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Roatan, Honduras, 5 to 6 June 2019

**POLLUTION RESEARCH STRATEGY FOR THE UNDP/GEF CARIBBEAN
LARGE MARINE ECOSYSTEMS**

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

www.theCLME.org

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

A.A. Acosta and R. A. Glazer

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Project Background

The Caribbean and North Brazilian Shelf Large Marine Ecosystems (collectively the CLME+) represent one of the most ecologically, politically, socially, culturally, and economically diverse regions in the world. Not unsurprisingly, these complexities have resulted in challenges to the effective management of the associated marine resources. The inefficient governance structures, as well as a dearth of relevant scientific information, have resulted in inaction or, worse yet, maladaptation. To build a strong, resilient, and sutainable region able to support growing pressures requires that local and regional policy-makers create approaches built on ecosystem approaches (i.e., ecosystem-based management.) The UNDP/GEF CLME+ project is based on this principle.

The Gulf and Caribbean Fisheries Institute (GCFI) has been engaged as a partner in this effort. Specifically, GCFI is working to develop research strategies that are at the nexus between policy and science. GCFI is developing research priorities that are useful for policy-makers to use when developing well-informed approaches to deal with marine resource related issues. For the scope of work of this initiative, those issues relate to unsustainable fisheries, habitat degradation, and pollution. This report represents the effort focused on addressing *Expand[ing] the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+.*

Research Strategy Development – Linking Research Actions to Objectives

GCFI has taken the approach of developing objectives as the basis for research strategy development. The objectives have specific policy and management focus and they provide the direct linkage between policy and science. In this way, the research activites that are identified have a policy/management focus.

GCFI has further recognized that research needs to address not only pollution science, but also the social sciences that are needed by policy-makers to achieve the goals of their programs. For example, how best to communicate with a specific stakeholder group.

Thus, four broad themes were used in this document to address this approach: 1) pollution science, 2) governance research, 3) communcations research, and 4) monitoring research. Taken together, this methodology provides a holistic approach for achieveing the goal of reduction of LBS in the CLME+ region.

The four themes are further divided into broad goals and from there, specific objectives. The objectives are used as the target for development of the research actions.

Each of these categories (Themes, Goals, Objectives, and Actions) are included in tables that highlight specific research actions that tie directly to objectives. In this way, research was directly linked to policy.

Identifying Categories and Research Actions

Using the results from surveys, a workshop, and individual interactions, Goals were identified within each theme. Each Goal was further refined to identify Objectives. From these, research actions were developed.

There was a strong emphasis on a holistic approach that would include 'hard' science (in this case, toxicology, ecology, and related sciences) as well as social sciences which would taken together focus on reducing impacts from LBS.

The themes that were identified included pollution science research, governance research, communications research, and monitoring research.

For the Pollution Science Research theme, there were two goals identified: 1) reduce the resks to species, populations, and habitats, and 2) reduce the risks to human health from LBS. There were 27 Objectives and 38 research actions associated with these goals.

Within the Governance Research theme, two goals were identified: 1) Creating or enabling policies and legislation that contribute to the reduction in source pollution, and 2) Integrate public and private sectors to achieve policy and management-based solutions to pollution. Seven Objectives and 23 research actions were identified.

The Communications Resarch theme consisted of one goal: Effective communication to ensure pollution mitigation and reduction. Four objectives and seven research actions were identified.

The Monitoring Research theme identified three goals: 1) Increase monitoring activities related to LBS, 2) Increase Inputs from scientific research in monitoring activities related to LBS, and 3) increase inputs from stakeholder participation in monitoring activities related to LBS.

Acosta and Glazer
FOREWORD

The Gulf and Caribbean Fisheries Institute (GCFI) has long been a not for profit organization dedicated to disseminating information related to the sustainable and wise-use of the region's marine resources. To accomplish this goal, GCFI has focused on bringing together disparate stakeholders to exchange the results of their research, share ideas, and develop working solutions to some of the most vexing issues facing society. In this spirit, GCFI is working together with the CLME+ project and project partners to address regional priorites all under the umbrella of Ecosystem-Based Management.

This project supports implementation of the 10-year Strategic Action Programme (SAP) for the sustainable management of shared Living Marine Resources in the Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME+ region).The CLME+ project focuses on three of the most important problems affecting coastal societies and small island developing states (SIDS): unsustainable fisheries, habitat degradation, and pollution. GCFI's role in the project is to examine the three targeted research strategies (O2.6 in the CLME+ project document) Specifically, GCFI's role in the project is to identify research strategies and priorities related to the CLME+ project:

1. Expand the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+.

2. Expand the knowledge base required for implementation of Ecosystem Approach of Key Fisheries including flying fish, spiny lobster, shrimp, and groundfish in the CLME+ region.

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

To ensure a regional perspective as well as technical diversity, GCFI leveraged the scientific community within both its membership as well as scientists and other stakeholders who attended the annual scientific meetings. Furthermore, GCFI contacted colleagues within the CLME+ project who were knowledgable on the subjects under consideration.

The list of participants in the activities related to this project is numerous; acknowledging each of them would be excessive. However, the authors would like to specifically acknowledge Christopher Corbin of UN Environment, Caribbean Environment Programme for his input throughout this process.

This report represents the results from the first of the three research strategies outline above: identification of research needs to achieve a reduction in pollution.

Fig. 1 | Women collecting litter during a beach cleanup activity in the Caribbean.

1. INTRODUCTION

The concept of Large Marine Ecosystems (LMEs) has emerged as a mechanism for the promotion of an ecosystem-based approach to oceans 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. EBM requires a broad understanding of all the components and functions of the ecosystem. Although it is not possible to understand all the components about the ecosystem, we can prioritize our monitoring, analysis and research so that in the short term we focus on activities that will inform our understanding of the most critical and influential components and functions of the ecosystem and help us to understand how these are affected by human actions.

The Caribbean Sea marine biodiversity is inextricably linked to human activities and the environment. It is changing fast 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 resources at risk. At the same time, the Caribbean's exclusive marine ecosystems provide major opportunities for the sustainability and growth of activities such as fisheries and tourism.

The CLME+ is one of the most biophysically and geopolitically diverse and complex marine regions in the world (Mahon et al., 2010). Twenty-six independent States and 18 overseas territories are coastal to the CLME+. 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 that they identified were weak governance; pollution from both land-based sources (eg, agricultural run-off, liquid waste discharges) as well as offshore origins (eg, shipping, mining, oil and gas exploration). Over-exploitation of living marine resources is another major threat, particularly in areas where there is no legal control or enforcement.

Debels et al (2017) further concluded that better ecosystem-based management 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 principle that was 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 and their function. 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.,2013). Without recognizing the human capacity to alter ecosystems and formally including this dimension in developing management approaches, failure to develop sustainable management pratices is almost a certainty.

Fig. 2 | Sustainable marine resources require healthy ecosystems free from the pressures of overfishing and pollution.

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 framework for joined up governance of the marine environment, has been developed. This approach requires the design of an effective framework that engages scientists, policy-makers and the public to achieve shared understanding and importantly informed decision-making based on sound scientific knowledge.

2. Background

2.1. The Need for Policy-Guided Research

The Caribbean and North Brazil Shelf Large Marine Ecosystem Project (CLME+) is a politically diverse and environmentally complex region. This expansive region constitutes over 4.4 million km^2 and is a major contributor to regional economic development. The coastal and marine environments are a complex mosaic of intertwined ecological, social, and economic processes.

Yet, the CLME+ region is plagued by many of the issues affecting marine environments elsewhere. Overfishing, pollution, and habitat degradation have become pernicious threats to the sustainability of the region's resources. Add to this the overarching threat of climate change and it becomes clear that there is a great deal of work that needs to be done to increase the sustainability of the natural resources, and the people and communities who 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. Local and regional governmental authorities are often paralyzed because of the lack of clear and substantive science which is relevant to policy.

The CLME+ GEF-funded project is designed to address regional governance approaches to facilitate the sustainability of the region's marine resources using an Ecosystem-Based Management approach. To accomplish this, the Strageic Action Programme (SAP) is built on the Governance Effectiveness Assessment Framework (Figure 3). This template demonstrates how the effectiveness of polices can be evaluated ultimately leading to the condition of individuals in a society. It is from this framework that policies should ultimately be based.

Given this framework, this project focuses on three of the most important problems affecting coastal societies and small island developing states (SIDS): unsustainable fisheries, habitat degradation, and pollution. The three targeted research strategies GCFI is examining (O2.6 in the CLME+ project document):

1. Expand the knowledge base required for implementation of Ecosystem Approach of Key Fisheries including flying fish, spiny lobster, 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 LBS pollution in the CLME+.

Taken together, the three strategies will provide a more holistic view of the CLME and its research needs.

2.2. Addressing the CLME+ regional complexity

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

Capacity-building to encourage the development of new approaches to achieve policy-relevant goals in research and governance. New skills and educational initiatives are needed to attract new professionals and to address the interdisciplinary nature of the marine research.

The lack of capacity related to effective management is a critical bottleneck to enhancing the growth of a sustainable blue economy, and to supporting policy implementation that is both achievable and effective. Careful planning is needed to ensure that a sufficient critical mass of workforce is developed 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 systems. Reference CSA update.

