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A large marine ecosystem governance framework

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Abstract

A large marine ecosystem (LME) governance framework, developed from a need to effectively address the sustainable management of the shared living marine resources of the Caribbean, is proposed. The framework is based on four propositions and focuses on a linked examination of two well-known components of LME-level governance: the policy cycle process by which decisions are made and the multi-level nature of LMEs. It accommodates the diversity of policy cycles at multiple levels and the linkages among them required for effective governance of LMEs. The framework takes into account of factors such as context, purpose, jurisdictional scale, capacity and complexity and provides a means to identify critical areas for intervention.
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1. Introduction and rationale

In the past two decades there has been a shift in the governing concept for the world's natural renewable resources from perceiving them strictly as commodities towards appreciation of the full range of goods and services that ecosystems can provide [1,2]. This has led to a new focus on restoring and maintaining ecosystem function while allowing for sustainable use and to increased emphasis on ecosystem-based management (EBM) at appropriate scales [3–5]. In the marine environment, 64 large marine ecosystems (LMEs), defined on the basis of bathymetry, hydrography, productivity and trophically-interdependent populations have been proposed as ecologically rational units of ocean space in which EBM can be applied [6]. These areas of ocean space, in the order of $200,000 \, \text{km}^2$ or greater are primarily coastal and include many of the world's enclosed and semi-enclosed seas [6].

LMEs produce about 90% of the world's total marine fish catch, which provides some US$50 billion annually in international trade [7,8]. However, most of these LMEs have been overexploited, with declining catches and major shifts in biodiversity [9]. These LMEs are also where most of the world's land-based and ocean-based pollution and habitat alteration take place. These impacts arise primarily from anthropogenic factors such as the exponential growth of coastal mega cities, the industrialization of large scale agricultural practices, increased atmospheric deposition from the burning of fossil fuels and marine-based transportation of hazardous goods [10–12]. With an estimated US$10.6 trillion per year of renewable goods and services at risk, it has been argued that LMEs are an appropriate scale at which to integrate and mobilize national and multi-national level efforts for EBM [13,14].

A modular approach to LMEs has been developed to facilitate LME level EBM [15]. The five modules use suites of indicators to assess and monitor key ecosystem attributes. Three of the modules are natural science based (productivity; fish and fisheries; and pollution and ecosystem health), another is focused on assessing the socioeconomic benefits to be gained from the sustainable management of the ecosystem goods and services and the fifth on assessing the governance mechanisms needed to support EBM.

With respect to governance, defined as the ability to get things done without necessarily having the legal competence to command that they be done [16], much has been written on theory, effectiveness and recommendations for enhancement [17–20]. However, little guidance has been provided on how actors might practically bring about beneficial change and, as noted by Sherman et al. [14], development of this module has lagged behind the others. Nonetheless, the five-module indicator-based LME approach has been deemed useful for LMEs around the world [14,21].

The LME approach has led to a suite of projects that are being implemented throughout the world to promote integrated marine ecosystem governance of LMEs [14]. One of these, currently in development for the Caribbean Sea and adjacent regions (CLME Project), led us to examine the applicability of the LME modular approach to governance. In our view, further elaboration is needed to provide an adequate basis for interventions to enhance governance appropriate to networks of actors within the Caribbean LME. In order to address this gap for the CLME Project we offer a complementary governance framework that provides the needed basis for effective interventions at the LME level. The framework may also be applicable outside the Caribbean.

2. The Wider Caribbean context for the LME governance framework

The Wider Caribbean Region, as defined by the UNEP Regional Seas programme and adopted by several regional initiatives, extends from the northeast coast of Brazil to Cape Hatteras and includes all coastal states in between (Fig. 1). It is one of the most geopolitically complex regions in the world. Its countries range from among the largest to the smallest, the richest to the poorest and the most
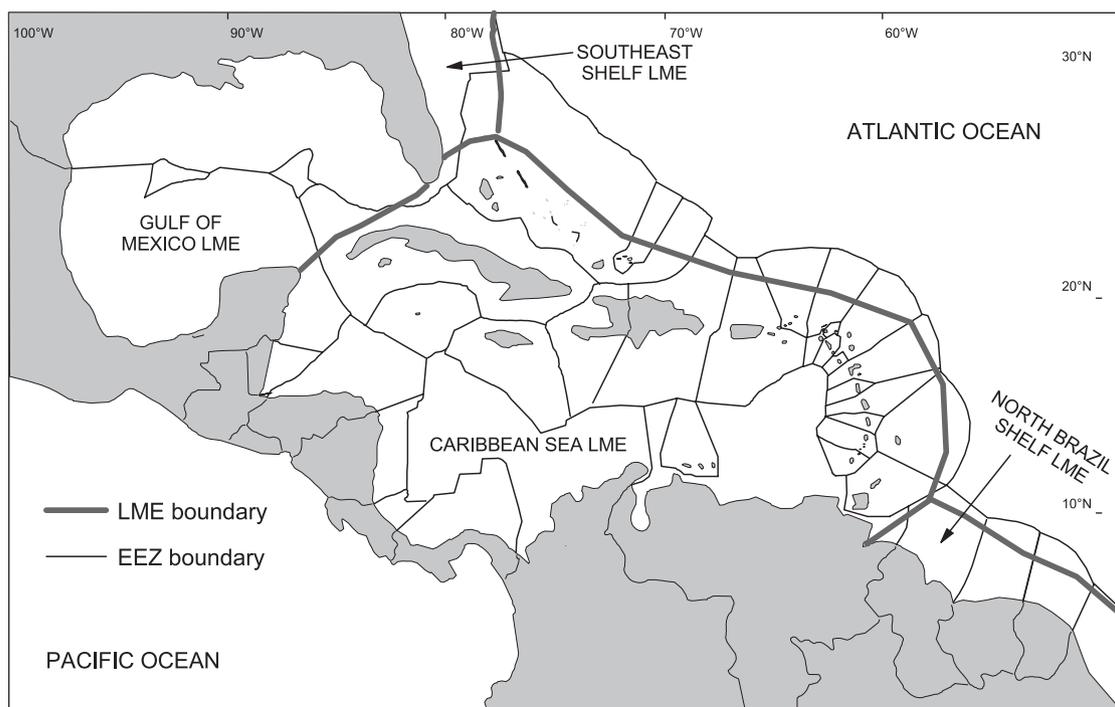

