fishery in the southern Lesser Antilles where it is shared by seven different countries. These countries, in order of importance, are Barbados, Grenada, Martinique, Saint Lucia, Trinidad and Tobago, Dominica, Martinique (France), and Saint Vincent and the Grenadines (FAO 2002, Oxenford et al 2007, Headley 2010; Figure 6.11). Fishers in Dominica reported that Flyingfish, once important, have 'disappeared' from their grounds (Grant 2008). In the northern Leeward Islands (Saint Kitts and Nevis, Antigua and Barbuda), Flyingfish are rarely caught and has never been an important fishery species. This may simply reflect a focus of the fishers on the demersal resources of the extensive, relatively shallow-water shelves surrounding the northern islands rather than on the Flyingfish (Oxenford et al. 2007). Besides fishing for demersal species, participants in the Flyingfish fishery also target other species including the large pelagic species (e.g., Dolphinfish (Mahi mahi), Kingfish, Wahoo and Albacore), all of which feed on the Flyingfish.

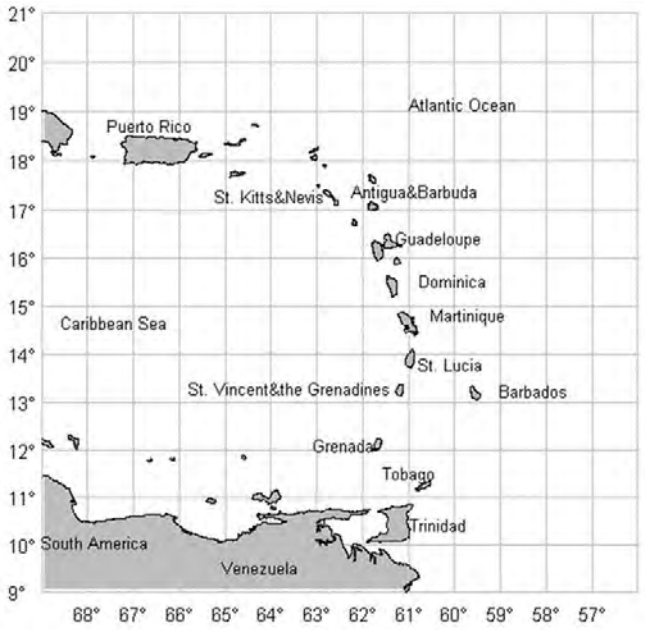


Figure 6.11 | A Map of the Eastern Caribbean and Flyingfish countries (from Oxenford et al 2007)

6.4.2 The Status of the Fishery

The characteristics of the Flyingfish fisheries of the eastern Caribbean islands are well-described at both the country and regional scales (Oxenford et al., 1993; Boyce 1995; CFRAMP 1996; FAO 1999; FAO 2002; FAO 2010; Oxenford et al. 2007; Boyce et al. 2007; Fanning and Oxenford 2011; CRFM 2014, and others). Therefore, only a brief overview is provided here.

In Barbados, the Flyingfish fishery represents an important part of the fishing economy employing approximately 2,000 fishers, 500 vendors, and 325 persons employed as 'de-boners' or workers in fish processing plants (FAO 2012). Between 1997 and 2009, the average annual recorded catch of Flyingfish was 1,736 mt. After a sharp drop in 2011 and 2012, landings recovered and stabilized around 2,000 mt from 2013 to 2015. Since then, landings have dropped significantly, reaching a low of 544 mt in 2016 attribute, in part to a particularly strong Sargassum influx event in the Eastern Caribbean that year (Ramlogan et al. 2017, Oxenford et al 2019) (Figure 6.12).

Other countries in the area also have important Flyingfish fisheries including Tobago (Trinidad and Tobago),Saint Lucia, and Martinique. There are no targeted Flyingfish fisheries in Saint Vincent and the Grenadines; however, Flyingfish are caught opportunistically while fishing for other pelagic fish, or at times when other pelagics are not available (Oxenford et al. 2007). In Dominica, there has been a shift from fishing for Flyingfish to the large pelagic fish since 2011 due to the increased use of FADs.

The Caribbean Regional Fishery Mechanism (CRFM 2014) reported that the stock of Flyingfish in the Eastern Caribbean is not overfished with respect to maximum sustainable yield; however, they later reported (CRFM, 2018) that the total annual proposed catch (i.e., 5,000 mt) in the 2014 fisheries management plan should be revisited due to recent low catches and new information from the 2018 stock assessment. They also recommended that a renewed effort to collect more data is increasingly important given the challenges of managing a fishery that may be under more pressure than previously thought (CRFM 2018). It was therefore deemed appropriate to establish a multi-year, sub-regional plan with the objective of ensuring that the stock will be exploited under sustainable biological, economic, environmental, and social conditions.

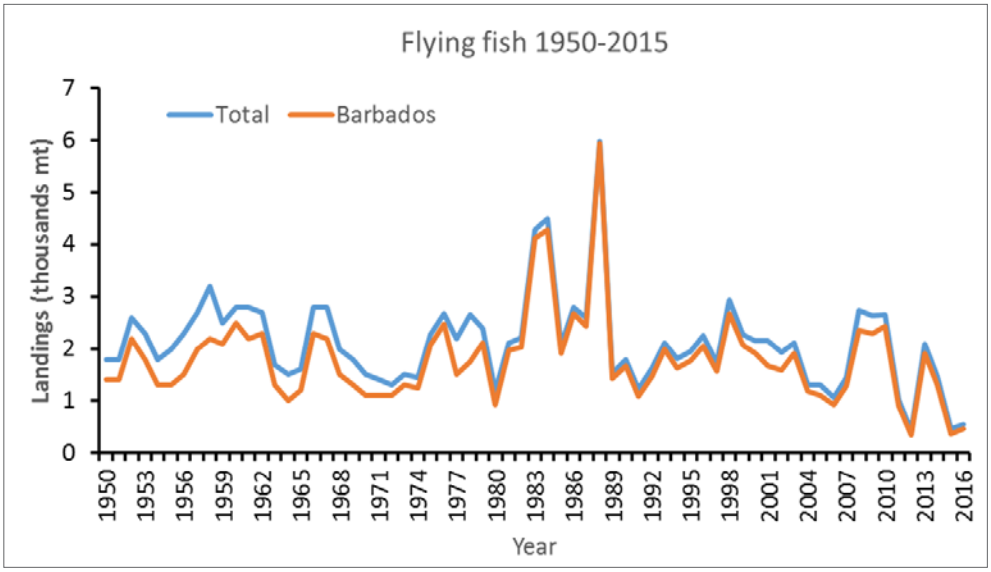


Figure 6.12 | Eastern Caribbean countries Flyingfish landings (1950 - 2016) in metric ton (mt) combined for Barbados, Grenada, Martinique Saint Kitts and Nevis, and Saint Lucia (data from FAO 2017).

6.4.3 Governance of Flyingfish

There is currently a Sub-Regional Management Plan for Flyingfish in the Eastern Caribbean which aims to foster the progressive implementation of an ecosystem-based approach to their management (CRFM 2014). The WECAFC Ad Hoc Working Group on Flyingfish in the Eastern Caribbean initiated the first draft of the Eastern Caribbean Flyingfish Fisheries Management Plan (ECFF-FMP) in 2001. Subsequently, WECAFC further developed and amended the plan in 2008 (FAO 2010). The 2008 version was subsequently updated in the 2014 ECFF-FMP. As of March 2019, none of the six Member States (i.e., Barbados, Dominica, Grenada, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago) have implemented a Flyingfish management plan (2019 ECFF-FMP). The plan recognizes that national authorities are responsible for fisheries management and carry the main responsibility for implementing the sub-regional management plan within their national jurisdictions. They are also responsible for monitoring and evaluating the status of implementation.

All the member states agreed that management of the eastern Caribbean Flyingfish resource must be a collaborative venture among all participants in the fishery. A review of the governance issues impacting Caribbean fisheries is provided in Chapter 3 of this document.

Participants' discussions at the GCFI 2017 workshop "Identifying Research Priorities for Three Focal Fisheries in the CLME+ Region with an Emphasis at the Management/Research Interface" indicated that:

1. The Flyingfish fishery sector is not a high governance priority. There is a lack of political will to engage in efforts to advance scientific and socio-economic monitoring of the Flyingfish fishery, the application of those findings to policy decision-making, and the implementation of management strategies.
2. There is a need for long-term political 'buy-in' in support of effective management of the fishery.
3. A distinct disconnect exists between policy and the human element of the fishery. There is no mechanism to bridge the gap between fishers' concerns and resource management.
4. There are critical communication gaps and a need for improved communications among all stakeholders in the sector.

6.4.4 Biology and Ecology of Flyingfish

The life-history and ecology of Flyingfish have been widely studied and published in the scientific literature. Oxenford et al. (2007) prepared a synopsis of the biological characteristics and management options for the Four-Wing Flyingfish in the wider Caribbean. Other research efforts that have focused on its biology and fishery assessment in the eastern Caribbean including some early studies by Hall (1955), Lewis et al. (1962), and Storey (1983). Various review papers and national reports produced under the Small Coastal Pelagics and Flyingfish Sub-project of the CARICOM Fisheries Resource Assessment and Management Program (CFRAMP) (e.g., CFRAMP 1996) and the WECAFC Ad Hoc Flyingfish Working Group of the Eastern Caribbean (FAO 1999, 2002, 2010, 2012; CRFM 2014, 2018; WECAFC 2019c) have added to that literature.

Oxenford et al. (1994) described age, growth, and longevity of the Four-wing Flyingfish, *Hirundichthys affinis*. *Hirundichthys affinis* completes its lifecycle to a maximum of 24 cm in approximately 18 months essentially making it an annual species (Campana et al. 1993). In the Eastern Caribbean, it is considered one of three genetically distinct sub-regional stock units along with a southern Netherlands Antilles unit and northeast Brazil unit (Gomes et al. 1999).

Flyingfish exhibit two peaks of spawning activity including a larger peak in April and May and a smaller

peak from November to January (Hunte et al. 2007). This suggests the risk from overfishing is not related to growth overfishing (i.e., where fish are caught before they can grow to their full size); rather, the primary risk is recruitment overfishing where fishing during spawning stages may reduce the number eggs supporting the next generation (CRFM 2018). There are concerns that genetic pressures associated with fishing will select for smaller fish.

Flyingfish are batch spawners, depositing non-buoyant eggs on floating material from November through the following July (Oxenford et al. 1994; Khokiatiwong et al. 2000). The floating materials include natural flotsam, fish aggregation devices (FADs), and gillnets used to catch the adult Flyingfish. The scarcity of flotsam in the eastern Caribbean may be constraining Flyingfish population size, or alternatively, Flyingfish may be using submerged spawning substrates. This issue needs further investigation and may reveal preferred spawning areas for this species (Hunte et al. 2007).

Throughout their range, the various species of Flyingfishes are important prey for large pelagic predators. Flyingfish comprise more than 15% of the diet of Bigeye Tuna, Dolphinfish, and large mesopelagic predators; the diet of billfish, Blackfin Tuna, and squid consists of more than 5% Flyingfish (Oxenford and Hunte 1999; Heileman et al. 2008). Because of this, *H. affinis* is an important baitfish for fisheries targeting these large pelagic species (CRFM 2014). The strong trophic dependence of Dolphinfishes on Flyingfishes has been demonstrated using an Ecopath with Ecosim (EwE) model of the Lesser Antilles pelagic ecosystem (LAPE) (Mohammed et al. 2008) and is further explained by Fanning and Oxenford (2011).

6.4.5 The Assessment of the Flyingfish Fisheries

Assessments of the regional Flyingfish stocks have been conducted since 1990 (Samlalsingh and Pandohee 1992; Medley et al. 2010). They concluded the eastern Caribbean Flyingfish stock is not overfished (FAO 2010), a finding that is particularly interesting given that Flyingfish is both a key forage species and an important fishery species with many trophic and economic linkages throughout the Caribbean (Fanning and Oxenford 2011).

The WECAFC working group (FAO 2010) also found that there is no immediate action required by management to conserve the stock unless there is a significant increase in regional Flyingfish catch. It was further agreed that a catch trigger point of 5,000 mt/year should be established beyond which action should be taken to ensure the stock does not become overfished. If catches rise to or above the trigger point, the agreed actions include a freeze on further development of the fishery(ies) until a full scientific reassessment of the stock has been completed. Previous assessments conducted by Mahon (1989), the extensive research conducted by the Eastern Caribbean Flyingfish Project, as well as by staff and graduates of the University of the West Indies (Oxenford et al. 2007), outlined the difficulties in assessing the species, primarily due to their biology (i.e., short-lived, open-water species), the nature of the fishery (i.e. targeting spawning adults), and the susceptibility of the species to environmental variability.

Reports from FAO (2010) and CRFM (2011; 2014; 2018) recommended treating the existing data cautiously as they likely underestimate the true catches in the sub-region. This uncertainty is further compounded because catches associated with bait fisheries were not well-documented and estimates of fishing effort are uncertain.

The most recent resource and fisheries assessment (CRFM 2018) concluded that the Flyingfish stock biomass has declined, and that maximum sustainable yield is approximately 2,744 mt which is lower than the 5,000 mt proposed in the 2014 fisheries management plan. The latest assessment also recommended to revise the annual catch limit of 5,000 mt based on recent low catches and the information from the 2018 stock assessment. However, the assessment suffers from the same gaps and sources of uncertainty described in the 2014 fisheries management plan (i.e., lack of accounting

for bait catches). It is noteworthy that in the most recent assessment the best available data were used; however, as in previous assessments, the problems with underreporting Flyingfish catches, and data quality concerns have not been addressed. The assessment mentioned the impacts of Sargassum and other environmental factors on the fishery. These variables are not included in the assessment.

Socioeconomic issues in the Flyingfish fishery are wide-ranging and deal with market fluctuations, access to fishing areas, costs of vessels, fuel and gear, fishing and processing technology, facilities, and others.

6.4.6 Sargassum and Flyingfish

Sargassum is an emerging issue on the coasts of the islands of the Wider Caribbean. Since 2011, thousands of tons of pelagic Sargassum seaweed have been deposited on beaches and in nearshore waters of many countries across the region (Franks et al. 2016). These influx events are now considered to represent a 'new normal' (Maréchal et al. 2017) and have significant negative implications across multiple sectors including tourism, fisheries, environment, and human health.

Oxenford et al. (2019) and WECAFC (2017) reported that the first significant influx of Sargassum in mid-2011 had a dramatic impact on the Flyingfish fishery in Barbados resulting in extremely low catches throughout 2012 (Figure 6.13). Landings of Flyingfish then increased as conditions returned to pre- Sargassum levels of 2013. However, when the Sargassum influx re-occurred even more severely in 2014, Flyingfish landings again declined and the season when they were typically available for capture became abbreviated (Figure 6.13). The Saint Lucia Flyingfish fishery exhibited a similar decline in landings correlated to the Sargassum influx (Oxenford et al. 2019).

As the impacts from the Sargassum influx become more pronounced, there is an increasing need to understand the ecosystem-level impacts of its movements since it likely plays an important role in the population dynamics of numerous species that depend upon it as habitat, including Flyingfish. Effective Flyingfish management requires an understanding of the biology of Sargassum including its reproductive strategies, growth rates, and the spatial distribution of the different Sargassum species and how Sargassum responds to temperature, ocean

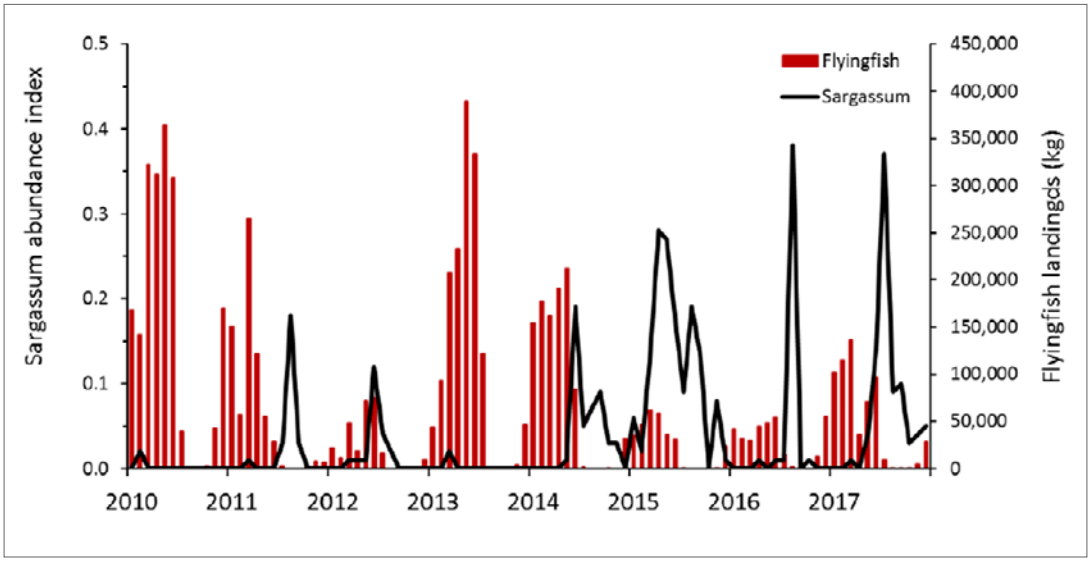


Figure 6.13 | Comparison of Sargassum abundance and landings data for Flyingfish from Barbados (from Oxenford et al. 2019).

currents (including those that are wind-driven), and nutrients are all necessary for effectively understanding its impacts. The management of Flyingfish fisheries in the face of Sargassum influxes will require local action as well as regional coordination and collaboration beyond areas under national jurisdiction.

6.4.7 Research Agenda for Flyingfish

Based on the reported shortcomings in the collection and analysis of Flyingfish fishery data, as well as the limitations that exist in national and regional fisheries management frameworks. The limitations are detailed as research topics in Tables 6.7 to 6.11. Despite several active research projects in the Caribbean Flyingfish fisheries, countries still lack national and regional coordination plans or a defined research agenda. This research agenda provides a coherent and strategic approach to address information needs.

The approach and scope employed to develop the research topics and identify the priority research topics was described in Chapter 5.

6.4.7.1 Flyingfish Science Theme

Table 6.7| Goals and research topics associated with the Flyingfish Science Research theme. The score column (DM) represents the value of the one decision-maker's ratings for each research topic within each goal. The score column (DM+PM) represents the mean value of the decision-maker plus the policy makers' ratings (n=3) for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest in that goal whereas the red is associated with the least important rated research topic.

Goal 1: Understand Flyingfish population status	Score (DM)	Score (DM+PM)
Estimate stock abundance of Flyingfish, such as a regional synoptic survey, prior to any significant development in the fishery	4.00	3.33
Identify best approaches to develop human capacity building related to developing stock assessments	4.00	3.33
Create stakeholder networks to encourage participation on data collection and stock assessment	4.00	3.00
Compare existing stock assessment results to better determine the status of the Flyingfish stocks	4.00	3.00
Assess patterns in connectivity of Flyingfish stocks	4.00	3.67
Develop mechanism to evaluate the status implementation of the national and sub-regional fisheries management plans	3.00	3.33
Determine estimations of fishing mortality for different fishing gears	4.00	3.33

Table 6.7 continued

Goal 1: Understand Flyingfish population status	Score (DM)	Score (DM+PM)
Determine estimations of Flyingfish natural mortality	4.00	3.33
Evaluate ecosystem impacts of overfishing on the Flyingfish fishery	4.00	4.00
Evaluated and address managers and stakeholders concern about underreporting the low quality of data used in the assessments.	3.00	2.67
Develop, biomass and catch target reference points and limit reference points to be adaptable to fisheries changes	4.00	3.00
Goal 2: Examine potential impacts of climate change on the Flyingfish fishery	**Score (DM)**	**Score (DM+PM)**
Develop a system to assess impacts of climate change in Flyingfish stocks, including, ocean acidification, coral bleaching, sea level rise, ocean warming, and extreme events	3.00	3.33
Build on existing vulnerability assessments to identify Caribbean-specific needs and risks related to climate change and variability on the Flyingfish populations	4.00	3.67
Develop decision support tools and application and ecosystem modelling with a broad group of stakeholders aimed to maintain/increase Flyingfish population stability	4.00	3.00
Goal 3: Examine Potential Impacts of Sargassum on the Flyingfish fishery	**Score (DM)**	**Score (DM+PM)**
Investigate the relationships between Sargassum abundance, and fishery landings data	4.00	3.67
Investigate the impact of the Sargassum influx on the Flyingfish population abundance and structure	4.00	3.00
Investigate the relationships between Flyingfish and Dolphinfish populations associated with influxes of Sargassum	4.00	3.33
Develop a Sargassum abundance index model to understand Flyingfish stocks abundance as a function of Sargassum influx	4.00	2.67
Determine the impact of Sargassum influx on the Flyingfish spawning habitat	4.00	3.00
Investigated the relationships between Sargassum influx, catch and the behavior of Dolphinfish and Flyingfish to inform future policy and management decisions.	4.00	3.33
Assist the sector in adapting to the reality of continued Sargassum influxes into the region	3.00	2.67
Develop new fishing techniques to increase catchability of Flyingfish in the presence of Sargassum	4.00	3.33

6.4.7.2 **Flyingfish Governance Theme**

Table 6.8 | Goals and research topics associated with the Flyingfish Governance Research theme. The score column (DM) represents the value of the one decision-maker's ratings for each research topic within each goal. The score column (DM+PM) represents the mean value of the decision-maker plus the policy makers' ratings (n=3) for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest in that goal whereas the red is associated with the least important rated research topic.

Goal 1: Strengthen regional coordination in support of Flyingfish fishery governance	Score	Score (DM+PM)
Integrate adaptation to climate change and weather extremes into regional plans	4.00	3.00
Identify best approaches to establish regional and national research agencies	3.00	3.00
Determine how to best engage bottom-up stakeholders' groups in governance among all Eastern Caribbean countries	4.00	3.67
Develop a marine spatial plan to mitigate potential conflicts between resource user groups due to possible changes in the fishery.	4.00	3.00
Develop a mechanism for timely dissemination of diverse types of data and information from management bodies	4.00	3.00
Re-examine and refine objectives to ensure that priority is given to sustainable fisheries and the ecosystem approach to fisheries management at national and regional level	4.00	3.33
Identify actions needed to counteract Flyingfish IUU fishing in the Eastern Caribbean	4.00	3.67
Identify best approaches for law enforcement mechanisms and bodies and identify human and economic resources to perform their functions effectively.	4.00	2.33
Structure a regional observer program for improving monitoring of the Flyingfish fishing activities	3.00	2.67
Identify best approaches to strengthen the role of Community fishing organizations	4.00	3.00

6.4.7.3 **Flyingfish Monitoring Theme**

Table 6.9 | Goals and research topics associated with the Flyingfish Monitoring Research theme. The score column (DM) represents the value of the one decision-maker's ratings for each research topic within each goal. The score column (DM+PM) represents the mean value of the decision-maker plus the policy makers' ratings (n=3) for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest in that goal whereas the red is associated with the least important rated research topic.

Goal 1: Harmonize and enhance data collection systems at the local and regional level	Score	Score (DM+PM)
Evaluate existing fishery dependent data collection protocols and identify best approaches to gather data on total catch, standardized fishing effort and associated population abundance indices	4.00	3.33
Work with stakeholders to determine approaches to the application of best fishery dependent data collection protocols	3.00	3.33
Harmonize and improve national vessel registration and licensing systems and software used to enhance identification of Flyingfish vessels	4.00	3.00
Determine long-term abundance fluctuations of Flyingfish and relationships with abundance of other larger pelagic stocks	4.00	3.33
Determine estimations of Flyingfish natural mortality	3.00	3.00
Assess recruitment patterns and relationships for Flyingfish stocks	3.00	3.00
Assess historical changes in spawning patterns of Flyingfish	4.00	3.33
Identify data sources that can be used to compile and update biological and ecological information	3.00	3.00
Determine population dynamics and interactions between large pelagic fisheries and the Flyingfish fishery	4.00	4.00
Assess impacts of marine pollution on Flyingfish population abundance and structure	4.00	4.00
Assess impacts of oil and gas exploration activities on Flyingfish population abundance and structure	4.00	3.00
Assess impacts of shipping activities on Flyingfish population abundance and structure	4.00	3.00
Assess impacts of sargassum influx on Flyingfish population abundance and structure	4.00	3.33
Investigate innovative approaches and technologies for improving fisheries data collection and oceanographic and environmental monitoring	4.00	4.00
Develop a participatory monitoring initiatives local ecological knowledge of fishers	4.00	3.67
Goal 2: Understand ecosystem role of the stocks	**Score**	**Score (DM+PM)**
Study connectivity between the three Flyingfish stock units	3.00	3.33
Develop oceanographic water quality maps for local and regional areas	4.00	2.67
Develop oceanographic maps of essential Flyingfish spawning grounds for local and regional areas	4.00	3.33
Evaluate the health of essential flyingfish habitats	4.00	3.33
Identify best approaches to integrate ocean technology and its use in the Flyingfish fishery	3.00	3.67

6.4.7.4 **Flyingfish Economics Theme**

Table 6.10 | Goals and research topics associated with the Flyingfish Economics Research theme. The score column (DM) represents the value of the one decision-maker's ratings for each research topic within each goal. The score column (DM+PM) represents the mean value of the decision-maker plus the policy makers' ratings (n=3) for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest in that goal whereas the red is associated with the least important rated research topic.

Goal 1: Enhance the social and economic value of the Flyingfish fishery	Score	Score (DM+PM)
Explore new Flyingfish value added products	4.00	2.67
Examine ways to increase trade efficiency of existing market products	3.00	2.33
Identify ways to implement a cost-efficient regional catch traceability program	3.00	3.00
Determine the total value of the Flyingfish fishery in Barbados, Grenada, Saint Lucia, Trinidad and Tobago, Dominica, Martinique (France), Saint Vincent and the Grenadines	4.00	2.67
Evaluate socioeconomic impacts of potential Flyingfish fishing effort reduction	4.00	3.33
Determine linkages between fishery dependent indices and socioeconomic indices	4.00	3.00
Determine the employment level and market networks in the Flyingfish fishery at national and subregional levels	4.00	2.67
Determine the income level of Flyingfish fishers	4.00	3.00
Evaluate the importance of Flyingfish as baitfish for fisheries targeting large pelagic species	4.00	3.33
Evaluate marked seasonality in availability Flyingfish and its impact on the discontinuous market supply and seasonal fishing effort	4.00	3.00
Evaluate the difficulties with accessing credit and insurance in the fisheries sector	4.00	2.67

6.4.7.5 **Flyingfish Communications Theme**

Table 6.11 | Goals and research topics associated with the Flyingfish Communications Research theme. The score column (DM) represents the value of the one decision-maker's ratings for each research topic within each goal. The score column (DM+PM) represents the mean value of the decision-maker plus the policy makers' ratings (n=3) for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest in that goal whereas the red is associated with the least important rated research topic.

Goal 1: Increase interest of managers/stakeholders in information and management measures	Score	Score (DM+PM)
Investigate a mechanism to ensure that fishers prioritize the exchange of information and standardize data collection	4.00	3.67
Identify and facilitate the transfer of knowledge, best practices, and appropriate technologies aimed to emphasize the importance of data collection, scientific analysis, research, training, and capacity-building to manage the transboundary Flyingfish fishery.	4.00	3.33
Identify and/or develop education and outreach materials needed for better Flyingfish fishery management	3.00	3.00
Identify options to enhance communication among Regional Fisheries Bodies (RFB) and local fishers' associations	3.00	2.67
Identify ways to enhance research cooperation in support of shared policy interests and transboundary issues	3.00	3.00
Identify approaches that can promote and strengthen diverse, inclusive, and accountable partnerships	3.00	2.67
Develop effective training programs that enhance fishers' organizations involvement in data collection/analysis	3.00	3.00
Goal 2: Strengthen regional science partnerships and capacity building	**Score**	**Score (DM+PM)**
Identify best approaches to develop regional capacity programs to enroll local scientists, managers, practitioners and stakeholders in addressing fishery management needs and risks	4.00	3.67
Address the inadequate human capacity in fishery departments to conduct required level of research and data analysis	4.00	3.33
Identify existing and develop new practical training programs for promoting sound fishery management and conservation topics including, biological, ecological and socio-economic data	4.00	3.33
Develop programs to actively educate the community about fishing rules and conservation through a range of educational resources, online content, social media and targeted communication campaigns for specific issues related to the Flyingfish fishery	4.00	2.33
Collaborate with fisheries management authorities, departments of education and educational institutions for the development and delivery of operational capacity trainings for fishers	4.00	2.67

6.4.8 The Overall Highest Priority Topics for Flyingfish research in the CLME+ region

Unfortunately, only one person self-identified as a decision maker responded on the online survey and follow-up requests to assess priorities from the research topics. This was not unexpected given the small scale of the fishery and the limited number of countries with Flyingfish fisheries. Despite this limitation, the response provides insight into how decision makers view the importance of a variety of research topics. Because of this limitation, there were numerous research topics in all themes that scored 4.0 and these together represented the priorities of decision makers. They can be viewed in Tables 6.7 to 6.11.

Because of the deficiency associated with only one decision maker responding to the survey, we decided to run a separate analysis to incorporate the responses of policy makers who were not decision makers. The scores of the two categories combined are presented in the column with the title Score (DM+PM). In some cases,the responses were very different an can be viewed perhaps as an indication of different priorities between the decision makers and the policy makers.

