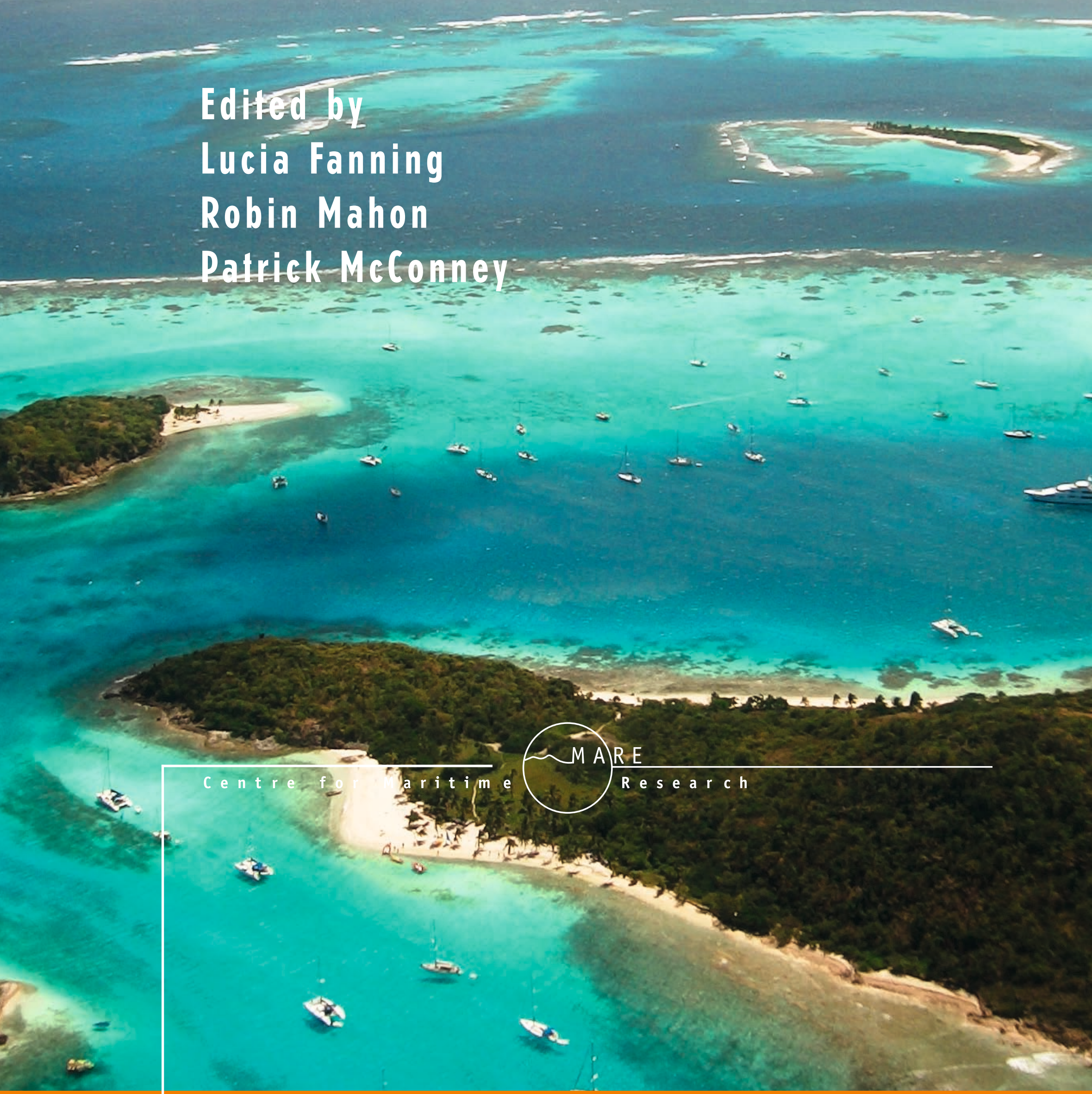

Edited by
Lucia Fanning
Robin Mahon
Patrick McConney

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6

Towards Marine Ecosystem-based Management in the Wider Caribbean

Amsterdam University Press

Towards Marine Ecosystem-based Management in the Wider Caribbean

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Contents

Preface

Dalhousie University and the International Ocean Institute (Nova Scotia, Canada), the Centre for Resource Management and Environmental Studies (CERMES), and the Caribbean Law Institute Centre (CLIC) at the University of the West Indies (UWI) in Barbados acquired funding from the Nippon Foundation in 2008-2009 for a project entitled *Strengthening Principled Ocean Governance Networks (PROGOVNET): Transferring Lessons from the Caribbean to the Wider Ocean Governance Community*. One of the aims of PROGOVNET was to contribute to the work being undertaken by the UNDP, UNESCO-IOCARIBE project *Sustainable Management of the Shared Living Marine Resources of the Caribbean Large Marine Ecosystem (CLME) and Adjacent Regions* (CLME Project). An objective of the CLME Project is to promote ecosystem-based management and an ecosystem approach to fisheries (EBM/EAF) in the Wider Caribbean. This PROGOVNET symposium on marine EBM/EAF in the Caribbean was developed to provide needed guidance to the CLME Project by bringing together regional experts to develop a vision and a way ahead for EBM/EAF. The aim of the symposium is to produce a body of background work on EBM/EAF in various Caribbean situations, and to synthesise these ideas under strategic headings that could provide guidance to the CLME Project and other stakeholders in marine resource use with an interest in moving in this direction. The symposium was held at the University of the West Indies, Cave Hill Campus, Barbados on December 10-12, 2008.

Thanks are due to the Nippon Foundation, the main supporter of the symposium (through PROGOVNET). Contributions from the Faculty of Pure and Applied Sciences at the UWI at Cave Hill were also valuable. The efforts of Ms. Bertha Simons, symposium coordinator, and the staff of CERMES at the UWI contributed greatly to the success of the meeting. The four facilitators who led the parallel processes of the symposium made it possible for participants to share their ideas in an engaging and interesting environment. Ultimately, however, the quality of this initiative is due to all those who gave their time to take part by presenting their ideas and participating freely in the group work. Responsibilities for any errors or omissions in this publication fall squarely on us, the editors.

Barbados, December 2010

Lucia Fanning, Robin Mahon and Patrick McConney

Part I

Setting the Stage for Principled Ocean Governance in the Wider Caribbean Region

1

The Symposium on Marine EBM in the Wider Caribbean Region

Lucia Fanning, Robin Mahon, Patrick McConney and Sharon Almerigi

Introduction

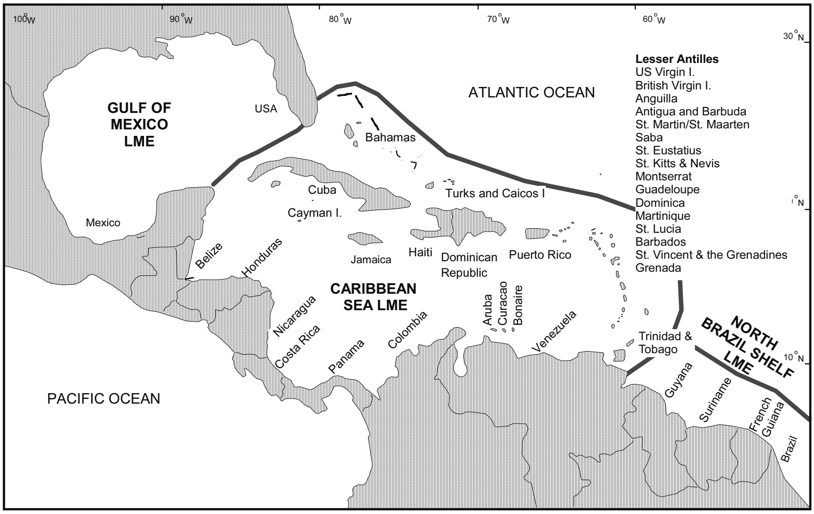
Countries of the Wider Caribbean have committed to principled ocean governance through several multilateral environmental and fisheries agreements at both the regional (e.g., the Cartagena Convention's SPAW Protocol) and international levels (e.g., the Convention on Biological Diversity, the United Nations Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fishing). They have also committed to the targets for fisheries and biodiversity conservation adopted at the 2002 World Summit on Sustainable Development (WSSD). However, the ongoing challenge is to put in place the measures required to give effect to these principles at the local, national and regional levels. The ecosystem-based management/ecosystem approach to fisheries (EBM/EAF) is prominent in these agreements and in the WSSD targets. Implementing an ecosystem-wide approach that encompasses both the human and natural dimensions of ecosystems is an essential component of principled ocean governance. This approach gives prominence to the principles of sustainability, participation and precaution that are needed to effectively govern the world's oceans.

The Wider Caribbean Region is the most geopolitically diverse and complex region in the world (Fanning et al. 2009a). Throughout the region, there are many local, national, subregional, regional and international organisations pursuing various aspects of ocean management. The challenge has always been to integrate or network these to improve their effectiveness and reduce duplication. At the outset of its development, the Caribbean Large Marine Ecosystem (CLME) and Adjacent Areas Project took up this challenge with a focus on institutional arrangements for good governance of living marine resources. After over 10 years of development, this multi-year initiative – funded by twenty-six countries in the region and the Global Environment Facility of the World Bank – began implementation in mid-2009 and is expected to pursue EBM/EAF for the Caribbean LME and adjacent areas as a basis for ensuring the sustainable use of the region's shared living marine resources (Fanning et al. 2009a). During the development of this project, it was evident that there was a lack of clarity and specificity within the Wider Caribbean about what moving towards EBM/EAF means for governance processes at various institutional levels and geographic scales or for specific coastal and marine resources and ecosystems.

Overview of the Wider Caribbean Region

The Wider Caribbean Region (WCR) extends from the mouth of the Amazon River in Brazil, through the Insular Caribbean, Central America, the Gulf of Mexico and along the east coast of North America to Cape Hatteras. The population of the countries of the region (excluding the United States, Mexico and Brazil, large parts of which are outside of the region) exceeds some 152 million inhabitants. The drainage basin of the Wider Caribbean is home to over 75% of the region's population (Burke and Maidens 2004) and covers 7.5 million km^2, encompassing eight major river systems, from the Amazon to the Mississippi (Hinrichsen 1998). Within the WCR are three large marine ecosystems (LMEs): the Gulf of Mexico LME, the Caribbean Sea LME, and the North Brazil Current LME (Figure 1.1) with a total area of approximately 15 million km^2, of which some 1.9 million km^2 is shelf area (Breton et al. 2006). These LMEs are closely linked, particularly the latter two, as the oceanography of the Caribbean Sea is strongly influenced by the highly productive upstream North Brazil Shelf LME.

Figure 1.1. The countries/states of the Wider Caribbean Region and the three Large Marine Ecosystems that comprise it



This overview focuses on the Caribbean and North Brazil Shelf LMEs as the geographic area covered by the Caribbean Large Marine Ecosystem

(CLME) Project funded by the Global Environment Facility. The information contained in this overview discusses the resources and ecosystems within the region, the existing socio-economic and political situation and the current governance arrangements. Its content is drawn from a recently published paper by the chapter's co-authors (Fanning et al. 2009a).

Resources and Ecosystems

The oceanography of the Caribbean region is highly variable both spatially and temporally. The North Coast of South America is dominated by the effects of two of the largest river systems in the world, the Amazon and the Orinoco, as well as numerous other large rivers (CLME 2007a). Most Caribbean islands are more influenced by the nutrient-poor North Equatorial Current that enters the Caribbean Sea through the passages between the Lesser Antilles. Islands with appreciable shelf area exhibit significant coral reef development. From Isla Margarita west to Mexico, the continental shelf is also extensively occupied by coral reefs at shallow depths. Seagrass and mangroves are also common coastal habitats. The WCR is a biogeographically distinct area of coral reef development within which the majority of corals and coral reef associated species are endemic. Thus the region is of considerable global biodiversity significance (Burke and Maidens 2004).

Areas of high productivity include the plumes of continental rivers, localised upwelling areas, particularly along the north coast of South America, and near shore habitats (e.g., reefs, mangroves and seagrass). Although reefs and related ecosystems have been extensively studied in the Caribbean, the trophic connection between these productive areas and other less productive systems (e.g., offshore planktonic or pelagic systems) is poorly understood. Likewise, food chain linkages between resources with differing scales of distribution and migration such as flyingfish and large pelagics, both of which are exploited, are not well known.

The fisheries of the Caribbean region are based on a diverse array of resources. Those of greatest importance are for offshore pelagics, reef fishes, lobster, conch, shrimps, continental shelf demersal fishes, deep-slope and bank fishes, and coastal pelagics. There is a variety of less important fisheries such as for marine mammals, sea turtles, sea urchins and seaweeds. These fishery types vary widely in state of exploitation, vessel, and gear used, as well as the approach to their development and management. However, most coastal resources are considered to be overexploited and there is increasing evidence that the pelagic predator biomass has been depleted (FAO 1998; Mahon 2002; Myers and Worm 2003).

The fisheries using the widest variety of gear are primarily artisanal, or small scale, using open, outboard-powered vessels 5-12 m in length. The most notable exceptions are the shrimp and groundfish fisheries of the Brazil-Guianas shelf, where trawlers in the 20-30 m size range are used

(Phillips et al. Chapter 15), and the tuna fishery of Venezuela, which uses large (>20 m) longliners and purse seiners. In many countries, there has been a recent trend toward more modern mid-size vessels in the 12-15 m range, particularly for large pelagics, deep-slope fishes, and lobster and conch on offshore banks.

The large pelagic species that are assessed and managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT) are the most 'high-profile' species with ocean-wide distribution sustaining the largest catches, often by distant water fleets. Few countries of the region presently participate in ICCAT. The Caribbean Regional Fisheries Mechanism (CRFM) of the Caribbean Community and Common Market (CARICOM) has been promoting the participation of CARICOM countries in ICCAT (Singh-Renton et al. 2003; Singh-Renton et al. Chapter 14). A major problem is that many countries of the Caribbean are facing specific social, economic and environmental vulnerabilities that meet with the United Nations definition of small island developing states (SIDS). These countries presently take only a small proportion of the catch of species managed by ICCAT. These countries may, by virtue of the size and productivity of their exclusive economic zones (EEZs), be entitled to a larger share but lack the technical capacity or the financial resources to participate in ICCAT, where their case would be made. A strategic approach through which these countries, particularly SIDS, can effectively take part individually or collectively in ICCAT is needed (Chakalall et al. 1998; Singh-Renton et al. 2003; Mahon and McConney 2004; Singh-Renton et al. Chapter 14).

Several large migratory pelagic species that are not managed by ICCAT are important to the fisheries of Caribbean countries (e.g., dolphinfish, blackfin tuna, cero and king mackerels, wahoo and bullet tunas). The information for management of these species is virtually non-existent. For these species, regional-level management is urgently needed (Mahon and McConney 2004). This must include an appropriate institutional arrangement for cooperative management as required by the UN Fish Stocks Agreement. Migratory large pelagics also support recreational fishing (e.g., billfishes, wahoo and dolphinfish), an important but undocumented contributor to tourism-based economies as well as to the harvesting of the resource in the region. This aspect of shared resource management has received minimal attention in most Caribbean countries (Mahon and McConney 2004).

The tendency is to think primarily of migratory large pelagic fishes as shared resources, but it is important to note that reef organisms, lobster, conch and small coastal pelagic may also be shared resources by virtue of planktonic larval dispersal. In many species, larval dispersal lasts for many weeks (e.g., conch) or many months (e.g., lobster) and may result in transport across EEZ boundaries (Ehrdhardt et al. Chapter 11; Appeldoorn et al. Chapter 12). Therefore, even these coastal resources have an important transboundary component to their management. They are the resources that have been most heavily exploited by Caribbean countries and are severely depleted in most areas. Their status has been discussed and documented by the Food and Agriculture Organization of the United Nations (FAO) and the Western Central Atlantic Fishery Commission (WECAFC) for several decades (FAO 1999c). These early stages are impacted by habitat destruction and pollution as well as overfishing of the spawning stock, and both improved knowledge and institutional arrangements are required to implement effective management.

Social and Economic Situation

The CLME Project Area is the most geopolitically complex region in the world. The countries range from among the largest (e.g., Brazil, the United States) to among the smallest (e.g., Barbados, St. Kitts and Nevis), and from the most developed (e.g., the United States, France) to the least developed (e.g., Haiti, Guyana). Consequently, there is an extremely wide range in their capacities for governance. Caribbean coastal states, especially SIDS, are highly dependent on the marine environment – for their livelihoods as well as their recreational, cultural and spiritual needs. Fisheries play a major role in the economic, nutritional and cultural well-being of Caribbean countries (McConney and Salas Chapter 7). Small-scale fisheries are particularly important, but are often undervalued (Schuhmann et al. Chapter 8). As near-shore resources have become depleted, and also in response to increasing demand for fish products, attention has turned to offshore resources, which are inevitably shared and already fully exploited by the major fishing nations (Mahon and McConney 2004). The number of people actively involved in fisheries was estimated to be approximately 505,000 in the 1990s, a doubling of the numbers involved during the 1980s (Agard et al. 2007).

Almost all the countries in the region are among the world's premier tourism destinations, providing an important source of national income. Marine-based tourism is a major contributor to the economy in many Caribbean countries. This sector is highly dependent on healthy marine ecosystems for beaches; clean water for recreational activities; healthy reef systems for snorkeling, diving and other marine life-viewing activities; recreational fishing; and a supply of seafood to tourism establishments.

The population in the Caribbean Sea region swells during the tourist season by the influx of millions of tourists, mostly in destinations offering sun, sea and sand coastal recreation, dive tourism and nautical tourism. For example, in 2004, the Mexican state of Quintana Roo received some 10.4 million tourists, 35% of which arrived by cruise ship (CLME 2007b).

Marine transportation of goods and passengers (e.g., cruise tourists) and the resulting high traffic of vessels using the region's shipping lanes is another key activity in the Caribbean. The Panama Canal remains the principal global focus of maritime trade in the region, handling about 5% of total world trade. Expanding ports and maritime trade lead to intensified transportation corridors in coastal ocean areas. The transshipment of hazardous goods through the Caribbean Sea to global destinations is also of concern due to the environmental risks of accidents that could have significant ecological and socioeconomic consequences in the region.

Current Governance Arrangements

The region is characterised by a diversity of national and regional institutional governance arrangements, stemming primarily from the governance structures established by the countries that colonised the region. There are also several intergovernmental organisations operating at various levels, for example the Organisation of Eastern Caribbean States (OECS), CARICOM and the Sistema de la Integraci´on Centroamericana (SICA). These organisations address living marine resource governance through various subsidiary bodies, often with overlapping and/or competing mandates and membership which lead to inefficiency and ineffectiveness (Chakalall et al. 2007). The EEZs of the Caribbean region form a mosaic that includes the entire region. Consequently, there is a high incidence of transboundary resource management issues, even at relatively small spatial scales.

The need for more attention to be placed on the management of shared marine resources in the WCR is well documented. From the 1980s, it has been a major subject for discussion by the WECAFC (e.g., Mahon 1987) and was stressed at its Commission meeting in 1999 (FAO 1999c). These issues have been discussed in many other fora and agreement reached on the need for a coordinated regional effort on shared resources (e.g., Haughton et al. 2004).

Several regional and global binding and non-binding agreements seek to address the governance of shared marine living resources: for example, the UN Convention on the Law of the Sea (UNCLOS), the UN Fish Stocks Agreement, the FAO Compliance Agreement and the FAO Code of Conduct for Responsible Fisheries. The national-level implications of these are being explored by Caribbean countries and include: (a) the need for capacity building at the national level to take part in international- and regional-level management of shared resources, and (b) the need for strengthening and expanding regional institutions to undertake this function.

Institutional arrangements for the management of transboundary living marine resources in the Caribbean region have been emerging by practice from the ongoing efforts of various institutions (Chakalall et al. 2007). These reflect the fact that the Caribbean does not have any major fish stocks attracting large commercial fleets, revenues from which can be expected to support a regional fisheries management institution. The emerging approach in the Caribbean is potentially more suited to the large diversity of resources that are already mostly exploited by indigenous fleets, so the issues relate primarily to conservation, optimisation and intra-regional equity (Chakalall et al. 2007). The complexity of the situation is illustrated by the overlapping country membership among the seven regional and international organisations with interest in fisheries alone (Chakalall et al. 2007). If organisations with responsibility for biodiversity, coastal zone management, land-based sources of pollution, and other aspects of marine governance are included, the picture becomes extremely complicated.

The emerging institutional arrangements are flexible and involve adapting and creating networks among existing institutions (McConney et al. 2007). This approach has been endorsed by the countries of the region at two WECAFC meetings (FAO 1998, 2001) and in the Caribbean Large Marine Ecosystem Project. These arrangements involve a number of fledgling initiatives for various types of resources. For example, in the case of conch, the Caribbean Fishery Management Council has taken the lead in pursuing regional management. However, some countries have difficulty taking part to the extent required for successful management. For shrimp/groundfish and flyingfish, the WECAFC Ad Hoc Working Groups are the lead agencies. The newly established CRFM has identified large pelagics as a priority (Haughton et al. 2004; Singh-Renton et al. Chapter 14).

Most international conventions relating to the sustainable management of transboundary living marine resources and marine environmental protection are subscribed to by Caribbean countries. The regional environmental legislative regime comprises several international conventions that are related to marine and coastal resource management. For the Caribbean region in particular, the United Nations Environment Programme (UNEP) Caribbean Environmental Programme (CEP) has, through its Regional Coordinating Unit (RCU), played a leading role in establishing key conventions, protocols and action plans that are specific to the WCR. The Cartagena Convention, which came into force in October 1986, provides the basis for the implementation of the CEP. It covers various aspects of land-based marine pollution and oil spills for which the contracting parties must adopt measures. In addition, the countries are required to take appropriate measures to protect and preserve rare or fragile ecosystems as well as the habitat of depleted, threatened or endangered species and to develop technical and other guidelines for planning and environmental impact assessments of important development projects in order to prevent or reduce harmful impacts (Sheehy 2004). Sheehy (ibid.) notes that few countries have put in place the legal and administrative measures required to give effect to these agreements.

In 1991 the International Maritime Organization designated the WCR and the Gulf of Mexico as a Special Area under Annex V of the MARPOL Convention. In 2007, the UN General Assembly adopted a resolution entitled: "Towards the Sustainable Development of the Caribbean Sea for present and future generations" (UN General Assembly Resolution 61/197). This resolution is a further step in a process known as the 'Caribbean Sea Initiative' that was started in the late 1990s by organisations in the region including the Association of Caribbean States and CARICOM to secure recognition by the international community of the Caribbean Sea as a special area in the context of sustainable development (CLME 2007a).

The reality of Caribbean ocean governance is a diversity of networks of actors serving various purposes that seldom intersect effectively, but with the potential to do so if greater attention is paid to networking. Notably absent in most cases are interactions at the critical stage of communicating analysis and advice to shape coordinated decision-making (Fanning et al. 2007). 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 at levels up to the ecosystem scale of the CLME.

Differences in size and capacity among the countries of the region present particular challenges in many areas. To engage effectively, smaller countries often require sub-regional organisations to provide technical support and collective representation. This can lead to issues of sovereignty that must be considered in strengthening policy cycles at sub-regional levels. At the technical level, data and expertise are highly aggregated in a few of the larger countries. The capacity to access and use the data is likely to be a key challenge in building an equitable framework. While its cultural diversity enriches the region, it also presents certain challenges. The development of shared principles and values, appreciation of the diversity of approaches that may be culture-based, and the ability to communicate across language barriers are challenges that face all aspects of regional development and Caribbean Sea LME governance (Mahon et al. Chapter 2). The marine resources of the Caribbean Sea are largely shared resources, and the effectiveness of any management initiative will depend on collaborative and cooperative actions at the regional level, or other appropriate scale, depending on the issue and the resource (Fanning and Mahon Chapter 18). The best hope lies in the use of ecosystem-based management approaches that protect coastal ecosystems and their living marine resources so that they are resistant and resilient to the suite of natural and human-induced perturbations confronting the Wider Caribbean Region (Bianchi and Cochrane Chapter 3).

The Status of Ecosystem-Based Management

No comprehensive definition of EBM has been adopted for the CLME and Adjacent Areas Project yet or can be said to be in general usage in the CLME Project Area. There is a need to elaborate on what EBM means in the variety of resource contexts and geographical scales in the CLME Project Area. This is scheduled to be an early activity of the CLME Project. However, it is recognised that EBM or any other kind of management cannot be pursued effectively unless governance institutions are in place and operational. Consequently, the project emphasises governance. EBM is likely to be introduced incrementally and to be context specific as noted for the Benguela LME (Cochrane et al. 2007).

The Symposium on Marine EBM/EAF in the Caribbean

This symposium on marine EBM/EAF in the Caribbean aims to take forward the process of developing EBM for the Wider Caribbean Region by producing a body of background work on EBM/EAF in various Caribbean situations and synthesising these ideas under strategic headings. It will provide guidance to the CLME Project and other stakeholders in marine resource use with an interest in moving in this direction. With this aim, the organisers have brought together a diverse group of participants from around the region and beyond, in a designed and facilitated process. Given that a common understanding of EBM/EAF must be worked out among stakeholders, it is important that this be done in a transparent and inclusive way. Thus the process by which this is achieved is as important as the outcome. This symposium has been designed to meet these criteria. This is viewed by the organisers as an innovative approach to developing a common understanding of EBM/EAF among diverse stakeholders. This volume documents the symposium process, the contributions of the many participants and the outputs of the group sessions aimed at developing a principle-based vision for Caribbean marine EBM and ways of achieving this vision.

Figure 1.2. The overall organisational flow of the symposium

The flow of the symposium...

Day one ➔	**Day two** ➔	**Day three**
Building blocks	**What is the vision?**	**Achieving the vision**
Two keynote and twenty-one topical presentations	Workshop process with focus question:	World café process with focus question:
Prioritisation process for EBM principles	*What do you see in place in 10 years time when EBM/EAF has become a reality in the Wider Caribbean?*	*How do we get from here to where the vision is a reality?*

The overall flow of the symposium is depicted in Figure 1.2. It was planned as an integrated process that would start with the sharing of information, move on to participatory consideration of EBM/EAF principles and be followed by group work in four breakout groups that used facilitated sessions to address two key questions. The process for participatory consideration of EBM/EAF principles and the results from that process are described by Mahon et al. (Chapter 2). The first of the two key questions addressed by the breakout groups was aimed at developing the shared vision of the participants: 'What do you see in place in 10 years' time if EBM/EAF has become a reality in the Caribbean?' The second question related to what must be done to achieve the vision: 'How do we get from here to where the vision is a reality?' In this section, we describe the methods used to address these two questions. The symposium was planned with input from a professional facilitator, and four facilitators led the parallel breakout sessions on days two and three.

Developing the Shared Vision

The visioning process that was employed to address the first question was adapted from the Technology of Participation (ToP) Participatory Strategic Planning Method (Spencer 1989; Stanfield 1995; Holman et al. 2006) developed by the Institute of Cultural Affairs[1]. This process assumes that everyone has the wisdom to communicate and therefore can provide individual puzzle pieces that, when assembled, make up the vision. The process assumes that the vision – the hopes and desired outcomes for the future – are latent in the group. These are assumed to be hidden and concealed in the subconscious, below the level of everyday workplace reality (Stanfield 1995). In the visioning workshop process, stakeholders are presented with a question regarding their hopes or expectations for a future scenario, extending some five to ten years They are then given the opportunity to generate ideas, first individually and then in small groups, about what will have changed in a specified timeframe. The best ideas of the small groups are then put on cards and organised into clusters on a sticky wall[2] by the group, with the assistance of a facilitator (Figure 1.3). Each cluster is identified with a specific name that represents what would have been accomplished if the vision ideas within the clusters become a reality. This name becomes one of the elements of the groups' shared vision and represents the groups' consensus.

For the purposes of developing a vision for EBM/EAF in the Wider Caribbean, participants were divided into four groups, each representing a specific area of interest among participants or for which they had direct responsibility. These groups represented the following elements of the Caribbean Sea ecosystem: i) the continental shelf; ii) offshore pelagic resources; iii) coral reef resources; and iv) governance. Care was taken to ensure that there was a mix of backgrounds among the participants in each group. Each group then undertook a visioning exercise, led by a professional facilitator using the methodology described above.

After the visioning process was completed, participants were asked to indicate the ideas on the sticky wall that they felt should be addressed first using dot prioritization – an established facilitation process for prioritizing ideas among a large number of people (Diceman 2006). Each person was given three red dots to indicate their top three priorities and seven blue dots to specify other areas of importance. Participants then reviewed the vision elements and indicated the principles that underlie each element. This was done by selecting them from a list of the top ten principles, as described by Mahon et al. (Chapter 2).

Figure 1.3. A visioning breakout session with the ideas being grouped on the sticky wall

Achieving the Vision

Assisting and Resisting Factors

Following the completion of the shared vision exercise, the four groups discussed factors that assist movement toward the vision and those that that resist it. The identification of assisting and resisting factors is a concept that is adapted from force field analysis. The concept, developed by the American psychologist Kurt Lewin, is based on factors (forces) that are either driving movement toward a goal (helping forces) or blocking movement toward a goal (hindering forces) (Wikipedia 2008). The exercise was carried out in two parts. In the first part, each group brainstormed assisting factors. These factors were then sorted into those that signified 'strengths' and those that suggested 'opportunities'. The second part identified factors that were either 'weaknesses' or 'threats'.

Strategic Directions and Actions

In the next stage of the symposium, participants were asked to consider what actions will be necessary for EBM/EAF to become a reality in the Wider Caribbean. To do this, the World Café process was used (Creative Commons 2008). Each EBM/EAF breakout group used this process to developing appropriate actions for each element of the vision they had identified earlier.

World Café is a conversational methodology that is useful in accessing the best thinking of groups. In a World Café session, four to five people sit at a café-style table to explore a question or issue that matters in their life, work or community. Other persons seated at similar tables explore similar questions. As participants talk, they are encouraged to write down key ideas or sketch them on paper tablecloths provided for that purpose. After a 20-30 minute 'round of conversation', participants are invited to change tables – carrying insights from their previous conversation to a newly formed small group. One 'host' remains to share with new arrivals any key ideas or questions from the previous dialogue. After three rounds of discussion, the groups meet as a whole to 'harvest' the ideas from the conversations.

The World Café is based on a set of 'integrated design principles' that are intended to foster authentic dialogue. These are:

Setting the *context* – Define the purpose for convening the Café plus the desired outcomes and range of perspectives that need to be included in the process.

Creating a hospitable space – A warm and friendly café setting alerts participants that this gathering is not a business-as-usual meeting. Additionally, meeting in small groups creates conversations that are quite different than tables set for ten. Every effort is made to provide natural light, flowers and refreshments to nourish good conversation.

Explore questions that matter – The questions to be considered by the group are those they most care about. In addition, participants are invited to explore possibilities rather than thinking about what went wrong or who is to blame.

Encourage everyone's contributions – The process encourages all participants to contribute to the conversation. Each participant in the Café represents a part of the whole system's diversity, and as each person has the chance to contribute, more of the insights inherent in the group become accessible.

Connect diverse perspectives – As each person shares their perspective, new ideas may emerge. Tablecloths are used plus paper and markers to create a 'shared visual space' through drawing the emerging ideas.

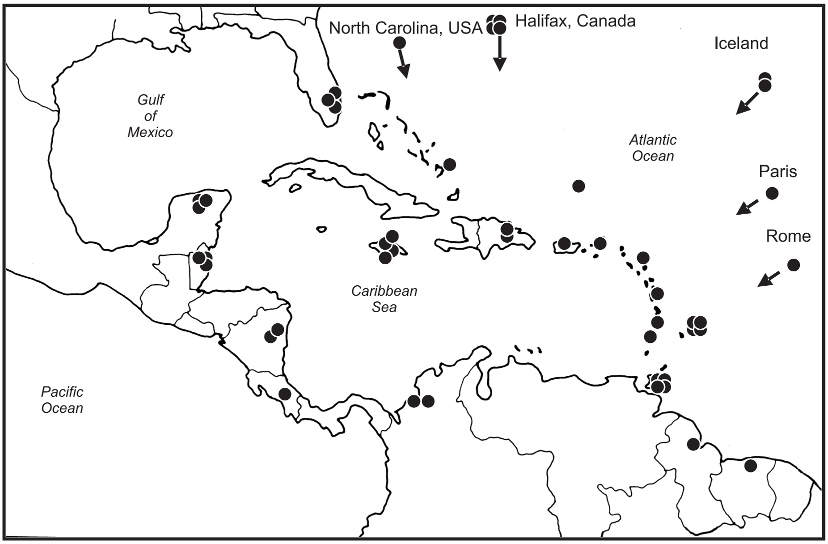
Listen together and notice patterns – The quality of the listening is an important factor determining the success of a Café. Participants are encouraged to listen closely to each other and to try not to formulate their ideas while another is talking.

Share collective discoveries – Conversations held at one table reflect a pattern of wholeness that connects with the conversations at the other tables. The last phase of the Café involves making this pattern of wholeness visible to everyone. To do so, the facilitator holds a conversation with the individual tables and the whole group.

The Participants at the Symposium

In determining the participation in the symposium, special attention was paid to having participants from all around the Wider Caribbean Region and also to having a diversity of backgrounds among them. The 70 participants came from 19 countries in the Caribbean and four countries outside of the region (Figure 1.4). With regard to background, although academics were the predominant group, fishers and the fishing industry, NGOs, intergovernmental organisations and government departments were well represented (Figure 1.5). Many participants were from a fisheries background, as the symposium was oriented to fishery ecosystems. The value of broadening the discussion to include input from the marine transportation, oil and gas, and tourism sectors was recognised from the outset but for logistical reasons it was decided to start with a focus on fisheries.

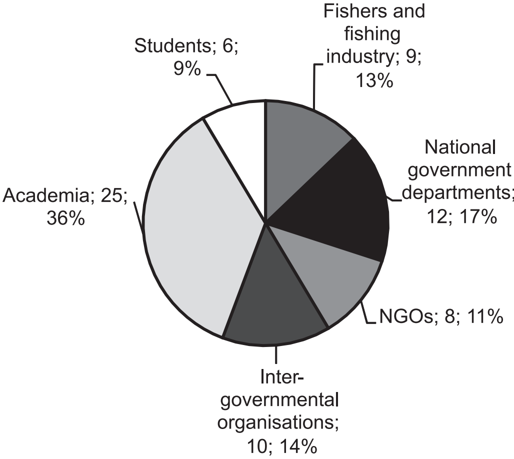
Figure 1.4. The geographical origin of symposium participants



The Organisation of the Book

The organisation of the book follows that of the symposium. It has five parts, each with a brief introduction. Part 1 provides a broad overview of the symposium, the relationship between principled ocean governance and marine ecosystem-based management, and the ecosystem approach to fisheries as conceived by the Food and Agriculture Organization of the United Nations. In Parts II-IV, the presented papers that make up the building blocks of information that the participants worked with are organised by topic: social and economic aspects; fisheries; and governance issues. In Part V, the outputs of the facilitated sessions are presented in a chapter for each of the four working groups, coauthored by all working group participants, followed by an overall synthesis.

Figure 1.5. Occupational breakdown of symposium participants



Notes

1. The Institute of Cultural Affairs in the U.S.A. (ICA-USA) is a private, non-profit, social-change organisation that promotes positive change in communities, organisations and individual lives. ICA Head Office: 4750 N. Sheridan Road, Chicago, Ill, 60640 (http://www.ica-usa.org/).
2. A nylon sheet sprayed with a non-permanent adhesive that allows for the repositioning of cards by a facilitator.

2

Principled Ocean Governance for the Wider Caribbean Region

Robin Mahon, Lucia Fanning and Patrick McConney

Abstract

Cumulative human impacts on oceans have gradually resulted in increased attention directed to ocean governance. Principled ocean governance (POG) seeks to place generally accepted principles front and centre in the governance process. These principles are derived from fundamental values and our beliefs about how humans should behave. They attempt to encode how values should be expressed in both decision-making and actions. Principles often considered as 'substantial', such as sustainability, efficiency, rationality, inclusiveness, equity and precaution are general in nature, and thus give rise to more detailed subsets, including 'procedural' principles that help to guide day-to-day activities. Ecosystem-based management (EBM) comes in a variety of forms. At one end of the spectrum, it is focused largely on ecosystem conservation. At the other end, it also includes aspects of social justice such as equity, preservation of livelihoods, and food security. The prominent role for EBM in POG is evolving and will vary from situation to situation. It is for stakeholders to determine its role through examination, adoption and incorporation of the principles that will guide their particular ocean governance situation.

Introduction

Attention to the sustainable use of the living resources of the oceans has lagged behind that given to terrestrial resources. In the 18th century, the oceans were considered inexhaustible and impervious to human impact. That view gradually gave way in the early 1900s to a grudging acceptance that indeed fishery resources could indeed be overfished. By mid-century it became clear that in addition to stock depletion, fishing was causing both direct and indirect changes on the ecosystems in which it was taking place (FAO 1995). Furthermore, there was the additional realisation that humans were degrading the oceans in other ways as well: through non-extractive uses in coastal areas and land-based impacts on watersheds and coastal zones (World Bank 2004; GESAMP 2001).

This lag in addressing oceans was due to a unique set of issues that are linked to the subject of sustainability: issues of scale, accessibility, jurisdiction and ownership of resources. The advent of the UN Convention on the Law of the Sea (UNCLOS) in 1982 was a major step forward in addressing jurisdictional issues and resulted in supplementary agreements regarding the deep seabed and highly migratory and straddling stocks (Rothwell and VanderZwaag 2006a). Intensified fisheries management efforts followed the adoption of UNCLOS, but with limited success. Conventional management practices were found to be conceptually weak. The management record of the large commercial fisheries of the world has not been good; one might have expected it to be better. Nor have management practices been any more successful at addressing the needs of small-scale fisheries, which predominate in the Caribbean. One might even say that management practices have missed the point entirely where small-scale fisheries are concerned (Berkes et al. 2001). Experience showed that matters pertaining to the management of the oceans were too complex and uncertain to be addressed by government-based deterministic approaches. The search for appropriate approaches to dealing with this complexity and uncertainty broadened in several directions, including a reduction in the uncertainty with science, a reduction of the social unpredictability with participation and consensus, and increases in responsiveness to change through building adaptive capacity (Mahon et al. 2005; NRC 2008).

The 1992 United Nations Conference on Environment and Development (UNCED) resulted in a major shift in global thinking from environment to ecosystems through the vehicles of the Rio Declaration, Agenda 21, and the Convention on Biological Diversity (Vallega 2001). It also helped to bring civil society to the fore in sustainable development. Subsequently, new ideas are steadily gaining currency, e.g., thinking in terms of governance rather than government, considering entire ecosystems rather than their separate parts, and promoting resilience through self-organisation. In response to this trend, ecosystem-based management (EBM) and/or the ecosystem approach to fisheries (EAF) (FAO 1995) have been gaining credibility, even though they lack the specificity necessary to address some of the fisheries and oceans governance issues that were identified earlier. For some, EBM has a strong 'ecosystem first' component, while for others, the social and economic dimensions are of equal importance to conservation (Christie et al. 2007). Discussion continues worldwide, both verbally among practitioners as well as in the professional literature. Considerable effort has been expended to understand what is meant by EBM and EAF, especially at the different scales and locations where they ultimately must be implemented.

Whatever the orientation of the EBM being considered may be, it cannot take place in a governance vacuum. Therefore, a focus on governance must be the launching point for this discussion of POG and the role of EBM in helping to achieve it. Even though distinctions exist, for the sake of brevity, future discussions of EBM will also be understood to refer to

EAF as well. In addition to the pursuit of POG through the Caribbean Large Marine Ecosystem (CLME) Project by countries of the Wider Caribbean Region, other regional level initiatives are also underway. A diverse array of countries and stakeholder groups are attempting to work together to address complex problems associated with the sustainable use of marine resources (Chakalall et al. 2007). Consequently, there will be an increasing need to ensure that institutions and processes are guided by commonly agreed-upon principles. This chapter aims to bring forward the discussion of principles as they apply to future considerations of the sustainable use of marine resources.

Governance and Principles

Governance is not management, nor is it government, but it does encompass both. The movement towards the use of this term reflects a global shift in awareness of the increasing diversity of stakeholders (actors) involved in determining the patterns of actions and ideas that we see and hear around us daily. This shift also applies to the oceans and the use of its resources (Johnston 2006). Current definitions reflect this. For example, in fisheries, Kooiman et al. (2005) define governance as:

> … the whole of public as well as private interactions taken to solve societal problems and create societal opportunities. It includes the formulation and application of principles guiding those interactions and care for institutions that enable them.

The definition by Armitage et al. (2008) is a variation of this:

> The public and private interactions undertaken to address challenges and create opportunities within society. Governance thus includes the development and application of the principles, rules, norms, and enabling institutions that guide public and private interactions.

The definitions above lend prominence to the principles embraced in the concept of governance. Acknowledging the importance of diverse stakeholders in governance draws even greater attention to the need for and importance of specific guiding principles (Bavinck et al. 2005). In many stakeholder discussions, especially informal ones that are typical of small-scale fisheries, principles are often assumed and seldom made explicit. As principles may vary with the perspectives of different stakeholders, explicit articulation is essential in order to ensure that actors operate from a common or agreed-upon set. At the very least, all stakeholders should have a common understanding of the base from which each set of actors will negotiate. In order to give principles the position of prominence considered necessary, Kooiman et al. (2005), in their interactive governance approach to fisheries, place them in the following orders of governance:

- First-order governance – Action-oriented problem solving or day-to-day management;
- Second-order governance – The institutional framework for problem solving including laws and organisational structure;
- Third-order governance – Overarching meta-governance which is about the vision, principles and values that underlie the institutional frameworks.

Treating governance this way allows us to think about each order separately, and about each order's relationship with the others.

Principles and Where They Come From

Principles are derived from our fundamental values and beliefs about how humans should behave. They are an attempt to encode how values and norms can be expressed in decision-making and some actions. It is useful to divide principles into two categories – those that are substantial, i.e., based on deep beliefs that guide our vision for the future and thus the way that we approach governance; and those that are procedural, i.e., that guide the way we interact, make decisions and do business on a daily basis. Some common substantial principles that are regularly encountered in ocean governance (and many other arenas as well) are summarised in Table 2.1, while one formulation of procedural principles is shown in Table 2.2.

Table 2.1. Some substantial principles based on deeply held beliefs and ethical positions with highly paraphrased explanations (after Kooiman et al. 2005)

Sustainability	Preservation of opportunities and options for future generations
Efficiency	The avoidance of waste in any valuable commodity, whether material or immaterial
Rationality	What is being done or needs to be done should make logical sense
Inclusiveness	The need to involve those who are affected
Equity	Fairness and justice in the way that benefits are allocated
Precaution	The acknowledgement of uncertainty and risk and the consequent exercise of care to avoid undesirable outcomes
Responsiveness	The capacity and commitment to respond to needs and concerns

Table 2.2. 'TACIRIE' procedural principles (after Hobley and Shields 2000)

Transparency	All participants should be aware of who makes decisions and how they are made.
Accountability	Local and governmental decision-makers should be answerable to those they represent.
Comprehensiveness	From the outset, all interest groups will be consulted relative to the definition of problems and opportunities, prior to the formulation of any management decisions.
Inclusivity	All those with legitimate interests (in particular, livelihood dependent groups) should be involved.
Representativeness	Decision-makers should represent all interest groups.
Information	All interest groups understand the objectives of the participatory process and have adequate and timely access to relevant information.
Empowerment	All interest groups (women and men) are capable of actively participating in decision making in a non-dominated environment.

Considerable diversity exists in principle sets, which is not surprising given that they may have been developed for a variety of specific purposes. These principles can range widely, such as those created for the sustainable governance of the oceans proposed by Costanza et al. (1998); those found in the U.S. Commission on Ocean Policy (2004); those prepared for the St. George's Declaration of Principles for Environmental Sustainability in the Organisation of Eastern Caribbean States (OECS 2006); and those developed to guide a specific task, such as the principles upon which the Framework for Integrated Assessment and Advice for Small Scale Fisheries is based (Garcia et al. 2008). Many of the principles that are currently used in living marine resource management are articulated in the multilateral environmental agreements (MEAs) that individual countries have signed. Those drawn from the FAO Code of Conduct for Responsible Fisheries (FAO 1995) and the Convention on Biological Diversity (CBD 2000) will be among the most familiar. Recently, some elaborations have been made relating specifically to EBM, two examples of which appear in Tables 2.3 and 2.4. These range from conservation-focused principles to social justice and livelihoods.

The role of EBM in ocean governance generally is evolving, while its role within the specific context of POG in the Wider Caribbean has yet to be determined (Rothwell and VanderZwaag 2006b). When EBM is set in the conservation end of the spectrum, it occupies a specific and readily identifiable place in ocean governance (Figure 2.1). It is seen as acting to maintain the integrity of the non-human aspect of ecosystems and its capacity to produce the full range of goods and services, use and non-use, that oceans can provide as described by Schuhmann et al. (Chapter 8). When EBM is viewed more broadly to include the human component of ecosystems such as social justice, livelihoods and access to goods and services, it expands in scope towards equivalency with existing ideas of comprehensive principled ocean governance (Figure 2.1).

Table 2.3. An ecosystem bill of rights (after Beamish and Neville 2006)

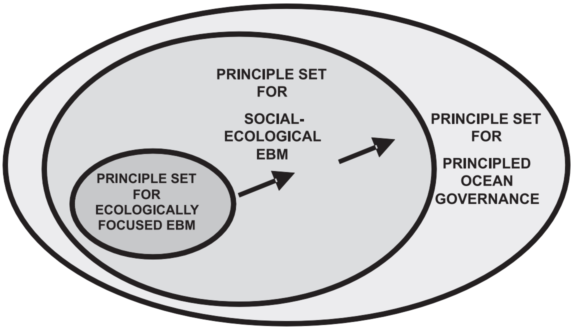
Principle 1:	Interventions into the dynamics of marine ecosystems occur naturally, intentionally and unintentionally. Ecosystem management must improve our understanding of these interventions and communicate the knowledge to the public.
Principle 2:	All natural species in an ecosystem are recognised as being important to the health of the ecosystem.
Principle 3:	Surplus production of some species may be available for human consumption, but estimates of surplus production must include consideration of the impact on associated species.
Principle 4:	Ecosystems must be able to re-organise naturally, which may result in declines of charismatic species.
Principle 5:	Humans are part of the ecosystem and will introduce change, but because of our trophic level we must be stewards of our changes.

Table 2.4. Principles developed for the ecosystem approach to fisheries (after FAO 2003)

Fisheries management under EAF should respect the following principles:

- Fisheries should be managed to limit their impact on the ecosystem to the extent possible;
- Ecological relationships between harvested, dependent and associated species should be maintained;
- Management measures should be compatible across the entire distribution of the resource (across jurisdictions and management plans);
- The precautionary approach should be applied because the knowledge on ecosystems is incomplete;
- Governance should ensure both human and ecosystem well-being and equity;
- Avoid overfishing;
- Ensure reversibility and rebuilding;
- Minimise fisheries impact;
- Consider species interactions;
- Ensure compatibility in management measures across the resource range;
- Apply the precautionary approach;
- Improve human well-being and equity;
- Allocate user rights;
- Promote sectoral integration;
- Broaden stakeholders participation; and
- Maintain ecosystem integrity

Figure 2.1. The extent to which EBM principles may coincide with those for principled ocean governance depending on the EBM perspective taken



Working with Principles

As the above examples illustrate, many different articulations are possible in relation to ocean governance and ecosystem-based management. In most cases, these can be linked back to a relatively small number of substantial principles; the different elaborations are simply attempts to provide detailed delineations to specific circumstances.

As the stakeholders of the Wider Caribbean proceed towards principled ocean governance, the process should include opportunities to reflect explicitly on the substantial principles that are most relevant to the issues of concern to them and the details of how these should be elaborated to meet their needs. As with most other endeavours, there is much that can be learned from what others have done, but the final product must be tailored to the context of the region where it will be used.

At the symposium on EBM for the Wider Caribbean (Fanning et al. 2009), participants were provided with a list of principles culled and adapted from the various sources cited above (Table 2.5). They were asked to identify those that they thought deserved the highest priority. The results are shown in Table 2.5 and Figure 2.2. We do not suggest that this is the definitive set of prioritised principles for EBM in the Wider Caribbean, but it does reflect the perspective of the cross-section of stakeholders attending the symposium. Further, it suggests that the orientation in the region is towards a broader perspective on EBM as shown in Figure 2.1, one that includes key aspects of social justice, such as empowerment and equity, along with the conservation of natural resources.