Fig. 1. The hypothetical EEZs and LMEs of the Wider Caribbean Region.

developed to the least developed. There is a complex colonial legacy from European countries, including five official languages in the region (English, Spanish, French, Dutch and Portuguese) as well as indigenous cultural elements. The region encompasses four LMEs [6]: the North Brazil Shelf LME, the Caribbean Sea LME, the Gulf of Mexico LME and the Southeast United States Continental Shelf LME (Fig. 1). The Caribbean LME Project focuses on the first two, covering an area in excess of two and a half million km^2 and including the second largest sea in the world.

Many living marine resources (LMR) in the Caribbean LME are in crisis. Most of the fishery resources are coastal and are intensively exploited by numerous small-scale fishers [22]. Most of the 100 million people in the Wider Caribbean region live in coastal communities and depend on LMR for employment and food. There is also high demand for seafood in the tourism industry, a mainstay of the economy in many of the countries. These pressures have led to widespread depletion of resources. This depletion has led to increased dependence and fishing pressure on offshore resources, which are already considered to be fully, or overexploited [23]. In addition, LMR such as corals and other components of biodiversity that are extremely important for tourism economies and coastal defense against sea level rise and storm surges are severely degraded by human activity and require urgent attention for restoration [24].

The countries of the Caribbean have repeatedly indicated the need for attention to shared LMR management at the regional and international levels through participation in regional arrangements and through signing various international treaties and agreements [25]. To address this need, the Global Environmental Facility (GEF) has funded a region wide effort to develop a full project proposal with a focus on management of shared LMR. The CLME Project proposal will address the need for EBM of shared LMR in the Caribbean Sea and adjacent regions and for mechanisms facilitating informed decision making, based on sound natural and social science. It aims to build on and complement existing projects and initiatives that emphasize technical and institutional aspects of sustainable LMR use by focusing on governance, knowledge and institutional issues in a transboundary marine context. The project includes 26 countries of the Wider Caribbean Region and will seek to engage 19 associated territories of France, the Netherlands, United Kingdom and the United States. Primary stakeholders are the national government departments responsible for fisheries, marine affairs, and environment and the principal beneficiaries will be resource users. National and regional marine research institutions and universities will have a significant role to play in generating information and capacity building. Partnerships at the national, regional and international level with civil society, the private sector, governments, agencies and organizations are considered essential success parameters for the CLME Project.

However, the reality of Caribbean governance is a diversity of networks of actors serving various purposes that seldom intersect effectively. Notably absent in most cases are interactions at the critical stage of communicating analysis and advice to shape coordinated decision making. Thus, the importance of having a framework that focuses on critical nodes for effective LME governance and on strengthening linkages across multiple levels became increasingly evident. Most countries also lack capacity, and there is seldom a clear mandate by any national, sub-regional or regional level institution for management policies that address integration among sectors.

3. Trying to apply the LME modules in the Caribbean

In light of the diverse, complex and dynamic situation described above within the Caribbean LME, we examined the LME 5-module approach as a potential framework for addressing LMR governance. The modular approach with its suites of indicators was considered insufficient for the Caribbean LME in two important ways. First, it has a bias towards science-dominated top-down governance. We recognized that though important for guiding sound decision-making, knowledge-based assessments of biophysical and socioeconomic LME components will be under-utilized or even unusable if there are no governance mechanisms in place to facilitate their uptake. In the Caribbean, many resources and resource situations are such that the revenues generated cannot support substantial technical assessments thus calling for alterative approaches [26]. Second, whereas the modules can provide a framework for application of indicators for assessment and monitoring, they do not provide a comprehensive framework within which interventions can be developed and implemented in a coordinated way that can be communicated to all actors so that they can see where they fit into the framework.

A recent elaboration of the governance module for LMEs provides a variety of normative guidance as to what should occur for there to be good governance, but still does not provide the governance framework that we perceive as being required to address the complex Caribbean situation [20]. In fact, we argue that rather than being one of the five modules to be undertaken in LME management, governance is overarching and needs to be rigorously examined at the outset of any effort to implement EBM. Viewing governance as overarching also provides the opportunity to separate the 'governing system' from the 'system to be governed', even though there may be many actors in common, and allows us to look at the relationship between them [19,27]. This is what the proposed framework attempts to provide as it interprets effective governance to be determined by a set of nested and laterally linked institutions and actors that are both governmental and non-governmental.