Integration across established marine and maritime
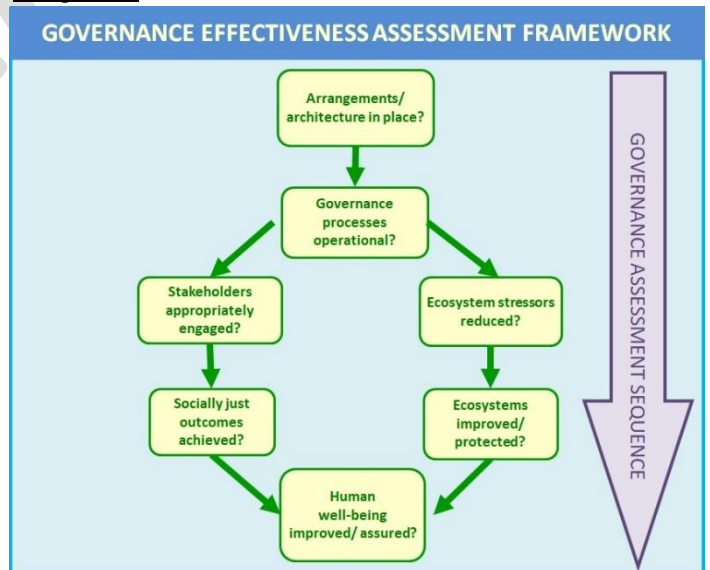
Fig. 3 | The governance effectiveness assessment framework (GEAF) adopted by the CLME+ project.

research disciplines and governance to ensure more environmentally relevant policies are developed. This topical priority category ensures the closer integration of

knowledge and 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.

Synergies between and among CLME+ countries, government and non-government institutions, tourism industry, and fishery and marine industry sectors that taken together provide additive benefits for the States, Territories, and region. A focus on developing synergies will ensure that the flow of information and funding through the different stakeholders is achieved.

Fig. 4 | Sewage outfall onto a Caribbean reef.

3. Making science relevant: The Role of Science in the Effective Governance of the Caribbean Sea, North Brazilian shelf, and the Gulf of Mexico
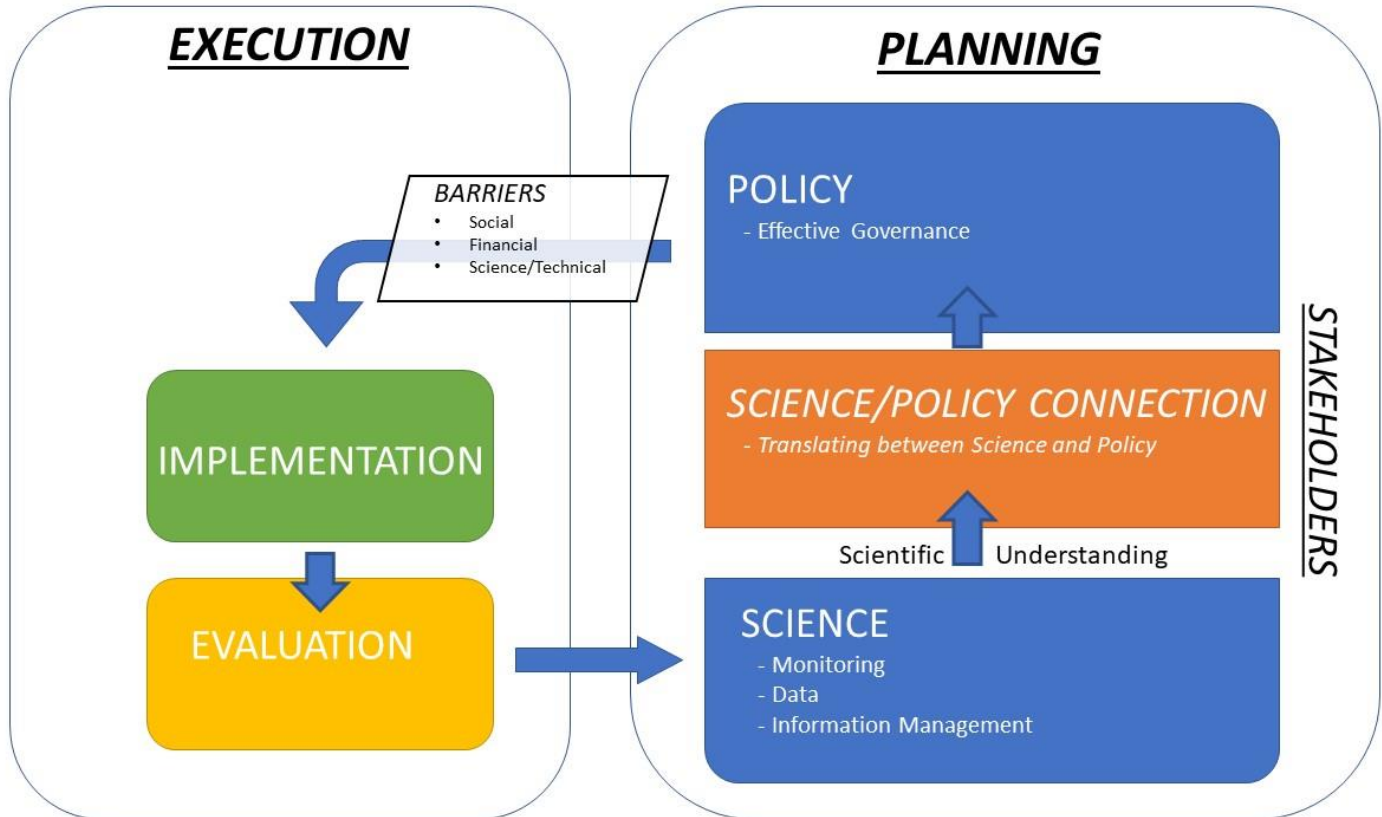
Fig. 5 | The cycle that links science and policy. The planning part of the prcess is stekehlder driven. However, even when the plans are created, there are barriers to implemention. Ultimately, the effectiveness of the policies must be evaluated and the results from this fed back into future plans.

Effective policy development is dependant upon scientific input that is relevant, unimpeachable, and easily understood at both the policy-making level and to the stakeholders who are impacted by the implementation of the policies. However, implementing policies shold not be the end game – effective policies should be adaptable and dependant on the results of monitoring the effectiveness of their implementation.

This project has developed a direct linkage between policy and science; all research actions are driven by policy-oriented priorities. This has been done by using a hierarchical approach that cascades from the Theme to a Goal to an Objective, and finally to the Research Actions (Figure 5).

Using the theme of Governance Research as an example, there is a Goal of: *Creating or enabling policies and legislation that contribute to the reduction in source*

pollution. Under this Goal, the following objective is included: *Increase the integration of policy across sectors.* Finally, several research actions are identified one of which is: *Identify areas of commonality with respect to pollution-related policy among political jurisdictions*. In this way, research has a direct link to policy priorities.

This approach has the added benefit of identifying what part of an organization is responbile for the detail that goes into this process (Fig 6). In this case, the Themes are often developed based on priorities of ministries. For example, a Ministry of the Environment may have as a priority the understanding a policy's effects on an ecosystem or on a group of stakeholders. Alternatively, a Ministry of Education may identify communciations as a Theme for their purposes.

Of course, non-governmental organizations may operate similarly or perhaps the themes are all decided at a level.

analogous   the ecology of The Goals and Objectives are often shaped at the ministerial or departmental levels. The research roles often fall directly to individual programs including universities and other research facilities.
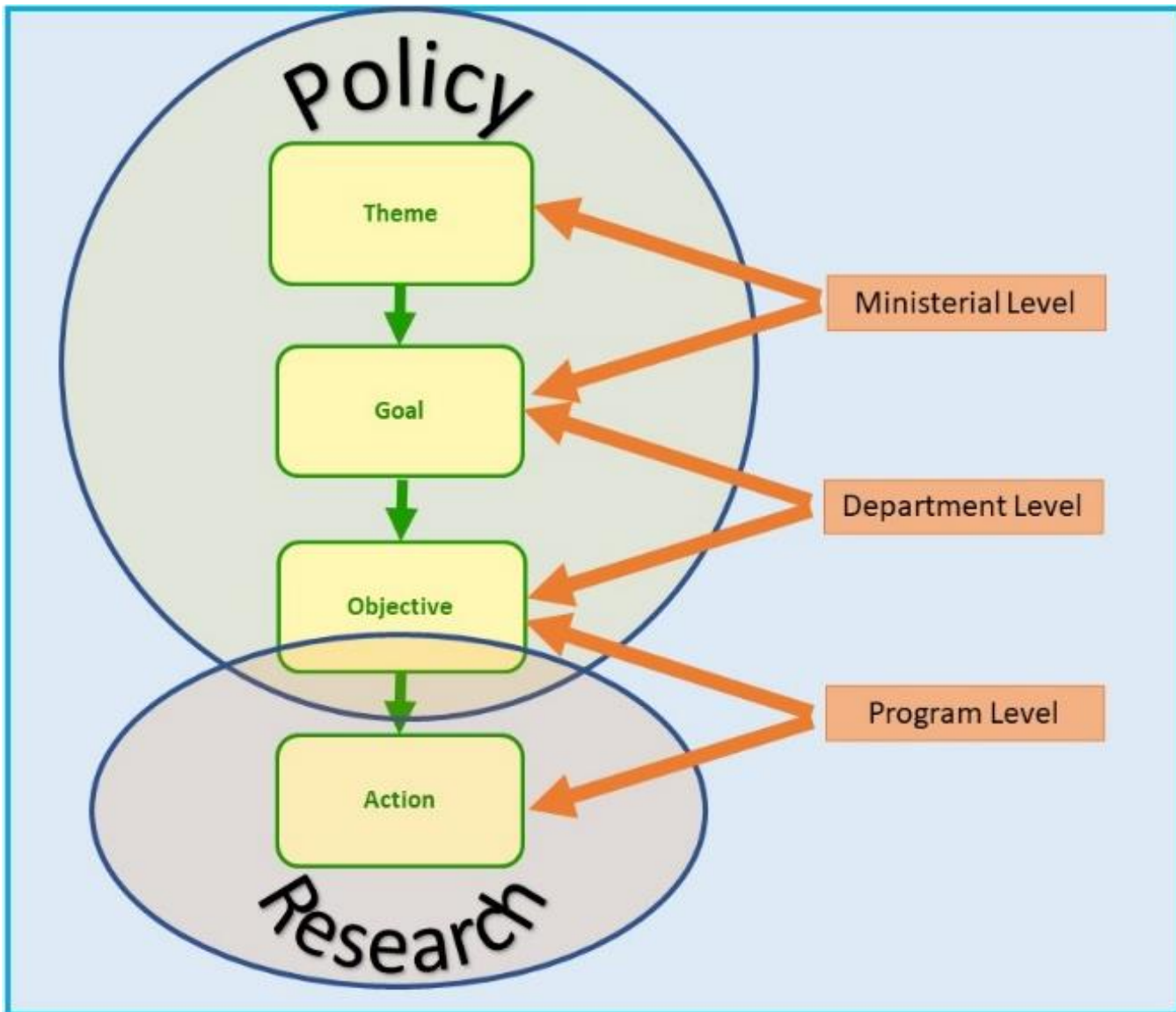
Fig. 6 | Linkages between policy and research used in this project to develop research strategies. This approach was adopted to provide a goal-oriented, policy-driven method to ensure that research is driven by the needs of managers and policy makers. The governmental responsibilities for each level are illustreated; however, this will apply similarly to non-governmental entities.