Photo by Tomas Willems

6.5 Shrimp and groundfish fisheries

6.5.1 Introduction

The fisheries resources of the North Brazil Shelf LME (NBSLME) support important shrimp and finfish fisheries (i.e., groundfish). The main target groups are the penaeid shrimps (e.g., various pink and brown species, *Farfantepenaeus* spp.; white shrimps, *Litopenaeus* spp.; Atlantic seabob, *Xyphopenaeus kroyeri*), weakfishes (e.g., *Cynoscion* spp.; sea trout, *Cynoscion virescens,* King weakfish *Macrodon ancylodon*), croakers (e.g., Whitemouth croaker *Micropogonias furnieri*), sea catfishes (*Ariidae*), and deep-slope benthic finfishes including deepwater grouper species (e.g., misty, *Epinephelus mystacinus*; red, *E. morio*), deepwater snappers (e.g., southern red, *Lutjanus purpureus*; queen, *Etelis oculatus*; vermilion, *Rhomboplites auroruben*), and shallow water snapper (e.g., Lane snapper, *Lutjanus synagris*). The Western Central Atlantic (WCA) represents the area covered by the FAO Western Central Atlantic Fishery Commission (WECAFC), which includes FAO major fishing area 31 and the northern part of FAO major fishing area 41 (Figure 6.14).

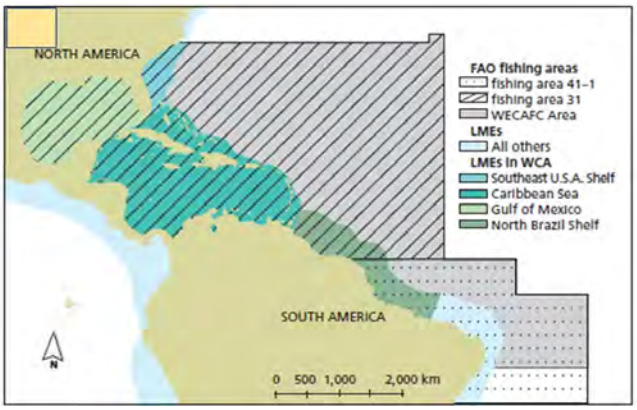


Figure 6.14 | Map of Western Central Atlantic region showing the LME boundaries and FAO fishing areas

The Red Snapper is likely the most important groundfish in the region based on its wide distribution and its high commercial value in foreign markets. Other groundfish such as snappers, weakfishes, Whitemouth croaker or corvine, and sea catfishes are also important for commercial and social reasons. These groundfish species are exploited by the industrial trawlers that mainly target shrimp species with a large number of small-scale fishers dependent on these species for their livelihoods. Hence, the groundfish fisheries are multi-fleet, multi-gear, multispecies, and multinational and use fishing methods that can be classified as both industrial or artisanal. The complexity of these fisheries makes collection of statistical data for these species difficult to obtain. Nevertheless, they represent significant contributions to food security and poverty alleviation in the region, as well as constituting a valuable commodity in national and international markets (FAO 2013).

Detailed descriptions of the fleets and fisheries in each country are available from national reports (CRFM 2011). Fishing gear consists of commercial and artisanal demersal trawls for shrimp (slow moving with small mesh nets) and finfish (faster moving with larger mesh nets). In addition to trawls, artisanal fleets contain a much wider variety of gears including gillnets, pots, handlines, and different types of seine nets. Pelagic longlines may be used, but not on the Brazil-Guiana shelf region.

No RFMO is in place for this region. Shared responsibility for assessment and management of shrimp and groundfish resources of the Guianas/Brazil shelf is recognized under the Western Central Atlantic Fishery Commission and Caribbean Regional Fisheries Mechanism (WECAFC/CRFM). Fisheries information is collected through the FAO Fisheries and Resources Monitoring System (FIRMS). Currently, the FIRMS partnership involves 14 intergovernmental organizations representing 19 regional fishery bodies (RFBs). National legislation and management plans for some key species exist across the different countries. This program examines current status of FIRMS fisheries and produces resource inventories in the NBSLME. The information is used to identify data gaps and establish necessary actions to populate FIRMS inventories for the sub-region (WECAFC 2018; FAO 2019).

In a background assessment conducted by CLME+ on the shared stocks of the shrimp and groundfish fishery of the Guianas-Brazil shelf (FAO 2013), it was concluded that most of the country's stocks are considered at least fully exploited and some are likely overexploited. The penaied shrimp stocks are likely to be in better condition, but some penaied species are at risk of overexploitation. Atlantic seabob is likely to be in good conditions in Suriname. Generally, stock status is difficult to determine in many species of shrimp and groundfish due to the lack of data or any recent stock assessment.

6.5.2 Background of the multi-species shrimp fishery of CLME+ region

The shrimp stocks represent valuable fisheries throughout the entire region and therefore have been subjected to intense pressure for more than six decades. The countries that comprise the fisheries include those found in both Central and South America such as Northern Brazil, Venezuela, Colombia, Nicaragua Honduras, Mexico, Belize, Cuba, Trinidad and Tobago, Suriname, the Guyana and French Guiana, among others. For those countries with Exclusive Economic Zones in both Caribbean and Pacific oceans, the shrimp fishery is conducted mostly in the Pacific.

The shrimp fisheries in the southern Caribbean are capture fisheries and include the southern brown shrimp (*Farfantepenaeus subtilis*), the pink spotted shrimp (*F. brasiliensis)*, the southern pink shrimp (*F. notialis*), the white shrimp (*L. schmitti*), and the smaller Atlantic seabob shrimp (*Xiphopenaeus kroyeri*). In particular, Atlantic seabob shrimp fishers trawl from vessels usually using Chinese seine carrying 2 to 4 crew, and more than 95% of its production gets exported, primarily to the U.S.A. and smaller amounts to Japan, Canada, and CARICOM countries. In comparison, the northern Caribbean more frequently exploits the northern brown shrimp (*Farfantepenaeus aztecus*), the pink shrimp (*Penaeus*

duorarum) and the white shrimp (*L. schmitti*). In the US Gulf of Mexico, the shrimp fishery is comprised primarily of the so-called royal red shrimp (*Pleoticus robustus*), a native species. However, there are other shrimp species exploited to a lesser degree and are often not targeted.

Marine shrimp landings usually consist of whole animals or processed tails that represent important economic value for the countries involved. In general, shrimp fishing is conducted at industrial (mostly for exports) and artisanal levels (mostly for national consumption). Various types of vessels are utilized (FAO 2017). For example, in Trinidad and Tobago, there are four types of fishing vessels: artisanal Type I (7 to 10 m vessels with outboard engines), artisanal Type II (8 to 12 m vessels with inboard diesel engines), semi-industrial Type III vessels (10 to 12 m with inboard diesel engines), and industrial Type IV (24 to 30 m Gulf of Mexico double-rigged vessels). In northern Brazil, there are small-scale vessels and industrial vessels which are outfitted with trawls (puca-de-arrastro or guizo), cast nets (tarrafa), and fixed traps (zangaria). In the case of Venezuela, the fleet is artisanal comprised of trawlers of 8 m in length with outboard engines. In Honduras, Nicaragua, Colombia, and Mexico, the industrial shrimp-trawl fishery appears to be more intense than the fishery associated with artisanal fishing. In addition, some indigenous people utilize these resources at subsistence levels.

The shrimp fishing areas are extensive ranging from the Gulf of Mexico to Brazil. One of the primary shrimp fishing areas in the Caribbean is the Gulf of Paria and Orinoco river delta (7,800 km^2) where Trinidad and Tobago and Venezuela share the stocks (FAO 2017). Other shrimp fishing areas include 48,700 km^2 comprised of the Guyana shelf (138,200 km^2 EEZ), Suriname (128,300 km^2 EEZ), French Guiana (130,000 km^2 EZZ), and the mouth of the Parnaiba River in Northern Brazil (992,200 km^2 EEZ). In Honduras, the shrimp fishing area is the continental shelf around Colon, the cape of Gracias A Dios, Atlantida, and the Bay islands with 648,000 km^2 in the EEZ (Pratt and Quijandria 1997).

The Gulf of Mexico (1,500,000 km^2) is also a very important fishing ground for wild commercial shrimps and prawns. The Gulf of Mexico extending to the Campeche/Yucatan Bank (the Mexican continental shelf in the Gulf of Mexico) represents approximately 57,000 km^2.

Artisanal fishing usually occurs in coastal lagoons and along the nearshore depending on the existence of soft sediments. Industrial fishing occurs in more distant offshore areas by trawling the seafloor at depths from 30 to 90 m, with best catches gathered during the wet season.

In general, the historical landings show a negative trend in stock abundance for the Caribbean/region. For example, in the last 15 years, the trend of whole weight catch for Guyana, Suriname, French Guiana, and Northern Brazil have decreased; from 3,019 tons to 1,019 tons in Guyana, from 3,267 tons to 624 tons in Suriname, from 3,940 tons to 732 tons in French Guiana, and from 6224 tons to 2482 tons in Northern Brazil (FAO 2017).

Similarly, the industrial and artisanal shrimp annual production in Nicaragua went from 4 million pounds from 1997-2005 to only 2.9 million pounds in 2010 and 2.5 million in 2016 with 19 industrial fishing vessels (INPESCA 2011; INPESCA 2016). They have attributed these results to a reduction in productivity and a slight reduction in fishing effort. In Belize, based on FAO/fishstat data, marine shrimp tails landings reached its peak in 2006-2010 with an estimated 250-350 mt annually, but dropped to less than 50 mt since 2013 (Fugazza et al. 2018). However, it is still considered significant to the two main cooperatives (4 locally owned trawlers) (FAO/FID/CP/BLZ 2005). The shrimp fishery is also a valuable fishery within Cuban waters; however, overfishing has led to declining catches; from 6,400 mt in 1975, 3,370 in 1985, 1,850 mt in 1995, 1,580 mt in 2005, and 620 in 2014 (Claro et al. 2001; Baisre et al. 2003).

In the US-Gulf of Mexico, shrimp are exploited by the States of Louisiana, Texas, Mississippi, Alabama, and Florida. The fishery is managed by the Gulf of Mexico

Fishery Management Council (GMFMC). Since 1981, they have adopted a progressive management plan that sets annual catch limits and incorporates restrictions such as the use of NMFS-certified bycatch reduction devices (BRD), limiting trawls deeper than the 100-fathom contour, requiring vessels to have a federal commercial vessel permit, implementing a moratorium in entry into the fishery, and considering on an ad hoc basis emergency rules. Commercial landings for the past 50 years have never exceeded 392,000 lbs of tails, and more recently, commercial landings over the previous 19 years have not exceeded the ACL of 334,000 lbs of tails (Gulf of Mexico Fisheries Management Council 2014).

With the exception of the US Gulf of Mexico, this negative trend is confirmed with estimations made by the project *Sea Around Us* by reconstructing shrimp production data combining official reported data and estimates of unreported data (including major discards), with reference to individual EEZs. Officially reported data are mainly extracted from the Food and Agriculture Organization of the United Nations (FAO) FishStat database (for a summary, see Table 6.12).

Table 6.12 | Historical shrimp production from Caribbean countries based on reconstructed data from the Sea around us project (*http://www.seaaroundus.org/data/#/eez*). Values are expressed in metric tons.

Country	Taxon	1951	1961	1971	1981	1991	2001	2011	2014
Colombia	Commercial shrimp and prawns	100	1800	1000	830	5890	2150	120	40
French Guiana	Southern brown shrimp	390	1420	2450	5220	3170	2430	880	690
Guyana	Atlantic seabob	130	160	120	1960	4460	2379	1965	1670
Haiti	Shrimp and prawns	420	600	770	850	960	1350	180	110
Honduras	Atlantic seabob	90	220	730	520	290	180	230	220
	Northern brown shrimp	80	200	660	470	290	180	210	190
	Commercial shrimp and prawns	200	460	1400	1040	720	470	630	470
Mexico	Northern brown shrimp	8600	14020	21420	24670	29300	21580	15960	14250
Netherlands	Common shrimp	9230	9260	2580	2610	4840	8005	8790	13810
Nicaragua	Southern white shrimp	60	210	630	300	200	490	250	170
	Southern brown shrimp	60	210	630	300	200	490	250	170
Trinidad & Tobago	Commercial shrimp and prawns	20	170	1000	1370	2290	700	590	590
US Gulf of Mexico	Northern white shrimp			35230 -1978	33940	34900	42120	47570	48080
Total		21331	30691	70591	76061	89501	84525	79636	82474

The overall reduction in shrimp production often corresponds to a significant reduction in fishing effort due to either changes in the management regimes (e.g., exit of vessels, annual quotas, closed seasons, area closures, special artisanal fishing zone) or economic conditions (e.g. increase in fuel prices, prices associated with the international fish market, decline in quality of adequate processing facilities) (MSU 2015).

Still, there is uncertainty in acquiring the fishery dependent data needed to perform rigorous stock assessments in the region, particularly in those areas where the stock is shared. This results in either incomplete or outdated data and subsequent analyzes.

The region's shrimp resources are mostly fully exploited. Analyses from 1999 (CLME 2013) suggested that the Brown Shrimp and Pink Shrimp fisheries in Guyana were fully exploited. In Suriname in 2000, the fishery was determined as having low recruitment and low yields primarily due to high fishing mortality, increasing selectivity on small shrimp, environmental disturbance impacting recruitment, and natural mortality (CMLE 2013). In Trinidad and Tobago in 2002, analyses of Pink Shrimp females suggested that that the stock was fully exploited, and therefore, increased exploitation could put recruitment at risk.

Despite reductions in fishing effort there is no apparent stock recovery. This is likely due to exploitation from IUU fishing, the increase in fishing mortality of juvenile shrimp, and habitat degradation due to the impacts caused by heavy net doors and tickler chains associated with traps scraping the sea floor. These disturbances are believed to be less impactful on soft sediments than on other bottom types. In addition, the shrimp abundance is affected by degradation of estuarine nursery habitats due to reduced river outflow caused by extensive damn construction, coastal erosion, dredging, pollution from the petrochemical, mining, and agricultural industries, and habitat enrichment from fresh water inflows (Pratt and Quijandria 1997; De la Pava and Mosquera 2001; Mohammed and Shing 2003; Rueda et al. 2006; Rivera 2007; INVEMAR 2012; Seijo 2013). Other impacts are emerging as significant threats including those related to a changing climate such as increasing water temperatures and changes in rainfall (WECAFC 2019c).

Significantly, increasing by-catch in the shrimp fisheries remains a considerable threat to biodiversity and ecosystem integrity in areas where wild shrimp are harvested (Mohammed and Chan 2003). Currently, in many Caribbean countries, all industrial and semi-industrial shrimp trawlers are required to use Turtle Excluder Devices (TEDs), but compliance is inconsistent across different fleets. Nevertheless, the use of TEDs has led to decreased mortality not only of turtles, but also all larger components of marine assemblages such as sharks, rays, sawfish, and sea mammals (Medley 2016). Similarly, a bycatch reduction device (BRD) was introduced into Atlantic seabob trawls in Suriname and Guyana that has reduced the discarded catch of small fish (FAO 2017).

In Colombia, the by-catch from the shrimp fishery represents 65% of the catch. In response, fisheries authorities there are testing BRDs that have demonstrated a significant reduction in discards and incidental catches (Rueda et al. 2007). The use of the BRD reduced the discard volume from 58% to 19% in the Caribbean. Unfortunately, the shrimp catch was also reduced. The continued reduction in shrimp abundance along with the increase in the incidental catches (of low commercial value) has resulted in an overall reduction of the economic performance of shrimp fishing (Rueda et al. 2006; INVEMAR 2012).

Venezuela has traditionally been the second largest producer of shrimp until trawl fishing was banned in 2009. The commercial trawl fleet was mostly comprised of vessels 24 to 30 m in length. They operated in the southern Gulf of Paria at the mouth of the Orinoco river delta. This fleet targeted shrimp (*P. subtilis* and *P. schmitti*) and finfish of the families Sciaenidae, Carangidae, Haemulidae, Trichiuridae, Lutjanidae, Arridae, and Mustelidae.

Because of the ban, the Venezuelan shrimp fishery is currently comprised of only an artisanal fleet with most vessels 8 m or more in length and equipped with outboard engines. The fleet operates mostly in the northern Orinoco river delta. This fleet targets only juvenile *P. schmitti*, as artisanal fishing takes place in estuaries and coastal lagoons where only juveniles occur (CLME-FAO 2013). The trawl ban resulted in a marked decline in catch in 2009/2010; however, landings have increased since then (WECAFC 2017, WECAFC 2019a).

6.5.3 Background of groundfish fishery of CLME+ region

In the southeastern Caribbean, snappers and groupers have been exploited traditionally on the expansive continental shelves and slopes off Venezuela, Trinidad and Tobago, and the Guianas between Suriname and northeastern Brazil. The groundfish resources are targeted by various countries, using a variety of fishing gears. These fisheries are multigear, multispecies, and multinational. Fishing methods can be classified as industrial or artisanal depending on the level of mechanization. Industrial fleets are dominated by trawlers and large pot/line vessels and are often owned by international corporations. The eastern Venezuelan snapper–grouper fishery is comprised of medium-range and long-range handliners and longliners. The medium-range fishery operates in the southeastern Caribbean region, whereas the larger, long-range vessels operate on the Guianas shelf between Suriname and northeastern Brazil. The main species exploited by the medium range fishery are southern red snapper, *L. purpureus*, and yellowedge grouper, *Epinephelus flavolimbatus* (Mendoza and Larez 1996; Mendoza and Larez 2004).

Groundfish are important socially and economically as they sustain the domestic fish market by providing an accessible and affordable protein source. Some species are also exported and therefore receive foreign exchange. From a social perspective, groundfish provide the basis for an artisanal fishery. Management issues are complicated because of the variety of gears used and the multispecies and transboundary nature of the fisheries.

To further complicate matters, there are a lack of data pertaining to the species' biology, productivity, catch, and fishing effort. As a result, there is uncertainty related to species-based assessments due to suitable data quantity and quality needed for fisheries assessments (WECAFC 2017; FAO 2019).

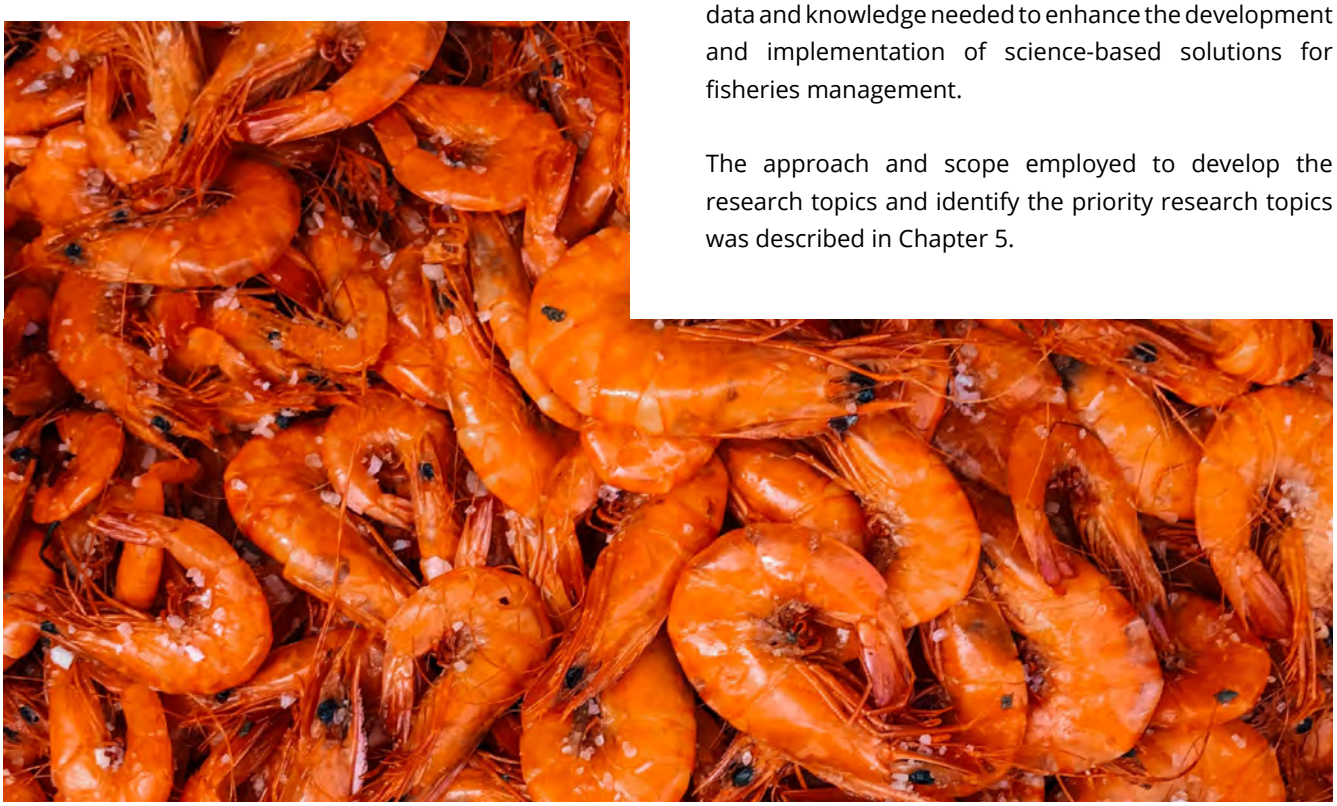
The WECAFC 2015 update on the state of fisheries in the region estimated that 12% of species/species groups were overfished, 42% of species/species groups were considered between overfished and fully fished, and 36% of species/species groups were estimated to be fully fished. It was not possible to estimate the status of 9% of species/species groups due to lack of sufficient information (WECAFC 2017).

Overfishing of any of the species is likely to have significant adverse economic consequences for the communities and countries that exploit those resources. Of the fish stocks that had some form of stock assessments, 56.8% of them are fully exploited, 37.8% are over-exploited, and status could not be determined for 5.4% (WECAFC 2019a).

Many commercially and ecologically important species form annual fish spawning aggregations (FSA) and represent the primary source of fertilized eggs and larvae to replenish and sustain fish populations. However, relatively little is known in the scientific community about the timing and location of most events associated with FSAs. Yet, fishers are often familiar with the patterns of aggregating fish and therefore high catch rates are common at spawning sites. FSAs are targeted by both commercial and small-scale fishers, who often complement their seasonal catch or focus their annual activity entirely on these brief events (Sadovy de Mitcheson and Erisman 2012). As a result, many FSAs are now extirpated. An extirpated FSA is an aggregation that because of its low abundance at times of spawning, no longer functions as an FSA. Identifying the timing and location of FSA sites is critical for fisheries management. Once the baseline abundance of fish populations is established, the reproductive population can be more

easily monitored for improvements or declines based on management action or natural disturbances (Erisman et al. 2017). Regional organizations such as WECAFC, CRFM, OSPESCA and CFMC have promoted and drafted a regional Fishery Management Plan for Fish Spawning Aggregations (WECAFC 2019d).

With many of the resources fully to over-exploited, and with gaps in strategy ranging from minimal management to no management in place, proactive and rational management based on sound scientific information is imperative. To maintain sustainable harvests, research and monitoring needs to be strengthened across the region. This should include on-going collection of accurate and adequate catch, effort, size frequency, and age data for each country. All landings should be recorded, wherever they occur, identifying the country of origin, which will elucidate stock structure and movement patterns within, and most importantly, among countries.



6.5.4 Research Agenda for Shrimp and Groundfish Fisheries

Effective management of shrimp and groundfish requires knowledge of both the science and social activities associated with their fisheries. Accurate scientific information is important for assessing shrimp and groundfish population levels, changes to those levels, and changes to ecosystems. Collectively they provide data on the longer-term impacts on population levels (e.g., recruitment, temperature changes).

However, this information must be coupled with an understanding of the social structure of the fisheries, and ways to best communicate with the stakeholders. Taken together, this information is critical for use in designing effective management systems, annual limits on catch, and fishing practices that are both effective and socially acceptable.

OSPESCA, CRFM, and WECAFC have identified regional research priorities focused on obtaining the scientific data and knowledge needed to enhance the development and implementation of science-based solutions for fisheries management.

The approach and scope employed to develop the research topics and identify the priority research topics was described in Chapter 5.

6.5.4.1 **Shrimp and Groundfish Science Theme**

Table 6.13 | Goals and research topics associated with the Shrimp and Groundfish Science theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Investigate shrimp and groundfish population status & its role in the ecosystem for industrial and artisanal fisheries	Score
Determine the status of stocks and desirable management measures, such as suitable effort by updating national and regional stock assessments	3.83
Determine optimal catch quotas by countries and by regions (for example, utilizing the precautionary approach)	3.83
Investigate innovative approaches and technologies for improving fisheries data collection and oceanographic and environmental monitoring	3.50
Identify and evaluate best approaches for implementing alternative livelihood programs in response to potential local and regional reduction of shrimp and groundfish stocks	3.17
Identify best approaches to quantify shrimp and groundfish species connectivity patterns at subregional level	3.67
Conduct genetic analyses of stocks in the region	3.33
Evaluate of existing and emergent critical habitats, migration corridors, and spawning areas to provide effective conservation	3.83
Investigate the potential use of aquaculture alternatives as a way to promote the stocks' recovery and increase family income including involving fishers' networks	3.83
Develop pilot projects aimed to understand risks associated with the use of low-quality data utilized in shrimp and groundfish stock assessments	3.67
Develop research projects to understand how biological fluctuations interact with management, economic, and social factors to influence the adaptive flow of fishing effort across these fisheries	3.67
Develop programs that collect and analyze data that can provide information leading to the elimination of harmful fishing gear to improve ecosystem health	3.67
Develop maps of Essential Fish Habitats (i.e., nurseries and spawning areas) that can be used in models that inform more ecosystem-based fisheries management strategies	3.67
Investigate the effects of "hybrid" management approaches including spatial/temporal-based scenarios (e.g., the combined effects of more traditional regulation of effort with spatial/temporal closures)	3.67

Table 6.13 continued

Goal 2: Reduce the potential impacts of climate change on the shrimp and groundfish fisheries	Score
Assess the impacts of climate change on the shrimp and groundfish fisheries populations, including sea level rise, ocean warming (sea temperature), changes in precipitation (including river runoff), ocean acidification, and extreme events	3.50
Identify the impact of sea water temperature on the reproductive success of this commercially important group by affecting spawning behavior (timing and/or location), the quality and quantity of reproductive output (eggs/larvae)	3.50
Evaluate the risks related to climate change and variability on the shrimp and groundfish fisheries resources populations by building on existing vulnerability assessments	3.33
Investigate the role of climate change in essential fish habitats and nursery habitats for shrimp and groundfish species	3.83
Develop decision support tools and ecosystem modelling approaches with a broad group of stakeholders aimed to maintain/ increase the shrimp and groundfish fisheries resources	3.50
Continue to develop of climate-based management tools	4.00
Identify best pro-active adaptation approaches that can ensure the sustainability of the populations and the fisheries	3.33
Identify how climate change impacts on food systems in general and economics may lead to changes in demand and in market prices.	3.67

6.5.4.2 **Shrimp and Groundfish Governance Theme**

Table 6.14 | Goals and research topics associated with the Shrimp and Groundfish Governance theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Improve shrimp and groundfish fisheries governance	Score
Develop mechanism(s) to address important gaps in current knowledge and understanding of scientific, institutional, and socio-economic aspects of these fisheries	3.50
Explore how more integrated management of fisheries can be used to increase resilience and human benefits derived from shrimp and groundfish fisheries	3.50
Identify capacity gaps including preparing national adaptation plans and establishing a monitoring and evaluation system in the shrimp and groundfish fisheries	3.33
Identify best approaches to engage disparate parts of the fishery management community (locally and regionally managed fisheries) in the development and application of the research and modelling tools needed to implement ecosystem-based fishery management	4.00
Identify ways to improve the access to market intelligence information by collaborating with regional unions to counteract IUU fishing	3.50
Determine how to best engage bottom-up stakeholder groups in governance participating in the shrimp and groundfish fisheries at the subregional level	3.33
Identify how best to improve the legal and institutional frameworks in the project countries for shrimp/bottom trawl fisheries and bycatch co-management	3.67
Identify best approaches for developing regional agreements to enhance control and surveillance protocols to be followed by stakeholders' networks counteracting subregional IUU in the shrimp and groundfish fisheries	3.00
Identify ways to overcome legal concerns about issues of sharing countries' VMS information needed authorities to counteract IUU shrimp fishing	3.50
Identify approaches that facilitate effective implementation of regional collaboration on shrimp/bottom trawl fisheries and bycatch management	3.33
Identify the best structure for a regional observer program for improving monitoring of the shrimp and groundfish fishing activities	3.50
Develop a baseline of the existing knowledge of the ecological risks associated with bycatch, by assessing the contemporary bycatch management framework, existing fishing practices, and gear designs	3.67
Identify and evaluate all the potential ecological and economic benefits of eliminating bycatch	3.33
Design a holistic, integrated bycatch management system geared toward EBFM	3.40
Increase innovative technologies that reduce bycatch	3.40
Identify options or opportunities available for commercial fishers to adapt to changes in target species, capture methods, risk management approaches, industry diversification, or relocation	3.33