4. A policy cycle, multi-scaled governance framework

Here we describe a framework that we believe provides for the processes and linkages at the multiple geographic and organizational scales that prevail in the Caribbean. In addition to addressing the diversity and complexity inherent in an LME such as the Caribbean, the framework must also account for the range of policy-relevant activities practiced by a diversity of stakeholders who are influenced by, and who exert influence on, decision-making at multiple levels. To be appropriate for use, it should provide all actors with the opportunity to see how their actions can affect the sustainable management of the shared LMR of the Caribbean LME. It should also provide guidance on the identification of critical areas and timing for interventions and for an assessment of the success of such interventions.

The framework is parsimonious in that it comprises only two well-known components of LME governance: the process by which decisions are made in any governance regime, i.e. the policy cycle, and the multi-scale nature inherent in LMEs, be it jurisdictional, spatial, temporal or ecological. In proposing it, we note that it is based on standard principles and values for governance: transparency, accountability, equitability, sustainability and participation. We also note that the proposed framework is not so much an original construct as it is an identification of an existing weakly structured, self-organized framework and the provision of ideas on how to strengthen and enable it by focusing on properties that would be essential for LME level EBM.

4.1. The policy cycle component

The foundation for the proposed framework is a generic policy cycle (Fig. 2); an iterative process that should lead to incremental improvement in management [20]. The different stages in the cycle—data and information, synthesis and provision of advice, decision-making, implementation, and review and evaluation—require different inputs and actors, although there is overlap.
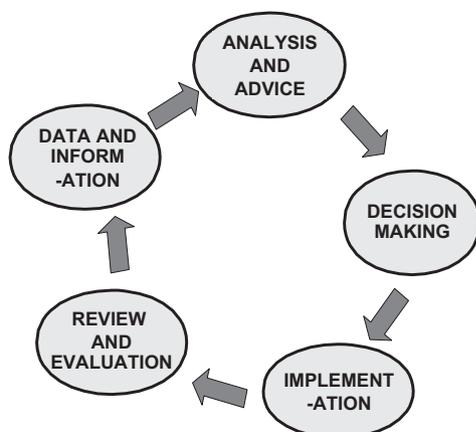

Fig. 2. A generic policy cycle used for the proposed LME governance framework.

The 'data and information' stage is where much of the science and technical input takes place. This information ought to be interdisciplinary and may range from highly technical, science-based to local/traditional knowledge provided by stakeholders either informally or formally. We consider this to be the primary area where the LME technical modules of productivity, fish and fisheries, pollution and socioeconomics make their contribution to the governance process.

The 'analysis and provision of advice' stage is likely to be closely related to the 'data and information' stage in terms of actors involved and also draws on technical expertise. Nonetheless, situations within the Caribbean and elsewhere can be envisaged where a different suite of actors may be charged with interpreting data and information for decision-making. This stage is purpose oriented and driven by problems and issues identified elsewhere in the cycle and compiled in the 'review and evaluation' stage. Its purpose is to provide specific policy and management options and recommendations to decision-makers in the next stage. Principles that are prominent in the 'analysis and provision of advice' and 'decision-making' stages are: (1) the use of the best available scientific information in formulation of advice, (2) that implementation should not be delayed for lack of information, and (3) application of the precautionary principle. In these stages of the cycle, the four LME technical modules contribute to governance while the governance process itself determines the consequences of the analysis and advice being provided and the decisions reached.

The 'implementation' stage may be the least directly connected to the previous stages and will involve the full range of tools and activities that are familiar to natural resource managers for achieving compliance, either voluntary or enforced, as appropriate to the particular situation. These include legislation, monitoring, control and surveillance (MCS), incentives and capacity building. The 'review and evaluation' stage completes the cycle and mainly feeds back into 'data and information' needs, but can also provide direct inputs across the cycle into 'analysis and advice' if policy changes are called for.

Clearly, this is a simplified depiction of the cycle, of which there are many variations. The various stages often overlap in function as actors play roles in more than one stage. There may also be cross-links that bypass various stages for some parts of the process [28]. We do not perceive these variations as compromising the cycle. What we consider to be important is that the cycle be complete and iterative. This leads us to our first proposition: '*Any interruption at any stage of the policy cycle will result in dysfunctional governance of the target resources or ecosystems*'.

4.2. The multi-scale multi-level component

For effective governance of LMEs, the policy cycle described above must be operational at several scales and levels [29,30]. The most obvious of these are local, national,
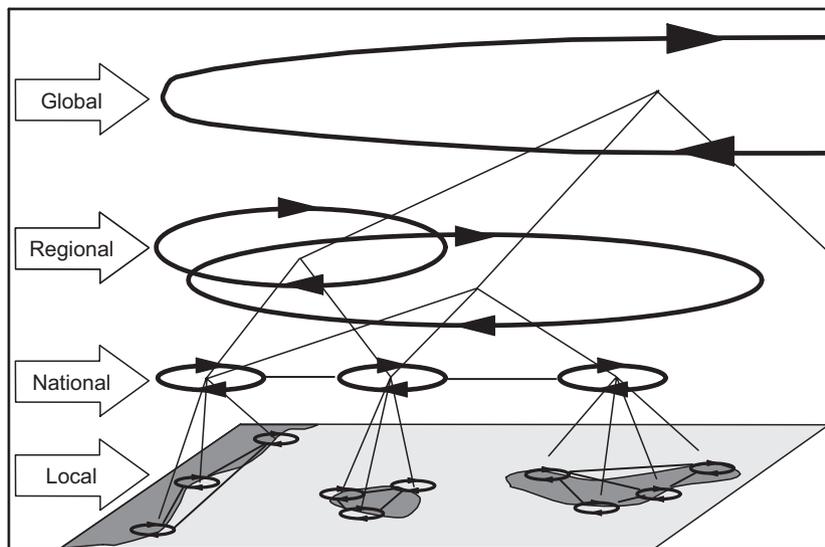
Fig. 3. The multi-scale component of the proposed governance framework with vertical and horizontal linkages among the different policy cycles. The multi-level linkages do not necessarily imply a controlling function.