Table 2.5. The principles and scores presented as a result of dot voting

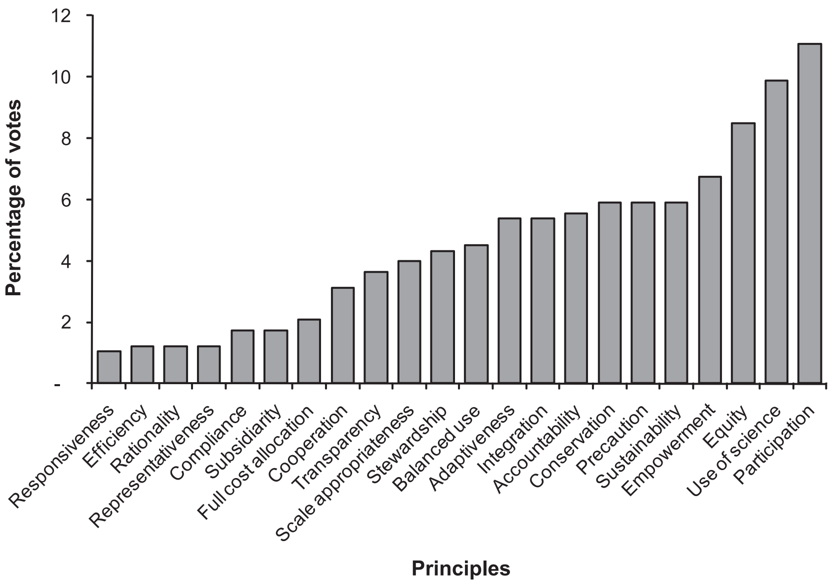
Principles		Row score	Group score
Accountability	Decision-makers and members of the public should be accountable for the actions they take that affect ocean and coastal resources	32	32
Adaptiveness	Given uncertainty in environmental resource management, decision-makers should gather and integrate ecological, social, and economic information for adaptation of management	26	31
	Management programs should be designed to meet clear goals and provide new information to continually improve the scientific basis for future management	5	
Balanced use	Management should seek the appropriate balance between, and integration of, conservation and use of biological diversity	6	26
	The many potentially beneficial uses of ocean and coastal resources should be acknowledged and managed in a way that balances competing uses while preserving and protecting the overall integrity of the ocean and coastal environments	18	
	The objectives of management of land, water, and living resources are a matter of societal choice	2	
Compliance	Ensure compliance with and enforcement of conservation and management measures	10	10
Conservation	All species in an ecosystem are recognised as being important to the health of the ecosystem	2	34
	Management should conserve aquatic ecosystems and protect critical fisheries habitats	25	
	To preserve marine biodiversity, downward trends in marine biodiversity should be reversed where they exist to maintain or recover natural levels of biological diversity and ecosystem services	7	
Cooperation	Cooperate at subregional, regional and global levels to ensure effective conservation and protection of living aquatic resources throughout their range of distribution	18	18
Efficiency	Ocean governance systems should operate with as much efficiency and predictability as possible	5	7
	The avoidance of waste of any commodity that is of value, whether material or immaterial	2	
Empowerment	All interest groups (women and men) are capable of actively participating in decision-making in a non-dominated environment	25	39

Principles		Row score	Group score
	Laws governing uses of ocean and coastal resources should be clear, coordinated, and accessible to the nation's citizens to facilitate compliance	14	
Equity	Fairness and justice in the way that benefits are allocated	14	49
	Management of fisheries should ensure allocation of user rights and equity	13	
	Management should ensure safe, healthy and fair working and living conditions in the fishing industry to improve human well-being	11	
	Management should protect the rights of fishers and fish workers, particularly subsistence, small-scale, and artisanal fishers	11	
Full cost allocation	All of the internal and external costs and benefits, including social and ecological, of decisions concerning the use of environmental resources should be identified and allocated	12	12
Integration	Ocean policies should be based on the recognition that the oceans, land, and atmosphere are inextricably intertwined	29	31
	Management of fisheries should promote sectoral integration	3	
Participation	All stakeholders should be engaged in the formulation and implementation of decisions concerning environmental resources	34	64
	All those who have a legitimate interest are involved prior to any decisions about management being taken	11	
	All interest groups understand the objectives of the participatory process and have adequate and timely access to relevant information	19	
Precaution	In the face of uncertainty about potentially irreversible environmental impacts, decisions concerning their use should err on the side of caution and the burden of proof should shift to those whose activities potentially damage the environment	20	34
	The acknowledgement of uncertainty and risk and the consequent exercise of care to avoid undesirable outcomes	10	
	Management should not postpone or fail to take action due to absence of adequate scientific information	4	
Rationality	What is being done or will be done should make logical sense to stakeholders	7	7
Representativeness	Decision-makers must represent all interest groups	7	7
Responsiveness	The capacity and commitment to respond to needs and concerns	6	6

Principles		Row score	Group score
Scale appropriateness	Management measures should be compatible across the entire distribution of the resource	4	23
	Management should be undertaken at the appropriate spatial and temporal scales	12	
	Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term	7	
Stewardship	Access to environmental resources carries attendant responsibilities to use them in an ecologically sustainable, economically efficient, and socially fair manner	12	25
	Humans are part of the ecosystem and will introduce change, but because of our trophic level we must be stewards of our changes	4	
	Promote awareness of responsible fisheries through education and training	9	
Subsidiarity	Management should be decentralised to the lowest appropriate level	10	10
Sustainability	Conserve target species, species belonging to the same ecosystem or associated with or dependent upon the target species	1	34
	Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems	10	
	Ecosystems must be able to reorganise naturally, which may result in declines of charismatic species	5	
	Management of fisheries should ensure reversibility and rebuilding and limit their impact on the ecosystem to the extent possible	2	
	Ocean policy should be designed to meet the needs of the present generation without compromising the ability of future generations to meet their needs	16	
Transparency	Everyone should see how decisions are made and who makes them	21	21
Use of science	Ocean policy decisions should be based on the best available understanding of the natural, social, and economic processes that affect ocean and coastal environments	25	57
	Use of best scientific evidence available, including traditional knowledge	32	

Development of a shared vision can be a proxy for a direct discussion on shared principles. If the vision is truly shared, then it is likely that the underlying principles are also shared. However, it can be useful to examine the components of the vision so as to make note of what principles are embodied and to ensure that none that are considered to be important are omitted or compromised. One aim of taking this approach is to bring principles into the discussion arena as a prominent and common topic that sets the stage before focusing on detailed issues.

Figure 2.2. Priority scoring of principles considered essential for EBM in the Wider Caribbean



Conclusion

Ensuring effective progress with the adoption of principled ocean governance for the Wider Caribbean should include explicit attention to underlying principles. Strategies and plans should be checked against these principles. Ecosystem-based management is emerging as a significant factor in principled ocean governance and is evolving its own supporting set of principles. This evolutionary process must be carried out with appropriate oversight to ensure that EBM principles are complementary to those of POG and that they give greater effect to the values that are of the greatest concern to stakeholders. In this symposium, a start has been made in reflecting on appropriate principles for marine EBM in the Wider Caribbean, both directly and through the development of shared visions for three major Caribbean marine ecosystems and their governance as presented in Chapters 22-26.

3

Meeting the Challenge of Applying an Ecosystem Approach to Fisheries Management

Some Experiences and Considerations Based on the FAO's Work

Gabriella Bianchi and Kevern Cochrane

Abstract

Originally motivated by ecosystem sustainability concerns, the ecosystem approach to fisheries (EAF) has come to integrate all the elements needed for the realisation of sustainable development in fisheries, including those relevant to the ecological, socio-economic and institutional dimensions. Despite its perceived complexity, pragmatic approaches are developing such as the one adopted by the FAO guidelines (FAO 2003, 2005), and FAO is introducing and facilitating actual implementation in a number of countries and regions. While lack of detailed scientific knowledge is seen by many as the main hindrance to the realisation of EAF, preliminary observations based on the work done through FAO projects indicate that stakeholders regard poor governance and external drivers as the main threats to sustainability. In relation to knowledge needs, two opposite attitudes have emerged to address the broad range of issues and the complexity that EAF entails. One must almost dismiss the usefulness of scientific knowledge for sustainable management and instead focus on the participatory decision-making process to achieve sustainability. This attitude also recognises that scientific knowledge is often not understood and therefore not perceived as legitimate by stakeholders. The other, opposite view regards detailed scientific knowledge as a prerequisite for the EAF to succeed. The FAO's EAF guidelines, consistent with the Code of Conduct for Responsible Fisheries, encourage the use of the 'best available knowledge' in fisheries management, a phrase that embodies two basic principles of the EAF, i.e. seeking improved knowledge but not postponing important decisions because of lack of complete knowledge. Furthermore, given the high level of uncertainty that characterises many ecosystem issues and the increased number of fisheries management objectives, more attention

should be given to risk assessment/management techniques for decision-making.

The FAO's Ecosystem Approach

During the past decade the world community has largely adopted the ecosystem approach as the most adequate means to meet the challenges of sustainable development in relation to the utilisation of natural resources. This has happened in response to widespread unsustainable practices and despite many uncertainties about the exact nature and intent of the concept. As a result, there has been a proliferation of efforts to define the ecosystem approach and its principles. While this has led to the adoption of somewhat different approaches and acronyms (e.g., FAO 2003; Murawski 2005; Ward et al. 2002; Garcia et al. 2003; UNEP 1998; Christie et al. 2006), these efforts have largely resulted in a broad convergence in the understanding of the key motivations and ways of implementing this approach (Bianchi and Skjoldal 2008). Furthermore, it is also broadly recognised that the key principles that underlie the ecosystem approach are not new and can all be traced back to earlier instruments, agreements and declarations, while it is the implementation that lags behind as shown by the lack of synchronism between the international discourse and the actual situation on the ground.

The ecosystem approach emphasises sustainability principles, making their application more compelling. The FAO's definition clearly emphasises the need to consider human aspirations as an integral part of the approach:

> An Ecosystem Approach to Fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries. (FAO 2003)

While this definition clearly addresses the human and ecological components of ecosystems, the term 'ecosystem approach' on its own does not explicitly state the importance of taking into account the other essential components of sustainability (social, economic and institutional). Moreover, it often evokes the idea that the approach is mainly a natural-science undertaking based on unattainable knowledge requirements. This is a perception that the authors have often noticed particularly in developing countries, where human and financial resources are usually very limited, and amongst some social scientists.

Notwithstanding this common confusion, the FAO process for planning and implementing EAF shows how to comprehensively implement sustainability and equity principles. This process is described in the FAO guidelines (FAO 2003; 2005) and was derived from the Australian Ecologically Sustainable Development (ESD) process (Fletcher et al. 2002). Operating with the understanding that the best available knowledge will be used in the management process, the FAO guidelines introduce a participative and adaptive process that utilises a risk management approach to deal with uncertainty and is consistent with a precautionary approach. It should be noted that while the FAO guidelines are still in need of further development, they are probably among the most complete set of conceptual and operational tools for the implementation of the ecosystem approach to fisheries. Furthermore, it should be noted that the FAO's guidelines may be considered to have a certain legitimacy, as the process that led to their formulation has its roots in intergovernmental consultations (the 2001 Reykjavik Conference on sustainable fisheries in the marine ecosystem). Moreover, the guidelines were the result of the efforts of an international expert group and benefited from further discussions by the international community in connection with the 23rd session of the Committee on Fisheries (COFI) in 2003.

Framework for Implementation

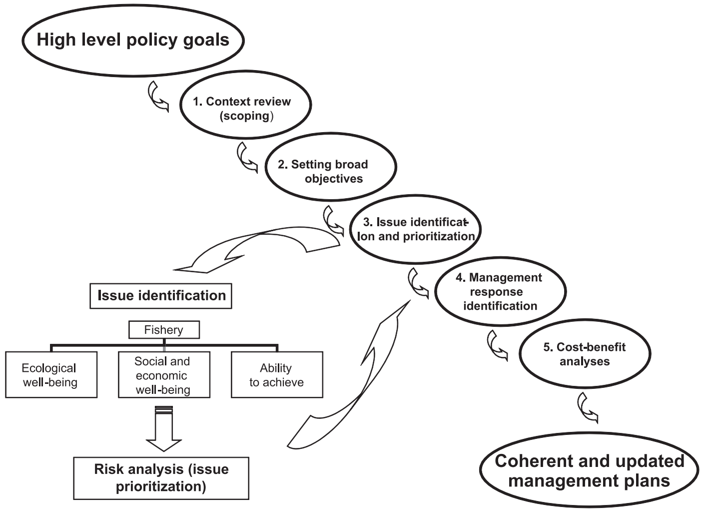
The key features of the framework proposed in the FAO guidelines for planning and implementing EAF can be summarised as follows:

- It is participatory, at all levels of planning and implementation;
- It is comprehensive, ensuring that all key components of the fishery system are taken into consideration, including those related to the ecological, social-economic and governance dimensions, while also taking into account external drivers;
- It encourages use of the 'best available knowledge' in decision-making, including both scientific and traditional knowledge, while promoting risk assessment and management and the notion that decisions should also be made in cases where there is lack of detailed scientific knowledge;
- It promotes adaptive management and stresses the importance of establishing mechanisms for feedback loops at different time-scales to adjust the tactical and strategic performance based on past and present observations and experiences;
- It evolves from existing fisheries management institutions and practices.

Realisation of an EAF will require sincere societal commitment to a vision that promotes conservation, sustainable use and the equitable sharing of ecosystem benefits. Its actual application does not need to follow a single blueprint but must be consistent with the local context and culture as well as local means.

Given the complexity and the vastness of the issues to be considered under an EAF, the FAO guidelines adopt a pragmatic approach following that used in the ESD process but expanded in some areas. This includes a planning process that consists largely of examining existing or developing fisheries to identify priority issues to be dealt with by management in order to be consistent with an ecosystem approach. The main result of this planning process is the backbone of EAF management plans. The implementation of EAF should be about improving participatory decision-making and implementation in an ecosystem context and does not require, in principle, a detailed scientific understanding of how the ecological, social or economic systems work, although reducing uncertainties with more knowledge would clearly improve implementation.

Figure 3.1. Main Steps for Developing or Modifying EAF Management Plans, Including the Process of Issue Identification and Prioritisation (from Bianchi et al., 2009)



The main steps of the planning process are presented in Figure 3.1, showing how high-level policy goals that are often too general to be useful in day-to-day management can be translated into operational objectives and rules on decision-making for actual implementation. A fundamental step of this process is related to the identification of the issues that are recognised by the various stakeholders as requiring attention by management as a matter of priority. This process is carried out in a structured way, following three major categories: 'ecological well-being', 'social well-being' and 'ability to achieve'. The latter includes governance issues but also drivers that are external to the fisheries systems (Figure 3.1). The identification process results in a number of issues whose priority is set though a process of qualitative (and if possible also semi-quantitative or quantitative, according to data and information available) risk analysis. This process is innovative, especially compared with conventional fisheries management, as it uses a holistic approach that considers various aspects of environmental and social sustainability.

The subsequent steps in the process summarised in Figure 3.1 are related to identifying how management can actually deal with the priority issues, including the identification of operational objectives (i.e. targets), the management tools that are most appropriate to achieve these, and assessing the costs and benefits of alternative management options. The results of these steps provide the basis for the development of fisheries management plans. The process described here is not radically different from the one that could be described under conventional fisheries management. However, a few important differences exist. These relate mainly to the expanded scope of the fisheries management concerns andissues that EAF management plans deal with and, perhaps also because of this, a more explicit need to develop fisheries management plans that is often not felt under conventional fisheries management.

The existing guidelines (FAO 2003; 2005) provide a broad overview of the fundamentals of EAF and a basic process for planning and implementing the approach. Full implementation addresses many dimensions and the details will vary from case to case. To this end, FAO is developing a 'toolbox' for facilitating the implementation of the ecosystem approach (FAO 2008a) by making best practices available to fisheries management practitioners and stakeholders. The toolbox is structured on the main steps of the fisheries planning and implementation processes in order to help the user move through the various steps of implementing the EAF and choose which tools are appropriate for the characteristics of the system under consideration. The toolbox recognises that implementation may not be a sequential process, and entry is possible from several entry points (policy, implementation, etc.). The toolbox will be adaptive and open, allowing for innovations and improvements to be quickly inserted. Tools include concrete measures that managers and other stakeholders can directly apply such as guides to the use of appropriate and effective consultations and consensus-building mechanisms, bycatch reduction devices, time and area closures, and marine protected areas (MPAs).

Preliminary Observations Based on Case Studies

In response to FAO member countries' requests to receive assistance in applying the ecosystem approach, several trust fund projects are being implemented by the FAO. Their purpose is to address EAF through concerted efforts aimed at simultaneously achieving progress in several, if not most, of the relevant aspects of EAF in selected locations or ecosystems.

The project *Ecosystem Approaches for Fisheries Management in the Benguela Current Large Marine Ecosystem*, a cooperative effort between the FAO, the Benguela Current Large Marine Ecosystem programme (BCLME) and fisheries agencies of Angola, Namibia and South Africa, examined the feasibility of implementing EAF in the Benguela region. This project pursued a structured and participatory approach based on the FAO guidelines in order to identify and prioritise the gaps in the existing approaches and to consider potential management actions to address them.

Scientific Basis for Ecosystem-Based Management in the Lesser Antilles Including Interactions with Marine Mammals and Other Top Predators was another project that provided technical assistance to fisheries institutions of selected countries in the Lesser Antilles. The assistance consists of developing information tools including ecosystem modelling and Geographic Information Systems (GIS), collecting standard fisheries data and improving the management of their pelagic resources and fisheries in accordance with EAF (Fanning and Oxenford Chapter 16). This project was funded by the government of Japan, which is currently also funding another project providing extended capacity building for EAF to selected countries mainly through smaller-scale pilot studies and workshops examining the needs and priorities for EAF. The Japanese government is also supporting ongoing investigations into ecosystem indicators and modelling approaches as well as the production of an abridged version of the Technical Guidelines on EAF aimed at a more general audience.

Yet another project aims to strengthen the knowledge base for implementing EAF in developing countries, in partnership with various GEF-LME regional projects. Core funding for this project comes from the government of Norway. With an initial focus on the African region, this project will promote capacity building, standardised data collection and the monitoring of marine fisheries and related ecosystems while supporting policy development and management practices consistent with EAF principles.

Several complementary sub-regional projects that implicitly address the various biological and socio-economic aspects of EAF in the Mediterranean region are also being implemented with funding from the governments of Greece, Italy, and Spain as well as the European Union and in cooperation with the General Fisheries Commission for the Mediterranean (GFCM).

EAF is an underlying feature of projects funded by the GEF (Global Environment Facility) in the Bay of Bengal, Canary Current ecosystem and the Mediterranean Sea in which the FAO is playing a leading role.

The above projects have allowed the introduction of principles and methodologies for the application of the ecosystem approach in a number of countries and regions, mainly through workshops at the national and regional levels. The regions covered and the types of activity held are shown in Table 3.1.

Table 3.1. Summary of activities undertaken by FAO to introduce the EAF principles and methodologies for application

Region	Countries	Activity
Lesser Antilles	Antigua and Barbuda, Barbados, Dominica, Grenada, St Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago	Introduction of EAF principles and methodologies at the regional level (in connection with Project meetings) Issue identification and risk analysis at national level
North-West Africa	Morocco, Mauritania, Senegal, The Gambia, Guinea Bissau	Introduction of EAF principles and methodologies at the regional level
Gulf of Guinea	……	Introduction of EAF principles and methodologies at the regional level
Southern Africa	Angola, Namibia, South Africa	Introduction of EAF principles and methodologies at the regional level Issue identification and risk analysis at national level Cost-benefit analyses Development of performance reports Consideration of institutional constraints, potential incentives for EAF, methods for strengthening decision-making Consideration of the ways forward to strengthen implementation
East Africa	South Africa, Mozambique, Madagascar, Comores, Mauritius, Kenya, Tanzania, Seychelles	Introduction of EAF principles and methodologies at the regional level
Pacific Island Countries and Territories		Introduction of EAF principles and methodologies at the regional level
Mediterranean Sea		Introduction of EAF principles and methodologies to the GFCM
South and Southeast Asia		Introduction of EAF principles and methodologies at the regional level

The initial approach taken in all regions and countries is to examine existing issues, problems and needs associated with the implementation of EAF through a systematic analysis of major national fisheries. Through this process, the priorities for action are identified and options for addressing them developed in performance reports. In line with the FAO guidelines, the approach is stepwise. The entry point for implementation of EAF can range from, for example, all human sectors within a specified ecosystem to a much narrower but still useful focus on a particular fishery (or other sector) within the same ecosystem. In practice, the starting point for the activities shown in Table 3.1 has been mainly from a particular fishery or group of fisheries. This has commonly been for the simple reason that in the field of fisheries, the FAO works mainly through the national and regional fisheries agencies. Although this approach may not seem consistent with the principle of an ecosystem approach implemented across all human activities, it is a practical transition from existing management arrangements and existing institutional arrangements and constraints. As a starting point for implementation of a multi-sectoral ecosystem approach, it is therefore commonly more tractable.

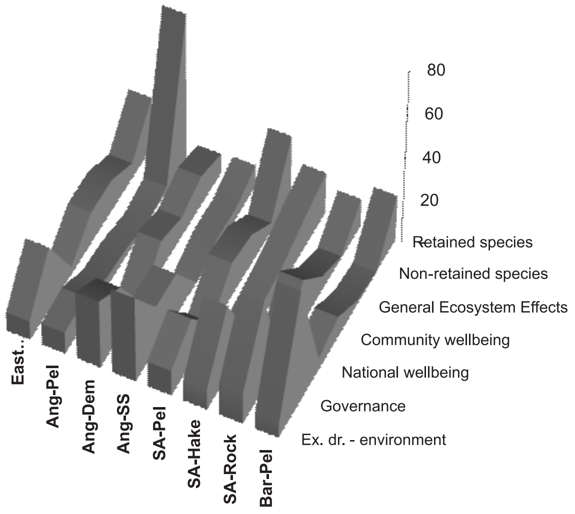
Table 3.2. Main steps followed in introducing EAF (modified from Cochrane et al. 2007)

Step	Description
1	Reviews of the major fisheries, their ecological, economic and social characteristics
2	Issue identification, including all those issues of concern within the context of EAF, that were not satisfactorily addressed under the existing management strategies and systems
3	Risk assessment in which the issues identified under (2) were prioritized by assessment of their relative risk (consequence x likelihood)
4	Performance reports prepared for each issue of moderate to high priority, as indicated by the risk assessment, including an appropriate management response
5	Priority issues aggregated into groups that could be addressed through the same management response. This step is required to simplify the problems by reducing what is typically a large number of issues to a manageable number
6	Performance reports for issues in the same group amalgamated to produce a single performance report for each group
7	Evaluating, based on the best available information, of the benefits and costs (i.e. positive and negative impacts) of alternative management responses for those issues requiring a management response. These should form the starting point for implementation

The key steps taken for each fishery (e.g., the hake fishery in Namibia) or major subsector (e.g., small-scale fishery in Angola) are summarised in Table 3.2. While steps 1-4 have been introduced to all regions, the full process as shown in Table 3.2 was carried out in the Benguela Region only because of the project funding and goals and because of the national and regional institutional commitment and support which enabled a comprehensive feasibility study. The process of expanded implementation is continuing within the three BCLME countries and at the regional level as well, through the recently created Benguela Current Commission.

Collaboration has been initiated with the Pacific Island States to merge their community-based approach with the EAF. The aim is develop a Community-Based Ecosystem Approach to Fisheries Management (CEAFM), with a methodology to plan and implement EAF in the socio-cultural and ecological conditions that typify these islands. In this region, coastal fisheries are small-scale, multispecies and often managed through traditional arrangements or tenure systems. These, however, often prove not to be fully satisfactory at present, given the rapid changes taking place both in the environment and in society as a result of external pressures outside the control of these communities. In fact, in addition to overfishing and destructive fishing practices, many non-fisheries activities including land reclamation, uncontrolled development, siltation, eutrophication and pollution are impacting marine ecosystems and fish stocks in this region (SPC 2008).

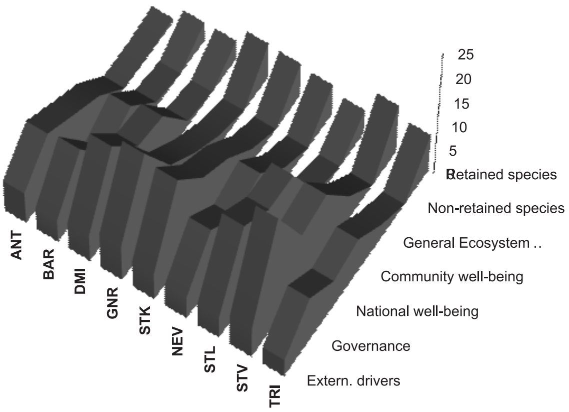
Figure 3.2. Summary Results of Issue Identification for Seven Main Fisheries from East Africa (reef), Angola (pelagic, demersal and small scale); South Africa (pelagic, hake and rock lobster); Barbados (pelagic fishery). The vertical axis shows percentage of issues in each category.



Drawing from examples of some of the projects that have been implemented by the FAO, Figure 3.2 shows the distribution of issues identified for some fisheries and countries or regions. The figure represents quite different examples of fisheries, i.e., from the industrial pelagic fishery in South Africa to the small-scale fishery in Angola and the reef fishery of East Africa. While at this stage it may be premature to perform detailed analyses based on the results obtained, the examples shown in Figure 3.2 indicate a bimodal dominance of issues, with one mode related to governance and to external drivers and a second one related to retained species. It needs to be recognised that this may be partly a function of the representation in the stakeholder workshops which, despite efforts to gain wider representation in all cases, has tended to be dominated by scientists from the management agencies. Despite this and the fact that it probably leads to some bias in the results of the issue identification process, it is also interesting to note that these results seem to indicate that the process of systematically examining a fixed set of key categories of issues, along the key dimensions of the fishery system, contributes to a result that is less correlated with the background of the assessor.

Figure 3.3 summarises the results obtained from the issue identification and risk analysis process carried out in the Lesser Antilles region as a result of one of the activities under the Lesser Antilles Pelagic Ecosystem (LAPE) project (data from Grant 2008). The strong representation of issues related to governance and national and community well-being is apparent in these examples.

Figure 3.3. Distribution of Average Number of Issues Identified as Posing Moderate to High Risk for Countries in the Lesser Antilles Region, by Main Categories



Some key general lessons from these initial experiences can be summarised as follows:

- In order to ensure the appropriate level of legitimacy of the process, a formal and comprehensive identification of stakeholders taking part in the issue identification process and risk analysis is needed.
- The workshops must be facilitated in a way that the opinions of less articulate participants are sufficiently represented.
- The EAF concepts and ideas are usually introduced to a well-educated audience and the available materials are usually tailored to this level. There is a need to develop extension material to explain and facilitate

EAF with various stakeholders and fishers communities, including poorly educated and illiterate members.
– The high frequency of governance issues identified in all case studies demonstrates that these are perceived as the most critical to address sustainability issues.

What is an Adequate Knowledge Base for an Ecosystem Approach?

For a few decades there has been broad agreement that knowledge-based management is the most appropriate approach to natural resources management, including in fisheries. Bruntland (1997), for example, writes:

> In ocean management, as in most other areas of human endeavour, close cooperation between scientists and politicians is the only way to move forward. Science must underpin our policies. If we compromise on scientific facts and evidence, repairing nature will be enormously costly, if possible at all.

This view has its roots in normal science and positivism (see, for example, Garcia 2008) and has been largely reflected in the conventional fisheries management paradigm.

Experience in fisheries management has shown that the importance of science should not overshadow the importance of other elements that are necessary for successful management such as good governance and compliance. Already in the early 1970s, John Gulland saw the willingness of fisheries administrations to take action as the key element for successful management. He underscored the fallacy that complete scientific understanding was necessary for effective management (Gulland 1971). Ludwig et al. (1993) attribute limited value to science in relation to natural resources management and indicate that better ecological understanding is not the solution that leads to a better performance of management.

The advent of the ecosystem approach to fisheries management, with its much-expanded view of the fishery system, has highlighted two extremes in perspectives as regards the usefulness of science in fisheries management. One perspective, quite common in fishery institutions in developed countries, is that much more effort is needed to improve our knowledge of ecosystems as a fundamental requirement for the implementation of an ecosystem approach. According to this view, effective ecosystem-based management requires knowing how ecosystems function and being able to predict, with some reliability, their productive capacity and the consequences of management actions. Based on this, scientists advocate for more funds to be made available, and substantial efforts are often being put into increasing our understanding of ecosystem and resource dynamics before ecosystem-based approaches can be implemented (e.g., Cury 2004; NOAA, http://www.nwfsc.noaa.gov/research/divisions/fram/science.cfm).

Degnbol (2002) refers to the strict science requirements under conventional fisheries management noticing that, if adopted in applying the ecosystem approach to fisheries, the resources required for ecosystem research and management would be immense, and a high level of uncertainty would probably still persist around ecosystem processes.

Based perhaps on the perception of the inapplicability of the 'positivist/reductionist' paradigm to ecosystem-based management, another school of thought questions the dominance and, in a few extreme cases, even the usefulness of scientific knowledge in dealing with environmental management. Scepticism towards the conventional science decision-making paradigm is also based on the common disconnect between science and people, the dangers of an inbreeding of knowledge based on strictly disciplinary peer-review processes, and the frequent lack of incorporation of other sources of knowledge such as traditional knowledge (Galloping et al. 2001). In fisheries this would be especially relevant in relation to applying science to a cultural context where it may not be understood, as may be the case for many small-scale fisheries in developing countries.

It is out of the scope of this contribution to review different approaches as regards the use of science in fisheries. However, we would like to highlight the basic principle that, in accordance with the Code of Conduct for Responsible Fisheries, implementation of EAF should be 'based on the best scientific evidence available, also taking into account traditional knowledge of the resources and their habitat, as well as relevant environmental, economic and social factors' (FAO 1995: para 6.4).

In the case of high-value fisheries that are currently well-monitored and managed, the available – and potentially available – knowledge is likely to enable a rapid evolution to effective EAF. This can be seen, for example, in the case of Australia's federal fisheries, the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), and management in the Gulf of Alaska. The study undertaken in the Benguela ecosystem indicates that EAF, which reconciles conservation of the ecosystem and resources with sustainable fisheries, is immediately feasible there too, at least in the upwelling portions of the ecosystem in South Africa and Namibia. The real problems arise at the opposite end of the fisheries spectrum, in multispecies, small-scale fisheries with limited management capacity and limited existing knowledge of fishery or ecosystem status and trends.

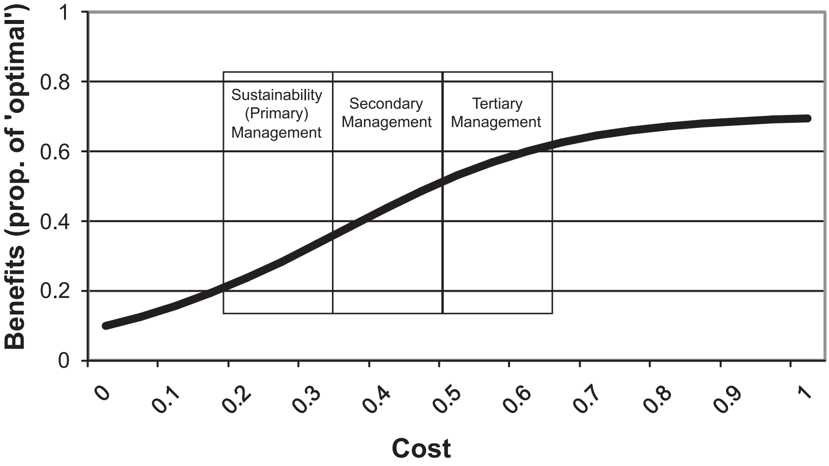
In those situations where adequate scientific information is not available but there is a perceived need for management action (also in accordance with the precautionary principle), a risk assessment approach can be taken utilising qualitative and semi-qualitative risk assessment techniques that are proving to be useful in multispecies and data-poor situations (e.g., Sainsbury and Sumaila 2001; Dowling et al. 2008). Risk assessment can be used for prioritising issues to be dealt with by management as part of the EAF planning process (see Figure 3.1). Where possible, a semi-quantitative risk assessment can be used to provide greater justification of the risk categorisation and in relation to management response (examples provided in Dowling et al. 2008).

The prevailing approach advocated in cases of limited knowledge and management capacity is one of avoiding long-term damage and staying above undesirable thresholds rather than aiming for optimal long-term benefits. The scientific basis of such management is similarly modest, relying on 'dataless' management and rapid appraisals for example, making extensive use of local knowledge (e.g., Johannes 1998; Berkes et al. 2001; Andrew et al. 2007). Given the management constraints in such cases, these 'sustainability' approaches are probably the only realistic solution. However, as discussed in Cochrane (2009), they imply high levels of uncertainty and require full application of a precautionary approach to minimise the risk of undesired outcomes. This in turn means that some social and economic benefits, realisable with better knowledge, will be forgone; often in cases where poverty most requires making full use of whatever resources are available. Cochrane (2009) therefore referred to such limited information approaches as being primary fisheries management, drawing a parallel with the equivalent in human health care. By comparison, tertiary management would be characterised by sophisticated and typically costly methods of obtaining all necessary information, analysing and using that information, and implementing and reviewing. Such tertiary management is typically found only in high-value commercial fisheries, where the costs can be justified by the direct economic return. Cochrane proposed that primary management should be seen as the minimum level required, but that the longer-term goal should be to reduce key uncertainties in order to allow for optimal benefits from the ecosystem in a sustainable manner, which could imply a need for secondary or tertiary management (Figure 3.4). The means to reduce uncertainties will vary from case to case but must inevitably include full stakeholder participation and input, reinforced as much as possible by formal scientific advice. Rightly or wrongly, in practice, the determining factor for how much scientific knowledge is likely to be available in any case will be set by the economic tradeoff between the cost of research and the resulting benefits (Figure 3.4).

A few important conclusions emerge from the above:

- Science is a necessary but insufficient condition for successful resources management. One of the consequences of an overreliance on science is that the huge investment made in fisheries science is often nullified because of poor governance;
- The recognition of the wider limitations in management systems lead to the need for an expanded scope of fishery research, from being mainly biological to also include social, economic and policy-oriented disciplines;

Figure 3.4. Relationship between Costs and Benefits of Research (from Cochrane 2009)



- Because of the knowledge they can bring, stakeholders must be an integral part of this expanded research;
- Decisions have to be taken also under conditions of limited scientific knowledge (consistent with the precautionary approach), but improved knowledge will result in improved decision-making and increased benefits to society;
- When detailed scientific knowledge is not available, a participatory process based on the best available information and applied in a precautionary and adaptive manner should enable sound management decisions to be made and implemented.

Part II

Social and Economic Aspects

Introduction

The second part of this book is concerned with the social and economic aspects of marine EBM/EAF. The distinction is not sharp and it includes several of the background presentations that addressed topics other than commercial fisheries and governance institutions. Bearing in mind that marine EBM does not stop or start at the shoreline, Sweeney and Corbin address the implications of land-based activities in small islands for marine EBM (Chapter 4). They show how important terrestrial influences can be for the nearshore environment and activities within it, as well as reminding us how these influences extend offshore and are transboundary given the hydrographic conditions associated with the Caribbean Sea and its major river inflows. This topic is taken further in Chapter 5 by Gil and Wells who specifically address the impacts of land-based marine pollution on ecosystems in the Caribbean Sea and the consequent implications for EBM.

Bustamante and Vanzella-Khouri write in Chapter 6 about building capacity and networking among managers as essential elements for an effective large-scale, transboundary ecosystem-based management through effective marine protected area (MPA) networks. They remind us that marine protected areas often have multiple objectives related to both commercial use and biodiversity conservation. Some see MPAs as the ultimate conservation tool, while others are sceptical. In the chapter their focus is, however, on how the human resources to manage MPA can be enhanced through social networking to build capacity. McConney and Salas ask "Why incorporate social considerations into marine EBM?" and then proceed, in Chapter 7, to answer by dissecting the principles of the ecosystem approach to illustrate the relevance of social perspectives.

Schuhmann, Seijo and Casey (Chapter 8) tackle the economic considerations for marine EBM in the Caribbean. This is an important topic, especially in terms of resource valuation, as scientists and managers seek a common currency for communicating with policymakers and the public on marine environmental matters in ways that everyone can appreciate. The final contribution (Chapter 9) in this section is about an ecosystem approach to fisheries: linkages with sea turtles, marine mammals and seabirds by Horrocks, Ward and Haynes-Sutton. It is a fitting bridge to the next part on fisheries and applies many of the perspectives in the previous chapters to the conservation and utilisation of these animals, many of them prized as 'charismatic megafauna'. The chapter provides a vivid illustration of how social and economic values combine with coastal and marine uses to create issues and opportunities for conservation and sustainable utilisation through adaptive management.

4

Implications of Land-based Activities in Small Islands for Marine EBM

Vincent Sweeney and Christopher Corbin

Abstract

Ecosystem-based management (EBM), which can be considered an integrated watershed and coastal area management (IWCAM) approach, is an innovative way to address the additional challenges faced by human activities in the context of small islands. These activities threaten the ability of coastal and marine ecosystems in the Caribbean to provide benefits such as seafood, safe and clean beaches, and shoreline protection from storm surges and flooding. Small islands are considered "one big watershed", since most activities on land can create negative impacts on the marine environment. Human activities on land, along the coasts, and in the ocean are unintentionally but seriously affecting marine ecosystems by altering marine food webs, changing the climate, damaging habitat, eroding coastlines, introducing invasive species, and polluting coastal waters. Concern over this situation led to the development of the Cartagena Convention and its Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol). The LBS Protocol may force countries to bear in mind the interconnectedness of marine ecosystems from the context of small islands in planning for interventions addressed by the Protocol. The marine EBM response to land-based activities must seek to link approaches such as integrated land-use planning with IWCAM in the Caribbean. One of the key challenges will be the coordination of national efforts and regional mechanisms. The specific implications of land-based activities and their impacts are discussed.

Introduction

The Caribbean Sea is an important natural resource for tourism, fisheries and general recreation. The associated coastal and marine ecosystems are extremely fragile and vulnerable to human activities, especially those that take place on land. Regional and national actions are urgently needed to protect these vital marine resources in the Wider Caribbean region.

Human activities on land as well as in the ocean have changed coastal and marine ecosystems in the Caribbean and threaten their ability to provide benefits to society. These benefits include seafood, safe and clean beaches, and shoreline protection from storm surges and flooding. Ecosystem-based management (EBM) promotes an innovative approach to address the additional challenges faced by such human activities. The ecosystem-based management approach is a strategy for the integrated management of land, water and living resources that provides sustainable delivery of ecosystem services in an equitable way.

EBM considers the whole ecosystem, including humans and the environment, rather than managing one issue or resource in isolation. In the context of small islands, EBM can be considered an approach that looks at what has been described by the United States Agency for International Development (USAID) as the ridge-to-reef approach, or more recently the integrated watershed and coastal area management (IWCAM) approach. IWCAM refers to both an approach and a Global Environment Facility-funded project. The goal of IWCAM is to enhance the capacity of countries to plan and manage their aquatic resources and ecosystems on a sustainable basis (see http://www.iwcam.org).

Small islands, based on their overall sizes, geography, extent of their watersheds, and the fate of their runoff, which ultimately ends up in the same place (the sea), are considered, for all intents and purposes as "one big watershed". Whereas this is not really the case, as small islands can have many smaller distinct watersheds, the reality is that most activities on land that can create negative impacts on the marine environment actually do so more obviously in the case of small islands. For example, land clearing in the upper reaches of a watershed on a small island can result in silt being carried through the watershed via rivers, drains and streams and discharged directly into the marine environment (Figure 4.1). This cannot necessarily be said for larger countries, where pollution can be intercepted miles inland from the coast and therefore has no direct impact on the coast.

An ecosystem approach to management is geographically specified and adaptive, takes account of ecosystem knowledge and uncertainties, considers multiple external influences, and strives to balance diverse societal objectives. Implementation will need to be incremental and collaborative and can occur at both the national and regional levels.

Ecosystem-based management is an integrated approach to management that considers the entire ecosystem, including humans. According to a group of scientists and policy experts based at U.S. academic institutions who contributed to the Scientific Consensus Statement on Marine Ecosystem-Based Management (21 March 2005), "Ecosystem-based management differs from current approaches that usually focus on a single species, sector, activity or concern; it considers the cumulative impacts of different sectors". Specifically, they noted, ecosystem-based management:

– emphasises the protection of ecosystem structure, functioning, and key processes;
– is place-based in focusing on a specific ecosystem and the range of activities affecting it;
– explicitly accounts for the interconnectedness within systems, recognising the importance of interactions between many target species or key services and other non-target species;
– acknowledges interconnectedness among systems, such as between air, land and sea; and
– integrates ecological, social, economic, and institutional perspectives, recognising their strong interdependences.

Figure 4.1. Upstream pollution affecting the coastal zone in a small Caribbean island (Photo courtesy Buccoo Reef Trust)

This interconnectedness among and within ecosystems includes human and non-human parts of ecosystems as well as both terrestrial and marine ecosystems.

Implications of Land-Based Activities in Small Islands

The Pew Oceans Commission (2003) and the U.S. Commission on Ocean Policy (2004) have both concluded that a combination of human activities on land, along coasts, and in the ocean are unintentionally but seriously affecting marine ecosystems by altering marine food webs, changing the climate, damaging habitat, eroding coastlines, introducing invasive species, and polluting coastal waters (in and around the United States). Similar observations from the Caribbean have been made by many organisations including the United Nations Environment Programme and the Caribbean Environmental Health Institute, and have led to the development of multilateral environmental agreements such as the Cartagena Convention and its Protocol Concerning Pollution from Land-Based Sources and Activities (LBS Protocol).

The Cartagena Convention is the only legally binding, regional agreement for the protection and development of marine ecosystems in the Wider Caribbean Region. The Convention was adopted in 1983 and entered into force in 1986. A total of 23 countries have ratified the Convention, which focuses on land-based sources of pollution, dumping of waste at sea, pollution from ships, biodiversity protection, and airborne pollution. To deal comprehensively with these issues, three protocols have been developed: the Oil Spills Protocol, the Specially Protected Areas and Wildlife (SPAW) Protocol and the LBS Protocol.

Many coastal and marine ecosystems in the Caribbean are hotspots of pollutant loading, and pollution from land-based activities is a principal driving force impacting the productivity of marine ecosystems, ecosystem processes and services. The LBS Protocol is a set of procedures developed to respond to the need to protect the marine environment and human health from land-based point and non-point sources of marine pollution. The contracting parties to the Cartagena Convention adopted the LBS Protocol in Oranjestad, Aruba on 6 October 1999. The Protocol entered into force in 2010. The Protocol is perhaps the most significant agreement of its kind, with the inclusion of regional effluent limitations for domestic wastewater (sewage) and the requirement of specific plans to address agricultural non-point sources of pollution. In addition, the LBS Protocol sets the stage for the development and adoption of future annexes to address other priority sources of pollution.

The main text of the LBS Protocol sets forward general obligations and a legal framework for regional co-operation. It provides a list of priority source categories, activities and associated pollutants of concern. These priority sources are further defined in a series of technical or "operative" annexes. These annexes describe the work that each contracting party must comply with and also give direction to the development of regional actions.

Through its general obligations and annexes, the LBS Protocol has the potential to catalyse the efforts of countries into considering terrestrial ecosystems and marine ecosystems in a holistic manner. It will force countries to bear in mind the interconnectedness of these ecosystems from the context of small islands in planning for interventions that address the Protocol. These interventions would include upstream activities such as pollution control measures. Planning for them includes determining which of these measures (e.g., nutrient reduction) would be most appropriate, bearing in mind the impacts on the downstream ecosystems (e.g., a coral reef).

An improved understanding of the cumulative impacts on marine ecosystems from land-based activities including pollution through EBM is needed to support the development of more effective management policies. While many technical and political options are available to reduce the negative impacts from pollution and other land-based activities, the fact that many of these tools have not yet been implemented on a significant scale suggests that additional technological options and new policy approaches are needed. Ecosystem-based management offers such an approach. The specific implications of land-based activities and their impacts are discussed below.

Climate Change

A number of climate change studies have been conducted worldwide, including within the Caribbean, and a number of Caribbean experts have been involved in the debate. Efforts to address the impact of climate change have resulted in the establishment of the Caribbean Community Climate Change Centre (CCCCC), based in Belize. Typically, studies centred on climate change and its impact on marine ecosystems take temperature increases into account. However, other variables also require consideration, such as:

- changes to ocean chemistry (i.e., acidification), which impedes the ability of organisms to build calcareous shells;
- ocean circulation, which influences population dynamics;
- change in cloud cover, which affects light supply to the ocean's surface.

Findings from recent studies (e.g., Hobday and Okey 2007) include the following:

- While ocean temperature has a significant influence on observed changes in marine flora and fauna, it is the combined effects of multiple climate and other factors (such as oceanographic) that will shape marine life in the future.
- The ecological effects of non-climate-related stress factors such as fisheries, coastal runoff and pollution may reduce ecosystem resilience to climate change.
- Programmes to measure the change in and the modelling of climate change impacts will be crucial components of national assessment of climate change impacts so that management strategies can be developed.

Some likely impacts from climate change include a reduction in the abundance of species that rely on building shells, the earlier migration of species, and a drop in the rates of reproduction and development of species. Longer-term changes affecting just two key factors – ocean temperatures and nutrients – will have a significant influence on marine biodiversity, according to Hobday and Okey (2007).

Coastal resource managers face parallel climate change challenges in terms of maintaining watershed quality and the health and resilience of nearshore marine ecosystems. Studies have indicated that warmer and wetter climate, with increased rainfall and coastal runoff, can negatively affect fish stocks. This may occur due to increased turbidity in the water, introduction of nutrients from the land, decreased light penetration to the seafloor, and changing habitat and food resources.

Habitat Destruction

Coral reefs are dying around the world as people and cities put more stress on the environment. Climate change alone could trigger a global coral die-off by 2100 because carbon emissions warm oceans and make them more acidic, according to a study published in December 2007. But according to a Reuters article ("Pollution slowly killing world's coral reefs", 29 September 2008), local environmental problems that are primarily land-based, such as sewage, farm runoff and overfishing, could kill off much of the world's reefs decades before global warming does.

In economic terms, reefs generate billions of dollars a year worldwide in tourism and fishing, according to The Nature Conservancy environmental group (see global and regional statistics on protected areas at http://www.nature.org/initiatives/protectedareas/features/art24892.html). Across the Caribbean, the amount of reef surface covered by live coral has fallen about 80% in the last three decades, according to the Global Coral Reef Monitoring Network (Wilkinson 2008). It is hard to tell how much of that damage was caused by global warming and how much by local factors like pollution. What is clear, however, is that habitats such as coral reefs are being damaged and/or destroyed, and efforts to arrest this destruction can benefit from a wider ecosystem-based approach. Arresting the destruction of coral reefs should incorporate multi-sectoral approaches towards the treatment and diversion of sewage, nutrients, sediments and other waste, which is primarily generated by land-based activities. This approach, which would need to involve sectors such as agriculture, public utilities and tourism, should seek to foster collaboration, public-private partnerships, and technological as well as institutional solutions to this problem.

Coastline Erosion

Coastline changes due to human intervention, in addition to natural processes, represent a major concern of coastal planners and citizens in the Caribbean, who have interests in beaches and seaside property. The disappearance of beaches through erosion can be devastating to those who live, work, relax and build close to the shore, including those involved in the very important tourism industry. Since tourism became the major industry in the Caribbean in the 1970s, coastline changes have taken on paramount importance. Despite their economic value in a region where tourism is dependent for the most part on sun, sea and sand, beaches have unfortunately not been perceived as areas needing management, protection and funding, but rather as permanent features of the landscape (Cambers 1999).

Extreme events such as hurricanes are the major cause of shoreline changes in the Caribbean. The rainfall, high winds and storm surges associated with these severe weather events have caused major destruction of the coastlines in the region. Hurricane waves erode the beaches (Figure 4.2) and penetrate farther into the land behind the beach, causing flooding, erosion of sand dunes and the destruction of coastal highways and buildings.

Figure 4.2. Coastline erosion along the Northwest coast of Antigua (Photo courtesy Vincent Sweeney, UNEP)

Coral reefs supply much of the sand for the region's beautiful beaches, and draw divers and snorkelers to explore the diversity of marine life that they support. Stretching along great lengths of the Caribbean coastline, reef and mangrove ecosystems also provide a natural barrier that protects the land from the worst ravages of tropical storms. The threats to coral reefs have been outlined earlier. In addition to coral reefs, mangroves are also at risk due to human activities, particularly physical destruction for coastal development and charcoal production. As reefs and mangroves degrade and disappear, the protective services are diminished, resulting in coastline erosion and economic losses to coastal communities. The World Resources Institute provides relevant information in its web page "Economic Valuation of Coastal Ecosystems in the Caribbean" (http://www.wri.org/project/valuation-caribbean-reefs).

Invasive Species

An invasive species is one whose establishment and (often rapid) spread threatens ecosystems, habitats or species, including marine ecosystems. Many invasive species are alien, having been deliberately or accidentally introduced to an area from their native range, or from another site of introduction (Kairo et al. 2003). Indigenous species as well as alien species may become invasive, usually in response to environmental change (typically human-mediated habitat disturbances).

Invasive species are now widely cited as the second greatest global threat to biodiversity, after habitat destruction (Kairo et al. 2003). These two phenomena can, however, interact: habitat destruction can make areas more vulnerable to invasive species, and species invasions can result in the destruction of habitats. According to Kairo et al. (2003), islands appear to be particularly vulnerable to the impact of invasive species. Marine and coastal invasive species have ecological, economic and health effects. They can reduce biodiversity by displacing indigenous species through predation, competition, habitat modification and food-web disturbance. They can also disrupt ecological processes and compromise ecosystem services such as flood attenuation and shoreline protection. Economic effects include losses due to productivity and efficiency, but there are also costs associated with the prevention and management of invasive species. Ballast water can transfer bacteria and viruses that can cause diseases, as well as toxic phytoplankton or algae that form harmful algal blooms, often resulting in shellfish poisoning or allergic reactions in people.

Unfortunately, the capacity to tackle invasive species is limited even though marine species make the smallest contribution to invasive species in the Caribbean. Recent reports do suggest an increase in the occurrence of marine invasive species throughout the Caribbean, and work is ongoing to assess the scope of the problem. Invasive species therefore represent a real threat to marine ecosystems and should not be overlooked when considering EBM approaches. EBM approaches to invasive species management in Caribbean islands need to consider the involvement of multiple sectors, which could see a combination of resources from each sector utilised, recognising that each sector would be motivated by different factors in seeking to address the impacts.

Pollution of Coastal Waters

Pollution of the Caribbean Sea and the marine ecosystem continues to be one of the major challenges to environmental managers. Streams and rivers are easily polluted by human activities such as mining, agriculture and manufacturing (e.g., tailings, agrochemicals, industrial effluents). Human, animal and household waste is other major environmental contaminants on most islands. The indiscriminate disposal of household waste has also led to the pollution of the environment, and due to the size of most islands much of the household waste can potentially find itself in and affect the marine environment.

Rapid population growth (particularly the urban population), improvement in the provision of drinking water supply and sewage services, the expansion of industry, and the technification of agriculture – all unaccompanied by the development of waste treatment facilities and pollution control measures – are among the factors leading to the rise in pollution. The main causes of point sources of pollution in the Caribbean Sea are:

- domestic sewage;
- oil refineries;
- sugar factories and distilleries;
- food processing;
- beverage manufacturing;
- pulp and paper manufacturing;
- chemical industries.

However, the single largest point source of pollution is domestic sewage and the main non-point source of pollution is runoff from the land. Agriculture is the prime source of contaminated runoff in the Caribbean. This contamination can be via suspended solids and salts or by man-made substances such as pesticides, herbicides, insecticides, fertilisers and other chemical substances. Irrigation water can be a major source of pollution, dissolving naturally-occurring salts on its way through the soil and carrying these salts to surface water bodies and the sea.