Integration of the Research Strategies with the Driver, Pressure State, Impact Response framework (DPSIR)

Driving Forces

Science
Governance

Responses

Communication
Governance

Pressures

Science
Governance

Impacts

Science

State

Science
Monitoring
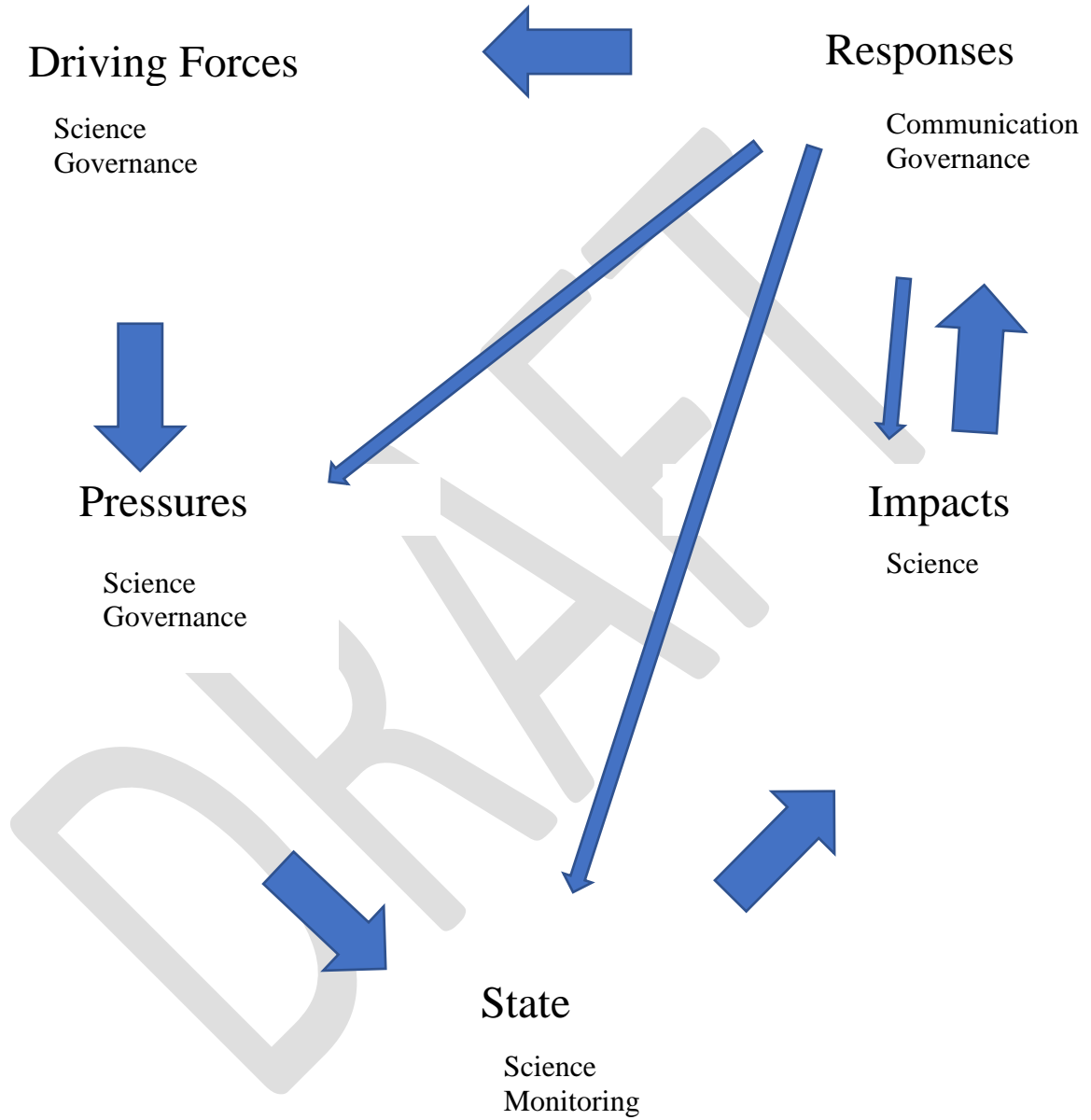
4. Previous Efforts at Developing Marine Pollution Research Strategies in the CLME+ Region

There have been few efforts that have focused specifically on marine pollution research strategy development in the CLME+ region. In an IOC-UNEP workshop conducted in 1989 in Costa Rica developed pollution monitoring and research strategies for the Caribbean (UNESCO, 1988).

[CONSULTANT WORKING ON THIS - MORE INFORMATION COMING]

THE REGIONAL ACTION PLAN ON MARINE LITTER (RAPMALI)

The RAPMaLi was originally developed in 2007 under the directive of the United Nations Environment Programme (through its Regional Seas Program) in response to growing global concerns of litter in our oceans. The RAPMaLi highlighted the existing issues as well as those newly emerging (e.g., microplastics.)

From: https:// http://www.cep.unep.org/cep-documents/rapmali_web.pdf

A number of cases studies highlighted different issues within the region and attempts to address them. Strategic actions were identified within

5. Approach and Methodology

The Strategic Research agenda to Identify Science-Policy Gaps in the countries sharing the Caribbean and North Brazil Shelf Large Marine Ecosystems is built through a process to harmonize activities and create synergies in the research areas related to the marine resources in the CLME+ region. Consequently, this document represents the combination of a regional research framework informed by national, regional, and stakeholder driven agendas. It is this adherence to the regional social, economic and environmental complexities that formed the basis for the holistic approach to the development of the pollution research strategy.

This project was developed from several sources and serves as a roadmap to address pollution research priorities in the CLME+ region. The outline is based first and foremost upon 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.")

The identification of needs and gaps for the strategic approach have been conducted by GCFI through a comprehensive consultation process consisting of 3 different approaches including:

- Consultations with national research funding agencies/relevant ministries
- Review and compilation of Strategic Research agendas in the CLME+ regions
- Stakeholder consultation workshops

4.1. Survey instruments and data collection

The Gap Analysis – A Framework for Identifying Research Priorities

The process of identifying gaps related to pollution was multi-step. The first step in the process was to develop a single questionnaire for researchers, managers and stakeholders to complete during the workshop. The second step was to host the workshop during the annual meeting of the GCFI. In conjunction with the workshop, a special session related to marine debris in the CLME+ region was conducted at the meeting. A final step was an open consultation and dissemination of the survey among GCFI participants of the annual meeting.

Consultation Workshops and Surveys

GCFI conducted a workshop at the GCFI conference in November 2016 in Grand Cayman, Cayman Islands. The workshop focused on identifying priorities for pollution research by identifying gaps in existing knowledge and goals and objectives for pollution mitigation and, specifically, gaps in knowledge related to Land-Based Sources of Pollution in the CLME+ region. This theme was selected for the first workshop because there was already a special session scheduled for the GCFI conference entitled: "Identifying, Understanding, and Reducing Marine Debris in the Gulf and Caribbean". The workshop leveraged the expert opinions of the participants in that session by enlisting their participation in the workshop.

The workshop focused at getting additional information on research needs, gaps and tools relevant for the development of the pollution strategy. The workshop was comprised of representatives from diverse stakeholders group representing different communities (science, industry and policy) and CLME+ Project Coordingating Unit (PCU).

The specific focus of the workshop was to get the inputs of stakeholders on:

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

Expert Input

The experts 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 Gulf Caribbean Fisheries Institute membership and registration list for the annual conference. We further refined the pool of experts through recommendations from CLME+ members and by asking the respondents to recommend other potential experts (a snowball sampling procedure (Meyer 2001).

GCFI categorized experts as associated with academia, agencies, nongovernmental organizations, or private scientists or managers with expertise in the ecology and/or management in different regional coastal and marine ecosystems of the region, members of industry, and artisanal fishers (Table 1. Expert participants). Each expert had worked on the waters of the CLME+ region for two or more years with some exceptions related to indsutry.

Before the workshop the questionnaire was sent to a subset of the participants, who were asked to fill in that questionnaire, to help them prepare their input for the workshop on potential needs/actions/tools to achieve the goals of the workshop and to stimulate the discussion. At

the workshops stakeholders were asked to provide inputs and give their view on the questions of the workshop questionnaire. These inputs were debated during the workshops between participants and GCFI moderators and CLME+ partners which allowed to highlight several commonalities between the stakeholders participating in each workshop.

Additional Sources

To ensure that the research topics list was as complete as possible, a literature review was conducted to identify other relevant research topics. These are included in the tables and are referenced in the Source column.

4.2. The Use of Objectives to Identify Research Topics

GCFI has adopted a process that uses specific objectives to develop research strategies. This approach provided a target for the research strategies based on management and policy-driven needs.

Categories (Themes)

Prior to convening the first strategy meeting on Pollution, GCFI and the UN Environment LBS programme conducted a series of email exchanges to define the themes for defining research priorities. The themes extended beyond traditional view of research focusing strictly on the issue. Instead, the focus was broadened to provide a holistic approach to accomplishing the goal of ' the efficient and cost-effective reduction of LBS pollution in the CLME+'. To meet this goal, it was clear that research needed to focus on activities that would not only better understand the nature of the problem, but also research that examines the social and political barriers to implementing effective policies.