regional (LME region) and international, in which jurisdictional and geographical scales are correlated (Fig. 3). Depending on the size of countries involved and the particular LME, there may be other levels such as between local and national (provincial) in large countries and subregional, involving subsets of countries within the LME. For simplicity, we limit our discussion to those in Fig. 3. Discussions of scale in natural resource management often focus on the degree of match between institutional scale and the scale of the resource that it is to be managed [31,32]. In the proposed framework, our attention is primarily on jurisdictional scale and the relationships between levels while acknowledging the importance of the fit of these to the systems to be governed as a matter to be taken up during implementation. The multi-scale framework facilitates application of the subsidiarity principle by allowing for implementation of governance at the scale that is closest to the problem to be addressed [33]. It also recognizes that resource governance regimes operating at different jurisdictional levels are scale dependent and that tensions arising from cross-level interactions will tend to increase with the degree of scale dependence [34].

The policy cycle described in the previous section may occur in a wide variety of forms determined by several factors that will be explored later. At this point we wish to emphasize that cycles at different jurisdictional levels have different roles in the proposed framework, each of which is necessary but not sufficient for LME level EBM. Consequently, linkages between jurisdictional levels are essential (Fig. 3). These are bidirectional linkages that may or may not include control and are also referred to as interactions in the interactive governance approach [19]. When the linkages are predominantly controlling from upper to lower levels, the system is a conventional top-down hierarchy. Another situation is where the linkages are predominantly for communication and cooperation. This is essentially a network structure where the linkages facilitate self-organization, which may be negative or positive relative to the goal of sustainability. The latter structure appears to be more likely in LMEs with numerous levels in geographic and jurisdictional scales. Network linkages are also typically diverse and dynamic [35]. They may simply be for sharing of data and information which can either be offered or sought. Alternatively, they may be used to share ideas and concepts including principles and values. Even further, they can be used for joint decision-making [35].

Different kinds of interactions are likely in each direction. For example, there is likely to be a downward flow of information on analysis, rationale and decisions from each level to the level below. However, flows in the other direction are equally important. They can provide information on what is desired and feasible. These flows can lead to cross-scale relationships that are mutually sustaining in the long term, being neither exploitative from above nor parasitic from below [28]. We see these upward and downward linkages in the multi-scale system are an integral component of a functioning LME governance framework. This leads us to the second proposition: 'Vertical linkages between functional policy cycles are necessary for effective LME governance.'

4.3. Dimensions of diversity in policy cycles and linkages

The proposed policy–cycle-based, multi-scaled LME governance framework recognizes that there will be a diversity of policy-cycle types and linkage types, and provides for this diversity to be accommodated within a single framework. The diversity of individual and organizational policy-cycle actors from multiple jurisdictional levels is illustrated in Fig. 4. The nature of a policy cycle may vary according to factors that determine character-
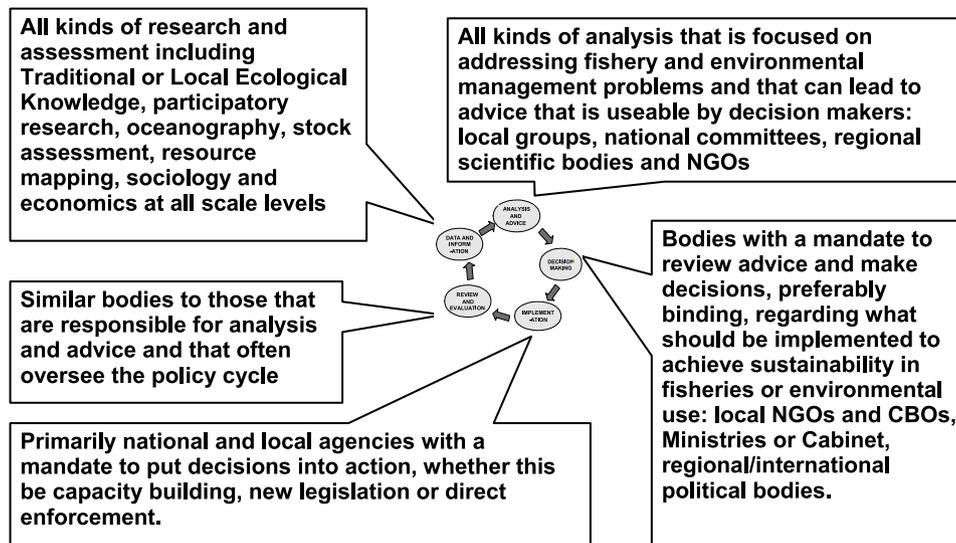
Fig. 4. The diversity of stakeholders that may be involved in the policy cycle depending on cycle stage and scale level.

istics such as the degree of stakeholder participation or formality of arrangements. Factors that we have identified within the Caribbean LME as influencing the nature of a policy cycle include: the sociocultural/political context; purpose; jurisdictional scale; capacity, and complexity.