In the Mesoamerican region of the Wider Caribbean, for example, over 300,000 hectares of land are allocated to banana, oil palm, sugar cane, citrus and pineapple crop production (Gil-Agudelo and Wells Chapter 5). Eroded sediments and fertiliser and pesticide residues used by farms drain through rivers and streams and enter coastal waters along the Mesoamerican reef. The increasing use of fertilisers in the Caribbean results in the accumulation of nutrients in water bodies which can lead to eutrophication and can also pose potential health hazards. Pesticides, herbicides, insecticides and other chemical substances enter water bodies by percolation, precipitation, and runoff or by direct application. They are toxic to both aquatic life and humans and tend to accumulate rather than degrade. To compound this problem, some countries in the Caribbean have continued to employ chemical substances whose use was restricted or forbidden in other countries with more stringent environment legislation (such as DDT).

The Marine EBM Response to Land-Based Activities in Small Islands

Management that emphasises the protection of the ecosystem structure, its functions and key processes is much more likely to ensure the long-term delivery of important ecosystem services. Implementation of an ecosystem approach will also enable more coordinated and sustainable management of land-based activities that affect the oceans. The ecosystem-based management approach, if properly adopted, should reduce duplication and conflicts, and in the long run be more cost effective. Conversely, any delay in implementing management based on an ecosystem approach will result in continued conflicts over resources, the degradation of coastal and ocean ecosystems, disruption of fisheries, the loss of recreational opportunities, health risks to humans and wildlife, and loss of biodiversity. Below, we present some practical approaches/considerations for the Caribbean islands.

Climate Change

The traditional approach to the management of resources within the region would suggest that marine resource management had nothing to do with climate change. The CCCCC, for example, would typically not be talking with the Caribbean Regional Fisheries Mechanism (CRFM). New approaches must involve marine resource managers in discussions and planning of climate change adaptation strategies for the region.

Coastline Erosion and Habitat Destruction

The same approach is recommended in any response to disasters and emergencies, where measures to recover after disasters such as hurricanes should involve marine resource and coastal zone managers who have been impacted by such disasters. Recovery measures for marine ecosystems can add benefits to the approaches used on land. For example, the establishment of marine protected areas or no-anchor areas, which necessarily involve the participation of fisher folk, recreational vessels and even dive operators, while designed to reduce damage to reefs, should also be considered measures to protect the coastline from erosion (i.e., a disaster reduction measure). EBM will also facilitate improved land use planning including assessment of carrying capacities and the establishment of appropriate buffer zones to safeguard critical ecosystem services.

Pollution of Coastal Waters

We have already discussed how various human actions and their consequences extend across jurisdictional boundaries and impact the functioning of important ecosystems shared by multiple jurisdictions. As an example, the widespread and heavy use of fertilisers applied many hundreds of kilometres from the coast has resulted in water bodies such as the Gulf of Mexico adjacent to the Mississippi River delta becoming oxygen-depleted 'dead zones'. In the case of the Caribbean, these same practices, which result in fertiliser runoff, can have a much more rapid impact on the marine environment, not having to travel more than a few kilometres (or even much less) to reach the coast. Farming practices – or best management practices (BMP) in agriculture – within the Caribbean must therefore consider the effects on the marine ecosystem.

The siting and design of wastewater treatment facilities, considered the remit of environmental engineers, must also take into account the potential impact on the marine environment and associated effects on the health of the population, who use the coastal areas for recreation, as well as the tourism industry and hoteliers, who rely on safe beaches for their livelihoods. Design criteria for sanitary landfills and treatment plants, more typically of a scientific nature, should therefore now be considering other factors such as location, aesthetics and nutrient removal in addition to the physical removal of solids from the wastewater.

The eco-regional efforts made under the International Coral Reef Action Network – Mesoamerican Reef Alliance (ICRAN-MAR) project demonstrated the value of addressing key drivers or root causes of global environmental problems at the local level. One example from this project was the poor agricultural practices in the upper watershed areas which ultimately contributed to the solution of a much larger regional marine pollution problem beyond the boundaries of an individual country.

It is clear from the discussion above that marine EBM should form an essential component of integrated land use planning (for any and all types of development in the Caribbean) and be incorporated into integrated watershed and coastal area management (IWCAM) type management processes on land. The marine EBM response to land-based activities in its broadest sense must therefore seek to link approaches such as integrated land use planning with watershed and coastal area management in the Caribbean.

Governance frameworks that further incorporate EBM such as integrated coastal area management and the effective use of marine protected areas can further help in dealing with marine habitat degradation and responding to pollution drivers. This will be particularly effective in dealing with the transboundary nature of impacts from land-based activities. One of the key challenges in an ecosystem approach will be the coordination of national efforts and regional mechanisms such as the UNEP's Caribbean

Environment Programme. The Cartagena Convention and its Protocols could play a central role in such a process.

5

Impacts of Land-based Marine Pollution on Ecosystems in the Caribbean Sea

Implications for the EBM Approach in the Caribbean

Diego L. Gil-Agudelo[1] *and Peter G. Wells*

Abstract

Land-based marine pollution (LMP) is complex, population dependent, expensive to remedy, and a threat to both human and marine ecosystem health. It is one of the most difficult marine issues to tackle and resolve successfully. Scientists, managers, and policy makers have addressed it in many coastal states since the 1960s, placing pollution control into several treaties, agreements, and conventions, most of them still being implemented. This chapter discusses sewage (domestic and industrial), heavy metals, hydrocarbons, sediment uploads, and agrochemicals as the most important sources of LMP pollution to the Caribbean Sea region. It also addresses invasive species, marine debris, and thermal contamination as threats to the health of the most important coastal and offshore ecosystems of the region. The harm that pollutants cause to species and habitats, e.g., coral reefs and mangrove forests, is contrasted with the potential of some marine ecosystems to resist and recover from some types of pollution, e.g., oil spills. The chapter serves as a guide to environmental managers on the priority LMP issues in the Caribbean Sea region, aspects of each issue to consider with urgency and commitment and the importance of ecosystem-based management (EBM) for prevention, mitigation, and remediation of LMP.

Introduction

The Caribbean Sea is one of the world's largest salt water seas, with approximately 2,500,000 km^2 encompassing a wide variety of ecosystems including coral reefs, mangroves, seagrass beds, rocky shores, soft bottoms, and others (Sheppard 2000). An estimated 100 million people now live in the area in 26 countries and 19 dependent territories (Fanning et al. 2007), using the Caribbean Sea as a source of goods and services and in many places highly impacting its ecosystems (Jackson 1997).

Land-based marine pollution (LMP) is a well recognised coastal issue for coastal states globally and is considered, due to its inherent complexity from sources to governance, to be one of the most difficult marine environmental issues to tackle and resolve successfully. Scientists and managers alike have been addressing the issue in many countries since the 1960s. Marine pollution was defined early on by the United Nations Group of Experts on Scientific Aspects of Marine Environmental Protection (GESAMP), in an internationally-accepted definition, as being '... the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to maritime activities including fishing, impairment of quality for use of sea water and reduction of amenities' (GESAMP 2001a). Pollution from the land was given special attention in the 1980s, through recognition in Part XII of the United Nations Convention on the Law of the Sea (LOSC) (1982); at the United Nations Conference on the Environment and Development (UNCED – the 'Rio' Conference), with Agenda 21 (UNGA 1992); at the various intergovernmental meetings producing the Montreal Guidelines (1985), and the Washington Protocol (UNEP 1995); and with an emphasis on the problem in GESAMP's state of the marine environment reports (GESAMP 1990; GESAMP 2001a; GESAMP 2001b).

Article 207 of LOSC (1982) states that 'States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from land-based sources, including rivers, estuaries, pipelines and outfall structures, taking into account internationally agreed rules, standards and recommended practices and procedures.' This set the stage for further international discussion of how to address the issue comprehensively, without setting up a new legally-binding convention or agreement. The United Nations-led Washington Protocol Conference of November 1995 was particularly important as the problem was exhaustively described, an international framework of priorities was prepared, and the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA), with national programmes of action, was initiated with the intention to report on progress every five years. Whether this approach will be effective at reducing pollution impacts remains to be seen (VanderZwaag et al. 1998), but to date, parties have met regularly to report on activities, despite the increasing challenges.

Article 7 of the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (the Cartagena Convention), which was subscribed in 1983, stipulates that '[t]he Contracting Parties shall take all appropriate measures to prevent, reduce and control pollution of the Convention area caused by coastal disposal or by discharges emanating from rivers, estuaries, coastal establishments, outfall structures, or any other sources on their territories.' The 1999 Protocol on Marine Pollution from Land-based Sources and Activities (LBS Protocol) came into force in 2010 (Sweeney and Corbin Chapter 4).

This chapter highlights what we consider to be the major pollutants in the continental Caribbean and their effects at the organism, population and ecosystem levels. It shows the importance of considering this problem from an ecosystem-based management (EBM) perspective and how EBM can be an effective approach for mitigation of their effects and remediation of the affected ecosystems.

Major marine pollutants in the continental Caribbean region and their effects on marine ecosystems

Throughout the years, authors have classified land-based pollutants in different categories (see GESAMP 1990; GESAMP 2001a; GESAMP 2001b; UNEP 1999; Islam and Tanaka 2004). For the purpose of this chapter, and to assist focusing on their ecological consequences and management, we are considering the major pollutants as below.

Sewage (Domestic and Industrial)

Domestic and industrial sewage, i.e., municipal effluents, constitutes the largest volume of waste discharged to marine ecosystems (Islam and Tanaka 2004). These pollutants are discharged mainly by cities as domestic and industrial wastes, but also are discharged by aquaculture facilities and other types of developments (Loya et al. 2004), including discharges from ships legally permissible under the MARPOL 73/78 International Convention for the Prevention of Pollution from Ships.

Sewage contains a wide variety of pollutants at highly variable concentrations and volumes. These include nutrients that are probably the most noxious wastes at national and regional levels (GESAMP 2001a), to organic substances, heavy metals (see below), endocrine disrupting chemicals, such as estrogens (Atkinson et al. 2003) and microbes, including pathogens (Harvell et al. 1999; Sutherland and Ritchie 2004). Other growing industries in the Caribbean region, such as aquaculture, exacerbate the problem by discharging their wastes directly into the ocean and nearby ecosystems. Such discharges contain not only organic matter and nitrogenous compounds produced by the metabolism of organisms, but also dissolved and suspended solids, large amounts of antibiotics used in intensive farming (Gautier 2002), pathogens, and other compounds and agents harmful for marine life (GESAMP 2008).

The chemical constituents of sewage affect aquatic organisms in many different ways, as they range from trace metals to complex organics such as polycyclic aromatic hydrocarbons (PAHs), pesticides, surfactants, and drugs and their metabolites, with many different scenarios of uptake and toxic action. Effects include sub-cellular responses, direct toxicity or poisoning, disruption of reproductive behaviour, changes in reproductive development, e.g., feminisation of male fish, and other lethal and sublethal effects, some of them difficult to evaluate, especially under field conditions. Effects are only understood for a relatively small number of species, although there is some capacity for inter-species comparisons and extrapolations. These responses are initiated largely at the molecular and cellular levels of biological organisation (Elliott et al. 2003). At the ecosystem level, sewage pollution can promote bacterial and plant growth; cause declines of oxygen levels in the water column (Islam and Tanaka 2004), contributing to the so-called dead zones that are proliferating in coastal waters; create changes in the productivity of ecosystems, species distribution, and diversity, altering size distributions of populations; and increase disease prevalence in fish and invertebrates, a notable problem near urbanised coastlines, among others (Elliott et al. 2003; Bruno et al. 2003).

Under low and moderate nutrient increases from sewage, productivity increases with little change in biomass or trophic structure of the ecosystems. When these levels increase, algae usually take control of the ecosystems, causing shifts in species dominance (Pastorok and Bilyard 1985). In Caribbean coral reefs, for example, such changes might cause coral stress by reducing light penetration, but they also promote the growth of filter feeders (e.g., sponges) that compete for space with corals. Nutrients such as nitrates at high concentrations and toxic substances (polychlorinated biphenyls (PCBs), chlorine, hydrocarbons, etc.) usually found in sewage waters can also be toxic for corals and other marine organisms (Pastorok and Bilyard 1985; Loya et al. 2004). Sewage water and its residues may also affect the cellular defence mechanisms of organisms (Cheng 1988) and, together with the introduction of pathogens, increase disease in coastal and marine ecosystems.

It is estimated that less than 20 percent of sewage is treated in Latin America and the Caribbean Sea region (Idelovitch and Ringskog 1997; UNEP 2003), with most of it flowing untreated to rivers and the oceans (Martinelli et al. 2006; PNUMA 2007). As well, aquaculture facilities dump most of their residues into mangroves, expecting them to act as biofilters (Gautier 2002; GESAMP 2008).

Heavy metals

Fernandez et al. (2007) reviewed the literature of several contaminants in the Caribbean, with special emphasis on heavy metals (Hg, Al, Cr, Cu, Fe, Mn, Cd, Pb and Zn) and organotins. Typically, heavy metals and substances like tributyl tin (TBT) are found near cities, ports, and industrial developments across the region. Traces of some of these contaminants have been found in remote areas across the region, with unknown impacts in these ecosystems.

Olivero-Verbel et al. (2008), amongst others, have shown how contaminants such as Hg (mercury) can move through and accumulate in food chains, including humans, even after more than 30 years of the closure of a source of contamination. Accumulation of metals and other compounds in organisms depends on factors such as their specific properties, exposure levels, routes of uptake, and sequestration and excretion by organisms (Bryan 1971; Peters et al. 1997). They can accumulate in mangroves and seagrasses and then be transferred to higher trophic levels of the food chain, including birds and humans (Peters et al. 1997; Fernandez et al. 2007; Olivero-Verbel 2008; Langston and Bebianno 1998).

Some heavy metals, such as Cu (copper), inhibit photosynthesis causing growth inhibition and death in plants at high levels (Overnell 1975; Clijsters and Assche 1985) and in animals can cause deformities, sexual irregularities (Miloslavich et al. 2007), decrease in size (Strömgren 1982), and erratic behavior (Peters et al. 1997), among others. In some cases, synergistic (i.e. more than additive) effects have been observed in laboratory experiments with the addition of several metals (Braek et al. 1976). In other cases, antagonistic (i.e., less than additive) effects occur. Sediments act as sinks and sources of heavy metals, and organisms associated with the sea floor may be more affected by elevated levels of these pollutants (Elliott et al. 2003). Microbiota are also affected by heavy metals; there is evidence showing that they are far more affected than higher organisms (Giller et al. 1998), disrupting the food web, colonisation, and other ecological processes of importance.

In the continental Caribbean region, several places show high levels of heavy metals. Cartagena Bay, Colombia, for instance, showed concentrations of Hg of 7.67 μg/l in sediments (Camacho 1979), mainly due to the operation of a chlor-alkali industry during the 1970s, while Cr (chromium) reached values of 1.40 μg/l in sediments close to a tannery industry in the bay (CIOH 1997). In Ciénaga Grande de Santa Marta, also in Colombia, concentrations of Cd (cadmium), Cu, and Zn (zinc) of 11.1 μg/l, 39.2 μg/l and 171 μg/l, respectively, have been found in sediments (INVEMAR 2004a; INVEMAR 2004b).

Guzmán and García (2002) evaluated Hg concentrations along the Caribbean coast of Central America, both in sediments and coral skeletons. Widespread Hg concentrations in the regions, in sediments (average 71.3 μg/l) and in coral skeletons (average 18.9 μg/l), suggests that these pollutants are being carried along the region by ocean currents, with high concentrations of this metal being found even in 'pristine' reefs. Other routes of Hg dispersal, through air and biota, are also possible, as has been shown in other parts of the world.

Hydrocarbons

In general, the major concern of contamination from petroleum hydrocarbons in the Caribbean region is from accidental events, i.e., major oil spills, since operational discharges are well regulated in general (GESAMP

2001a; GESAMP 2007). Oil seeps also contribute crude oil naturally to the system in some locations (Geyer and Giammona 1980; Agard et al. 1993). Although of great concern, long-term effects of hydrocarbons in the ocean are generally limited, and largely affect sea birds, turtles, marine mammals, and sensitive invertebrates and intertidal habitats. However, large spills can have devastating short-term lethal and sub-lethal consequences for local flora and fauna (NRC 1985; NRC 2003).

In the Caribbean region, the extensive coastal mangrove forests are the most vulnerable marine ecosystem to hydrocarbon pollution. Many invertebrate and vertebrate species living within the mangrove systems, as well as the young plants themselves, are very sensitive to hydrocarbon exposures. Crude oil and refined products can be trapped in mangrove forests due to the high tidal ranges, as occurred during the 1986 oil spill on the Panamanian coast (Jackson et al. 1989). Pneumatophores are present in some plant species that allow them to survive in oxygen depleted environments; these can be smothered by heavy oils, causing oxygen deprivation and often mortality (Peters et al. 1997). Oil spilled along shorelines can also be covered with and be incorporated into sediments and remain for decades, contacting, contaminating, and killing organisms, preventing recruitment, and being transferred to other organisms (Chouksey et al. 2004).

Seagrass meadows, coral reefs, rocky shores, sedimentary flats, the water column, and other marine and coastal ecosystems are also vulnerable to hydrocarbons. Oil and its refined products are a complex mixture of substances such as PAHs, aliphatic hydrocarbons, alkanes, cycloalkanes, waxes, olefins, benzenes, and many others, and trace metals, some of them with highly toxic properties for different organisms (NRC 1985; NRC2003). As well, oily substances can adhere to the bodies of organisms, killing them by hypoxia or direct toxicity, or causing sub-lethal effects such as lower resistance to diseases, decrease in growth, and damage to reproductive organs (Guzmán and Jackson 1991; Burke and Maidens 2004).

A usual contingency measure for oil and derivate substances spills is the application of oil spill dispersants. They may be toxic at low concentrations to marine organisms (NRC 1989; NRC 2005) and their effects and possible joint effects with oil have to be considered (Peters et al. 1997; NRC 1989; NRC 2005).

The presence of oil refineries in the area, the exploitation of offshore oil in the Gulf of Mexico, Brazil, and Venezuela, together with oil spills throughout the region, have been a cause of concern in the area (PNUMA 2007), with the potential for pollution being classified as severe in the area by the Global International Waters Assessment report (UNEP 2006). Leaching of drilling oils and other residues of exploration and exploitation, vandalism, shipping traffic discharges (mainly bilge oil and fuel oil sludge), and accidents are the main causes of elevated hydrocarbon concentrations in the area (Jackson et al. 1989; Garay et al. 2001; INVEMAR 2007; PNUMA 2007;). In some areas, high concentrations of hydrocarbons have been found, such as in Cartagena Bay, with values of up to 50 μl/l of aromatic and aliphatic hydrocarbons in waters and 500 μg/g of total hydrocarbons in sediments (CIOH 1997; Garay et al. 2002; INVEMAR 2004 a; INVEMAR 2004b). In the Orinoco Basin, concentrations of up to 1.3 mg/g and 0.8 mg/g have been found in sediments by Senior et al. (1999) for aliphatic hydrocarbons (UNEP 2006). In Central America, the major concern lies in Panama due to the high ship traffic and a history of major oil spills (UNEP 2006), although spills have been decreasing in numbers over time (GESAMP 2007).

Sediments

Increased sediment loadings to coastal environments due to deforestation and other poor land use practices can have severe effects on shallow water organisms and ecosystems (GESAMP 2001a). Undoubtedly, the largest sediment load to the Caribbean Sea comes from the Magdalena River in northern Colombia, which brings an estimated 144 MT/yr (Restrepo et al. 2006). Another important source of sediments is dredging near harbour areas, which affect ecosystems usually on small spatial scales. Sediment loadings from the land are exacerbated by the increase in deforestation and coastal clearing for tourism and industrial development (Rogers 1990; GESAMP 2001a).

Sediments can affect ecosystems physically and chemically. Increases in sediment loads in the regions have been linked to changes in coral reef cover and algae composition and reduction of seagrass beds (Alvarado et al. 1986; Cortés 2003; Restrepo et al. 2006). Sediments block sunlight, decreasing the photic layer and limiting algae growth and productivity of the water column (Rogers 1990; Islam and Tanaka 2004). A decrease in ecosystem diversity has also been related to high sediment loads (Rogers 1990).

Extreme sediment loads can smother ecosystems such as coral reefs and seagrass beds. They can cause declines in fish populations and other important organisms by altering their habitats, especially nursery areas such as mangroves and seagrasses. Excessive sedimentation can also alter food webs by burying organisms that serve as food sources for others and alter recruitment of certain sessile organisms (Rogers 1990). Sediments may reduce growth in sessile organisms since they have to use extra energy for cleaning (Pastorok and Bilyard 1985).

Sediment particles may carry pollutants such as heavy metals and pesticide residues, depending on their geology, size, and quantity of organic matter associated with the particles (Islam and Tanaka 2004). They can also create anoxic areas, especially due to the presence of chemicals such as hydrogen sulfide (Pastorok and Bilyard 1985).

In the continental Caribbean, sedimentation causing damage to marine ecosystems has been documented in several locations. In Colombia and

Venezuela, the Orinoco, Magdalena, and Sinú rivers discharge large amount of sediments that can be carried out long distances, affecting coral reefs and seagrasses (CIOH 1997; Alvarado et al. 1986; Garzón-Ferreira et al. 2000; Restrepo et al. 2006). This problem is considered to be moderate by GIWA for this area (UNEP 2006).

Similarly, Central America has small but numerous rivers carrying sediments to the Caribbean Basin (Thattai et al. 2003). Erosional processes due to deforestation, infrastructure construction, and agricultural practices, together with the presence of fragile ecosystems such as coral reefs, show that higher sedimentation is a severe problem for Central America (UNEP 2006).

Agrochemicals

Together with sewage, fertilizers are the most important contributors to the increase of nutrient load to coastal seas such as the Caribbean. Furthermore, nutrients from fertilizers are continuously increasing due to the relentless growth of human populations, agriculture, and industry. Eutrophication is the main consequence of the increase of nutrients to the environment (GESAMP 2001a; GESAMP 2001b). Nutrients also have fertilisation effects in some oligotrophic environments such as coral reefs, promoting the growth of algae and other plants, competing and changing the characteristics of these environments (Lapointe 2004; Lapointe et al. 2005).

Agrochemicals also include a wide range of pesticides (herbicides, insecticides, fungicides, and other compounds) commonly used to increase yield of crops and to control pests (GESAMP 1986; Islam and Tanaka 2004). These agrochemicals, mostly organics, usually affect a range of organisms other than the target species, causing major effects in some ecosystems (GESAMP 1986). Tumors, cancer, reproductive effects, and cellular and molecular damage are only some of the deleterious effects that pesticides cause at low levels in some species or groups of organisms that can lead to death, creating disruption to food webs. They generally affect young stages of organisms to a higher degree than adults, affecting recruitment and causing problems in species abundance and distribution of these organisms (McKenney 1986).

Agrochemicals usually have a long mean degradation time (often years and decades) and persist in soil. Degradation results in intermediate compounds that are often toxic (Rawlins et al. 1998), and they bioacumulate and biomagnify through the food web (Islam and Tanaka 2004).

Pesticides have been used in the Caribbean region for a long time (UNEP 1999; PNUMA 2007). INVEMAR (2004a, 2004b and 2007) showed the importance of pesticides to the water quality of the Caribbean coast of Colombia. Pesticide residues from crops such as bananas, coffee, cotton, sugar cane, and illicit crops in the coastal areas and watersheds, are reaching the ocean; aldrin (0.36 to 1.07 ppb), lindane (0.40 to 44.2 ppb), dieldrin (0.13 to 1.91 ppb), and DDT (0.01 to 0.08 ppb) have been found in the estuarine waters of the Ciénaga Grande de Santa Marta. Similarly, in Cartagena and other areas of the northern coast of Colombia, concentrations of aldrin, DDT, heptachlor, dieldrin, and hexachlorocyclohexane (HCH) are higher than 30.0 ng/l (CIOH 1997).

Central America presents similar problems due to high agricultural activity. It is estimated that Costa Rica imported near 5,000 tons of different types of pesticides in 1993, and high concentrations of organochlorines and organophosphates are found in environments throughout the region. Guatemala, Honduras, Nicaragua, Panamá, and other countries in the region share the same problem due to their high economic dependency on agriculture and the little apparent awareness of the correct use of pesticides (UNEP 1999). An efficient regulatory framework to control pesticide use in these countries is needed.

The presence and concentration of agrochemicals in coastal environments are considered moderate and severe in the areas of Colombia, Venezuela, Central America, and Mexico respectively, by the GIWA report (UNEP 2006), with effects in the environment still to be established.

Invasive species

Although not recognised formally as land-based pollution, invasive species are a major threat to marine ecosystem health worldwide. Land-based activities such as aquaculture and the aquarium and ornamental trades can introduce invasive species to coastal and marine environments. One third of the world's worst aquatic species are ornamental species (Padilla and Williams 2004). Invasives are the second cause of extinction of species around the world (Wilcove et al. 1998).

Alien species can hybridise with native organisms, even creating new taxa. They may cause changes of fitness of organisms, increase the possibility of species extinction, or be a threat to ecosystem integrity through competitive exclusion and niche displacement, mutualism, among other mechanisms (Mooney and Cleland 2001).

Although the status of alien and invasive species is largely unknown in the Caribbean, the Global Invasive Database (www.iss.org) reports several species in the region. Fish such as tilapia (*Oreochromis niloticus, Oreochromis mossambicus* and other species and hybrids), corals (*Tubastraea coccinea*), algae (*Kappaphycys* spp.), and bacteria (*Vibrio cholera*) are some of the species reported on the list. In the case of tilapia (*Oreochromis niloticus, Oreochromis mossambicus* and some hybrids), introduced for freshwater aquaculture, the fish are widespread throughout the region reaching estuarine environments with undetermined consequences for local biota (Wedler 1996; INVEMAR 2004b; GISP 2005). *V. cholerae* were transported in ballast waters and flourished in nutrient enriched waters, causing epidemics in South America (Levins et al. 1994).

More recently, Whitfield et al. (2002) reported the presence of lionfish (*Pterois volitans*) in waters off the eastern coast of the United States and in Bermuda in the northwest Sargasso Sea. This fish, native to the Western Pacific, was apparently introduced by aquarium releases in North America, adapting and successfully reproducing in the new environment. Kimball et al. (2004) showed the possibility that this organism can spread throughout the Caribbean with still undetermined consequences for the ecosystems due to their highly predatory habits (Ruiz-Carus et al. 2006).

The above examples illustrate the imminent possibility of major new biological invasions in the Caribbean Sea region, with uncertain consequences to the environment and human activities (PNUMA 2007).

Other topics of concern

Other types of contamination are present in the area, including litter (plastic debris) and thermal contamination. Litter, mainly composed of plastic, accumulates in beaches and shallow waters, and can affect turtles, birds, and mammals (GESAMP 2001a; GESAMP 2001b). It can also affect fish and other forms of marine life by entanglement (particularly in fishing gear), smothering, and ingestion. Plastics as currently made are virtually indestructible and can accumulate over time, creating ecological and aesthetic problems (Islam and Tanaka 2004). Plastics originate from inadequate waste disposal in coastal cities, and litter generated by ships, fishing vessels, ports, and people (UNEP 2006; PNUMA 2007). In the region, UNEP (2006) considered the problem of plastics and solid wastes as moderate for Colombia, Venezuela, and Central American sub-regions.

Although considered slight and localised (UNEP 2006), thermal pollution due to the use of sea water for cooling processes in industries and energy plants, is understudied in the Caribbean area. The discharge of water several degrees above normal temperature causes changes in benthic communities (Barnett 1971). Tropical marine animals are generally unable to withstand a temperature increase of more than 2-3 degrees C°, and benthic diversity decreases in the vicinity of cooling water discharges (Clark 1992).

Effects of pollutants on fisheries and other socio-economic activities

Besides the effects on natural environments as illustrated above, pollutants can have major impacts on human activities and economies. Some of these impacts are illustrated below.

Contamination of coastal waters, especially by sewage, causes a direct threat to human health. High numbers of micro-organisms, including human pathogens, are introduced into the marine realm in untreated waste waters. These microorganisms can contaminate food products, mainly fish and shellfish, causing epidemics in human populations (Levins et al. 1994; GESAMP 2001a; GESAMP 2001b; Pimentel et al. 2007), as well as infections and diseases from direct contact with sewage contaminated waters (Shuval 2000). Indirectly, sewage waters can damage and even destroy delicate ecosystems like coral reefs and seagrasses (Bruno et al. 2003); these ecosystems provide different services to humans, being an important habitat for numbers of species of economic importance (GESAMP 2001a; GESAMP 2001 b).

Oil spills also cause vast damage to ecosystems such as mangroves and their associated organisms, which affects local fisheries by eliminating habitats, depleting oxygen from shallow areas, and smothering and killing shallow bottom organisms. Oil spills also kill fauna in soft bottoms and on mangrove roots and rocky shores, some of which are of economic importance (NRC 1985; NRC2003). Contingency measures usually include the application of oil dispersants, which can add toxicity to oil spills, killing plankton (including fish eggs and larvae) and benthos (Peters et al. 1997; NRC 1989; NRC 2005).

Tourism, one of the leading economic and recreational activities of the Caribbean region, can be affected by sewage and oil pollution, through damage to the aesthetic values of the region and coastal ecosystem health, especially if coral reefs are impacted.

Heavy metals can also affect human health and economies. Metals bioaccumulate and biomagnify in the food web (mainly in bottom feeding and filtrating organisms) and create risks to humans that use these organisms as food. High concentrations of heavy metals are mutagenic, damage the nervous system, cause organ failure, and increase the incidence of cancer and other diseases in human populations (Järup 2003). Heavy metals can also kill early stages of marine organisms or disrupt ecological processes like photosynthesis, creating imbalances in the natural realm and changes in the natural values of certain areas (Peters et al. 1997). Agrochemicals, especially pesticides, can have similar effects as heavy metals, killing organisms and changing the ecological balance of exposed ecosystems.

Sedimentation can cause significant damage to natural ecosystems, smothering benthic communities, blocking sunlight, and decreasing the productivity of the water column, and releasing organic matter and other substances into the water. For local economies, this may represent a reduction in fishing potential (Grigalunas et al. 2001), a decrease in the aesthetic value of ecosystems, and a decrease of aquaculture potential of some marine species, among other impacts.

Ghost nets are a real threat to fisheries around the world. These nets, which are difficult to degrade, can stay active for years and decades, killing organisms and possibly changing the structure of natural pelagic communities (Kaiser et al. 1996). Litter, especially plastics, causes aesthetic damage to beaches and shores, creating costly problems for the tourist industry.

Finally, invasive species can displace organisms, leading some species to extinction and changing the composition of natural communities. Invasive species can also hybridise with local organisms, changing the fitness of populations. This is an imminent threat to fisheries that can see their yields decrease or even be eradicated (Elliott 2003). Invasive species can also be a threat to human health, as is the case with *Vibrio cholerae*. In the past, introductions of these organisms through ballast waters have created epidemics that have killed thousands of people (Levins et al. 1994; GISP 2005).

Recovery of marine ecosystems after pollution events

Changes in ecosystems due to human activity depend on the nature, intensity, and frequency of the disturbance (Chapin et al. 1996). During pollution events, ecosystems pass through alternate states, both after the initial disturbance and during the recovery process (Knowlton 2004). If these alternate states result in habitat loss, recovery rarely replaces this habitat, but the best option for recovery is to remove the stressor (Elliott et al. 2007). In order for recovery to happen (i.e. return of the ecosystem to the predisturbance condition), favourable conditions are needed. Alternatively, ecological recovery (MacMahon 1997) can happen at a slow pace (years to decades), depending greatly on the degree of connectivity to other similar ecosystems. In terms of conservation, a slow recovery can be similar to the permanent presence of the alternate or disturbed state (Knowlton 2004). Some ecosystems may have greater recoverability than others depending on the stressor, the impacted species/community, and the spatial and temporal intensity of the stressor (Elliott et al. 2007). There are also 'thresholds' in some organisms and ecosystems that determine their possibility of recovery (Knowlton 2004). Some pollutants (e.g., DDT and its residues, PCBs, organotins) can also remain in the ecosystem for long periods of time.

In the Caribbean Sea region, the ecosystems most sensitive to pollution and habitat disturbance are coral reefs and their inhabitants (Sapp 1999). These ecosystems appear to have two alternate states, one dominated by corals and the other by algae (Knowlton 2004). In the region, coral cover has decreased by nearly 80 percent (Gardner et al. 2003), a consequence of natural and anthropogenic factors (Hughes 1994), including pollution by sediments and nutrients. After interventions to reduce pollution, recovery of these ecosystems has been slow if at all, creating the urgent need for new management strategies (Coelho and Manfrino 2007), a reduction of sources of pressure, and real-time measures of the success of interventions.

Mangrove forests are also critical coastal ecosystems in the region. As in many other ecosystems, recovery of mangrove forests after pollution events has been minimal, usually recovering only near channels and in time frames of decades to centuries (Peters et al. 1997; Twilley et al. 1999). It is estimated, for example, that the recovery of the Ciénaga Grande de Santa Marta after the deterioration that occurred in the 1970s and 1980s would take hundreds of years, passing through different alternate states (Twilley et al. 1999).

The examples of coral reefs and mangroves show how difficult it is to restore and see recovery in degraded marine and coastal ecosystems, giving strong support to applying the precautionary principle with more vigour. Marine ecosystems and communities do not often respond to stress and pollutants as predicted, and recovery from these anthropogenic disturbances is often much slower than expected from the life history of the individual organisms (Knowlton 2004).

Discussion and conclusion

Sewage and municipal effluents are still on top of the list of the wide range of land-based marine pollutants. Sewage control is a problem considered almost intractable in many countries, given the size of their coastal populations and cities, the volumes and complex composition of the effluents, and the costs of effective treatment and the maintenance of the sewage treatment plants (STPs). While coastal sewage treatment is considered a high priority in some countries like the United States, with very large investments being made (e.g., the Deer Island sewage treatment plant (STP) in Boston at US$4.1 billion), other advanced countries such as Canada and the United Kingdom are still in the process of developing systems to treat discharges to the sea, sometimes at only basic levels of treatment. Most countries in the Caribbean region are well behind, pumping their screened raw sewage directly into the ocean, despite affecting water and amenity beach quality close to the discharge points. Advanced secondary treatment is considered minimal for the protection of human and ecosystem health (Dan Smith, University of Alberta, pers. comm.). The costs of discharging untreated sewage into coastal ecosystems are very high, both in terms of closed fisheries (especially shellfisheries) and risks of disease to humans (GESAMP 2001a, GESAMP 2001b) compared to the initial high costs of building STPs and the costs of long-term maintenance. Additionally, alternative treatment technology that could serve to reduce the need for high initial capital investment, as required for STPs, are being developed and implemented.

If persistent, chemical contaminants from the land can be bioaccumulative and toxic at low levels and can cause many problems in coastal regions. Many constituents are endocrine disrupters, affecting growth and development. Nutrients such as nitrogen contribute to oxygen deficits, eutrophication, and harmful algal blooms. Sediments become contaminated and act as sinks and sources of chemicals for many years. The extent of impacts depends upon properties of the chemicals, volumes, flushing rates, and characteristics of the organisms and ecosystems being exposed. Some organisms take up many contaminants, from metals to pesticides to PAHs, but are relatively resistant to effects, e.g., clams and mussels. Others are highly sensitive to water quality changes and low levels of organics, e.g., many marine larvae, decapods, and echinoderms. Many of the organisms found in coral reef and mangrove ecosystems are sensitive to pollutants at very low levels, especially during reproduction and development. Ecosystems can recover from some chemical exposures, such as from petroleum oil spills, again if oceanic conditions lead to diminished exposures, degradation of the chemicals, and high recruitment from adjacent non-impacted areas. In the long term, constant elevated sediment loadings to coral reef ecosystems may have a greater impact on overall reef health than chemical exposures. Table 5.1 shows an approximation to the potential damage to human goods and services of different pollutants and ecosystems, it also shows the potential of recovery of such ecosystems after removing the source of contamination.

Table 5.1. Potential effects of different sources of pollution on human activities (bold) and possibility of recovery of the ecosystems (italicized)

	Estuaries	Mangroves	Coral Reefs	Seagrasses	Soft Bottoms	Pelagic Ecosystems	Beaches	Coastal Lagoons	Rocky Shores
Sewage	**2** *2*	**2** *2*	**3** *3*	**3** *2*	**2** *1*	**1** *1*	**3** *2*	**3** *3*	**3** *3*
Heavy Metals	**3** *1*	**2** *2*	**2** *3*	**2** *2*	**1** *1*	**1** *1*	**2** *1*	**3** *3*	**2** *3*
Hydrocarbons	**2** *2*	**3** *2*	**3** *3*	**3** *3*	**2** *2*	**1** *1*	**3** *2*	**3** *3*	**3** *3*
Sediments	**1** *1*	**1** *2*	**3** *3*	**3** *3*	**1** *3*	**1** *1*	**1** *1*	**2** *3*	**3** *3*
Agrochemicals	**2** *2*	**2** *2*	**3** *3*	**3** *2*	**1** *3*	**1** *1*	**1** *1*	**3** *3*	**3** *3*
Invasive Species	**3** *3*	**2** *3*	**3** *3*	**3** *3*	**2** *3*	**1** *3*	**2** *3*	**3** *3*	**3** *3*

1 = Slight potential impact 2 = Medium potential impact 3 = High potential impacts
1 = High recovery potential 2 = Medium recovery potential 3 = Slight recovery potential

In general, ecosystems with high dynamics such as estuaries, soft bottoms, and the pelagic ecosystems seem to be less susceptible to most pollutants and, once removed, have minor problems recovering. Important ecosystems like coral reefs, rocky shores, and seagrass beds are more susceptible to pollutants, especially those that can smother surfaces or change the composition of species. Similarly, these ecosystems recover at a very slow pace since their main constituents require long periods of time to structure the community. This makes them more vulnerable to drastic changes due to pollution events. Coastal wetlands are highly susceptible to pollutants for the goods and services provided as nursery area; furthermore, due to their low water dynamics, pollutants remain in the system for long periods of time.

Pollutants with high residency times like heavy metals and some agrochemicals can stay in the environment for long periods of time and pass through the food chain, biomagnifying and bioaccumulating. Suppression of these pollutants requires the change of state of the metal and their extraction from the ecosystem and often requires direct human intervention.

The case of invasive species is unique, since for the recovery of ecosystems altered by this type of pollution it is not sufficient to remove the source of pollution. Once exotic species are established and become invasive, they require eradication measures, which is not always feasible.

Many inshore areas around the Caribbean countries are degraded for water and sediment quality; this situation will only become worse if not directly addressed (Bryant et al. 1998; Burke and Maidens 2004). Cumulative changes to many habitats have taken place along coastlines. Unfortunately, not enough is known comprehensively about the ecotoxicology of tropical and sub-tropical ecosystems, including their resilience and recovery rates, to permit more refined comment on the persistence of land-based pollution impacts, and their recovery potential, in the Caribbean. On the positive side, this question is being addressed by programs such as the Large Marine Ecosystem (LME) (Sherman et al. 2005) and by professional organisations such as SETAC (Society for Environmental Toxicology and Chemistry), Latin America section. Hopefully, these projects will provide results fast enough to make a difference to the quality of Caribbean coastal and offshore waters.

Effective control of land based sources of pollution requires not only assessment of the effect of pollutants to organisms and ecosystems and their resilience or recovery potential, but it also requires decisions regarding the human perception of the use and services provided by ecosystems in the framework of ecosystem-based management. The suppression of the source of pollution is the first step to recover the natural characteristics of ecosystems. However, this recovery can take ecosystems through stages not desirable from the human point of view, which requires political decisions for intervention and an adaptive approach.

Note

This is contribution CTRB-1038 of INVEMAR.

6

Building Capacity and Networking among Managers

Essential Elements for Large-scale, Transboundary EBM through Effective MPA Networks

Georgina Bustamante and Alessandra Vanzella-Khouri

Abstract

Recent research on the biological connections of marine populations in the Wider Caribbean has shown that they are more restricted than previously thought. These results have allowed delineation of a highly partitioned ecoregional scenario of the Tropical NW Atlantic Coastal Biogeographic Province. The results point out the need to use such information in the development of large-scale – including transboundary – ecosystem-based management of coastal resources. In addition, the recent proliferation of social networking initiatives, and their success in communicating with people and advancing knowledge, stresses the importance of using stakeholder networks to disseminate best management practices and increase the effectiveness of marine protected areas at both site and system levels. This paper addresses these topics by describing the ecoregional scenario of the Wider Caribbean and the regional policy background, objectives, activities and cooperative working approach of the Caribbean Marine Protected Area Management (CaMPAM) Network and Forum. This social networking initiative has a capacity building programme for practitioners in the Wider Caribbean marine protected areas.

Introduction

Within the Wider Caribbean Region (WCR), there is an estimated 26,000 km^2 of coral reefs, developed in isolation with very few of the many thousands of species of flora and fauna in these waters found anywhere else in the world (Burke and Maidens 2004). Living coastal and marine resources in the WCR are under tremendous pressure. Much of the human population lives near the coast and is highly dependent on living marine resources for their livelihoods, employment and food. Fishery resources are intensively exploited by large numbers of small-scale fishers. Some species, such as lobster and conch, are in high demand for export. Coastal development and the rapid expansion of tourism exacerbate the situation as important habitats deteriorate or are being destroyed. These pressures have led to a widespread depletion of marine resources, including offshore resources, which are already considered to be fully or overexploited. Living resources such as coral reefs and associated habitats (mangroves, seagrass beds, sandy beaches and rocky shores) are extremely important for tourism economies as well as coastal defense against sea level rises and storms. Although not yet depleted, these are also severely degraded by human activity.

Oceanographic Features and Connections among Living Marine Resources in the Wider Caribbean

The Caribbean is the largest marginal sea of the Atlantic Ocean. It is enclosed by the continental masses of South America and Central America to the south and west, and is connected to the North Atlantic Ocean via the Lesser Antilles and the Windward Passages to the east, and the Gulf of Mexico via the Yucatan Strait to the north. It consists of a succession of five basins: the Grenada, Venezuelan, Colombian, Cayman and Yucatan Basins. The variable bathymetry is an important factor in the formation of eddies moving water masses through to the western Caribbean Sea.

As it reaches Brazil, the equatorial current branches into the Guiana Current. One part of this current remains windward of the Lesser Antilles and the Bahamian Archipelago to form the Antilles Current. The other part, the Caribbean Current, penetrates through the southern portion of the Lesser Antilles, running offshore to the eastern Venezuelan shelf. At the shelf, this current mixes with the freshwater runoff from major rivers – the Magdalena (Colombia), the Orinoco (Venezuela) and the Amazon (Brazil) – with annual discharges of several to hundreds of millions of cubic metres each. The Magdalena River interacts with the circulation in the SW Caribbean, while the Orinoco plume flows first northward along the South American coast and influences the islands of southern Lesser Antilles and of the Greater Antilles. During the high runoff period or wet season, estuarine waters flow west-northwestward.

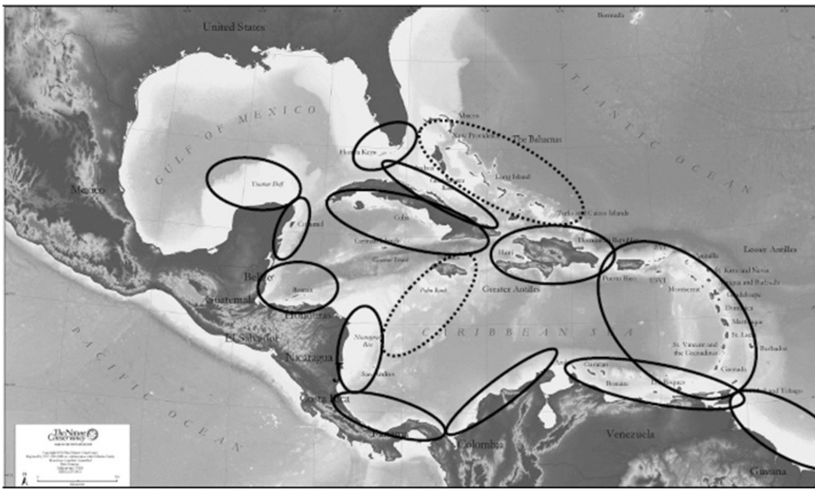
The Caribbean Current moves up off the coast of Central America, funnelling first through the passage between the NW end of the Honduras shelf and Pedro Bank (SW Jamaica), and then through the Yucatan Channel. At the Gulf of Mexico, the Yucatan Current deflects to the west, forming the Loop Current that turns abruptly back to the east through the Straits of Florida into the Florida Current. The submarine shelves are generally wider in some continental countries (i.e., the North Yucatan, Honduras, Florida), as well as in the large archipelagos of Cuba and the Bahamas. In the Lesser Antilles they are very narrow and drop off a few hundred metres away from the coast. The overall circulation pattern is shaped by dominant winds, coastal orientation, and sea bottom topography that combine to form meanders, eddies, gyres and nearshore counter-currents. This complex circulation influences the way propagules are dispersed from the places they originate to the place they settle. However, the connection between species populations across the region, which are also influenced by biological interactions with the environment, are still the subject of investigations (Paris et al. 2007).

The region is occupied by the Tropical NW Atlantic Biogeographic Province (Sullivan-Sealey and Bustamante 1999; Spalding et al. 2008). This large area contains two Large Marine Ecosystems (LMEs): the Gulf of Mexico LME and the Caribbean Sea LME. The division of the Wider Caribbean into ecoregions is fundamental to understand the connections of populations across the region and to be able to apply this knowledge to coastal resources management. Ideally, we would like to understand the spatial dynamics of the organisms that reside in the area that we intend to manage. While available information is still very limited, it is nonetheless the focus of research projects and conservation programmes in the region. However, research data on ocean circulation and larval dispersal for the Wider Caribbean (Cowen et al. 2003a, 2003b; Andrade and Barton 2000; Paris et al. 2002a, 2002b, 2004, 2005, 2008; Thattai et al. 2005, 2007; Ezer et al. 2005; Sale et al. 2005; Colin 2004; Baums et al. 2006; Cherubin et al. 2008; Heyman et al. 2008) and its application to the marine world heritage listing (Bustamante and Paris 2008) have provided important insights into how biological and oceanographic barriers and linkages operate in the Wider Caribbean. The data suggest a new ecoregional scenario of about 15 ecoregions, a significant departure from the number proposed previously (Sullivan and Bustamante 1999; Spalding et al. 2007). This new ecoregional scenario suggests that the biological connectivity of marine populations in the Caribbean is more restricted than previously thought (Figure 6.1).

Major distinctions of the new scenario are that the Mesoamerican Reef System region is divided near the Mexico-Belize border; larval exchange is limited between Honduras and Nicaragua, Costa Rica and Panama, Panama and Colombia, and Colombia and Venezuela; the San Andres and Providencia archipelago may play the role of a corridor for the replenishment of Jamaican reef-related populations; the Lesser Antilles islands are weakly connected to one another and form a large, fragmented unit of biological connection from Trinidad and Tobago to Puerto Rico; the Mona Passage represents a seasonal barrier to dispersal between Puerto Rico and Hispaniola. For more information on the biological connectivity of the Wider Caribbean, see Grober-Dunsmore and Keller (2008).

These ecoregional divisions have important implications for marine EBM, as it would be ideal to know where the sources are for the recruits of biological populations at any site. If this is known, then relevant management interventions can be targeted and applied in the most appropriate places. In areas where marine populations are shared by different countries, transboundary and regional policy and cooperation is necessary to ensure regulations are effective. Even with the existence of such policies, good communication and understanding between environmental managers are essential to developing working relationships and facilitating the coordination of adaptive management plans. Regional or sub-regional professional or social networks may assist in this process.

Figure 6.1. Tentative units of biological connectivity (enclaves or marine ecoregions) of the Wider Caribbean or Tropical NW Atlantic Coastal Biogeographic Province (ovals with dotted lines depict less documented or a potential additional division) (after Bustamante and Paris, 2008)



Human Connections for Marine Protected Areas: the Caribbean Marine Protected Areas Management Network and Forum (CaMPAM)

Background

The existence of transboundary marine biological connections and threats that are common to most Caribbean countries (overfishing, inadequate coastal development and watershed management, and irresponsible tourism) show the need for cooperation at various geopolitical scales. In recognition of this need, the countries of the WCR adopted in 1983 a legally binding environmental treaty, the Convention for the Protection and Development of the Marine Environment in the Wider Caribbean (also known as the Cartagena Convention), which became international law in 1986. As a framework agreement it is complemented to date by three specific protocols that address responses to oil spill emergencies, biodiversity conservation and land-based sources of marine pollution. The goal of the Cartagena Convention is to address the inadequate institutional, legal and policy frameworks or mechanisms for managing shared living marine resources across the region. It also provides assistance to do this by improving knowledge and information bases, building capacity and promoting better practices.

The parties to the 1983 Cartagena Convention adopted, in 1990, the Protocol Concerning Specially Protected Areas and Wildlife (SPAW). It is the only legal agreement on conservation and sustainable use of biodiversity for this vast region. The SPAW Protocol emphasises conservation through ecosystem-based management (predating the Convention on Biological Diversity in this regard), accentuating the role of local communities and the need for education and public information at all levels of conservation efforts.

The Protocol is administered by the Caribbean Environment Programme of the United Nation Environment Programme (UNEP-CEP) based in Kingston, Jamaica. Since its adoption it has been supported by an operational programme developed in conjunction with governments and relevant organisations to respond to the needs and priorities of the region regarding biodiversity conservation and sustainable use within the context of the Protocol's objectives. While a number of activities of the SPAW Protocol Programme are targeted at conservation of specific threatened and endangered species, most activities relate to biodiversity conservation through a spatial, ecosystem-based management approach, through the use of marine protected areas (MPAs). Among the major activities committed to by the signatory parties are the development of a programme to strengthen MPAs in the Wider Caribbean through building the capacity of MPA managers and practitioners as well as providing targeted technical assistance.