In this spirit, four themes were selected for focusing the development of research topics.
 These themes included:

1. ***Pollution Research*** – this theme focused on research into the sources and effects of pollution on the environment and society
2. ***Governance*** – the governance theme examined the limitations in existinggovernance structures and research need to overcome these limitations
3. ***Communications*** – the communciations theme recognizes that effective communication to a wide suite of stakeholders is necessary to achieve effective and efficient reduction of pollution in the CLME+ region. The objectives associated with this theme provided the context for research topics that examined how to develop communciations

approaches that provide stakeholder buy-in that will support the development of effective policy.
4. ***Monitoring*** – this theme formed the basis for assessing the effectiveness of policy-driven management activites
5. ***Economics*** - this theme …

This policy to science approach serves as the basis for the Large Marine Ecosystem (GEF LME:Learn 2017) approach, and ensures ecosystem-based considerations are addressed.

Fig. 7 | Scientific research is critical for the development of effective policies.

6. Pollution Research Agenda

6.1. Pollution Science Theme

The Pollution Science Theme focused on the scientific research needs that were identified to achieve specific outcomes relative to achieveing the goal of: Expand(ing) the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+. In general, this theme focused on the physical, chemical, and ecological sciences rather than social and economic sciences.

The Pollution Research Theme is divided into 2 goals, each with a specific set of objectives focused on that goal. The Goals for the Pollution Research theme include:

1. Reduce the risk to species, populations, and habitats from LBS
2. Reduce the risk to human health from LBS

There were 27 Objectives and 38 research topics associated with these goals.

The sources for the research topics were:
1. GCFI workshops
2. GCFI staff
3. Vegter et al. 2014.
4. Knowledge Action Network
5. SDG 14.1 Tier 3.
6. Rudd 2014
7. NOAA Marine Debris Research Priorities
8. RAPMaLi
9. SOCAR

Fig. 8 | A sea turtle misidentifies a plastic bag as food.

THE CARIBBEAN NODE OF THE REGIONAL ACTION PLAN 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

Table. 1 | Objectives, indicators, measurements, research topics, and outcomes associated with the Pollution Science Research theme.

6.1.1. Theme: Pollution Science Research

Goal 1: Reduce the risk to areas, wildlife, and habitats from marine pollution

Number	Objective	Research Topics	Priority
S1.1	Identify and assess the environmental impacts of marine pollution including nutrients, chemicals, and plastics (for broader regional and national decision-making)	Identify appropriate tools to examine alternative future scenarios that incorporate multiple stressors and anticpater outcomes for better planning	
		Identify the impacts of marine plastics on specially protected species such as sea turtles, marine mammals, sea birds among others	
		Conduct a literature reveiw to determine the state of knowledge of pollution impacts on protected species	
		Identify and/or create standard measurements for categorizing impacted fish and wildlife	
		Develop research programs to monitor key indicator species	
		Identify existing test indicator organisms and, when appropriate, convene experts to identify other organisms	
		Survey countries to evaluate existing studies examining the impacts of marine pollution in the environment	
		Monitor and evaluate the impacts of emerging issues such as: sargassum, ocean acidification, electronic waste, marine litter and micro-plastics on the environment including identification of causes/sources, movement and sinks/hot spots (SOCAR)	
		Examine existing documents to create a baseline on areas impacted and conduct research into the most effective database design to identify areas impacted and areas that need more research	
		Develop region-wide spatial database on areas impacted	
		Conduct a GAP analysis of overlap of high density pollution areas with areas of high sensitivity (endangered species, key habitats, etc.) in order to prioritise clean-up and mitigation efforts	
		Conduct research to determine how LBS and marine litter alter ecosystem function including trophic assemblages, energy transfer, connectivity and settlement, biodiversity, etc.	
S1.2	Identifying pollution hotspots and assess their major sources and the processes that transport them in the CLME+ region	Develop comprehensive and multi-disciplinary approach to understand hydrographic patterns that facilitate accumulation of pollutants in localized areas	
		Develop remote sensing approaches for identifying marine pollution	
		Evaluate the efficiency and the environmental changes resulting from emerging technologies used to identify hotspots of marine pollution	
		Identify point and non-point sources of pollution	
S1.3	Identify best practices and develop technologies to reduce input of pollutants to coastal systems	Identify and facilitate the transfer of knowledge, best practices and appropriate technology aimed at pollution prevention and reduction in the Wider Caribbean Region	
		Evaluate most appropriate habitat restoration mechanisms that can reduce pollution	
		Investigate innovative approaches and technologies for improving marine pollution management including monitoring, recovery and removal	
		Identify existing, new, emerging, and cost-efficient technologies to enable and support anti-pollution initiatives	
		Identify obsolete or ineffective technologies counterproductive for pollution mitigation	
		Identify how marine pollution contributes to the transfer of non-native species	
S1.4	Increase the understanding of the dynamics of contaminants between air-sea surface interphase	Develop models that link the atmosphere and sea surface and the transfer mechanisms of contaminants between the two	
S1.5	Increase the number of programs dedicated to study feasibility of bio-remediation or other recovery actions	Identify gaps in coverage from existing networks of local and regional-level research institutions to further promote cooperative research	
S1.6	Mitigate the climate-linked impacts from pollutants including plastic	Model the effects to individuals and populations resulting from climate-driven increased pollutant toxicity	
		Identify indicators to improve the interface between science and policy	
		Identify how pollutants including litter are affected by changing conditions including acidification	
		Conduct gap analysis to determine current state of knowledge and research needed to understand how changing condtions including sea surface temperatures, acification, precipitation, etc. impact the toxicity of marine pollutants	
S1.7	Increase the understanding of impacts of emerging pollutants (endocrine disruptors, hormones, noise pollution) on marine biodiversity and ecosystems	Create list of all known impacts of pollutants on marine biodiversity and ecosystems, identify gaps in knowledge, and prioritize actions.	
		Conduct a gap analysis to identify what are the information needs related to the impacts of pollutants on marine diversity	
S1.8	Improvement in research on impacts of ballast water and cruise ships contaminants in the coastal and marine biodiversity	Increased participation on local or regional water ballast convention	

		Develop approaches that eliminate contamination from ballast waters	
S1.9	Increase the quantity of information on the impact of pollution on marine ecosystems and human health and the associated economic cost (SOCAR)	Gather data on the direct links between the water quality observed at sampling sites and the ecological condition at these sampling sites (SOCAR)	
S1.10	Assess the relative contribution of different sources of nutrients to the marine environment (SOCAR) and identify the impacts to marine biodiversity and ecosystems	Develop a nutrient reduction strategy and investment/action plan for the region (SOCAR)	
		Develop integrated models to offer a defined approach to understand how socio-economics, biochemistry, hydrology and climate etc interact to transport nutrients from their source to coastal waters (SOCAR)	

Goal 2: Reduce the risk to human health from marine pollution

S2.1	Reduce the impacts of toxicants on human health	Analyze existing regional, national, and local datasets and soruces of information to identify point and non-point sources of LBS	
		Conduct risk assessments	
		Conduct gap analysis on existintg pollution risk assessments and identify areas that need to be addressed	
		Identify thresholds of exposure to contaminants	
		Survey countries to determine existing studies examining the impacts of marine pollution on human health	
		Examine existing documents to create a baseline on areas impacted by marine pollution	
		Monitor and evaluate the impacts of emerging issues such as: sargassum, ocean acidification, electronic waste, marine litter and micro-plastics on human health including identification of causes/sources, movement and sinks/hot spots (SOCAR)	
S2.2	Reduce the impacts to social well-being from marine pollution	Identify and quantify social impacts from pollution to multiple sectors	
S2.3	Increase the understanding of impacts of emerging pollutants (endocrine disrupters, hormones, noise pollution) on human health	Create list of all known impacts of pollutants on human health, identify gaps in knowledge, and prioritize actions.	
		Conduct a gap analysis to identify what are the information needs related to the impacts of pollutants on human health	
S2.4	Reduce the impact of domestic wastewater loads on human health (SOCAR)	Assess what proportion of domestic wastewater loads reach to treatment plant and how much gets disposed to coastal waters directly untreated (SOCAR)	
		Identify national standards and indicators for bacteriological contamination of coastal waters to develop regional standards for harmonised monitoring (SOCAR)	
S2.5	Improve land use management to reduce erosion and the transport of excessive sediment loads within the CLME+ region (SOCAR)	Identify and quantify the adsorption potential of sediments for contaminants (including mercury, PAH, PCBs,) and their ability to resuspend contaminants after acting as a source (SOCAR)	
S2.6	Reduce the impacts of shipping to the marine environment (SOCAR)	Identify and quantify the impacts of the shipping sector (oil discharges, loss of containers, garbage, sewage, noise, anti fouling treatments, transport of invasive species, dredging of ports) on the marine environment (SOCAR)	
S2.7	Increase the quantity of information on the impact of pollution on marine ecosystems and human health and the associated economic cost (SOCAR)	Gather data on the direct links between the water quality observed at sampling sites and the impacts on humans at these sampling sites (SOCAR)	
S2.8	Reduce the impact of untreated sewage discharge on human health (SOCAR)	Identify and quantify the impacts of faecal material and contamination by microorganisms of recreational water and seafood on human health (SOCAR)	

6.2. Governance Research Theme

The Governance Theme focused on the research needed to achieve effective governance at the local, countyr/terriroty, and/or regional scales. As with all the research themes, the overall focus was on achieveing the goal of: Expand the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+. In general, this theme focused on the legal and enforcement research needs.

The Governance Research Theme is dividied inot 2 goals, each with a specific set of objectives focused on that goal. The Goals for the Governance Research theme include:

1. Creating or enabling policies and legislation that contribute to the reduction in source pollution
2. Integrate public and private sectors to achieve policy and management-based solutions to pollution

Seven Objectives and 23 research topics were identified.