4.3.1. Sociocultural and political context

The sociocultural and political context of the community, country or region in which the policy cycle occurs will determine many of its characteristics. Whereas the establishment of common principles and values for natural resource and environmental management can be pursued throughout an LME at upper jurisdictional levels, the way in which these are approached nationally and locally must fit cultural norms if governance is to be effective. For example, the importance of fish in the diets of Caribbean nationals will affect the decisions taken and implemented at local levels. These actions could undermine national and regional conservation efforts if the local cultural norms are ignored. Sensitivity to cultural norms and a shared awareness of threats to their continuation can encourage support for harmonized policy cycle arrangements across jurisdictional levels.

4.3.2. Purpose

Policy cycle arrangements related to LMR governance may be in place for a variety of purposes: to address fisheries sustainability, biodiversity conservation, marine recreational use, rural livelihoods, or any combination of these as well as other purposes. These arrangements can be species specific, fisheries specific, area-specific, focus on protected areas, or topic specific, such as mangrove restoration. Cycles at lower levels are most likely to be resource and location specific, whereas those at higher levels are most likely to be oriented towards harmonization of lower-level cycles. An effective national-level cycle is critical to ensure the effective functioning of LME-level

governance since it serves as the interface between local and regional/international-levels. For example, with the adoption of the FAO Code of Conduct for Responsible Fisheries [36], CARICOM countries have pursued the development of an integrated Common Fisheries Policy and Regime at the regional level [37]. For the decisions from these regional level policy cycle arrangements to be successful, national level policy cycles with respect to activities such as controlling fishing effort are needed. Equally important is the flow of data and information from the lower levels to the higher levels for the generation of advice and for use in decision-making.

4.3.3. The jurisdictional scale

At the local level, policy cycle arrangements may be under the auspices of community-based organizations which may either already exist for other purposes such as village councils, or which may have a specific purpose, such as fisherfolk organizations or conservation groups. At the national level, a given policy cycle will be undertaken most often in the government domain and will be carried out by the government department that is responsible for implementing particular legislation. Parastatal bodies may also have responsibility for policy cycles, e.g. a National Parks Commission. At the regional and international levels, undertaking policy cycles will primarily be the responsibility of intergovernmental organizations that will often have been established for broader purposes than natural resource and environmental management, but which may often have subbodies that focus on these issues, such as the Caribbean Regional Fisheries Mechanism (CRFM) of CARICOM and the Organización del Sector Pesquero y Acuícola del Istmo Centroamericano (OSPES-CA) of El Sistema de la Integración Centroamericana (SICA) [38].

Each level has important roles to play in achieving LME-level governance, whether for transboundary resources or

for resources which, although not specifically transboundary, are best dealt with through LME level cooperation since economy of scale can mitigate national undercapacity [38]. The international level ties the LME into the global arena. The regional and subregional levels provide transboundary integration and connections while also adapting the international picture to regional realities. The national level is the pivotal one at which international and regional recommendations and decisions are enabled through policy and legislative action. The local level is where much of the implementation must take place, as unless individuals change their behaviour in response to national-level policy decisions, the effectiveness of efforts to improve governance is threatened. Throughout the jurisdictional scale, the "nestedness" of the levels within each other should be evident [17], while taking into account the actual allocation of legal and political authority at each of the jurisdictional levels [34].

4.3.4. Capacity

The capacity of the implementing organization or organizations can determine the nature of a mature policy cycle arrangement. In situations of limited human resources, as often occurs in developing countries or small island developing states (SIDS), the arrangement that is in place to address a particular management need may differ from that which is in place to address the same need in large or developed countries. In human-resource-limited systems, the emphasis may be less on technical, science-based approaches and more on consensual, people-based ones [39].

4.3.5. Complexity

The implications of complexity in determining governance arrangements for natural resource management are becoming increasingly clear. Policy cycles that address highly complex systems may need to operate differently from those that address simpler ones. At the extreme of complexity, the cycle may function primarily in a learning and adaptation mode with implementation pertaining largely to enabling self-organization and building resilience [27,40].

A policy cycle can be expected to adapt to changing expectations being placed upon it. These changing demands may arise as a result of an exogenous shock, learning, human capacity growth or increased resources being allocated by a growing network of actors as awareness of the value of the system to be governed increases. Furthermore, a diversity of communication linkages can take place among the policy cycle components of the LME governance framework. Whereas in conventional hierarchical systems only vertical linkages are needed, complex systems require a richer diversity of linkages in order to be adaptive and resilient. Many valuable linkages may be horizontal, in which policy cycles at the same level learn from each other without being linked through the level above, although it may be the role

of each level to promote horizontal linkages at lower levels. This leads us to our third proposition: '*Horizontal linkages between functional policy cycles are often necessary for effective LME governance.*'

Linkages can take place at any point in a policy cycle and will differ accordingly. Technical linkages amongst actors in the data and information stages, scientists and technologists will differ substantially from linkages amongst actors in the implementation stages such as trainers and enforcers. There may be imbalances also. Technical linkages may be strong among the actors in the data and information stages through the literature, internet and technical conferences, yet weak at other stages. It appears likely that when linkages, especially vertical ones, are absent between cycles at the 'analysis and advice' and 'decision-making' stages, integration of governance at higher levels is ineffective. We, therefore, offer a fourth proposition that '*Linkages between functional policy cycles specific to the 'analysis and advice' and 'decision-making' stages of the cycle are essential for effective LME governance.*'

5. How the framework facilitates intervention

The goal of interventions aimed at promoting effective governance of LMR in the Caribbean LME would be to have fully functional policy cycles at all appropriate levels with appropriate vertical and lateral linkages. The policy-cycle, multi-scale, multi-level approach provides an avenue for change agents at all levels to make a valuable input within the context of an overall LME governance framework. Different agents will have different focal levels. Many non-governmental organizations (NGOs) and community-based organizations (CBOs) will focus at the local level to build effective policy cycles and to enhance linkages with other similar agencies. Multi- and bilateral donor agencies will usually focus at the national and regional levels through intergovernmental organizations.