Marine Protected Areas in the Wider Caribbean and Ecosystem-Based Management

The spatial extent of MPAs in the region has grown in the last two decades but management effectiveness remains a big challenge. Out of 285 MPAs in the Caribbean, only 6% and 13% were estimated to be effectively and partially effectively managed respectively (Burke and Maidens 2004). An estimated 20% of corals were found to be located inside MPAs but only 4% were located within MPAs that were rated as effectively managed (Burke and Maidens 2004). Therefore, an immediate concern regionally and globally within internationally agreed initiatives and goals is to rapidly increase effective MPA coverage, to encourage the application of the ecosystem approach in marine management and to establish representative MPA networks by 2012 (Laffoley 2008).

An MPA network can be defined as a collection of individual MPAs or reserves that operate cooperatively and synergistically, at various spatial scales, to meet objectives that a single reserve cannot achieve. MPAs must be placed, spaced and sized appropriately to function collectively as an ecological network and successfully achieve biodiversity goals (Laffoley 2008). MPA networks are therefore vital tools to maintain marine ecosystems, given the physical connectivity and genetic isolation of certain species in the marine environment. Networks of MPAs spanning through entire ecoregions or biological connectivity units are necessary to ensure the viability of the resources shared by many interdependent MPAs. It is critical to understand that MPA networks can only be effective if they are implemented within larger frameworks of ecosystem-based management, integrated marine governance and coastal area management. It must be further understood that establishing MPAs and building MPA networks is as much about people as it is about biodiversity.

MPA social networks can be formed to facilitate learning, coordination and optimisation of resources. In the MPA social network the institutions, managers and stakeholders share the same overall goals and provide a platform to coordinate with each other, share experiences and grow and enhance each others' efforts in managing their respective MPAs (IUCN 2008).

In this context, UNEP-CEP, with the co-sponsorship of the US Biscayne National Park, held a meeting in 1997 where some 50 MPA managers from 22 countries proposed the creation of a network, the Caribbean Marine Protected Area Management Network or CaMPAM. Its mission was as follows: *"the enhancement of marine and coastal area management in the Wider Caribbean Region through sharing and collaboration to strengthen our national and regional systems of existing and future marine and coastal protected areas"*. Therefore, CaMPAM is a social network of MPA management stakeholders established under the framework and objectives of the SPAW Protocol with a view to improving management effectiveness through building capacity, strengthening communications and promoting collaboration and exchange.

CaMPAM Capacity Building Programme

The Network has been administered by UNEP-CEP, which has coordinated to date the following capacity-building activities:

- regional training of trainers programme (CaMPAM flag programme);
- exchange visits of fishers and MPA managers;
- small grants for projects aimed at strengthening MPAs and promoting sustainable fisheries and alternative livelihoods for fishers in or around MPAs;
- a regional comprehensive MPA database (http://cep.unep.org/caribbeanmpa);

– information dissemination via list server (campam@yahoo.groups);
– publications; and
– discussions among a mix of managers and scientists.

In 2004, during the "White Water to Blue Water" conference in Miami, CaMPAM was revitalised by creating partnerships with other institutions that can contribute with funding and expertise, such as the Gulf and Caribbean Fisheries Institute (GCFI, www.gcfi.org), the National Oceanic and Atmospheric Administration's National Marine Sanctuaries Program, and The Nature Conservancy.

Training the Trainers

Since 1999, six regional courses for MPA Managers (which had 90 participants) were implemented in Saba (Netherlands Antilles, 1999), in Parque del Este (Dominican Republic, 2000), in the Soufriere Marine Management Area (St. Lucia, 2003), in the Florida Keys NMS (USA, 2004 and 2006), in the Sian Ka'an Biosphere Reserve (Tulúm, Mexico, 2007), and in Buccoo Reef Marine Park, Tobago (Trinidad and Tobago, 2009) (Figure 6.2).

Figure 6.2. Participants of Training of Trainers Regional Course. Trainees meet leaders of the Cooperative Vigia Chico in Punta Allen, within the Sian Ka'an Biosphere Reserve in SE Mexico, to exchange experience on community-based fishing/tourism practices within an MPA, on September, 2007

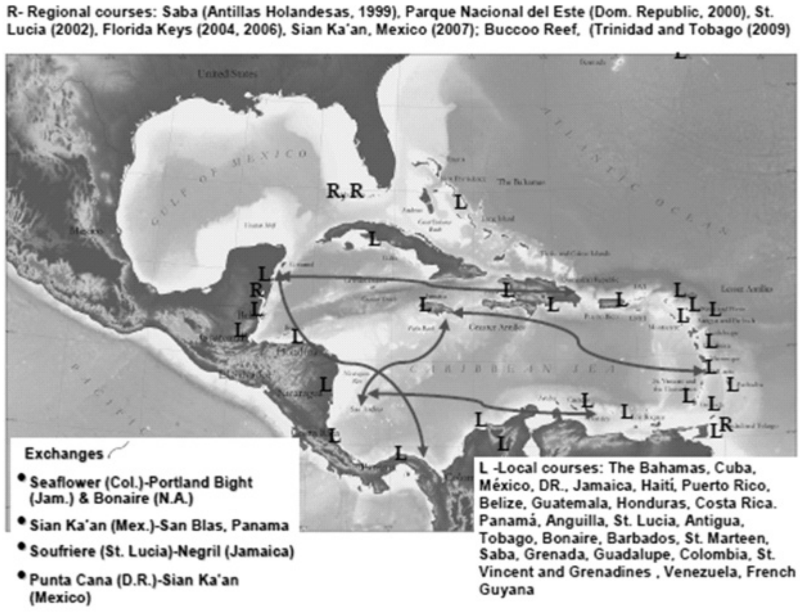
The courses have been funded by several donors and in-kind contributions of numerous local experts and institutions (NOAA's Florida Keys National Marine Sanctuary and Coral Reef Conservation Programs, Instituto Universitario de Tulum, Fundación Orígenes de Quintana Roo, Environmental Defence, Energía Renovables de Quintana Roo, The Nature Conservancy, Amigos de Sian Ka'an, Sian Ka'an Biosphere Reserve, Comisión de Areas Naturales Protegidas of Mexico (Yucatan Región), Fishing-tourism Cooperative Vigía Chico, Oceanus A.C, Instituto Tecnológico de Chetumal, Florida Fish and Wildlife Conservation Commission, Buccoo Reef Trust, Organization of Eastern Caribbean States-Protected Areas and Alternative Livelihood Project, Gulf and Caribbean Fisheries Institute, etc.).

Approximately 60 follow-up local training activities were held by the regional course alumni with more than 1200 persons trained in about 25 countries and territories. The impact at both the local and national levels was significant (http://www.cep.unep.org/publications/spaw/TOT-evaluation.pdf). A manual was created in both Spanish (http://www.cep.unep.org/publications/spaw/tot-manual-es.pdf) and English (http://www.cep.unep.org/publications/spaw/tot-manual-en.pdf). It comprises eight modules on Caribbean MPA planning, management, research and monitoring, and regional policy, along with communication and teaching skills. The manual was recently updated and now includes a list of over 300 bibliographic references with hyperlinks to download papers, as well as class presentations.

Small Grants Programme

In order to promote MPA and fisheries sustainable practices, a grant programme was run by UNEP-CEP and more recently in conjunction with GCFI, an active partner of CaMPAM (see http://www.gcfi.org/SGF/SGFEng.php). The following sites have benefited from this programme: Bonaire Marine Park (Netherland Antilles); Buccoo Reef Marine Park (Tobago); the Centre for Resource Management and Environmental Studies (University of West Indies) for Antigua, Barbados, Grenada, St. Kitts, Nevis and St. Lucia; Hol Chan Marine Reserve (Belize); Juanillo-Punta Cana (D.R.) and Yucatan Peninsula MPAs; Negril Marine Park (Jamaica), Portland Bight Protected Area (Jamaica); San Blas Is. (Panamá); Seaflower Biosphere Reserve (San Andrés Is., Colombia); Sian Ka'an Biosphere Reserve (Mexico); Soufriere Marine Management Area (St. Lucia); and St. Eustatius Marine Park (Netherland Antilles). The exchanges involved MPA and fisheries managers and have covered a number of countries and MPAs. Figure 6.3 shows the geographic coverage of the Training the Trainers and Small Grants Programmes combined.

Figure 6.3. Locations that benefited from the training the trainers courses, and the Small Grants Program Exchange Visits program



Fishers and MPA managers have highly appraised both programmes. The Training of Trainers Programme has both enriched knowledge and promoted networking among practitioners. The SMP allowed participants to see firsthand how other MPA managers and fishers address the same issues they need to cope with. These exchanges have widened their perspective on how to manage fisheries' resources within and around MPAs, and how to develop partnerships and business relationships with local stakeholders. One of the most relevant examples is the dissemination of the experience of the community-based fishing/ecotourism businesses in Punta Allen to other Caribbean countries such as the Dominican Republic (Punta Cana) and Panama (San Blas Is.). The residents of the coastal town of Punta Allen, organised in fishing/ecotourism cooperatives, have been granted exclusive rights to use coastal resources in certain areas by the Sian Ka'an Biosphere Reserve authorities.

MPA Database

In 2006-2007, the Regional MPA database was restructured (77 fields grouped into four categories: identity, legal, biophysical, management) and is now online at http://cep.unep.org/caribbeanmpa (Figure 6.4). The database will establish links with similar efforts elsewhere having different geographic coverage and detail. When fully completed, it will be the best standardised depository of detailed data on Caribbean MPAs. The information will allow for the production of summary reports and news via the CaMPAM and other e-discussion groups.

Figure 6.4. Home page of the Caribbean MPA Database (http://cep.unep.org/caribbeanmpa), a work in progress

The existence of a depository of detailed, standardised and reliable information of the more than 300 MPAs that exist in the region will be a useful information resource for managers, academics, students, environmental planners, policymakers as well as the business sector. The interoperability with similar web-based databases is essential for ensuring data uniformity.

Exchange Information in Technical and Scientific Fora

In order to facilitate the exchange of information and discussion of emergent issues with a diverse audience, CaMPAM has coordinated or co-sponsored meetings at regional conferences. One of the most regular gatherings has been the GCFI annual meetings, which are held each year in a different country. The GCFI conference agendas have a regular scientific session dedicated to MPA science and technical issues. In addition, special MPA-related sessions have been implemented in almost all editions of the conference since 2001.

Between 1998 and 2006, 196 papers related to MPA science and practice (Bustamante, forthcoming) were presented at the GCFI scientific sessions and special workshops. Hundreds of marine conservation scientists and managers of the Wider Caribbean Region with different responsibilities (from site managers and environmental agency officers to NGO staff and academia) attended, from all over the Caribbean. This forum has become the most popular gathering of MPA scientists and practitioners of the region, attracting the attention of participants and international conservation organisations who like this venue to implement their workshops and technical meetings related to MPA issues, as it provides such a varied mix of attendees.

Coordination

Due to the lack of staff and resources, CaMPAM activities have been almost fully coordinated and supervised by UNEP-CEP, with significant contribution from GCFI, occasional support from a few agencies, and volunteer contributions from some individuals. These contributions have fluctuated over the last few years but have never been sufficient to fulfill the role of a coordinator. A Coordinator was hired to supervise the network and expand its activities, with seed funding provided by NOAA's Coral Reef Grant Program and GCFI, a long-time partner of CaMPAM. The Coordinator is expected to maintain as well as enhance the activity of the network. This role will also fulfill the goal for which CaMPAM was created and enhance the capacity of Caribbean MPA managers through better utilisation of the resources available while seeking additional resources.

Adapting Human Connections to Biological Connections to Enhance MPA Effectiveness in Coastal Conservation

The constantly changing challenges of the region's conservation issues and the world at large require the enhancement of communication and information management among the MPA community in the Caribbean. Despite the numerous programmes and initiatives to enhance MPA management effectiveness, the role of CaMPAM as a vehicle for communication, training and information dissemination seems to be more relevant than ever.

The experience of alumni and instructors over the last 10 years and the external evaluation of the Training the Trainers programme (http://www.cep.unep.org/publications/spaw/TOT-evaluation.pdf) suggest the need for the incorporation of new training tools. CaMPAM needs to evolve and adapt to the changing conditions of the Caribbean MPA community. The improvement of the training and communications tools will assist the region in building its capacity to address new challenges, including the creation of effective networks (national, ecoregional, sub-regional) of MPAs.

Activities identified to strengthen CaMPAM in the near future include (but are not limited to):

- Expansion of the network communication tools so that a wider audience can be reached, including not only MPA managers and scientists but also policymakers and the business sector.
- Engage governmental and non-governmental organisations via cooperative agreements or joint initiatives with the subsequent benefits of resource optimisation, synergy building and buy-in.
- Improve the Training the Trainers programme by making it more flexible and incorporating new training tools and targeted workshops.
- Nominate activists or mentors for each ecoregion according to the suggested biological connectivity divisions of the Wider Caribbean, and develop exchange programmes to enhance coordination of the management of transboundary, ecoregionally-related MPAs.
- Share the knowledge of MPAs skilled in community-based ecotourism, sustainable financing, natural resources or socioeconomic monitoring. This is a valuable resource for the establishment of a mentorship programme where expert managers can assist others in need of tutoring.
- Sponsor MPA-related sessions during GCFI annual meetings and procure sponsorship for the attendance of MPA managers and conservation-minded fishers.
- Complete and maintain the Regional MPA Database, and use these data to produce summary reports on the State of the Caribbean MPAs. These data can be disseminated to a diverse audience (coastal managers, business sectors, regulators and academia). Develop its interoperability with other international and site databases.
- Expand membership with the recruitment of experts who can impart lectures or assist with the development of local business with best management practices.
- Provide assistance for grant proposal opportunities and development, as well as sources of information for enhancing MPA management effectiveness.
- Mobilise volunteer efforts to expand CaMPAM activities.

We expect that these activities will become a significant resource for the region and contribute to the creation of a Community of Caribbean MPA Practitioners, thus supporting the process of developing effective MPA networks in the next decade.

The role of MPAs for effective ecosystem-based management is undeniable and practically intrinsic. Similarly, it is obvious and imperative that the effectiveness of MPAs can only be built through effective, clear and consistently available networking amongst MPA practitioners (MPA managers and staff, conscious-minded fishers and other stakeholders). Through the social networking of MPA practitioners, the goal of exchange of data, information and experiences can only further contribute to the creation of a true learning community of the Caribbean MPA practitioners and consequently to more effective MPAs.

Just as networks that span entire ecoregions of ecologically connected MPAs are vital tools for maintaining marine ecosystems and for ensuring the viability of the resources shared by many interdependent MPAs, equally important is the networking of the people involved or participating in the management of these MPAs. Collaboration, communication, sharing and exchange are all key components of networking and required elements for effective management. In this context, establishing MPAs and building MPA networks is as much about people as it is about biodiversity.

7

Why Incorporate Social Considerations into Marine EBM?

Patrick McConney and Silvia Salas

Abstract

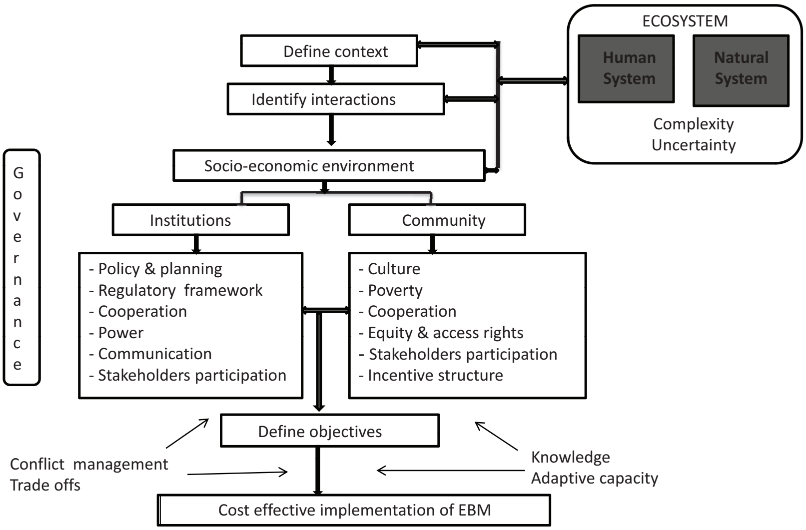
Socio-cultural factors play prominent roles in coastal and marine resource use and management in the Caribbean region. Approaches to marine ecosystem-based management (EBM) that ignore social considerations may have a higher risk of failure. The internationally agreed-upon twelve principles of the ecosystem approach form a useful starting point for identifying relevant social considerations (for the list of twelve principles, see http://www.cbd.int/ecosystem/principles.shtml). Some of these principles involve stakeholders, institutions, communities, power, participation, culture, adaptive capacity, livelihoods, poverty, knowledge and conflict. Incorporating social considerations into marine EBM, from design to evaluation, should be seen as an asset and not a liability. Addressing social issues, linked closely to the governance of social-ecological systems, may contribute significantly to the success of marine EBM initiatives in the Caribbean. Social considerations should be of high priority in all marine EBM situations, and the competence exists in the region for these to be taken into account.

Why Consider Social Aspects?

Broadly speaking, marine EBM encompasses a whole suite of arrangements, approaches, processes, methods, tools, activities and the like that concern very comprehensive ocean (here taken as both marine and coastal) resource governance. Familiar examples may include the ecosystem approach to fisheries (EAF) or ecosystem-based fisheries management (EBFM), marine protected area (MPA) management, integrated coastal area management (ICAM), the ecosystem approach (EA) to biodiversity conservation, marine pollution control, sustainable tourism and more. Authors often make very fine distinctions among these terms based mainly on views of how and when ecosystem thinking gets integrated into management; see Christie et al. (2007) for an analysis. Since such fine distinctions are largely irrelevant to an examination of the social aspects, we will ignore them in this chapter and use marine EBM to include any of their components applied to marine ecosystems.

Marine EBM is part of principled ocean governance. Governance can be defined as the whole of public as well as private interactions taken to solve societal problems and create societal opportunities, including the formulation and application of principles guiding those interactions and care for institutions that enable them (Bavinck et al. 2005). Furthermore, human direct or indirect use of marine ecosystems (provision of ecosystem services) takes place in the context of social-ecological systems (SES). The SES view emphasises that social and ecological systems are inevitably linked and integrated, and that the delineation between the two systems is artificial and arbitrary (Berkes and Folke 1998). Social-ecological systems are hence more intricately interwoven than if humans were simply fitted into ecosystem models or natural resource dynamics were added to social models. The social dimension is prominent in these conceptual underpinnings of marine EBM. Social and institutional factors can drive, support or constrain EBM implementation (Seijo 2007; DeYoung et al. 2008). Furthermore, specific social and economic situations need to be understood in the context of the larger social-ecological system. A good understanding of a broad range of actors at a variety of levels may facilitate cost-effective implementation of marine EBM once its objectives have been collectively and comprehensively defined (Figure 7.1).

Figure 7.1. Social-ecological systems and the implementation of EBM



The concepts of governance and SES provide the main planks for including social considerations in marine EBM. But for marine resource managers, users, researchers and other stakeholders to appreciate the practical reasons and consequences of incorporating social considerations, we must examine some details. In order to do this the next section looks at what we consider 'social' and how this understanding links to working definitions and principles related to marine EBM. We then address some of the many social dimensions of marine EBM that may be most relevant to the Wider Caribbean, and end with brief conclusions.

Defining What is Social in EBM

For the purposes of this chapter we take a broader, more interdisciplinary, view of what is 'social' than you may find in some academic texts. We include most aspects of social science except economics, which is dealt with in another chapter. Social here therefore also includes cultural, institutional and political factors.

Taking this broad view, where do we encounter social considerations in definitions related to marine EBM, such as from international agreements? We choose two for the main thrust of our analysis. The EA concept associated with the Convention on Biological Diversity (CBD) is very broad. The FAO concept of EAF associated with the Code of Conduct for Responsible Fisheries (CCRF) is more specific (Box 7.1).

Box 7.1. EA and EAF Definitions

Definition of ecosystem approach (EA): The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way "to reach a balance [between] conservation, sustainable use and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources" (CBD 1992).

Definition of ecosystem approach to fisheries (EAF): An ecosystem approach strives to balance diverse societal objectives by taking account of knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO 2003).

Both definitions have been developed and elaborated upon by many stakeholders in many different contexts. They share a basic set of principles that serve as a valuable starting point for identifying the social considerations and their practical application (Table 7.1).

Table 7.1. Ecosystem Approach (EA) shared principles and social considerations

Shared principles	Examples of social considerations	Benefits from including the social consideration
(1) Management objectives are a matter of societal choice.	– Policy and planning, participatory processes, stakeholders, power, adaptive capacity	– Transparent, participatory societal decision-making facilitates stakeholder buy-in
(2) Management should be decentralized to the lowest appropriate level.	– Power, stakeholders, capacity, community, institutions, social structure	– Developing lower level capacity empowers and assists subsidiarity
(3) Ecosystem managers should consider the effects of their activities on adjacent and other ecosystems.	– Traditional and local ecological knowledge, culture, conflict management, social capital, adaptive capacity	– Understanding resources and their interactions from user perspectives mobilizes knowledge for management
(4) Recognizing potential gains from management there is a need to understand the ecosystem in an economic context, considering e.g. mitigating market distortions, aligning incentives to promote sustainable use, and internalizing costs and benefits.	– Equity, poverty, sustainable livelihoods, access rights, social strategies for coping with risk and uncertainty	– Socio-economic analyses and understanding of coping strategies based on livelihoods aid appropriate economic interventions, especially in cases of poverty
(5) A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.	– Traditional and local ecological knowledge, culture	– Viewing ecosystems from user perspectives mobilizes knowledge for management
(6) Ecosystems must be managed within the limits to their functioning.	– Adaptive capacity and management, intergenerational equity	– Acceptable limits to change and function are partly socially determined
(7) The ecosystem approach should be undertaken at the appropriate scale.	– Institutional jurisdiction, property regimes, capacity development	– Social and institutional scales and levels impact upon feasible management scales
(8) Recognizing the varying temporal scales and lag effects which characterize ecosystem processes, objectives for ecosystem management should be set for the long-term.	– Social strategies for coping with risk and uncertainty, livelihoods, intergenerational equity, political cycles, capacity development	– Social factors shape some attitudes towards time and planning horizons connected with risk and uncertainty
(9) Management must recognize that change is inevitable.	– Adaptive capacity and management, social strategies	– Attitudes towards change and change management are partly socially deter-

Shared principles	Examples of social considerations	Benefits from including the social consideration
	for coping with risk and uncertainty	mined
(10) The ecosystem approach should seek the appropriate balance between conservation and use of biodiversity.	– Decision-making institutions, power, conflict management, equity, property regimes	– Trade-offs among various objectives are social-political exchanges, and need to be understood as such
(11) The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.	– Traditional and local ecological knowledge, people's perceptions, cultural context of science	– Knowledge mobilization has socio-cultural dimensions, and can be performed more effectively if social factors are considered
(12) The ecosystem approach should involve all relevant sectors of society and scientific disciplines.	– Stakeholder analysis, participatory processes, knowledge systems, communication, patterns of cooperation	– Involving people in management, participatory management, requires good understanding of them and their interactions

Social Dimensions to Consider

Table 7.1 provides some social dimensions related to each of the principles. For each principle one could list additional considerations, and for each consideration, a finer disaggregation of the item is possible. For example, participatory processes and knowledge systems comprise many parts and perspectives and are entire multi-faceted fields of study on their own. However, it is not our purpose here to go into great detail. It is tempting to compare EBM to conventional management by concentrating only on what is different and pointing out the incremental costs and benefits of EBM. We do not take this comparative approach because social considerations should also apply to conventional management. The fact that they have customarily been ignored is one of the shortcomings of conventional management and a reason for the appeal of EBM. This section elaborates on some of the considerations identified above by providing brief points on what it is, why it should be considered and how to address it. Examples illustrate some points.

Stakeholders

Stakeholders are people (or groups) who have a stake, rights and responsibilities, or a high degree of interest in a situation and the outcomes of action or inaction. They can be categorised in several ways: they can be enabling or blocking in the case of specific initiatives, for example, or primary and secondary, based on involvement. Due to its wide scope, marine EBM typically involves numerous diverse stakeholders, some of whom may also be terrestrial (e.g., in ridge-to-reef scenarios). Knowing as much about stakeholders as possible is fundamental to EBM, particularly for the first, second and twelfth principles, and a way to do this is through stakeholder analysis. Recognising that problems may be examined individually or in sets (see McConney et al. 2003), stakeholder analysis asks questions such as:

- Who is directly affected by the problem situation being addressed?
- What are the interests of various groups in relation to the problem?
- How do groups perceive the management problem to be affecting them?
- How have groups already invested in strategies to cope with the problem?
- What resources do groups bring to bear on the problem?
- What organisational or institutional responsibilities do the groups have?
- Who should benefit, or be protected from, management interventions?
- What conflicts can be generated by the implementation of management schemes?
- Who will be impacted positively or negatively by management measures?
- What management activities may satisfy the interests of the various groups?

Marine protected areas (MPAs) often provide marine EBM scenarios in which stakeholder analyses are seen as being particularly useful (e.g. Renard 2000).

Institutions

People often use the word institution to mean organisation (a formal body guided by shared goals and procedures). However, institutions are really the customary, socially prescribed norms, rules and modes of interactions that people develop in order to function effectively (Ostrom 2005). There are many institutions in marine EBM, ranging from the division of labour on fishing boats to the processes of political decision-making at the highest transboundary levels (Chakalall et al. 2007; De Young et al. 2008). There are often institutions nested within institutions, and this is said to help confer resilience (Sosa-Cordero et al. 2008). For a marine EBM initiative to be sustainable, it may be useful to know what institutions are involved and how they are arranged. An institutional analysis can be used to identify institutions, their patterns of interaction, transaction costs and performance based on various criteria such as equity, along with outcomes and the learning that feeds back into the institution to sustain it. Institutional analysis is common in investigating governance such as co-management (Berkes and Folke 1998; Noble 2000). Also see the second principle of EA.

Community

There are many definitions of community, but they have in common the notion of people sharing some important characteristic that binds them together. There are geographic communities or settlements, communities of interest such as pressure groups, knowledge (epistemic) communities, communities of practice, and others. Similar to stakeholders and institutions, the understanding of what communities there are and how they are organised is fundamental to an appreciation of the kinds of positive and negative interactions, alliances and conflicts one can expect from the implementation of EBM given the diverse array of participants and interests. Communities are not free of conflict, and the latter is addressed later. In governance, determining the potential for community-based management is important for subsidiarity (EA Principle 2).

Power and Politics

Power is essentially a controlling influence that may enable or constrain. It is a very important and complex social concept that is hard to measure. Resources ranging from personal wealth to political position can be the basis for power. Politics is the set of social relations that people use to gain and exercise power. Their relevance to marine EBM stems from previous considerations in which diverse stakeholders and communities compete and collaborate via a variety of institutions (see Principles 1, 2 and 10). Natural scientists ignore power at their peril in management situations. A contribution of social science is to make considerations of power explicit and acceptable. For instance, when major international tourism interests and a few local resource users both have an interest in using or conserving a coastal area, it is inevitable that power and politics will come into play whether the interested parties are allies or rivals due to the disparities among them. Of particular interest is the policy domain in which the most powerful actors exercise their influence to shape EBM. Political changes can modify the direction of choices, actions and hence the implementation of EBM. The value of power analysis is usually to assist in determining how to increase equity and/or counterbalance existing power structures.

Social Structure

People in a society, comprising the human part of the social-ecological system, are organised in characteristic patterns of relationships that make up the social structure which changes with time and circumstance. Some authors use networks to depict social structure and explain how actors form institutions and communities, exercise power and otherwise relate to each other. Markets work through the exchanges of actors embedded in networks rather than operating independently. Understanding social structure can assist marine EBM practitioners to determine and predict how an intervention in one area (e.g., pollution or fishing) or with one group (e.g., women or the poor) can lead to outcomes in other areas or groups through network relationships (Ostrom 2005). Leaders or brokers who may be key change agents can be identified. Social hierarchy can influence equity and the distribution of benefits related to resource use, livelihoods, etc. (see Principles 1, 2 and 4).

Culture

Culture is the system of shared beliefs, values, customs, attitudes and behaviours that members of a society choose to live by and transmit intergenerationally through learning. Its relevance to marine EBM may range from ensuring that the conservation-oriented customary practices of indigenous people are incorporated into community-based coastal management to determining whether or not science and research are important in the organisational climates of marine management authorities and resource user groups (Principle 11). This illustrates that, like most social concepts, culture can be applied at different scales (Principle 7). If a community or society has a culture of integrated management, seeing itself as a part of nature with an ethic of stewardship (such as protecting nearby mangroves or seagrass beds), then it may be that marine EBM is highly culturally compatible (Palacio et al. 2006). Otherwise there may be a poor cultural fit.

Participation

Participation concerns engaging or getting involved in something, but there are numerous levels and modes of participation. It will be important to find appropriate processes through which stakeholders at the community or other levels (such as national organisations) can participate in marine EBM (Principles 1 and 12 especially). The qualifier 'appropriate' is important because not all stakeholders will be willing or able to participate at the same level, in the same way, at the same stage, etc. Hence participatory processes (e.g., for consultation or decision-making) must be properly tailored to the circumstances. In order to do this, social information is required. Often this is demographic such as knowing levels of education, ages, occupations, religion and the like. But it may also be more institutional and anthropological such as information on processes for decision-making and representation that are based on culture. Designing and ensuring participation can be a major undertaking in large-scale marine EBM as complexity increases, and participation even in technical and scientific fora is a social interaction.

Adaptive Capacity

Capacity is the multi-dimensional concept encompassing both the tangible and intangible resources required to perform. Adaptive capacity reflects learning and the ability to experiment and foster innovative solutions such as in complex SES (Armitage 2005). Adaptation is enhanced where stakeholders' social-ecological knowledge and institutional arrangements are tested and revised in dynamic, self-organised processes of learning-by-doing (Folke et al. 2005). This, to a large extent, is social and institutional learning. Marine EBM is fraught with situations of high complexity and uncertainty in both the social and ecological arenas that require the capacity to adapt quickly (see Principle 9). This is particularly so in the vulnerable small island developing states (SIDS) of the Caribbean which are subject to shocks from a variety of sources. Consider, for example, a marine protected area impacted by a hurricane. Reef damage may reduce fisheries harvests, but fishers may instead become involved in paid scientific surveys and rehabilitation measures as short-term coping strategies if they have the adaptive capacity. Understanding the diversity of people's livelihood strategies and the sources of their vulnerability can help to address the problems from the roots, design intervention processes and define programmes of capacity development to include the element of adaptation (see Pomeroy et al. 2006).

Livelihoods and Poverty

Livelihoods are basically the sets of activities that people engage in to earn a living, including the assets that they utilise. Poverty is an evolving concept that now encompasses income, nutrition and other basic needs, power and well-being (Allison and Horemans 2006; Bené et al. 2007; Janssen et al. 2007). Marine EBM needs to take livelihoods and poverty into consideration, particularly in addressing the fourth EA principle. The economic contexts of the poor necessitate different incentives than those suitable for the non-poor. Ideally, marine EBM should be pro-poor in assisting poverty reduction and alleviation. Equity is also relevant here, as power and other disparities can exacerbate the poverty of those subject to social exclusion unless policy, planning and management measures are designed to address this. Livelihoods analyses and poverty assessments can inform decisions to uphold Principle 4 (ADB 2001; Bené et al. 2007). Given the strong dependence of Caribbean people on coastal and marine resources, and the likelihood of livelihoods being impacted by marine EBM, it is important to fully understand livelihoods in order to facilitate the continuation or creation of suitable sustainable livelihoods.

Knowledge

Knowledge comprises processed information and practical understanding acquired by learning through experience or education and reasoning. One of the challenges of marine EBM is to take into account the various knowledge systems of the diverse stakeholders. Some may be very receptive to scientific knowledge whereas others rely upon traditional or local knowledge. Knowledge systems and preferences are often culturally embedded. Principle 11 suggests that all sources of knowledge should be respected and used as appropriate, and this can be taken as a signal that science should not be allowed to dominate. Knowledge mobilisation concerns putting knowledge of all types to good use. Ethnographic methods such as oral histories, cognitive maps and others can be used to elicit traditional and local knowledge (Palacio et al. 2006). This is powerful when combined with marine spatial planning or mapping such as through participatory geographic information systems (PGIS). Multi-disciplinary teams of social and natural scientists with interdisciplinary leadership can often help to combine different knowledge systems and types within the largely scientific and technical realm of marine EBM (Eúan-Avila et al. 2006; Degnbol et al. 2006).

Conflict

Conflict is a state of discord caused by the actual or perceived incompatibility or opposition of needs, relationships, information, values events, and interests. Conflicts are not necessarily negative. They may cause more equitable power relationships to emerge, correct bad management practices, or improve policy. In marine EBM we quickly realise that increasing the numbers and types of stakeholders usually leads to a potential for increased conflict. The issue and goal of conflict management is how to manage conflicts in order to reach (at least temporary) solutions in the most appropriate and least disruptive or harmful manner. In cases where winners and losers are inevitable, considerations such as social structure and power may determine which stakeholders fall into which category. Regardless of the type of conflict, the stages in conflict management (McConney et al. 2003) are often similar:

– Initiation – a stakeholder or outsider invites help to manage the conflict
– Preparation – conflict analysis, information sharing, rules, participant selection
– Negotiation – articulating interests, creating and packaging preferred win-win options
– Agreement – concluding jointly on best option package, recording final decisions
– Implementation – publicising outcomes, signed agreement (optional), monitoring

People must be able to express their differences and manage conflict to achieve win-win or acceptable trade-off consensus outcomes most of the time, otherwise conflict will cause EBM to fail (see Principles 3 and 10).

Conclusion

Even though few examples of the adoption of EBM exist in the Wider Caribbean, there is an increasing move towards its use (Fanning et al. Chapter 1). Given this momentum, consideration of social issues is crucial. It is unlikely that scientific and technical approaches to marine EBM will succeed on their own, or that the guiding principles for the ecosystem approach will be upheld, if social considerations are ignored. It is usually impossible to maximise all societal objectives concurrently, especially in as diverse an area as the Wider Caribbean. However, a variety of tools exist to evaluate tradeoffs under various governance arrangements and alternative management strategies. Taking into account socio-ecological ecosystem complexity and inherent uncertainty is becoming a priority in all marine EBM situations (Fanning et al. 2007; Mahon et al. Chapter 2).

Moreover, incorporating social considerations into marine EBM, from design to evaluation, should be seen as an asset and not a liability. Appropriately incorporating social considerations, linked closely to governance and social-ecological system thinking, may contribute significantly to the success of marine EBM initiatives in the Caribbean. There are encouraging signs of progress being made in this direction.

8

Economic Considerations for Marine EBM in the Caribbean

Peter W. Schuhmann, Juan Carlos Seijo and James Casey

Abstract

The economic consequence of the mismanagement of world fishery resources is estimated to be in the order of US$ 50 billion per year in terms of the difference between potential and actual net economic benefits from marine fisheries. Moving from the current situation of inefficient over-use toward efficient and sustainable fisheries outcomes will involve not only attention to biology and ecology but also the managing of political and economic processes and replacing incentives that damage ecosystems with those that foster improved governance and responsible use. Economic analysis can contribute to the successful implementation of ecosystem-based management and the ecosystem approach to fisheries in the Caribbean Region in many areas. In this chapter, economic models and methodologies are outlined, and suggestions for incorporating economics into the large marine ecosystem policy cycle are provided.

Introduction

It is increasingly evident that the single-species approach to fisheries management is often ineffective in promoting the efficient and sustainable use of living marine resources and limiting frictions between user groups. While there is considerable discussion regarding the definition of the term, there is consensus that the ecosystem approach to fisheries (EAF) presents a more holistic approach to resource allocation and management (Larkin 1996), with the maintenance of ecosystem status and sustainability as the primary goals. Toward that end, according to the Food and Agriculture Organization of the United Nations (FAO), the purpose of an ecosystem approach to fisheries 'is to plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardising the options for future generations to benefit from the full range of goods and services provided by marine ecosystems' (FAO 2003).

Recognising that humans are key components of ecosystems, prerequisites for implementing EAF include a thorough understanding of human-biological interactions and determinants of human and biological welfare. Implementing the ecosystem approach requires the definition of a desired ecosystem state or species mix (Link 2002). Once this target state has been defined, moving toward it via policy change requires cooperation across a diverse array of nations and stakeholders competing for scarce resources. As noted in Morishita (2008), a clear justification is needed for any EAF management action, and measurable criteria are needed to evaluate success. An open and continuing dialogue between scientists across disciplines, policymakers and local stakeholders to establish objectives, decision rules and means of evaluating management performance is critical to the success of implementing EAF (FAO 2003). This chapter serves to contribute to that dialogue by outlining how economic theories, tools and empirical results can inform ecosystem-based management (EBM) practices and contribute to successful implementation of EAF in the Caribbean Region.

Economics and EAF/EBM

EAF takes place in the context of societal objectives, which inherently reflect human aspirations and values (De Young et al. 2008). EBM/EAF should be characterised by fishery governance, institutional arrangements and management measures that produce fishery outcomes that are compatible with the objectives of society (De Young and Hjort 2008). As such, an understanding of the social and economic forces, and the incentives and disincentives that drive human behaviour, is paramount to a successful implementation of EAF.

The discipline of economics can contribute to EBM/EAF decision-making in many areas, including but not limited to: (1) modelling individual and market behaviours in response to the transition toward EAF, (2) modelling ecological-technical interdependencies inherent in multi-species fisheries, (3) building an operational and useful system of indicators and corresponding reference points, (4) designing fishery policy and goals that are consistent with economic incentives faced by fishers, and (5) understanding the range of economic values associated with fishery resources. An overview of these contributions to the large marine ecosystem policy cycle is provided in Figure 8.1. The rest of this chapter briefly outlines these areas, provides a review of the relevant literature and proposes initial steps for incorporating economic analysis into marine EBM for the Caribbean Region.

Figure 8.1. Economic contributions to the large marine ecosystem policy cycle

Economic Modelling of Human Behaviour

People respond to incentives. How they respond to them is the realm of economic modelling. Numerous economic models are available to estimate the determinants of baseline market and non-market behaviours and how such behaviour may change following natural or policy-induced changes in the marine ecosystem. In the limited space here, we attempt to introduce several economic models that are most appropriate for enhancing EBM. Seminal works on economic modelling of fisheries include Gordon (1954) and Clark and Munro (1975).

Financial economists use portfolio theory in determining the risks and rewards associated with investment portfolios. Recently, the emphasis of this theory has shifted away from choosing individual stocks to picking an entire, richly diversified portfolio, where taking cross-correlations between stocks into account can significantly reduce risks and simultaneously yield a desired rate of return (Sanchirico et al. 2007). As an application to EBM, we can think of the portfolio as the outputs associated with ecosystem services. Sanchirico et al. (2007) have used this approach for Chesapeake Bay and shown that the ecosystem approach can yield greater returns with less risk than traditional species-only approaches to fisheries management. Applying this approach to the portfolio of highly-valued species in the Caribbean Region (e.g., offshore pelagics, reef fishes, lobster, conch, shrimps, demersal fishes and coastal pelagics) could provide a useful benchmark for the species mix that would maximise region-wide fishery value.

Game theory is an analytical tool for modelling strategic interaction between agents based on Nash's theory of cooperative games (Nash 1953). Game theoretic approaches have been shown to be useful in understanding the behaviour of a large number of agents adapting to ecological and economic constraints through a process of learning and cooperating (Billari et al. 2006). Game theory also has strong predictive power for the behaviour of nations competing for transboundary fisheries (Munro 2002). Dynamic games and muti-agent modelling techniques are valuable for explaining how individuals make strategic decisions and how they will interact on multiple levels, i.e., across time and space (Dockner et al. 2000). These approaches are therefore ideally suited for considering the characteristics of effective cooperative arrangements necessitated by EBM in the Caribbean. Sumaila (1999) provides an excellent review of applications to fisheries.

An important implication of applying game theoretic analysis to coastal states sharing transboundary resources is that even if individual states effectively manage fishery resources domestically, in the absence of cooperation between states there is no reason to assume that region-wide management will be effective (Munro 2002). As such, cooperation between states must be viewed as a prerequisite for effective EBM in the Caribbean. Munro (1979) adapts the Clark and Munro (1975) dynamic fishery optimisation model to account for transboundary resource ownership and examines the implications for optimal management when countries sharing fishery resources differ with regard to discount rates, harvesting costs, or consumer preferences for harvested species. These are critical points of analysis for implementing EAF in the Caribbean Region, which is characterised by an array of cultures and socio-economic conditions. Notably, the latter difference creates the most complications for optimal management; hence an understanding of differences in consumer preferences for fish products across Caribbean states should be a priority consideration in developing agreements to move toward EAF in the region. Another implication particularly germane to shared management of transboundary resources in the Caribbean is that when states sharing resources differ in their management objectives, provision for monetary or non-monetary transfers between states ('side payments') may be necessary to reach a cooperative, sustainable and mutually beneficial agreement (Munro 1979, 2002). Such an agreement could result in an optimal solution from an ecosystem perspective, whereby region-wide fishery returns are maximised and the shares of those returns are subsequently bargained for or allocated across the states. Importantly, relative bargaining power and perceptions of equity will determine the distribution of economic gains from the fishery, and perfunctory allocations of harvest or revenues, such as those based on fractions of the resource found in each state's waters, may cause the agreement to be unstable and result in unsustainable resource outcomes (Munro 2002).

Perhaps the most widely used model in the fields of environmental and natural resource economics is the Random Utility Model (RUM). First introduced by McFadden (1973), it is a workhorse in the field of non-market valuation. Specifically, in the case of EBM, this class of models is useful for valuing changes in ecosystem characteristics and modelling how stakeholders may respond to those changes. For example, a policy to enhance ecosystem health in the region may require the trade-off of closing some areas to commercial fishing. Direct costs and opportunity costs of protected areas will be readily estimable as associated market expenses and losses in commercial fishing revenue, but additional impacts must be accounted for. As fishing site choice is largely an economic decision (again, incentives), the RUM can be used to estimate how affected fishers redistribute themselves among remaining sites – information that is useful in predicting the biological effects of increased fishing pressure at remaining sites. The RUM can also be used to measure the monetary benefits from ecosystem improvement (discussed in more detail in the last section of this chapter), thus providing an understanding of future economic gains and potentially garnering support from affected stakeholders.

More recent work expands the realm of economic modelling to include bio-physical dynamics and interactions between human and natural systems. These are basically extensions of traditional economic models, and are discussed in the next section.

Bioeconomic Modelling of Ecological/Technological Interdependencies

Van den Bergh et al. (2007) recently recognised the importance of expanding the single-species bioeconomic approach to include biological and economic interdependencies present in the ecosystem. This is the case of many fisheries of the Caribbean Large Marine Ecosystem (CLME), where many stocks of demersal and pelagic species are shared by Central American and Island nations. In the transition from single species to EAF, assessments should monitor: (i) changes in the abundance of prey and predators through appropriate survey-based indicators, (ii) changes in environmental factors of importance to their life histories, and (iii) changes in the catch composition.

In the CLME, where flexible switching of target species may occur seasonally by both artisanal and industrial fleets, exploitation by species is likely to be a function of catch rates and markets, and vessels will tend to switch between resources in response to demand and species availability.

A multi-species and multi-fleet bioeconomic analysis that incorporates ecological safeguards may suggest seasonal closures during periods of reproductive aggregation, technical measures to avoid capture of unwanted or charismatic species, and permanent closed areas (MPAs), in particular areas of sensitivity such as nursery grounds and critical habitats.

The major steps for a bioeconomic approach to EBM in fisheries involve the following (Seijo et al. 2008):

- Define fisheries management questions in the context of multiple users of the marine ecosystem;
- Identify possible ecological and technological interdependencies among species, habitats and fisheries within the ecosystem;
- Select biological/ecological and economic/social performance variables of ecosystem use;
- Define corresponding ecosystem performance indicators;
- Establish limit and target reference points for the indicators;
- Identify alternative management, co-management or community management strategies for the fishery within an ecosystem context;
- Design a dynamic bioeconomic model of the ecologically and technologically interdependent fishery;
- Collect data to estimate model parameters;
- Identify possible states of nature in uncertain and sensitive parameters;
- Build decision tables and apply decision criteria to deal with risk and uncertainty;
- Estimate probabilities of exceeding ecosystem limit reference points.

Bio-Ecologic, Economic and Social Indicators for EAF Management

The task of identifying indicators and corresponding reference points needed to implement an ecosystem approach to fisheries management has hardly begun (Degnbol and Jarre 2004). We are at the stage of identifying the adequate conceptual framework to select appropriate biological and economic indicators from growing lists of candidates. One of the issues has been the identification of adequate reference points (i.e., discrete values of indicators) for bio-ecologic and bioeconomic variables because of both the large unexplained variability of time series (when available), and the difficulty in distinguishing between anthropogenic impacts and other causes of change in the ecosystem. It is increasingly realised that ecosystem indicators must include meta-indicators that summarise the outcome of many complex underlying processes that may not be understood in detail.

The International Council for the Exploration of the Seas (ICES 2001) identified desirable properties for selecting adequate economic and ecologic meta-indicators for the Caribbean LME:

- Relatively easy to understand by non-scientists and those who will decide on their use;
- Sensitive to manageable human activity;
- Relatively tightly linked in time to that activity;
- Easily and accurately measured;
- Responsive primarily to human activity, with low responsiveness to other causes of change;
- Measurable over a large proportion of the area to which the indicator is to apply;
- Based on existing body of time-series data to allow a realistic setting of management objectives.

In their contribution in *Science*, Pikitch et al. (2004) provided two major recommendations:

> … we need to develop community and system level standards, reference points and control rules similar to single species decision criteria. New analytical models and management tools will be needed as well. Multispecies and eco-trophic models must be refined and expanded to better account for system-level uncertainties, to derive system-level reference points, and to evaluate the ecosystem-level consequences of proposed management EAF actions.

It should be pointed out that before specifying ecosystem indicators and reference points, as indicated by Sainsbury and Sumaila (2003), there are two basic questions to answer. First, is there a need for explicit reference points for the ecosystem, such as food web dynamics, ecological community structure and biodiversity, or are species-based reference points sufficient? And second, if ecosystem reference points are needed, should they be based on properties of the undisturbed coastal ecosystem? There seems to be an additional question: how to proceed in the absence of baseline studies of early stages of coastal development? Again, the use of dynamic models and techniques for parameter estimation in data limited situations seem to be a future research priority in this field. Given the inherent uncertainty of the 'original status' of ecosystem habitat and community structure, these modelling efforts should be stochastic in nature.

The last step of the bioeconomic approach to ecosystem-based fisheries management noted above is in essence the estimation of the *risk of exceeding* the specified limit reference points (Seijo and Caddy 2000). The potential and associated complexities of conducting risk analysis for ecosystem-based management are discussed further by Butterworth and Punt (2003).

Informing the Design and Evaluation of Policy Alternatives

According to the FAO, enhancing current fisheries management to complement the goals of EAF should include a broadening of existing management measures to include greater use of economic incentives. Indeed, most economists would likely agree that the lack of appropriate incentives is the root cause of the failure of top-down, adversarial approaches to fisheries management. Traditional command-and-control approaches to fisheries management provide insufficient incentive to engage in sustainable practices. Rather, fierce competition for the unallocated resource (the 'race to fish') leads to a host of problems including overcapitalisation, excessive bycatch, habitat destruction, political manipulation and conflicts between competing user groups (Wilen 2006), all contrary to the goals of EAF. The resulting inefficiencies are staggering – estimated to be in the order of US $ 50 billion per year in terms of the difference between potential and actual net economic benefits from global marine fisheries (World Bank and FAO 2008).

To be clear, in the view of economists, it is not 'greed' or 'the lure of large profits' that causes these inefficient and unsustainable outcomes. Rather, these outcomes are the natural and expected result of perverse incentives created by existing institutional governance structures built around the presumed need to control such bad behaviours (Wilen 2006). Command-and-control mechanisms such as gear restrictions, area/season closures or catch limits can (and do) channel fishing effort in desired directions via the threat of fines or fees for undesired behaviour. These mechanisms have resulted in the protection of some stocks, but they do not address the fundamental problem of too many people chasing too few fish. However, because individual motivation and incentives play a critical role in all economic endeavours, these same policies more often create conditions that ultimately harm the overall condition of an ecosystem (Sutinen 2007).

Many economists have thus come to approach fisheries management from a bottom-up perspective that focuses on the decision setting within which fishers operate. This perspective focuses on modifying governance structure, institutions and social networks in such a way that individuals are motivated to make choices that are good for the ecosystem (Edwards 1994; Wilen 2006; Sutinen 2007). Removal of the insecure nature of future access, harvest and wealth via the establishment of harvest privileges or property rights can augment effective governance and reduce the explicit and opportunity costs associated with management, generating considerable capacity for implementing EAF. Rather than raising the cost to the fisher through restrictions on how, when and where to fish, economists favour allocating the right to fish (addressing who can fish) and then allowing the individual fishers with the lowest opportunity cost to ultimately obtain those rights. This type of rights-based fishing provides the correct set of incentives for the fisher to be as efficient as possible, and by limiting the number of fishers, directly protects the fish stocks and the ecosystem.

Economic Valuation

The coastal and marine ecosystems of the CLME provide a wide range of goods and services. While the value of some of these goods and services appear in the measured market economy (commercial fishery revenues, for example), a majority remain largely unrecognised by traditional measures of economic activity and are largely ignored by policymakers. When a source of significant economic value is overlooked – despite continued and obvious threats to that value from anthropogenic factors such as over-fishing and coastal development – this creates an apparent conundrum. Simply put, the true economic value of marine resources, in the Caribbean and around the world, is largely unknown, and as a consequence is not given appropriate policy attention.

Understanding the range of economic values associated with goods and services provided by marine ecosystems through the process of economic valuation can help inform policy decisions and create incentives for optimal resource use. The process of valuation gives weight to the opportunity costs of use (or benefits of conservation) by presenting values in dollars, and can help avoid problems that often characterise policy debate, such as the often employed portrayal of 'the economy vs. the environment'. By expressing the disparate impacts of resource use with an easily understood metric – money – valuation provides a lucid and systematic accounting framework by which to enumerate the full array of benefits and costs of each alternative for policy analysis. With a proper consideration of discount rates (Sumaila 2005), valuation helps policymakers consider the distribution of costs and benefits across the population and across time and can therefore help clarify the equity consequences for EAF/EBM. Beyond the obvious merits of understanding the economic tradeoffs of potential policy actions, valuation serves to add transparency to the decision-making process so that stakeholders gain an understanding of how scarce resources, including both financial and natural capital, are appropriated.