The sources for the research topics were:
1. GCFI workshops, surveys, and interviews
2. GCFI staff
3. Vegter et al. 2014.
4. Knowledge Action Network
5. SDG 14.1 Tier 3.
6. Rudd 2014
7. NOAA Marine Debris Research Priorities
8. RAPMaLi
9. SOCAR

Fig. 9 | A governance word cloud.

Important 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 is administered by the UN Environment's Caribbean Environment Programme (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 discharge. The main treaties that govern the prevention of pollution are MARPOL 73/78, the International Convention on the Control of Harmful Anti-Fouling

Table. 2 | Objectives, indicators, measurements, research topics, and outcomes associated with the Governance Research theme.

6.1.2. Thematic area: Governance Research			
Goal 1: Create or enable policies and legislation that contribute to the reduction in marine pollution			
Number	**Objective**	**Research topics**	**Priority**
G1.1	Increase the integration of policy across government sectors	Research in taxes, subsidies (import, export, stressors)	
		Review and evaluation on the integration principles to synchronized approaches for research and monitoring to compare across different areas	
		Identify investment needs	
		Level of stakeholder participation	
		Stakeholder mapping at national and regional levels	
		Assessment of existing policies, identification of gaps, and preparation of guidelines for integrating LBS issues	
		Based on the assessment, address weaknesses and gaps in policies and legislation for effective integration of LBS issues	
		Identify areas of commonality with respect to pollution-related policy among political jurisdictions	
		Identify best practices for public-private partnership engaging scientist form companies to enhance products	
		Develop best practices for the development and operation of National Intersectoral Committees (NICs) on ocean governance including marine litter	
G1.2	Promote greater coherence amongst regional agencies to create consistency and have enhanced regional governance	Develop/Identify institutional mechanisms for coordination at the regional level	
		Identify how to best engage non-contracting parties	
		Conduct research on how to bring "interactive governance" into practice: CLME +RGF	
		Identify most-effective low-end solutions that are reliable and tailored to regional reality (SIDS)	
		Convene partnership forums to identify institutional mechanisms for coordination at the regional level	
G1.3	Overcome barriers to implementing pollution mitigation	Identify and assess the barriers to implementing pollution mitigation	
		Implement actions to break the barrriers down through governance, communication and capacity building	
G1.4	Promote an increase in stable long term policies	Conduct research to identify the main sources of LBS (e.g., micro plastic, sewage) of high priority for governance	
		Conduct research on how to identify and achieve consensus on what is best available information (results from science and empirical field information)	
		Identify effective approaches for expanding ratification of regional instruments including MARPOL Annexes IV, V and LBS Protocol of the Cartagena Convention	
		Create research incentives at different geopolitical levels to make a contribution to positive change	
		Identify the most effective approaches to engage judiciary/magistrates/ enforcement officers and sensitization of politicians on marine pollution issues.	
		Determine how to engage bottom-up/better engage grassroots groups in governance	
		Identify and achieve consensus on the current best available information (results from science and empirical field information)	
G1.5	Support design or update of new/appropriate legislation	Assessment of existing policies, identification of gaps, and preparation of guidelines for integrating LBS issues	
		Based on the assessment, address weaknesses and gaps in policies and legislation for effective integration of LBS issues	
Goal 2: Engage private sector to achieve policy and management-based solutions to pollution			
G2.1	Incentivize private corporate participation	Assess existing fiscal incentives, taxes, fines and subsidies (import, export, stressors) towards providing guidelines for fiscal policy reform and investment	
		Identify investment needs	
		Develop recognition programs for eco-friendly products/ services that promote litter-free products/ services targetting the tourism, agriculture, and manufacturing sectors	

		Analyse governance arrangements to incentivize private sector	

Goal 3: Identify and develop improved solid waste management approaches

G3.1	Assess the value of waste and identify potential markets	Anticipate trends and changes to market values of marine litter	
G3.2	Assess opportunities and associated risks for involvement of private sector	Conduct risk assessments	
G3.3	Identify needs, barriers and gaps for solid waste management	Identify best use of technology to enable and support marine pollution initiatives and remove counterproductive technology	
		Conduct risk assessments	
		Identify alternatives to existing products and technologies	
		Identify approaches for effective management of ship-generated waste	
		Support efforts to reduce excess and/or unnecessary consumer product packaging	
G3.4	Assess the social and cultural underpinnings of behaviour associated with consumption, waste generation and littering	Identify and quantify social impacts from pollution to multiple sectors	
		Conduct risk assessments	
		Conduct research on most appropriate types of messaging for effective communication at various levels to effect attitudinal and behavioural change	
		Conduct research on drivers of attitudinal and behavioural change	

Goal 4: Reduce the risk to society from marine pollution

G4.1	Identify and assess the social and political impacts of marine pollution (for broader regional and national decision-making)	Improve the socio-economical quantification of pollution impacts on selected key species / group of species including fishing resources	
		Identify and quantify social impacts from pollution to multiple sectors including the fishing sector	

6.3. Communications Research Theme

The Communications Research Theme focused on the research needed to achieve effective communications to stakeholders in order to achieve the goal of: Expand the knowledge base required for the efficient and cost-effective reduction of LBS pollution in the CLME+. This theme was primarily driven by the recognized need to effectively communicate policies, priorities, and research topics that can achieve the goals of pollution reduction.

The Communciations Research Theme is compriosed of one goal: Effective communications to ensure pollution mitigation and reduction Four objectives and seven research topics were identified.

The sources for the research topics were derived from workshop conducted in association with the GCFI annual conference.

Fig. 10 | Communicating the value of mangroves in a marine protetd area project. Photo courtesy Davon Baker.

Table. 3 | Objectives, indicators, measurements, research topics, and outcomes associated with the Communciaitons Research theme.

	6.1.3. Thematic area: Communications Research		
Goal 1: Ensure effective communication to ensure pollution mitigation and reduction			
Number	**Objective**	**Research topics**	**Priority**
C1.1	Develop effective advocacy approches (e.g., lobbying, influencing decision makers) that result in decreased impacts of marine pollution on environment and society	Identify most effective approaches for communication plans that effectively inform stakeholders and public about marine pollution including highlighting bests practices and case studies	
		Inform Governments and decision makers about what is being done elsewhere about measures to protect the environment	
		Conduct research to develop and improve open channels of communication between those responsible for the pollution issues including all levels of government and stakeholders.	
		Target community and national events to incorporate LBS reduction strategies	
		Identify existing and potential sources for communications funding	
		Promote best practices for effective waste management including collection, recovery and disposal	
		Create, compile and share best practices for communications and messaging	
		Host webinars for target audiences on relevant issues related to LBS	
		Establish and maintain a publicly available repository for relevant material related to LBS in the region	
		Promote best practices of effective waste management to influence decision makers	
		Inform Governments and decision makers about what is being done regionally and internationally about measures to protect the environment	
C1.2	Develop effective education approches that result in decreased impacts of marine pollution on environment and society	Implement communication plans to inform stakeholders and public about LBS	
		Inform Governments and decision makers about what is being done elsewhere about measures to protect the environment	
		Conduct research to develop and improve open channels of communication between those responsible for the pollution issues including all levels of government and stakeholders.	
		Identify existing and potential sources for communications funding	
		Create, compile and share best practices for communications and messaging	
		Host webinars for target audiences on relevant issues related to LBS	
		Establish and maintain a publicly available repository for relevant material related to LBS in the region	
		Highlight case studies within communication plan about marine litter advances and best practices	
C1.3	Develop effective awareness approches (e.g., by communicating and making things available) that result in decreased impacts of marine pollution on environment and society	Implement communication plans to inform stakeholders and public about LBS	
		Conduct research to develop and improve open channels of communication between those responsible for the pollution issues including all levels of government and stakeholders.	
		Include marine litter related events on community and national calendars	
		Identify existing and potential sources for communications funding	
		Develop and implement media efforts to targeted audiences including an effective website; email distribution lists, newsletters; social media, multimedia, other new tools,	
		Seek additional support and financing to assist in having existing and future Programme outputs and existing training material translated into the working languages of the region	
		Make all key content available in the working languages of the region	
		Create, compile and share best practices for communications and messaging	
		Host webinars for target audiences on relevant issues related to marine litter	
		Establish and maintain a publicly available repository for relevant material related to marine litter in the region	
		Highlight case studies within communication plan about marine litter advances and best practices	
C1.4	Develop effective outreach approches (e.g. by reaching out to communitiess) that result in decreased impacts of marine pollution on environment and society	Implement communication plans to inform stakeholders and public about marine litter (including microplastics)	
		Conduct research to develop and improve open channels of communication between those responsible for the pollution issues including all levels of government and stakeholders.	

		Identify existing and potential sources for communications funding	
		Develop and implement media efforts to targeted audiences including an effective website; email distribution lists, newsletters; social media, multimedia, other new tools,	
		Seek additional support and financing to assist in having existing and future programme outputs and existing training material translated into the working languages of the region	
		Promote best practices for effective waste management including collection, recovery and disposal	
		Make all key content available in the working languages of the region	
		Create, compile and share best practices for communications and messaging	
		Host webinars for target audiences on relevant issues related to LBS	
		Work with GCFI to host a Marine Litter special session at the annual meeting in November.	
		Attend and present at relevant regional and international environmental meetings	
		Establish and maintain a publicly available repository for relevant material related to marine litter in the region	
		Highlight case studies within communication plan about marine litter advances and best practices	

6.4. Monitoring Research Theme

The Monitoring Research Theme recognizes that monitori8ng is useful for a number of critical activities. First, monitoring is necessary to udnestand how resources are changing either for better of for worse. This includes not only living resources but also the environment which support organisms and habitats.

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 a given management strategy. After a strategy is implemented, its effectiveness myust be evaluated and this must be done using a well-developed monitoring program.