6.5.4.3 **Shrimp and Groundfish Monitoring Theme**

Table 6.15 | Goals and research topics associated with the Shrimp and Groundfish Monitoring theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Improve data quality needed for shrimp and groundfish to ensure sustainable industrial and artisinal fisheries	Score
Examine existing monitoring programs that efficiently collect fishery dependent data at sea, at landings sites and at processing facilities to identify gaps related to data needs	3.83
Identify ways to ensure the on-going collection of accurate and adequate catch, effort, size frequency, and age data for shrimp and groundfish fisheries by country	3.83
Review and update historical information of marine fisheries landings for shrimp and groundfish fisheries by country	3.33
Identify best approaches to construct and validate standardized fishing effort by various fishing methods/gears	3.83
Develop a digitized local and regional fishing vessel registry for industrial and artisanal fishing vessels	3.83
Design and implement a strategy to develop a groundfish fishing logbook program by gear/ country, for industrial and artisanal fisheries	3.67
Identify best approaches on how to update protocols of collecting fishery dependent data with stakeholder participation	3.67
Identify optimal fisheries independent sampling programs including optimal sampling time intervals	3.83
Develop a regular regional reconciliation and standardize data collection across the different countries to ensure accuracy and completeness	3.50
Study the shrimp and groundfish species reproductive behavior to update variability in the breeding season, size at sexual maturity, and other relevant life history parameters	3.83
Conduct a review and update information on shrimp and groundfish species natural mortality for stocks across the CME+ region	3.67
Identify possible spawning aggregation sites for snappers and grouper resources	3.67
Identify and fill gaps in information on bycatch (species, volumes, bottom impacts) and monitoring systems improved in selected industrial and artisanal fisheries	3.83
Identify and fill gaps in life history characteristics including size, age and sex structure as well as issues related to recruitment, population dynamics and potential fishery yield	4.00
Evaluate changes in key life history characteristics (age and size at maturity, maximum size, growth rate) with consequences for fisheries (regulations, gears used, catchability, yield)	4.00
Increase understanding of the environmental analysis on recruitment population abundance and structure	4.00

Table 6.15 continued

MONITORING THEME

Goal 1: Improve data quality needed for shrimp and groundfish to ensure sustainable industrial and artisinal fisheries	Score
Increase understanding of the effects of pollution on the shrimp and groundfish resources in term of population abundance and structure	3.67
Evaluate the value of MPAs for stock replenishment of shrimp and groundfish species and as value to fishing-related livelihoods	3.83
Evaluate the impact of MPAs on nursery habitats for shrimp and groundfish fisheries	3.83
Identify nursery areas, reproductive stocks, and migration patterns for shrimp and groundfish species	4.00
Design a harmonized data collection program at processing plants in all countries participating in the shrimp and groundfish fishery	3.33
Conduct a census on fishers and other stakeholders to assess socioeconomic aspects of these fisheries	3.50
Identify and develop effective standards to verify that shrimp and groundfish fisheries products in trade have been legally caught, are properly labelled, and can be safely consumed	3.33
Identify best approaches and practices for shrimp and groundfish market networks at national and subregional level	3.50
Determine how to better harmonize social and economic data collection programs to ensure shrimp and groundfish fisheries are explicitly included	3.17

6.5.4.4 **Shrimp and Groundfish Economics Theme**

Table 6.16 | Goals and research topics associated with the Shrimp and Groundfish Economics theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

ECONOMICS THEME

Goal 1: Better understand the social and economic importance of the shrimp and groundfish fisheries	Score
Identify the best regional approach(es) to progressively allow shrimp products in trade to be certified as 'sustainable' promoting the access to more specialized markets	3.33
Update the socioeconomic valuation of these fisheries	3.17
Explore how exogenous changes (e.g., climate variability, price changes) impact the economics of these fisheries	3.33
Identify ways to best develop a regional catch and health certification program along with a cost-efficient traceability program	3.33

6.5.4.5 **Shrimp and Groundfish Communications Theme**

Table 6.17 | Goals and research topics associated with the Shrimp and Groundfish Communications theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Increase communication effectiveness for the shrimp and groundfish fisheries	Score
Identify best practices and appropriate technologies to facilitate the transfer of knowledge and to understand the importance of data collection, scientific analysis, research, training, and capacity building to manage the transboundary shrimp and groundfish fisheries	3.83
Identify best approaches to communicate with local, regional, and international consumers	3.17
Identify sources, and compile /update education and outreach materials needed for better shrimp and groundfish fisheries management	3.50
Identify effective approaches that will actively educate the community about fishing rules and conservation through a range of educational resources, online content, social media, and targeted communication campaigns for specific issues	3.83
Identify most effective options for enhancing communication among Regional Fisheries Bodies (RFB) and local fishers' associations	3.50
Goal 2: Enhance research cooperation in support of shared policy interests and transboundary issues	**Score**
Identify and evaluate existing trainer of trainer's programs to develop training programs that build on the region's skilled human resources	3.67
Identify ways to best develop a network of research, training and academic institutions to address gaps and capacity building	3.67
Improve the understanding of the gender dimensions for the shrimp and groundfish fisheries	3.50
Identify best approaches for a regional capacity program that will consist of local scientists, managers, practitioners and stakeholders that address fishery management needs and risks	3.67
Identify best approaches to develop a fishery monitoring and research program that will include identifying optimal standards for data collection, identify data needs, and include an implementation strategy	3.83
Identify and evaluate best new technologies to improve fishers' digital reporting	3.33
Identify best practices related to cooperative approaches that support shared policy interests and transboundary issues	3.17
Identify capacity enhancing approaches and opportunities that create sustainable and diverse livelihoods and promote gender equality in the shrimp and groundfish fisheries.	3.33

6.5.5 The Overall Highest Priority Topics for shrimp and groundfish research in the CLME+ region

Six individuals self-identified as decision makers for the shrimp and groundfish survey. A total of 79 research topics were considered in the shrimp and groundfish survey. Several research topics scored 4.0 indicating unanimous recognition of the importance of those topics (Table 6.18).

Table 6.18 | The topic that ranked highest for the Shrimp and Groundfish research priorities. Both topics received a score of 4.0 which indicates that the recognition of these as high priorities by the respondents was unanimous.

Overall highest Shrimp and Groundfish research priorities

Theme/Goal	Priority Topic
SCIENCE/GOAL: Reduce the potential impacts of climate change on the shrimp and groundfish fisheries	Develop climate-based management tools
GOVERNANCE/GOAL: Improve shrimp and groundfish fisheries governance	Identify best approaches to engage disparate parts of the fishery-management community (locally and regionally managed fisheries) in the development and application of the research and modelling tools needed to implement ecosystem-based fishery management
MONITORING/GOAL: Improve data quality needed for shrimp and groundfish to ensure sustainable industrial and artisanal fisheries	Identify gaps in the life history characteristics including size, age, and sex structure as well as issues related to recruitment, population dynamics, and potential fishery yield
	Evaluate changes in key life-history characteristics (age and size at maturity, maximum size, growth rate) with consequences for fisheries (regulations, gear used, catchability, yield)
	Increase understanding of the effects of pollution in the shrimp and groundfish resources in terms of population abundance and structure
	Identify nursery areas, reproductive stocks, and migration patterns for shrimp and groundfish species

Chapter 7

Habitat Protection and Restoration Science Research Agenda

7.1 **Introduction**

The major coastal ecosystems in the tropics include coral reefs, mangroves, seagrasses, and deep-water habitats (Figure 7.1). These are among the highest gross primary productivity producers of terrestrial or marine ecosystems; yet, they are also among the most vulnerable (Nagelkerken 2009). Habitats from coastlines (mangroves), coastal shallows (corals and seagrass), open ocean, and deep seas (ocean benthos) are being lost, eroded, or undermined as a result of extractive and non-extractive activities at local and global scales. Marine and coastal ecosystems are subjected to numerous threats including those from pollution, overexploitation, climate change, the spread of invasive species, habitat loss associated with coastal development and these may have profound effects on coastal communities (Allnutt et al 2012) (Figure 7.2).

The Organization for Economic Co-operation and Development (OECD) projects rapid growth in economic activity associated with the oceans' industries and that they will have the potential to outperform the growth of the global economy in terms of commodities, services, and employment. Their projections suggest that between 2010 and 2030 on a business-as-usual scenario, the ocean economy could more than double its contribution to the global economy reaching over US$3 trillion per annum (OECD 2016). In conjunction with the established ocean industries, emerging and new activities will bring new opportunities for growth and greater diversity to ocean commerce (Table 7.1)

With this rapid growth comes conflicts; the best habitats for productivity, diversity, and coastal geography are also the most attractive for human settlement and activity. A significant proportion of the population in the wider Caribbean lives in the coastal zone and these communities depend to a great extent on marine resources for their recreation, livelihoods, and health. This is particularly true among the Small Island Developing States (SIDS) (CANARI 2019). In the CLME+, approximately 43 million people live on the coast within 30 km of a coral reefs (Burke et al. 2011) with approximately 42% of these living in rural areas. Thirty-two percent of the population is considered indigent (One Shared Ocean 2018).

In order to protect and conserve coastal habitats, it is necessary to improve the amount and quality of research on best approaches to conserve marine biodiversity, identify trophic relationships and dynamics, characterize the physical-chemical environment, and develop sustainable approaches to address resource users' priorities. This also includes a better understanding of marine habitats, their distribution and characteristics, and the physical and ecological processes that govern ecosystems and sustain their biodiversity.

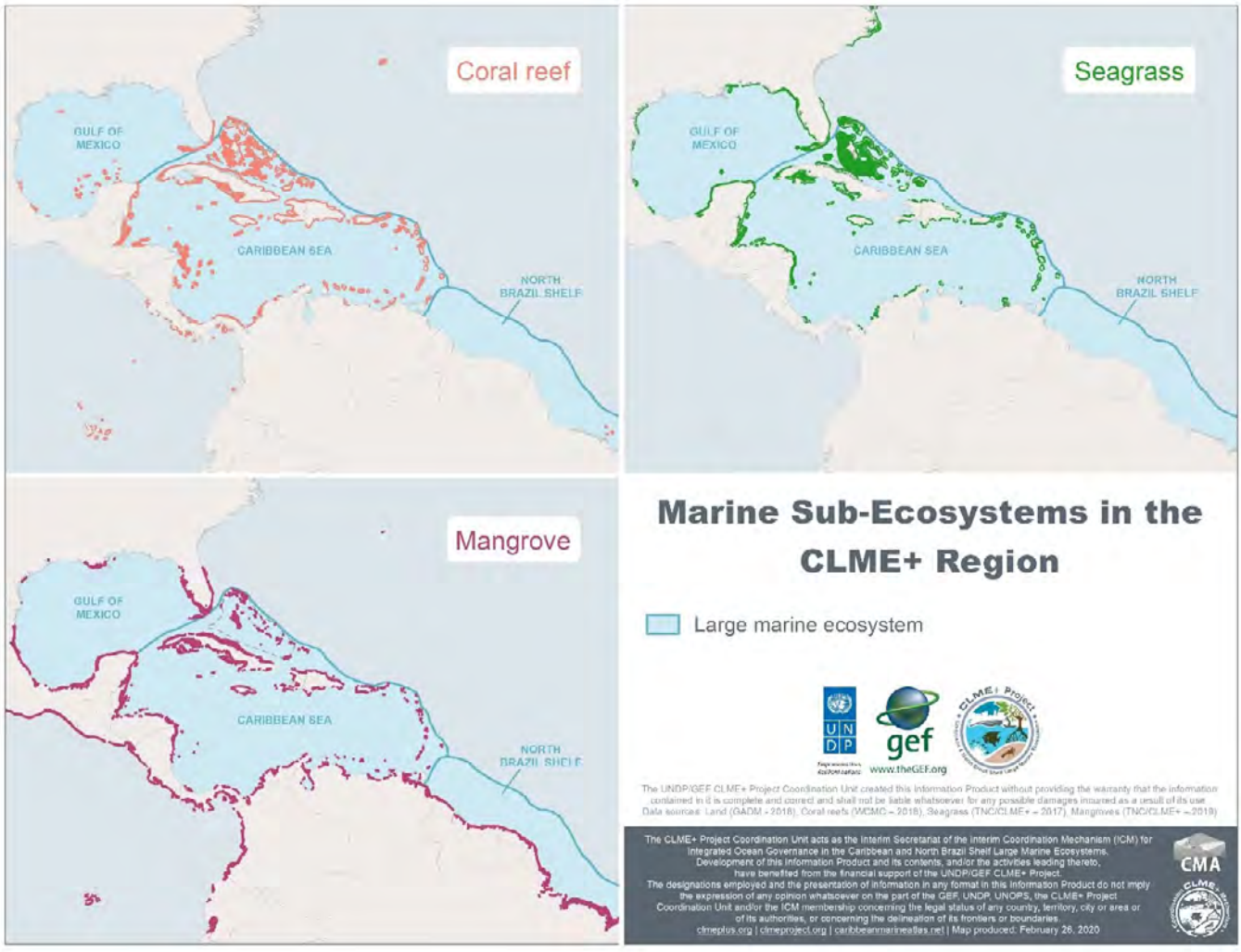


Figure 7.1 | The distribution of major marine habitats in the CLME+ region. The CLME+ region is delineated in light blue.

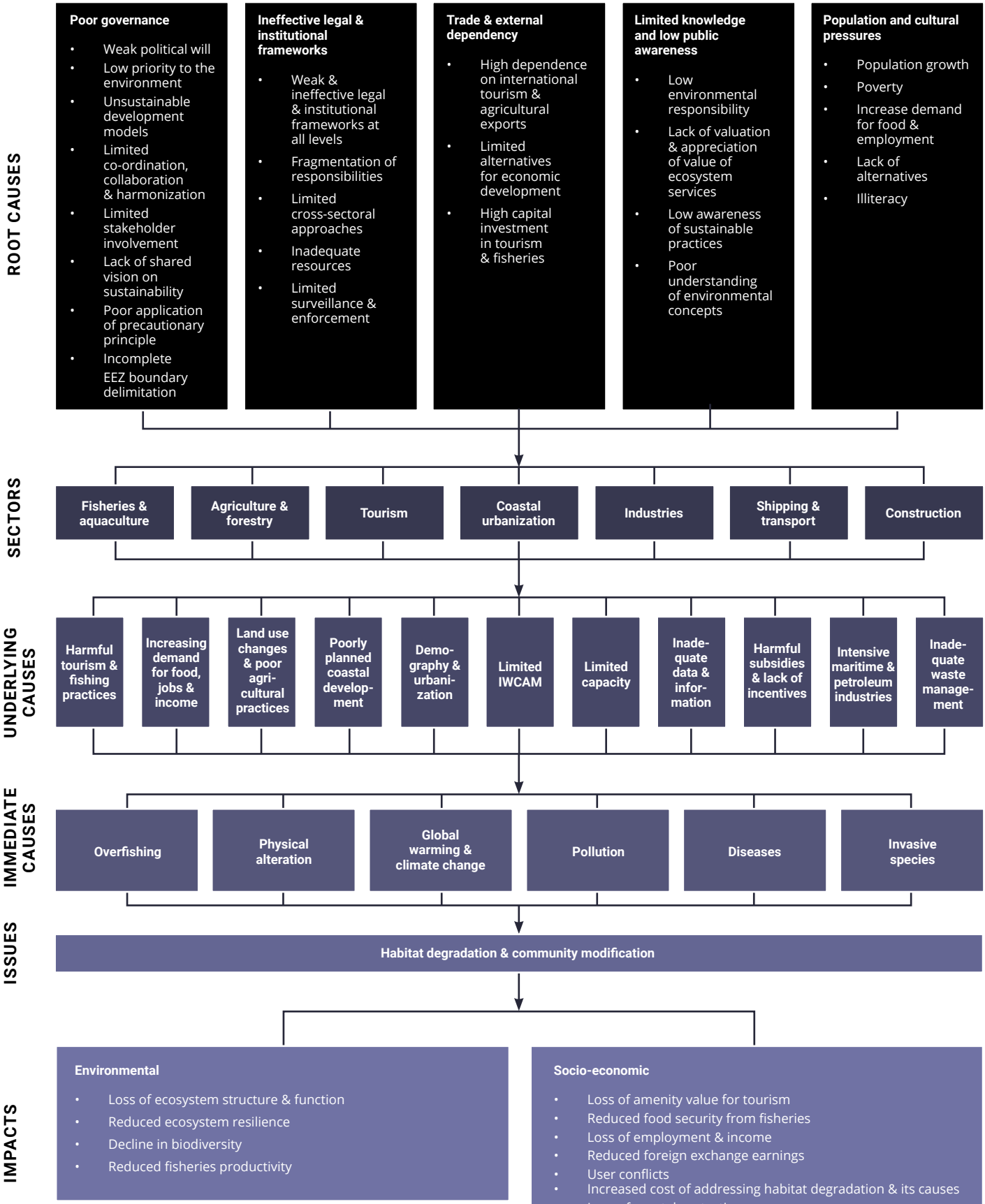


Figure 7.1 | The causal chain analysis linking the root causes of habitat degradation with impacts.

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

This chapter and the research priorities identified in Tables 7.2-7.6 draw on a range of information. A principal source originates from the results of questionnaires distributed during a workshop conducted to E*xpand the Knowledge Base to Support Habitat Protection and Restoration in the CLME+ Region* convened as part of the GCFI Annual Conference in November 2018 in San Andres Colombia. At this workshop, the participants identified the need for actions to address gaps in research related to the five themes of science, governance, monitoring, economics, and communications. The discussions included a focus on the risks to habitats and ecosystems with topics such as gaps in knowledge and data related to 1) the state of our oceans, 2) seabed resources, 3) fisheries and aquaculture resources, 4) deep water resources, 5) socioeconomics, 6) the blue economy, 7) marine spatial planning including MPAs, and 8) biodiversity including marine life.

Table 7.1 | Ocean industries including emerging activities (The Economist Intelligence Unit 2015).

Type of activity	Ocean service	Established industries	Emerging industries	New industries	Drivers of future growth
Harvesting of living resources	Seafood	Fisheries	Sustainable fisheries		Food security
			Aquaculture	Multi-species Aquaculture	Demand for protein
	Marine bio-technology		Pharmaceuticals, chemicals		R&D in healthcare and industry
Extraction of non-living resources, generation of new resources	Minerals	Seabed mining			Demand for minerals
			Deep Seabed mining		
	Energy	Oil and gas			Demand for alternative energy sources
			Renewables		
	Fresh water		Desalination		Freshwater shortages
Commerce and trade in and around the ocean	Transport and Trade	Shipping			Growth in seaborne trade
		Port Infrastructure and services			International regulations
	Tourism and recreation	Tourism			Growth in global tourism
		Coastal development	Eco-tourism		Domestic regulation
Response to ocean health challenges	Ocean monitoring and surveillance		Technology and R&D		R&D in ocean technologies
	Carbon sequestration		Blue carbon (i.e., coastal vegetated habitats)		Growth in coastal and ocean protection and conservation activities
	Coastal protection		Habitat protection, restoration		
	Waste disposal			Assimilation of nutrients, solid waste	

The pressures affecting marine habitats are not unique to the CLME+ region. Societies have been transforming the coastal environment for the benefit of supporting economic and social structures for millennia. All too often, this has come at the expense of the environment. However, there are clear messages that governments are receptive to building a blue economy comprised of a sustainable marine economic development model that emphasizes development of marine economic activity while also protecting marine ecosystems (Wenhai et al. 2019). Nevertheless, there are still forces that prioritize growth over coastal protection under the assumption that a few changes to policy, governance, and enforcement should be sufficient to manage the impact of a growing competition for coastal resources. This suggests that the issues affecting our oceans, and consequently the coastal communities, are not fully understood.

The goals and research topics in this chapter are meant to examine gaps that will reduce threats and enhance protection of marine habitats. However, we recognized that some of these topics by their nature cross themes and, therefore, interactions among the themes are necessary for a successful conservation outcome.

7.2 Marine Spatial Planning (MSP) and Habitat Conservation

Marine Spatial Planning (MSP) is considered an appealing option for managing human uses in oceans and coastal waters in ways that can protect sensitive habitats. MSP provides a mechanism for balancing economic development and use with environmental conservation in order to ensure a sustainable economy while addressing important conservation priorities (e.g., biodiversity). It is a process that identifies the spatial distribution of human activities in the marine environment and the natural resources and habitats that are available (Douvere 2008; Foley et al. 2010). MSP is not necessarily a new tool; it has been used for applying marine ecosystem-based management, for integrating planning and decision-making across sectors, for mitigating user-to-user and user-to-environment conflicts, and for identifying areas (zones) appropriate for defined types of uses (Ehler and Douvere 2009; McCann et al. 2014). MSP has been used before in coastal zone management, establishment of marine protected areas (MPAs), designation of shipping lanes, etc. All these activities required a planning process that considers, to some extent, the spatial distribution of resources and uses.

Spatial analyses are key elements in marine and coastal management programs and high-quality information is needed for their design and implementation. Unfortunately, comprehensive biological and ecological databases and maps are often scarce and usually conducted at small spatial scales because they are time consuming and expensive to conduct (Dalleau et al. 2009). MSP employs systematic techniques with clear and specific conservation objectives to facilitate decision-making. These planning processes often include many criteria and elements such as biological or ecological components as well as human activities and potential threats (Sala et al. 2002; Stewart and Possingham 2005; Richardson et al 2006).

One of the most significant obstacles faced by marine spatial planners is the absence of appropriate spatial data (e.g., benthic habitat maps). Even in data-rich areas, the available data are often acquired for an entirely different purpose and therefore may not necessarily represent the relevant environmental elements from an organism-based or from a management- based perspective. Given the lack of suitable data, researchers and managers frequently use environmental data with unknown accuracy and data that often do not match the spatial and temporal resolution of the ecological/management processes of interest. Also, very little is known about the relative importance to marine species of different seascape features or variables. McCann et al. (2014) identified the MSP practitioner challenges, and gaps fall under some major groups such as MSP implementation, commitment to MSP, MSP capacity, MSP and traditional knowledge, and stakeholders and private sector engagement in MSP.

7.3 Ecosystem-Based Management

Ecosystem-based management (EBM) is an integrated approach to management that considers the entire ecosystem, including humans. Ehler et al. (2009) suggested that "The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the goods and services humans want and need." However, the complexity and linkages of the ecological, biological, socioeconomic, and transboundary issues call for an EBM approach that integrates transboundary governance by considering cumulative impacts of different sectors and human activities on specific ecosystems. It further emphasizes the precautionary and adaptive principles tailored to the ecosystem (CERMES 2011).

In the Caribbean, over the last few decades, a number of international initiatives have concurred on the benefits of the EBM approach as an overarching principle to management e.g., the SPAW Protocol of the Cartagena Convention. This has resulted in a progression from traditional species-based management, or from examining single issues, to considering decisions based on a mixture of interacting elements and ecosystems. This approach has been advocated to enhance livelihoods and reduce vulnerability resulting from historical reduction in resource abundance, emerging climate change impacts, as well as other causes (Fanning et al. 2011). The CLME+ initiative has provided and developed a collaborative approach towards building a truly regional approach to transboundary living marine resource governance and ultimately regional ocean governance in the CLME+ region based on an EBM approach (Debels et al. 2017). However, the Caribbean region suffers from the same problems as many other LMEs (Munoz Sevilla and Le Bail 2017). Although LMEs provide a wide range of goods and services that directly and indirectly benefit the coastal and inland communities, a very low percentage of Caribbean habitats are protected and/or very limited progress toward their protection has been achieved. Consequently, biodiversity is being lost and many ecosystems have been altered thus diminishing their capacity to deliver their wide range of goods and services. Sustained efforts by all stakeholders at all levels of governance are needed to demonstrate the value of the EBM approach for sustaining marine ecosystem services to better livelihoods, economic and social development, resilience, and stability (Debels et al. 2017).

EBM focuses on an adaptive route that considers the cumulative effects of different activities on the diversity and interactions of species. Thus, EBM facilitates connectivity among and within marine ecosystems and social systems by accounting for the inherent uncertainties related to changes in ecosystems. A successful research and implementation plan will depend on the connectivity of researchers and practitioners as well of the support of governmental and non-governmental stakeholders. In addition, as in the other research agendas, a critical requirement is connecting these stakeholders with those making decisions.

7.3.1 Marine Protected Areas (MPAs)

It is well documented that MPAs can help to maintain and restore fish populations, increase ecosystem resilience, and provide socio-economic benefits (Roberts et al 2002; Mellin et al 2016; Ban et al 2017; Aalto et al 2019). These benefits are only realized, however, if MPAs are appropriately sited, protected, and effectively managed (Gill et al. 2017; Giakoumi et al. 2018; Jantke et al. 2018). Many of the world's MPAs fail to meet such standards (Sala et al. 2018) due, in part, to the fact that MPA siting has not always been based on the best available science (Jantke et al. 2018; Fischer et al. 2019).

The effectiveness of MPAs depends on several key aspects of design and management including a) their spatial properties (Palumbi 2004; Mazaris et al. 2017), b) staff capacity, c) clearly defined boundaries, and d) appropriate regulations (Gill et al. 2017). MPA size, location, and spacing are critical parameters to consider in the design of an effective MPA or network of MPAs (Glazer and Delgado 2006). The size of the site determines whether the area of the enclosed habitats can ensure viable populations. The spacing among

the sites in a network is critical as it allows or limits dispersal and connectivity of species' populations. These structural elements (i.e., size and spacing) should be based on estimates of dispersal and connectivity to ensure population persistence.

A thorough understanding of the potential benefits of MPAs for marine biodiversity conservation requires examining the different types of management schemes and regulations as applied to individual sites. Critical questions that need to be addressed include the number and properties (e.g., spatial properties) of sites that are categorized as fully, strongly, or weakly protected, and the type of activities regulated in those sites (e.g., fishing, boating, recreational diving; Lubchenco and Grorud-Colvert 2015). However, conducting these analyses at broad scales is often limited by data availability. Strong staff and budget capacity were the greatest predictors of the conservation impact of an MPA; MPAs with adequate staff capacity had a 2.9 times greater ecological benefit than MPAs with inadequate capacity (Gill et al. 2017).

7.3.2 MPA Coverage and Networking

Over the past two decades, various international, regional and national organizations, NGOs, and academic institutions have put substantial effort into identifying areas of the ocean that warrant special consideration for protection (Grorud-Colvert et al., 2019). The past decade has been marked by a growing recognition of the need for enhanced protection of marine ecosystems including the setting of conservation targets for ocean protection by the Convention of Biological Diversity (CBD) through Aichi Target 11. Positive and measurable action toward meeting such targets has been made through commitments at international, regional, and local levels. Achieving these targets continues to be a focus of effort in the Caribbean. Since 2004, the Programme of Work on Protected Areas (PoWPA) has encouraged parties to the CBD to develop and manage ecologically representative networks of protected areas on land and sea (Knowles et al. 2015).

Existing MPA networks in the Caribbean, such as CaMPAM (administered by UNEP-CEP under the SPAW Protocol) and MPAConnect, work to enhance the effectiveness of MPA management through targeted capacity-building efforts and the establishment of a network of MPA practitioners to share experiences and best practices. MPAConnect, an initiative of the Gulf and Caribbean Fisheries Institute, the Coral Reef Conservation Program of the US National Oceanic and Atmospheric Administration (NOAA) and 32 Caribbean MPAs, has found that the highest priority regional capacity building needs of Caribbean MPA managers are sustainable financing, law enforcement, fisheries management, bio-physical monitoring, and outreach/education (Bustamante et al 2017; Doyle et al 2017). MPAConnect is addressing these shared regional management capacity-building needs and the specific needs of individual MPAs through a variety of means including regional peer-to-peer workshops, site-specific technical support, learning exchanges, mentorship opportunities, and direct grant funding. Through MPA networking, these activities are raising local MPA management capacity in the Caribbean and promoting the exchange of best practices. In this way, MPA networking is facilitating the implementation of effective marine protection in the Caribbean..

7.3.3 MPAs in the High Seas

MPAs are also a tool for protection of marine ecosystems and living resources in the high seas, including the seabed. However, High Seas MPAs have yet to be formally incorporated into international law [e.g., as a treaty under United Nations Convention on the Law of the Sea (UNCLOS)] Houghton 2014, Anonymous 2018). The Regional Seas Conventions can designate MPAs in the High Seas, but such areas still lack legal protection (Grip and Blomqvist 2019). In 2010, as an example, a network of six high seas marine protected areas was designated by the OSPAR Commission in coordination with the North-East Atlantic Fisheries Commission (O'Leary et al. 2012) but these lack legal protection.

7.4 Habitat Connectivity

Improving our understanding of ecological connectivity in tropical marine ecosystems is one of the most pressing needs of resource managers and decision makers today. For example, optimally connected habitats for specific species can be identified and mapped providing valuable spatially explicit information in support of resource management activities such as the design of Marine Protected Areas (Glazer and Kidney 2004). In addition, such information can also contribute to the design of optimally connected habitat-restoration projects. At present, we have little knowledge of the behavior of tropical marine organisms at spatial and temporal scales relevant to their key life-cycle movements.

Defining the scale of connectivity or exchange among marine populations and the factors driving this exchange are critical to our understanding of the population dynamics, genetic structure, and biogeography of many coastal species (Cowen et al. 2006). Yet, we remain largely ignorant of the spatial and temporal patterns of ecological connectivity that are likely to exist in marine environments. Understanding connectivity among mangroves, seagrasses, coral reefs, and offshore ecosystems is fundamental to conserving marine biodiversity and fisheries resources in the Caribbean.