Within the region, countries that place greater weight on market values can be expected to sustain lower stocks of biomass than countries that place greater emphasis on non-market and non-use values (Sumaila 2005). In moving toward EAF, conservation-oriented policies that transfer economic surplus from market to non-market uses may disproportionately affect stakeholders with direct ties to market values (e.g., commercial fishers). Understanding the importance of the components of value across nations and across stakeholders within each nation can therefore aid in anticipating the requirements and impediments for effective transboundary management. Understanding the causal relationships between and among physical, economic and socio-cultural factors is critical to a sustainable approach to fisheries management (Evans and Grainger 2002). These elements have been discussed in the sections above. The process of economic valuation can aid in establishing targets and objectives related to economic value and activity as well as evaluating the success of attaining those goals. In short, economic valuation can contribute to implementing sustainable approaches to EAF/EBM in all of the areas noted in this chapter.

Through properly designed valuation studies, the economic consequences of potential policy changes can be examined *ex ante*, and can therefore inform policy formation required to operationalise EAF/EBM. Hence, directed economic valuation studies – coupled with education of stakeholders regarding economic values and efficient, sustainable uses of resources – are a natural component of the 'data and information' and 'analysis and advice' stages of the CLME policy cycle. For example, recent estimates suggest that the annual value of shoreline protection provided by coral reefs was around US$ 231 to US$ 347 million for Belize and US$ 33 million for Tobago (Burke et al. 2008b). An understanding of these values allows policymakers to determine the true cost of any policy, i.e., the lost non-market value.

Regularly updating and revising such efforts based on new or changing information is also a necessary component of the cycle. Figure 1 illustrates the contributions that economics can make to the LME policy cycle, which is represented by the actions shown in the inner circle.

Conclusion

Combining our understanding of value with an appreciation for the importance of incentives in shaping behaviour reveals that implementing EAF/EBM in the Caribbean will not be an easy task. Unlike personal assets such as homes or retirement accounts, the coastal and marine assets of the Caribbean are publicly owned, and that ownership is shared among a large and diverse group of nations. As such, even with a complete understanding of value, the current incentives for sustainable use are not properly aligned. For example, numerous studies show that marine resources are considerably more valuable when conserved rather than exploited (Burke et al. 2008a, 2008b). The benefits of exploitation accrue in the near term, to individuals, and are readily observed using market measures. The costs of exploitation, on the other hand, are spread across society, occur over longer periods of times, and are not easily measured. The lack of market signals that favour sustainable actions results in market-based activities being favoured at the expense of ecosystem function. Valuation alone is therefore not enough. Resource value estimates should be used to raise public awareness of the economic consequences of mismanagement, to guide policy in the direction of efficient and equitable use, and to create incentives (e.g., taxes, subsidies, tradable permit systems and/or side payments) that encourage sustainable use.

In moving from single-species management towards EAF in the Caribbean, fisheries policymakers must attempt to balance competing present-day societal objectives with the welfare that future generations derive from marine ecosystems. Economic models, theory and empirical tools can contribute to the successful transition toward EAF by informing the discussion and analysis in many areas. These include providing an understanding of baseline economic conditions in fisheries, building an operational and useful system of indicators and corresponding reference points, and providing information regarding the efficiency and equity of alternative policy options. Moving beyond transition to application, economic models can be used to estimate individual and market behaviours in response to changes in fishery characteristics, support the formation of fishery policies that are consistent with the economic incentives faced by fishers and other stakeholders, and assist in understanding the nature, scope and distribution of values associated with marine ecosystems. Finally, economic methods can be used to estimate how ecosystem values may change with natural or anthropogenic changes to fishery characteristics, and how fishery stakeholders may respond to such changes. Due to the diverse character of the countries and territories in the Caribbean LME, the transboundary nature of marine resources, and the critical dependence of the region's economies and livelihoods on marine resources from fishing and tourism, incorporating economic considerations into all stages of the policy cycle seems critically important to successful implementation of EAF in the Caribbean LME.

9

An Ecosystem Approach to Fisheries

Linkages with Sea Turtles, Marine Mammals and Seabirds

Julia Horrocks, Nathalie Ward and Ann M. Haynes-Sutton

Abstract

Sea turtles, marine mammals and sea birds are important and vulnerable components of exploited marine ecosystems. Many species are directly exploited because of the economic value of their products, others are indirectly impacted through bycatch, entanglement or prey removal, and some are key consumers that, in their natural abundance, can greatly influence the ecosystems of which they are part. An ecosystem approach to fisheries (EAF) requires enhanced understanding of these cumulative and synergistic interactions. Priority actions identified to minimise negative impacts on these taxa through an EAF are: an assessment of bycatch in the Caribbean region, including nearshore artisanal fisheries; monitoring programmes to fill information gaps on the distribution, abundance, life history, behaviour and health of sea turtles, marine mammals and seabirds; mapping and protection of critical habitats; investigations of the ecological relationships that link sea turtles, marine mammals and sea birds either directly or indirectly with fishery resources; capacity building of local and regional NGOs; and programmes to inform fishers about the value of sea turtles, marine mammals and seabirds and how they can contribute to their conservation and sustainable use. Finally, note that sea turtles, marine mammals and seabirds can be indicators of ecosystem health and serve to educate and motivate the public about marine ecosystems.

Introduction

The goal of ecosystem-based management (EBM) is to maintain an ecosystem in a healthy, productive and resilient condition, so that it can continue to provide services that humans want and need. The use of this approach in fisheries management emerges from an appreciation that exploited species are not independent entities but are integral parts of the ecosystem within which they function. Sea turtles, marine mammals and sea birds are important but little understood components of exploited marine ecosystems. Many of these species are, or were, themselves directly and often heavily exploited, whilst others may be indirectly impacted by other fisheries (e.g., through bycatch, entanglement or removal of their prey), as well as by other anthropogenic environmental impacts on their predators, prey or habitats. Many of the species are themselves key predators, and changes in their population sizes may reverberate through the ecosystems of which they are a part. Effective EBM requires knowledge of these cumulative and synergistic interactions, as well as the effects of human activity and environmental stress on these interactions. Sea turtles, marine mammals and sea birds may be particularly likely to benefit from an EBM approach because of their generally wide ranges (spanning large geographical areas and many political jurisdictions), their dependence on combinations of marine, coastal and/or forest ecosystems, and the varied impacts that people have on their survival. In this chapter, we identify some of the issues that should be considered for these taxa in the context of an ecosystem approach to fisheries in the Wider Caribbean.

Sea Turtles

Distribution, Biology and Status

Six species of sea turtle are recorded to be resident in the Wider Caribbean (Appendix 9.1), and all nest broadly but unevenly throughout the region (Dow et al. 2007). The species most commonly seen in coastal waters, and most commonly exploited by fisheries, are juvenile and adult green turtles and hawksbill turtles. Eggs and nesting females are also taken (of all six species), often illegally. There have been several reviews of the management and exploitation of Caribbean sea turtles (e.g., Fleming 2001; Bräutigam and Eckert 2006). All sea turtle species are considered endangered or critically endangered. Sea turtles are fully protected from harvest by more than half of all Caribbean governments (Dow et al. 2007), many of which are also party to regional and international environmental agreements (e.g., CITES, IAC, SPAW) that protect sea turtles.

Ecological Roles

Although long valued for their parts and products, the importance of ecological interactions of sea turtles within marine ecosystems has only recently been recognised. As large vertebrates, often with specialised diets (e.g., green turtles feed primarily on seagrasses and macroalgae, Bjorndal 1996, and hawksbills on coral reef-associated sponges, Leon and Bjorndal 2002), their influence when at historical population sizes on the community structure of marine and coastal ecosystems was probably significant. Green turtles would have been responsible for seagrass biomass entering grazing food chains rather than decomposing *in situ* and entering detrital food chains, as typically occurs today (Valentine and Duffy 2006). Hawksbills would have played a controlling role in competitive interactions and thus community structure of coral reefs between recruiting sponges and corals for space; and, through their ability to bite through the tough exoskeleton of sponges, would also have facilitated feeding by smaller spongivorous species (e.g., Van Dam and Diez 1997). As all sea turtle species lay their eggs on beaches, they are also important in transferring nutrients between marine and terrestrial ecosystems (Hannan et al. 2007).

At current population sizes, sea turtles are unlikely to fulfill their ecological roles (Bjorndal and Jackson 2003). Since this may have serious consequences for important coastal ecosystems upon which fisheries rely, it is essential to learn more about the ecological services of sea turtles and how many sea turtles may be needed in order to fulfill these services (e.g., Frazer 2001; León and Bjorndal 2002; Mast et al. 2006). Released from the grazing pressure of green turtles and other overexploited mega-herbivores, seagrass blades can grow longer, baffle currents more effectively and decompose *in situ*, encouraging growth of slime molds that may contribute to seagrass wasting disease (Jackson et al. 2001). Overexploitation of these higher trophic levels may be a factor in the rise of marine diseases amongst marine organisms generally (Jackson et al. 2001).

Vulnerability

Sea turtles have characteristics that make them especially vulnerable to anthropogenic threats as summarised below.

- Economically valuable sea turtle products (e.g., eggs, meat, shells and sometimes skins) are still utilised in many local economies, and until recently were also traded internationally. Turtle meat is still a major source of protein in parts of the Caribbean (e.g., Nicaragua, Bräutigam and Eckert 2006), trafficking in hawksbill shell is still reported in some jurisdictions (Chacón 2002; Reuter and Allan 2006), and leatherback oil is used for medicinal purposes (Eckert et al. 1992). Turtle eggs are widely considered to be an aphrodisiac.
- All sea turtles are slow-growing, late-maturing, and long-lived, making them vulnerable to overexploitation and also slow to recover (Heppell et al. 2004). One population may often be harvested at different life stages (e.g., eggs, juveniles and adult females) and in different locales.
- Sea turtles are air-breathing, deep-diving and highly migratory, and are thereby vulnerable to bycatch and to entanglement in marine debris. Efforts to mitigate bycatch have focused on gear modifications of industrial scale fisheries, e.g., the installation of turtle exclusion devices (TEDs) in shrimp trawl nets and development of circle hooks and smart hooks for longlines. Small-scale artisanal fisheries may also be respon-

sible for high bycatch – e.g., the coastal gillnet fishery in Trinidad (Eckert and Eckert 2005).
- Sea turtles must reproduce on sandy beaches, where they are especially vulnerable to human depredation. Hatchlings and adults are disoriented by coastal lighting (Witherington and Martin 2000), and eggs are vulnerable to mortality caused by flooding on eroding beaches, compaction due to vehicular use on beaches, and predation by introduced species (e.g., dogs, mongooses).
- Sea turtles are ectotherms with temperature-dependent sex determination (Wibbels 2003). Consequently, their growth, reproduction and operational sex ratios are likely to be impacted in a number of ways by warming temperatures. Since females exhibit philopatry (Lohmann et al. 1997), they may adapt poorly to loss of nesting beaches due to rising sea levels.

Sustainable Use of Sea Turtles

Obtaining a sustainable and economically viable harvest of depleted populations of long-lived species is a challenge for fisheries management (Musick 2001). Countries in the region with sea turtle fisheries have seasonal and/or size restrictions (Dow et al. 2007). However, enforcement is often weak, particularly on remote beaches or within impoverished communities. Survivorship of large juveniles and adults is critical to population maintenance or recovery, a concept introduced by Crouse et al. (1987). Amendments to fisheries legislation to recognise this – i.e., legislating maximum rather than minimum size limits – is therefore essential.

Sustainable non-consumptive use of sea turtles includes watching nesting turtles as well as turtles at sea using snorkeling and scuba gear. To be sustainable, the impacts of these types of eco-tourism on sea turtle populations must be carefully managed. Not all species or beaches are equally suited to watching, and typically an ecotourism enterprise can provide only seasonal income. Watching turtles from a boat or by snorkeling has proved to be very popular and lucrative in Barbados, but has negative impacts (Horrocks et al. 2008). The scuba industry relies heavily on sea turtles as an attraction, especially in countries where other reef biodiversity is scarce. Efforts by one country to conserve sea turtles and to use them non-consumptively can, however, be rendered ineffective by exploitation of the same population elsewhere (Bräutigam and Eckert 2006).

Replacing sea turtle harvest with viewing of sea turtles does not directly compensate turtle fishers for a loss in revenue, but the benefits in terms of increasing tourism as a result of the sea turtle attraction may boost sales of other fishery resources to restaurants (Tröeng and Drews 2004).

Marine Mammals

Distribution, Biology and Status

At least 33 species of marine mammals (one quarter of the world's marine mammal species) have been documented in the Wider Caribbean (Ward and Moscrop 1999, see Appendix 9.1). These include resident, migratory and extralimital species encompassing three orders (Cetacea, Sirenia and Carnivora). There are six species of baleen whale (Mysticeti), 24 species of toothed whales (Odontoceti), one sirenian (the West Indian manatee) and three pinnipeds – the Caribbean monk seal, now thought to be extinct, the hooded seal (extralimital), and the accidentally introduced California sea lion (Ward and Moscrop 1999). Of all marine mammal species in the region, four are classified as endangered, and most other species as data deficient.

For many species, Caribbean waters are primary habitat for critical activities including feeding, mating and calving (Ward et al. 2001). However, data are scarce on the distribution, biology and status of most cetacean (whales and dolphins) and manatee populations in the Caribbean Sea (Reeves 2005), and at least some stocks may be confined to particular parts of the Caribbean (Ward et al. 2001). Studies of life history, habitat use, ecological roles, presence and scope of threats as well as conservation status are urgently needed (Ward and Moscrop 1999), particularly for populations with limited distribution, whose viability may already be affected by multiple stressors/threats.

In recognition of the threats facing marine mammals and of the large information gaps, parties to the Specially Protected Areas and Wildlife (SPAW) Protocol of the Convention for the Protection and Development of the Marine Environment for the Wider Caribbean Region (the Cartagena Convention) adopted the Marine Mammal Action Plan (MMAP) for the Wider Caribbean. All thirty-three species of marine mammals are listed in SPAW's Annex II for protection. Their capture, take and possession are prohibited under SPAW, with exceptions provided for in Article 11 (2) and for aboriginal take. The MMAP provides a framework wherein the information gaps, potential threats, prioritisation of actions and possible mitigation factors can be addressed.

Ecological Roles

Marine mammals are an integral part of the marine and coastal fauna of tropical and sub-tropical waters of the Caribbean Sea (Reeves 2005). They are major consumers at most trophic levels, from primary consumers (e.g., manatees) to predators of other marine mammals (e.g., killer whales), and their large size suggests that they have a major influence on marine community structure and functioning (Katona and Whitehead 1988). Manatee grazing of seagrasses may aid in dispersal when plant fragments escape ingestion, and their faecal matter may increase nutrient levels (Provancha and Hall 1991). Some seabirds and fishes may benefit from feeding in association with cetaceans; and odontocetes, which are largely piscivorous, may prey on fish that compete with fishers for commercially harvested fish (Katona and Whitehead 1988). However, on present evidence, only one species of baleen whale, the Bryde's whale, depends on the Wider Caribbean for food (Reeves 2005).

One controversial issue is the extent to which cetaceans compete with humans for harvestable fish (Kaschner and Pauly 2004). The Lesser Antilles Pelagic Ecosystem (LAPE) project of the FAO included a preliminary examination of marine mammals in its trophic modeling of the Lesser Antilles region. Trophic linkages among all species in the ecosystem were considered and impacts of fishing on both the target and non-target species were examined. They concluded that cetacean predation in the LAPE region was relatively small and was concentrated on mesopelagic food sources (Mohammed et al. 2008).

Vulnerability

Marine mammals are vulnerable to short-term natural and anthropogenic threats caused by activities on land and at sea, but also to the chronic and cumulative effects of various stressors (Borobia 2005). The known or suspected threats to marine mammals in the Wider Caribbean are summarised below.

- There is incidental killing by interactions with fishing gear; primarily entanglement and bycatch in finfish fisheries. Tuna purse seines, pelagic trawls and gill nets are fishing gear where bycatch is of concern, but bycatch may also occur in longline fisheries, pot fisheries and by derelict fishing gear. Aside from the impacts on cetaceans, this causes financial losses to fishers.
- Vessels of sizes ranging from oil tankers and cruise liners to yachts and fishing boats are numerous in the Wider Caribbean, and vessel collisions pose a threat to marine mammals. Manatees are at particular risk in coastal waters, and large cetaceans are particularly vulnerable (http://www.nmfsnoaagov/pr/pdfs/shipstrike/lwssdata.pdf).
- Degradation and loss of habitat results from coastal development, introduction of pathogens and pollutants, and impacts of climate change. Contamination sources include untreated sewage, agricultural run-off, industrial wastes, mining and leaks of oil from tanks, refineries and other sources. Contamination from oil and gas is a serious issue around Trinidad and Tobago (Siung-Chang 1997). Concerns about environmental contamination are growing in the Caribbean, but empirical data are not available to document which chemicals are of the greatest

concern and where. Even manatees, which occupy a low trophic level, can have levels of PCBs and pesticides that affect their health and reproductive ability.

- Noise from shipping, dredging, drilling, seismic testing and sonar can interrupt biologically significant activities (e.g., nursing, breeding, resting), impair communication (i.e., by masking their signals), and drive animals away from critical habitat (e.g., feeding grounds, migration routes). New types of military sonar have injurious and even lethal effects on deep-diving cetaceans (Hooker et al. 2009).
- Artisanal fishing may target small or medium-sized cetacean species, and occasionally Bryde's whales. A humpback whale fishery in Saint Vincent and the Grenadines falls under the purview of the International Whaling Commission. Manatees, in particular, are subjected to illegal, poorly documented hunting over much of the species' range.
- Removals of live animals from coastal populations for public display facilities that target a specific sex or age group can negatively impact the viability of wild populations when populations are small and limited in distribution.
- Commercial or intensive artisanal fishing for fish can disrupt food webs and potentially deplete the prey resources of marine mammals.
- The effects of tourism on marine mammals are important to consider. Intensive, persistent and unregulated vessel traffic that focuses on animals while they are resting, feeding, nursing their young or socialising can disrupt those activities, and may cause long-term problems for populations. The establishment and promotion of best practices is necessary for nature tourism.
- Climate change in the Caribbean may include increased frequency and intensity of hurricanes, which physically impact nearshore marine environments and can resuspend contaminated sediments. To assess the form and extent of changes, baselines must be established. The potential effects of climate change on marine mammals range from direct effects on the health of animals to indirect effects on prey resources. There has been little investigation thus far, partly because the impacts of climate change are considered less imminent than those caused by other anthropogenic factors. However, in this regard it is important to exercise the precautionary principle.

Sustainable Use of Marine Mammals

The socio-economic effects on marine mammals in the Wider Caribbean include captive and interactive programmes, whale watching (including dolphins and manatees) and artisanal or subsistence harvest. Information on the basic biology and distribution of marine mammals and on current levels of utilisation and commercialisation is insufficient to meet the challenge of conserving marine mammals while addressing the diverse societal, economic and historical needs of Caribbean peoples. Specific data on the costs and benefits of different forms of use are needed.

Management of Consumptive Use

With the exception of the humpback whale fishery in Saint Vincent and the Grenadines, directed fisheries in the Wider Caribbean usually target small or medium-sized cetacean species, and occasionally Bryde's whales. In the Eastern Caribbean, although directed takes of marine mammals are often considered sustainable, many of the species taken that are collectively referred to as 'blackfish' (e.g., pilot whales, false and pygmy killer whales, melon-headed whales, pygmy and dwarf sperm whales), are classified as Data Deficient, meaning that there has been no evaluation of status due to insufficient data. Other species taken in the artisanal Saint Vincent fishery include spinner, spotted, striped, Fraser's, rough-toothed and Risso's dolphins (Scott 1995), many of which are also Data Deficient.

Direct exploitation is usually driven by the demand for products. However, bottlenose dolphins are also captured for public display and for touching, feeding and 'swimming with dolphin' programmes (e.g., Mexico, Antigua, Dominican Republic, Cuba). As with the artisanal fisheries, assessment of source populations prior to removals is generally lacking, and there is insufficient information to determine levels of sustainable consumptive use.

Sustainable Non-Consumptive Use

Whale watching has been promoted as a sustainable, non-consumptive use that promises monetary rewards to people, and benefits to local communities and governments, without animals being killed or removed from their natural environment. However, wildlife viewing must be conducted in a manner that is respectful of the animals, local communities, tourists and the environment. It also requires some degree of tourism infrastructure, a steady supply of tourists and the interest of local communities in becoming involved. Guidelines and codes of conduct are increasingly available, and are being adopted and promoted by the tourism industry and government agencies. Marine mammal watching also has the potential of providing opportunities for research and monitoring, especially in countries where funding for surveys is unavailable.

Seabirds

Distribution, Biology and Status

Seabirds are among the most threatened birds globally, and Caribbean seabirds are no exception (Bradley 2009), with many populations in decline (Schreiber and Lee 2000). Twenty-three species of seabirds breed in the insular Caribbean and a further twenty-eight species winter in the region or migrate through it. Of the breeding species, one may now be extinct and at least two more, the Bermuda petrel and the black-capped petrel, are listed as endangered. Overall, eleven species have been identified as at risk in the Caribbean (Bradley 2009).

Population assessment is complicated, as many Caribbean seabirds function as meta-populations and are widely distributed. While philopatry is important in some species (e.g., masked boobies) (E.A. Schreiber, personal communication), there is greater post-breeding dispersal in others – e.g., sooty terns banded as chicks in the Dry Tortugas have been recovered at many colonies throughout the region, including Morant Cays, Jamaica (Haynes-Sutton, personal observation). BirdLife International and partners have recently designated 138 Important Bird Areas in the insular Caribbean, most being breeding sites for seabirds (Wege and Anadon-Irizarry 2008). The impacts of fishing and other activities on seabirds are difficult to assess because most seabirds have large feeding ranges, and information on the locations of important seabird feeding areas in the region is scarce.

Ecological Roles

Seabirds are important predators in marine ecosystems, consuming fish, crustaceans and/or cephalopods (Waller 1996). Their feeding strategies include picking food from or just below the surface while flying, swimming on the surface and shallow diving, plunge diving for deeper prey, and stealing and/or scavenging from other species. Fishers may use seabirds to locate fish schools.

Although in some oceans seabirds are estimated to consume large amounts of fish, they are not generally seen as significant competitors with fisheries in the Caribbean. However, fisheries for large predatory fish with which species such as sooty terns have near commensal relationships (Higgins and Davies 1996) may adversely affect some seabirds. Furness (2003) suggests that seabird numbers may increase when prey-fish abundance increases as a result of the depletion of predatory fish stocks, or due to offal and discards from fisheries.

Seabird colonies are a source of nutrients and may locally enrich marine nursery areas around seabird colonies. Loss or reduction of seabird populations may therefore contribute to declining fish stocks.

Vulnerability

The major threats to which seabirds are vulnerable in the Caribbean region (Haynes 1987; Haynes-Sutton 1995; Schreiber 2002; Bradley 2009) are listed below.

- Habitat loss threatens seabirds which typically breed in large, clumped groups. Fishing camps and villages may be constructed in or near seabird colonies, decreasing available nesting area.
- Many seabirds nest on the ground. Fishers and others may use seabird colonies as campsites, or walk through them for other reasons (i.e., tourism), thereby causing damage to habitats and large-scale mortality, especially of eggs and chicks.
- Introduced species such as rats and mice are accidentally introduced to seabird colonies by fishing boats. Cats, dogs, goats and chickens, and sometimes even rabbits and monkeys, are deliberately introduced by fishers. All can damage nesting colonies directly by preying on eggs, chicks and adults, and indirectly by destroying nest sites and vegetation.
- There is still a lack of knowledge about the ecology and distribution of seabirds. Fishers often have long-term recollections of seabird colonies, but these are rarely recorded. There is even less information about the most important areas for foraging seabirds in the Caribbean, making it difficult to assess the form and severity of interactions with fisheries.
- Seabirds (eggs, chicks and adults) are still harvested for food and for sale in some places, although the extent and scale is declining.
- Pollution from runoff of agricultural chemicals and soil, the ocean dumping of pollutants, and garbage all affect seabirds. Pesticides and heavy metals accumulate in seabird tissues and eggs. Although seabirds are potentially good indicators of marine pollution, there are no recent data on trends in bioaccumulation from the Caribbean (Schreiber and Lee 2000). Seabirds frequently become entangled in discarded monofilament lines and nets. An unknown number die from the direct and indirect impacts of oil spills.
- The direct and indirect impacts of Caribbean fishing practices on seabirds have not been assessed, although longlining and gillnetting (Alverson et al. 1994) are known to kill many seabirds in other regions.
- Hurricanes accentuate the impacts of anthropogenic threats, further reducing nesting and feeding habitats and bird survival. Reduction in the number of nesting colonies increases the risk that populations will not be able withstand stochastic events.
- Changing climate patterns may alter migration patterns of schooling fish, in turn affecting seabird reproduction and the viability of nesting

colonies. The rise in sea level will reduce the area of many colonies and completely destroy some.

Sustainable Use of Seabirds

Although there is a long history of harvesting seabirds (eggs, chicks and adults) in the Caribbean region, colonies are rarely protected by law or the laws are inadequately enforced. Traditionally, fishers have harvested eggs to supplement their income from fishing. They may also catch birds, such as pelicans, for sport. The impacts of harvesting by refugees or 'boat people' on offshore island colonies remain to be assessed. Indequate protection may stem from the perception that seabird populations are large, and from a lack of awareness among fishers, the general public and the global conservation community of the importance of Caribbean seabirds and of their vulnerability. This makes it difficult to get support for conservation initiatives.

Seabirds in the Caribbean are often seen by fishers as allies that indicate good fishing areas, rather than as competitors for fish. They also provide excellent opportunities for nature tourism, where visitors are taken to see seabird colonies. However, the establishment and promotion of best practices is necessary for nature tourism at seabird colonies to avoid disturbing breeding birds.

Priority Actions for Ecosystem-based Management: Sea Turtles, Marine Mammals and Seabirds

The Impact of Fisheries Bycatch on Sea Turtles, Marine Mammals and Seabirds Needs to be Quantitatively Assessed

Project GloBAL (Global Bycatch Assessment of Long-Lived Species), a joint venture between Duke University and the Blue Ocean Institute, aims to characterise the bycatch of marine mammals, seabirds and sea turtles by synthesising existing information on bycatch from various sources and across different geographic regions. One of the first issues to be tackled in the case of sea turtles and marine mammals is the definition of bycatch. Incidental catch in seine nets, long lines, gill nets or other fishing gear is not always considered bycatch; instead, fishermen may regard marine mammals and sea turtles that die in fishing gear as 'catch not to be wasted'.

Stranding networks can provide cost- and time-efficient means to assess the species affected by bycatch, if mortality attributable to bycatch can be differentiated from that of other factors. However, monitoring to determine more useful estimates of bycatch (total kill and kill rates) requires the engagement of key local and national fisheries stakeholders in all stages. On a regional scale, collaboration is needed among regional fisheries organisations (e.g., the Organisation of Eastern Caribbean States), local fisheries agencies and Stranding Networks to incorporate bycatch monitoring and outreach in their operations. The Pacific Islands Forum Fisheries Agency (FFA) Action Plan for Sea Turtle Bycatch Mitigation provides one model.

Other recommended actions include strengthening the relationships and partnerships between fisheries bodies such as the Western Central Atlantic Fishery Commission (FAO-WECAFC) and existing observer programmes, and taking advantage of ongoing initiatives and the expertise of countries that have more advanced experience in bycatch reduction devices. Reducing bycatch and labeling the discard of unwanted catch as a non-sustainable practice is already the policy of an increasing number of regional and sub-regional fisheries management organisations. For example, Colombia, Costa Rica, Cuba, Mexico, Trinidad and Tobago and Venezuela are engaged in a five-year FAO Global Project for bycatch reduction in shrimp trawling, with Guatemala and Suriname also participating (FAO 2005). Studies to mitigate leatherback turtle bycatch in coastal gill net fisheries in Trinidad are also underway (Eckert and Eckert 2005).

Strengthening of Monitoring Programmes

National and regional monitoring programmes, stranding networks, and whale and bird-watching organisations are needed to gather baseline information on distribution, abundance, life history, behaviour and health of sea turtles, marine mammals and seabirds. Systematic monitoring of index areas (e.g., nesting beaches, foraging and calving grounds) should be undertaken, particularly for rare and/or harvested populations, recognising their often uncertain status in the Wider Caribbean. There is a particular need to develop and/or support capacity in the region to assess marine mammal health and the effects of various stressors, particularly contaminants and noise. Investigation is necessary into the natural forces (e.g., oceanographic regime shifts) as well as anthropogenic factors (e.g., fishing, contaminants, noise) that influence or 'stress' marine ecosystems, to allow differentiation between these factors and the assessment of their individual and combined influences on marine mammals.

Mapping of Critical Habitats

The mapping of critical habitats of sea turtles, marine mammals and sea birds (e.g., important nesting beaches and colonies, feeding and resting grounds and migratory corridors) is a priority in order to protect important life stages from human impacts. It has already begun for some species –

e.g., the West Indian Seabird Atlas of Breeding Sites compiled by the Seabird Working Group of the Society for the Conservation and Study of Caribbean Birds (SCSCB) (www.wicbirds.net) and Wider Caribbean Sea Turtle Nesting Sites compiled by WIDECAST (www.widecast.org; Dow et al. 2007). Notably, land-based data are easier to obtain, and data on breeding sites for significant marine mammal fauna in the Caribbean is rudimentary. Important foraging grounds and migratory corridors remain to be identified for all three taxa. The incorporation of fishers' knowledge will be particularly important in this context.

Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) is a spatially referenced online database, which attempts to aggregate existing marine mammal, seabird and sea turtle data from across the globe. Data sources include at-sea surveys, stranding data, fisheries bycatch information, land-based counts and information on individual movements, including tagging and telemetry studies. The WIDECAST nesting site database is already incorporated into OBIS-SEAMAP. Contribution of data to this database will facilitate the study of potential impacts of fisheries and other anthropogenic impacts on these taxa in the Caribbean.

Protection and Management of Species and Critical Habitats

Regional environmental instruments (e.g., SPAW) oblige signatory governments to implement legislation to "protect, preserve and manage in a sustainable way, areas that require protection to safeguard their special value; and threatened or endangered species of flora and fauna". The Inter-American Convention (IAC) places great importance on the reduction of bycatch, with signatories being obliged to use more selective fishing gear and practices. Amendments to fisheries legislation to implement maximum rather than minimum size limits in order to safeguard larger, more reproductively valuable, age classes of harvested sea turtles are needed in those countries that retain legal harvests. The protection of seabird breeding colonies is particularly important given an anticipated loss of nesting habitat with rising sea levels. To this end, the Western Hemisphere Migratory Species Initiative, which is focused on an integrated approach to management and conservation of all migratory species in the Americas, is supporting regional training on seabird monitoring by the SCSCB.

Management of existing marine protected areas (MPAs) is being enhanced in the region through the Caribbean Marine Protected Area Management Network and Forum (CaMPAM), which seeks to increase MPA effectiveness by enhancing communication of lessons learned and strengthening the network of managers, researchers, planners and educators. As information gaps are filled and important habitats are identified, further marine and coastal protection is likely to be required. The implementation of EBM in the context of sea turtles, marine mammals and sea birds must take into account that the habitats these taxa utilise often cut across traditional management sectors, and therefore management units may best be designated bio-regionally. The use of ecologically linked networks of marine protected areas should be explored in order to protect species across their whole range and life cycles, thereby preventing extractive activities from entering particularly sensitive areas (IUCN 2004).

The establishment of the sister sanctuaries between the United States and the Dominican Republic was the *first* international relationship in the world to protect an endangered migratory species, the humpback whale, at both ends of its range; specifically in its northern feeding and nursery grounds in the Stellwagen Bank National Marine Sanctuary (SBNMS), and its southern mating and calving grounds in Marinos Mammiferos de Sanctuario de Republica. The sister sanctuary model can clearly play a powerful role in protecting endangered transboundary species, preserving special marine areas, increasing public awareness and support for marine conservation, and providing sites for research and monitoring. Programmes to control or eradicate alien predators in critical sea turtle and seabird nesting habitats, particularly on islands, is essential for EBM.

Investigations of Ecological Relationships

Investigations of the ecological relationships that link sea turtles, marine mammals and seabirds into ecological communities or ecosystems are needed through long-term, multidisciplinary programmes suitably scaled to ecosystem complexity. Some Caribbean nations still hold the view that cetaceans are in competition with fishers; an issue that requires more investigation. Developing a better understanding of the ecological role of marine mammals in marine ecosystems is complex and challenging, but both conservation and resource management will ultimately benefit from this EBM approach.

Enhanced Enforcement Capacity

Enhanced enforcement capacity is required for the protection of species at sea and on offshore islands. The development of programmes to inform fishers about the ecological importance, value and vulnerability of sea turtles, marine mammals and seabirds and what they can do to protect them (including reducing bycatch, avoiding disturbance to breeding areas and avoiding introduction of alien predators) can greatly assist in compliance.

Sea Turtles, Marine Mammals and Seabirds as Indicators of Ecosystem Health

Sea turtles, marine mammals and seabirds will be affected by human-induced ecosystem changes, including climate change, and all three taxa have been described as good indicators or sentinels. The World Wildlife Fund project *Developing an approach for adaptation to climate change in the insular Caribbean – the hawksbill turtle as an indicator species* considers sea turtles as indicator species from which much can be learned because of their interdependence on terrestrial and marine resources. Marine mammals, being fully adapted to aquatic environments, are particularly suited to act as sentinels (Wells et al. 2004; Moore 2008). Seabirds often feed at the top of food chains, and the bioaccumulation they experience can also be used as an indicator for potential threats to human health. They can also provide valuable data on where and in which species contaminants are located.

Assess Proposed Human Interventions

The form of human intervention into the EBM of sea turtles, seabirds and marine mammal populations needs to be examined. For example, consideration should be given to situations in which culling of marine mammals is proposed to address concerns that they may be considered "out of balance" with the environment due to loss of natural predators (e.g., seal culls in Eastern Canada; http://bleudeterre.wordpress.com/2007/09/07/seal-hunt-human-role-essential-to-balance-of-ecosystem-minister-of-newfoundland-government/).

Capacity Building of Existing Groups

Linkages need to be created between NGOs such as the SCSCB Seabird Working Group, the Eastern Caribbean Cetacean Network (ECCN) and WIDECAST and fisheries bodies in order to integrate sea turtle, marine mammal and seabird conservation and management into fisheries research and management activities.

Conclusion

The marine megafauna of the Caribbean have significant ecological, economic, aesthetic and amenity value to the peoples of the region. Success in developing and implementing an ecosystem approach to fisheries that manages and protects sea turtles, marine mammals and seabirds and their habitats will require that Caribbean states not only develop their internal capacities but also recognise that effective conservation and management of these diverse and wide-ranging taxa will often require a regional approach to the development of the most effective strategies and actions.

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Appendix 9.1. Species List of Sea Turtles, Seabirds and Marine Mammals of the Wider Caribbean

Scientific name	Most common English name
Sea turtles	
Chelonia mydas	Green turtle
Eretmochelys imbricata	Hawksbill
Caretta caretta	Loggerhead
Lepidochelys kempii	Kemp’s ridley
Lepidochelys olivacea	Olive ridley
Dermochelys coriacea	Leatherback
Sea birds	
Stercorarius skua	Great skua
Stercorarius maccormicki	South polar skua
Stercorarius pomarinus	Pomarine jaeger
Stercorarius parasiticus	Parasitic jaeger
Stercorarius longicaudus	Long-tailed jaeger
Rynchops niger	Black skimmer
Larus delawarensis	Ring-billed gull
Larus marinus	Great black-backed gull
Larus argentatus	Herring gull
Larus fuscus	Lesser black-backed gull
Larus ridibundus	Black-headed gull
Larus philadelphia	Bonaparte's gull
Larus atricilla	Laughing gull
Larus pipixcan	Franklin's gull
Rissa tridactyla	Black-legged kittiwake
Sterna nilotica	Gull-billed tern
Sterna caspia	Caspian tern
Sterna maxima	Royal tern
Sterna sandvicensis	Sandwich tern/cayenne tern
Sterna dougallii	Roseate tern
Sterna hirundo	Common tern
Sterna paradisaea	Arctic tern
Sterna forsteri	Forster's tern
Sterna antillarum	Least tern
Sterna anaethetus	Bridled tern
Sterna fuscata	Sooty tern
Chlidonias niger	Black tern
Anous stolidus	Brown noddy
Anous minutus	Black noddy
Phaethon aethereus	Red-billed tropicbird
Phaethon lepturus	White-tailed tropicbird
Morus bassanus	Northern gannet
Sula dactylatra	Masked booby
Sula sula	Red-footed booby

Scientific name	Most common English name
Sula leucogaster	Brown booby
Phoenicopterus ruber	Greater flamingo
Pelecanus occidentalis	Brown pelican
Fregata magnificens	Magnificent frigatebird
Pterodroma cahow	Bermuda petrel
Pterodroma hasitata	Black-capped petrel
Pterodroma caribbaea	Jamaican petrel
Bulweria bulwerii	Bulwer's petrel
Calonectris diomedea	Cory's shearwater
Puffinus gravis	Greater shearwater
Puffinus griseus	Sooty shearwater
Puffinus puffinus	Manx shearwater
Puffinus auricularis newelli	Newell's shearwater
Puffinus lherminieri	Audubon's shearwater
Oceanites oceanicus	Wilson's storm-petrel
Oceanodroma castro	Band-rumped storm-petrel
Oceanodroma leucorhoa	Leach's storm-petrel
Marine mammals	
Order Cetacea	
Suborder Mysticeti	
Family Balaenopteridae	The Rorquals
Balaenoptera musculus	Blue whale
Balaenoptera physalus	Fin whale
Balaenoptera borealis	Sei whale
Balaenoptera edeni	Bryde's whale
Balaenoptera acutorostrata	Minke whale
Megaptera novaeangliae	Humpback whale
Family Balaenidae	
Eubalaena glacialis	North Atlantic right whale
Suborder Odontoceti	
Family Physeteridae	The Sperm Whales
Physeter macrocephalus	Sperm whale
Family Kogiidae	The Pygmy and Dwarf Sperm
Kogia breviceps	Pygmy sperm whale
Kogia sima	Dwarf sperm whale
Family Ziphiidae	The Beaked Whales
Ziphius cavirostris	Cuvier's beaked whale
Mesoplodon densirostris	Blainville's beaked whale
Mesoplodon europaeus	Gervais' beaked whale
Mesoplodon bidens	Sowerby's beaked whale
Mesoplodon mirus	True's beaked whale
Family Delphinidae	The Oceanic Dolphins

Scientific name	Most common English name
Orcinus orca	Killer whale
Peponocephala electra	Melon-headed whale
Feresa attenuata	Pygmy killer whale
Pseudorca crassidens	False killer whale
Globicephala macrorhynchus	Short-finned pilot whale
Steno bredanensis	Rough-toothed dolphin
Lagenodelphis hosei	Fraser's dolphin
*Delphinus delphis*1	Short-beaked common dolphin
*Delphinus capensis*1	Long-beaked common dolphin
Tursiops truncatus	Common bottlenose dolphin
Stenella attenuata	Pantropical spotted dolphin
Stenella frontalis	Atlantic spotted dolphin
Stenella coeruleoalba	Striped dolphin
Stenella longirostris	Spinner dolphin
Stenella clymene	Clymene dolphin
Grampus griseus	Risso's dolphin
Sotalia fluviatilis	Tucuxi
Suborder Sirenia	
Family Trichechidae	
Trichechus manatus	West Indian manatee
Order Carnivora	
Suborder Pinnipedia	
Family Phocidae	
Monachus tropicalis 2	West Indian monk seal (extinct)
Family Otariidae	
Zalophus californianus	California sea lion (introduced)

1 Because of recent addition of Delphinus capensis *species listing and difficulty in differentiating between previous sighting records of* Delphinus delphis, *both* Delphinus *spp. are listed to note the occurrence of separate species, but sightings and strandings are combined and do not differentiate between species.*

2 Boyd and Standfield (1998) report some indications that monk seals might still survive off Jamaica and Haiti.

Part III

Fisheries Ecosystems

Introduction

Part 3 deals with fisheries ecosystems in the Wider Caribbean. In Chapter 10, reef resources are tackled by Appeldoorn, who perceives a "fog of fisheries and ecosystem-based management". His lucid treatment of the issues helps to clear away some of the confusion while not denying that these fisheries are some of the most complex to manage for multi-objective sustainability among competing resource users. Ehrhardt, Puga and Butler deal specifically with the Caribbean spiny lobster in Chapter 11. It is one of the region's most valuable commercial fisheries resources, and the other is queen conch, discussed in Chapter 12 by Appeldoorn, Castro, Glazer and Prada. Although these can be single-species fisheries, the authors stress the critical importance of habitat and non-fishery interactions that demand an ecosystem approach.

Deepwater snapper fisheries, discussed by Heileman in Chapter 13, are both valuable and vulnerable. The author notes that these resources are easily overfished if targeted intensively, especially at very vulnerable stages in their life histories such as during spawning aggregations or when they become collateral damage through habitat destruction of nursery grounds such as mangroves and seagrass beds. Singh-Renton, Die and Mohammed address large pelagic fish resources and the international complexity of their management in Chapter 14. Although some may argue that the ecological complexity is less than for more coastal species, the migration of these fishes through multiple jurisdictions adds considerable legal-institutional complexity to their management.

Phillips, Chakalall and Romahlo write about management of the shrimp and groundfish fisheries of the North Brazil Shelf LME in Chapter 15. These are continental shelf artisanal and industrial fisheries that span several marine jurisdictions and make a significant contribution to international trade. Although the ecosystem issues pertaining to the flyingfish fisheries of the Eastern Caribbean (Chapter 16) are somewhat different, as explained by Fanning and Oxenford, they are both similar in requiring sub-regional approaches to their management based on ecosystem principles.

The final chapter (17) on coastal lagoons and estuaries by Yáñez-Arancibia, Day, Knoppers and Jiménez tackles the land-sea interface characterised by problems and productivity. Although less important to the smaller islands of the insular Caribbean, these ecosystems are of major significance in South and Central America, especially to indigenous peoples and artisanal fishers. As with many other coastal ecosystems, they are under threat from both development and competing uses by economic sectors that, in combination, add to the complexity of EBM/EAF.

10

Reef Resources, the 'Fog of Fisheries' and EBM

Richard S. Appeldoorn

Abstract

Caribbean reef fisheries are predominantly dependent on nearshore coral reef ecosystems, which are characterised by strong habitat dependence, susceptibility to coastal impacts, diffuse landing sites, and strong multi-species and multi-gear interactions. The complexity of this socio-ecological system precludes knowing the system state in space and time sufficiently for management under a single-species approach. Ecosystem-based management (EBM) offers a distinctly different approach, one which is based on maintaining ecosystem health and productivity and focusing on system resilience. In the absence of complete data, management must be based on first principles regarding productivity and ecosystem health. These include maintaining ecosystem integrity and function, protecting habitats and water quality, applying the precautionary approach, monitoring reference points, and recognising that production has limits. These principles dictate management strategies for data collection, expanded authority, and management tactics and regulations such as marine reserve networks, closed spawning aggregations, gear restrictions to maintain trophic balance and habitats, targeted data collection and assessments, ecosystem-based or community-based metrics, and adopting co-management practices. The potential socio-ecological impacts of management failure suggest that fisheries adopt the approach of highly reliable organisations. Current activities within the Caribbean region indicate the basis for change is present, but adoption of full EBM will require refocusing and integration across multiple agencies.

Introduction

Napoleon wrote of the fog of war: 'A general never knows anything with certainty, never sees his enemy clearly, and never knows positively where he is.' One can equally speak of a 'fog of fisheries': A manager never knows anything with certainty, never sees the fishery clearly, and never knows positively where the stock is. Here the word 'where' can refer to the location of the stock in physical space, but more importantly it also can refer to its position relative to some optimal target value or critical threshold. Levels of fishing effort, fishing methods, the behaviour of fishers, market forces, community composition, trophic structure and competing sources of anthropogenic stress (from habitat degradation to global warming) evolve at rates that make it difficult for managers to know the current status of a stock with any certainty. In the Caribbean, as elsewhere, there is a long history of fisheries managers having to deal with an ever increasing array of factors affecting ecosystem health and fish productivity (Appeldoorn 2008a). Reef fisheries are characterised by a high diversity of species, gear and landing sites, each complicating data collection and analysis; stock structures are largely unknown; and the capacities of fisheries departments are limited with respect to personnel, equipment and training. Reef fisheries management is operating in a thick fog.

The traditional approach to this problem, an approach based on single-species stock assessment, is to invest in more data collection and analysis. Yet is this approach viable? The immensity of the challenges facing reef fisheries managers would argue that the answer is 'no'. While more and better targeted data is clearly essential for fisheries management, it will only be viable if the goals and context for management are changed to deal with the uncertainties inherent in complex socio-ecological systems. If one cannot amass and analyse all necessary data in real time, the alternative is to base fisheries management on basic principles. Routine data collection and stock assessment will be used to ground truth the system by monitoring stocks and ecosystem feedbacks, while additional scientific studies will expand knowledge on ecosystem connection and functions and test underlying assumptions (Hughes et al. 2005; Appeldoorn 2008b). Ecosystem-based management (EBM) offers the framework for principled ocean governance of reef fisheries. The goal of EBM should be to maintain system resilience.

Resilience is 'the amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime – essentially retaining the same function, structure, and feedbacks' (Walker and Salt 2006). It is clear that fisheries have altered ecosystems in significant ways (Jackson et al. 2001) and that in some cases, thresholds have been surpassed that have led to dramatic ecosystem regime shifts. Notable examples include the shift from cod to lobster off New England (Zhang and Chen 2007), the rise in pelagic species and the starvation of cod off eastern Canada (Choi et al. 2004) and in the Caribbean, and the shift from coral to algal dominated systems (Hughes 1994). As a consequence, the primary objective of EBM must be to maintain overall system health and productivity, as opposed to maximising yield (Appeldoorn 2008b). As such, management must identify and respond to ecosystem indicators. Further, it must be based on principles that promote resilience, and fishing practices that aim to avoid disrupting system functions must be derived from these principles.

Principles of Ecosystem-Based Management

The adoption of first principles is a key component of EBM, and these need to be agreed upon by all stakeholders. These first principles form the bounds that limit the extent of the fishery (or other activities), the manner in which it can operate and the external practices that also affect system productivity. Adoption of first principles should facilitate the practicalities of management, as there should already be strong consensus on practices that are derived from them. Appeldoorn (2008b) identified seven principles governing the biological productivity of reef ecosystems and the exploitation of species, and these are presented briefly below. Additional principles would be applied to governance and the human dimension of fisheries.

Rigorously Protect Structural Habitat

A critical concept in terrestrial systems is that the unit of management is not the species or community but the habitat, and that habitat can be used as a surrogate for demography (Merriam and Wegner 1992). Reef fishes also show a close association with habitat, with many species varying this association through ontogeny. As such, habitat can equally serve as a unit of management for reef fisheries. Facilitating management, habitats can be mapped and classified at various spatial scales using a variety of methodologies. These include diver-based assessments of a resolution of 1 m^2 (Lindeman 1997), habitats resolved from satellite (Mumby and Harborne 1999) and side-scan sonar imagery (Prada et al. 2008), and those based on aerial photographs (NOAA/NOS/Biogeography Team 2002).

Protect Water Quality

Water serves as both a critical habitat and an important mechanism for transporting materials and nutrients. Primary productivity of coral reefs is based on benthic production of algae, sea grasses and coral-symbiotic zooxanthellae, yet this is severely impacted when turbidity reduces light penetration. Suspended sediments and eutrophication are the main factors responsible for high turbidity, and terrestrial activities such as coastal development, poor land-use practices, offshore sewage outfalls and pollution events all threaten water quality and enhance sediment erosion and runoff as well as nutrient eutrophication. Sedimentation, eutrophication and turbidity also can affect the structural composition of coral reefs (Cardona-Maldonado 2008) and associated fish communities (Bejarano Rodríguez 2006). While the maintenance of water quality is an important component of ecosystem management, it is an area typically not included in the authority of fishery management agencies. Ultimately, such authorities will have to cover land use practices affecting reef environments, and management strategies will have to expand to include indicators of water quality and ecological health (Bejarano Rodríguez 2006).

Maintain Ecosystem Integrity

The maintenance of ecological integrity has long been a goal in terrestrial ecosystems (Leopold 1966; Merriam and Wegner 1992) and should have similar status in reef ecosystems. Ecosystems comprise not only structural habitats but also the species that create them, are supported by them, and that contribute to the linkages between them. This biodiversity underlies all aspects of the ecosystem. Yet, due to the numbers of species and the way they interact, it is impossible to model these in fine detail and therefore to know the long-term consequences of the biodiversity loss that may result from exploitation or management intervention. Species may be classified into similar functional groups, as in trophic models such as Ecopath (Opitz 1996), giving the impression that there is duplication within the system. However, resilience is enhanced when response diversity is high within functional groups, suggesting that the subtle differences within functional groups are key to absorbing shocks to the ecosystem (Neutal et al. 2007).

Maintain Ecosystem Function

It is important not only to keep all the parts (biodiversity) of an ecosystem intact, but also that these parts maintain their ecological function (Hughes et al. 2005). Key functional components would be primary production, herbivory, predation, water filtering, trophic pathways, nurseries, migration, shelter and reproduction. It is well established that fishing and other anthropogenic stressors can reduce species to ecological irrelevance, such as the loss of Nassau grouper populations throughout much of the Caribbean (Bohnsack 2003). Management should be cognizant that recovery times for lost function may be decadal, especially with long-lived species or when the number of spawners has been reduced to the point where behaviours (e.g., aggregations) are affected or Alee effects kick in. Many ecological functions are habitat based, such as the use of distinct nursery habitats by newly-settled and small juvenile fishes (Eggleston 1995) or site-specific spawning aggregations for snappers and groupers (Ojeda-Serrano et al., forthcoming). Equally important functions relate to the flow of nutrients and species across habitats within the seascape. The movement of species across habitat boundaries during ontogeny, for feeding or reproduction (Appeldoorn et al. 2003), not only result in the transport of organic matter and nutrients (Deegan 1993) but also the transfer of important ecological functions (e.g., herbivory) and services (e.g., fisheries).