The Monitoring Research theme identified three goals: 1) Increase monitoring activities related to LBS, 2) Increase Inputs from scientific research in monitoring activities related to LBS, and 3) increase inputs from stakeholder participation in monitoring activities related to LBS.

The sources for the research topics were derived from workshops conducted in association with the GCFI annual conference.

Fig. 11 | 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 exisiting 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
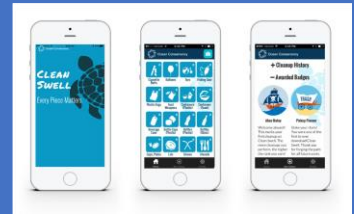
2. OSPAR – OSPA together with WWF has been testing the feasilbity of using the OSPAR approach to monitor litter in Bonaire. This approach has been used in coastal northern Europe and has a rigorous scientific protocol.
3. The US Environmental Protection Agency Trassh Free Waters – this is an international initiative but does not appear to be widespread in the WCR.
4. US NOAA Marine Debris Monitorig and Assessment Project – this is an intiative that does not have widespread use

Table. 4 | Objectives, indicators, measurements, research topics, and outcomes associated with the Monitoring theme.

	6.1.4. Thematic area: Monitoring Research		
Goal 1: Increase monitoring and assessment activities related to LBS			
Number	Objective	Research topics	Priority
M1.1	Establish a statistically valid pollution and marine litter monitoring program at national and regional levels	Identify and share opportunities for improving LBS monitoring and assessment programmes, laboratory strengthening and monitoring capacity, and technical training and assistance	
		Identify existing scorecards and adapt or create as appropriate	
		Implementation of harmonised monitoring and reporting	
		Recommending indicators to harmonize monitoring, report and assess methodologies, taking into account the key sources of LBS including plastic litter and microplastics in cooperation with relevant international organizations	
		Long-term monitoring of the effect of climate change on ocean circulation patterns, water masses formation and water exchanges through straits and the feedbacks on the climate	
		Identify and evaluate existing apps developed for citizen science LBS monitoring programs	
M1.2	Increase the proportion of coastal and marine areas being monitored/assessed	Conduct survey with regional partners to determine the existence of monitoring plans and their current status	
		Identify whether there are mechanisms in place to ensure national-regional monitoring interactions	
		Identify whether regional/subregional strategic plans are created for monitoring LBS	
M1.3	Increase investment dedicated to monitor pollution effects on coastal communities and coastal and marine biodiversity	Identify funding approaches to support monitoring activities	
		Identify potential partners and sources of funding for ongoing and new projects and activities in particular unfunded projects	
Goal 2: Enhance inputs from scientific research in monitoring activities related to LBS			
M2.1	Enhance science based monitoring in response to management goals and objectives	Develop harmonised monitoring protocols	
		Development of long-term datasets that track persistent change in the environment. The data from these datasets provides context for policy development around management actions, spatial and temporal planning	
		Identify an internationally recognised protocol for identifying microplastics in biotic and abiotic samples	
M2.2	Improve coordination and understanding of monitoring objectives and surveys	Develop harmonised monitoring protocols	
		Development of long-term datasets that track persistent change in the environment. The data from these datasets provides context for policy development around management actions, spatial and temporal planning	
		Appoint national and/or sub-national co-ordinators for monitoring activities	
		Identify opportunities for convergence between different marine research infrastructure projects, with a view to ensure that they respond better to societal and policy needs	
		Identify and secure funding for monitoring activities	
M2.3	Implement regional database for monitoring data	Review databases and determine if an existing database can be used, or if a new database needs to be created	
M2.4	Strengthen laboratories capable of conducting complex contaminants monitoring	Identify and survey laboratories to determine their ability to meet international standards for examining pollutants	
M2.5	Create progress in monitoring changes in circulation patterns due to contaminants and climate change	Long-term monitoring of the effect of climate change on ocean circulation patterns, water masses formation and water exchanges through straits and the feedbacks on the climate	
		Identify research to assess the role of sargassum as a transfer mechanism for marine litter	
		Identify how pollutants including litter are affected by changing conditions including acidification	
		Model the effects to individuals and populations resulting from climate-driven increased pollutant toxicity	
		Constructing usable climate change indicators improving the interface between science and policy	
Goal 3: Increase stakeholder participation in research and monitoring activities related to LBS			

M3.1	Involve stakeholders in pollution reduction decisions, actions and financing	Survey of marine pollution focused organizations	
		Identify potential partners and sources of funding for ongoing and new projects and activities in particular unfunded projects	
		Identify the domain of stakeholders involved in pollution reduction decisions, actions and financing	
		Evaluate the level of involvement of stakeholders involved in pollution reduction decisions, actions and financing	
		Develop an enabling environment for increased civil society and private sector investment in the prevention and reduction of LBS (including marine litter and microplastics)	
		Reduce the economic impacts from LBS	
M3.2	Develop effective and sustained citizen science programs	Convince government on the value of citizen science?	
		Identify social barriers to long-term commitments by volunteers	
		Identify or create accessible database for contributions for regional LBS data from citizen scientists	

6.5. Economic Research Theme

The Economic Research Theme integrates the societal drivers associated with commerce, trade, and economic well-being.

The Monitoring Research theme identified three goals: 1) Increase monitoring activities related to LBS, 2) Increase Inputs from scientific research in monitoring activities related to LBS, and 3) increase inputs from stakeholder participation in monitoring activities related to LBS.

The sources for the research topics were derived from workshops conducted in association with the GCFI annual conference.

Table. 5 | Objectives, indicators, measurements, research topics, and outcomes associated with the Economic Research theme.

6.1.5. Thematic area: Economic Research			
Goal 1: Mitigate the economic impacts from pollution			
Number	**Objective**	**Research topics**	**Priority**
E1.1	Reduce the economic impacts from LBS pollution	Evaluate the economic impacts of emerging issues such as: sargassum, ocean acidification, electronic waste, marine litter and micro-plastics on human health including identification of causes/sources, movement and sinks/hot spots (SOCAR)	
		Quantify the economic effects from chronic exposure to contaminants including microplastics on important commercial and recreational fish species	
		Identify and quantify economic impacts from pollution to multiple sectors	
E1.2	Increase the value of information on the assessmemnt of the impact of pollution on marine ecosystems and human health and the associated economic cost (SOCAR)	Identofy the direct links between the water quality observed at sampling sites and the impacts on humans at these sampling sites (SOCAR)	
E1.3	Improve the socio-economic quantification of pollution impacts on coastal communities and economically-valuable species.	Develop socio-economic study and funding support to quantify the effects of pollution on the social and economic well-being of coastal communities including the fishing sector	
Goal 2: Identify and develop improved solid waste management approaches			
E2.1	Assess the value of waste and identify potential markets	Develop models that anticipate trends and changes to market values of marine litter	
E2.2	Identify needs, barriers and gaps for solid waste management and assess the cost-effectiveness of each	Identify best use of technology to enable and support marine litter initiatives and remove counterproductive technology	
		Conduct risk assessments	
		Identify cost-effective, environmentally-friendly alternatives to existing products and technologies	
		Identify approaches for cost effective management of ship-generated waste	
		Identify case-studies that reduce excess and/or unnecessary consumer product packaging and assess the economic benefits of each approach	

7. Towards a Cleaner CLME+ Region – Recommendations for Implementation

Implementation of strategies is often the most difficult part of the process associated with achieving a goal – in this case, reduction of LBS pollution. To overcome barriers to implementation, it is often necessary to map those barriers and to tackle each one in a strategic and methodical approach.

The following points should be considered and lead the process towards the implementation of a strategy on LBS in the Caribbean Sea:

- LBS protocols are available for most geographical areas of the Caribbean; however, the greatest difficulty is that the protocols need to be adjusted to match regional needs and distribution of pollutants

- LBS protocols are available for the above indicators but with different levels of information at the country level

- The science and monitoring strategies must be coordinated, compatible, coherent, consistent and comparable.

- Science strategies need to adaptable and able to react to changes in the marine environment and in governance in response to emerging issues.

- Knowledge about the amount and distribution of LBS at the country and regional level in many crucial environments is still insufficient. Pilot studies could guide us a better design of future monitoring, and thus provide cost-efficient alternatives in the long run.

- Data acquisition should be organized effectively between government agencies, stakeholders, NGO' and scientific research community

- Development of a research funding consultation or portal to identify funding opportunities to address future LBS national and regional research and development needs.

8. Conclusions

Pollution is recognized as one of the more insidious threats impacting the ecological and socio-economic ecoystems in the CLME+ region. Ecosystems have changed, biodiversity has been reduced, and livelihoods have been affected. Policies need to be adopted that can ensure that the effects from this anthropogenic source are mitigated.

8.1. POLLUTION SCIENCE

There are several marine debris-oriented policy approaches that have taken form around the world and in the CLME+ region, from banning plastic bags to sponsoring clean-up technology. However, it is clear that there is an urgent need for new regional and national approaches to limit LBS marine pollution. Though there has been some progress made on identifying, measuring, and responding to the problem, there is no existing regional approach and researchers and policy-makers are still learning about the damaging impacts of microplastics and nanoplastics and other less-surveyed and studied aspects of this issue. For example, we need to know more about the foodweb transfer, the pernicious effect on metqapopulation dynamics, and ecotoxicological impact of microplastics, Additionally, the effects are just emerging relative to persistent organic pollutants including endrocrine disruptors, metals and plastic additive chemicals, on marine ecosystems. We also need to explore further the impact of microplastics on transport of viruses and bacteria.

There are two types of knowledge gaps in the region pertaining to pollution science. First, there is a real lack of scientific information required for managing and reducing marine pollution in the region. This includes information on pollution hotspots, and on how and where pollution is attenuated on land, in rivers, and in the sea. Second, there is a perceived lack of information. This is information that does exist but is not widely known or available in the region or is not in a useable form. This type of information includes knowledge on clean technologies for industry and treatment of wastes, and best practices for agriculture and aquaculture among others.