Interventions can be specifically targeted at establishing policy cycles or completing them by identifying the weak stages and developing projects to strengthen them. Empirical evidence within the Caribbean LME has led us to propose that linkages between policy cycles at the analysis and decision-making stages are critical for effective LME governance and yet we have found that these stages are often the weakest in marine resource management. Efforts can focus on establishing or enhancing mechanisms for analysis and provision of advice on a regular and timely basis and on ensuring it is considered by decision-makers in appropriate fora.

Interventions can also be specifically targeted at building or enhancing linkages. The nature of interventions will vary with the nature of the links themselves. Where the links are primarily communication and cooperation based, interventions will be largely aimed at enabling self-organization and adaptation through building the capacity

Table 1
Interventions to strengthen and establish mechanisms for improving management of the shrimp and ground fish fisheries of the North Brazil Shelf LME

Scale level	Policy cycle stage					
	Data/information	Analysis and advice	Decision making	Implementation	Review and evaluation
Local	Data collection systems (catch, effort, biological, social, economic environmental, etc.)	Include data and information inputs generated by fishing community	Identify and develop mechanisms for management of fisheries at the community level	Relevant decisions implemented by fishing community based on the level of decentralized authority with assistance from National level	Define the indicators
	Record local knowledge		Improve stakeholder participation (fisher and other relevant community groups) in the decision-making process	Identify and develop mechanisms to encourage "self-policing"	Provide inputs to the policy cycle
	Strengthen relevant local government agencies	Provide options	Organise and/or strengthen fisher and other stakeholder groups at local level	With support from National level	Provide inputs to the policy cycle
	Develop programme for awareness building and knowledge sharing (field school approach) among stakeholders			With support from National level	
National	Improve on the data collection systems based on feedback from review and evaluation	Defined by national level authority with inputs from local level	Options for strengthening national mechanisms for participation in the decision-making processes	Decisions implemented by national level authority e.g. strengthen MCS	Define the indicators / Provide inputs to the policy cycle
	Institutional structure, capacities	Undertake analyses for community related and national level fisheries and provide inputs to decision making	Promote and develop mechanisms to improve intersectoral interface and planning	By local and National levels	
	Awareness building (field school approach) among stakeholders	Undertake analyses and provide policy options	Update and implement FMPs	By relevant agencies	Define the indicators
		Undertake analyses provide policy options	Promote an ecosystem-based approach to fisheries management	Strengthen relevant agencies by National level	
			Establish or strengthen trawler owner, processors and other stakeholder organizations at National level		
Regional	Establish a protocol for sharing data and information involving regional partners (e.g. FAO/ WECAFC, CRFM)	Promote intersectoral planning, collaboration/cooperation	Integrated ecosystem approach to natural resource use	Implemented by the economic sectors involved	Provide inputs to the policy cycle
	Promote and facilitate harmonisation of data collection systems	Options the development of a multidisciplinary shrimp and groundfish working group comprising countries of North Brazil Shelf LME	North Brazil LME approaches to managing shared resources	Design and establish mechanisms for management of the shared resources	Define the indicators / Provide inputs to the policy cycle
		Regional Partners (e.g FAO/ WECAFC, CRFM) provide policy advice	Promote ecosystem-based approach to fisheries management	Implementation at all levels	Provide inputs to the policy cycle
		Network stakeholder groups, NGOs and partners at the regional level for inputs to decision making	Facilitate stakeholder inputs		Define the indicators

Note: Actions/activities at the local level depend heavily on sustained inputs and technical support from the national level. Similarly, actions at the regional level depend on inputs from the national level. Thus, the national level serves as the pivot around which the local and regional levels revolve and could be described as the primary driver of the proposed LME governance framework. Implementation is at all levels and depends on the degree of authority accorded to the jurisdictional levels.

needed for the various interactions that should take place in developing learning systems [27,40].

While there can be emphasis on specific links, the structure of the entire system is also likely to be an important focus. The proposed framework is essentially of nested networks in which the policy cycles can be seen as nodes. However, each cycle is itself a subnetwork in which the stages can be seen as nodes. Drilling deeper still, one reaches the point where individual actors functioning within the cycles can serve as nodes. It is at this level that many cross-linkages may occur as these actors have roles in several cycles at various levels. Some nodes can be readily identified as network hubs. It is becoming increasingly clear that network structure, characterized by the distribution of links per node and the presence or absence of nodes with large numbers of links, can significantly affect network resilience and power relationships [28,41].

Finally, the framework also provides a context within which to assess the status of governance arrangements. At any level for any resource system, one can ask whether the conditions of the four propositions are being met. Within the Caribbean LME Project, pilot projects are being designed to test the applicability of the framework and the significance of the propositions to effectively govern shared LMR. Using an EBM approach to address priority areas of concern, the pilots will examine weaknesses in existing policy cycles at multiple scale levels to identify and implement targeted and timely interventions.