Maintain a series of reference points for monitoring

Ecosystem-based management cannot rely on models to predict the state of the ecosystem. Our inability to determine both the current state of the fishery and its theoretical point of optimal production is well established when faced with incomplete data, unknowns and the annual variability of natural systems (Sissenwine et al. 1982). However, EBM does require monitoring. Monitoring can be used to determine directions and rates of change, which then can be used by management for adjusting tactics as needed. Under EBM, monitoring would not only include fish stocks, but also key aspects of the environment. Comparisons between fished and unfished areas are critical to assessing the impacts of fishing versus other natural or anthropogenic stressors, estimating key variables and determining the validity of theoretically constructed reference points. Reference points are fundamental to current single-species fisheries management, and these will continue to be valuable under EBM. For example, Spawning Potential Ratio (SPR) can be used to indicate proximity to the threshold of stock collapse and subsequent ecosystem alteration, and although based on detailed life-history information, this can often be approximated from length-frequency data when collected in sufficient numbers (Ault et al. 2008). The latter constraint will limit the application of length-frequency analysis to the most important and abundant species, but this will allow some degree of ground truthing for ecosystem assessments. Nevertheless, even reference points for single-species assessments will have to take into account functional roles. Thus, for example, the harvest rates of grunts, which serve important roles as prey species and in nutrient/biomass transport, must be kept well below traditional limits calculated from maximum sustainable yield. The same would be true for key herbivores, which are critical in controlling the abundance of algae on reefs, thus keeping the system away from the threshold separating the switch from coral-dominated to algae-dominated systems. In addition, new reference points will need to be developed at the ecosystem level. Some of these may be specifically related to ecosystem health, such as indexes of biotic integrity. Others (see for example FAO 1999; Busch et al. 2003) may be developed based on theoretical and practical considerations.

Employ a Precautionary Approach at All Times

The present degree of uncertainty in Caribbean fisheries is high due to the limited data relative to the large numbers of species, the ways they are harvested and the socio-economic factors driving exploitation, all of which change at variable rates. Such problems with uncertainty led to the development of the precautionary approach to fisheries, as embodied in the Code of Conduct for Responsible Fisheries and outlined in the FAO's guidelines (1999). The Code of Conduct recognises that all forms of fishing have negative impacts and that management should be forward looking, but must also operate with incomplete data. The precautionary approach requires a standard of proof for authorising fishing activities that is commensurate with the potential risk to the resource, and 'that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource' (FAO 1999). In this view, adopting an ecosystem-based approach to fisheries management is itself a fundamental component of the precautionary approach.

Recognise Limits to Production and Control Rates of Extraction

All species have limits to their rate of production, and these control the ultimate rate of harvest possible. Limits to production can be affected by fishing practices as well as other environmental stress such as an increase in turbidity leading to a decline in primary production. Regardless, the rate of fishing cannot exceed the rate of production for long without serious consequences. As a first rule of limiting harvest to maintain production, management should control fishing practices that directly affect production, i.e., those related to growth, reproduction and survival. Thus, for example, forage species should be maintained to feed more highly prized species, juveniles should be allowed to mature and adults should be allowed to spawn. Additionally, large and long-lived species will have lower production rates (Beverton and Holt 1959; Pauly 1980) and consequently lower allowable harvest rates. Such variability makes it impossible to maximise production across species in a multi-species fishery: either larger species will be overfished or smaller species will be underfished. However, under EBM, additional limits apply; limits to production must also account for key trophic and other functions important for maintaining overall ecosystem productivity. Thus, recognition of the ecological roles of trophic groups – e.g., the important role of larger predatory species in top-down control of ecological processes (Jackson et al. 2001) coupled with the importance of maintaining forage species – indicates that management strategy should target the underfishing of small species.

From First Principles to Management

Adherence to first principles should lead to significant alterations in management, including an expansion of management concerns, targeted data collection programmes and the adoption of tactics designed to protect ecosystem function and lead to sustainable production.

Expanded Management Concerns

Under EBM, fisheries management must expand its role to control negative impacts to habitat and water quality that potentially result from anthropogenic activities outside the immediate activity of fishing, such as those that might result from sewage discharge, coastal development and agricultural practices. This can be done either through expanded authority or by strengthening interactions among pertinent agencies. For reef resources, fisheries and coastal zone management should be fully integrated and water quality standards should be set to the needs of the ecosystem, and not just human health. Fisheries should also be fully integrated with agencies responsible for establishing marine protected areas (MPAs) and marine spatial zoning. Environmental impact assessments should be required to assess impacts on marine habitats and ecosystem productivity.

Although not addressed here, fully incorporating stakeholders into fisheries management is a necessary component of EBM. Fisheries agencies will have to develop protocols and capacities for dealing with larger groups of stakeholders in decision-making, adopting co-management practices wherever possible.

Data Collection and Assessment

Fisheries data collection should be focused on monitoring the catch and status of only a selected and representative number of species that are ecologically or economically important. This will allow limited resources to be aimed at obtaining the level of data required for reliable assessments and to track system behaviour. For example, certain species can be targeted for the collection of length-frequency data within short time periods (e.g., three months) and demanded by assessments based on these data, with a focus of then moving on to a different suite of species, instead of trying to collect insufficient data across all species. Additional data collection will be needed for selected multi-species or community-based metrics. Simple multi-species approaches can be used to maintain controls on the ecosystem, including monitoring of community catch composition, size structure, trophic structure, predator-prey ratios, etc. Routine monitoring of water quality and indicators of reef ecosystem health (e.g., coral cover, diversity and disease; fish counts) should be incorporated; these types of data are often collected within coastal zone management agencies. An important point of data collection efforts would be to compare fished and unfished areas in order to ground truth stock assessments and track the overall impacts of fishing versus other natural or anthropogenic sources of stress. Lastly, although not representing routine data collection, efforts should be made to map habitats using whatever data or imagery is available.

Management of Fishing Practices

One of the most important management recommendations under EBM is the establishment of marine reserve networks. Such networks would serve multiple goals of EBM, some not achievable otherwise, that enhance system resilience. These include acting as control areas (i.e., reference points for monitoring fishing impacts); providing insurance against management failure; protecting spawning stocks, trophic structures, genetic and biodiversity, and essential habitat; and the control of fishing effort. A large enough area within marine reserves might, in itself, fulfil the requirements for controlling catch levels. Where spawning aggregation sites are numerous, the protection of spawners (and generally higher predators) can be accomplished through seasonal closures.

Most fishing gears, when used improperly, can have significant impacts. While some of these can affect habitat directly (e.g., setting of entangling nets or traps in reef habitat), often unappreciated is the impact that gear can have on community structure and hence the health and productivity of the system. Restrictions on gear and fishing practices should be enacted to protect ecosystem function. These might include restrictions on entangling nets (to protect herbivores), spear guns (to protect predators), mesh size (to protect spawners and reduce bycatch and fishing mortality) and trawling (to protect habitat). At the same time, the requirement that traps have escape panels (to reduce overfishing) should also be implemented.

Discussion and Conclusion

Fisheries management acts in a fog due to the complex nature of socio-ecological systems. Management failure can have dire consequences such as stock collapse or ecosystem regime change, economic dislocation among stakeholders (commercial and recreational fisheries, tourist operators) and accompanying political fallout. As a consequence, resilience must be built into management practices. Ecosystem-based management, with its emphasis on ecosystem health and productivity, is an approach that can increase resilience within the ecosystem, especially with respect to the biological component. But fisheries management should go beyond this to ensure that fisheries (both the biological and human components) do not undergo collapse. Aligned with increasing resilience is to develop a culture that can manage the unexpected; this is the approach taken by Highly Reliable Organisations (HROs), such as those managing nuclear power plants or transportation networks where failure leads to catastrophic consequences. Such organisations have developed a culture of being cognizant of signs of impending problems and enacting strong responses to keep them in check. Weick and Sutcliffe (2001) give five characteristics of HROs, which below are couched in a framework of fisheries management.

Preoccupation with Failure

Management should encourage reporting of potential problems – e.g., changes in species, ecosystem or economic indicators – and give attention to these immediately. Past experiences – e.g., the shift from coral to algae-dominated systems in Jamaica (Hughes 1994) – should be viewed as opportunities for adaptive management. Complacency, especially the temptation to reduce safety margins – e.g., accepting optimistic assessments as the likely state and increasing catch limits – should be actively avoided.

Reluctance to Simplify Interpretations

Simplification is a necessary component in any activity, and there are not better examples of this than fisheries' assessment models. Management must, therefore, look beyond these simplifications and actively contemplate the more complete and complex natural and social processes behind them. In the words of the noted philosopher Alfred North Whitehead, 'seek simplicity, then distrust it'. Resilience is particularly concerned with potential positive feedback loops, where changes will be re-enforcing and escalate rapidly. Seeking and respecting diverse opinions and sources of expertise – e.g., scientific and traditional ecological knowledge – will broaden management's view and diversify possible management actions.

Sensitivity to Operations

Fisheries management should pay special attention to what is happening in the fishery itself, including all aspects of fishing, marketing, data collection and enforcement. This is the front line, where the work in fisheries gets done. The early detection of potential problems is facilitated when input is received closest to the source. Importantly, this can only occur when there is mutual trust among managers and the people at the front lines. For example, fishermen who refuse to submit timely and accurate catch statistics because of the fear they will be used to cut fishing efforts cause management to be ill-informed and unable to react until problems grow much larger, when indeed greater cuts are mandated by the best available (but faulty) data.

Commitment to Resilience

That EBM is an approach to enhance ecosystem resilience is the main premise of this chapter, and the first principles discussed above are meant to drive management in that direction. Equivalent to a man-overboard drill, management must think of potential worst-case scenarios and then devise potential responses. Yet no system is perfect, which is why, for example, networks of marine reserves are valued for their ability to provide insurance against management failure.

Deference to Expertise

Rigid, top-down management has its own vulnerabilities that can combine with those occurring within the system to magnify problems and make them harder to deal with. Thus, fisheries management should be as inclusive as possible, with operational focus diversified, as with co-management systems. Yet, in emergencies, when timely response is most important, rigid management systems at any level should defer to accepted expertise, regardless of its source. The open atmosphere that fisheries management should foster among all stakeholders is key to allowing management to move forward in crises based on trust in that expertise. In some cases, such as pollution events and ship groundings, there are designated agencies designed to respond quickly and their expertise is usually unquestioned, while in other cases (e.g., fish kills of unknown origin) appropriate expertise may not be readily available. Of course, not all emergencies (e.g., impending ecological regime shifts) will unfold rapidly, and the needed course of action will not be obvious due to uncertainties in underlying causes. Still, in these situations, expertise (e.g., marine ecologists) will still be needed and advice heeded to avoid more serious problems later.

The scope of factors affecting reef fisheries is rapidly expanding, and the management challenge seems daunting. Yet, in many areas of the Caribbean, management systems are already expanding and developing the necessary tools, capacities and frameworks. Most notable is the active development of MPAs within much of the region. Effective MPAs require systems for stakeholder engagement, local management and conflict resolution, as well as sustainable funding sources to implement these. In general, the process to realise these is essentially the same required for fisheries management as a whole (and exactly the same for establishing no-take marine reserves); thus, great strides can be implemented through the integration of the appropriate agencies.

One of the main impediments of instituting EBM is the inertia within the system, either due to unwillingness to change on the part of managers and scientists (relative to their particular training and professional cultures) or the lack of trust between management and stakeholders.

However, experience has shown that when given a set task that further protects the productive capacity of the ecosystem, stakeholders are fully capable of reaching consensus weighing conservation and fisheries (e.g., Bohnsack 1997; Delaney 2003) although there may be the need to carry out specific activities to overcome inertia and build trust (Appeldoorn 2008b).

11

Implications of the Ecosystem Approach to Fisheries Management in Large Ecosystems

The Case of the Caribbean Spiny Lobster

Nelson Ehrhardt, Rafael Puga and Mark Butler IV

Abstract

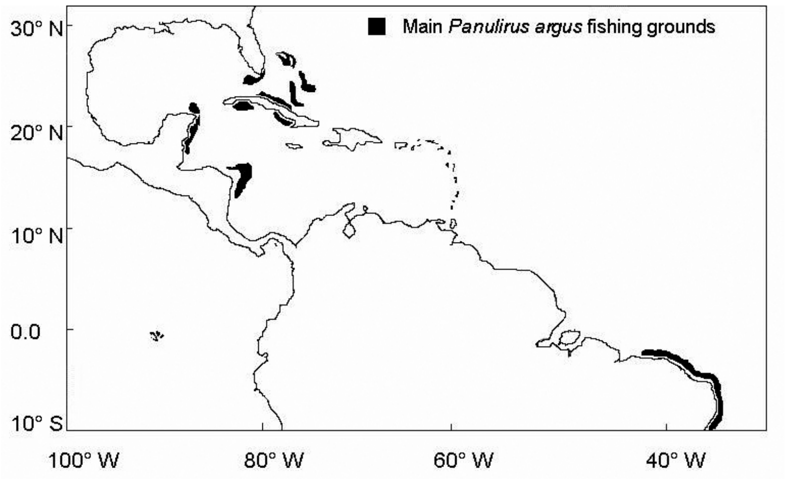
The Caribbean spiny lobster, or *Panulirus argus*, is one of the most economically important resources to Caribbean fisheries. High demand and low supply of spiny lobster have driven most fisheries to an excess of fishing capacity and created overfishing conditions in most fisheries. All fisheries are recruitment driven and in the last 10 years, recruitment has followed decreasing trends in most fisheries. Along with exploitation, changes in environmental and ecological conditions are likely to be impacting the spiny lobster's habitat. In this chapter, we identify and discuss population dynamics and fisheries processes that are key to the ecosystem approach to fishery management of the resource.

Introduction

Pragmatic management of fisheries resources requires stock assessment advice that promotes yields that are sustainable in the long term. This is not only a statutory requirement in many countries but paramount to achieving the long-term potential harvests of living marine resources. Fishery scientists strive to incorporate indices and functional relationships in stock assessment to improve forecasts of the implications of environmental change and fishing on the current and future status of those resources. Modeling environmental variables jointly with changing predator-prey interactions resulting from selective removals by fisheries and their overall effect on recruitment success is important to be able to forecast the implications of shifts in ocean conditions relative to the distribution, productivity and exploitation of fishery resources. Such an approach has to take account of ecosystem effects in setting harvest policies and therefore must depart from the old paradigm of single-species stock assessments in support of fishery management. From an ecosystem point of view, it is important to understand the impact of climate variability on the structure and locations of the habitat that a conglomerate of species needs to sustain the trophic dynamics of a productive ecosystem. One must answer questions such as: how does the relationship between climate and ecosystem affect such manifestly different patterns in population dynamics? How does knowledge of such relationships affect individual or collective fishery management objectives?

Scientists have developed processes for analysing a vast array of ecosystem indicators into a suite of models that try to explain the interactive dynamics between species, the environment and fishing. Multi-species and ecosystem models are currently available as tools for the provision of scientific information on fisheries in an ecosystem context (Plagányi 2007), while concepts on ecosystem approaches to fishery management have been significantly expanded during the last decade (Garcia et al. 2003; FAO 2003a, 2003b; Pikitch et al. 2004), with many successful present-day applications throughout the world (Pauly et al. 2000). In the case of the Caribbean spiny lobster, several fundamental issues remain unresolved due to the imprecise parameter estimation, given the piecemeal nature of the data and the associated limited understanding of how large ecosystems function. For these reasons, this work focuses mostly in the identification of the principal issues and constraints that limit the use of the ecosystem approach to Caribbean spiny lobster fishery management.

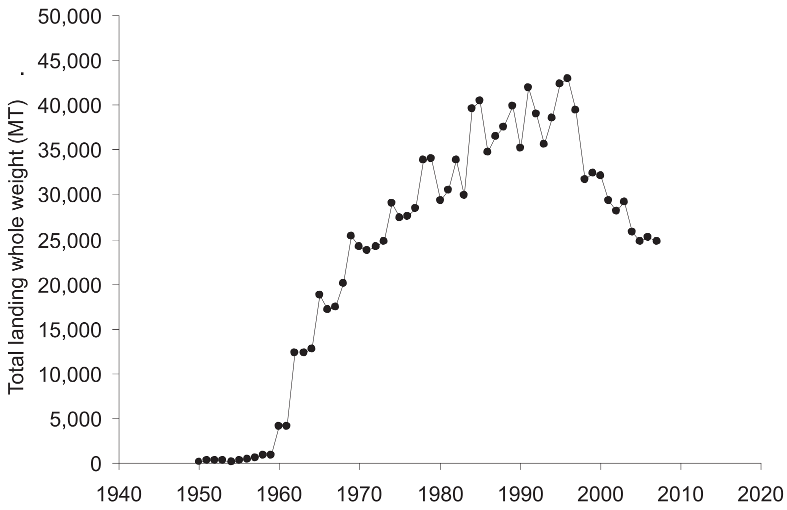
Figure 11.1. Geographical distribution of the main commercial spiny lobster fisheries in the Western Central Atlantic Ocean



The Caribbean spiny lobster sustains one of the most economically important fisheries in the region with the greatest stock abundances observed in the Western Caribbean and Brazil (Figure 11.1). Fisheries developed from circumstantial operations in the early 1960s to fully overcapitalised industries in the 2000s. Landings peaked during 1987-1997 at about 37,000 to 43,000 metric tons whole weight, with a value exceeding US$ 300 million dockside. Regional landings decreased 45% in the 2000s (Figure 11.2), mostly due to intensive exploitation as well as environmental and ecological changes in the spiny lobster's habitat. High demand and reduced supply significantly increased prices paid for lobster and have promoted further overcapitalisation. Industries and governments are concerned about the existing conditions that may generate missed management opportunities.

Management of the resource is unilaterally attempted in most countries through regulations on minimum size, spawning season closures and no-take of ripe (berried) females. Control of fishing capacities and landings are rare, and an overriding region-wide lack of enforcement and illegal fishing prevent an orderly utilisation of the resource. In this work, we briefly describe the main issues concerning the sustainability of Caribbean spiny lobster stocks from a large ecosystem (Caribbean Sea) point of view. We include general meta population biological characteristics that frame fisheries management and the core issues of fishery exploitation.

Figure 11.2. Total Caribbean-wide (including Brazil) landings of Caribbean spiny lobster

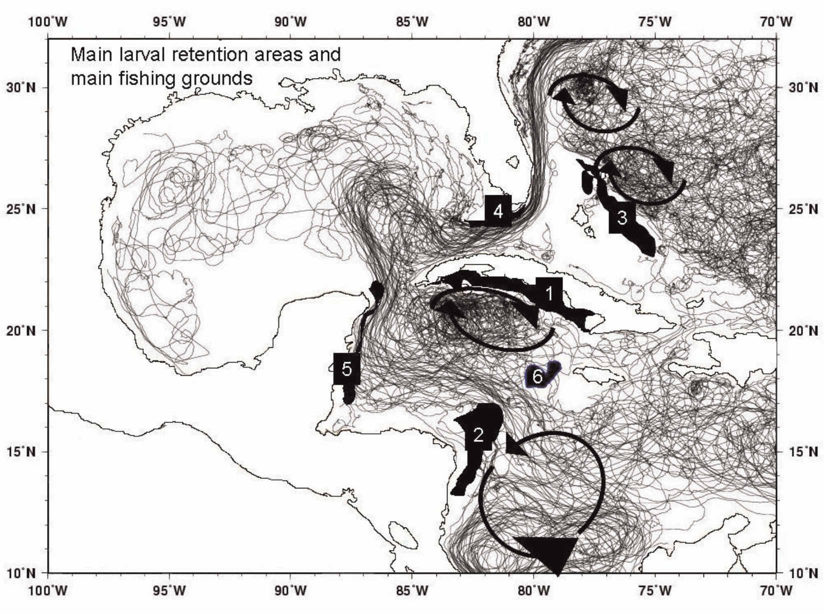


Considerations Regarding Population Dynamics

The first significant issue regarding the implementation of ecosystem-based fishery management in the case of the spiny lobster is the difficulty of defining units of stock due to the long planktonic lifespan of the larvae, which disperse over very wide areas in the open ocean before settling in a suitable juvenile habitat. Estimates of pelagic larval duration (PLD) for *P. argus*, extrapolated from size modal progressions of phyllosomal stages from plankton samples, range from five to 12 months (Lewis 1951; Sims and Ingle 1966; Farmer et al. 1989; Briones-Fourzán et al. 2008). Only recently has this species been reared in captivity from egg through all its larval stages to the benthic juvenile stage with an observed PLD of 140 to 198 days (mean = 174 days; Matsuda et al. 2007) but the laboratory conditions may have a profound effect on the larval growth (Matsuda and Takenouchi 2006). Given the strong ocean currents dominating the Caribbean Sea environment where these larvae are found, it is plausible that they may colonise regions downstream – hence the pan-Caribbean theory of spiny lobster population structure (Lyons 1980). This theory is supported by genetic studies showing a lack of geographical differentiation in *P. argus* stocks among Caribbean nations (Silberman et al. 1994a), an absence of seasonal variation in the genetic structure of postlarvae arriving at presumed 'downstream areas' like the Florida Keys (Silberman et al. 1994b) and occasional intrusions of genetically distinct Brazilian *P. argus* postlarvae into Florida (Sarver et al. 1999). Biophysical modeling of localised *P. argus* larval dispersal suggests that regional hydrodynamics can have a large impact on the degree to which local populations are self-recruiting or serve as sources of larvae for other regions (Lipcius et al. 1997; Stockhausen and Lipcius 2001). A set of simulations of *P. argus* dispersal from 13 spawning sites in the Caribbean (Butler et al. 2008a) predicts that the majority of larvae released in the Caribbean may only disperse about 200 kilometres because of the strong effects of larval vertical migration on dispersal. However, other larvae in those simulations were advected thousands of kilometres from their natal source, the difference being that dispersal is also strongly affected by local oceanographic conditions. Although some *P. argus* fisheries located in strongly retentive oceanographic environments probably experience significant self-recruitment, there is likely a high degree of larval connectivity in the Caribbean. As more detailed and reliable estimates of larval dispersal become available, large ecosystem fishery management of *P. argus* stocks should take into account the degree of self-recruitment likely for particular management units, but clearly management actions in one country may have consequences on other regional fisheries. Similarly, significant ecological shifts in some local spiny lobster habitats may be reflected on fisheries in other regions.

The Caribbean spiny lobster's larvae are dispersed in the prevailing ocean currents but can be retained in offshore gyres that are persistent enough to constrain their long-lived larvae (Figure 11.3). The latter are conspicuous in the Gulf of Honduras, off Costa Rica-Panama, off the south of Cuba and the north of the Bahamas. Gyres and counter currents represent important physical mechanisms for local larval retention and, combined with larval behaviour (e.g., diel and ontogenetic vertical migration can sig-

Figure 11.3. Ocean currents expressed from satellite oceanographic buoys, areas of major larval retention indicated by circle arrows, and main fisheries in the Caribbean region: 1) South of Cuba, 2) Nicaragua-Honduras Rise, 3) The Bahamas, 4) Florida, 5) Mexico-Belize, and 6) Jamaica

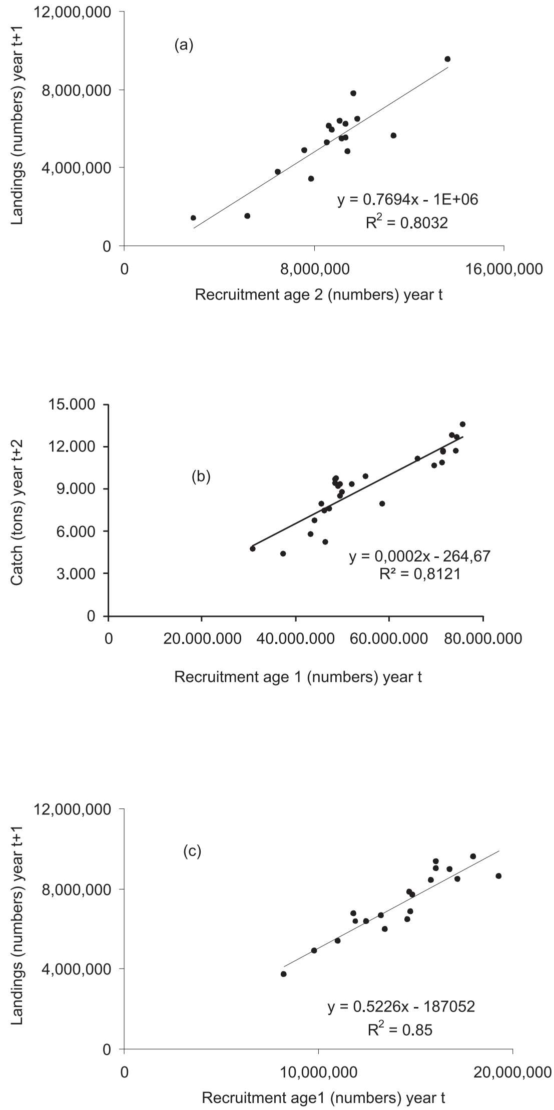


nificantly influence recruitment to local stocks, reviewed in Pineda et al. 2007), contribute to some of the most productive fisheries in the Caribbean (Figure 11.3).

Landings mostly correspond to fluctuations in recruitment because they consist primarily of new recruits (Figure 11.4) (Cruz et al. 1995; Ehrhardt 2005a, 2007; Puga et al. 2008). Therefore, the dynamics of recruitment mechanisms and the resulting recruitment abundance play an overriding role on the outcome of local spiny lobster fisheries. Studies of recruitment dynamics in Cuba (Cruz et al. 2001; Puga and de León 2003; Puga et al. 2005, 2006, 2008), Florida (Ehrhardt and Fitchett, 2010) and Nicaragua-Honduras (Ehrhardt 2005a) demonstrate the varying levels of complexity of the processes that control annual production.

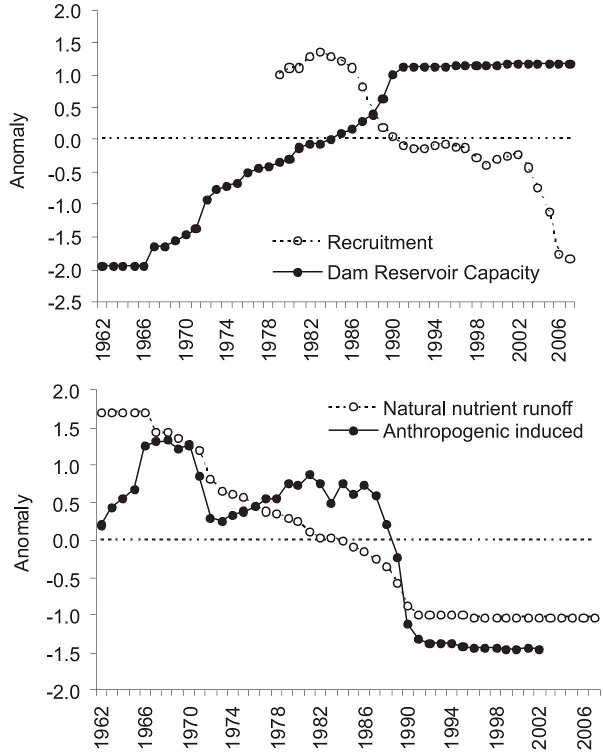
However, along with postlarval supply, a sufficient nursery habitat is crucial for successful postlarval settlement and the growth and survival of juveniles that recruit to fisheries (reviewed in Butler et al. 2006). Those regions with the greatest *P. argus* fishery production in the Caribbean are those with large shallow coastal zones and a habitat suitable for nurturing juvenile lobsters. Local recruitment is not necessarily greatest in areas with the highest concentrations of arriving postlarvae (Herrnkind and Butler 1994; Lipcius et al. 1997). Indeed, the potential for habitat limitation of *P. argus* recruitment has been experimentally demonstrated in the Bahamas

Figure 11.4. Recruitment driven landings in main Caribbean fisheries. (a) Nicaragua-Honduras, (b) Cuba and (c) Florida



(Lipcius et al. 1997), Florida (Butler and Herrnkind 1992, 1997) and Mexico (Eggleston et al. 1990; Sosa-Cordero et al. 1998; Briones-Fourzan et al. 2001). This is compelling evidence of the importance of nursery habitat for fishery production. The protection of shallow-water nursery habitats for the Caribbean spiny lobster should be of major importance to managers seeking to sustain viable fisheries. Settling *P. argus* postlarvae are attracted to the chemical and physical cues produced by red macroalgae

Figure 11.5. Effects of dam construction and natural nutrient depletion in coastal regions of Cuba and recruitment trend. Also, significant decrease of fertilizer use impacting anthropogenic induced nutrients to coastal areas (data from Puga et al. 2008)



and appear to also use pressure cues to select shallow water nursery habitats (Herrnkind and Butler 1986; Butler and Herrnkind 1991; Butler et al. 1997; Goldstein and Butler, forthcoming). Macroalgal rich hard-bottom and, secondarily, seagrass are the species' preferred settlement habitats but areas with ample crevice shelters are crucial for high survival of later stage benthic juveniles (Marx and Herrnkind 1985; Herrnkind and Butler 1986; Eggleston et al. 1990; Acosta and Butler 1997; Herrnkind et al. 1997; Behringer et al., forthcoming; Bertelsen et al., forthcoming).

Ecological studies carried out on spiny lobster habitat in Cuba recognise several fundamental environmental conditions as negatively impacting juvenile recruitment habitat. They include: 1) decreased amounts of natural and anthropogenic induced nutrients, with the advent of dam constructions interrupting the natural runoff of nutrient-rich fresh water to the spiny lobster habitat (Figure 11.5; Puga et al. 2008), 2) increased salinity in juvenile habitats affecting larvae and prey species, 3) the incidence of major and more frequent hurricanes impacting habitat structure, and 4) significant coastal zone development including highways that impacted inshore-offshore water exchange. Therefore, the effects of environmental conditions on recruitment are independent of fishery exploitation impacting the adult stock two to three years later (Figure 11.6). Experimental studies in Florida confirm the negative effects of siltation (Marx and Herrnkind 1985b; Herrnkind and Butler 1986; Herrnkind et al. 1997), extreme salinity (Field and Butler 1994) and the loss of physical structure (Herrnkind and Butler 1986; Butler and Herrnkind 1997) on postlarval and juvenile lobster survival.

Figure 11.6. Significant decreasing trend in recruitment in areas off Southern Cuba antecedes in 3 years the drop in exploitable population (data from Puga et al. 2008)

In Florida, the relationship between decreasing parent stock and trends in postlarval recruitment is significant both in the slopes as well as the variances (Figure 11.7), which may imply strongly linked processes (Ehrhardt and Fitchett, 2010). Such decreasing trends are identified with very high exploitation rates exerted on the parent stock, as fishing mortality rates are at least twice the magnitude of the natural mortality rate in this fishery (Ehrhardt 2007). However, the most significant feature with this stock is the shift in recruitment success as a function of parent stock density-dependent effects (Figure 11.8), which was found to be correlated with Caribbean mean sea level shifts (Ehrhardt and Fitchett, forthcoming). A strikingly similar situation was found for the stock in the Nicaragua-Honduras rise (Ehrhardt 2006) (Figure 11.9). These conditions are indicative of a shift to lower recruitment success among the most vulnerable early benthic stage postlarvae or juveniles of *P. argus* – this could therefore potentially be related to physical changes in the suitability of nursery habitat or perhaps disease. It is interesting to note that such effects have been more negative during the early 2000s than in the 1990s. These negative trends in Florida are possibly linked to the dramatic loss and slow recovery of sponge shelter for juvenile lobsters over large portions of the nursery (Butler et al. 1995, 2005; Herrnkind et al. 1997) or perhaps the emergence of a pathogenic disease infecting juvenile lobsters that was first reported in Florida in 1999 (Shields and Behringer 2004).

Figure 11.7. Parent stock-post larval recruitment in the Florida population (from Ehrhardt and Fitchett 2010)

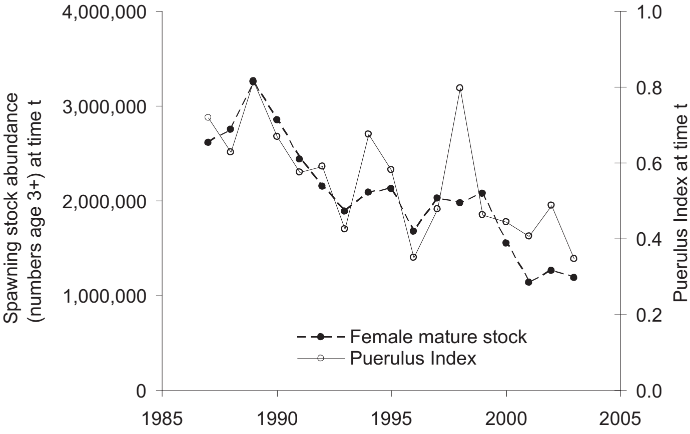


Figure 11.8. Density dependence of recruitment success on parental stock abundance for P. argus in Florida and the effects of Caribbean Mean Sea Level (CMSL) (from Ehrhardt and Fitchett 2010)

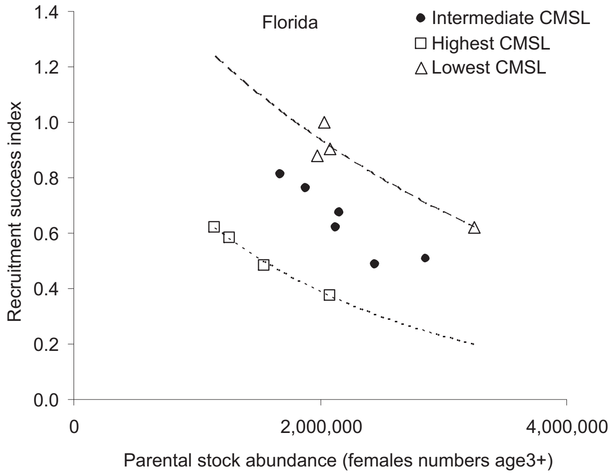
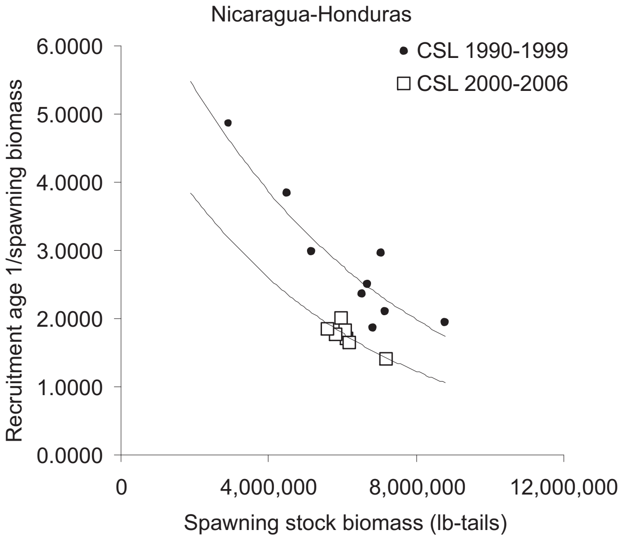


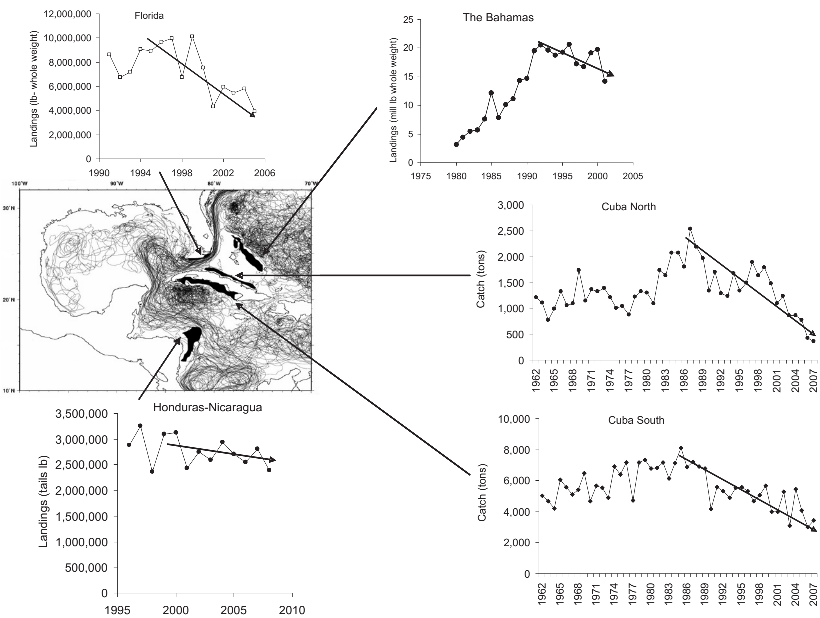
Figure 11.9. Density dependence of recruitment success on parental stock abundance for P. argus in Nicaragua-Honduras and the effects of Caribbean Mean Sea Level (CSL) during 1990-1999 and 2000-2006 (from Ehrhardt 2006)



Discovery of and research on a pathogenic and lethal viral disease (PaV1) that infects primarily juvenile *P. argus* suggests that the disease may be widespread in the Caribbean and at high local prevalence in some areas (Li et al. 2008; Butler et al. 2008b; Behringer et al. 2008, Lozano-Alvarez et al. 2008). These authors estimate that in Florida and Mexico, at least 25% of the benthic juveniles die from the disease per annum, which is equivalent to an instantaneous natural mortality rate of 1.39 – a rate that is four times higher than the natural mortality rate assumed for the recruited age classes. The virus can be transmitted by several mechanisms (contact, ingestion and, to a more limited extent, waterborne), but lobster avoidance behaviour appears to limit the local spread of the virus in nature (Behringer et al. 1986; Butler et al. 2008). Early benthic juvenile susceptibility to infection may increase at higher temperatures, but not so for larger juveniles or adults whose susceptibility to disease also does not appear to be associated with changes in salinity or individual nutritional condition. There is no obvious management mechanism that might thwart the further spread of this disease but it will be important to link these episodic events to populations and assess their impacts on production.

Another important consideration regarding decreasing trends in postlarval recruitment is the close association of the coral reef habitat to spiny lobster population dynamics. There has been a considerable loss of critical coral habitat throughout the Caribbean region since the 1980s, particularly after the significant coral bleaching events of 1998 and 2005. It is not known, however, if there are functional links between those events and the health of the lobster spawning stock that depends in part on the coral reef habitat for food and shelter.

Figure 11.10. Landing trends according to countries and localities in the Western Caribbean



Fishery Considerations

Landings from each of the main spiny lobster fisheries in the Caribbean decreased consistently from the mid-1990s to the mid-2000s (Figure 11.10). Most conspicuous are declines in northern Cuba (75%), southern Cuba (45%) and Florida (50%), whereas landings from the Nicaragua-Honduras rise are the least affected, with only an 18% reduction, and the Bahamas with a decline of 28%. Historically, and in decreasing order, Cuba, the Bahamas, Nicaragua-Honduras and Brazil have been the most important *P. argus* producers (Figure 11.11). This order is changing rapidly as Nicaragua-Honduras and the Bahamas followed by Brazil are becoming the principal producers. While natural and anthropogenic effects on the spiny lobster's habitat, ecology and population dynamics may be playing a role in this decline, so too may fishing harvests. Therefore, sustainability of the fisheries through reasonable management is still statutory.

One issue facing an ecosystem approach to fishery management is the open, unregulated character of most fisheries except those in Cuba and

Figure 11.11. Percentage contribution to total landings by main spiny lobster producing countries until the early 2000's

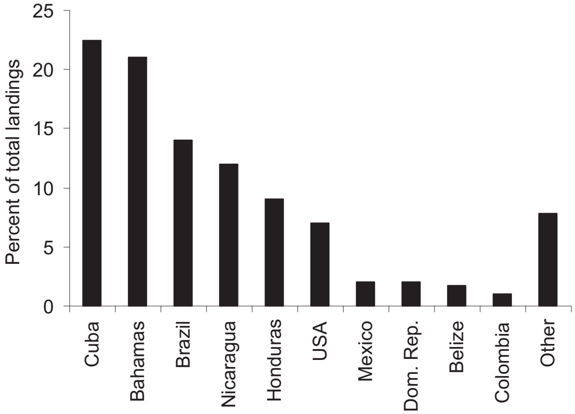
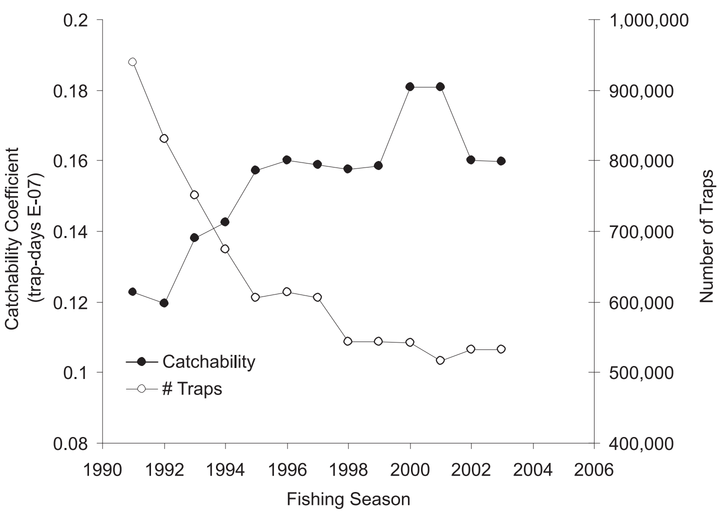
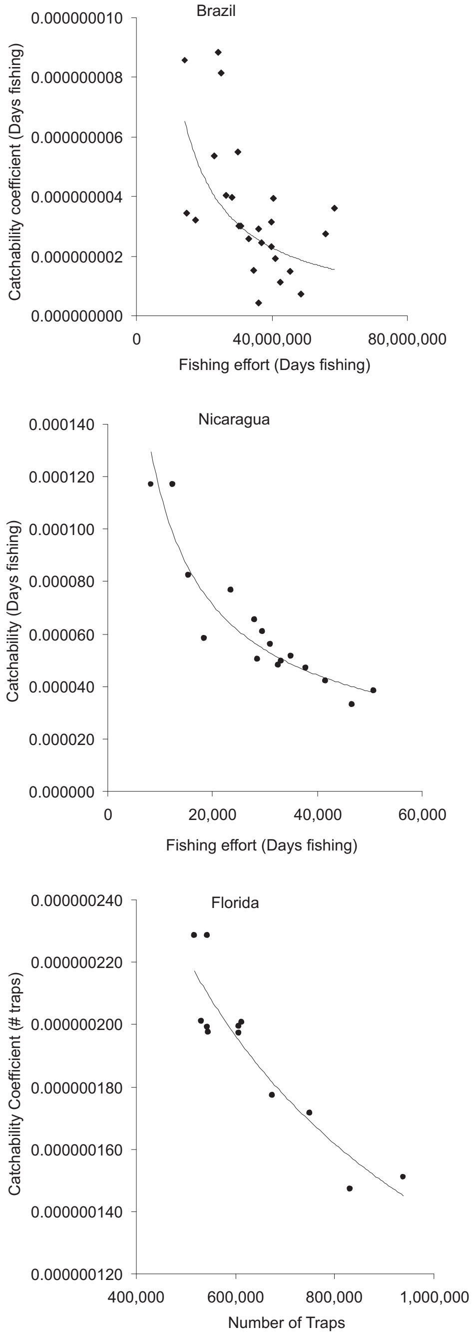


Figure 11.12. Increased trap efficiency with reduction in number of traps deployed (Florida) (from Ehrhardt and Deleveaux 2009)



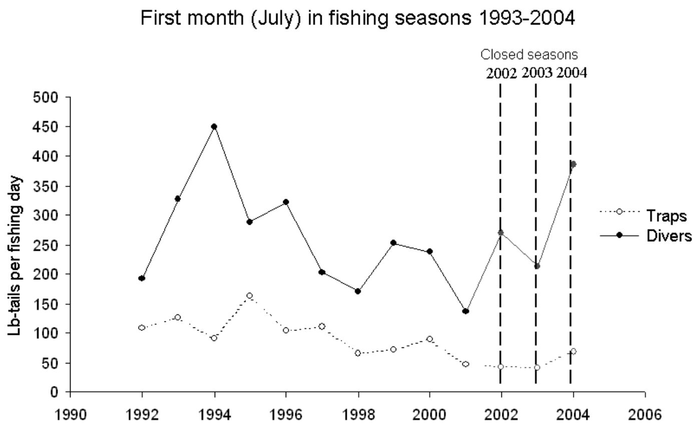
Florida. In Cuba, centrally planned fishing operations are based on a projected and sustainable strategic biological catch, and effort quotas are used to control fishing capacity. Florida has a number of well-enforced size and effort regulations in place, including a limit on the number of traps used in the fishery and a trap reduction programme that reduced the number of traps in the fishery over the past decade (reviewed in Phillips and Melville-Smith 2006 and Ehrhardt and Deleveaux 2009). Until 2007, Nicaragua had a unique biologically allowable annual catch that was abolished in favour of open access competition. Research on the socio-economic condi-

Figure 11.13. Catchability per trap as a function of total fishing capacity or fishing effort (data sources: Brazil-Ehrhardt 2007b; Nicaragua-Ehrhardt 2006; Florida-Ehrhardt 2007a)



tions of the spiny lobster fisheries in Nicaragua (Ehrhardt 2006) and on-going research in Honduras (Ehrhardt, personal communication) show that over 600,000 traps and more than 24,000 compressed air tanks are used in the Nicaragua-Honduras region by 215 trap vessels and 86 dive vessels. In Cuba, the number of vessels was reduced from 310 in 1980-1989 to 198 in 2007 with a reduction from 45,161 to 21,574 days fishing. In the meantime, the closed season was increased from 90 days to 150 during the same period. In spite of these drastic fishing capacity reductions, landings were not reverted. In Florida, close to 1 million traps were operated until 1992 and these were reduced to about 50% by 1996 through a planned trap reduction that resulted in an attrition of fishers, a significant increase in the efficiency of traps (Figure 11.12) and less capital at risk. In spite of this management action, the Florida fishery has not halted the continued decline in landings. In the Bahamas, there are 700,000 to 800,000 artificial spiny lobster refuges (i.e., condominiums or casitas) in operation that are never retrieved from the fishing grounds and are replaced at the rate of about 20% per year. These are deployed in shallow habitats where they attract many juveniles and where regulations concerning minimum sizes are not respected, controlled or monitored. The environmental impact of 'casita-like' devices has not been assessed in the Bahamas but their effect on nursery habitat and on the survival and growth of juvenile lobsters should be a matter of serious concern in these and other fisheries. Generally, fishing effort in spiny lobster fisheries is negatively correlated to catchability (hence efficiency) because of competing gear factors (Figure 11.13). Fishing capacity controls should therefore be an important element in fishery management strategies, contributing to less environmental damage and increasing economic productivity.

Figure 11.14. Effects of closed seasons and non-retrieval of traps on the catch rates of trap fisheries relative to diving fisheries in areas not affected by ghost gear (data from Ehrhardt 2006)



Another significant issue that many trap fisheries face is the cryptic mortality exerted by not retrieving fishing gear (traps) during the closed fishing season. This cryptic mortality by ghost gear may be very large, as may its effect on stock productivity and impact on the reproductive potential of stocks. Ehrhardt (2006) analysed the catch rates of trap and diving fleets operating over the same stock but in gear-segregated fishing areas of Nicaragua. Since the implementation of closed-season regulations in 2002, catch rates were much higher in the diving operation areas than in the trap operation areas, which in part is a consequence of ghost trap mortality (Figure 11.14). The situation is more dramatic when seasonal statistics by fleet are compared (Figure 11.15). Retrieving the gear at the end of the fishing season has a significant operational cost because of the large number of traps used per vessel (up to 6000 traps/vessel) and because it requires many trips to faraway grounds. However, reduced production is an obvious result of not investing in retrieving the gear. Additionally, more studies assessing the ecological impact of trap 'debris' left in critical spiny lobster habitats are needed to evaluate this potential threat to the environment and future fishery production.