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 Existing programs or arrangements have not provided enough incentives for LBS control by way of information exchange, technical cooperation, and funding assistance. The main reason for this gap is the lack of adequate funding, mostly at the national level, since most of the developing countries in the CLME+ region cannot address LBS issues without special financial incentives and international assistance. Thus, protection of the marine environment from LBS pollution has been limited for funding reasons.

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.
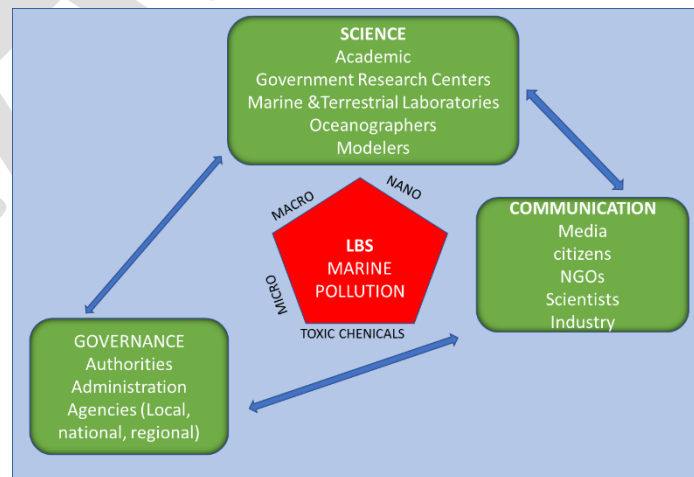

Figure 12| Schematic of interconnected parts and paths of the LBS issues, and how we can connect science, governance and communication.

8.2. GOVERNANCE

The issue of LBS pollution has raised the profile of marine degradation in general and has brought the wider issue of pollution and marine waste into focus at the global, regional and local level. One of the most

pressing issues over the next decades will be to ensure that human activities are carried out (managed) in a sustainable way. More multidisciplinary and cross-sectoral research involving science, technology, service providers, industries, policy makers, and society is required to develop the knowledge needed to understand the risks and environmental impacts of different economic uses of the sea (e.g. shipping, fisheries, aquaculture, tourism, marine structures, oil production) and other pressures such as pollution from land-based sources and the effects on the marine and coastal environment.

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.

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

Many of the problems of pollution associated with industry, runoff, aquaculture, treatment plants, tourism and other developments could be minimized through proper use of 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.

The current existing legal and policy framework at the international, regional, national, and local levels does not provide a comprehensive global strategy that adapts to industry innovation and emerging scientific evidence, and does not provide a collaborative platform for all stakeholders and polluters. (UN environment, 2017). The UN environment report on plastic litter and microplastic (2017) 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.

Another important governance issue facing the WCR is related to communications (i.e., citizens' abilities to access information). Poor access to LBS and marine pollution information means people don't have basic information about what's in the water and air upon which their communities depend. Without information, the public's ability to participate in key decision-making processes—such as 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.

There is also a recognized need to empower local governments. Local governments need better capacity and incentives to undertake their role as local pollution managers. National governments need to consider ways of increasing human capacity, improving

working conditions, and improving the facilities and mechanism for funding LBS operations.

This strategy 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. There are still existing gaps related to science, governance and lack of capacity.

8.3. COMMUNICATIONS

Dissemination of information is acknowledged as an important component of the research process. Designing and implementing a successful communication strategy is essential for the achievement of effective and timely communication of research results. The key issue of success of a dissemination tool 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. Effective communication enhances the impact of a project and the possible uptake of the results. Therefore, the communication strategy of a research project should be discussed in detail and the various phases of the communication strategy.

Designing and implementing effective public policies and projects to address the impacts require active stakeholder participation, huge financial investments, political will and valid technical analysis (Ramachandran et al 2014). Despite increased demand for technical projects and analysis, there is an increased recognition that much of the analysis produced are not being effectively converted in to policies, plans and projects that can prevent or reduce negative environmental, health and economic impacts such LBS pollution [Ramachandran et al 2014; Pielke, 2007; Slaughter and Rhoades,2005; Van Kerkhoff,2005].

The flow of communication of science to policy makers and stakeholders will be facilitated by addressing the differences in language used, and the understanding between scientists, managers and stakeholders. In addition, including policy makers and stakeholders in all stages of Research, Development and implementation activities (definition, development, management and dissemination of outcomes), so as to ensure that their communication needs are met.

Each stakeholders group has specific characteristics and needs in terms of information related to LBS pollution. It is important to identify these information requirements and gaps to design an adequate communication strategy. Engage Community groups and NGOs in pollution awareness; NGOs have been focusing on pollution in the WCR region for a long time, however, there is scope for them and other community groups to take more of a role in large-scale awareness, as watchdogs, and for bringing small-scale innovative technology to communities.

Building large-scale awareness is one of the most effective ways of providing the basis for action on issues of LBS of pollution in the region is through 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 (such as fishermen, farmers), and all levels of civil society.
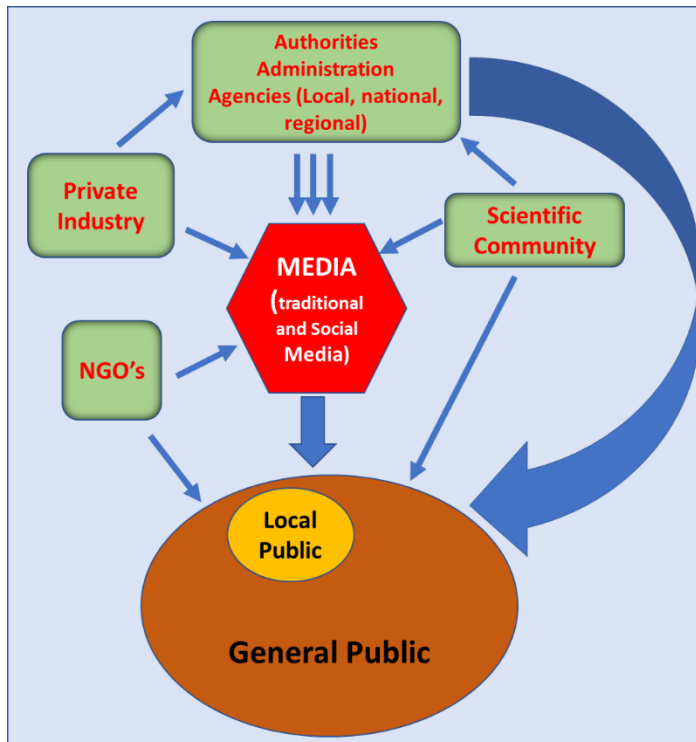
Figure 13| Flow of information among stakeholders. Modified from Ampera 2007.

8.4. MONITORING

Overall, the successful implementation of componenets within the monitoring research theme depends on a high level of cooperation between CLME+ Member States, and other countries and regional bodies mandated with environmental and LBS pollution protection responsibilities. Monitoring programs need to be compatible within marine regions or national levels and monitoring methods need to be consistent to facilitate comparability of monitoring results. Implicit in the proposed research topics within this theme are the understanding that standardized methods for monitoring and assessment should be adopted thus putting the responsibility of the activities in the WCR countries, through coordination by the Regional bodies such as UNEP/CEP.

Nevertheless, important questions need to be addressed to meet the requirements of the research topics within the theme including some basic questions such as:
 (a) what are the types of monitoring currently in place?
 (b) who does what and how?

 (c) is the monitoring designed, or at least sufficiently robust, for purpose of addressing the LBS pollution? and
 (d) what are the impediments to better monitoring (e.g., fiancial, shared responsibilities between countries, governance, cooperation)?

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

Siung-Chang (1997) reported that these efforts started in 1975 with the United Nations Economic Commission for Latin America and the Caribbean (ECLAC). She conducted studies in Barbados, Guyana and Trinidad and Tobago, to make an inventory of problems of the environment (ECLAC, 1975). 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-explicit 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.

Although, we can generate a WCR spatial and temporal assessment of LBS pollution, there are still gaps which need to be further addressed. For example, there is an uneven distribution of LBS monitoring activities. This uneven distribution of monitoring activities at spatial (sampling sites and stations) and temporal (sampling interval and frequency) scales. Additionally, in some cases monitoring programs

addressed only a specific target (e.g., a pollutant, habitat, species, pressure) resulting in an uneven distribution of monitored components (i.e., not all components are monitored in all countries).

Integrated monitoring (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 the Ecosystem-based approach, remains a central pillar of this theme (Elliott, 2014).

8.5. EMERGING THREATS

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 inclduign those associated with nutrient run off, oil spills, mercury and other heavy metals, and radioactive substances. Emerging issues now focus on plastic debris including microplastics and microfibers. 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.
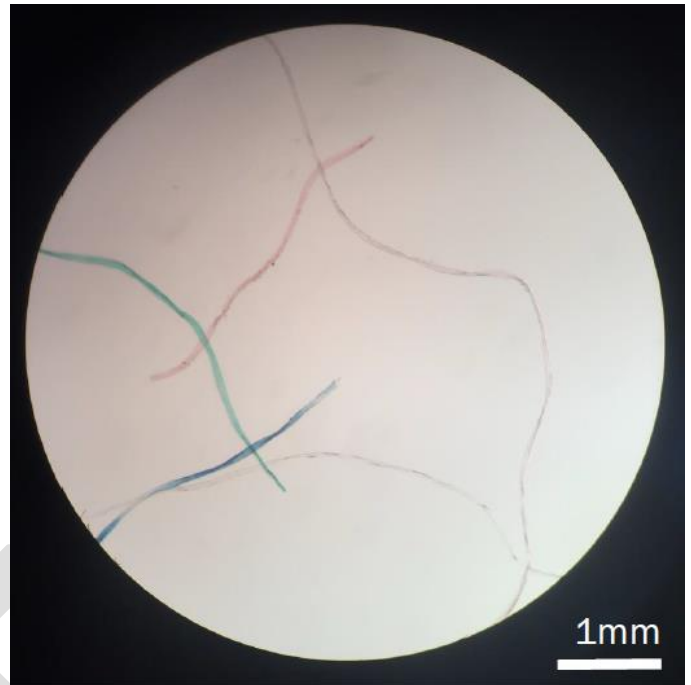
Finally, as the earth's climate changes, so too will the impacts associated with pollution as well as the effects on society. Inevitably, this will require a strong focus on developing adaptive capacity for ecological and social systems; building resilient systems will be necessary. It is also inevitable 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 change. How society addressed these changes will dicatate 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.