To illustrate using an example, we developed a preliminary assessment of strategic interventions needed to strengthen and establish mechanisms for management ("ownership") of the shrimp and groundfish fisheries of the North Brazil Shelf LME (Table 1). This preliminary assessment shows that policy cycle levels generally possess similar attributes, such as technical skills, knowledge, socioeconomic view, authority and perceptions, but to different degrees because of the scale. The bidirectional flow of data and information among the different levels leads to coherence and a common vision. Data analysis and advice are required for interventions aimed at the decision-making stage for all jurisdictional levels. The definition of specific indicators is considered critical for the review and evaluation component of policy cycles occurring at all levels. Similarly, efforts to improve data and information at all levels were also flagged and interventions at the review and evaluation stage were considered critical for all policy cycles regardless of level. Interventions in each component of the generic policy cycle were seen as necessary at the local, national and regional/international levels. However, the level of intervention depends on the authority and mandate afforded to each jurisdictional level.

6. Conclusions

The proposed LME governance framework comprises complete policy cycles at multiple jurisdictional levels that are networked through both vertical and lateral linkages. It is based on four propositions that we consider to be fundamental properties of the framework:

- Any interruption at any stage of the policy cycle will result in dysfunctional governance of the target resources or ecosystems.
- Vertical linkages between functional policy cycles are necessary for effective transboundary LMR governance.
- Horizontal linkages between functional policy cycles are often necessary for effective transboundary LMR governance.
- Linkages specific to the 'analysis and advice' and 'decision-making' stages of functional policy cycles are essential for effective multi-scale LMR governance.

The framework accommodates the diversity of policy cycles arrangements and linkage types that are likely to be required for comprehensive governance and is sufficiently flexible to incorporate the diversity of EBM approaches identified by Christie et al. [42]. The goal of interventions would be to establish and enhance cycles and linkages that are context specific and appropriate to purpose, capacity and complexity. This long-term goal can be approached incrementally by targeted interventions that focus on specific subcomponents of the framework.

The majority of countries of the Caribbean LME are either small island developing states (SIDs) or developing countries with an overwhelming lack of capacity at the national level. Nonetheless, countries are generally dependent on their limited natural resource endowments, especially coastal and marine resources, for their economic well-being. As such, hierarchical authority may not be needed and is unlikely to be feasible in the Caribbean [22]. A great deal may be accomplished by a mechanism that focuses on networking and linkages among lower level policy cycles. The inherent inclusiveness of the governance framework provides for such decentralization of authority and encourages co-management arrangements. It focuses on people and their actions, which, through the policy cycle, if effectively implemented at the different jurisdictional levels, will determine the future sustainability of the resource. The framework also has the inherent potential to improve and strengthen democratic processes at local and national levels which is essential for good governance.

The challenge of developing an overarching governance framework that would serve to highlight *how* LME-level management might be accomplished, as opposed to listing *what* steps and principles need to be incorporated, is daunting but must be met. We argue that it is essential to provide guidance on how to implement governance mechanisms that lend themselves to protecting ecosystem-wide goods and services and to achieving the WSSD targets for fisheries and EBM. We have come to this realization by working within the complex realm of the Caribbean LME but we believe that a governance framework developed to address the range of diversity within the Caribbean can find

applicability among other LMEs because of its flexible and multi-scale nature.

References

[1] Lubchenco J. The scientific basis of ecosystem management: framing the context, language and goals. In: Zinn J, Corn ML, editors. Ecosystem management: status and potential. 103rd congress, second session, Committee Print, US Government Printing Office, Superintendent of Documents, 1994. p. 33–39.

[2] Browman HI, Stergiou KI. Perspectives on ecosystem-based approaches to the management of marine resources. Marine Ecology Progress Series 2004;274:269–303.

[3] Yaffee SL. Three faces of ecosystem management. Conservation Biology 1999;13(4):713–25.

[4] WSSD. The Johannesburg declaration on sustainable development. In: World summit on sustainable development, Johannesburg, 24 August–4 September 2002, 2002 (available online at ⟨www.uneptie.org/Outreach/wssd/postjoburg/wssdoutcomes.htm⟩. Accessed November 28, 2006).

[5] Rosenberg A, McLeod K. Implementing ecosystem-based approaches to the management for the conservation of ecosystem services. Marine Ecology Progress Series 2005;300:270–4.

[6] Sherman K. Sustainability, biomass yield and health of coastal ecosystems: an ecological perspective. Marine Ecology Progress Series 1994;112:277–301.

[7] Jackson J, Kirby M, Berger W, Bjorndal K, Botsford L, Bourque B, et al. Historical overfishing and the recent collapse of coastal ecosystems. Science 2001;293:629–38.

[8] Garibaldi L, Limongelli L. Trends in oceanic captures and clustering of large marine ecosystems: two studies based on the FAO capture database. Fisheries Technical paper 435, Rome, Italy, 2003.

[9] Pauly D, Christensen V, Guénette S, Pitcher TP, Sumaila UR, Walters C, et al. Towards sustainability in world fisheries. Nature 2002;418:689–95.

[10] Miles EL. The concept of ocean governance: evolution toward the 21st century and the principle of sustainable ocean use. Coastal Management 1999;27:1–30.

[11] GESAMP. The state of the marine environment. Group of experts on the scientific aspects of marine pollution. Regional Seas Reports and Studies, Nairobi, UNEP, 2001.

[12] USCOP. An ocean blueprint for the 21st century. Final report to the President and Congress, US Commission on Ocean Policy. Washington, DC, 2004 (available at ⟨www.oceancommission.gov⟩. Accessed November 27, 2006).