Figure 11.15. Effects of seasonal non-retrieval of traps on the catch rates of trap fisheries relative to diving fisheries in areas not affected by ghost gear in Nicaragua (data from Ehrhardt 2006)

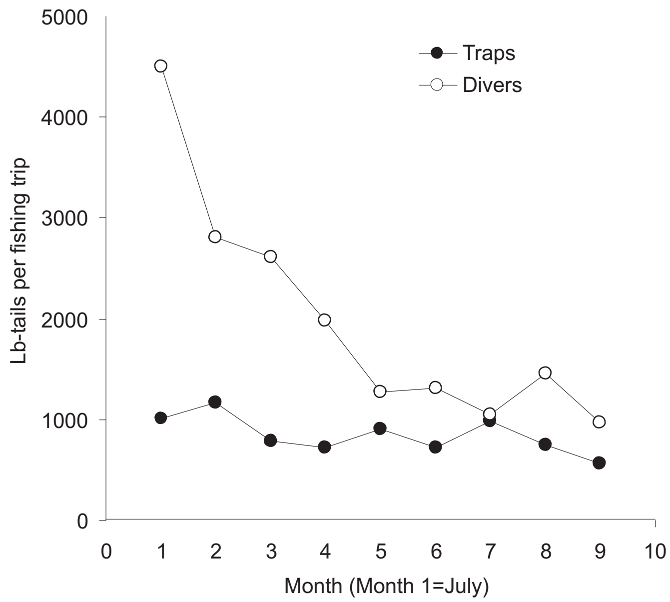
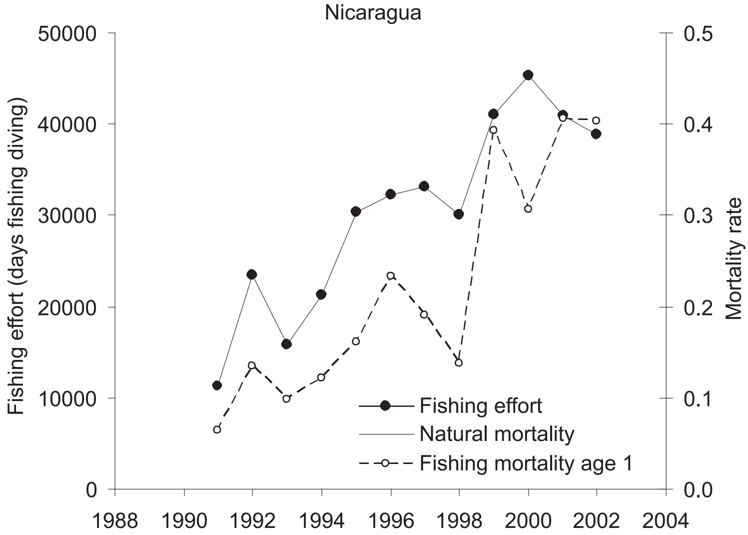
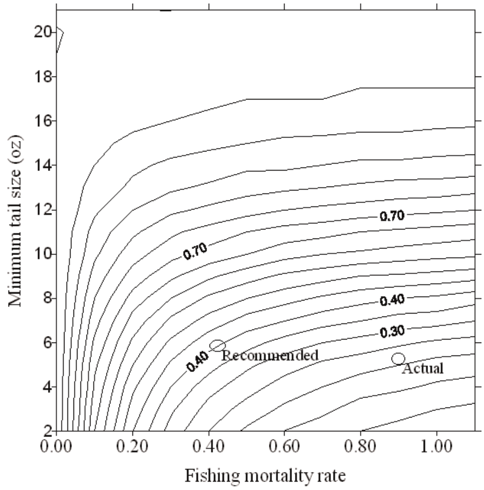


Figure 11.16. Fishing mortality trend of juvenile lobsters and fishing effort in the Nicaragua fishery (data from Ehrhardt 2005a)



The rampant violation of minimum size regulations is undoubtedly one of the most serious issues undermining the sustainable management of *P. argus* stocks in the Caribbean. The countries in the region generally recognise a five-ounce tail weight as a minimum size reference; however, landings include all sizes of spiny lobsters caught in traps or by divers or even with gillnets (i.e., Brazil). Only in Cuba and Florida do strict regulations and consistent enforcement control such practices. In Florida, however, between 100,000 and 300,000 juvenile spiny lobsters are used seasonally as attractants in traps, and although this practice makes traps significantly more efficient, the biological impact on future spawning potential fecundity and biomass production is estimated to be very large (Lyons and Kennedy 1981; Hunt and Lyons 1986). In the Honduras fishery, about 60% of the landings in weight are illegal-size spiny lobsters, while in Nicaragua the figure is about 30% (Ehrhardt 2005a). The fishing mortality at age 1 for lobsters in the latter fishery has increased significantly as a function of fishing effort and the practice of retaining all lobsters that are caught (Figure 11.16). The waste in potential reproductive capability by this practice is observed in Figure 11.17. Thus, successful ecosystem fishery management needs successful local and regional enforcement because illegal-size lobsters are trans-shipped to international markets, usually via third-party countries with no fishery regulations regarding the Caribbean spiny lobster. Also, some countries have developed sophisticated markets (e.g., Chinese restaurants) to dispose of the very large quantities of illegal-size lobsters landed throughout the region. These events are probably responsible for the largest fraction of the depletion observed in spiny lobster stock exploited with no controls, regulations or enforcement. A positive step forward in this regard is legislation just enacted in 2009 in the United States that bans all importation of spiny lobster that does not meet current US minimum size (three-inch carapace length or 5.5 inch tail length) or weight (five ounces tail weight) regulations.

Figure 11.17. Spawning potential ratio of spiny lobsters under different minimum tail weight size and fishing mortality. Gains in this ratio by increasing minimum size indicated by the dots and their trajectories.



A related issue is the preservation or building of lobster spawning stocks via the protection of large individuals. The exponential relationship between female lobster size and egg production is well established for *P. argus*, as it is for all spiny lobsters (reviewed in MacDiarmid and Sainte-Marie 2006). In addition, there is evidence for *P. argus* (MacDiarmid and Butler 1999) among other species of lobster (see MacDiarmid and Sainte-Marie 2006) that male size may also affect reproductive success via sperm limitation. Thus, there is good reason for some degree of protection for large male and female lobsters, which together contribute far more to egg production than smaller individuals (Bertelsen and Matthews 2001).

The creation of no-take marine protected areas (MPAs) that exclude fishing in areas where lobsters spawn is one management action that leads to demonstrable increases in lobster size and abundance within MPAs (reviewed by Butler et al. 2006), including those inhabited by *P. argus* (Bertelesen and Matthews 2001; Cox and Hunt 2005). As with all management measures, the effectiveness of MPAs in boosting spawning stock potential depends on enforcement and the fraction of the stock that is ultimately protected by regulation. There is often considerable resistance by the fishing industry to expand the size or number of MPAs, so increasing spawning stocks remains a challenge for fishery managers. One approach proposed by Steneck et al. (forthcoming) is to expand the spawning stock 'footprint' of small, scattered MPAs by linking the benefits of no-take MPAs with those attained by implementing maximum size limits throughout the rest of the fishery ecosystem. In this way, lobsters that attain a large size within MPAs but venture beyond the MPA boundaries remain protected. Over time, the abundance of large lobsters would build up not only within MPAs but also within the fishable population, thereby significantly boosting spawning stocks. Such measures may be more acceptable to the fishing community than others, because the fishermen need not relinquish any of their current catch. In today's overexploited *P. argus* fisheries (FAO 2004), they now catch very few large lobsters anyway. However, before implementing such measures, more detailed simulations to explore optimal MPA coverage and lobster maximum sizes are needed.

Conclusions

1. Most Caribbean spiny lobster fisheries are recruitment driven; therefore, understanding recruitment mechanisms as well as the environmental and ecological effects on recruitment dynamics are paramount to the objectives of ecosystem-based fishery management.
2. Environmental and ecological effects on *P. argus* stocks are evident in fisheries in Cuba and Florida. In spite of strict fishery regulations, low production has not been averted. The disappearance of the spiny lobster's habitat in the region is apparent and perhaps unavoidable, but assessments of long-range impacts must be done to correctly dimension sustainability. Without a proper understanding of the environmental and ecological features that affect recruitment and how those conditions are likely to change in the coming years, it will be impossible to implement sustainable spiny lobster fishery management actions.
3. With a few exemptions (i.e., Cuba and Florida), enforcement of spiny lobster fishery regulations is absent or not effective. No attempts to manage these valuable fisheries will succeed in the absence of adequate enforcement.
4. Illegal harvest of juvenile spiny lobsters is rampant in most countries, and an open market for these products has flourished in the Caribbean region and in many countries that import *P. argus*. Enforcement of minimum size regulations presents a unique opportunity for successful Caribbean-wide management of the resource.
5. The excess of fishing capacity is much larger than is needed in most countries, with the possible exception of Cuba and Florida where regulations maintain effort-controlled fisheries. Fishing capacity reduction should be a fundamental initiative in an ecosystem approach to spiny lobster management in the Caribbean.
6. Related to the overcapitalisation of fisheries, the cryptic mortality exerted by lost gear (i.e., 'ghost gear'), especially during the off season, is

a problem that remains largely unaddressed in most Caribbean nations.

7. Virus infections of mostly juveniles are a major source of mortality that needs to be assessed relative to stock production and reproductive potential under present exploitation schemes. This represents one of the most challenging scientific issues regarding ecosystem-based management.
8. In the face of so many potentially negative and, at least in the short term, unmanageable impacts on Caribbean spiny lobster stocks (e.g., pollution, habitat loss, climate change, disease), protection and even expansion of spawning stocks is the most beneficial management action available for safeguarding the region's valuable lobster fisheries. Traditional fishery management actions (e.g., minimum size limits, protection of berried females and seasonal closure of fishing during the breeding season) as well as new ecosystem-based approaches (e.g., no-take MPAs combined with maximum size limits throughout the fishery) are needed to help ensure the long-term sustainability of Caribbean spiny lobster stocks.

These conclusions provide a fundamental set of research platforms that will need to be implemented before a serious attempt can be made to develop models that could be adopted for a Caribbean ecosystem approach to fishery management of the spiny lobster metapopulation.

12

Applying EBM to Queen Conch Fisheries in the Caribbean

Richard S. Appeldoorn, Erick Castro Gonzalez, Robert Glazer and Martha Prada

Abstract

Queen conch fisheries are important throughout the Caribbean, yet most stocks have been seriously overfished, such that conch has been listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Ecosystem-based management (EBM) offers the possibility of sustaining conch fisheries by addressing aspects of conch biology that directly support production and are otherwise overlooked in quota-based management. Adherence to first principles concerning the maintenance of ecosystem health and a precautionary approach should guide management considerations. For queen conch, critical EBM goals are the maintenance of adult density (especially with respect to reproduction), nursery areas and water/habitat quality. Consideration must also be given to the limits of connectivity through larval dispersal, predator-prey interactions (and the management of other species) and the factors that enhance vulnerability to exploitation. Resulting management strategies would seek to protect adults and juvenile nursery areas through the banning of fishing during the peak of the reproductive season, banning the harvest of small juveniles, integrating fisheries management with coastal zone management to protect nearshore areas and the establishment of a network of marine reserves. Monitoring of the stock and fishery (including comparisons with protected populations and the development of a spatial GIS database) should be used to track and set the level of catch.

The Problem

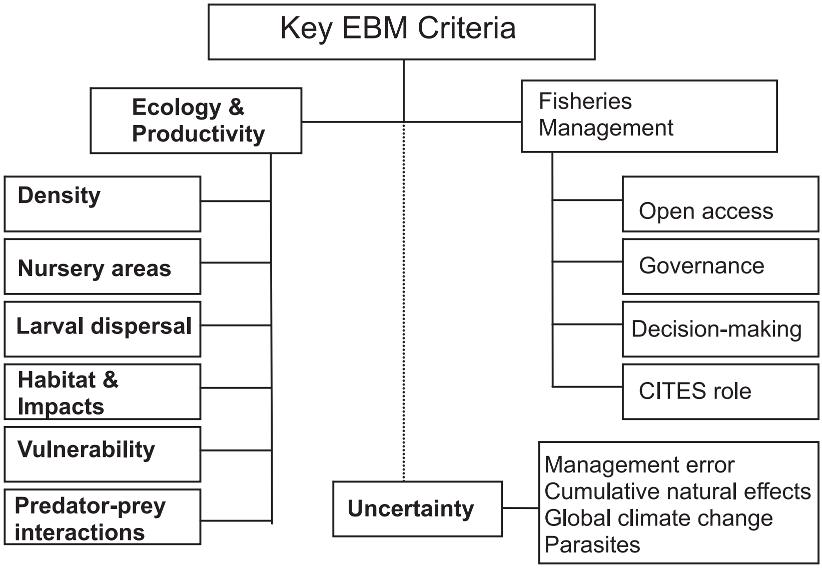
In the Caribbean, as elsewhere, fisheries management has become more complex, as both the scale of ecosystem exploitation and the nature and extent of anthropogenic impacts have increased (Appeldoorn 2008). Given that much of the region consists of island states with narrow shelves subjected to coastal and land-based activities and resource impacts, the merging of fisheries management and coastal zone management is a trend that is perhaps long overdue. Additionally, fisheries management is hindered by difficulties in data acquisition and analysis due to the high diversity but relative low abundance of species caught, the variety of gears and landing sites, and limited capacity of national and regional agencies. At the same time, many key Caribbean resources, especially those associated with reef environments, are closely tied in space and time to the benthic habitats that provide food and shelter. In this context, Appeldoorn (2008) argued that ecosystem-based management offers a way to redirect management efforts by focusing on ecosystem health as the basis for supporting fisheries productivity. The first principles underlying ecosystem-based management, regardless of specific management tactics, are to protect structural habitat and water quality, maintain ecosystem integrity and function, maintain no-take control areas to assess fishing impacts, recognise limits of productivity and use a precautionary approach.

The queen conch, or *Strombus gigas,* has historically been one of the most important fisheries in the Caribbean, both economically and culturally (Brownell and Stevely 1981; Appeldoorn 1994; Theile 2003). However, overexploitation has resulted in declining annual harvests. Indeed, landings were estimated at more than 7.4 billion metric tonnest in 1993, but reduced to 3.2 billion metric tonnes in 2001, with an annual wholesale value of US$ 60 million (Theile 2003). Fishing is pursued primarily through scuba diving or the use of hooka, except in certain countries (e.g., the Bahamas, Belize, Colombia, Martinique) where use of such gear is prohibited. The fishery for conch encompasses the entire Caribbean and consists of both industrial and artisanal fleets. Industrial fleets operate primarily out of Jamaica, Honduras, Nicaragua, Colombia and the Dominican Republic, and vessels fish the outer shelves and offshore banks, particularly in the western Caribbean. Despite the importance of the fishery, management at the local, national and regional levels has been slow to respond to the rapid growth of the fishery. As a result, overfishing, fuelled primarily by international demand for the meat and pearls of conch (Prada et al. 2009), has reduced most stocks throughout the region. In 1992 the species was listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Daves and Fields 2006). Species listed in Appendix II are not in immediate danger of extinction but are threatened by international trade if they are not strictly controlled. Trade controlled by CITES requires exporting countries to verify that the fishery is not threatening the local population and to establish export quotas consistent with this goal. In 1996, the International Queen Conch Initiative was established in an effort to improve regional management through harmonised regulations, enhanced communication and the application of scientific advice to management and assessments (Daves and Fields 2006). Despite these efforts, two Significant Trade Reviews have followed the listing, triggered by concerns over the volume of conch in international trade.

Why Conch are Well-Suited to EBM Approaches

Ecosystem-based management, in its broadest sense, encompasses both the ecology of the species and the human context of the fishery. The key criteria for conch fisheries under EBM are given in Figure 12.1, but attention here will be limited to examining this from an ecological perspective. Queen conch have unique life-history attributes that render them particularly susceptible to habitat degradation and to overfishing and that argue for more non-traditional approaches to management. In particular, they are sensitive to low densities, nursery habitat quality, spawning habitat quality and water quality; they are also acutely vulnerable to overfishing. The latter point is critical and is underscored by the collapse of fisheries throughout the region (e.g., Florida, Bermuda, mainland Colombia and the Yucatan in Mexico), while in other areas complete closures were necessary to revive stocks (e.g., Belize, Cuba, US Virgin Islands) (see references in Appeldoorn and Rodríguez 1994). The objectives of this paper are: (1) to examine key ecological criteria relevant to the first principles of ecosystem-based management, and (2) to recommend how EBM can be applied to conserve and enhance conch productivity and sustain its fishery.

Figure 12.1. Key criteria for conch fisheries under ecosystems-based management. Areas in bold are addressed below



Key Criteria for Ecosystem-Based Management

Density

Density is probably the single most important criterion affecting conch productivity throughout its life history, as it affects growth, successful reproduction, fecundity, settlement and early juvenile survival. Density is also one of the most easily measured and monitored attributes for assessing the status of conch populations.

Density affects the ability of conch to reproduce in several ways (Appeldoorn 1988b, 1999). First, conch must copulate to reproduce. During the reproductive season, conch are typically found aggregating in areas preferential to egg deposition, often characterised by clean loose sand (Glazer and Kidney 2004), but at low densities such aggregations may not form and it can be difficult for slow moving adults to find mates. Second, there is circumstantial evidence that contact between males and females stimulates gamete production, termed sexual facilitation (Crews 1977; Crews et al. 1986). For example, in experimental enclosures, Appeldoorn (unpublished data) found that females kept with males underwent gametic development and maturation, but females kept in isolation did not. In the Exumas, Bahamas, Stoner and Ray-Culp (2000) demonstrated an Allee effect in conch, where reproductive activity (% conch egg laying, % conch pairing) declined to zero when cross-shelf density fell to approximately 50 conch/hectare. Reproductive activity reached a maximum asymptote at approximately 200 conch/hectare. A similar pattern was observed in Florida, where copulation was only observed where within-aggregation densities exceeded 185 conch/hectare (Glazer, unpublished data).

Because conch aggregate, reported measures of density are not necessarily comparable across studies – measured density will be a function of the area surveyed relative to both appropriate habitat and stock abundance. Nevertheless, it is clear that conch require high-density aggregations in order to achieve their full reproductive potential. Fishing activities preferentially target conch aggregations, with the result that any individuals not harvested will now remain at low density, with a potentially strong impact on reproductive output. This effect would be exacerbated in a heavily exploited fishery where remaining conch occupy less preferred habitats (Glazer and Kindey 2004) at a higher frequency, resulting in a habitat-driven decline in reproduction. Thus, protection of critical reproductive habitat, and the densities of populations that occupy them, must be a consideration under ecosystem-based management.

Nursery Areas

Newly settled juveniles are found in soft sediments and spend much of their first year buried. In reef systems, settlement often takes place in back reef areas near channels through the reef, where larval supply is high but water currents are sufficiently slow to allow settlement. But conch larvae may also settle in deeper water. At lengths ranging from 50 to 100 mm, young juveniles begin to emerge and take up an epibenthic existence. In shallow areas, Stoner et al. (1988) and Sandt and Stoner (1993) documented a habitat shift at the time of emergence, from the area of settlement into nearby seagrass beds characterised by high algal productivity. General movement rates are low and size-related (Miller 1972; Hesse 1979; Appeldoorn and Ballantine 1983, Appeldoorn 1987). As a consequence, juvenile nursery areas tend to occur in specific locations that meet a number of ecological requirements (Stoner 2003), and may display continuity across years depending on the strength of larval supply (Stoner 1997; Stoner et al. 1998b).

In the Bahamas, Stoner (1989), Stoner and Waite (1990), and Stoner et al. (1995a) have shown that juvenile conch in back reef areas have a preference for seagrass of intermediate density and clean sand. Grazing activities of these juveniles help to maintain seagrass at the preferred density. Additional work by Stoner et al. (1995b, 1998b) suggests that this grazing activity by larger juveniles may promote survival of small juveniles by removing sufficient benthic structure such that small conch predators are devoid of shelter and suffer higher mortality themselves. Again, density becomes a critical factor. If the density in nursery areas is lowered through the harvesting of juveniles, seagrass density may increase and the subsequent survival of recruiting conch may be reduced.

In summary, the work of Stoner and colleagues documents that juvenile settlement and nursery areas can be special places where a combination of optimal environmental and ecological attributes yield rapid growth and reduced mortality. This suggests that maintenance of these locations in terms of both quality and quantity is essential to maintaining fishery production (Stoner 1998a).

Larval Dispersal and Connectivity

Dispersal of planktonic larvae is the primary mechanism for maintaining connectivity over large spatial scales. The exact length of larval life may be quite variable. Mariculture programmes routinely culture larvae to metamorphosis in two to four weeks (Dalton 1994), and Davis et al. (1996) recorded a larval duration of 14 days for larvae reared in field enclosures with natural assemblages of phytoplanktonic food. The maximum age of larvae sustained in culture is 60 days (D'Asaro 1965). Observations by Posada and Appeldoorn (1994) and by Stoner and Davis (1997) indicate that the average extent of larval dispersal is in the range of tens to hundreds of kilometres. However, conch larvae have been found in the middle of the Eastern Caribbean (Posada and Appeldoorn 1994) and in the North Atlantic Drift (extension of the Gulf Stream) (Sheltema, personal communication), indicating that some long-distance dispersal is possible.

Despite this potential, it is likely that dispersal is limited within sub-regions, a conclusion supported by empirical observations of larval distributions (Posada and Appeldoorn 1994; de Jesús-Navarrete 2001; Delgado et al. 2008). Therefore, the precautionary principle argues that populations within different countries should be managed as separate stocks (Delgado et al. 2008).

Habitat Quality and Anthropogenic Impacts

Queen conch are particularly sensitive to the quality of their environment. Relative to other Caribbean strombids, queen conch typically are not found in sediments containing silt or clay, preferring instead clean, coarse sand or hard bottom (Mateo et al. 1998; Glazer and Berg 1994; Glazer and Kidney 2004). Thus, any changes in benthic conditions resulting from land-based increases in sedimentation or turbidity will adversely affect the available productive habitat.

Water quality is equally important. Conch are very sensitive to pollutants, and even sub-lethal exposures can result in behavioural and physiological changes that lead to reduced growth and greater susceptibility to predation (Sanders 1984). Large-scale impacts of this effect are evident by the loss of reproductive capacity in adult conch found in inshore Florida waters (Glazer and Quintero 1998), thought to be due to a high exposure to anthropogenic compounds that impact reproductive development. This effect is reversible, however, as adults placed at offshore sites quickly undergo gametogenesis and successfully copulate and spawn (Delgado et al. 2004).

Larval conch are also sensitive to water quality. In studies on larval development and settlement in Florida, ambient waters with lower oxidation reduction potentials indicative of eutrophication resulted in longer larval duration, and larvae exposed to organophosphate pesticides were stimulated to undergo metamorphosis, even if they were not yet competent (Glazer, unpublished data.)

Vulnerability to Exploitation

Conch are slow-moving and tend to aggregate, making them easy to exploit once located, especially during reproduction. Several aspects of their behaviour result in an increase in vulnerability at this time. In many locations, conch move inshore to spawn as temperatures start to increase in

March (Hesse 1979; Weil and Laughlin 1984) and return to deeper water in October. This migration is manifest as a general shift in the distribution of conch, with conch in deep water migrating but still remaining deep relative to conch in shallow water areas. For example, Coulston et al. (1987) reported seasonal migrations ranging from 20 to 45 metres in a deep-water population. However, when habitats are optimal for reproduction and linked closely to forage habitats, conch may have limited annual movements (Glazer and Kidney 2004) with high site fidelity (Glazer et al. 2003) and with annual home ranges less than 2 hectare (Glazer et al. 2003).

Spawning habitat also makes conch vulnerable to harvest. During spawning, adult conch will tend to move on to sandy substrate (Stoner et al. 1992), and females will need about 24-36 hours to deposit an egg mass (Randall 1964; D'Asaro 1965); males will attempt to copulate during this time. Taken together, during spawning, conch are found in shallower water where they are more accessible, over open sand where they are more visible, and move less so they remain longer in this state.

The changing climate may also have direct implications for conch harvest. The exact length of the spawning season is temperature dependent, with the vast majority of spawning activity occurring between the months of July and September. However, in Puerto Rico, Florida (Glazer, personal observation) and other locations where minimum winter temperatures have been trending upward, conch now spawn year-round, thus making them vulnerable to harvest for longer periods of time.

Adult conch may have a prolonged lifespan; coral aged on the shell of live conch captured in Bermuda were at least 30 years old (Glazer, unpublished data). Given that mortality is particularly high in juveniles but decreases steadily (Appeldoorn 1988c), mortality in these older conch must be low for them to achieve observed longevities. Unfortunately, mortality for older adults has not been studied. The implication is that the probability of survival to reproduction (age 3-4 years) is low with high annual variation (dominant year classes have been documented) (Appeldoorn 1988a), and thus the extended reproductive lifespan of conch is needed to ensure successful replacement. Observed fishing mortalities suggest that this reproductive lifespan can be reduced to two to three years, which threatens sustained production.

Finally, what were once inaccessible refugia delineated by deepwater and remote locations are now easily exploited due to improvements in fishing efficiency and technology (i.e., engine-powered boats, the use of better quality fishing gears and the use of SCUBA or hooka). Populations that may have once been critical sources of larvae for downstream populations may now be vulnerable.

Predator-Prey Interactions

Conch are exposed to a variety of predators during ontogeny (Iversen et al. 1986). Several of these are exploited commercially, and resulting impacts to trophic pathways could affect conch production. For example, several sharks (e.g., nurse shark) and rays (e.g., spotted eagle ray) are important predators of larger conch and their declines may reduce mortality on larger juveniles and adults (*sensu* Myers et al. 2007).

Perhaps the most important predator-prey interaction is with the spiny lobster itself. Lobsters are major predators on small and medium-sized juveniles (Randall 1964; Herrera et al. 1994; Davis 1999), and Glazer et al. (1997) hypothesised that significantly lower mortality of hatchery-reared conch outplants released in the fall relative to other seasons was due in part to the removal of spiny lobsters by the Florida lobster trap fishery, which peaks during the fall. However, the nature of this interaction is complex, as spiny lobster production is probably enhanced due to high exploitation rates on its predators, but lobsters are heavily exploited as well. One cause for concern is the introduction of lobster casitas (Eggleston et al. 1992) which, by providing new shelter, may expand the range of lobsters into areas that previously offered refuge to juvenile conch.

Recommendations for Management

The unique aspects of queen conch biology and ecology form a basis for understanding the factors affecting production, which should be incorporated into any management plan. The pertinent aspects include the importance of density for reproduction and maintaining nursery areas, the identification of nursery areas as special places, the vulnerability of conch to degradation of habitat or water quality, the interaction of conch with other harvested species, and the vulnerability of conch to overfishing. Specific management tactics can be incorporated to address these and other general first principles of EBM. The following tactics are recommended.

Protect Nearshore Habitats

Ecosystem-based management must expand beyond the traditional scope of in situ protection and incorporate principles and methods of coastal zone management. Many conch nurseries are located in back reef areas such as seagrass beds. Many of these are close to shore and hence vulnerable to anthropogenic stresses associated with coastal development as well as enhanced sedimentation and siltation from poor land-use practices.

Protect Juveniles

This will help facilitate settlement and maintain the juvenile densities needed to maintain preferred seagrass densities and reduce early mortality.

Protect Spawning Adults

Queen conch are most vulnerable at this time, and protection will aid in maintaining needed adult density.

Establish Marine Reserves in Juvenile and Adult Habitat

Marine reserves serve many valuable management goals. They help maintain density at critical levels, as well as enhance overall spawning stock. For example, studies in the Exuma Keys Land and Sea Park estimated that a 20% closure supplies 70% of the larval production of queen conch (Stoner and Ray-Culp 1996). Furthermore, given the depensatory nature of their reproduction, reproductive output from small, high-density aggregations likely far overshadows that from vast areas at low densities. Thus, the impact in intensely fished areas would be even greater. Reserves would also help maintain genetic diversity and allow for a longer reproductive life.

Marine reserves also serve other critical functions. They support the precautionary approach by acting as a buffer against management error or failure, and they serve as reference or control areas. Comparisons between protected and unprotected areas allow for an assessment of population status independent of formal stock assessments and allow for fishing and non-fishing impacts to be independently assessed.

Multiple reserves should be established within a broad area where larval connections can be assumed. This will contribute to self-maintenance and provide spawning stock to repopulate overfished areas. This recommendation includes the offshore banks of the southwestern Caribbean, where high adult densities may be playing an important role in larval production and dispersal on a regional scale.

Monitor the Fishery

Ecosystem-based management does not remove the need for timely data collection and analysis. Queen conch fisheries are often conducted as an exclusive endeavour or combined with spiny lobster. This simplifies data collection and makes conch amenable to traditional stock assessment techniques (e.g., Medley and Ninnes 1999), despite difficulties in ageing adults. Periodic surveys of conch abundance (e.g., Aiken et al. 2006) are useful for tracking the impact of fishing, monitoring recruitment and assessing status by comparing densities with control or unfished areas. However, EBM does require additional types of data, the most important of which are the location where fishing is occurring and the location of known conch aggregations, especially juvenile nurseries and spawning grounds (Marshak et al. 2006). Much of the aggregation data may be obtained from fishermen interviews, or through the use of remote sensing (Stoner et al. 1996). Because habitat and water quality considerations are paramount in managing queen conch, knowledge of the location of key fishery or aggregation areas with respect to potential sources of anthropogenic impacts will be important to management. Also, because of limited migratory capability, complete mixing of the conch population cannot be assumed. Knowledge of where fishing is occurring will be important to determine what components of the stock are actually being exploited and thus if quotas (e.g., for CITES) need to be adjusted, or to ensure that fishing is only occurring in appropriate areas.

Caveats to EBM

At present, the main tool utilised for managing queen conch stocks is the quota, particularly as emphasised by CITES. Instituting an EBM approach requires a different perspective to management, one that may not be easy for management to adapt to given the long history of the single-stock assessment approach (Appeldoorn 2008). Clearly, some difficulties will arise, particularly due to lack of knowledge or inexperience. For example, little is known about the dynamics of conch stocks on the deep offshore banks targeted by the fisheries of Jamaica and Honduras, for example, especially with respect to the presence and location of nursery areas and spawning grounds. These may occur at spatial scales not easily amenable to the scale of fishing. While establishing no-take reserves in these areas can be used to address this uncertainty, such reserves are a challenge to enforcement and to fisheries departments with little expertise in aspects of co-management or working with stakeholder communities. Nevertheless, it is clear that quotas alone will be insufficient for maintaining healthy conch stocks, and many of the EBM recommendations can be implemented and monitored without substantial change in current procedures.

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EBM for Fisheries in the Wider Caribbean

Deepwater Red Snapper Fisheries

Sherry Heileman

Abstract

Deepwater red snappers (Lutjanidae) support valuable fisheries throughout the Wider Caribbean Region (WCR). Management of these fisheries, where it exists, is based on the single-species approach. Life history traits such as slow growth and spawning aggregation make snappers highly vulnerable to overfishing, and their essential habitats are under increasing threat from human activities. The limited potential yield in the WCR means that this resource is likely to become quickly overcapitalised and overexploited. Being top predators and keystone species, reduction in the abundance of snappers could have profound adverse impacts on the whole ecosystem. In this chapter, a number of ecosystem-based fisheries management (EBFM) measures for deep slope snappers are discussed. The impacts on fishers and the demands on the countries would have to be considered when developing EBFM plans for these species. The low potential yield favours small to medium-scale fisheries for deepwater snappers in the WCR.

Introduction

Deepwater snappers support valuable artisanal, commercial and recreational fisheries throughout their range, including in the WCR. Many deepwater fish stocks are exploited beyond sustainable levels and some have already collapsed (Koslow et al. 2000; Morato et al. 2006; Clark et al. 2006). Overexploitation is also evident in the deepwater snapper fisheries throughout the WCR. It is widely acknowledged that fisheries management needs to move from a single-species approach to one that integrates ecosystem considerations. EBFM is an improvement over single-species management because it ensures that the health and productivity of ecosystems will be maintained, and provides the foundation for long-term sustainability of the fisheries they support. This chapter, which is not meant to be exhaustive, presents a brief discussion of what the ecosystem approach would entail for management of deep slope snappers in the WCR, and the underlying biological, ecological and socio-economic considerations.

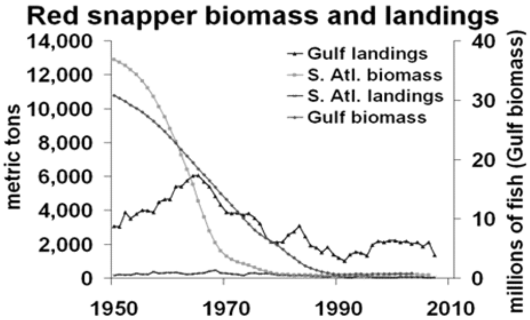
Red Snapper Fisheries and Their Status in the Caribbean

There is a long history of fishing for deepwater snappers in the WCR, with several species targeted in artisanal, commercial and recreational fisheries. The US has the highest annual landings of snappers (over 2,000 tonnes/yr), while in the southern Caribbean, Venezuela had the highest landings with over 3,800 tonnes in 2003 (FAO 2005a). Landings in the US fishery are dominated by the northern red snapper (*Lutjanus campechanus*) and vermilion snapper (*Rhomboplites aurorubens*) (SAFMC 2005). The southern red (*Lutjanus purpureus)*, silk (*L.vivanus*) and vermilion snapper are the major species exploited along the South American continental shelf from Colombia to Brazil, including Trinidad and Tobago. In fact, the southern red snapper fishery is one of the most important in the area between eastern Venezuela and northern Brazil (Charuau et al. 2001). In the insular Caribbean, the major species targeted in the deep slope and bank fisheries (e.g., in Puerto Rico, Barbados, St. Lucia, Jamaica and the French West Indies) are the queen (*Etelis oculatus*), silk and vermilion snapper. In St. Lucia, the queen snapper is specifically sought by fishers in a traditional fishery operating when migratory pelagics are not fished (Murray et al. 1992). The snapper/grouper fisheries in the Lesser Antilles are small-scale, and have been depth-limited by the fishing gear used and the artisanal state of the fishery (Mahon 1990). This is changing, however, as larger and more mechanized vessels enter the fishery. A variety of gear types are used in the deepwater snapper fisheries, including bottom longlines, wire-mesh fish traps and bottom trawls.

Deepwater snappers are generally considered to be overexploited throughout the waters of the southeastern US and Gulf of Mexico (SAFMC 2005; SEDAR 2005, 2008). Along the South American continental shelf, the southern red snapper is fully or overexploited (Manickchand-Heileman and Phillip 1996; Asano Filho et al. 2000; Charuau and Die 2000; Charuau et al. 2001). In contrast, the deep slope and bank fish stocks are probably underexploited in most of the Lesser Antilles (Mahon 1990), although in some areas, such as around Barbados, the resource may be fully exploited (FAO 2005b). Overfishing is evident in declining landings, biomass (Figure 13.1) and a reduction in the average size of the catch (Charuau and Die 2000; SEDAR 2008).

The US snapper fisheries are generally managed with size and gear restrictions, seasonal and area closures, and some limited entry and catch quotas. The trend of single-species management is changing, however. For example, in the southern US, ecosystem objectives are increasingly being integrated into the management of the deep slope snapper-grouper complex (SAFMC 2004). On the other hand, in the southern and insular Caribbean, EBFM is still at an embryonic stage, and few countries have regulations that are specific to deepwater snappers. On the Guianas-Brazil shelf, the snapper fishery is poorly regulated, and inadequate enforcement capability in most, if not all countries, is a serious limitation (FAO 2002). In order to address this, both coastal and flag states need to co-operate in controlling fishing and reducing effort, in the first instance, to ensure enforcement of existing regulations such as minimum sizes and effort regulations.

Figure 13.1. Northern red snapper biomass and landings from the US Gulf of Mexico and South Atlantic (SEDAR 2008)



Ecosystem-Based Fisheries Management for Deep Slope Snappers

EBFM for deep slope snappers would entail consideration of the following factors.

Avoidance of Excessive Fishing Capacity and Rebuilding Depleted Stocks

Deepwater snappers are generally slow-growing and long-living, with high ages of maturity and low natural mortality rates (Manooch 1987). These factors, combined with considerable variation in larval recruitment, make deepwater snappers highly susceptible to overfishing and slow to recover from population collapse. Vulnerability of northern and southern red snappers and silk snapper to fishing is estimated to be high to very high, while their resilience to environmental perturbations is low (Froese and Pauly 2008).

Among the required measures to address overexploitation of deepwater snappers are reductions in or prevention of further growth in fishing effort/capacity and rebuilding of depleted stocks. Assessments for southern red snapper on the Guianas-Brazil shelf recommended that current fishing effort should be reduced by 25-50% (Charuau and Die 2000). For the Venezuelan southern red snapper fishery, Mendoza and Larez (2004) showed that biomass levels in the year 2000 were 13-25% of virgin biomass. Significant population recoveries are possible if catches are maintained at relatively low levels, but biomass recovery to maximum sustainable yield (MSY) levels may take more than 10 years.

Other factors that demand a lower fishing capacity for deepwater snappers are the limited amount of deep slope and bank habitat, and therefore the limited potential yield, in the WCR, which means that this resource is likely to become quickly overcapitalised and overexploited (Mahon 1990). This situation favours small to medium-scale fisheries for deepwater snappers in this region.

Management of deep slope snapper fisheries should include adoption of the precautionary approach in view of the risk of undesirable outcomes (biological, social and economic) associated with this fishery and the uncertainties and limited knowledge. This approach is advocated in the FAO Code of Conduct for Responsible Fisheries and the UN Fish Stock Agreement. FAO has provided guidelines on the precautionary approach to the management of capture fisheries (FAO 1995). The precautionary approach also involves adaptive management as improved knowledge becomes available. Measures should also be taken to eliminate or reduce illegal, unreported and unregulated (IUU) fishing for deepwater snappers, as this contributes significantly to the uncertainties in knowledge about the fishery.

The above is consistent with conclusions and recommendations for the southern red snapper of the Western Central Atlantic Fisheries Commission Ad Hoc Working Group on Shrimp and Groundfish Fisheries in the Guianas-Brazil shelf (FAO 2002).

Reduction in Bycatch

In the southern US snapper-grouper fishery, several thousand kilograms of bycatch (which includes sea turtles, sea birds, fish and shark) are discarded each year, with variable mortality rates (Poffenberger 2004). Large quantities of juvenile deepwater snappers are also caught as bycatch in other fisheries, especially shrimp trawls and bottom longlines. This has contributed to the overfished status of this species and has significantly reduced the yield in the directed fisheries in some areas (SEDAR 2005, 2006). Similarly, on the Brazil-Guiana shelf, shrimp trawlers are an important cause of mortality for young southern red snappers. Preliminary estimates of the number of juveniles caught by typical shrimp trawlers in the French Guiana fleet are 1.5 to 2 million individuals (Charuau and Die 2000). Without some reduction in bycatch, stock assessments have projected that red snapper stocks cannot rebuild even if no harvest was allowed by the directed fishery. Several countries, including Brazil, Mexico and the US, have mandated the use of various bycatch reduction devices in shrimp trawl nets.

Protection of Snapper Spawning Population

Snappers, like groupers, aggregate to spawn, migrating long distances to specific spawning sites (Lindeman et al. 2000; Jackson et al. 2006). Available information suggests that shelf edge environments of moderate to high structural relief are spawning sites for many species, perhaps throughout the entire South Atlantic region. This spawning behaviour makes snappers easy to catch and many spawning aggregations have been eliminated in the Caribbean as a result of overfishing.

Management of snapper stocks should include denying access to known spawning aggregation sites during spawning seasons. Such fishing bans have been implemented for reef fish in many areas of the Caribbean. The migration routes should also be protected, but as they may be hard to identify, a blanket ban of fishing at times of aggregative spawning would be more effective. The impact of such drastic measures on fishers' livelihoods, however, would have to be taken into consideration.

Maintaining Biodiversity and Species Interactions

The broad management objectives are to protect the relationships that maintain the stability and diversity of ecosystems and sustain species, and thus fisheries (Sainsbury et al. 2000). Red snappers (including southern red snapper) are important components of the fish assemblages identified on the northeastern South American continental shelf by Bianchi (1992). Off the southeastern US, deepwater snappers form part of a snapper-grouper complex that includes over 70 species of fish (snappers, groupers, tilefishes, triggerfishes, grunts, porgies, sea basses, etc).

Snappers, which are keystone species, are active predators of a variety of prey items. Trophic interactions of deepwater snappers have been quantified in Ecopath with Ecosim (EwE) trophic models (Christensen et al. 2005), for example, for the Gulf of Mexico (Arreguin-Sanchez et al. 1993; Manickchand-Heileman et al. 1998) and the East Brazil Large Marine Ecosystem (Freire et al. 2008). Snappers are top predators that are usually the first to be fished out, with trophic cascades down the food web. These predators are usually replaced by smaller individuals and low-value, low-trophic-level species (Pauly et al. 1998; Bianchi et al. 2000). Using EwE simulations, Arreguin-Sanchez and Manickchand-Heileman (1998) found that changes in the biomass of the northern red snapper led to significant changes in the biomass of other groups in the system. Trophic interactions in deepwater snapper communities need to be better quantified, and the ecosystem impact of fishing better understood, so that these issues can be accounted for in EBFM for this group.

Protection of Essential Fish Habitat

EBFM also requires the protection of essential fish habitats ((EFH)-habitats) for the survival and growth of each life history stage. These stages of deepwater snappers are distributed over a wide depth range (coastal and surface waters to over 500 m) and diversity of habitats that are vulnerable to degradation from anthropogenic activities. Inshore habitats such as mangrove lagoons, coral reefs and seagrass beds are known nursery areas for juveniles of many of the species caught on deep slopes and banks as adults. Juvenile and adult snappers are typically bottom dwellers and are relatively sedentary, with fidelity to certain sites (Workman et al. 2002; Szedlmayer and Schroepfer 2005). Adults are found in deepwater, usually associated with hard structures that have moderate to high relief. Snappers are also associated with unique and vulnerable deepwater coral (*Oculina*) habitats found in the Caribbean and off the southeastern US (Lutz and Ginsburg 2007; Ross and Nizinski 2007; NOAA 2008), which have been identified as EFH for federally managed species (NOAA 2008). In recent years, commercial fishing on these reefs has caused extensive damage to corals and significantly depleted members of the snapper-grouper complex (Koenig et al. 2005).

While no significant threat of deepwater trawling has been reported for the WCR, shrimp trawlers have been exploring deep areas off Colombia. The impacts of trawling on the deepwater coral banks off Colombia need to be assessed (Reyes et al. 2005). On the South American continental shelf, extensive trawling occurs in the penaeid shrimp fishery, including in nursery areas for snappers, but the impact has not been studied in this area. Nevertheless, studies in other areas have already shown that this causes profound changes in habitat quality and community structure. The large, heavy traps used on the slopes could also cause significant habitat damage, and the use of less harmful gear such as handlines might be more suitable in these areas. Lost fishing gear also damage habitat and fish populations through 'ghost fishing'.

The destruction and degradation of EFH can be expected to adversely impact fishery yields. Yet, important habitat areas for snappers are generally not protected in the WCR. In this region, shallow water habitats are under increasing threats from development activities and land-based pollution, as well as from climate change impacts (e.g. coral bleaching). Assessments conducted in the Caribbean by the Global International Waters Assessment found that destruction and modification of coastal habitats are severe in many areas throughout the region (UNEP 2004a, 2004b). Potential threats to deep sea ecosystems include oil and gas drilling activities, which are considered to have the greatest impact after fishing operations (Glover and Smith 2003).

In view of the above, the importance of coastal habitats for deepwater fisheries should be emphasised in the coastal zone planning and management process (Mahon 2002). This will include assessing and minimising adverse environmental impacts on the resources and their habitats. These measures are consistent with a number of environmental agreements, notably the Cartagena Convention and the Convention on Biological Diversity, to which several WCR countries are parties. A number of the countries are also developing integrated coastal zone management plans and establishing marine protected areas (MPAs), although not specifically geared towards protecting deep slope snapper EFH.

Progress has been made by the SAFMC and Caribbean Fisheries Management Council (CFMC) in protecting snapper EFH in the southern US. EFH in the Caribbean, South Atlantic and Gulf of Mexico has been described and measures for protecting EFH from fishing effects have been implemented by the respective fishery management councils. For example, fish traps have been banned in the South Atlantic reef-fish fishery. The SAFMC Fishery Management Plan for the snapper-grouper complex includes MPAs off South Atlantic states where fishing for and retention of snapper-grouper species would be prohibited. In 1984 the '*Oculina* Banks' was designated a Habitat Area of Particular Concern (HAPC) – the world's first marine protected area specifically designed to protect deep sea corals. The CFMC is considering protection of Bajo de Cico – an area west of Puerto Rico that may contain deep sea coral resources (NOAA 2008).

Despite some progress, more needs to be done in nearshore EFH and in other parts of the WCR to protect EFH. An important requirement for EBFM is to identify and map EFH for deep slope snappers, which would also help in the placement of MPAs and assessing the potential impact of human activities.

Consideration of Global Environmental Changes

Other factors that are likely to affect fish stocks, including their biology and their habitats, are global environmental changes such as climate change and ocean acidification (Mahon 2002; Nellemann et al. 2008). As the effects of climate change cannot be easily controlled nor predicted with certainty, it is important to maintain healthy ecosystems and fish populations so that they are more resilient to climate change impacts. Therefore, a general strategy to conserve these habitats both in quantity and in quality would be an appropriate precautionary adaptation to the effects of climate change (Mahon 2002). Climate change issues should also be fully integrated into regional and national decision-making and planning for the fisheries sector.

Regional Approach to Assessment and Management

The Task Group on Snapper Fisheries of the Brazil-Guiana Shelf suggested that the snapper fisheries in the Brazil-Guiana region were in particular need of a regional approach to management because of the extent of foreign fishing in the region and the artisanal nature of the fisheries in some areas, requiring close cooperation and sharing of information if the resources and fisheries are to be accurately assessed and monitored. In addition, while the stock structure of the snapper species in the region is unknown, it is likely that stocks are separated by the major rivers, with shared stocks north of the Orinoco delta and between the Orinoco and Amazon deltas (FAO 2002). Such cooperation should include open and transparent sharing of data and information on snapper fishery operations as well as cooperation in scientific research, assessments, monitoring, and control and surveillance of the fishery. In order to achieve a sustainable red snapper fishery, snapper stocks should be assessed throughout their range and the operations of the fleets described for the whole region. It is also important to determine the extent to which deepwater snapper stocks are shared and to identify the different stocks and their geographical distribution.

Integration of Human Aspects

Fisheries are not only concerned with the exploited resource and its habitat, but also with the human aspects (governance, social and economic aspects, including the impact of management measures on fishers), which must be taken into consideration in EBFM. Deepwater snapper fisheries provide an important source of food (including for the tourism market), employment, income and recreation for people in the WCR. Snapper fisheries support a lucrative export market in the WCR and, along with other groundfish species, are an important source of employment and income in many rural communities. A decline in these fisheries could lead to loss of income, employment, food supply and foreign exchange in some countries in the region. At the same time, EBFM would also affect fishers' livelihoods, which must be also considered. The FAO guidelines for responsible fisheries (FAO 2003) discuss a number of principles related to the human dimension that needs to be taken into account in the ecosystem approach to fisheries.

Research for EBFM of Deepwater Snappers

Some of the data needs for EBFM are similar to those for the conventional single-species approaches to fisheries management. EBFM requires additional knowledge about the ecosystem and human dimensions, including the impacts of fishing. Topics for EBFM research would include: the ecosystem structure and function, including trophic interactions and implication for fisheries productivity; the impact of fishing on the deep slope snapper stocks, non-target species, habitats and the ecosystem as a whole; stock identity and distribution in the WCR (including larval dispersal); the identification and mapping of EFH of deepwater snappers; the potential of MPAs as a fisheries management measure for deep slope snappers; minimum levels of biomass compatible with the maintenance of the species' ecosystem function; the impact of environmental changes on deepwater snapper stocks and their habitats; quantification of socio-economic benefits of the fishery as well as of the impact of stock collapse; development of reference points and a suite of robust indicators (socio-economic, fish stock and ecosystem); an economic valuation of the fishery and of other ecosystem services that these species and their associated ecosystem provide.

Conclusion

The WCR is still a long way from mainstreaming ecosystem objectives into the management of its deepwater snapper fisheries. Countries will need to re-orient their legal and policy framework and decision-making structures, which should be complemented by building capacity for EBFM in the region. Depending on the deep slope snapper stock structure in the WCR, a sub-regional and/or regional approach might be necessary. This would require dialogue at the appropriate level, harmonisation of data collection, and collaboration in research, monitoring and surveillance as well as data and information sharing, among others. EBFM implementation will place a considerable burden on the countries of the WCR, in terms of technical capacity, data and information, and financial and other resources that are already limited. Furthermore, the operation of this fishery in offshore areas makes monitoring and surveillance all the more difficult. These challenges should not deter the implementation of EBFM of deepwater snappers in the WCR, which could be done in small, incremental steps over a period of time.

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An Ecosystem Approach to Fisheries for Large Pelagic Fish Resources in the Caribbean Large Marine Ecosystem

Susan Singh-Renton, David J. Die and Elizabeth Mohammed

Abstract

Large pelagic fish resources, such as tuna and wahoo, are usually migratory and are often not confined to specific sea areas such as the Caribbean Large Marine Ecosystem (CLME), but are shared with and utilised by stakeholders outside the CLME. Implementing an ecosystem approach to fisheries (EAF) for these resources therefore requires coordination of policy and management, from local through regional to international levels of governance in order to integrate multiple stakeholder objectives and achieve compatibility across all sea areas relevant to these stocks. In this paper, we propose that a principal EAF authority for large pelagic fish resources be assigned at each recognised level of governance (local, national, regional, international) to serve a central coordinating role for networking and reporting at that level. A management partnership arrangement involving the International Commission for the Conservation of Atlantic Tunas (ICCAT) and Caribbean regional fisheries organisations (RFOs) may provide the best option for a principal EAF authority at the Caribbean level. As with organisations charged with conventional fisheries management, each principal EAF authority will be expected to pursue good governance and management practices while nurturing the required inter-sectoral integration and compatibility over the entire sea areas and governance boundaries concerned. Capacity building, public education and the cost of implementing an agreed EAF for large pelagic fish resources also warrant special attention.

Introduction

An ecosystem approach to fisheries strives to manage fishery resources by managing and conserving the whole ecosystem concerned. EAF retains a central focus on human well-being but links this to the well-being of the ecosystem that provides for a strengthened approach to a sustainable development of fisheries (Garcia et al. 2003; FAO 2003). Recognised as a critical component of the management of large marine ecosystems (LMEs), EAF is prescribed by a number of legal instruments (Wang 2004).

Applying an EAF to large pelagic fish presents many challenges. Large pelagic fish resources include a range of species from sharks, large tunas and billfishes that can migrate long distances over entire oceans to smaller tunas, mackerels and dolphinfish that migrate over smaller sea areas. All of these species, however, are top predators of the ocean environment, and so their health and survival are closely linked to the health and survival of their prey species. Such prey species are often smaller-sized pelagic fishes that are themselves the target of other fishing operations. As such, there is also a close 'trophic' link between the fisheries that harvest these large predators and those that harvest their prey. Additionally, fishing gears used to target large pelagic fish resources, such as longlines, can also catch other marine resources such as sea turtles, sea birds (Horrocks et al. Chapter 9) and various other species of fish (Heileman Chapter 13) that are not retained and constitute a bycatch. Hence the impacts of fishing activities directed at large pelagic fish resources extend beyond these resources and are linked to other parts of the ecosystem.

In view of the transboundary nature of large pelagic fish resources, regional EAF initiatives must consider ecosystem management units of interest beyond those that are defined by their boundaries of regional responsibility – e.g., the appropriate unit could be the whole of the Caribbean or the entire Atlantic. Additionally, because these resources are often harvested in the High Seas by distant water fishing nations, regional EAF initiatives have to consider these additional stakeholders. Strong coordination and linkages within and among different levels of governance are therefore critical (Garcia and Charles 2008).

The International Commission for Conservation of Atlantic Tunas (ICCAT) is the regional fisheries management organisation (RFMO) that coordinates management and conservation of tuna and tuna-like fishes for the Atlantic Ocean and adjacent seas. Most of ICCAT's efforts have focused on the large tunas and billfishes that support highly profitable fisheries. For those Atlantic stocks believed to be severely overexploited, e.g., northern bluefin tuna, blue and white marlin, and shortfin mako shark, ICCAT stock rebuilding programmes are in effect.