Transport and settlement processes drive marine population connectivity. Connectivity plays a large role in the relationship between the key biotic factors that influence larval mortality, the length of the pelagic larval phase, and settlement success. Connectivity as driven by hydrodynamics also influences abiotic factors such as habitat complexity and inter-relatedness, and biotic factors such as fish and invertebrate distribution (Treml et al. 2015; Wetmore et al. 2020). Ultimately, the dynamics of connectivity influence meta-population stability and persistence in complex environments. Gaining a better understanding of these factors and how they vary across species and habitat will greatly enhance our ability to manage and protect essential fish habitats.

7.5 Marine Deep-Water Habitats

While coral reefs, seagrasses, and mangroves rightfully receive significant exposure as high-profile and valuable tropical marine habitats, other lesser-known environments are also critical for supporting species and services. The deep sea provides our global society a diversity of ecological and ecosystem services which are likely to expand in the coming decades. At the same time, a number of co-occurring stressors are likely to impact the ecological integrity and health of deep-sea communities including fishing, mining, oil and gas exploitation and climate change. As society makes critical decisions about the use and conservation of deep-ocean ecosystems, it is important that we recognize the vulnerability of life on the ocean floor to anthropogenic and climate-related stressors, and the direct influence that this stresses can exert on the world's largest biome (Sweetman et al. 2017).

Weaver et al. (2011) indicated that one striking feature on the study of deep-sea ecosystems is the paucity of scientific information due to the immensity of the oceans and the complexity of the environment. Even though the deep sea may host the highest biodiversity on the planet, very little is known of this ecosystem. This is likely a result of the vast areas the deep seas encompasses (64% of the Earth's surface lies more than 200 meters below sea level). Yet still there is only a relatively small amount of scientific activity occurring in our oceans (Weaver et al 2011). Only about 0.0001% of the deep-sea floor has been subject to biological investigation (UNEP 2007). New habitat-types are still being discovered and our understanding of the ecological processes in the deep sea is only gradually increasing (Ramirez-Llodra et al. 2010).

Deep-sea fisheries are those that take place at great depths (up to 1,600 meters). Many deep-sea fisheries occur in waters beyond national jurisdiction (such as the exclusive economic zone [EEZ]), that is in the high seas (FAO 2008). While we are still in the process of discovering deep-sea species and communities, we know that deep-

sea fish species found in >500 m water depth are often more long-lived and have lower recruitment rates than shallow-water species (Koslow et al. 2000; Morato et al 2006).

Deep-seafloor communities are vulnerable to impacts from bottom fishing (Clark and Koslow 2007; Althaus et al. 2009; Clark and Rowden, 2009;) which is worrisome considering that it can take decades to centuries for deep-sea ecosystems to recover from damage; unfortunately, sometimes recovery is not possible (Althaus et al. 2009; Weaver et al. 2011). Much of the fishing activity is conducted without knowledge on fish stock structure, genetics, and life-history characteristics of either the fished species or the bycatch species. This makes it impossible to use conventional fisheries management measures (such as catch quotas), which are based on estimates of stock biomass. However, other approaches, such as closures of large fishing areas can be also implemented.

7.6 **Habitat Mapping**

The coastal zone is the area where human activities have had the most impact on the marine environment as large numbers of people live close to the coast and many of our industries are associated with ports. The coastal zone, like the offshore environment, also has diverse types of habitats and knowing and understanding these habitats has a major influence on future planning decisions. Currently, in the Caribbean, there is no common base map that is suitable for the wide suite of resource managers. Thus, the many different maps that exist must be integrated and this effort requires significant technical, human, and financial effort.

Marine habitat mapping is a critical part of moving toward sustainable use of the marine environments. Habitat maps provide us with a greater understanding of the distribution and the extent of marine habitats. They allow us to see what we have and where it is in relation to human use. Maps allow us to assess if habitats are rare or threatened by human activities; they can be used to understand whether particular habitats are important to fish stocks, as fish nurseries, or spawning grounds. Ultimately, they help to identify areas that may need protection as Marine Protected Areas or any other marine zoning, but most importantly, they allow us to begin making informed choices about how to manage our marine resources.

Due to the complexity of the topography and the processes that impact the seafloor, it is difficult to predict the habitat types in areas that are poorly mapped. Because large areas of the globe as well as of the Caribbean seafloor remain unmapped, maps of these habitats will provide the level of detail needed to protect vulnerable parts of the marine environment.

Marine habitats mapping are diverse, ranging from broad scale (e.g., remote sensing from satellites, from vessels sounders, sonars) to fine scale (e.g., diver assessments). The mapping or monitoring approaches depend on the objectives of the program, the funding, and the technological resources available. With few existing monitoring programs in the region, there is a need to standardize the marine habitats metrics (habitat type, distribution, etc.) and the mapping approaches.

There is an increasing demand for high-quality information on the coastal zone and the seafloor around the Caribbean. Fisheries, aquaculture, oil and gas and renewable energy infrastructures, shipping, and many other marine activities are competing for the same habitats. Today mapping information is more important than ever before. With new surveying techniques available, the secrets of the seafloor and coastal zone can be uncovered. A better understanding of the marine environment can result in more detailed maps and a better understanding of the marine habitats and its uses.

7.7 Aquaculture and its Influence on Habitat

Although Latin America and the Caribbean only contribute 2.1% of the world aquaculture production, aquaculture in the region is still in a growing phase (FAO 2018). However, the development of aquaculture has caused great concern over the management and protection of coastal environments including coral reefs, seagrass communities, coastal lagoons, and mangrove forests (Price and Morris 2013). In the Caribbean, the main reasons for the loss of mangroves were the conversion of mangrove forests to other uses including infrastructure, aquaculture, rice production, salt production, and tourism development (CARSEA 2007). The Caribbean islands and parts of Central America and northern Australia are forecast to lose more mangrove area than other parts of the world (Record et al. 2013).

In recent years, there has been growing interest in aquaculture development in the Caribbean as a path forward to increase both local seafood supply and economic development (Van Wyk and Davis 2006; CRFM 2014; Pérez-Ramírez 2017). Thus, aquaculture has the potential to make a greater contribution to economic and social regional development provided that appropriate policy frameworks and incentives are provided to stakeholders in the sector (CRFM 2014). The recent development of offshore aquaculture in several islands of the Caribbean (i.e Puerto Rico and The Bahamas) offers a promising alternative to near-coastal production (Benetti et al 2006); offshore submersible cages will allow aquaculture development in areas that were previously considered unsuitable due to wave intensity and/or high risk of damage from severe storms and hurricanes (Benetti et al. 2010a; Benetti et al. 2010b).

Yet, aquaculture development may also impact the habitats with which it is associated. The intensity and type of environmental impacts of aquaculture are dependent upon the species farmed, the intensity of production, and on the farm location. Monitoring and research to quantify downstream impacts and the long-term effects of fish farms beyond the immediate location perimeter will be essential to understand the long-term impacts of aquaculture to the sensitive habitats with which they may be associated.

7.8 Tourism and its Influence on Habitat

Tourism is a major contributor to the gross domestic product (GDP) in the Caribbean region. In 2018, the direct contribution of the travel and tourism sector to the GDP of the Caribbean Islands was 5.1% ranging from 32.2% for Aruba to 2.16% for Guadeloupe (Statista, 2020). Tourism in marine and coastal areas brings along both positive and negative effects on the environment as a result of activities conducted on these areas by tourist proponents and users. As the Caribbean's economy is often based on sun, sea, and sand, tourism development in some coastal zones have been exposed to rapid and uncontrolled development on sensitive ecosystems therefore increasing the risk of environmental degradation. The environmental quality of marine ecosystem in the Caribbean and hence the sustainability of the tourism industry are impacted by factors such as: poor sewage disposal, ship/boat-generated waste, beach erosion, water quality, over-fishing, destruction of habitats, over-crowding, carrying capacity limits and the treatment of solid waste. In addition, tourism has also contributed to global warming through excessive energy use, transportation, water consumption, and waste generation, among others.

A range of tourism activities directly or indirectly causes impacts on natural habitats. For example: mangrove forests and seagrass meadows have been removed to create open beaches. Tourist developments such as piers and other structures have been built directly on top of coral reefs, and nesting sites for endangered marine turtles are also impacted or disturbed by large numbers of tourists on the beaches. Tourist attractions and activities such as unrestricted fishing (which leads to overfishing), diving and snorkeling, and boating also impact coastal habitats.

This research agenda highlighted the importance of coastal habitats for sustainable tourism. Although these coastal and marine resources clearly provide services for tourism activities, there is the need to focus on practical concerns of environmental protection. Local and regional efforts have focused on designating marine protected areas and reserves. Countries should implement effective programs to rehabilitate damaged ecosystems and commit themselves to increase the sustainability of coastal zones. Raising the awareness of local stakeholders in coastal areas about the impacts of uncontrolled tourism development on the environment is very important for conservation of resources. Positive strategies such as the development of ecotourism and community-based tourism provide opportunities to raise awareness about the value of species and ecosystems. Examples include mangrove tours in Guyana and Puerto Rico, wetlands tours in Jamaica, and turtle watching in Trinidad and Tobago and many other in several countries of the region (CARICOM, 2018).

7.9 **Science Research Theme**

Marine ecosystem services contribute significantly to human wellbeing. However, impacts to the benefits they provide will endanger the continued welfare of human societies, especially in coastal communities (Naeem et al. 2016). An altered environment and shifts in biodiversity can have potentially wide-reaching and unpredictable societal consequences by impairing ecosystem resilience and recovery (Worm et al. 2006; Beaumont et al. 2019). Productivity, viability, profitability, and safety of the maritime and ocean industries including the fishing and aquaculture sectors are highly vulnerable to impacts to marine habitats, particularly when coupled with climate change and over-exploitation (Beaumont et al. 2019). The high dependency on seafood for nutrition leaves the wellbeing of a significant proportion of the world's population highly vulnerable to any changes in the quantity, quality, and safety of this food source and the vulnerability of their habitats (Golden et al. 2016).

Among the factors that slow the progress in the development and implementation of effective management approaches are the gaps in knowledge and data about the state of our oceans, seabed resources, marine life, and risks to habitats and ecosystems. This is compounded by the dispersed monitoring and research efforts in the marine and maritime sciences. The lack of scientific capacity is related to the dearth of scientists, engineers, and skilled workers available to apply new technologies and therefore hinders the development and sustainable use of the marine resources and conservation of habitats in the region.

Indicators tied to habitat quality are important for assessing the status and progress of achieving sustainable management solutions. These may include both social indicators such as measurements of management efforts to restore and protect coastal habitats and fish passages, and science-based indicators including the abundance of submerged aquatic vegetation nearshore.

Landscape ecology provides a well-developed conceptual and operational framework for addressing complex multi-scale questions regarding the influence of spatial habitat patterns on ecological processes. Landscape ecology can provide quantitative and spatially-explicit information at scales relevant to resource management decision making. This discipline also facilitates discussions of fundamental questions such as 'how much habitat to protect?', 'what type of habitat to protect?', and 'which seascape patterns enhance connectivity for mobile marine organisms?'. While landscape ecology is increasingly being applied to tropical marine seascapes, only recently has this approach been more widely used due, in part, to new technologies.

Miloslavich et al. (2010) described the different sub-ecosystems and their extent found on the coral reef-mangrove-seagrass complex of the wider Caribbean. These include coral reefs (26,000 km^2), mangroves (11,560 km^2), and seagrass beds (66,000 km^2) (Jackson 1997; FAO 2003; Burke et al 2004) (Figure 7.1). The geographic complexity of the CLME+ region results in a very rich biodiversity with at least 12,046 species reported in the Caribbean Sea (Miloslavich et al. 2010). Of these, 987 are fish species. A detailed overview of the Status and Trends of the Nearshore Marine Habitats in the Caribbean was prepared for the SPAW Programme, linked to the SPAW Protocol (CANARI 2019).

The science research theme questionnaire (Table 7.2) was distributed in an electronic survey involved in ecosystem management and research The results were used to prioritize the topics associated with each goal. The survey was sent to a diverse group of stakeholders and regional organizations (CRFM, OSPESCA, WECAFC-FAO, CAR-SPAW and UNEP-CEP). The science research theme focused on providing guidance to provide the best available science, tools, and strategies to inform decision makers. Description of the science research theme (Table 7.2) will focus on six goals:

- Assess the ecological role and value of marine habitats
- Apply best practices to collect and share data to conduct research on marine habitats
- Assess the impacts of emerging issues on marine habitats
- Assess the potential of habitat restoration for conserving marine habitats
- Identify and reduce the incidence of threats to marine habitats
- Identify which management actions are most effective for conserving marine habitats

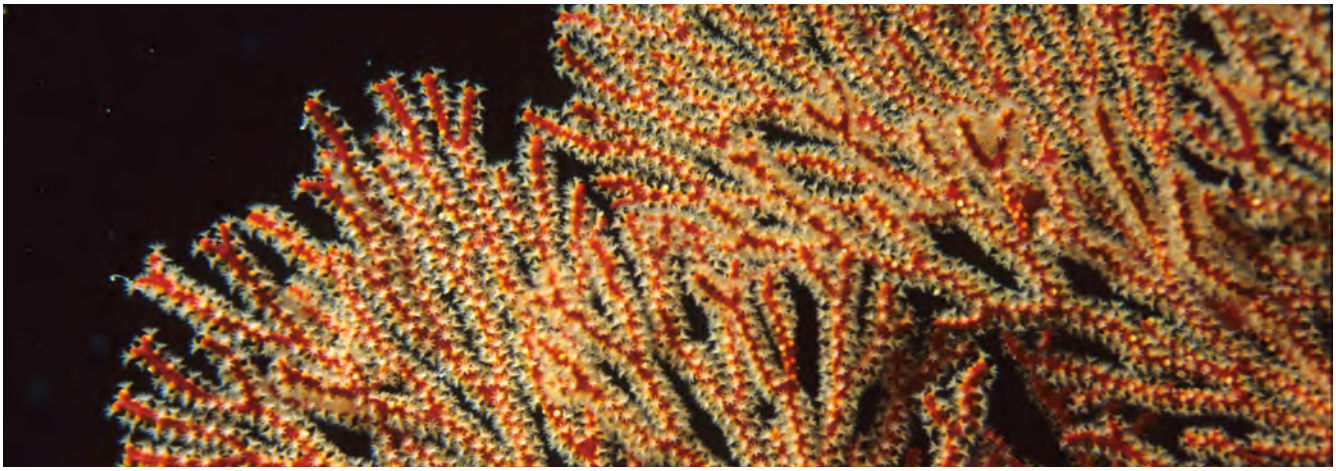


Table 7.2 | Goals and research topics associated with the Habitat Science Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Assess ecological role and ecological value of marine habitats	Score
Compile comprehensive information on diseases affecting coral reef ecosystems including on the incidence, distribution, trends, causative agents, and mechanisms of transmission	3.60
Conduct region-wide mapping of coral reefs, mangroves, and seagrass beds to establish a baseline of the distribution of the habitats and associated species	3.80
Develop criteria for integrating different spatial scales in the application of criteria to select coastal areas of outstanding ecological value	3.80
Develop a regional GIS database of habitats	3.60
Evaluate remote-sensing techniques to identify best technologies to effectively monitor habitats at different spatial scales	3.20
Identify key marine habitat-connectivity components that determine the sustainability, persistence, and resilience of marine populations and metapopulations	3.60
Encourage research and monitoring of the relationships of related ecosystems, particularly seagrass meadows, mangrove forests, tidal wetlands, and coral reefs	3.40
Identify how aquaculture impacts habitats at the local scale and develop cost/benefit analyses of these activities	3.60
Evaluate how individual and interactive effects of multiple stressors affect the capacity of marine ecosystems and species to adapt to changing ocean conditions	3.80
Identify migration corridors for important marine species at the local and transboundary scales and develop approaches for their protection	3.80
Goal 2: Apply best practices to collect and share data to conduct research on marine habitats	**Score**
Determine what strategies are effective that promote long-term, integrated, and cross-disciplinary collaborations in ocean science and management	3.20
Identify existing or, if needed, develop new, systematic approaches to coastal habitat classification	3.40
Develop practical targets to provide measures of success towards achieving long-term ecosystem integrity related to sustainable use	4.00
Consider the likely historical conditions when assessing current habitat quality assessments	3.00
Encourage the development of a statistical framework that is sufficiently robust to identify the status and trends of marine habitats	3.60
Identify best approaches to crosswalk and/or standardize multi-institutional and multi-national survey data or recommend adjustments in approaches to facilitate standardization	3.60
Survey countries to identify how data are used to understand and influence decisions that reduce impacts to habitats	3.60

Table 7.2 continued

Goal 3: Assess impacts of emerging issues on marine habitats	Score
Develop climate-change adaptation approaches that identify options to prevent the population decline or extinction of vulnerable species (e.g., geographically constrained)	4.00
Identify impacts of the Sargassum influx on marine habitats and identify case studies, or develop new programs, that demonstrate effective local and region-wide approaches to managing the influx	3.50
Develop methods to contain, dispose of, or utilize massive amounts of Sargassum associated with influxes	3.17
Develop region-wide coordinated research, monitoring, planning, and actions to address Stony Coral Tissue Loss Disease (SCTLD) and other coral diseases	4.00
Evaluate how marine ecosystems and species adapt and respond to the individual and interactive effects of ocean acidification, anoxia, and warming and what options for adaptation exist	3.80
Identify ways to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters	3.80
Examine the ecological effect of ocean acidification on benthic habitats and species	4.00
Conduct research on new technologies including conservation approaches to address alien invasive species	3.60
Investigate how changing terrestrial hydrological regimes affect coastal and marine ecosystem structure, function, and services	3.60
Goal 4: Assess the potential of habitat restoration for conserving marine habitats	**Score**
Identify best practices and potential case studies for projects that restore or enhance habitat extent or quality (e.g., replanting mangroves or restoring linked habitats)	3.60
Identify what restoration methods (e.g., in situ habitat restoration, translocation) are most likely to enhance natural marine ecosystem form, function, and services	3.80
Identify how implementation of LBS best management practices and other strategies reduces nonpoint runoff to nearshore waters.	3.60
Evaluate effectiveness of mangrove, seagrass, and coral reef restoration programs and identify ways to scale up successful projects	4.00

Table 7.2 continued

Goal 5: Identify and reduce the incidence of threats to marine habitats	Score
Identify approaches that reduce mangrove, seagrass, and coral destruction including from coastal development	3.80
Identify the waters most vulnerable to single and repeated hypoxic events	3.40
Investigate the source(s) contributing to increased occurrence of algal blooms in coastal river systems in order to reduce their occurrence and severity	3.20
Determine the appropriate level of Total Suspended Solids, chlorophyll a, and other parameters needed to achieve acceptable water clarity for sustained habitat health including for Submerged Aquatic Vegetation	3.40
Investigate the long-term impacts on ecosystems and sentinel species due to oil spills	3.40
Identify ways to reduce sediment and contaminant runoff (including toxic chemicals) originating from agricultural and aquaculture practices and coastal development	3.60
Investigate how human resource use will change as climate change impacts the resources upon which they depend	3.60
Identify practical ways to integrate environmental, management, and socioeconomic data to better understand the primary factors responsible for coral reef decline and how to mitigate these pressures	3.40
Goal 6: Identify which management actions are most effective for conserving marine habitats	**Score**
Assess what forms of scientific evidence, risk assessment, and knowledge transfer most effectively increases the probability of achieving marine ecosystem management objectives	4.00
Identify the characteristics of effective Decision Support Systems (DSSs) that focus on the protection of reefs and associated ecosystems and the sustainable management of associated living marine resources	3.80

7.10 Governance Research Theme

This research theme is based on addressing gaps to governance capacity and how governance capacity and frameworks can be strengthened. It provides approaches to capacity-building that can bridge the gaps between science, planning, and the implementation of effective management policies and plans of action. A major emphasis is placed on sustaining investments in capacity-building programs and on identifying how international partnerships can participate and collaborate in long-term programs.

The CLME+ approach to maritime activities is centered on the inter-relatedness between marine-based human activities. Integral to this approach is a sensitivity to the fact that changes to one aspect of the system may affect others. Additionally, various stakeholders at the regional, sub-regional, and national levels have been encouraged to cooperate, for example, with the sharing of data across policy areas. Cooperation may result in more holistic evaluations and solutions. The institutional framework that governs decision-making for the Caribbean Sea reflects a complex arrangement of overlapping mandates which involve multiple agendas such as those involving: (a) multiple United Nations programmes, commissions, regional offices, and sub-regional offices; (b) technical agencies of the Caribbean Community (CARICOM); (c) the Central American Integration System (SICA) and its technical agencies; (d) the Organisation of Eastern Caribbean States (OECS); (e) the Association of Caribbean States (ACS); (f) the Organisation of American States (OAS); (g) bilateral agencies (such as the United States Coast Guard); and (h) national governments (CANARI 2019).

A better awareness of relevant governance forces requires a multi-disciplinary approach that addresses impacts to the environment and society including those to environmental processes, conservation of biodiversity, human activities (land-based and marine), climate change (including sea-level rise), and the socio-economic impacts of marine protection. As such, CLME and CLME+ have been providing the necessary framework to address transboundary issues related to governance and implementation, communication, and funding research initiatives to integrate ocean governance across the Caribbean region.

The governance research theme focuses on an adaptive approach that is based on solid science, innovative management schemes, enforcement, collaboration, and stakeholder's participation. Description of the governance research theme (Table 7.3) will focus on two goals:

- Apply best practices to improve effectiveness of existing legislation and programs protecting marine habitats
- Identify and reduce the incidence of threats to marine habitats
- Strengthen capacity to improve effectiveness of existing legislations and programs protecting marine habitats

Table 7.3 | Goals and research topics associated with the Habitat Governance Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Apply best practices to improve effectiveness of existing legislation and programs protecting marine habitats	Score
Determine the best inter-governmental frameworks for ensuring effective and credible high seas governance outside the legal jurisdiction of any single country	3.40
Identify where existing conventions and protocols need improvement and how best to achieve those improvements including, for example, how best to encourage non-contracting parties to SPAW to become signatories	3.80
Determine how best to influence the likelihood of compliance with ocean legislation and regulations at local, national, and international levels (including identifying conflicting policies)	3.40
Review existing and, when necessary, recommend new legislation and rules regulating aquaculture to ensure they sufficiently consider habitat protection	3.40
Identify case studies that highlight effective management that balances resource use (e.g., fishing, diving) with habitat protection	3.80
Identify strategies to incorporate uncertainty and risk into effective marine habitat conservation and policy making.	3.40
Goal 2: Implement ecosystem based approaches for conserving marine habitats	**Score**
Create a minimum set of performance criteria including robust indicators for MPA evaluations	4.00
Create baseline habitat assessments of existing or proposed marine managed areas	3.20
Identify areas for updating existing MPA management plans and marine spatial plans based on analysis of assessments	3.60
Formulate, adopt, and implement integrated ecosystem-based approaches for the sustainable management of related and/or interconnected ecosystems	3.80
Identify alternative livelihoods for stakeholders impacted by changing conditions (including regulations, climate change)	3.80
Identify approaches to strengthen localized early-warning networks including a regional rapid response program for coral bleaching, diseases, invasive species, and other emerging events	3.40
Identify ways to improve connectivity among habitats to support sustainable marine populations and healthy ecosystems and make them resilient to climate change	3.80
Identify ways to integrate blue carbon ecosystem protection into the management of marine habitats	3.80

Table 7.3 continued

Goal 3: Strengthen capacity to improve effectiveness of existing legislations and programs protecting marine habitats	Score
Identify ways to improve existing approaches, or develop new approaches, to enhance cooperation between regional and national intergovernmental agencies, ministries, and institutions	3.60
Identify ways to encourage the mainstreaming of sustainable habitat management into the priorities of relevant international agencies, programs, conventions, financial institutions, and the donor communities	4.00
Identify ways to enhance participatory decision-making in national environmental governance	3.60
Identify guidelines for compensation for ship groundings, illegal discharges, and other habitat disturbances at national levels	3.40
Identify ways to strengthen gender-sensitive marine resource management including MPA management	3.40
Identify best approaches to engage the International Maritime Organisation (IMO) to address maritime issues affecting marine biodiversity	3.60
Develop legislative approaches to establish locally-managed marine areas	2.80
Develop approaches that integrate information from shifting historical baselines into planning and effectiveness analyses	3.60
Investigate how best to integrate policies across sectors and, where appropriate, reformulate existing domestic legal instruments that promote sustainable management of coral reefs and their related ecosystems	3.60
Review, assess, and recommend updates to legislation, regulations, and procedures related to habitat protection and conservation	3.60

7.11 **Monitoring Research Theme**

Scientific approaches must guide the collection of data needed to evaluate the ecological outcomes of policy actions and human processes. Evaluation must be more systematic in its analyses. It is important to document and learn from failures about policy actions taken to improve ocean health. This includes taking a scientific approach to recognizing when existing types of ocean data are not policy-relevant. Holistic approaches are needed to understand the ecological trade-offs associated with different policy actions and sustainable development pathways, the impact of poor decisions, and behavior changes.

A key issue is the improvement of the baseline data and set reference levels for non-commercial species, benthic organisms, and habitats. Such needs for data would not be fulfilled without a substantial increase in observation capacities including long-term time series, related infrastructures for monitoring and development of capacities, systems and technologies for management large amounts of multidisciplinary data and enhanced coupled data bases.

While an extensive number of existing regional and national initiatives exist that can provide important sources of data, there are still many gap on data sources in the CLME+ region. For a global comparative assessment of CLMEs (Level 1 assessment), temporal and spatial datasets are required for the key indicators (IOC-UNESCO 2011). However, data resolution and coverage (spatial and temporal) could present some constraints for local and regional assessment comparisons. Nevertheless, assessments should be based on the best available datasets.

Monitoring has three roles. First, it must provide a framework for determining what impacts to resources are occurring. In other words, how the resources are changing and, ideally, what is causing those changes. Secondly, monitoring must provide the information needed to determine when to implement specific actions. In this regard, monitoring informs when trigger points have been reached and thus provide the scientific rationale for implementing specific management actions. Finally, monitoring must provide the basis for evaluating the effectiveness of the implemented strategy and whether adaptive adjustments must be made to the action.

The monitoring research theme focuses on the link of methodologies and approaches of the natural and social sciences including socioeconomic, as well as emerging and innovative technologies. A critical requirement is connecting with those making decisions (e.g., through existing networks), as well as engaging other stakeholders supporting decision makers. Description of the monitoring research theme (Table 7.4) will focus on four goals:

- Apply best practices to collect and share results of marine habitat monitoring
- Monitor marine habitats in deep water
- Monitor the ecological role and value of marine habitats
- Monitor anthropogenic threats to marine habitats

Table 7.4 | Goals and research topics associated with the Habitat Monitoring Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Apply best practices to collect and share results of marine habitat monitoring	Score
Identify most appropriate existing surveys or develop new surveys to assess management effectiveness including restoration program effectiveness	3.00
Develop approaches that incorporate traditional and local knowledge to assess changes to marine habitats	3.40
Develop guidelines, tools, and the training necessary to integrate marine biodiversity conservation priorities into monitoring programs	3.80
Develop or enhance methods to map marine habitats (intertidal, shallow, and deep habitats) using remote sensing or other rapid assessment techniques, in combination with field verification	3.80
Identify existing and potential funding sources for monitoring programs	4.00
Identify appropriate sentinel monitoring sites for early warning signal detection of emerging threats	3.80
Identify best practices and approaches to standardize, increase, and integrate the collection of biophysical coral reef data across the region to fill gaps and to provide data on local and regional habitat condition (including for coral reefs) to support policy and management decisions	4.00
Develop or create monitoring approaches that can capture information from a variety of sources and formats to make effective assessment of resource condition and changes and to create associated national or regional policy	3.60
Identify and, if necessary, develop monitoring approaches that integrate biophysical and social-science dimensions to identify changes to ecosystems based on those linkages	3.40
Use existing datasets (such as CARICOMP) to help understand the condition of coastal ecosystems	2.80
Goal 2: Monitoring marine habitats in deep water	**Score**
Identify existing deep-sea environmental monitoring programs in the CLME+ region	3.00
Identify effective emerging technologies to help assess the conditions of deep water habitats	3.00
Develop routine monitoring programs of oil and gas industry activities to identify ongoing impacts on deep-water habitats	3.40
Identify research to improve monitoring effectiveness of the marine deep habitats including identifying the impacts of anthropogenic pressures	3.00
Understand the role of deep water habitats in supporting various life stages of living marine resources and the processes that regulate these ecosystems including Fish Spawning Aggregations	3.40

Table 7.4 continued

Goal 3: Monitor the ecological role and value of marine habitats	Score
Establish improved monitoring programs to determine the current status and critical habitat of key focal habitat components	3.60
Identify and, if necessary, develop monitoring approaches that integrate biophysical and social-science dimensions to identify changes to ecosystems based on those linkages	3.40
Evaluate the long-term trends of key oceanographic variables (temperature, biomass, oxygen saturation, salinity, carbon system, sea-level change, currents, etc.) in three dimensions within the CLME+ region	3.80
Identify how key large-scale ecological processes impacting marine habitats can be identified, protected, and, when impacted, restored	3.60
Investigate the loss of habitat value from non-native aquatic vegetation and invertebrates	3.25
Goal 4: Monitor anthropogenic threats to marine habitats	**Score**
Develop innovative and less impactful fishing gear and techniques to minimize habitat damage	3.60
Identify the impacts of recreational fishing on marine ecosystems	3.80
Identify and quantify marine habitat damage due to ghost fishing and what is the most effective way to reduce this impact	3.83
Assess the effect that beach nourishment has on the benthos and make appropriate recommendation on improvement, if needed	3.60
Assess the impact of boat traffic, marinas, piers, and dredging on shallow-water habitats	3.60
Identify the cumulative impact of mechanical disturbances including boat wakes and groundings on shallow water ecosystems	3.00
Investigate the impacts of coastal development and changing patterns of land use have on the health of coastal, estuarine, and marine habitats and the communities they support	3.60
Develop region-wide coordinated research, monitoring, planning, and actions to address invasive species	3.60
Develop a network of continuous water quality monitoring stations within the region (CARICOM) to better evaluate long-term water quality conditions and ensure water quality standards are not violated	3.80
Evaluate existing point and non-point pollutant discharge-monitoring programs including aquaculture discharges to ensure sampling is sufficiently widespread and captures the suite of pollutants at relevant concentrations that can impact habitats	3.40
Develop monitoring approaches that identify the extent that hypoxia is impacting benthic habitats and associated species and quantify trends in habitat changes	3.00

7.12 Economics Research Theme

Marine habitats provide a wealth of ecosystem services, including food provisions for billions of people, carbon storage, waste detoxification, and cultural benefits including recreational opportunities and spiritual enhancement (Worm et al. 2006; Liquete et al. 2013). Ecosystem services provided by the ocean play an essential role in society. We all depend on the ocean for the oxygen that we breathe and for its role in controlling and moderating the weather and climate (Ranyer et al. 2019). Any threat to the continued supply of these ecosystem services has the potential to significantly impact the welfare of humans across the globe for food security, livelihoods, income, and health (Naeem et al. 2016). On a global scale, it was estimated that for 2011, marine ecosystem services provided benefits to society approximating $49.7 trillion per year (Constanza et al. 2014). The Caribbean Sea makes up just 1% of the global ocean but with its estimated value of $407 billion (in 2012) it accounts for between 14% and 27% of the global ocean economy (Patil et al. 2016).