Figure 13| Microfibers collected from fish samples in Grenada. Photo courtesy Michelle Taylor, St. Georges University.

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ACRONYMS

CARICOM Caribbean Community and Common Market	Integrating Water, Land and Ecosystem Management in Caribbean Small Island Developing States (GEF)
CBO Community-Based Organisation	**LBS** Protocol concerning Pollution from Land-Based Sources and Activities (Cartagena Convention)
CCAD Central American Commission for Environment and Development	**LME** Large Marine Ecosystem
CEP Caribbean Environment Programme (UNEP)	**LMR** Living Marine Resources (CLME Project)
CERMES Centre for Resource Management and Environmental Studies	**MARPOL** International Convention for the Prevention of Pollution from Ships
CFMC Caribbean Fisheries Management Council	**MCS** Monitoring, Control and Surveillance
CITES Convention on the International Trade of Endangered Species	**NAP** National Action Plan
CLME Caribbean Large Marine Ecosystem	**NBSLME** North Brazil Shelf Large Marine Ecosystem
CLME+ Caribbean and North Brazil Shelf Large Marine Ecosystems (CLME Project)	**NGO** Non-Governmental Organisation
CRFM Caribbean Regional Fisheries Mechanism	**NPOA** National Plans of Action
DSS Decision Support system	**OECS** Organisation of Eastern Caribbean States
EAF Ecosystem Approach to Fisheries	**OSP** Oil Spills Protocol (Cartagena Convention)
EBM Ecosystem-based Management	**OSPAR** Convention guiding protection of marine environment in northeast Atlantic
EcoQO Ecosystem Quality Objective (CLME SAP)	**OSPESCA** Central America Fisheries and Aquaculture Organisation
FAO-WECAFC Food and Agricultural Organisation of the United Nations - Western Central Atlantic Fisheries Commission	**PCU** Project Coordinating Unit of the CLME+ project
GCFI Gulf and Caribbean Fisheries Institute	**REMP** Regional Environmental/Ecosystem Monitoring Programme (CLME Project)
GDP Gross Domestic Product	**RFMO** Regional Fisheries Management Organisation
GEF Global Environment Facility	**RGF** Regional Governance Framework (CLME Project)
GPA Global Programme of Action for the Protection of the Marine Environment from Land Based Activities	**SAP** Strategic Action Programme (CLME Project)
ICCAT International Commission for the Conservation of the Atlantic Tuna	**SBO** Societal Benefits Objective (CLME SAP)
ICM Integrated Coastal Management	**SD** Strategic Direction (CLME SAP)
IGO Inter-Governmental Organisation	**SGP** Small Grants Programme (GEF)
ILO International Labour Organisation	**SIDS** Small Island Developing States
IMO International Maritime Organisation	**SLMR** shared Living Marine Resources (CLME Project)
IOC Intergovernmental Oceanographic Commission of UNESCO	**SPAW** Specially Protected Areas and Wildlife Protocol (Cartagena Convention)
IOCARIBE IOC UNESCO Sub-commission for the Caribbean Sea and Adjacent Regions	**TDA** Transboundary Diagnostic Analysis (CLME Project)
IUU Illegal, Unreported and Unregulated fishing	**UN** United Nations
IWECO	**UNDP** United Nations Development Programme

DRAFT

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ANNEX 2 – RESULTS OF WORKSHOP ON LBS INDICATORS

Table 1. Indicators for Gaps in Governance

A total of 26 indicators or threats were identified associated with governance. The numbers at the top of the table represents the breakout group number. The numbers in the table represent the number of people in each group identifying that indicator as being important.

Group Number	1	2	3	4	Total
Indicator					
Integration of policies across sectors	2	3	1	3	9
How to deal in geopolitical complexity for enhanced regional governance	6	0	1	1	8
Science: low end solutions, reliable, tailored to regional reality (SIDS)	2	0	3	1	6
Stable long-term policies	0	1	5	0	6
How to identify and achieve consensus on what is best available information (results from science and empirical field information)	1	2	2	1	6
Best practices for public-private partnership engaging scientist form companies to enhance products	0	2	2	1	5
What are the main sources (micro plastic, sewage) priorities for governance	3		1	1	5
How to engage non-contracting parties	0	1	1	2	4
Deficiencies in E/A processes	3	0	0	1	4
How to increase capacity "across borders" institutional	0	1	0	3	4
How to engage bottom-up/better engage grassroots groups in governance	1	2	0	1	4
Research incentives at different geopolitical levels to make contribution to positive change	2	0	1	0	3
Best practices for including fisher folks in governance processes	1	2	0	0	3
Transboundary issues	1	0	1	1	3
How to complete (bottom-up; top-down; transversal) continuum enhance at all levels	0	3	0	0	3
Research on "byproducts" of processes (life cycle)	0	0	2	1	3
Regional systems of marine laboratories (AMLC)	0	0	0	2	2
Analysis of current legislation, how to Harmonize	0	1	0	1	2
Defining common languages/terminology across P-PP	0	0	0	2	2

Research of how to bring "interactive governance" into practice: CLME +RGF	0	0	2	0	2
Identify investment needs	0	0	1	1	2
We know source/problem; but not the solution	0	1	0	0	1
How to establish regional database	0	1	0	0	1
Redefine "Waste"	0	0	0	1	1
What governance arrangement is needed:	0	0	0	0	0
Research in taxes, subsidies (import, export, stressors)	0	0	0	0	0
Total Rank	22	20	23	24	89

Table 2. Indicators for Gaps in Communication.

Four indicators or threats were identified during the workshop. The numbers at the top of the table represents the breakout group number. The numbers in the table represent the number of people in each group identifying that indicator as being important.

Group Number	1	2	3	4	Total
Indicator					
Communication Targets	8	3	3	0	14
Millennials	1	1	0	1	3
Public	0	1	0	1	2
Special interest groups	0	0	0	0	0
Managers					0
Policy makers	3	0	0	1	4
Scientists				1	1
Communication educators	1	1	1	1	4
					28
Communication strategies	5	5	3	3	16
Value	1	0	0	0	1
Networking map-local	1	2	0	1	4
Specialist in communication	0	0	3	0	3
Sensitive information	0	0	0	1	1
					25
Communication Delivery	3	4	3	4	**14**
Methods	0	0	0	0	0
Opportunity	0	0	0	0	0
					14
Financial resources		5	9	7	**21**
Total rank	**23**	**22**	**22**	**21**	**88**

Table 3. Indicators for Gaps in Monitoring
8 indicators or threats were recommended during the workshop.

Group Number	1	2	3	4	Total
Indicator					
Why monitoring					
Knowing the purpose of monitoring	5	3	0	2	10
Standardize the identification	1	0	0	0	1
Establish baselines	0	0	0	2	2
Define terms: Monitoring, survey, assessment	0	1	0	3	4
How to monitor					
Holistic approach to monitoring	0	3	0	0	3
Data standardization	2	3	2	1	8
Survey Design sampling	0	0	0	0	0
Holistic approach to monitor sources of pollution	1	0	0	0	1
Standardization	0	0	1	0	1
Sampling/survey design	1	0	2	1	4
Low-cost Technologies	0	0	0	1	1
Intercalibration	0	0	0	1	1
When and where to monitor					
Spatial Coverage of monitoring	0	0	0	0	0
Time-series monitoring, not only snapshots	0	0	1	1	2
Identify different objectives and timescales	0	0	0	0	0
Scale: broad to specific	1	2	1	1	5
Local to regional	0	0	0	0	0
What to monitor					
Having correct indicators and common baselines	6	0	0	0	6
Link between variables and synergetic effects	0	0	1	0	1
nutrient monitoring and impacts	0	0	1	0	1
Impacts on Health and Income	0	1	0	1	2
Monitoring not only for science (impacts)	0	2	0	1	3
Monitoring not only for science (effectiveness)	0	0	1	0	1
Government and public capacity					
Private sector investment and capabilities	0	0	0	0	0
Government funding	1	1	1	1	4
Citizen science	0	0	1	1	2
Social Perceptions	0	1	0	0	1
Perception of the public to problems	2	1	0	0	3

Accountability of regulation	0	0	0	1	1
Laboratory capacity	0	0	1	0	1

Lack of information

Gaps in the analysis	2	2	0	0	4
Identifying the main problems	0	3	0	0	3
Identify priority risks	0	0	0	1	1
Unused data, lack of capacity to analyze data	0	0	0	0	0
Skills in Bioinformatics	0	0	0	0	0
Biochemical indicators	0	0	0	0	0

Other

No need for standardization	0	0	0	0	0
Situation change by location	0	0	0	0	0
Geographic info on pollution	0	0	0	0	0
Total Rank	**27**	**28**	**21**	**24**	**100**

Table 4. Indicators for Gaps in Pollution

8 indicators or threats were recommended during the workshop.

Group Number	1	2	3	4	Total
Indicator					
Feasibility/ business cases for investment in pollution reduction/prevention	7	2	1	3	13
Quantifying economic impacts of pollution on society	3	10	3	2	18
Identifying sources of contamination from multiple stressors	8	3	2	3	16
Impacts of pollutants on ability of ecosystems to sequester carbonate	0	0	1	0	1
Understanding sources of pollution	1	2	2	4	9
Developing pollution criteria standards	2	2	3	3	10
Research on policies to incentivize private sector	1	3	8	3	15
Research on impacts of emerging contaminants (hormones, noise pollution)	0	2	4	6	12
	22	24	24	24	94