[13] Duda AM, Sherman K. A new imperative for improving management of large marine ecosystems. Ocean and Coastal Management 2002;45:797–833.

[14] Sherman K, Sissenwine M, Christensen V, Duda A, Hempel G, Ibe C, et al. A global movement toward an ecosystem approach to management of marine resources. Marine Ecology Progress Series 2005;300:275–9.

[15] Sherman K, Duda AM. An ecosystem approach to global assessment and management of coastal waters. Marine Ecology Progress Series 1999;190:271–87.

[16] Czempiel EO. Governance and democratization. In: Rosenau JM, Czempiel EO, editors. Governance without government: order and change in world politics. Cambridge: Cambridge University Press; 1992.

[17] Ostrom E. Governing the commons: the evolution of institutions for collective action. Cambridge: Cambridge University Press; 1990.

[18] Stoker G., Governance as theory: five propositions, In:, U.N.E.S.C.O., editor, Governance, 1998, Blackwell Publishers, Oxford, vol. 17, p. 26.

[19] Kooiman J, Bavinck M, Jentoft S, Pullin R, editors. Fish for life: Interactive governance for fisheries. Amsterdam: University of Amsterdam Press; 2005.

[20] Olsen SB, Sutinen JG, Juda L, Hennessey TM, Grigalunas TA. A handbook on governance and socioeconomics of large marine ecosystems. Coastal Resources Center: University of Rhode Island; 2006 95 p.

[21] Wang H. An evaluation of the modular approach to the assessment and management of large marine ecosystems. Ocean Development and International Law 2004;35:267–86.

[22] Chakalall B, Mahon R, McConney P. Current issues in fisheries governance in the Caribbean Community (CARICOM). Marine Policy 1998;22:29–44.

[23] Mahon R, McConney P, editors. Management of large pelagic fisheries in CARICOM countries. FAO Fisheries Technical paper no. 464. Rome, Italy, 2004, 149.

[24] Burke L, Maidens J. Reefs at risk in the Caribbean. Washington, D.C: World Resources Institute; 2004.

[25] Haughton M, Mahon R, McConney P, Kong GA, Mills A. Establishment of the Caribbean regional fisheries mechanism. Marine Policy 2004;28:351–9.

[26] Berkes F, Mahon R, McConney P, Pollnac R, Pomeroy R. Managing small-scale fisheries: alternative directions and methods. Ottawa, Canada: IDRC; 2001 309pp.

[27] Bavinck M, Chuenpagdee R, Diallo M, van der Heijden P, Kooiman J, Mahon R, et al. Interactive governance for fisheries: a guide to better practice. Delft: Eburon Academic Publishers; 2005 72 pp.

[28] Anderies JM, Walker BH, Kinzig AP. Fifteen weddings and a funeral: case studies and resilience-based management. Ecology and Society 2006;11(1):21 [online] URL: ⟨http://www.ecologyandsociety.org/vol11/iss1/art21/⟩.

[29] Berkes F. From community-based resource management to complex systems: the scale issue and marine commons. Ecology and Society 2006;11(1):45 [online] URL: ⟨http://www.ecologyandsociety.org/vol11/iss1/art45⟩.

[30] Cash DW, Adger W, Berkes F, Garden P, Lebel L, Olsson P, et al. Scale and cross-scale dynamics: governance and information in a multilevel world. Ecology and Society 2006;11(2):8 [online] URL: ⟨http://www.ecologyandsociety.org/vol11/iss2/art8/⟩.

[31] Young O. The institutional dimensions of environmental change: fit interplay and scale. London: MIT Press; 2002. p. 221.

[32] Cumming GS, Cumming DHM, Redman CL. Scale mismatches in social-ecological systems: causes, consequences, and solutions. Ecology and Society 2006;11(1):14 [online] URL: ⟨http://www.ecologyandsociety.org/vol11/iss1/art14/⟩.

[33] Fanning LM. Evaluating community fish quota management in Atlantic Canada: lessons from the start-up years. Maritime Studies 5, No. 2, submitted.

[34] Young O. Vertical interplay among scale-dependent environmental and resource regimes. Ecology and Society 2006;11(1):27 [online] URL: ⟨http://www.ecologyandsociety.org/vol11/iss1/art27/⟩.

[35] Cross R, Parker A. The hidden power of social networks: understanding how work really gets done in organizations. Boston: Harvard Business School Press; 2004. p. 212.

[36] FAO. Code of conduct for responsible fisheries. FAO, Rome, Italy, 1995.

[37] CARICOM. 2003. Fourteenth inter-sessional meeting of the conference of heads of government in Trinidad and Tobago, 14–15 February 2003.

[38] Chakalall B, Mahon R, McConney P, Nurse L, Oderson D. Governance of fisheries and other living marine resources in the Wider Caribbean. Fisheries Research, 2007; accepted for publication.

[39] Mahon R, McConney P. Managing the managers: improving the structure and operation of fisheries departments in SIDS. Ocean and Coastal Management 2004;47:529–35.

[40] Mahon R, McConney P, Roy RN. Governing fisheries as complex adaptive systems. Ocean and Coastal Management, submitted.

[41] Barabasi A-L. Linked. New York: Plume; 2002 294pp.

[42] Christie P, Fluharty DL, White AT, Eisma-Osorio L, Jatulan W. Assessing the feasibility of ecosystem-based fisheries management in tropical contexts. Marine Policy 2007;31:239–50.