Agriculture, fisheries, and tourism are important economic sectors and therefore the region has a high dependence on its natural resources to provide supporting ecosystem goods and services. For example, ecotourism focusing on diving and snorkeling provide benefits linked to healthy marine and coastal ecosystems (Wood 2000). Cruise tourism is also dependent on the region's biodiversity and as noted by the Florida-Caribbean Cruise Association (2013), the Caribbean is ranked as the dominant cruise destination accounting for 37.3% of all global itineraries in 2013 (CANARI 2018).

Habitat degradation or the loss of marine habitat has a wide range of economic implications from clean-up expenses to loss of tourism revenue. It can also have direct consequences on human health. The marine and maritime activities continue to undergo a profound transition worldwide as well as in the CLME+ region. Traditional industries of shipping, fisheries, tourism, and marine recreation are now under regulatory scrutiny due to impacts to the ocean resources. In addition, other industries are impacting habitats. These include large-scale industrial activities associated with exploitation of offshore oil and gas, aquaculture-based food production, and emerging new activities such as ocean mining and marine biotechnology. A 'Transboundary Diagnostic Assessment' of the marine ecosystems conducted by the CLME project indicated that there is strong evidence that the Caribbean Sea's natural capital is being depleted, largely due to the anthropogenic drivers of overfishing, coastal development, pollution, introduction of invasive species, and the impacts of climate change (CLME Project 2011). Such depletion represents a significant risk to the economic benefits generated by the region's ocean economy and likely to future growth prospects.

Overall, economic development in the coastal Caribbean must be conditional upon environmental sustainability. Several regional and national strategies or initiatives are framed around the concepts of Green Economy, Blue Economy, Green Growth, Green Jobs, and Sustainable Consumption and Production. These include the Regional Strategy for Sustainable Consumption and Production and its Action Plan (2015-2016), the OECS Eastern Caribbean Regional Ocean Policy (ECROP) and Strategic Action Plan (2013), Grenada's Blue Growth Coastal Master Plan and planned outputs of Guyana's Green State Development Strategy initiative (CARICOM 2017; CARICOM 2018).

The blue or marine economy can contribute competitiveness, resource efficiency, job creation, and offer new sources of growth while safeguarding biodiversity and protecting the marine environment. The blue economy involves every aspect of national and global governance, economic development, environmental protection and sustainability, and international communication. At the heart of the concept is the use of ocean resources (natural capital from living and non-living marine resources and ecosystems and their services) for economic growth and sustainable livelihoods while maintaining the ocean, its ecosystems, and their processes. If properly managed, many of these natural

capital assets are renewable and capable of yielding a sustained flow of benefits (Caribbean Development Bank 2018). The blue economy gives special attention to both established and emerging economic sectors with high potential for job creation and innovation in such sectors as coastal tourism, aquaculture, gas and oil, blue energy, blue biotechnology, and mining. Coastal tourism, by far the largest blue economy sector in the Caribbean region in terms both of jobs and of value, continues to grow but poses ongoing challenges to the environment and local communities as well.

The concept of the blue economy is gaining traction in the CLME+ region, especially in SIDs, but its potential has not been maximized, primarily because the blue economy has not been formally recognized as an important economic driver (Caribbean Development Bank 2018; UNEP-CEP 2020). Increasingly, the CLME+ region's opportunities for sustainable blue growth are jeopardized by habitat degradation, unsustainable fisheries practices, and pollution (CLME Project 2011). Multilateral institutions such as the Caribbean Development Bank, the InterAmerican Development Bank, and the World Bank have identified the blue economy as a strategic development opportunity for the Caribbean. Some countries in the region, like Barbados and Grenada, have taken steps to enhance the blue growth policy framework.

The Economic research theme focuses on the recognition of the limitations of underestimating the social and economic cost of the direct and indirect impacts of the tourism, transport, and fisheries sectors on the marine resources. This research theme will encourage cross-sector collaborations of stakeholders (e.g., between science and socioeconomic stakeholders) to quickly address gaps in research and implementation of the identified actions. In addition, as in the other research themes and agendas, a critical requirement is connecting these stakeholders with those making decisions. Description of the economic research theme (Table 7.5) will focus on three goals:

- Assess the value of marine habitats
- Promote gender equality and cultural values of marine habitats
- Investigate sustainable financing options for marine habitats

Table 7.5 | Goals and research topics associated with the Habitat Economics Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Assess the value of marine habitats	Score
Conduct ecosystem valuation studies to help quantify the value of habitats	3.60
Assess the costs and benefits to society of marine protected areas, how the benefits are distributed, and how costs and benefits vary based on resource management approaches	3.40
Investigate the effects of economic growth, coastal development, and the subsequent displacement of resource users on traditional cultures and values	3.40
Conduct social and economic studies to quantify the value of healthy and resilient habitats on the social and economic well-being of society including the fishing sector	3.40
Quantify the value of the loss of ecosystem services as a result of changing conditions associated with climate change	4.00
Goal 2: Promote gender equality and cultural values of marine habitats	**Score**
Develop a better understanding of cultural attitudes toward marine resources at the local community level	3.20
Develop approaches that ensure that cultural and historical heritage values are considered when developing programs that maximize benefits for stakeholders	3.60
Identify ways to promote gender equity in employment and education	3.60
Goal 3: Investigate sustainable financing options for marine habitats	**Score**
Assess the feasibility of blended finance approaches and public-private partnerships as sustainable financing options	3.67
Identify ways to encourage landowners to implement habitat conservation activities through tax incentives and other financial incentives	3.40
Identify ways to increase financing for natural resource management including marine managed areas (for example, from resource-dependent sectors)	3.60
Investigate the value of economic subsidies to the function of marine ecosystems and services at local, regional, and international scales	3.00

7.13 Communications Research Theme

Communication

Effective communication of scientific knowledge is a prerequisite for generating commitments among governments and other stakeholders, and for creating a new level of awareness in the public about the current and potential future state of the oceans. This conveyance of information may also trigger and guide substantial technological developments and related transfer of marine technology, including modelling tools, new forecasting capabilities through sustained cooperation, and new partnerships. Ultimately, this can result in stimulating capacity building. Mass communication is likely to continue to be a major driver of change in human behavior that affects marine ecosystems in the form of social media or forms of mass communication that are being developed and can serve as powerful catalysts of change (Friedman et al. 2020).

How scientists and citizens best communicate with policy makers and managers is crucial for the management of the marine resources. Marine scientists must find innovative and concise ways to communicate their science to environmental decision makers who are often overloaded with information from competing stakeholders. Score cards and other summaries are an increasingly popular means to provide a concise visual summary of often complex environmental information at regional and national scales. The role of advertising in driving behavioral change is well-researched (reviewed in Stewart et al. 2002). However, the effective use of media to promote environmental action is less understood (Friedman et al. 2020).

The Communications research theme focused on the identification of what are the most effective communication topics to increase stakeholder support for ocean conservation and communicate scientific knowledge to a wider group of government and non-governmental stakeholders. The success of this research theme will enhance the communications on marine knowledge and is intended to improve the use of scientific knowledge on the Caribbean seas and oceans through a coordinated approach to data collection and data dissemination. In addition, as in the other research themes, a critical requirement is connecting these stakeholders with those making decisions. Description of the communication research theme (Table 7.6) will focus on three goals:

- Apply best practices to enhance communications for the sustainable management of marine habitats
- Build capacity in all facets of marine conservation and sustainable use to disseminate and apply best practices to engage communities in the sustainable management of marine habitats
- Enhance communications related to marketing, funding, and education initiatives

Table 7.6 | Goals and research topics associated with the Habitat Communications Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Apply best practices to enhance communications for the sustainable management of marine habitats	Score
Develop a list of case studies or projects that examined marine and coastal habitat conditions that are policy-relevant	3.60
Develop best-practice guidelines for the restoration of seagrasses, mangroves, and coral reefs	3.60
Develop sub-regional, country, and site-specific report cards and similar products that can be used to communicate information that informs policy and management	3.40
Identify best practices for public-private partnerships to encourage corporate sector participation in habitat conservation	3.80
Identify the optimal approaches to convey marine conservation messages with consideration of different values and perceptions held by different stakeholders	3.80
Conduct inventory of ecosystem services valuation studies that support habitat conservation	3.40
Identify best practices to strengthen approaches for translating data and scientific research for uptake by policy/decision makers, the private sector, and the general public	3.60
Identify ways to promote green infrastructure and blue carbon concepts for climate adaptation and mitigation and biodiversity conservation	3.80
Identify the best methods to encourage change to stakeholders' behavior to increase conservation of the marine environment, and identify what behaviors are most important to change.	3.40
Goal 2: Build capacity in all facets of marine conservation and sustainable use to disseminate and apply best practices to engage communities in the sustainable management of marine habitats	**Score**
Identify ways to strengthen stakeholder capacity to address invasive alien species	3.40
Identify ways to support and facilitate participation of civil society and the private sector in programme and project design, implementation, and evaluation	3.40
Identify approaches that increases the technical capacity of scientists, technicians, and managers through access to environmental education, training, and capacity development so they are better able to communciate with decision makers	3.60
Identify approaches to create new or strengthen existing effective communication networks of professionals and institutions to highlight habitat value and sustainability, for example the Global Coral Reef Monitoring Network (GCRMN)	3.60
Identify most effective approaches to deliver training in MPA management	3.25

Table 7.6 continued

Goal 3: Enhance communications related to marketing, funding, and education initiatives	Score
Identify best approaches to encourage and support public awareness and education programs on the values and threats to marine ecosystems including global awareness campaigns	3.40
Develop approaches that integrate local and traditional knowledge with scientific knowledge to help guide policy and actions	3.60
Identify the communication targets needed to develop specific strategies for habitat conservation or restoration	3.20
Identify existing and new sources for funding communication efforts	3.60

7.14 The Overall Highest Priority Topics for Habitat Conservation and Restoration research in the CLME+ region

A total of 19 survey respondents self-identified as decision makers and their responses, as with the fisheries and pollution agendas, were used to identify their most important research topics. Ten topics received a score of 4.0 indicating that there was unanimous recognition among them that these topics were the highest priority and most the topics that were most critical for future efforts (Table 7.7). Most research topics that scored 4.0 were within the Science theme (six research topics). The Governance theme followed in importance with two research priority topics scoring 4.0. One priority topic scored a 4.0 in each of the Monitoring and Economics themes. Interestingly, the Communications theme did not have any priority topics that were scored as critical by all respondents.

Table 7.7 | The ten topics that ranked highest for the habitat and restoration research priorities. All topics received a score of 4.0 which indicates that all respondents scored these topics as high priority.

Theme/Goal	Priority Topic
SCIENCE/GOAL: Apply best practices to collect and share data to conduct research on marine habitats	Develop practical targets to provide measures of success towards achieving long-term ecosystem integrity related to sustainable use
SCIENCE/GOAL: Assess impacts of emerging issues on marine habitats	Develop climate-change adaptation approaches that identify options to prevent the population decline or extinction of vulnerable species (e.g. geographically constrained)
SCIENCE/GOAL: Assess impacts of emerging issues on marine habitats	Develop region-wide coordinated research, monitoring, planning, and actions to address Stony Coral Tissue Loss Disease (SCTLD) and other coral diseases
SCIENCE/GOAL: Assess impacts of emerging issues on marine habitats	Examine the ecological effect of ocean acidification on benthic habitats and species
SCIENCE/GOAL: Assess the potential of habitat restoration for conserving marine habitats	Evaluate effectiveness of mangrove, seagrass, and coral reef restoration programs and identify ways to scale up successful projects
SCIENCE/GOAL: Identify which management actions are most effective for conserving marine habitats	Assess what forms of scientific evidence, risk assessment, and knowledge transfer most effectively increases the probability of achieving marine ecosystem management objectives
GOVERNANCE/GOAL: Implement ecosystem-based approaches for conserving marine habitats	Create a minimum set of performance criteria including robust indicators for MPA evaluations
GOVERNANCE/GOAL: Strengthen capacity to improve effectiveness of existing legislations and programs protecting marine habitats	Identify ways to encourage the mainstreaming of sustainable habitat management into the priorities of relevant international agencies, programs, conventions, financial institutions, and the donor communities
MONITORING/GOAL: Apply best practices to collect and share results of marine habitat monitoring	Identify existing and potential funding sources for monitoring programs
ECONOMICS/GOAL: Assess the value of marine habitats	Quantify the value of the loss of ecosystem services as a result of changing conditions associated with climate change

Chapter 8

Pollution Research Agenda

8.1 Introduction to Pollution in the Caribbean and North Brazil Shelf

Pollution of the marine environment is a growing global concern and the Caribbean and north Brazilian shelf are not immune from its effects. As part of a comprehensive effort to address this threat, in 1983, 22 states in the region adopted the Caribbean Action Plan. This plan formed the basis for the adoption of the legal framework of the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (i.e., Cartagena Convention). Of the three protocols adopted under the Cartagena Convention, the Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol) specifically addresses issues related to marine pollution. In 1999, the Governments of the Wider Caribbean Region (WCR) signaled their commitment to reduce marine pollution from untreated wastewater and agricultural runoff by adopting the LBS Protocol, based in part on the recognition that sewage is the number one point-source of marine pollution in the region due to low wastewater treatment rates (Figure 8.1). The Protocol is administered by the UNEP Caribbean Environment Programme (UNEP-CEP).

The LBS Protocol entered into force in 2010, thereby committing the Governments which ratified or acceded to the Protocol to make major improvements in wastewater management by introducing innovative and cost-effective treatment technologies, improving policy as well as regulatory and institutional frameworks, and expanding access to affordable financing.

Siung-Chang (1997) reported that efforts to identify monitoring strategies and programs started in 1975 with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). There studies were conducted in Barbados, Guyana, and Trinidad and Tobago, to make an inventory of problems of the environment. Since then, many major pollution and marine environmental programs have been undertaken by various agencies and working groups. This long history of monitoring for marine pollution in the WCR has permitted the standardization of methodologies and the development of good practices. Many programs collect physico-chemical data simultaneously with biological data in a spatially-explicity format to explain the impact of LBS in the marine environment. Furthermore, some programs also addressed other descriptors such as socio-economic and governance factors. This integration provides a strong baseline for the implementation of actions resulting from the research topics.

GPML Caribe

Caribbean Node of the Global Partnership on Marine Litter (GPML-Caribe)

In 2015, the GPA and the Secretariat to the Cartagena Convention based in Kingston, Jamaica partnered with the Gulf and Caribbean Fisheries Institute (GCFI) to implement the Caribbean Node of the Global Partnership on Marine Litter (GPML-Caribe).

The goal of the node is to achieve the objectives of the GPML and the Regional Action Plan on Marine Litter for the Wider Caribbean Region (RAPMaLi 2014). The RAPMaLi was endorsed by the Contracting Parties to the Cartagena Convention. The action plan updates the 2008 regional plan and describes the road ahead for reducing marine plastic debris and microplastics and other solid waste pollution.

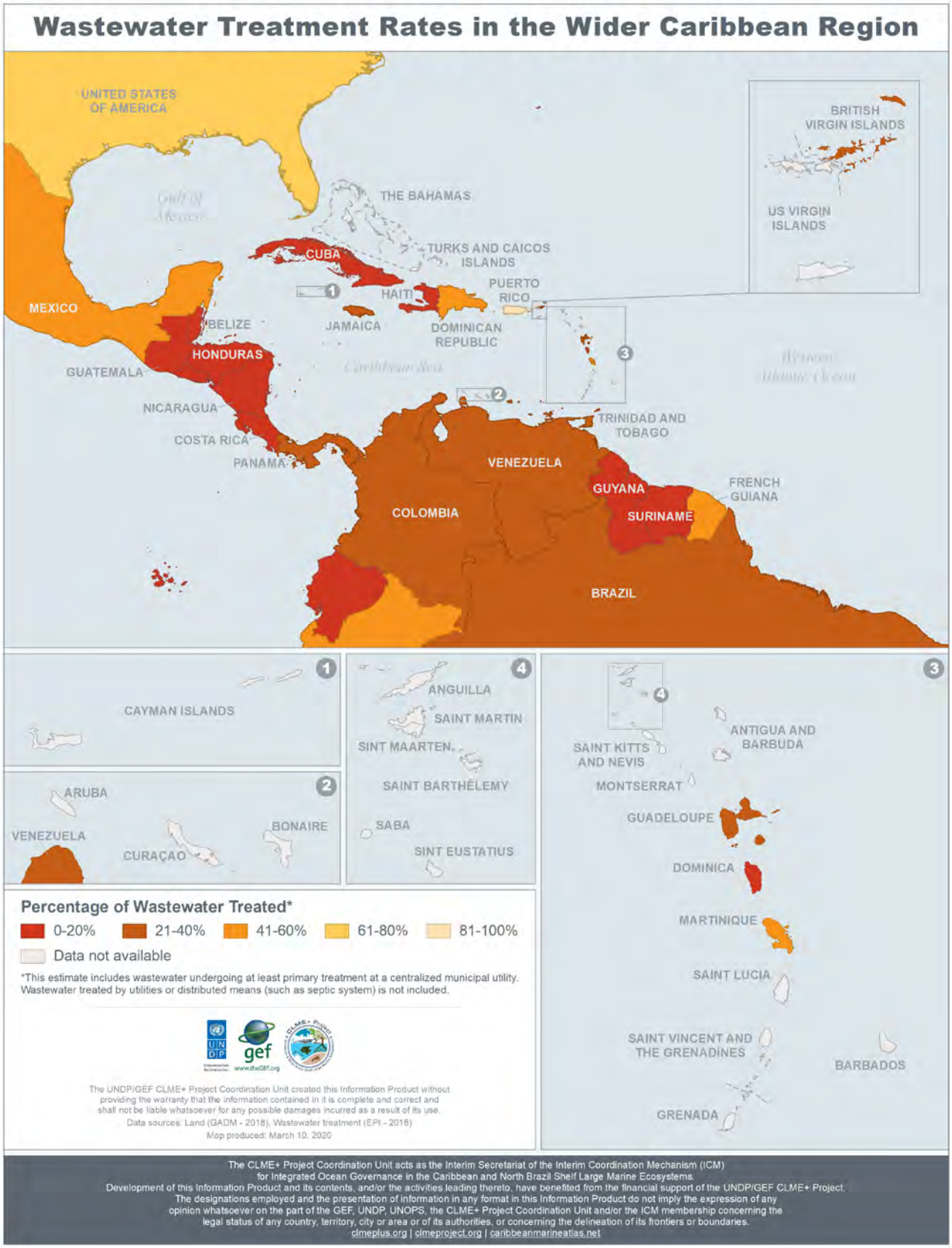


Figure 8.1 | Percentage of wastewater treated in the Caribbean and north Brazil Shelf.

The issue of marine pollution remains particularly troublesome for the region given that many countries, and especially the Small Island Developing States (SIDS), rely on a healthy and productive coastal ecosystem for their economic sustainability. Given that approximately 85% of wastewater generated in the region went untreated in 2015 (GEF-CReW 2015), SIDS are particularly vulnerable because waste often enters the coastal waters from dumpsites located alongside or adjacent to their waterways (UN Environment 2019). Furthermore, SIDS are often reliant upon tourism revenue and they are further dependent on the perception of pristine beaches and coral reefs, and a rich diversity of flora and fauna; the impacts of pollution to these resources can be catastrophic. The World Resources Institute estimated that for 23 countries or territories in the region, coral-reef tourism accounted for more than 15% of gross domestic product (GDP) (Burke et al. 2011). They further estimated that declining conditions of the marine and coastal environment represented annual revenue loss of between $350 million and $870 million in the early 2000s (Burke and Maidens 2004). Yet, coral reefs continue to suffer; estimates of the Caribbean-wide decline of coral cover through 2012 was 18.5% (Jackson et al. 2014). As far back as 2003, some estimates of coral loss at specific localities were as high as 80% (Gardner et al. 2003).

Marine pollution is a long-standing issue in marine science and management. Modern observing capabilities enabled more extensive mapping and assessment of the challenge. In recent years, new forms of ocean pollution have been identified that add to the suite of more traditional issues including those associated with nutrient runoff, oil spills, mercury and other heavy metals, and radioactive substances. Emerging issues now focus on plastic debris including microplastics and microfibers (Figure 8.2) These are emerging as significant threats to both fish and wildlife with linkages to human health. It is ubiquitous in the marine environment and recognized as a matter of increasing concern. Microplastics and nanoplastics are entering the marine food chain, altering sediment composition, and affecting integrated wastewater cycle treatment. There are several marine debris-oriented policy interventions that have taken form around the world, from banning plastic bags to sponsoring clean-up technology, but it is clear that there is an urgent need for new global approaches to limit land-based marine pollution.

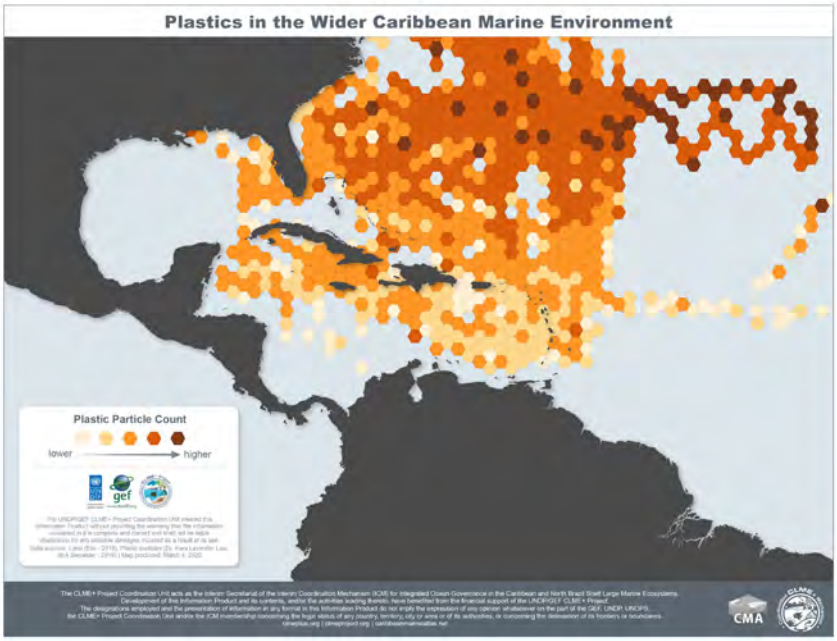


Figure 8.2 | The concentration of plastic particles in the Caribbean Sea.

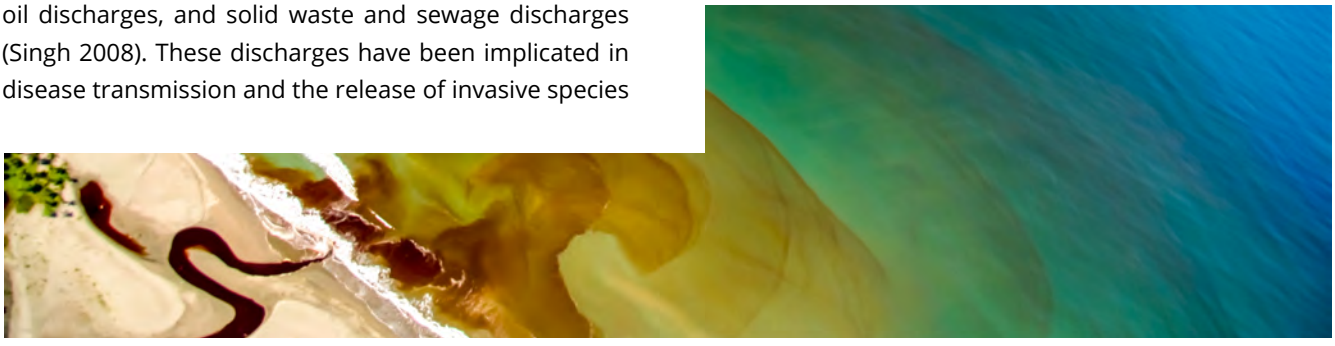
Furthermore as the Earth's climate changes, so too will the impacts associated with pollution as well as the effects on society. Inevitably, this will require a strong focus on developing adaptive capacity for ecological and social systems; building resilient systems will be necessary. It is also inevitable that from these changes will emerge a new suite of challenges and research questions. Chemistry of seawater will be affected, social systems for coastal communities will be threatened, and economies will be impacted. How society addressed these changes will dictate how healthy the coastal and marine waters of the CLME+ region remain. It is clear that as threats emerge, addressing them must be pro-active and adaptive.

8.2 The Causes and Sources of Marine Pollution in the Caribbean and North Brazil Shelf

The causes and origins of marine pollution are diverse (Figure 8.2) and may consist of both point and more diffuse non-point sources. Pollution originating from the land may include wastewater and sewage discharges, as well as agricultural runoff including pesticides (Siung-Chang 1997), herbicides, and siltation (GESAMP 2010). Added to these insults are the discharges from industrial pollution (Diez et al. 2019). Oil spills from onshore activities have been documented to have seriously impacted Caribbean coastlines including mangrove forests (Jackson et al., 1989) which serve as natural barriers to storm surge (Blankespoor et al. 2017). Some of the more pernicious activities that contribute to ecosystem degradation are associated with ship-borne discharges including ballast-water flushing, tank washing, accidental and deliberate oil discharges, and solid waste and sewage discharges (Singh 2008). These discharges have been implicated in disease transmission and the release of invasive species which both have serious ramifications on the integrity of marine ecosystems (Hughes 1994). Estimates from 2004 (Burke and Maidens 2004) indicate that 35% of the regions coral reefs were threatened by pollution.

Plastics and other forms of domestic solid waste often find their way to the sea via riverine discharges. Increasingly, coastal and marine litter is implicated in diseases to human communities by serving as breeding sources of mosquito-borne illnesses such as zika, chikungunya, and dengue fever. Marine litter originating from fishing (i.e., abandoned, lost or otherwise discarded fishing gear: ALDFG) is a significant source of sea-based pollution (United Nations Environment Programme 2016), especially considering that ALDFG may continue to entangle commercially-valuable fish and other elements of marine biodiversity.

The diversity of the sources of pollution and the amount of pollution impacting coastal waters, represent an increasing threat to society including to human health, economic sustainability, and impacts to the natural resources upon which those societies depend (Figure 8.3). Actions to mitigate the impacts from pollution have become increasingly difficult given the variety of sources, the impacts of pollutants, the often-transboundary nature of the dispersal, the inability to enforce international governance arrangements, and the gaps in knowledge related to how best to address the problem. The difficulty is further compounded by the considerable amount of uncertainty related to the specific effects to both ecosystems and society and the need for decision-makers to act in this cloud of uncertainty.



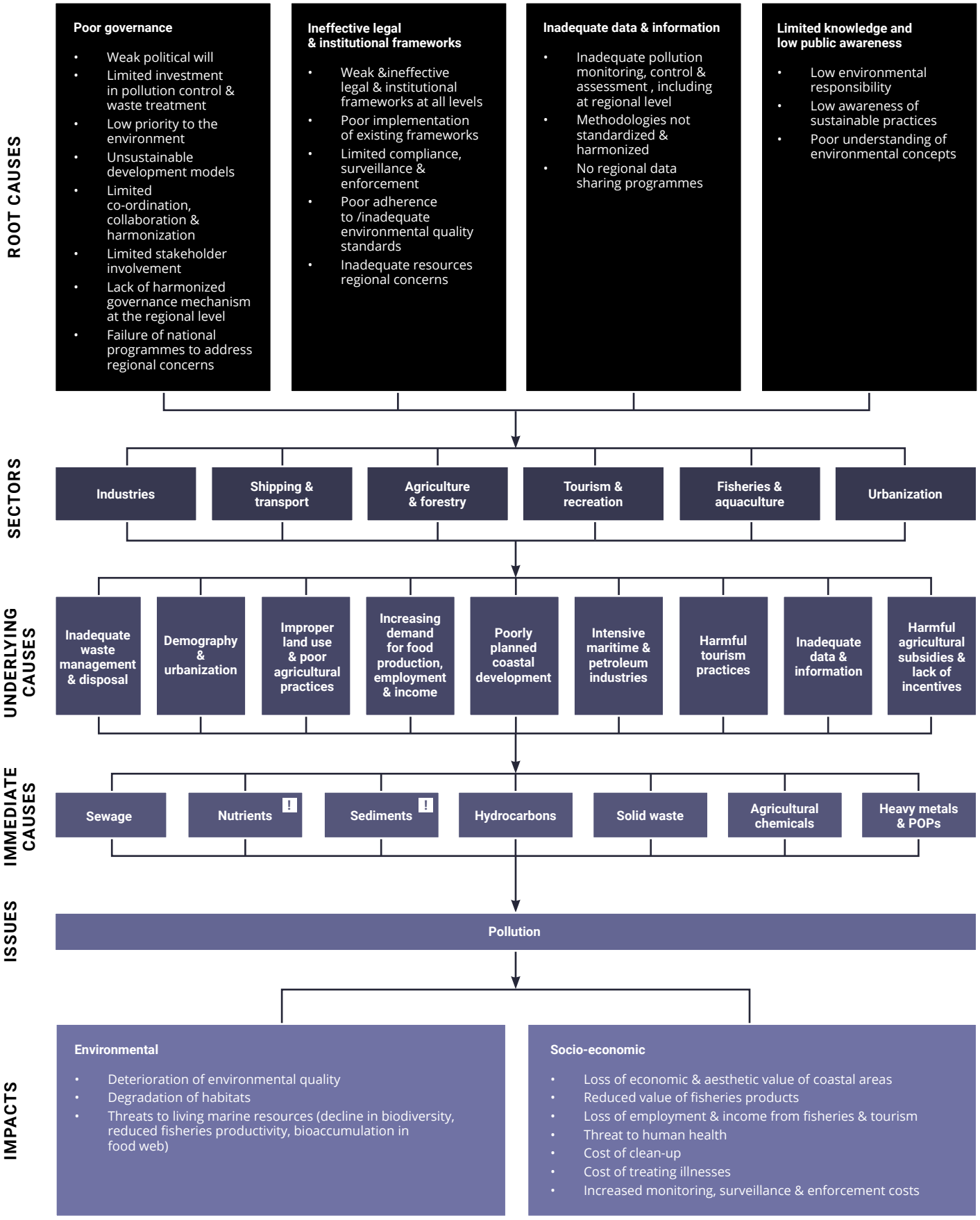


Figure 8.3 | The cascading linkages from causes to impacts of pollution on the environment and society (adapted from CERMES 2011).

! *These have major impacts on the reef ecosystem*

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

8.3 The Transboundary Nature of Marine Pollution

Transboundary pollution can be defined as instances where 'a potentially harmful environmental agent is released in one political jurisdiction (the source state) and physically migrates through a natural medium such as air, water, or soil to another political jurisdiction (the affected state)' (Merrill 1996). In other words, pollution becomes transboundary when one state or country's activities begin to negatively affect other states or countries (Bayramoglu 2006). A decline in water quality may become a significant transboundary environmental issue (Ukwe and Ibe 2010) when pollutants originate from land and sea-based activities (e.g., runoff from agriculture, sewage discharges, industrial effluent, and mining activities) and are discharged into coastal waters. In instances when the impacts of pollution transcend geographic and political boundaries, the ability for effective regulation and subsequent remediation becomes constrained (Merrill 1996). The multi-national nature of the problem inevitably results in impacts to various sectors of the economies including tourism and fisheries as well as human health and impairs the ability of downstream societies to reduce the threat.

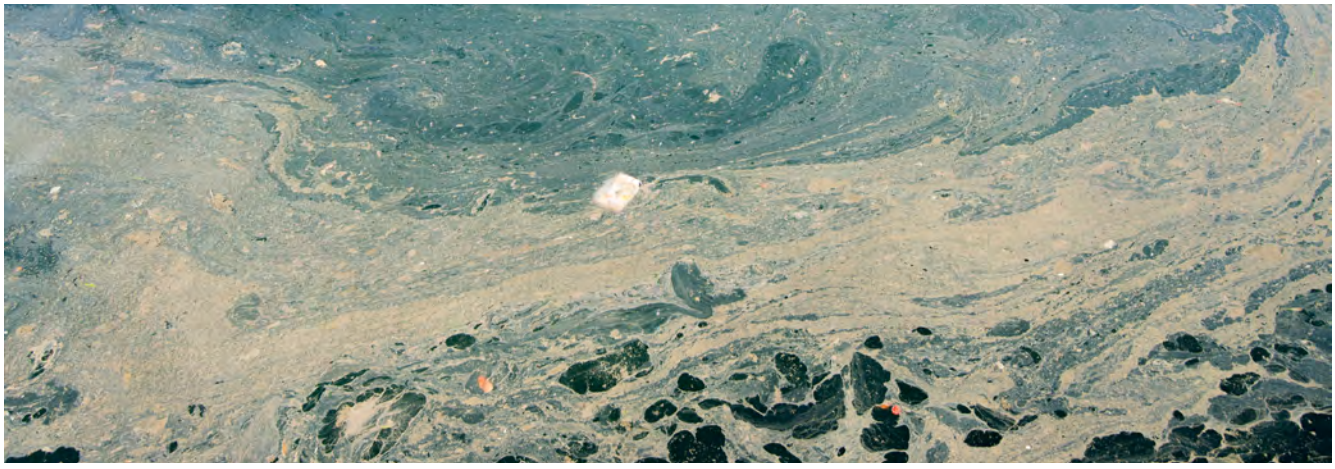
Another issue associated with transboundary pollution is the concept of 'pollution of a commons' where the area where pollution has occurred is not under the jurisdiction of any identified state, but then continues to migrate through air or water and cause negative impacts in one or multiple political jurisdictions, e.g., oil spills in the high seas (Merrill 1996). The ability to control the sources of this pollution is particularly vexing.

Finally, weather-related events are increasingly serving as vectors for dispersal of pollutants. As the globe warms and conditions change, models are suggesting that the strength of hurricanes will increase thus facilitating the long-range dispersal of contaminants. These event-driven vectors are particularly difficult to control given their unpredictability and high impacts.

To overcome this pernicious threat, robust governance arrangements must be developed and adhered to with consideration of the diversity of sources and impacts.

8.4 The Impacts of Marine Pollution

The impact of marine litter spans local, regional, and international scales and affects human health, the economy, marine life, general aesthetics, and public perception (Williams and Rangel-Buitrago 2019). Furthermore, impacts of marine litter are not restricted to only the physical effects they may have on the environment or marine life but also includes indirect issues such as bioaccumulation, vectors for disease or invasive species, and damaging seafloor species and coral reefs (Lamb et al. 2018).



Human health can be directly affected through contact with pollutants or ingestion of contaminated marine life or other toxins that bioaccumulate in the food chain (MEA 2005; United Nations Environment Programme 2016) whilst wildlife are affected through ingestion, entanglement, smothering, and other impacts on the complexities associated with the food web (Derraik 2002) (Figure 8.3). Forms of pollution such as marine litter also have the potential to become an additional economic burden through the cleanup, disposal, and remediation costs as well as loss of revenue from tourism and recreation activities (Calleja 2019). The shipping industry may also be negatively impacted through risks to navigation as well as additional costs to deal with fouling of propellers, damaged engines and equipment as well as the overall management of waste (UNEP 2019). The fishing industry, whilst serving as a contributing source of marine pollution, also experiences losses in the form of lost and damaged fishing gear and equipment as well as reduced and sometimes contaminated catch (UNEP 2019).

Figure 8.4 | A sea turtle misidentifies a plastic bag as food.

8.5 Pollution Linkages to Sustainable Development Goals (SDGs)

In 2015, the UN released an agenda that was comprised of 17 global sustainable development goals that taken together seek to reduce poverty by ensuring that "no one is left behind". The target for these goals was 2030. The reduction of marine pollution fits squarely within 11 of the objectives of many of the SDGs (Figure 8.5).

Pointedly, SDG14 – Life below water – has the most obvious linkage to reducing marine pollution through Target 14.1 which specifically aims to *prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution by 2025.* Additionally SDG6 - Clean water and sanitation – also addresses marine pollution through Target 6.3 which aims to *improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally by 2030.*

Figure 8.5 | Marine pollution linkages to sustainable development goals (from Diez et al. 2019; permission pending)

8.6 Overview of the Pollution Research Agenda

The Pollution Research Agenda is focused on the overarching CLME+ SAP goal of *Expand(ing) the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+.* This agenda highlights the issue that LBS presents a complex problem for the CLME+ region that will require a wide-ranging approach that incorporates regional social, economic, and cultural differences. Relative success has been achieved through regional and national frameworks. However, LBS pollution is still not adequately or effectively controlled. In this pollution research strategy, we have considered the current governance strategies and approaches and their gaps, in addition we have considered the transboundary nature and cultural differences existing in the CLME+ region.

This chapter seeks to address the recommendations from the World Bank report detailing pollution in the Caribbean region in which they identified a 12-point action agenda for combatting marine pollution (Diez et al. 2019). The research topics that are presented in this report address the difficulties that policy- and decision-makers confront regarding making robust decisions with incomplete information. The topics span the diverse and complex universe that must be considered when making decisions and include monitoring, increasing public awareness, identifying economic impacts, enhancing governance frameworks as they relate to strengthening existing policies, increasing capacity, developing partnerships, and improving controls. The approach adopted for this report provides a holistic treatment that seeks to understand critical gaps that prevent implementation of polices designed to address the pernicious problem of pollution.

8.7 Identification of priorities for Pollution Research Topics

As discussed in Chapter 5, an electronic survey was used to prioritize the topics associated with each goal. The survey was sent to over 2,000 individuals including national focal points. Although the roles of individual in the distribution lists were diverse, the survey had a selection box which allowed us to filter the responses from decision makers for analysis.

From 23 to 27 decision-makers responded to the survey depending upon the question. The responses are reported in Tables 8.1. to 8.5. In some cases, respondents did not score the particular topic and when this occurred, no score for that respondent was used in the calculations.

To identify priorities, respondents were asked to score each research topic based on their perceived priority as detailed in Chapter 5. The ranking of the highest priorities represents a simple way to understand the priorities for decision-makers and, therefore, represents targets for research efforts that will provide the most value for achieving management objectives from their perspective.

8.8 Pollution Research Themes

8.8.1 Pollution Science Theme

Control efforts of LBS pollution require innovative and new technological development, especially to identify sources, to gather scientific data, and for implementation of technologies that address this threat. Governments and policy-makers must have the best available relevant information on the science of pollution with which they can develop effective policies. The Pollution Science Theme focused on the scientific research needs that were identified to achieve the outcomes related to reducing LBS pollution in the CLME+ region. In general, this theme focused on the physical, chemical, and ecological sciences including human health rather than social and economic sciences; those topics are addressed in other themes.

The theme was subdivided into 2 goals: Goal 1: Reduce the risk to areas and wildlife from marine pollution, and Goal 2: Reduce the risk to human health from marine pollution. There are 20 research topics associated with these goals. Goal 1 included 14 research topics and Goal 2 was comprised of 6 research topics (Table 8.1).

Table 8.1 | Goals and research topics associated with the Pollution Science Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Reduce the risk to areas and wildlife from marine pollution	Score
Identify and assess the environmental impacts of marine pollution including nutrients, chemicals, and plastics (for broader regional and national decision-making) including impacts to ecosystems and biodiversity	3.88
Identify pollution hotspots and assess their major sources and the processes that transport them in the CLME+ region	3.88
Identify best practices and develop technologies to reduce input of pollutants to coastal systems	3.38
Standardize data collection protocols, analytical procedures, and reporting of water quality results	3.63
Increase the understanding of the dynamics of contaminant transport between air-sea surface interface	3.13
Increase the number of programs dedicated to study feasibility of bio-remediation or other recovery actions	3.25
Identify best approaches for assessing the impacts of pollutants in an uncertain future including, for example, the use of scenario-planning	3.13
Identify ways to mitigate the climate-linked impacts from pollutants including plastic	3.43
Increase the understanding of impacts of emerging pollutants (endocrine disruptors, hormones, noise pollution, Sargassum) on marine biodiversity and ecosystems	3.63
Improve research on impacts of ballast water and cruise ships contaminants in the coastal and marine biodiversity	3.13
Increase the quantity of information on the impact of pollution on marine ecosystems and human health and the associated economic cost	3.50
Assess the relative contribution of different sources of nutrients to the marine environment and identify the impacts to marine biodiversity and ecosystems	3.50

Table 8.1 continued

Goal 1: Reduce the risk to areas and wildlife from marine pollution	Score
Conduct an in-depth study of the circulation of currents and winds to assess how the transport of marine pollutants may be affected	3.13
Increase the understanding of nonpoint sources of land-based pollution from nutrients under Annex IV of the LBS Protocol on Agricultural Non-Point Sources, and to protecting groundwater resources	3.25
Assess the feasibility of using integrated models to help understand how socio-economics, biogeochemistry, hydrology, and climate interact to move nutrients from their sources to coastal and marine waters	2.63
Increase the quantity of integrated environmental assessments incorporating air, land, and sea interactions as well as the long range transport of airborne particles	2.88
Conduct quantitative and qualitative identification and mapping of land-based and offshore sources of nutrients through multidisciplinary approach (field sampling, fixed monitoring stations, remote sensing)	3.50
Identify high priority areas for further action based on most affected ecosystem types and socio-economic impacts	3.50
Identify the most important regionally relevant pollution sources	3.63
Evaluate best methodologies for efficiently organizing archived data to ensure information is readily available for decision making	3.43
Goal 2: Reduce the risk to human health from marine pollution	**Score**
Identify ways to reduce the impacts of toxicants on human health	3.75
Identify ways to reduce the impacts to social well-being from marine pollution	3.34
Increase the understanding of impacts of emerging pollutants (endocrine disrupters, hormones, noise pollution, Sargassum) on human health	3.50
Conduct an in-depth study of the circulation of currents and winds to assess how the transport of marine pollutants may be affected	3.00
Increase the quantity of integrated environmental assessments incorporating air, land, and sea interactions as well as the long range transport of airborne particles	2.88
Identify ways to best reduce the impact of domestic wastewater loads on human health	3.88
Improve land use management to reduce erosion and the transport of excessive sediment loads within the CLME+ region	3.5
Identify ways to reduce the impacts of shipping	3.25
Conduct quantitative and qualitative identification and mapping of land-based and offshore sources of nutrients through multidisciplinary approach (field sampling, fixed monitoring stations, remote sensing)	3.38
Increase the quantity of information on the impact of pollution on marine ecosystems and human health and the associated economic cost	3.50
Identify ways to reduce the impact of untreated sewage discharge on human health	3.71

8.8.2 Governance Research Theme

The Governance Theme focused on identifying the research needed to achieve effective governance at the local, country/territory, and/or regional scales. As with all the research themes, the overall focus was on achieving the goal of the efficient and cost-effective reduction of LBS pollution in the CLME+ region. In general, this theme focused on policy, legal, and enforcement research needs and gaps (Figure 8.6) as well as approaches that ensure that society and its associated governance structures are sufficiently well-equipped to respond to the impacts of marine pollution.

The Governance Research Theme is divided into four goals: Goal 1: Create or enable policies and legislation that contribute to the reduction in marine pollution, Goal 2: Engage the private sector to achieve policy and management-based solutions to pollution, Goal 3: Identify and develop improved solid waste management approaches, and Goal 4: Reduce the risk to society from marine pollution.

There were 20 research topics associated with these goals. Goal 1 included 8 research topics, Goal 2 included 1 research topic, Goal 3 included 4 research topics, and Goal 4 included 4 research topics (Table 8.2).

Figure 8.6 | A governance word cloud showing the considerations in analyzing governance structures.

Existing LBS Frameworks in the CLME+ Region

Several international treaties and agreements form the basis for a framework for overseeing the control of marine pollution in the wider Caribbean region.

The Cartagena Convention

This is the most comprehensive environmental agreement for the region and provides the legal framework for pollution activities under The Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol). This protocol is administered by the United Nations Environment Programme's Caribbean Environment Programme (UNEP-CEP) based in Kingston, Jamaica. The Cartagena Convention requires Parties to adopt measures to prevent and control marine pollution.

MARPOL

The International Maritime Organization (IMO) addresses pollution by applying standards for discharges from ships. The main treaties that govern the prevention of pollution are MARPOL 73/78, the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, and the International Convention for the Control and Management of Ships' Ballast Water and Sediment. The most relevant Annexes for marine pollution are Annex IV (sewage discharges) and Annex V (garbage discharge).

Table 8.2 | Goals and research topics associated with the Governance Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Create or enable policies and legislation that contribute to the reduction in marine pollution	Score
Identify approaches that increase the integration of policy across government sectors	3.88
Identify approaches that promote greater coherence among regional ministries and agencies to create consistency and enhance regional governance	3.38
Identify options to overcome barriers to implementing pollution mitigation	3.50
Identify approaches that promote an increase in stable long-term policies	3.75
Identify approaches that support design or update of new/appropriate legislation	3.50
Identify ways to increase accountability of pollution arrangements so that there are stronger repercussions for lack of compliance	3.75
Develop approaches that improve the design of transboundary governance for LMEs by ensuring that current and new agreements 1) have policy-cycle mechanisms in place that include a wide array of data and information providers, 2) provide for a strong, knowledge-based policy interface, 3) hold decision- makers and those responsible for implementation accountable; and 4) ensure that monitoring and evaluation mechanisms are implemented to facilitate adaptive management.	3.25
Identify ways to promote regional cooperation on ocean governance as it relates to Sargassum and ensure ecologically friendly management interventions	3.38
Identify best approaches for implementing effective management strategies under uncertainty	3.13
Goal 2: Engage the private sector to achieve policy and management-based solutions to pollution	**Score**
Identify ways to incentivize private corporate participation including case studies	3.88
Goal 3: Identify and develop improved solid waste management approaches	**Score**
Assess the value of waste and identify potential markets	3.75
Assess opportunities and associated risks for involvement of private sector	3.75
Identify needs, barriers, and gaps for solid waste management	3.75
Assess the social and cultural underpinnings of behavior associated with consumption, waste generation, and littering	3.75
Goal 4: Reduce the risk to society from marine pollution	**Score**
Identify and assess the social and political impacts of marine pollution for broader regional and national decision-making	3.63
Identify most effective approaches for knowledge exchange, policy reform, technological transfer, and capacity building	3.75
Identify best practices that enhance effectiveness of the LBS Protocol through collaborative, integrated, and innovative approaches at national, regional, and international levels by building synergies with other relevant environmental conventions	3.63

8.8.3 Monitoring Research Theme

The Monitoring Research Theme recognizes that monitoring is useful for a number of critical activities. First, monitoring is necessary to understand if resources are changing either for better or for worse. This includes not only living resources, but also the environment which supports organisms and habitats. This type of monitoring can take the form of different activities including instrument-based surveys (Figure 8.7), surveys of ecological systems, human-dimensions surveys, etc.

Secondly, monitoring is essential to understand when to implement strategies that are based on specific triggerpoints. For example, a regulation may be necessary when water quality falls below a certain threshold. In this case, an effective monitoring program will inform the implementation of a strategy.

Finally, monitoring is essential to evaluate the efficacy of an implemented management strategy. After a strategy is implemented, its effectiveness must be evaluated, and this must be done using a well-crafted monitoring program.

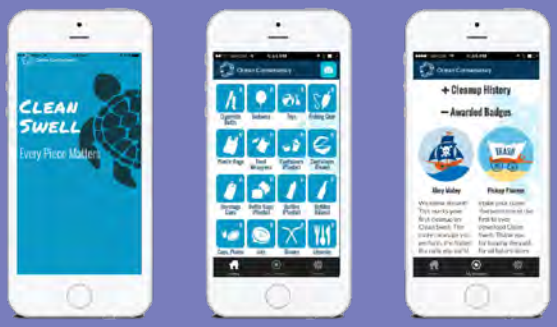
By identifying current monitoring strategies and programs, we can identify and highlight LBS gaps in knowledge related to biological components and marine habitats in the WCR at the regional, national, and/or local levels and provide a broad overview of the spatial distribution and temporal intensity of monitoring activities. This should purposefully aim to identify programs, or combinations of programs, that will address the requirements of the research topics within the theme, thus enabling decisions to be made about

Figure 8.7 | Monitoring water quality in a marine estuary.

Marine litter monitoring programmes in the CLME+ region

Several regional initiatives are monitoring coastal marine litter in CLME+ region. Each addresses a different need and audience. The following are a few of the existing efforts:

1. Ocean Conservancy – Trash Free Seas. Since 1989 coastal clean-ups have been done in 32 countries in the region. More recently, Dive against Debris has focused on cleaning up and cataloguing underwater debris. In 2016, a mobile app (Clean Swell) was developed easing data collection. This approach makes use of citizen science.



From: https://beaconfire-red.com/images/clean-swell-app

2. OSPAR – OSPAR together with WWF has been testing the feasibility of using the OSPAR approach to monitor litter in Bonaire. This approach has been used in coastal northern Europe and has a rigorous scientific protocol.

3. The US Environmental Protection Agency Trash Free Waters – this is an international initiative but does not appear to be widespread in the WCR.

4. US NOAA Marine Debris Monitoring and Assessment Project – this is an initiative that does not have widespread use in the CLME+ region.

the relevance, scope, and cost-effectiveness of future monitoring.

The Monitoring Research theme identified three goals: Goal 1: Increase monitoring and assessment activities related to marine pollution, Goal 2: Enhance inputs from scientific research in monitoring activities related to marine pollution, and Goal 3: Increase stakeholder participation in research and monitoring activities related to marine pollution. Goal 3, in particular, addresses the importance of citizen science to address marine pollution (Table 8.3).

Table 8.3 | Goals and research topics associated with the Monitoring Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Increase monitoring and assessment activities related to marine pollution	Score
Establish a statistically valid pollution and marine litter monitoring program at national and regional levels	3.63
Develop a standardized template for recording and reporting monitoring data and metadata	3.63
Develop an integrated databank and on-line platform for marine pollution issues - time-series for the CLME+ region	3.50
Develop regional standards and criteria for nutrient discharges including regional indicators for monitoring nutrient discharges into the marine environment	3.75
Identify ways to increase the proportion of coastal and marine areas being monitored to assess changes as a result of activities	3.75
Identify ways to increase investment dedicated to monitor pollution effects on coastal communities and coastal and marine biodiversity	3.38
Identify ways to increase stakeholder participation in monitoring activities related to LBS	3.50
Goal 2: Enhance inputs from scientific research in monitoring activities related to marine pollution	**Score**
Enhance science-based monitoring in response to management goals and objectives	3.86
Improve coordination and understanding of monitoring objectives and surveys	3.50
Implement regional database for monitoring data	3.50
Catalogue laboratories capable of conducting complex contaminants monitoring and identify their deficiencies	3.38
Identify most efficacious approaches for monitoring changes in circulation patterns due to contaminants and climate change	3.50
Identify, and when necessary, develop new approaches for monitoring pollutants including remote observation systems	3.38
Goal 3: Increase stakeholder participation in research and monitoring activities related to marine pollution	**Score**
Identify ways to involve stakeholders in pollution reduction decisions, actions, and financing	3.75
Identify best ways to develop effective and sustained citizen science programs including use of case studies	3.13

8.8.4 **Economic Research Theme**

The Economic Research Theme integrates the societal drivers associated with commerce, trade, and economic well-being. This theme focused on the financial impacts related to LBS pollution as well as financial opportunities that may be present. The impacts to a variety of sectors were considered including commercial and recreational fisheries, tourism, and community-based commercial activities (Figure 8.8).

The Economic Research theme consists of two goals: Goal 1: Reduce the economic impacts from pollution, and Goal 2: Identify and develop improved solid waste management approaches. Goal 1 was comprised of three research topics and an additional five research topics were identified for Goal 2 (Table 8.4).

Figure 8.8 | Marine litter in close association with a Sargassum influx. Sargassum has recently been disrupting tourism and fisheries throughout the region. Marine litter has been associated with the influxes.

Table 8.4 | Goals and research topics associated with the Economic Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Reduce the economic impacts from pollution	Score
Quantify the economic impact of pollution due to loss of ecosystem goods and services, and in so doing, assess the costs and benefits of "business as usual" scenarios versus the implementation of pollution prevention and reduction measures.	3.50
Develop an investment plan that outlines and costs high-priority actions to reduce pollution sources which cause substantial impacts on ecosystem goods and services of critical importance for human well-being and sustained socio-economic development	3.63
Increase the quantity of information on the impact of pollution on marine ecosystems and human health and the associated economic cost	3.75
Improve the socio-economic quantification of pollution impacts on selected key economically-valuable species / group of species including fishing resources	3.75
Goal 2: Enhance inputs from scientific research in monitoring activities related to marine pollution	**Score**
Assess the value of waste and identify potential markets	3.63
Identify needs, barriers, and gaps for solid waste management and assess the cost effectiveness	3.75
Identify most effective approaches for knowledge exchange, policy reform, technological transfer and capacity building	3.50
Assess the needs and opportunities for investments	3.75
Identify ways to implement evidence-based planning where assessment of tourism-generated waste in the other sub-regions are conducted to ensure that the expansion of tourism services is accompanied by the provision of smart waste management of sewage and solid waste, in particular, including problematic plastic waste	4.00

8.8.5 **Communications Research Theme**

The Communications Research Theme focused on the research needed to achieve effective communications to the diverse group of stakeholders in order to reduce LBS of pollution in the CLME+ region (e.g., Figure 8.9). The stakeholders may include the societies and communities impacted by pollution as well as the decision-makers and government officials who use the information provided to make decisions. In this sense, the research topics address both advocacy and information transfer.

This theme was primarily driven by the recognized need to effectively communicate policies, priorities, and the results of scientific endeavors that can achieve the goals of pollution reduction. Communicating science to management was also considered.

The Communications Research Theme is comprised of one goal: Ensure effective communication to ensure pollution mitigation and reduction. The goal contains five research topics (Table 8.5).

Figure 8.9 | Communicating the value of mangroves in a marine protected area project. Photo courtesy Davon Baker.

Table 8.5 | Goals and research topics associated with the Communications Research theme. The score column represents the mean value of all the decision-makers' ratings for each research topic within each goal. The scale is from 1 (not important) to 4 (very important). The green highlight is associated with the research topic rated the highest among decision makers in that goal whereas the red is associated with the least important research topic.

Goal 1: Ensure effective communication to ensure pollution mitigation and reduction	Score
Identify the most effective advocacy approaches (e.g., lobbying, influencing decision makers) that result in decreased impacts of marine pollution on environment and society	4.00
Identify the most effective education approaches that result in decreased impacts of marine pollution on environment and society	3.88
Identify the most effective awareness approaches (e.g., by communicating and making things available) that result in decreased impacts of marine pollution on environment and society	3.88
Identify the most effective outreach approaches (e.g., by reaching out to communities) that result in decreased impacts of marine pollution on environment and society	3.88

8.9 The Overall Highest Priority Topics for Pollution in the CLME+ region

The highest scoring topics represented the most important research priorities for decision makers. Two topics received a score of 4.0 indicating that there was unanimous recognition among the decision makers who responded to the survey that these topics were the highest priority. One priority topic originated in the Economic theme and focused on ensuring tourism development included provisions for addressing sources of pollution. The other priority topic was related to communications and addressed advocacy for decreasing impacts to society (Table 8.6). Within the WCR, tourism represents the primary industry contributing to and affecting local economies. As a result, there is a need to maintain pristine environments to encourage and maintain a regular tourism market. In the Caribbean especially, countries are heavily dependent on pristine beaches to attract tourists and studies have found that marine litter or other forms of pollution on beaches actually reduces the likelihood that tourists may return (UNEP 2019).

Table 8.6 | The two topics that ranked highest for the pollution research priorities. Both topics received a score of 4.0 which indicates that all respondents scored these topics as high priority.

Theme/Goal	Priority Topic
ECONOMIC/GOAL: Identify and develop improved solid waste management approaches	Implement evidence-based planning to ensure that the expansion of tourism services is accompanied by the provision of smart waste management of sewage and solid waste, including problematic plastic waste
COMMUNICATION/GOAL: Create or enable policies and legislation that contribute to the reduction in marine pollution	Develop effective advocacy approaches (e.g., lobbying, influencing decision makers) that result in decreased impacts of marine pollution on environment and society

Chapter 9

Towards a More Sustainable CLME+ Region – Recommendations for Implementation

9.1 A Framework for Implementation

The goals of implementing the research agendas in this report (Chapters 6, 7, and 8) are to mitigate the deleterious effects of ineffective management or unforeseen impacts on the fisheries and habitats in the CLME+ region and to diminish the effects of LBS pollution on societies and the environment. To address these goals, the primary focus needs to be on the development of mechanisms that integrate scientific information into governance frameworks. Often, local knowledge and participation is critical to successful outcomes. How to achieve this objective requires providing information that is both timely and relevant for robust decision-making.

Each research agenda addresses the five broad themes that have been described in previous chapters (Figure 9.1) and each theme has specific targets. The theme's targets represent multi-scale actions to achieve effective implementation. The targets are not isolated and may, in fact, span several themes.

Several overarching issues will affect the ability to implement the research topics within the agendas. Perhaps most significantly, climate change influences all activities (Figure 9.1) in ways that are currently unknowable, unpredictable, or unsolvable (see Chapter 10). How climate change plays out will ultimately determine whether the implementation of certain research topics are achievable.

Furthermore, the transboundary nature of the ecological, economic, and social structures in the region complicates implementation (Figure 9.1). However, transboundary obstacles are perhaps more easily understood and therefore easier to address than the complexities associated with climate change. Nevertheless, an approach to tackling those obstacles will require a well-constructed process (e.g., Section 9.10 of this report).

New approaches that are holistic in nature are now emerging to address the vexing issues associated with sustainability. Among these is the focus on economic development in concert with ecosystem conservation (i.e., the blue economy; see Section 7.8 of this report). Given the dependence of tourism on healthy ecosystems, this is not surprising. However, the emerging focus on the blue economy as an umbrella concept for sustainable development is gaining traction and may provide some opportunities to overcome specific barriers related to the conflicts between development and natural resources conservation.

Further, there has been a new focus on developing cross-sector solutions by integrating the users of marine resources into decision making from the bottom up by both developing capacity (e.g., MPAConnect; see Section 7.3.2. of this report) and including them in the development of policy (e.g., RFBs and RFMOs). The multi-sector teams must be built at all spatial scales from regional to national to local. Together, the management objectives are addressed by designating principles to guide data management, capacity development, and discusses how stakeholders and private sector can be engaged and integrated into decision making.

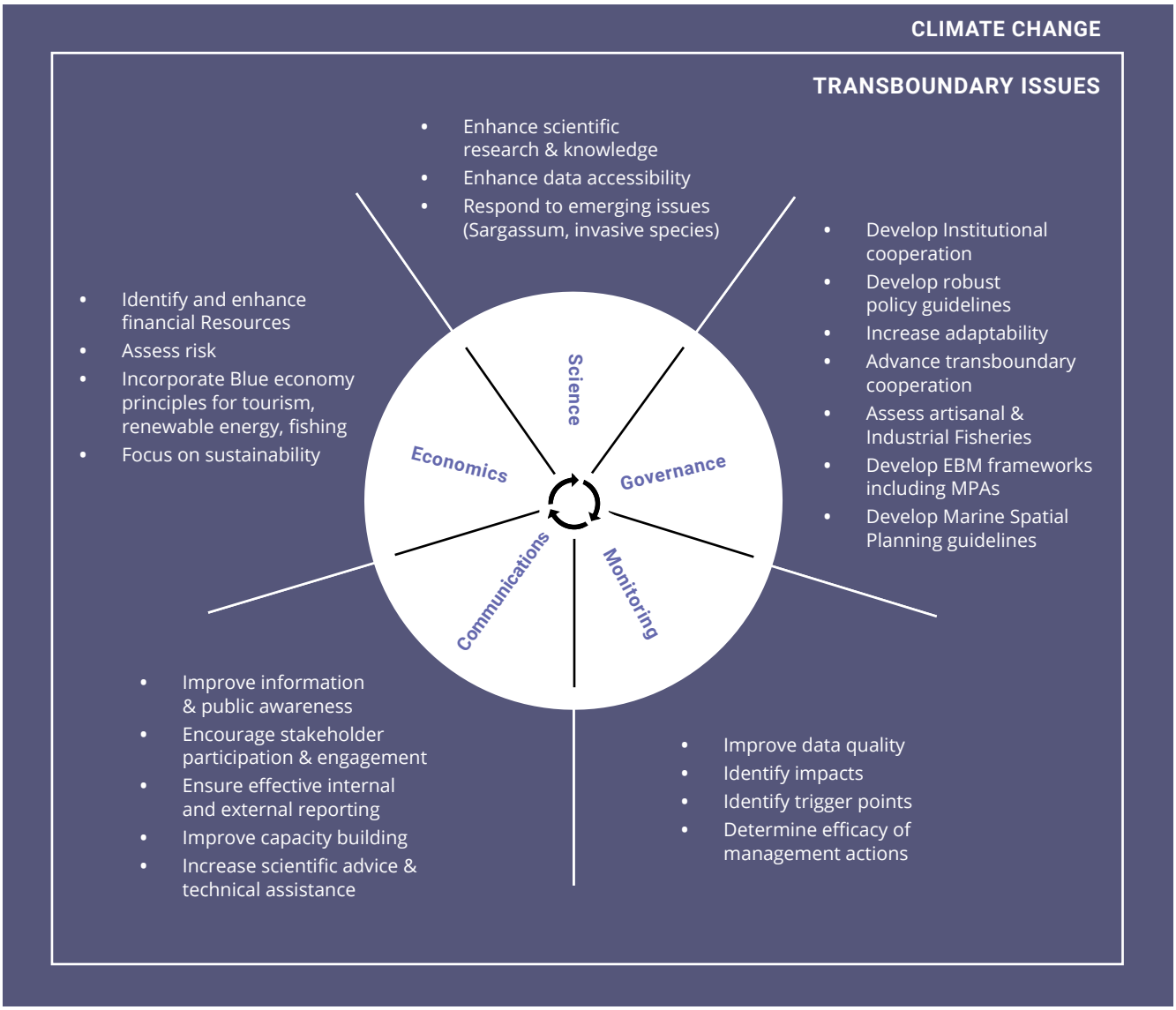


Figure 9.1 | The implementation framework representing the five research themes (yellow circle) and the key implementation targets (blue boxes). The overall implementation framework exists under the umbrella of climate change (see Chapter 10). Secondarily, transboundary issues serve an overarching consideration applicable to all themes.

9.2 Regional and National Governance for Effective Implementation of the Research Agendas

Complex governance arrangements and transboundary jurisdictions can lead to lack of clarity of roles and responsibilities, inconsistencies in direction, duplication of efforts, and inappropriate regulation. Governance arrangements that are simpler and easier to understand will better support effective management of the marine resources and deliver social, cultural, economic, and environmental benefits.

While legislation and policy already exist at the regional and national levels, their implementation and enforcement are often deficient. To further compound this issue, inter-sectoral cooperation to address ocean problems is still rather poorly developed in many countries and territories of the region. There are likely many factors. Some of these include lack of regional coordination, human capacity, funding, and stakeholder participation (Mahon et al. 2017 and Chapter 2). More specifically, obstacles include lack of marine spatial planning and outdated national fisheries regulations based in part on an absence of stock assessments or monitoring programs. There are also examples where legislation is in place, but it is ineffectively applied by the absence of implementation guidelines or the lack of enforcement required to have any impact (for example, coastal zones, the LBS pollution, fisheries regulations).

At the regional level, the need for a coordinating mechanism for ocean research is a critical component of the emerging regional ocean governance framework. This has been continuously emphasized throughout this strategy and under the implementation of the CLME-SAP. A number of institutions exist throughout the region, but none have overall regional research mandates. Ultimately, this results in research actions that are ad hoc rather than coordinated for regional priorities.

One possible exception is WECAFC; they define priorities, but have little budgetary authority for research so their recommendations often fall to national research institutions and universities with aligned priorities to implement. Nevertheless, at their 17th Session in July 2019, the member states endorsed a standardized mechanism setting a framework for data collection and information-sharing systems to support scientific and decision-making processes in the region. As they noted, the implementation of this framework is a necessary step to ensure adequate national and international capacity to collect relevant information for sustainable management of fisheries resources in the Western Tropical Atlantic.

Some institutions function at sub-regional scales, but these mostly address national issues. Similarly, UNEP CEP have addressed research priorities under the SPAW and LBS protocols of the Cartagena convention often in workplans and strategic documents; however, they too lack funding to implement research plans.

Thus, implementation of research programs is often left to national programs. Several elements may influence the extent to which the research strategies may be implemented including:

(i) adequate financial means within the national government to support research implementation,

(ii) effective coordination between agencies or institutions towards common cross-sectoral objectives, and

(iii) sufficient institutional, enforcement, financial, and technical capacity.

There are so many variables that may affect the success of the implementation of the research agendas that drawing a clear link between cause and effect

is challenging. This was clearly demonstrated by the processes of attempting to establish straightforward assessments with respect to fisheries management, habitat protection, and governance (Chapter 2).

The socio-political and biological complexities further complicate the ability to develop comprehensive regional research programs. The WCA includes the exclusive economic zones (EEZs) of 28 nation states and 16 territories belonging to the Netherlands, The United Kingdom of Great Britain and Northern Ireland, France, and the United States of America. A total of 29 of these are considered small island developing states (SIDS). There are five official languages and many local dialects. Taken together, this makes the region one of the most geopolitically complex regions of the world.

The region is also one of the most bio-diverse areas of the world's oceans and includes a wide range of oceanographic and hydrographic features and a rich diversity of tropical, subtropical, estuarine, coastal, shallow-shelf, deep-slope and oceanic habitats. Approximately eight percent of the world's coral reefs and six percent of the seamounts are found there. The rich diversity of habitats supports a wide diversity of commercially important fishery species.

Therefore, strong collaborations and partnerships across political boundaries, among the nations and territories, and the with stakeholders are needed for the successful implementation of this research strategy including CLME+ project and its partner organizations (i.e., UNEP-CEP, CRFM, OSPESCA, WECAFC, IOCARIBE, OECS, CARICOM, CANARI, GCFI, and UWI – CERMES).

9.3 Financial Resources for Effective Implementation of the Research Agendas

Countries in the region need to have access to adequate funding to address their implementation priorities under the research strategy framework. Differences in the financial resources available for each of the countries affects their ability to implement activities at the national level which in turn has implications on the regional level. Developing countries face different challenges in relation to those of more developed countries and overseas territories with respect to the funding available for research. Small Island Developing States (SIDS) are particularly challenged because they are limited in respect of not only their financial base but also their human capital (CARICOM 2017).

9.4 Fishery Monitoring and Assessment for Effective Implementation of the Research Agendas

Fishery monitoring and assessment programs should ensure that all the information required to achieve the management and the sustainability of the fishery objectives are obtained as cost-effectively as possible. A fishery monitoring program should be implemented by balancing data robustness and affordability without sacrificing the quality of the information needed for management. To promote cost-effective fishery monitoring, the fishery agenda within this report identifies the use of new technologies to collect fisheries data (e.g., electronic reporting, electronic monitoring systems, video monitoring systems). These technologies provide opportunities to reduce monitoring costs over the long term in some fisheries.

For the success of the implementation of a fishery monitoring and assessment program, a monitoring work plan that outlines priority actions and associated timelines must be developed at both national and regional levels. These work plans need to be updated regularly as new priorities arise (e.g., climate change adaptation or other emerging issues). They must contain the input from all stakeholders involved in the fishery including the incorporation of traditional knowledge. In the case of the monitoring and assessment of transboundary fisheries, the work plan should develop guidance in the form of harvest strategies, resource sharing, and management processes among the countries engaged in the fishery. This policy should be implemented through the Integrated Fisheries Management Planning process, legislated co-governance structures, or other fishery-planning processes.

9.5 Empowering Regional Networks to Implement the Habitat Conservation Research Agenda

The development of regional EBM networks (e.g., CaMPAM and MPAConnect) has provided an opportunity to develop capacity to address important issues. The managers on the ground are often the best informed about the relevant issues. In many cases, they also make the decisions related to creating policy and managing their resources. Thus, they are most in touch with the realities of research priorities for effective decision making. Empowering the managers through capacity building provides a way to create the direct linkage between management and policy. Developing approaches that mitigate the negative impacts of stressors on habitats requires the enhanced capacity for managers to understand the biological, social, and economic impacts on their resources. When this capacity increases, the decisions are made with less uncertainty.

The objective of both CaMPAM and MPAConnect is to enhance the ability of these managers to create effective approaches with enhanced information. Thus, these networks serve as valuable mechanisms to increase the capacity of managers at the local level while simultaneously building cross-boundary relationships. In this way, issues of common interest can be addressed effectively, priorities for research can be addressed synergistically, and repetitive research can be avoided.

9.6 A Regional Approach for Addressing Pollution Research – the Blue Economy

Pollution remains an issue that impacts all natural resources and all sectors of society. The costs of pollution on ecosystem services is enormous (Atkins et al. 2011). However, to mitigate the impacts, it is important to examine the ecosystem (including the human components) holistically.

Effectively addressing pollution requires different ways of thinking. As previously detailed throughout this report, the Blue Economy approach integrates the diverse sectors by recognizing the values of both strong economies and natural resources conservation. The region will prosper when the various sectors involved in the economies (e.g., tourism, shipping, oil exploration, mining) adjust their practices because they recognize that healthy marine and coastal ecosystems make good economic sense.

As the Blue Economy paradigm gains traction, the partnership model it represents serves as an ideal platform to implement the research agenda. This is especially true given the cross-sectoral nature of the research topics detailed in the agenda. To further reinforce the value of addressing the research topics, identifying the economic value of pollution mitigation becomes increasingly important. In this regard, the all-inclusive nature of the pollution research agenda becomes a pathway to understanding the impacts in scientifically and economically relevant ways. Building on that, integrating the economic and conservation sectors provides a way to elevate policy originating from the implementation of the research agenda to the level of decision making.

9.7 Enhancing Capacity for effective implementation of the Research Agendas

Any regional research strategy framework must be implemented first at the national scale for it to have any practical effect. Adaptations to existing programs must be made at the local and national level both in infrastructure and governance in order to properly implement the regional strategies suggested in this document. For many countries and overseas territories in the CLME+ region, these adaptations are major challenges. The unique vulnerabilities of many developing countries impose significant limitations on their ability to make structural and other adjustments necessary for effectively incorporating regional research frameworks into their national ways of doing business. Accordingly, the implementation process of this CLME+ research plan involves capacity building and finding ways of enhancing capacity and resource limitations. This research plan also recognizes that sustainable development is crucial to the survival of many countries and overseas territories including SIDS and encourages working in a number of cross-sectoral areas including capacity building, blue economy, and technology transfer in order to implement a sustainable development strategy.

9.8 Enhancing Communication for effective implementation of the Research Agendas

The communications agenda outlined the priorities to engage stakeholders. It encompassed the overall communication gaps and established some general principles to which communications can address those gaps. The communication agenda further attempted to identify the stakeholder groups and their corresponding communication needs. It also identified gaps associated with key messages together with some specific deliverables and communication mechanisms. Among them are the exploration of innovative and existing communications mechanisms and techniques to maximize awareness and promote understanding on ocean issues as well as improving the management of stakeholder expectations.

9.9 A Strategic Approach for Implementation

Effective implementation of this report will require ensuring that funders align their priorities with those of decision makers thus enabling the identified research priorities to trickle down to academic / research institutions and other organizations. The identification of the priority research topics by decision makers in this report exposes the existing gaps in management-focused priorities. For research to be relevant to management, the priorities articulated in this document should serve as a research framework upon which to build science-driven approaches which further address the needs of effective policy development.

To achieve this coordinated approach, research providers must reframe their objectives to align with policy priorities and managers need to articulate to decision makers the state of their resources and their needs for conservation. Furthermore, policy and decision makers must prioritize and fund the research necessary to achieve effective management and governance of marine resources. This ultimately requires recognition that effective management requires enhanced channels of communication in all directions among these groups.

The successful implementation of research focused on the priorities of decision makers (i.e., the priority topics in this report) will require a strategic approach which ensures priorities and incorporated into policy. This will require the integration of different actors to develop specific outputs that move the process along (Figure 9.2).

A critical element to achieving management goals is ensuring that the research priorities identified in this and similar analyses make their way into the priorities of funding entities. Given that funders can be at the national level (e.g., Ministerial offices), regional level (e.g., IGOs and NGOs), or the global level (e.g. global UN funding mechanisms), a clear understanding of which entitities may provide resources to achieve the objectives of the research topics is critical. This process requires clear and efficient communication to research funders. In this way, the research is driven by the management need that targets the sustainable management of the region's marine and coastal resources.

Not all priority research topics will be within the mission of any one funder. This report identified five research themes for each agenda: Science, Governance, Monitoring, Economics, and Communications. Different funders may focus their efforts on different themes by nature of their missions'. For example, many of the regional NGOs focus on science research. However, as shown in this report, in several instances higher-ranked research priority topics may include research needed for effective communications. Likewise, economics research may be squarely within the mission of various regional banks and management agencies. Governance research may be a priority for global funders such as the GEF

as well as others. Monitoring research may be driven more by regional (e.g., FAO) and national programs (e.g., ministries) that must identify trends in their resources (especially fisheries resources) to make informed management decisions. Communications research is perhaps the most difficult to fund and research into this theme may need to be a component of a larger effort and integrated in funding strategies as a crosscutting component.

Effective implementation of research priorities requires that funders recognize the priorities of the decision makers and ensure that these are integrated into their research options including their requests for outside proposals and consultants. It is important to understand who the entities are that fund research so they can be lobbied to include the decision makers' priorities in their research strategies.

Funders must also become cognizant of the needs of management and be receptive to including the priorities of decision makers within their funding opportunities. However, this integration won't be guaranteed. As noted in Chapter 3, policy-makers often vet scientific advice before being elevated to decision makers. In some cases, brokers are necessary to achieve this linkage between policy and science. Thus, this will require a concerted effort by staff of national, regional, and global management entities and their consultants to interface with funders to communicate the research needs and to lobby for including the priority research into funders' research opportunities. This will not be easy and may be a prolonged process to build relationships and align with funding cycles.

After the priority research is completed, there will be significant effort required to integrate the research results into policy. Again, this isn't an easy proposition. Numerous barriers may exist to achieving full integration (see Section 9.10). Additionally, the priorities of Governments and IGOs may change driven by shifting societal values including those that are social, economic, and political.

9.10 **Overcoming Barriers to Implementation**

Implementation is not easy. Many barriers to implementing specific activities exist and may fall within categories such as social, technical, administrative, political, legal/governance, economic, and environmental (Benedict et al 2019). By examining these categories in a methodical way, one can understand the nature of the barriers to implementation and develop strategies to overcome them. In this way, overcoming barriers requires understanding them, prioritizing those that are most impactful, and addressing them with well-developed strategies (Figure 9.2 from Benedict et al 2019). In general, overcoming the barriers will require a cross-disciplinary team with expertise in those categories.

Figure 9.2 | A framework for implementing and integrating the research priorities into policy. The group involved at each step of the cycle are identified alongside the activity.

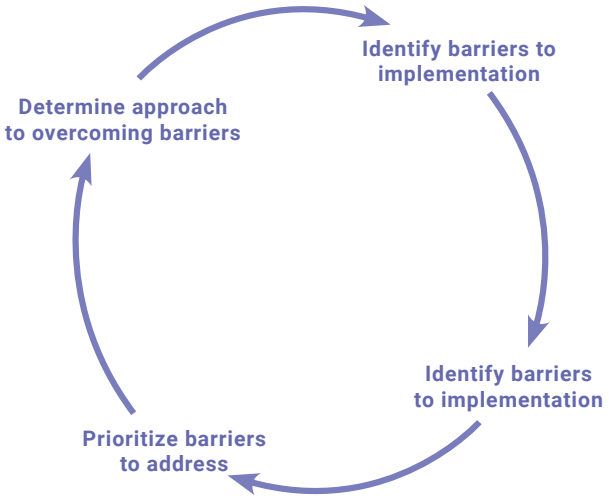


Figure 9.3 | The approach to identifying barriers, prioritizing those that must be addressed, and focusing on those priorities (from Benedict et al. 2019).

Chapter 10

The Anthropocene

The earth is changing. Atmospheric and seawater temperatures are increasing, the oceans are becoming more acidic, sea levels are rising, rainfall patterns are changing, and tropical storm systems are becoming more powerful. Each of these impacts results in changes to the environment within which natural systems and human societies exist. Unless the resources and society are able to adapt, they will face extreme consequences which will threaten their existence and alter ecosystems beyond recovery.

Based in part on these fundamental changes, there is an emerging consensus that we have entered the Anthropocene, a geological epoch where environmental change is predominantly human-driven and influenced by social, economic, psychological, and political forces (Aswani et al. 2018). This presents enormous challenges associated with identifying the research needed to understand how species and ecosystems will respond, as well as addressing the associated feedbacks between social and ecological systems (Woodhead et al. 2019).

The effects on marine and coastal species may not be similar across species or regions (Fulton 2011) due to spatial heterogeneity and biological and behavioral characteristics. Some species may perish while others may flourish (Pecl et al. 2014; Morrison et al. 2015). Furthermore, climate change can act independently or interact with other stressors in a synergistic manner thus intensifying impacts (Ateweberhan et al. 2013).

Small island developing states (SIDS) are often extremely vulnerable to climate change because they are typically geographically small with limited resources and limited capacity for resilience. Their high dependence on tourism increases their vulnerability (Jędrusik 2004); the coastal communities of SIDS are particularly vulnerable to sea level rise as well as other stochastic disturbances (Hernández-Delgado 2015).

The impacts on resources, coastal communities, and species in the Caribbean region may be profound (Table 10.1). The impacts, for example, will affect a wide suite of ecosystem and socio-economic systems and services. Effects may range from impacts to fishery species abundance, increases to coastal hazards, greater prevalence of disease, saltwater intrusion, and increased economic spending on mitigating these impacts. Furthermore, changes to ecosystem structure and function have been well-documented (e.g., Pandolfi et al 2011; Hughes et al. 2017).

The Caribbean Region's marine-fisheries industry is among the most vulnerable to climate change in the world (Barenge et al. 2018; FAO 2018). The fisheries are likely to be affected by increasing sea surface temperatures, ocean acidification, sea level rise, heightened rainfall, and changes to ocean circulation patterns (Johnson and Welch 2009). This, in turn, may impact marine fisheries both directly and indirectly by affecting ecosystem function, species abundance, productivity and distributions, habitat use and availability, as well as interactions with non-target species and bycatch incidence (Morrisson et al. 2016). Within the Wider Caribbean Region, as a result of amplified incidence and magnitude of storms and hurricanes, many fisheries have already experienced changes in species diversity, abundance and distribution along with an overall loss of fishing effort (Johnson and Welch 2009). The impacts on fisheries are further amplified by the increased influx of Sargassum which not only directly affects fisheries, but also leads to a loss of productivity due to reduced fishing activity or damage to boats and other equipment.

Table 10.1 | The projections and possible impacts from increasing atmospheric temperatures (1°C to 2°C) on the Caribbean region based on 2014 projections (information provided by the Caribbean Community Climate Change Centre).

System impacts	Climate change projections	Local impacts
Sea Level Rise	Sea level has already risen 10 to 20 cm over the past 100 years. Likely rise by around: • 13 cm (5 in) by the 2030s • 28cm (11 in) by the 2050s, • 100cm (40in) by the end of the century	• Increased flooding resulting in damage and loss of coastal homes and infrastructure • Increased coastal erosion from higher storm surges • Saline intrusion into coastal aquifers
Air Temperature	Average annual temperatures in the Caribbean will be ~ 0.5°C warmer by 2100	• Impacts on human health and health systems related to heat stress • Increased need for cooling systems and energy required for cooling • Air temperature impacts sea surface, storms, and precipitation
Sea Surface Temperature	Already risen by 0.74°C Expected further increase in the century of 1°C - 2.0°C	• Increased incidence of coral diseases • If temperatures increases 1–1.5°C higher than the normal maximum for more than 4-6 weeks, corals bleaching occurs
Rainfall Patterns	Total annual rainfall is expected to decrease up to 20% in most CARICOM countries	• Increased demand for water for agricultural and domestic purposes including population growth • Reduction in water quality • Reduction in groundwater recharge and river flows due to higher evaporation rates leading to drier soil conditions • Reduced rainfall
Storm Patterns	Overall, storms are likely to get less frequent but stronger	• Combined with sea level rise - increased coastal erosion from higher storm surges especially when combined with high tides • Increased flooding resulting in damage and loss of coastal homes and infrastructure
El Nino/La Nina – ENSO	El Nino years - Storms likely to get less frequent but more severe when they occur During La Nina – conditions are wetter, storms are more frequent but weaker It is unclear how ENSO will change with climate change	• Impacts vary depending on ENSO years but related to impacts of storm and rain activity • Storms are likely to get less frequent but stronger when they occur

A recent study examined the range of impacts from climate change on Spiny Lobsters (Table 10.2) and the Spiny Lobster fishing community (Table 10.3) in Xcalak, Mexico (Glazer 2017). The impacts are diverse with some being extremely detrimental and others beneficial. In this study, it was reported that the lobsters may respond to changes in water temperatures forcing them into deeper waters which will make them less accessible to the fishers who are restricted to fishing using free-diving. Additionally, increases in rainfall patterns and associated runoff may reduce visibility for free divers thus reducing catch per unit effort. Alternatively, a decrease in rainfall may reduce runoff thus increasing visibility and CPUE. With regards to the fishing community, it was found that the fishers are quite resilient and likely have a high ability to adapt.

As a result of local and global stressors, there is a high likelihood that tropical coral reefs in the future will be completely different (Hughes et al. 2017). Just like fisheries, the impact of climate change on marine habitats is likely to vary tremendously (Woodhead et al. 2019). For tropical marine ecosystems like coral reefs, some may continue to be dominated by calcifying organisms, others may be dominated by completely different structures or features or even shift to a different ecological state (Alvarez-Filip et al. 2013; Woodhead et al. 2019). Changing temperatures, sea level rise, and increased storm activity can lead to the destruction and impairment of other nearshore marine habitats like seagrass and mangrove. Furthermore, changes in ocean circulation patterns can lead to greater incidence of marine pollution and an amplified transboundary impact.

Photo credit: Jerry Corsaut

Table 10.2 | The anticipated impacts of climate change on the Spiny Lobster biology, distribution and demographics in Xcalak, Mexico (from Glazer 2017).

System Impacts	Impacts to the Biology and Ecology of the Spiny Lobster in Xcalak, Mexico
Sea Level Rise	**Biology** No impact likely
	Ecology and distribution Juvenile Lobster: positively affect recruitment by providing additional habitat that was previously inaccessible either because it was terrestrial, or because it previously did not provide conditions that were suitable for juvenile lobsters (e.g., temperatures or salinities that exceed tolerances.) Distribution of juvenile lobsters may be enhanced, at least in the short term. Adult Lobster: Possible positive impact from new habitat.
Increase in Sea Surface Temperature	**Biology** Sea surface temperature may have a profound effect. It is generally accepted that the thermal threshold is 31°C (Kearney et al. 2014) and that exposure to prolonged temperatures above this threshold will result in impacts to a number of critical organismal functions including reproduction and respiration.
	Ecology and Distribution Sea surface temperature will have a profound effect on the ecology and distribution of both juvenile and adult lobster. Juvenile lobster: Increases in SST will likely result in higher mortality for post-larval lobsters recruiting to currently used, shallow-water habitats because those locations will likely exceed the temperature threshold during certain times of the year. Adult lobster: According to the Government of Belize, a 0.5°C will result in lobsters migrating offshore into deeper water. Thus, as SST warm, lobsters will move away from shallow-water reef habitats to deeper-water refuges.
	Demographics Given the impacts on the biology, ecology, and distribution, it is likely that populations will relocate to deeper water locations and the shallower-water populations will decline. This will be similar for the populations occupying both the Xcalak Marine Park as well as the Chinchorro Biosphere Reserve.
Decrease in Rainfall	**Biology** Can lead to increased salinity which can exceed thresholds leading to chronic impacts to reproduction.
	Distribution Decreasing rainfall is likely not to change the distribution of lobsters. However, decreasing rainfall will likely be accompanied by other effects such as increasing salinity. This could have the net effect of reducing the areas that are suitable in the areas that are more coastal.
Increase in Storm Intensity	**Biology** Rapid decrease in salinity can lead to mass mortality.
	Distribution Likely to force lobsters into deeper waters. In 2013, increased rainfall in the region around Sian Ka'an resulted in the lobster population moving into deeper waters presumably as a result of decreasing salinity.

Table 10.3 | The anticipated impacts of climate change on the Spiny Lobster fishing community in Xcalak, Mexico (from Glazer 2017). The "+" symbol indicates a beneficial effect, the "-" symbol indicates a net negative effect, and the "O" indicates no net positive or negative impact. Most fishing occurs on Banco Chinchorro and most lobsters are landed in Mahahuil. The lagoon reference is a highly fished location associated with Banco Chinchorro.

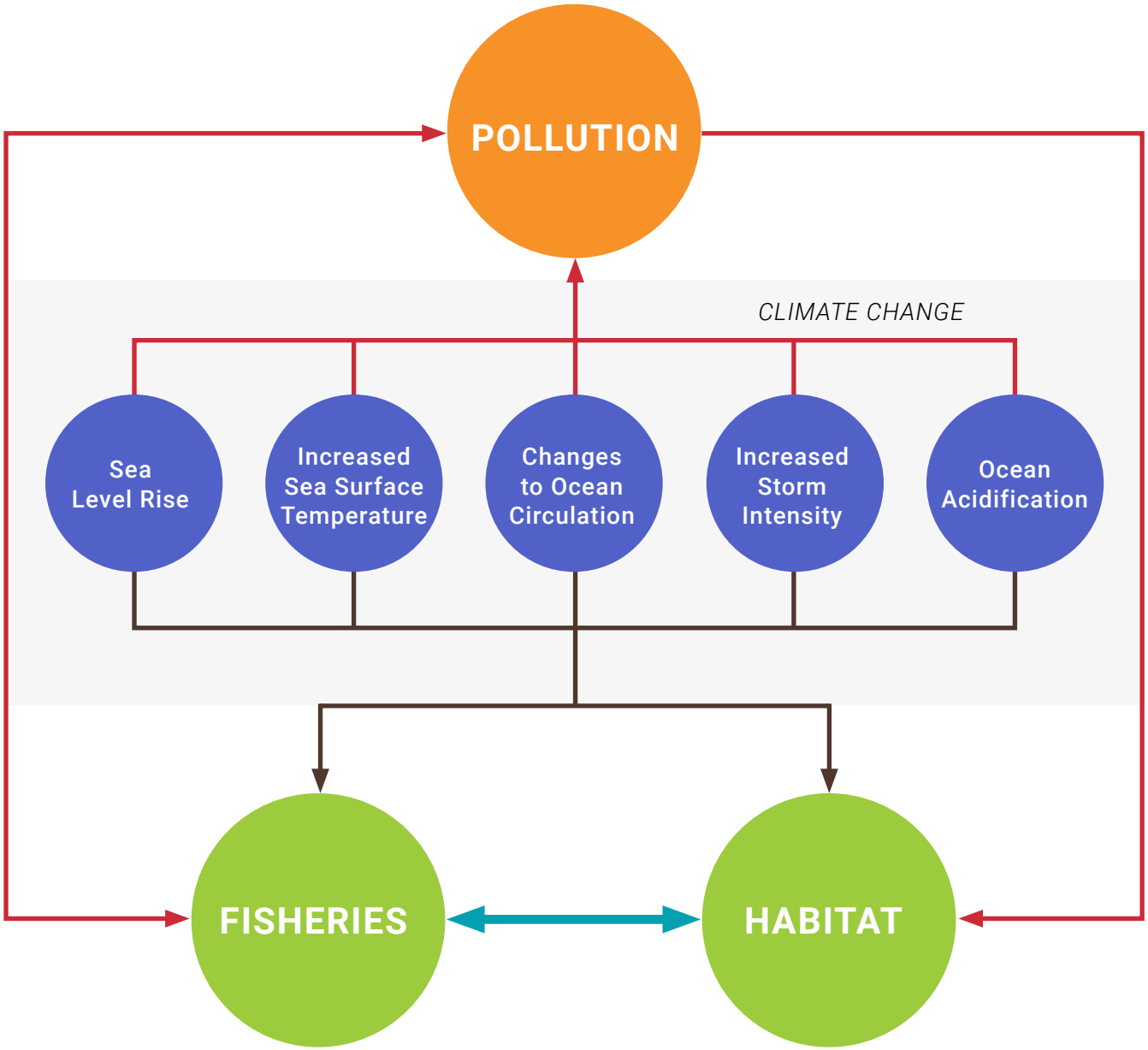
System Impacts	Impacts to the Spiny Lobster Fishery	
Sea Level Rise	**Infrastructure** • Increased flooding of Xcalak Fishing Cooperative • Little impact to lobsters landed in Mahahuil, Mexico • Housing in Chinchorro may become flooded	+-
	Fishing Practices • Likely few effects	O
	Lobster Catch • Increased recruitment may lead to increased catch in shallow waters inside lagoon	+
Increase in Sea Surface Temperature	**Infrastructure** • Likely no impact	O
	Fishing Practices • Lobster decrease in abundance inside lagoon results in increased fishing outside	-
	Lobster catch • Lobster moving deeper - > lower CPUE • Lobster chronic health impacts - > lower CPUE	-

The climate-induced changes to the physical and chemical conditions in the ocean will also likely affect the behavior of contaminants in marine environments including their distribution and toxicity (Cabral et al. 2019). More specifically, climate change will almost assuredly compound the effects of pollutants in coastal and marine waters by modifying the chemistry of compounds, changing the contaminant pathways, and impacting bioavailability and remobilization of contaminants (Schiedek et al. 2007). As sea temperatures increase, hypoxia will become more common resulting in changes to seawater pH that may interact with contaminants in deleterious ways. Changes in the oceanographic mechanisms for dispersal and entrainment will likely be important at local scales for entrainment and dispersal of both contaminants and marine debris. Additionally, as a result of shifting environmental conditions linked to climate change, some organisms may struggle to cope with additional exposures to chemicals or other pollution hazards (Cabral et al. 2019). Synergistic effects from multiple stressors are expected to occur impacting species, communities, and ecosystems (Cabral et al. 2019).

There are also likely to be impacts associated with marine litter. With changing ocean circulation patterns and increased storm intensity, there may be an increase in the incidence of land-based sources of marine litter discharges from increased stream flows. In particular, abandoned, lost, and otherwise discarded fishing gear (ALDFG) will likely increase. Given the high durability and slow degradation of these products, they will likely persist in the environment for many years (Pettipas et al. 2016). Furthermore, their low density and buoyancy facilitates dispersal by water and wind to distances thousands of kilometers away (Wabnitz and Nichols 2010). Weather related events are often the main cause of waste entering the marine environment, but there are cases, especially in SIDS, where waste enters from dumpsites located adjacent to waterways.

In the context of this report, the effects of climate change are expected to impact the fisheries and habitats of the region and to contribute to pollution, or the effects of pollution (Figure 10.1). Furthermore, the effects of climate change are expected to increase over time. What is not always known is the likelihood and consequences of these effects. This uncertainty often results in inaction. As a result, the effects of climate change are often not planned for very well and present major challenges for managers and policy makers (Lu et al. 2018). Planning requires anticipating changes and developing adaptation options to address the changes. Unless there is coordinated local, regional, and international action to address this threat, there will likely to be a decline in marine environmental quality and thus a decrease in the ability of ecosystems to support local communities (Ateweberhan et al. 2013).

Figure 10.1 | The complex relationships between climate marine system impacts and the three agendas examined in this report. The red arrows indicate those relationships that influence, or are influenced by, pollution. The brown arrows represent the direct relationships between climate system impacts and each agenda. The thick, double-headed arrow between habitat and fisheries denotes that habitat influences fisheries and fisheries influence habitat, especially with regards to fishing practices and influences on trophic relationships. Purple circles highlight climate change impacts.



In this context, impacts need to be anticipated and adaptation responses developed (see Section 11.3). Furthermore, climate change needs to be embedded into the culture of every organization so that responses are second nature. Managers must realize that changes to their environment will occur.

A new approach to management must emerge that focuses on managing for change rather than persistence. Acceptance of the emergence of the Anthropocene by definition recognizes that change is occurring and in many cases resisting these changes will be expensive and often ineffective. New management approaches must recognize that we live in this changing world and manage for different targets often with different indicators. For example, rather than managing to maintain the same species assemblages, perhaps the focus should shift to managing for ecological services or to maintain tropic functionality.

All actors in the research cycle including research providers and research users must be prepared to think differently. This will require that scientists develop more holistic views of their approaches to research. They must move beyond the quest for identifying all possible impacts to a species or habitat, to examining how ecosystems will shift, what the impacts are on ecosystem function, and how this will impact society. Managers must realize that the resources they are entrusted to conserve are changing and that the resource values must be reframed within an anthropogenic-driven world. Decision makers will likely be the most responsive to this changing world given their sensitivity to social needs and the changes that drive them.

Taken as a whole, communication in this new environment will be more critical than ever. Chapter 3 describes the relationship between science and policy in the context of 'research providers' and 'research users'. The interactive communication between 'research providers' and 'research users' is imperative to achieving effective climate adaptation both in terms of identifying priority research and integrating the results into policy. Section 3.6.5. details a number of activities that are necessary to ensure a line of communication is achieved between research providers and research users. The list of actions detailed in that section provides guidelines to facilitating the development of an interactive environment. The enhanced channels of communication will be necessary to ensure that research addresses societies' changing needs to guarantee that these changes filter down to managers and ultimately research providers. Conversely, communication channels must ensure the efficient transfer of information related to changing conditions is elevated to the decision makers. This adaptation to communication will only be achievable if climate change permeates how research providers and research users view the world.

Chapter 11

Final Reflections

11.1 The priorities of decision makers

This report was intended to provide guidance to decision makers on research priorities for the three agendas (i.e., three fisheries, habitat, and pollution). Each agenda had very specific research topics and responses from decision makers highlighting the uniqueness of each. This report was not intended to be an exhaustive review of any one topic; there are plenty of publications that go into greater depth than we were able to do here.

The development of the research agendas could be viewed as a whole-system approach to identifying and prioritizing research gaps and possible responses. It is unrealistic to expect that all the research responses that were identified can be implemented due to their vast scope and the technical and financial resources that would be required. However, addressing the priority research topics is certainly achievable, especially if addressed strategically. Since these priority research topics represent the priority issues for decision makers, it is important that these be ranked over the other research topics. From the perspectives of the decision makers, the priorities they identified represent the information needed to develop policies that can ensure that the sustainability of the fishery and habitat resources and address the issues associated with pollution.

When one thinks generically of research strategies, the first thought is often of the scientific gaps and the research needed to address them. Science is often the most highly-visible need and for good reason; research historically has focused on technical issues. For this reason, the scientific gaps and research needed to fill these gaps was a primary focus of the decision makers, especially in the fisheries and habitat agenda. The technical nature of research was addressed within the Science themes in this report. The highest-ranking research topic for Spiny Lobster focused on providing information needed for stock assessments, a very technical need. Interestingly, climate change information, a very recently considered impact in the management community, was tied with it for the highest-ranking research topic. Within the habitat theme, developing MPA indicators was tied as the highest priority along with the need for better spatial data on marine habitats. There is consensus among the decision makers that it is time to implement a marine spatial plan designed to address critical management needs and to guide the implementation of management strategies. Due to transboundary nature of the marine resources in the region, connectivity in both a natural resource and social sense is essential for the development and implementation of an ecosystem-based approach to management.

Environmental data are key to develop accurate modelling of fish stocks. Therefore, it is extremely important to ensure that data collected capture the dynamics of ecosystems at the appropriate spatial and temporal scales. This was identified as an issue of extreme importance in shrimp and groundfish fisheries (Chapter 6.5).

The analyses also indicated that the current status of fisheries science in the region is fragmented and there are important gaps in data and knowledge especially on population dynamics of the species harvested and their relationships to fisheries ecosystems. This is due, in part, to the complexity of marine ecosystems. The same situation also applies to the deep seas because deep sea areas are under increasing pressures from fisheries, marine pollution, and exploitation of mineral and energy resources. Furthermore, there are critical gaps in knowledge and in the understanding of deep-water species that are harvested in the region such as snappers and groupers and invertebrates (e.g., shrimp).

It was clear that the region needs to implement a multidisciplinary approach to fisheries science as a basis for sustainable management and exploitation. Currently fishery research is too cataloged, and it is necessary to address the problem from a holistic point of view through a better integration of landing data, environmental observations, socio-economic data, traditional knowledge, experimentation, and modelling.

Overall, the most pressing issue related to fisheries is to provide sound scientific knowledge for the management of fish stocks that will ensure the long-term sustainability of fishing, minimize impacts to the environment, and facilitate the recovery of depleted fish stocks. The decision makers noted that more research to support stock assessments and the development of models are needed. Currently, fisheries assessment rarely consider the negative effects of fishing on marine ecosystems (e.g., on the loss of biodiversity, the impact on other habitats, and other environmental effects), and it is necessary to develop assessment models, monitoring programs, and management framework that explicitly consider these impacts on marine habitats and communities. The fisheries strategy agenda strongly recommends the implementation of an ecosystem approach to the management of fisheries (EBMF).

Integrated monitoring in both time and space is more likely to capture complex ecological relationships. At the same time, the identification of cumulative or synergistic effects may be better identified. This includes bottom-up processes and top-down responses. Thus, an analysis of the function of an ecosystem as well as ecosystem structure, which underpins EBM approach, remains a central pillar of this theme (Elliott 2014).

Spatial scale is critical when developing EBM approaches. There is no one catch-all spatial scale at which an ecosystem-based approach should be implemented. The appropriate scale should be determined by the connections among ecosystem features, human activities, and their impacts.

It was clear that science alone will not answer the needs of the decision makers. Likewise, strong governance in the absence of a good scientific baseline will have limited value. Even when taken together improved cooperation among stakeholders will be necessary to achieve robust management.

11.2 Shifting Research Priorities in a changing world

As the marine and coastal conditions change, there will be an ever-evolving need for research to be responsive to those needs. We have already seen this relative to changing habitat conditions for coral reefs, decline of important fishery species, invasive species introductions and establishments, influences of Sargassum into the region, and the emerging impacts from climate change. Each of these changes, and those that will emerge, will have cascading impacts throughout the ecosystems from the changes to the resources as well as the human communities who rely on them. The ongoing challenge will be to respond to these needs in timely and robust ways.

Yet some issues remain incalcitrant. Overfishing and IUU fishing are still widespread despite efforts to control their prevalence and reduce their impacts. The possible effects of climate change on fisheries and the economic impact on coastal populations depending on these fisheries remains uncertain. Currently, there is not enough knowledge in many cases to distinguish between the effect of climate change and the effect of human activities on the fluctuations of fish stocks. Habitats continue to be affected by issues ranging from climate change to pollution.

Novel issues continue to emerge. For example, in recent years new forms of ocean pollution have been identified that add to the suite of more traditional issues such as nutrient run off, oil spills, mercury and other heavy metals, and radioactive substances. Researchers and policy-makers are still learning about the damaging effects of microplastics, microfibers (Figure 11.1), nanoplastics, and other less-surveyed and studied aspects of this issue. For example, more information is needed about how these plastics are transferred within the foodweb, the pernicious effect on metapopulation persistence, and the ecotoxicological impact of microplastics. Also, the effects of persistent organic pollutants in the environment are just beginning to emerge. These include the effects on marine ecosystems of endocrine disrupting chemicals including pharmaceuticals, pesticides, herbicides, industrial chemicals, fire retardants, metals, and plastic additive chemicals. We also need to explore further the impact of microplastics on the transport of viruses and bacteria.

Altogether, these issues are developing as significant threats to both fish and wildlife with linkages to human health. To address these issues, there are several marine debris-oriented policy interventions that have taken form around the world, from banning plastic bags to sponsoring clean-up technology. It is clear that there is an urgent need to understand the impacts of these threats and to develop new global, regional, and local approaches to limit land-based marine pollution.

Some of the ongoing impacts will be further compounded as the earth's climate changes as previously discussed. For example, the distributions of fish will change with warming seas, the shells of lobsters and shrimp may be negatively impacted by increasing acidity, and habitats will likely shift from coral dominated to those where algae is more common.

Conversely, some resources may benefit in a changing climate. Nearshore habitat for Spiny Lobster may increase with rising seas. Deepwater refuges may become more common for many species as they seek cooler waters. Fishing may become more difficult as targeted species begin to occupy previously unoccupied habitats (Glazer 2017). Governments must be prepared to respond to ever-changing fishing patterns and the spatial shifts of sensitive habitats. We need to increase our understanding and ability to predict interactions and feedback mechanisms between ocean and climate. In this vein, it is necessary to deepen the knowledge on changes in ocean circulation due to major changes in climate and ocean-climate processes, at not only regional or local scale, but also at global scale.

Taken together, changing conditions will require a strong focus on developing adaptive approaches for managing ecological and social systems. It is also inevitable that from these changes will emerge a new suite of challenges and research questions. Chemistry of seawater will be affected, social systems for coastal communities will be threatened, and economies will be impacted. How society addresses these changes will dictate how healthy the coastal and marine waters of the CLME+ region remain. As threats emerge, addressing them requires pro-active and adaptive approaches.

Figure 11.1 | Microfibers are an important emerging issue. These microfibers were collected from fish samples in Grenada. The impact of these on human health as well as larval organisms is not known. Photo courtesy Michelle Taylor, St. Georges University.

11.3 Research needed for adaptation

Adaptation planning is the development of responses to the actual or expected effects changes to the natural, social and econonmic environments (adapted from Smit et al. 1999). 'Smart' approaches to address these changes have been developed which provide guidance on how to identify the science needed, the strategies to address the impacts, prioritizing which strategies should be addressed, identifying when to implement the strategies (i.e., trigger points), identifying when trigger points are reached, and implementing priority adaptation responses (e.g., Figure 11.2). Each one of these steps requires well-developed research plans that can guide the activities that follow. These 'smart' approaches are designed to strategically develop effective adaptation strategies by incorporating the types of holistic approaches that have been mentioned many times in this report. Ultimately, how society adapts to changes will address its ability to reduce risks and address uncertainty.

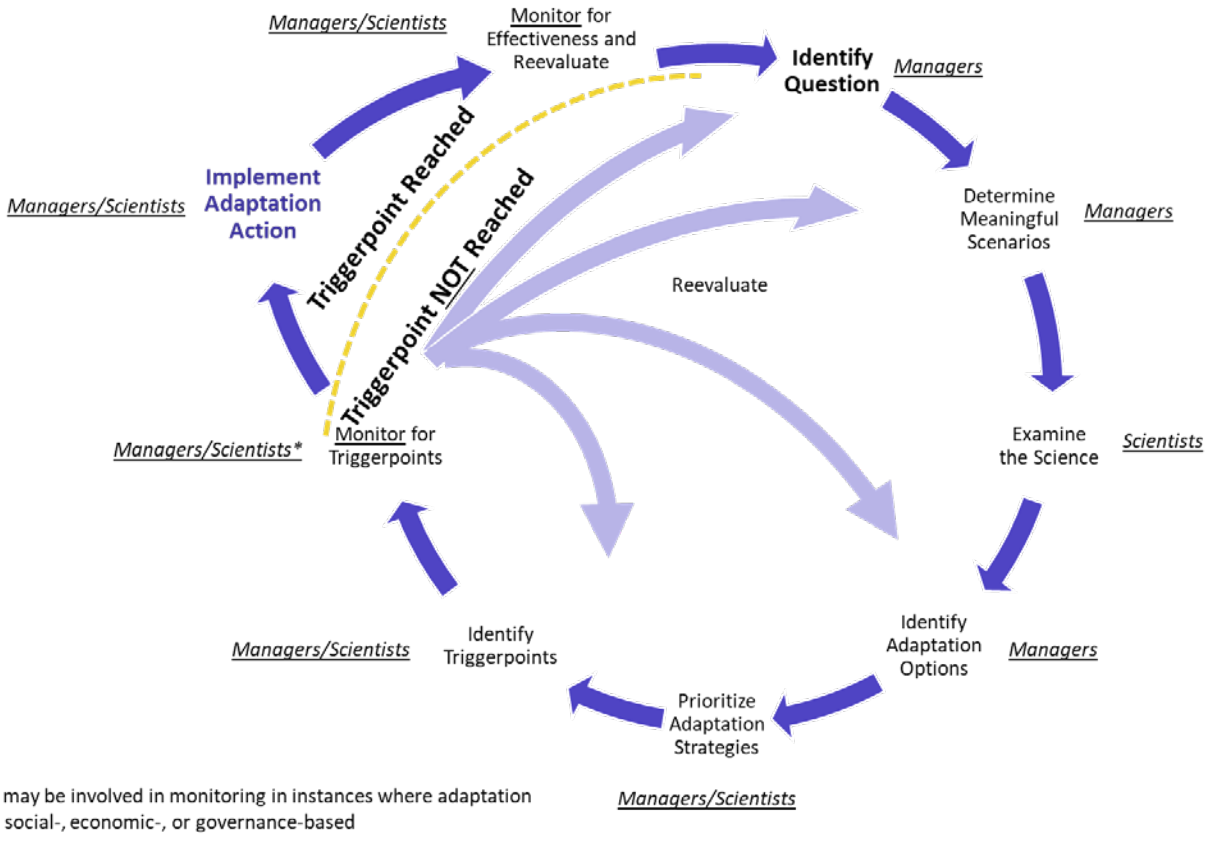


Figure 11.2 | Climate-smart cycle for developing and implementing adaptation strategies developed by the Florida Fish and Wildlife Conservation Commission (Benedict et al. 2018). The types of individuals responsible for each step in the cycle are identified. In the context of this report, managers can often be viewed as decision makers.

11.4 Research linkages to Effective Governance

Appropriate governance systems will need to integrate scientific, socio-economic, environmental, and political actions all geared towards the sustainable use of coastal and marine ecosystems. The research topics needed to improve governance are broad and need to approach the main issues from different angles including changing the way people think, empirically analyzing the impacts of unsustainable activities, and making interventions at a range of governmental and geographic scales. The most important aspects of these research topics are that they should be coordinated among the WCR and the CLME+ member countries, and that people, governments, and regional agencies along with academic and research institutions must work together to manage the issues affecting them. Most of the governance research topics identified in this report are unlikely to work if applied by a single entity.

With regards to fisheries, the analyses of the decision makers suggests that the compliance with the current international agreements, including environmental legislation, is limited by inadequate fisheries research and monitoring. This deficiency limits the ability to develop targeted management responses. International mechanisms and national governments need to consider ways to increase human capacity, improve working conditions, and enhance the facilities and mechanisms for funding fisheries research operations. This further impacts the development of fisheries and aquaculture-based blue economies.

Designing and implementing effective regional and local fisheries policies and projects will require approaches fueled by active stakeholder participation, significant financial investments, and integration of robust technical analyses. Despite the increased demand for technical analyses, there is an increased recognition that much of the analysis produced are not being effectively converted into policies, plans, and projects that can prevent or reduce negative environmental, health, and economic impacts such LBS pollution.

For pollution, the current existing legal and policy frameworks do not provide comprehensive global, regional, national, or local strategies that adapt to industry innovation or to emerging scientific advances. Furthermore, existing structures do not provide a collaborative platform for stakeholders and polluters (UN Environment, 2018). The UN environment report on plastic litter and microplastics indicated that the largest gap identified relative to governance is the lack of an international body with the mandate to regulate land-based sources of marine pollution. However, an international body is in place for the management of marine sources of pollution through the International Maritime Organization (IMO) and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA). The GPA is recognized as the competent international organization for land-based sources as per UNCLOS article 207(4). The mandate of the Regional Seas is mostly limited to the relevant convention areas, with only five regions including the high seas with the responsibility to prevent harm. Not all States are party to a binding Regional Seas convention, leaving geographic gaps in the duty to protect the marine environment. The Caribbean region is one of the 5 regions where a Regional Seas convention exist together with a LBS protocol. To date the Caribbean region has obtained a number of benefits from the existence of the regional Seas body in relation to activities to mitigate pollution.

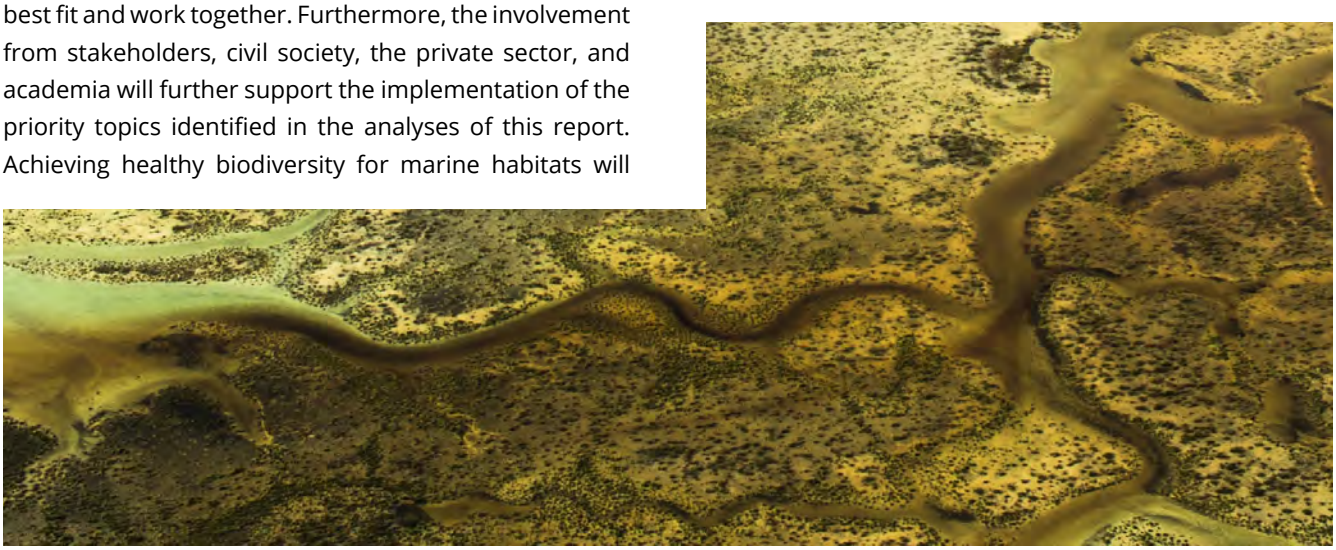
The institutional framework that governs decision-making for biodiversity and habitat conservation In the wider Caribbean reflects a complex arrangement of overlapping mandates involving multiple regional inter-governmental bodies, their technical agencies, and other organizations. This wide diversity is represented by a diverse universe including, among others, Caribbean Community (CARICOM), Central American Integration System (SICA), Organization of Eastern Caribbean

States (OECS), Association of Caribbean States (ACS), Organization of American States (OAS), multiple United Nations programs, commissions, regional offices, and sub-regional offices, and national governments and their agencies. Academia, NGO's, and other stakeholders are also involved and playing an important role in managing habitats and biodiversity (UNEP-CEP 2020).

Our current baseline of knowledge about marine habitats in the wider Caribbean is fragmented. One important initiative is the Cartagena Convention's SPAW Protocol which addresses the establishment of protected areas and buffer zones for conservation of habitats and wildlife. This program is applied to both national and regional scales and addresses the protection of wild flora and fauna, the introduction of non-native or genetically altered species, environmental impact assessment, research, education, and other topics. This type of initiative allows conservation practitioners to make better informed decisions on the sustainable use of the marine habitats and the conservation of biodiversity. However, according to the responses of the decision makers to the surveys, there are specific human activities that require further research to improve our understanding of the interactions among species, habitats, and the resulting cumulative impacts. We also need to improve our understanding of how different and often conflicting environmental policy objectives can best fit and work together. Furthermore, the involvement from stakeholders, civil society, the private sector, and academia will further support the implementation of the priority topics identified in the analyses of this report. Achieving healthy biodiversity for marine habitats will depend on fundamental changes on how we interact with the marine resources, coupled with a wider re-evaluation of our societal values.

Despite numerous efforts to implement policies that mitigate the effects of LBS pollution at the national and regional levels, difficulties are still experienced with respect to linking policy responses with observed on-the-ground changes and impacts. Addressing this issue is becoming increasingly important because decision-makers and the public, as well as international agencies, donors, and others, are demanding to see tangible results and actions. Nevertheless, there was a recognized need to empower local governments to increase their capacity and incentives to undertake their role as local pollution managers.

Many of the problems of pollution associated with industry, agricultural runoff, aquaculture, treatment plants, and poor tourism practices could be minimized through creating robust development strategies or Environmental Management Plans. The development of a common set of procedures and standards for the region, together with monitoring of the environment, would quickly begin to reduce pollution loads and LBS sources of pollution. It would also allow for better adaptive management because the LBS pollution outputs would be controlled and better understood.



11.5 The need for Effective Communications

The responses from decision makers were clear that there are other equally important needs that are more focused on the social and economic disciplines. For example, it was clear that decision makers recognize that designing and implementing a successful communication strategy is essential for both the communication of technical issues to policy makers as well as effectively achieving policy implementation. Poor access to information, or incomplete information, means they don't have the relevant, best available, and most current information with which to make policy. Often the information is available but does not make it to the decision makers either due to ineffective communications or poor interpretation of the information. The communication themes in this report focused on how best to overcome these barriers. Addressing the differences in language used by scientists, managers, and stakeholders will facilitate the communication of science to policy makers and stakeholders. In addition, policy makers and stakeholders should be included in all stages of research, development, and implementation activities to ensure that their communication needs are met. Communications also serves another critical function.

In many cases, even the best-developed policies will not gain traction without widespread community support. Successful dissemination of information depends on the ability to supply information and to transfer knowledge to the stakeholders and the potential users (Vermeulen et al. 2009) and then for stakeholders and potential users to use this knowledge. Without information, the public's ability to participate in key decision-making processes (e.g., the siting of industries and monitoring and regulation of LBS pollutants) is limited. Therefore, their ability to demand accountability from their government and industries is also limited.

Education is also an important component of communications. Building large-scale awareness is one of the most effective ways of providing the basis for action on issues by spreading awareness and empowering people. Large-scale awareness means programs in schools, media campaigns, social media, professional organizations (e.g., to keep up with technological developments), NGOs, stakeholder groups (e.g., fishermen, farmers), and all levels of civil society.

Each stakeholder group has specific characteristics and needs in terms of information. It is important to identify these information requirements and gaps to design an adequate communication strategy. All interests in the region's marine resources have a role to play in ensuring more sustainable Caribbean and North Brazil Shelf regions. Many organizations have been focusing on the region's resources for a long time; however, there is room for them and other community groups to take larger role in awareness building as watchdogs, for bringing small-scale innovative technology to communities, supporting policies that focus on sustainability, and advocating for blue economy initiatives. The existing governance structures are only as strong as the groups that support them. Research going forward must focus on both the impacts that society may experience as well as ways to assimilate all of society into developing solutions.

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