As the small tunas and tuna-like species tend to be more coastal in their distributions, ICCAT has been recommending local/sub-regional/regional assessments of these species. A few of such assessments have been attempted (CRFM 2006; ICCAT 2009). Recently, ICCAT has begun to investigate tuna fishing impacts on other ecosystem components such as seabirds and mammals, and a few ICCAT regulations are now directed at mitigating bycatch impacts. Nonetheless, ICCAT fisheries management policy remains oriented towards target species.

In the CLME, fisheries for large pelagic fish resources are still being developed and expanded in several countries. In the few instances of active large pelagic fisheries management, strategies have been generally restricted to the conservation of target species (e.g., NMFS 1999, 2006), and few fishery management plans currently contain specific operational strategies for ecosystem management approaches (Die 2009). In most countries, stakeholder consultation and participation in governance remain fragmented and weak, despite efforts to address this problem (CRFM 2004) and recognition of its potential role in effecting new and more successful ways of managing fisheries systems (Lane and Stephenson 2000; Mahon et al. 2008).

This chapter focuses on those issues related to the systems and mechanisms required for EAF management of large pelagic fish resources in the CLME. For this, we assume the same, general management system applied in conventional fisheries management: policy development, strategy development, management planning and implementation (Garcia and Cochrane 2005). We identify key research and resource assessment activities needed to inform the EAF management planning and decision-making process for these resources. When necessary, short term/interim measures are proposed as intermediate steps towards achieving an ecosystem approach to fisheries in the long-term.

The EAF Policy

Issue 1: Establish multiple-level governance network for integrated and compatible EAF policy planning and implementation

Relevance

EAF policies should be holistic, addressing the management and conservation of not only the fisheries resources of direct interest (hereafter referred to as 'target resources'), but also of other resources (hereafter referred to as 'associated resources') and the overall associated ecosystem. The adopted approaches must integrate the needs of fisheries stakeholders with those of stakeholders from other economic sectors (hereafter referred to as 'fisheries-related stakeholders') whose activities impact or are impacted by the health of these resources. For large pelagic fish resources, institutional networking is therefore critical to good governance (Garcia and Charles 2008), with inter-governance level networking needed for development of policies that are compatible over the entire resource area and stakeholder community concerned.

Recommendations

The policy must identify all key local, national, sub-regional and regional/international stakeholder partners, recognise their relative rights, the relationships to be fostered, and stipulate the responsibilities and roles of each partner. The most cost-effective option would be to establish an EAF network based largely on existing organisations, some of which may still need to incorporate the EAF concept into their mandates. For this option, Figure 14.1 illustrates the potential network of key organisational partners at each governance level required for EAF policy planning and implementation for large pelagic fish resources in the CLME region: that is, anticipated essential linkages within each governance level (intra-level networking), as well as those linkages anticipated across governance levels (inter-level networking). EAF policy would therefore also have to facilitate the establishment of formal intra-governance level and inter-governance level partnership arrangements, as shown in Figure 14.1.

Issue 2: Identify/assign a principal EAF authority to serve a coordinating role at each governance level, and a companion authority for general ecosystem conservation

Relevance

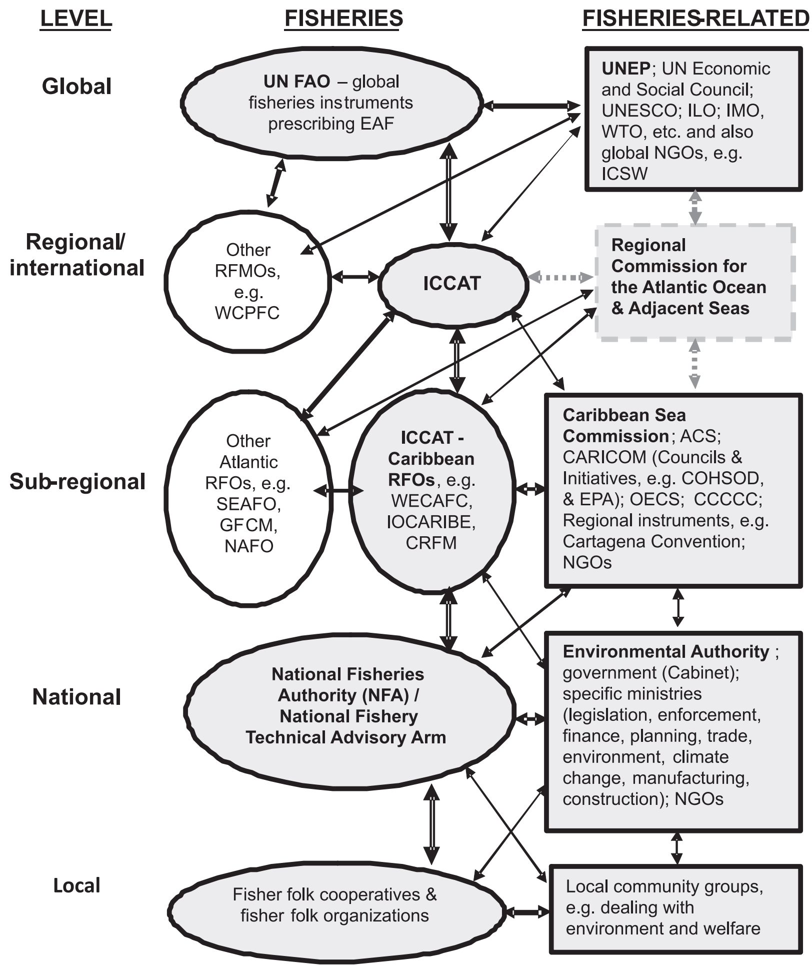
The identification and assignment of a principal EAF authority at each governance level is necessary for: (1) effective communication and coordination among all stakeholder groups at the same governance level (intra-level networking) and for coordinated representation of stakeholder group interests at other governance levels (inter-level networking); (2) recognition at all governance levels of the assigned, coordinating role of each EAF authority; and (3) integration and compatibility through coordinated networking.

Recommendations

At the global level, the FAO can be considered to serve the role of principal EAF authority, and the UNEP to oversee management of the ecosystem environment in general. Formal collaboration between the FAO and the UNEP could thus help to ensure that the wider global community incorporates EAF goals into all relevant planning processes.

A regional Atlantic Ocean commission should be established to serve the same role as the UNEP for the Atlantic region (Figure 14.1). Also, as the largest tuna RFMO operating within the Atlantic region, ICCAT could be assigned as the principal EAF authority for this area, especially as

Figure 14.1. A Cost-Effective Option of Organisational Networking Arrangements for Implementing EAF Management of Large Pelagic Fish Resources within the CLME. Direction and thickness of arrows show recommended communication and reporting flows and their strengths. Proposed EAF authorities and those for general ecosystem management are indicated by emboldened text. Non-Atlantic partners are enclosed in white-filled bubbles. The non-existence of the Regional Commission for the Atlantic Ocean and Adjacent Seas is shown by dashed lines.



ICCAT and tuna RFMOs from other oceans are now collaborating routinely to consolidate their approaches (ICCAT 2007). This said, the focus of ICCAT on tuna and tuna-like fish stocks may hinder its capacity to co-ordinate the management of target fisheries with that of associated resources in the ecosystem. Moreover, although ICCAT has recently collaborated with other organisations to help its work on some selected components of the ecosystem (seabirds), it may prove a big challenge for ICCAT to do so for all components of the pelagic ecosystem. ICCAT would also have to accept EAF as its guiding principle for management actions.

The Caribbean Sea Commission was established in 2006 for the purpose of overseeing general management of the Caribbean Sea, and could support the process by which EAF goals become incorporated into the relevant planning processes of the wider CLME stakeholder community. Given the current mix of RFO memberships and mandates, a principal EAF authority at the sub-regional/CLME level for large pelagic fish resources may best be achieved through a formal management partnership arrangement between ICCAT and Caribbean RFOs.

At the national level, most states have established environmental and fisheries management authorities. The environmental management authority could function as the general marine ecosystem guardian at the national level, especially as the health of the coastal marine ecosystem is so closely tied to terrestrial activities. The designated national fisheries authority (NFA) is usually supported by a technical advisory arm, such as a national fishery advisory committee (NFAC) in many CARICOM (Caribbean Community and Common Market) countries or a fishery council or other similar structures in the case of the Caribbean US. In view of this, the NFA, together with its technical advisory arm, is best suited to serve as the principal national EAF authority. As such, the NFA should engage in a formal collaborative relationship with the national environmental management authority.

The EAF Strategy

Issue 1: Achieve good practices by the principal EAF authorities

Relevance

The principal EAF authorities should follow fundamental principles of good governance as well as good fisheries science, development and management practices – i.e., principles of integration, collaboration, transparency, accountability, versatility, adaptability and sustainability (Garcia et al. 2008). These principles are particularly relevant to the EAF for large pelagic fish resources that require cooperation and compromise among stakeholder groups that, for some fisheries, are spread over the entire globe.

Recommendations

Each principal EAF authority should establish mechanisms for making these basic principles operational, and for providing the foundation for an integrated and compatible EAF policy and management framework.

The relevance of appropriate aggregation of stakeholder groups for shared resource governance has been noted by Chakalall et al. (2007). The interests of community groups at the local level should be aggregated into national goals, constraints and positions that, in turn, would require further aggregation to formulate sub-regional goals, constraints and positions, as well as strategies, for representation at the higher governance levels. All other principles should be made operational with agreed levels of aggregation as well. Caribbean RFO efforts to develop aggregated representation of fisheries stakeholder needs during ICCAT-level negotiations are noteworthy in this regard (Singh-Renton et al. 2003).

Issue 2: Assign principal EAF authority at the regional/international governance level

Relevance

Active participation in and cooperation with the ICCAT provides an opportunity to ensure integration and compatibility of CLME large pelagic EAF goals with those adopted by ICCAT, which has an extensive and growing membership.

Recommendations

Countries that target tuna, tuna-like fish resources and sharks, should: (i) invest in membership in the ICCAT, (ii) have active, planned input into ICCAT's policy and management planning and decision-making process, and (iii) urge the development of a robust ICCAT-level EAF that takes into account CLME national and sub-regional goals and objectives. Countries that do not harvest tuna and tuna-like species but whose social and economic development is significantly dependent on the health of these resources and their fisheries should also consider membership in ICCAT. For countries with an indirect interest in, or dependence on, large pelagic fisheries, it may be sufficient to participate in ICCAT in an observer capacity. National EAF frameworks regarding institutional, legislative, policy, management and technical matters must support meaningful participation in ICCAT, whatever the intended level.

Issue 3: Assign principal EAF authority at the sub-regional/CLME governance level

Relevance

Acknowledging varying limitations in the mandate, membership and jurisdictional boundaries of key Caribbean RFOs involved in large pelagic fisheries management, the establishment of a formal management partnership arrangement between ICCAT and Caribbean RFOs is recommended. This arrangement can provide a forum having both the necessary mandate and membership to achieve active and well-coordinated assessment and management of the region's small tuna and tuna-like species. It can also facilitate the sharing of knowledge and expertise among ICCAT and sub-regional organisations in order to establish robust EAF management strategies for all large pelagic resources in the CLME.

Recommendations

ICCAT and Caribbean RFOs such as the Western Central Atlantic Fishery Commission (WECAFC) and the Caribbean Regional Fisheries Mechanism (CRFM) should establish a suitable management partnership arrangement. Countries should participate actively in the ICCAT-Caribbean RFOs management partnership arrangement and make use of the arrangement for development of a meaningful EAF for all CLME large pelagic resources. National EAF frameworks regarding institutional, legislative, policy, management and technical matters must support meaningful participation in the established management partnership arrangement.

Issue 4: Assign principal EAF authority at the national level

Relevance

The NFAs and existing supporting technical advisory arms address the day-to-day challenges of advocating good fisheries governance, development, management and science at the national and local community levels. Foundations laid at this level will determine the success of any EAF policy adopted at higher governance levels for large pelagic fish resources.

Recommendations

For large pelagic resources, national fisheries policy and legislation need to facilitate integration across economic sectors, compatibility across governance boundaries and synchronisation of adopted actions. This involves identifying and making provisions to implement the essential networking and partnership arrangements. As in conventional fisheries management, the full range of national resources and expertise needed for all tasks must be identified, from data collection to surveillance and enforcement, and developing and negotiating positions. Very importantly, national policy and legislation should recognise the role of the NFA as the national EAF authority, and make provisions to realise its coordinating role, especially important for consensus-building among stakeholder groups and for effective representation and participation at higher EAF governance levels.

Issue 5: Develop agreed management goals and priority operational objectives

Relevance

Stakeholder interests for large pelagic fish resources can incorporate social, cultural, religious, economic, ecological, legal and political differences. Hence, education, consultation, cooperation, compromise and consensus are necessary for management goals and objectives to enjoy broad ownership, understanding and compliance by the entire stakeholder community.

Recommendations

The role of aggregate stakeholder groups, as outlined under Issue 1 of this section, is again emphasised. Principal EAF authorities should implement stakeholder educational programmes about the benefits of EAF, as this would help to guarantee more informed decision-making. A hierarchical framework of objectives should be developed and analysed, as outlined by the FAO (2003). For large pelagic resources, such a framework approach would have to be undertaken at each governance level, with inputs from other levels. Similar to conventional fisheries management, agreed management targets should be precautionary from the outset to account for uncertainty in data and scientific understanding.

It should be noted that the negotiating and decision-making processes at ICCAT can often be dominated by the larger, more industrialised member states. This can be overcome to a notable extent if the smaller, less developed countries pursue a planned approach to achieving their envisaged goals, and invest sufficiently, using their own national funds, in the management planning and implementation systems needed to help realise these goals.

The EAF Management Plan and Its Implementation

Issue 1: Ensure active EAF legislation and management cycle

Relevance

While management measures for large pelagic fish resources should be determined at the sub-regional or regional levels of governance, national legislation has to facilitate an effective and timely response to agreed regional decisions about management actions. At present, fisheries issues are not attributed a high priority in several CLME countries, resulting in passive fisheries management approaches. This can severely hamper the achievement of compatibility and synchronisation in implementing adopted EAF regulations for large pelagic fish resources.

Recommendations

Once suitable national legislation is in place, it is an available tool to aid management. The national principal EAF authority should then establish an active management cycle that would give life to all aspects of the legislation. For large pelagic resources, this active management cycle would also contribute more effectively to the timely updating of EAF regulations that are sometimes required when new EAF recommendations are adopted at the sub-regional and regional/international levels of governance. Clearly, for large pelagic resources, activities comprising the national management cycle should be synchronised with similar activities at other governance levels, e.g., data analysis, negotiation and decision-making.

Issue 2: (I) Develop a strong information base with good national statistics

Relevance

The success of sub-regional/CLME and regional/international EAF assessment and management efforts for large pelagic fish resources are highly dependent on good quality national level contributions in statistics and research that are harmonised and compatible among the contributing countries.

Recommendations

A sub-regional/CLME database on large pelagic fish resources is desirable to support sub-regional EAF assessment efforts in a sustained and progressive manner over time. Alternatively, or in the short term, an expansion of the ICCAT database is recommended with sub-regional components, e.g., a CLME component. Clearly, national data collection systems must be strengthened to guarantee adequate contributions to the agreed database. In addition, national scientists from fisheries and related agencies should collaborate to share various types of data needed for integrated evaluations, e.g., social, economic, environmental and climate data.

Issue 2: (II) Develop a strong information base through research and assessment

Relevance

Research and assessment improve our understanding of resource biology and ecology, and the role of each resource in sustaining a healthy ecosystem, as well as human well-being. In addition, for large pelagic resources, knowledge of fish movement and migration patterns and the linkages of these to specific fish behaviour such as spawning will highlight critical time periods and areas in need of protection, and will identify the nature and extent of resource sharing over distance and among stakeholder groups. This and other information on resource and ecosystem relations and functions can be used to define and defend the ecological boundaries for stakeholder operations. Additionally, proposed management measures will receive stronger support if these take into account social and economic contributions of the resources and their habitats, as well as stakeholder capacity for adaptive management.

Recommendations

Agreed priority operational objectives should guide research strategies at all governance levels. Recognising that statistics and research systems in many Caribbean countries have had difficulties meeting the challenges of conventional fisheries management, the region's scientists should explore and develop analytical methods for data-poor situations, applicable at least in the short term. Though evaluation of a range of EAF performance indicators would be desirable, simple indicators of resource health, food web stability and habitat health could be used in the short term. National scientific capacity could be strengthened through active participation in sub-regional RFO and ICCAT activities. This would also serve to improve work coordination within and among governance levels, and to nurture key scientific partnerships.

Single-species studies examining biology and ecology are recommended to provide the basic information for evaluating species-species and species-habitat relationships. Tagging and genetic studies determine stock boundaries and migration patterns where unknown, e.g., wahoo and king mackerel. Tagging studies usually require sustained effort and funds over a long period, but the results provide definitive proof of stock sharing and movement.

In terms of specific recommendations, the recently concluded Lesser Antilles Pelagic Ecosystem (LAPE) project that investigated trophic web relations and the ecosystem impacts of fishing should be continued and expanded (FAO 2008b; Mohammed et al. 2008). Other analysis tools, such as ecological risk assessment for the effects of fishing (ERAEF) (Hobday et al. 2006), examine ecosystem component interactions and can identify those species and habitats at most risk from fishing as well as from other human/human-induced activities. Also of direct relevance are evaluations of fishery-fishery interactions and fishery bycatches (biological interactions), as well as fishing gear-species interactions (technical interactions).

Social and economic studies are strongly recommended as well, to appreciate the link of these aspects to fishery performance and the adaptive capacities of stakeholders. The application of multiple criteria analysis/tradeoff analysis would allow stakeholders to appreciate the tradeoffs among various EAF management (operational objective) scenarios.

Issue 3: Establish controls consistent with practical monitoring and surveillance options

Relevance

Large pelagic fishing operations extend into the high seas and can involve at-sea transshipment and fish processing operations that make it difficult to monitor both numbers of operating vessels and catch levels by species. Measures that provide greater control and incorporate precaution at the input levels of stakeholder operations will be more effective at limiting operations than controls placed further along the stakeholder and industry chain.

Recommendations

Possible input controls include limiting fishing vessel construction, numbers of operating vessels, seasons of operation, fishing vessel size and hence capacity, numbers of participating fishers, numbers and sizes of fish processing companies, numbers of fishing gear units and types. Similarly limiting the input levels of fisheries-related stakeholders, e.g., hotel accommodation and tourist capacity, and limiting coastal developments to reduce pollution of critical habitats would also count as input controls. All management measures, whether input or output controls, should incorporate agreed levels of precaution to counter the potential negative impacts of incomplete monitoring, control and surveillance systems, false reporting and non-reporting.

Issue 4: Establish a suitable monitoring, control and surveillance (MCS) system

Relevance

For large pelagic fish resources, MCS systems for output controls typically involve a large component of 'at-sea' activities, e.g., observer programmes, vessel patrols, which could be complex and less than robust (e.g., ICCAT 2007). Input controls can reduce the cost and complexity of the required MCS, as well as its potential to fail. A strong MCS system is also likely to promote greater compliance with, and hence confidence in, management measures.

Recommendations

To the extent possible, input controls are recommended to avoid the need for a MCS that involves a large 'at-sea' component. The MCS system should include a licensing and registration (LRS) system for fisheries stakeholders and associated operations, e.g., vessel construction companies, vessel owners, fish purchasers, traders and transshippers should be registered and licensed to operate. Similarly, fisheries-related stakeholders, e.g., yacht and dive companies, should be registered and licensed to operate and should be obliged to report 'resource user' and 'habitat user' data, as required. If output controls are preferred, then additional resources would be necessary to support a more complex MCS system.

Issue 5: Develop national EAF management capacity

Relevance

By its nature, management of large pelagic fish resources is a collaborative enterprise because no single country or fishing entity has the capacity to provide the resources or knowledge to design, and even less capacity to implement, the EAF without relying on others. Notwithstanding differential capacities of countries, all have an equal responsibility to have in place at least an agreed minimum suite of expertise and resources required for EAF management.

Recommendations

An integrated and structured approach to management capacity building is essential to maximise efficiency, even when resources are limited. With limited funds, it may be necessary to build capacity in phases. While some capacity building requires governments to strengthen and/or expand relevant departments, others, such as technical expertise, can be addressed through networking and collaboration of counterpart staff at the sub-regional RFO and regional/international RFMO levels. For large pelagic fish resources, capacities for ensuring compatibility in statistics, resource assessment and management across governance boundaries and for conducting stakeholder negotiations at higher governance levels require particular attention. Such capacities may be nurtured by sustained manager and stakeholder participation in EAF activities, which then facilitates the accumulation of experience and intelligence.

Issue 6: The additional costs of EAF implementation

Relevance

Implementing any EAF is more costly than the cost of conventional fisheries management, and many Caribbean countries are challenged to meet EAF implementation costs. If costs are not met, the implementation framework will be weak, fragmented and ineffective.

Recommendations

A mechanism for sustainable financing of EAF is essential. Revenue generated by resource user license and registration fees could be used to help meet EAF costs. At each governance level, fees could be charged for stakeholder participation in the process, with an appropriate fee structure reflecting a stakeholder's capacity to pay, and the nature and extent of stakeholder impacts. Any stakeholder that has an impact on the pelagic ecosystem, including those that pollute the environment, should be taxed accordingly. Membership/participation contributions at national governance levels should be set at levels that automatically facilitate membership/participation at higher levels of governance, e.g. ICCAT. Public education programmes that include social and economic valuations can play a vital role in strengthening public support and political will for EAF.

Given the real costs associated with the shift from conventional to EAF management approaches, it may be appropriate to use tools such as an institutional analysis and development framework to evaluate and monitor the effects of such changes (Rudd 2004). A thorough analysis of costs and a careful system of monitoring future benefits of the change may also help to improve public support for the proposed change in management approaches.

General Conclusions and Recommendations

For large pelagic fish resources, the physical marine ecosystem management unit may often span beyond the limits of the CLME, and the stakeholder community can be spread globally. These conditions dictate that EAF approaches be integrated across sectors, and be well coordinated and compatible across the entire space of interest and across multiple levels of governance. EAF policy and management for these resources therefore requires the establishment of a multiple governance level network to facilitate inter-sectoral collaboration among the full range of stakeholders. Strengthening stakeholder ownership and leadership in the management process is crucial for improving on conventional, government-driven management approaches.

To facilitate coordination in and among governance levels, a principal EAF authority should be assigned at each level of governance. At the CLME level, EAF policy and management may be best implemented through a sub-regional management partnership arrangement involving ICCAT and key Caribbean RFOs, with overlapping mandates. Each principal EAF authority should establish mechanisms to ensure that its activities abide by principles of good governance, development, management and science. This will be crucial to guarantee transparency and stakeholder equity in setting goals and objectives and in so doing, foster universal respect for, and stakeholder cooperation in, implementing the agreed policy and management directions. Additionally, EAF authorities need to educate their stakeholder communities about the issues at hand in a manner that nurtures effective participation as well as aggregated stakeholder representation whenever feasible, at all levels of governance. Successful implementation of an EAF at the sub-regional and regional/international levels will be heavily dependent on the strength of national level capacities and contributions.

Given the multiple objectives of the extended stakeholder communities associated with large pelagic fish resources, it will be necessary to establish a process for prioritising objectives while nurturing cooperation and compromise among stakeholders in building consensus, and to determine and agree on precautionary targets and levels of actions when data and information are uncertain. Activities pertaining to statistics, research and management need to be compatible across the full extent of the ecosystem management unit. In the case of statistics for large pelagic resources, necessary for facilitating CLME-level EAF assessments, a suitable EAF database should be established for CLME assessments/evaluations, with links to the ICCAT database that already exists or, alternatively, the ICCAT database could be modified to facilitate CLME EAF needs. Regarding management regulations adopted at the higher governance levels, a robust and active national legislation and management cycle are needed to effect timely revision and updating of regulations in striving for compatibility.

To achieve more effective management control, input controls such as limiting the number of fishing licenses would require a less complex MCS than output controls such as setting catch quotas. Whichever controls and MCS are applied in practice, the education and cooperation of stakeholders will play a key role in contributing to its success.

To shift from a conventional fisheries mode to one of implementing EAF, many CLME countries will need to expand and strengthen their capacity in a number of areas, e.g., communication, negotiation, legal and science. In these instances, countries will need to develop an integrated and structured programme of capacity building. Where resources are limited, a phased approach can still yield benefits without compromising the overall long-term policy and management directions. Where stakeholders are sharing ownership and leadership of the management process, their inputs into capacity-building tasks will help to reduce overall costs to governments.

In addition to capacity building, countries will require funds to implement any agreed EAF for large pelagic resources. While governments are obliged to invest in the security of future generations, all benefiting stakeholders should contribute to the EAF through licensing, taxation as appropriate, and other fees. Educating and regularly communicating about the risks and benefits with the public, government and stakeholders will help to win the necessary public support and political will to put theory into practice.

15

Management of the Shrimp and Groundfish Fisheries of the North Brazil Shelf

An Ecosystem Approach

Terrence Phillips, Bissessar Chakalall † and Les Romahlo

Abstract

This paper describes the key transboundary issues as well as the initial steps for applying an ecosystem approach to fisheries in the North Brazil Shelf Large Marine Ecosystem and adjacent area, the Gulf of Paria, which supports one of the most important export-oriented shrimp and groundfish fisheries in the region. Most of the countries in this region are already party to several international environmental agreements which shows a wide acceptance of the need for the ecosystem approach, with some preliminary work on this having been initiated at the regional and national levels. This chapter argues that a decentralised regional approach to fisheries management that incorporates the proposed multi-scale Caribbean Large Marine Ecosystem governance framework would be required to achieve the goals and objectives of the ecosystem approach, with the recognition that the national level serves as the pivot around which the local and regional levels revolve. Implementing the ecosystem approach to fisheries would require robust, participatory decision-making mechanisms at all levels that would lead to more effective adoption of management advice based on the best available scientific information. However, the ecosystem approach will not be an instant replacement for traditional fisheries management and should be seen as an evolution of the existing fisheries management systems. As such, progress towards this goal is likely to be made in an incremental way rather than overnight.

Introduction

The Wider Caribbean Region (WCR) encompasses four large marine ecosystems (LMEs): the North Brazil Shelf LME, the Caribbean Sea LME, the Gulf of Mexico LME and the Southeast United States Continental Shelf

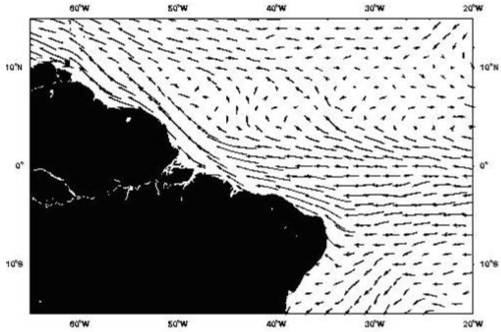
LME. The goal of the Caribbean LME (CLME) project, which focuses on the first two, is the sustainable management of the shared living marine resources through an ecosystem-based approach with mechanisms for facilitating informed decision-making based on sound natural and social science (Fanning et al. 2007; CERMES 2007).

The shrimp and groundfish resources are found in the area comprised of the North Brazil Shelf Large Marine Ecosystem (NBSLME) and the adjacent Gulf of Paria (Figure 15.1). For our purposes, the use of the acronym NBSLME includes the Gulf of Paria.

Figure 15.1. The Caribbean and adjacent large marine ecosystems

The NBSLME extends along northeastern South America from the Parnaíba River estuary in Brazil to the boundary with the Caribbean Sea and has a surface area of about 1.1 million km². It is characterised by its tropical climate and owes its definition to the influence of the North Brazil Current (NBC), which flows parallel to Brazil's coast. The hydrodynamics of this region is dominated by the North Brazil Current, which is an extension of the South Equatorial Current and its prolongation, the Guyana Current (Figure 15.2). The NBSLME is considered a Class I, highly productive ecosystem (>300 $gCm^{-2}yr^{-1}$), with the Amazon River and its extensive plume being the main source of nutrients (Heileman 2008, 2010). The Gulf of Paria is a 7,800 km² inlet of the Caribbean Sea lying between the Venezuelan coast (including the mountainous Paria Peninsula) and Trinidad. It extends about 160 km east-west and 65 km north-south, and is linked with the Caribbean to the north by the strait called the Dragon's Mouths and with the Atlantic to the south by the Serpent's Mouth (both roughly 16 km wide) (Encyclopaedia Britannica 2010). The extensive mangroves along the Venezuelan and Trinidadian coastlines are considered to be an important wildlife habitat and probably play a crucial role in regional fisheries (Wikipedia 2010).

Figure 15.2. North Brazil Current as represented by the Mariano Global Surface Velocity Analysis (MGSVA) Source: http://oceancurrents.rsmas.miami.edu/atlantic/north-brazil.html



Key Transboundary Issues

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

Shrimp and Groundfish Fisheries

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

In general, all the shrimp species in the region are subjected to increasing trends in fishing mortality, and the fishery is generally overcapitalised. However, the trends in fishing mortality were not high enough to have created the very conspicuous decline in abundance, which implies that environmental factors (seasonal river runoff and rainfall) may be more significant than fishing in determining recruitment in these species. Stock assessments conducted by the Western Central Atlantic Fishery Commission (WECAFC) and the Caribbean Regional Fisheries Mechanism (CRFM) over the past five years have indicated that the shrimp resources are generally fully or overexploited (Heileman 2008) (Table 15.1).

Table 15.1. Guianas–Brazil region: Status of the shrimp stocks (after Heileman, 2008)

Species	Status
P. brasiliensis	Fully exploited to overexploited
Penaeus subtilis	Fully exploited
P. notialis	Decline in abundance
P. schmitti	Unknown
Xiphopenaeus kroyeri	Unknown

The groundfish resources such as red snapper (*Lutjanus purpureus*), weakfish (*Cynoscion* sp.), whitemouth croaker or corvina (*Micropogonias furnieri*), and sea catfish (*Arius* sp.) in the Guiana-Brazil shelf region are important for commercial and social reasons, with the red snapper probably being the most important, as its distribution range is throughout the region and it is mainly exported (Heileman Chapter 13). The fisheries are multigear, multi-species and multinational, using fishing methods that can be classified as industrial or artisanal depending on the level of mechanisation (Booth et al. 2001).

In cases where assessments have been undertaken, there are clear signs of overexploitation (Table 15.2). The increasing capture of small individuals is potentially compromising recruitment to the spawning stock. For instance, in Brazil, immature southern red snappers comprise over 60% of the catch of this species. Trawl and Chinese seines harvest weakfish (*Cynoscion* sp.) at ages far below the age of maturity (Heileman 2008).

Table 15.2. Guianas–Brazil region: Status of finfish stocks (after Heileman, 2008)

Species	Status
Lutjanus purpureus	Overexploited
L. synagris	Overexploited
Macrodon ancylodon	Overexploited
Sharks	Overexploited

Excessive bycatch and discards as well as destructive fishing practices are severe and are of concern throughout the region, with the shrimp bycatch situation being well known (Heileman 2008). Analysis of the composition of shrimp bycatch in terms of species and sizes has indicated that many commercial species are included, with only a small part being utilised, and that undersized individuals generally predominate. It is also felt that the species composition has changed over the years and that several species have practically disappeared from the bycatch (Charlier 2001).

Illegal, unregulated and unreported (IUU) fishing poses one of the biggest threats to fisheries management in the NBSLME. The problem is compounded by a number of factors such as the large area of marine space to be policed; the migratory and transboundary nature of some fisheries resources and the fishing fleets that follow them; inadequate resources for monitoring, control and surveillance; and insufficient skilled manpower for maintaining adequate management systems (CRFM 2005). IUU fishing occurs within the Guianas-Brazil area, especially in the shrimp and red snapper fisheries, with Brazil, Suriname, Guyana, Venezuela and Trinidad and Tobago having identified illegal fishing as a key management issue that needs to be addressed (Chakalall et al. 2002).

The underlying causes for overexploitation of the shrimp and groundfish resources, excessive bycatch and IUU fishing include the high level of investment in the industrial shrimp fishery that is driven by the export demand for the product and the high demand for groundfish for local consumption and export. Other contributing factors include the need to earn foreign exchange by the countries and the dependence on the groundfish fishery as a source of employment and income in fishing communities. The main economic and political root causes affecting the sustainability of the shrimp and groundfish fisheries in the region include the need by the shrimp industry to obtain adequate returns on their large capital investment and inadequate integrated governance structures for fisheries and coastal management, rural poverty and illiteracy, and weak governance.

Among the interventions identified are determination of the level of poverty in the fishing communities and the identification of alternative livelihood programmes; institutional strengthening of the fisheries authorities at the national and regional levels; harmonisation of fisheries and related legislation in the region; strengthening of the existing mechanisms for regional collaboration in resource assessment and management; development of mechanisms for improved stakeholder participation in the management process; development of a regional database for fisheries and related data/information; evaluation of the tools being used for fisheries management; continued assessment, including bio-economic assessments, of the shrimp and groundfish resources; review and determination of the most suitable methods for bycatch utilisation and reduction; determination of the extent of IUU fishing in the region and the development of mechanisms to combat it at the national and regional levels; and determination of the environmental factors that may be influencing recruitment to the shrimp fishery (Phillips 2007).

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

Contamination by mercury from gold mining operations as well as by agrochemical wastes is the main source of chemical pollution in the Amazon Basin. Mercury contamination could, in the longer term, become a hazard for the coastal marine ecosystem and for human health if suitable measures to limit its use are not implemented. There is also the potential risk of pollution from oil extraction, both in the coastal plain and the sea. Agricultural development is concentrated along the coast and includes intensive cultivation of sugar cane, bananas and other crops and involves the application of large quantities of fertilisers and pesticides, which eventually end up in the coastal environment (Heileman 2008; LME 17: North Brazil Shelf.) Most of the coastal area of the Guianas-Brazil region has been described as an 'attenuated delta of the Amazon', which implies that contaminants in river effluents, particularly those of the Amazon, could be transported across national boundaries and exclusive economic zones (Charlier 2001; Heileman 2008).

The underlying causes for pollution by agrochemicals can be attributed to inadequate land-use policies, the need to produce crops for food (nutrition) and export, and limited job and income-earning opportunities in other sectors. The underlying causes for the pollution of the marine ecosystem by mercury from the gold mining industry can be attributed to the demand for gold in the world market, illegal immigration, unemployment and insufficient institutional capacity to regulate the mining sector. The root causes for pollution can be attributed to inadequate integrated development strategies, insufficient consideration being given to the effects on other economic activities or on the environment in sectoral planning, poverty and illiteracy, the need for adequate returns on investment and weak governance.

Among the interventions required are strengthening of the institutional framework for integrated coastal management, improved land use and mining policies, development and implementation of adult education and public awareness programmes, strengthening of the institutional mechanisms for monitoring and enforcement in the mining industry, and improved knowledge of the effects of agrochemicals and heavy metals on coastal ecosystems (Phillips 2007).

Habitat and Community Modification

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

Trawlers often operate without restriction in the shallower areas of the shelf, over ecologically sensitive areas inhabited by shrimp in their early life stages. The environmental impact of such activities is likely to be high, considering the intensity of shrimp trawling operations in these areas. Evidence from other regions suggests that precautionary measures should be undertaken in environmentally sensitive areas of the continental shelf (Charlier 2001).

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

The underlying causes for habitat and community modification can be attributed to inadequate land-use policies and limited job and income-earning opportunities in other sectors. The root causes can be attributed to a lack of integrated development strategies, with sectoral planning giving insufficient consideration to the effects on other economic activities or on the environment.

Among the interventions required are strengthening of the institutional framework for integrated coastal management; improved land-use policies; improved knowledge of the role that the entire shallow, brackish-water stretch along the seashore plays in the mobilisation of nutrients and energy transfer in the lower levels of trophic webs, in providing nursery grounds for many marine fish and shrimp species, and the impacts on these areas by human activities; and the creation of reserves to protect ecologically sensitive coastal ecosystems such as mangroves (Phillips 2007).

Socio-Economic Background

The coastal zone in the Guianas-Brazil region has not been an area of spectacular economic or industrial development, with the largest part of the coast being even virtually untouched by human activities. Urban development is concentrated in the neighbourhood of river mouths and on riverbanks close to the sea. Human impacts are probably the highest at both extremities of the region: on the right bank of the Amazon-Para estuarine system and along the Gulf of Paria on the Trinidadian side (Charlier 2001). Table 15.3 provides some socio-economic statistics for the countries in the Guianas-Brazil region (Phillips 2007).

Table 15.3. Selected socio-economic statistics for the countries in the Guianas–Brazil sub-region

Country	Population (x 1000)	Infant mortality rate	GDP/capita (USD)	HDI level	Per capita fish consumption (kg)
Brazil	188,078[1]	28.60[1]	8,600[1]	M (69)[1]	5.56[4]
French Guiana	195[2]	12.07[2]	8,300[3]	Na	na
Guyana	767[1]	32.19[1]	4,700[1]	M (103)[1]	45.7[3]
Suriname	439[1]	23.02[1]	7,100[1]	M (88)[1]	16.9[5]
Trinidad and Tobago	1,065[1]	25.05[1]	19,700[1]	H (57)[1]	7.0[5]
Venezuela	25,730[1]	21.54[1]	6,900[1]	M (72)[1]	18.1[6]

Notes: [1] 2006 estimates; [2] 2005 estimates; [3] 2003 estimates; [4] 2000 estimates; [5] 1998 estimates; [6] 2001 estimate.

Marine fisheries constitute an important economic sector in the region, providing foreign exchange earnings, employment, income and animal protein. A significant portion of the region's population depends upon fishing for its survival and is unable to substitute fish with other sources of animal protein. In general, unsustainable overexploitation of living resources as well as environmental degradation may result in threats to food security and loss of employment, as well as loss of foreign exchange to the countries bordering this sub-region (Heileman 2008).

Governance

The five countries (Brazil, Suriname, Guyana, Venezuela and Trinidad and Tobago) and one dependency (French Guiana) that border the NBSLME need to address the key transboundary living marine resources issues identified. The fragmented nature of coastal and marine resource management is a legacy of the colonial past. The languages and cultures of the colonial occupiers (Portugal, France, the Netherlands, Great Britain and Spain) were different, as were the management systems and laws they passed on to these territories, five of which are now independent democracies. These countries are party to several international environmental agreements, for example the Convention on Biological Diversity, the United Nations Framework Convention on Climate Change, the United Nations Convention on the Law of the Sea (UNCLOS) and the Ramsar Convention on Wetlands. However, there is presently a lack of coordinated support among them for ecosystem monitoring and management.

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

In most instances, fisheries administration and research fall under the umbrella of the Ministry of Agriculture of the countries of the region, with monitoring, control and surveillance (MCS) being delegated to the navy, air force, army, coast guard or police. In many of these countries, some level of institutional reform is taking place to better enable the fisheries administrations to carry out their mandates. Many of them are faced with such problems as insufficient staff to fulfill essential functions; poor communication between different decision-making levels and interest groups; and no clear decision-making procedures and responsibilities, with insufficient funding being an important factor in these problems (FAO 2001).

International, regional and sub-regional organisations, such as the Food and Agriculture Organization of the United Nations and its regional working groups and CRFM have been actively promoting regional co-operation in fisheries management and development in the Guianas-Brazil region. As they seek to address the key transboundary living marine resource issues facing the region, the countries may need to strengthen the institutional arrangements for good governance and sustainable fisheries development.

Also, while the underlying causes of the transboundary issues may be sector-specific, in some instances, the priority interventions for dealing with these concerns target common socio-economic, legal and political root causes. There are multiple, long-term benefits which can be accomplished by focusing on the sources of these problems, as opposed to just their symptoms. Thus the design and implementation of actions aimed at regional co-operation in the ecosystem approach to fisheries is essential for the sustainable utilisation of the shared living marine resources in the NBSLME.

In both large and small-scale fisheries (such as the shrimp and groundfish fisheries in the NBSLME), fishing activities usually affect other components of the ecosystem in which the harvesting is occurring. For example, there is often bycatch of non-targeted species, physical damage to habitats, food-chain effects or changes to biodiversity. In the context of sustainable development, responsible fisheries management must consider the broader impact of fisheries on the ecosystem as a whole, taking biodiversity into account. The objective is the sustainable use of the whole system, not just a targeted species (FAO 2003).

Shrimp and Groundfish Fisheries: The Ecosystem Approach

Current Situation

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

The shortcomings could be seen in terms of the absence of well-defined decision-making mechanisms at the national and regional levels that would lead to more effective adoption of management advice based on the best available scientific information. Also, the fisheries management advice was based mainly on the traditional single-species management, without adequate consideration being given to all the interactions the target fish stocks had with predators, competitors and prey species; the interactions between fish and habitat; the effects of fishing on species and habitat; pollution and ecosystem health; socio-economic effects; and governance arrangements. As such, well-defined and effective national and regional decision-making mechanisms, with the necessary administrative and management support, are essential for an ecosystem approach to fisheries management in the region.

Application of the Ecosystem Approach

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

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

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

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

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

– Agreement on policy, goals and management objectives for the goods and services provided by the ecosystem. In support, the required legislative and institutional framework should then be put in place.
– Involvement of all stakeholder groups in the application of EAF.
– Development and implementation of national and regional EAF fisheries management plans that include sustainability indicators (including reference points, targets and limits) and the accompanying monitoring and evaluation procedures.

- Review of the fisheries administrative and management institutional arrangements at the national level in the first instance, and the implementation of the necessary changes to support the institutional requirements for the delivery of EAF.
- Decentralised regional approach to fisheries management in the NBSLME, enabling management measures to be taken that are appropriate to biologically distinct areas and jurisdictional levels. Management measures could include technical measures, spatial management, effort-related controls and systems of access rights.
- Tailoring of research and information provision to support the ecosystem approach. Also, the documentation and use of traditional knowledge.
- Application of adapative management and the precautionary approach, given the degree of uncertainty and dynamics of the ecosystem.
- Development of an effective MCS capability.

In addition, fisheries management should not be seen in isolation from the management of the coastal zone, but over time should become better integrated with other social and economic sectors of coastal management.

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

In reference to a decentralised regional approach, the proposed CLME governance framework described by Fanning and Mahon (Chapter 18) as comprising complete policy cycles at multiple jurisdictional levels that are networked through both vertical and lateral linkages would apply. The foundation for the proposed framework is a generic policy cycle (see Figure 18.1), an iterative process that should lead to incremental improvement in management, with the different stages in the cycle (data and information, synthesis and provision of advice, decision-making, implementation, and review and evaluation) requiring different inputs and actors, although there is overlap. The 'data and information' stage can be regarded as the primary area where the LME technical modules of productivity, fish and fisheries, pollution and socio-economics make their contribution to the governance process.

The framework accommodates the diversity of policy cycle arrangements and linkage types that are likely to be required for comprehensive governance and is sufficiently flexible to incorporate the diversity of ecosystem-based management approaches identified by Christie et al. (2007). The goal of interventions would be to establish and enhance cycles and linkages that are context specific and appropriate to purpose, capacity and complexity. This long-term goal can be approached incrementally by targeted interventions that focus on specific subcomponents of the framework (Fanning et al. 2007). Additionally, strategic interventions needed to strengthen and establish mechanisms for management ('ownership') of the shrimp and groundfish fisheries of the NBSLME have been identified (Phillips 2007).

Conclusion

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

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

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

16

Ecosystem Issues Pertaining to the Flyingfish Fisheries of the Eastern Caribbean

L. Paul Fanning and Hazel A. Oxenford

Abstract

Eleven species of flyingfishes have been reported in the eastern Caribbean and the four-wing flyingfish (*Hirundichthys affinis*), in particular, supports valuable and growing fisheries in the region. Collectively, flyingfishes, or exocoetids, are an important component of the pelagic food web. Several species have been extensively studied in the eastern Caribbean and special attention has been given to the biology and fisheries for *H. affinis*, such that many of the issues surrounding them are well known. In spite of this, the regional flyingfish fisheries continue to operate essentially unmanaged and are poorly monitored. Taken in a single-species context, flyingfish, specifically *Hirundichthys affinis*, appear to be a productive and lightly fished resource, perhaps not warranting strong management measures. There are, however, possible dangers in this view when considering the broader ecosystem.

The Lesser Antilles Pelagic Ecosystem project of the United Nations Food and Agriculture Organization (FAO) has completed a four-year study that included flyingfishes and related issues under an ecosystem approach. The results of these investigations included both ecosystem models and stakeholder consultations on relevant issues. What emerged is consistent with our past knowledge, but also provides a means of estimating the less direct interactions of fish and fishing. The trophic dependence of dolphinfishes (coryphaenids) on flyingfishes in the eastern Caribbean was well known, but the sensitivity of their responses was modelled and shows dolphinfishes to be particularly vulnerable to any substantial decrease in abundance of flyingfishes, even without any change in fishing pressure on dolphinfishes. Furthermore, the growing longline fisheries of the region have both a technical and economic dependence on flyingfish to a much higher degree than was previously considered and also link the flyingfish and beach seine fisheries through the year-round demand for bait.

The continuing and often discussed weaknesses in the regional fisheries data collection systems are a particular concern for flyingfish under an

ecosystem management regime. Flyingfish landings remain poorly monitored or not monitored at all in the regional fisheries, and growth in flyingfish catch is taking place at completely unmonitored bait fisheries. This situation will need to be addressed if an ecosystem approach is to be seriously considered.

Introduction

The ecosystem approach to fisheries (EAF) is becoming the main reference framework for managing fisheries and implementing the principles of sustainable development. The following working definition is used for EAF:

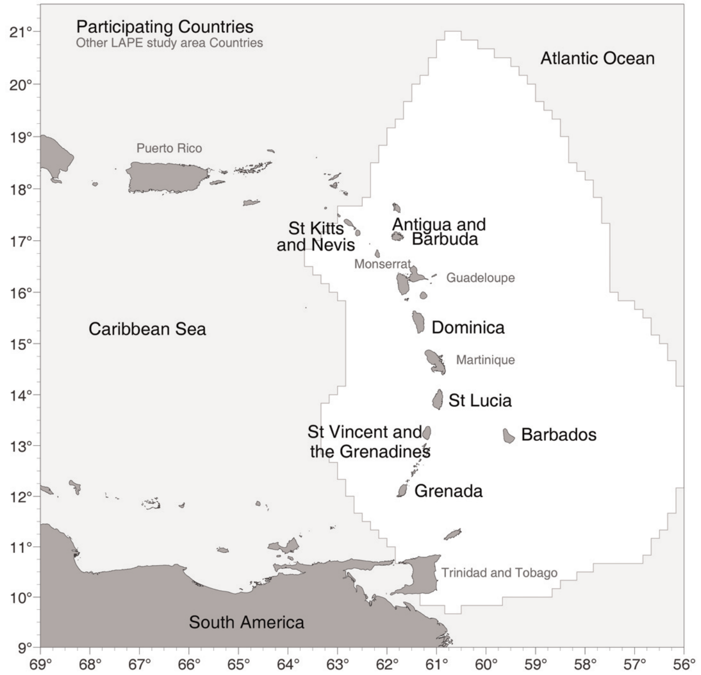
> An Ecosystem Approach to Fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries (FAO 2003).

The principles that underpin EAF clearly emerged in the 1995 Code of Conduct for Responsible Fisheries, although they were inherent in earlier international instruments. EAF was more explicitly addressed in the Reykjavik Declaration (2001), which was adopted at the Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem, and the Plan of Implementation of the World Summit on Sustainable Development (2002), which encourages states to apply the ecosystem approach by 2010 with specific reference to the Reykjavik Declaration. While applying EAF implies a sincere societal commitment to a strategy that promotes conservation, sustainable use and equitable sharing of ecosystem services, such application does not need to follow a single blueprint, rather it should be consistent with local context, means and culture.

The FAO, with funding from the government of Japan, provided technical assistance to fisheries institutions of selected countries in the Lesser Antilles to develop the information tools – including ecosystem modelling, use of geographic information systems (GIS) and collection of standard fisheries data – to improve management of their pelagic resources and fisheries in accordance with EAF. This project, the Lesser Antilles Pelagic Ecosystem (LAPE) project was completed in 2007 and has provided the Lesser Antilles countries with a comprehensive description of their pelagic resources and the technical and ecological relationships that govern them.

The LAPE project included field studies of marine mammal (cetacean) abundance and distribution, forage species abundance and distribution, as well as diet analysis of several important fish and cetacean species within and adjoining the LAPE study area (Figure 16.1). An extensive synthesis of published information with the project's own studies was used to estimate diet composition (Heileman et al. 2008) and other aspects of ecosystem structure for the entire gamut of pelagic species and functional groups. Fisheries in each of the participating states were characterised in terms of fleet composition, effort or capacity and annual catches (Mohammed et al. 2008a). The ecosystem structure and function was modelled using Ecopath with Ecosim to capture the roles, importance and sensitivity of key pelagic species, especially those of interest to local fisheries (Mohammed et al. 2008b). These modelling results were used to assess management issues identified by extensive stakeholder consultations (Grant 2008).

Figure 16.1. The Lesser Antilles Pelagic Ecosystem (LAPE) study area and participating countries



In addition to this recent work, flyingfish, especially the four-wing flyingfish (*Hirundichthys affinis*) in the eastern Caribbean, have been extensively studied by the 1987-1993 Eastern Caribbean Flyingfish Project, funded by the International Development Research Council (Mahon et al. 1986; Oxenford et al. 1993), by several researchers and graduate students (e.g., Lewis et al. 1962; Storey 1983; Khokiattiwong 1988; Lao 1989; Boyce 1995; Deane 1996; Gomes 1998) and are monitored and assessed through the FAO Western Central Atlantic Fisheries Commission (WECAFC) Ad Hoc Working Group on Flyingfish (FAO 1999, 2002, 2008). As a result, the biology and fisheries of flyingfish have been examined in considerable detail (Oxenford et al. 2007), allowing the ecosystem issues to be highlighted here. This species provides a good example of a resource that is both a key forage species and an important fishery species with many trophic, economic and technical linkages.

Flyingfish Biology and Ecology

There are at least eleven species of flyingfishes known from the eastern Caribbean (Carpenter 2002), although the four-wing flyingfish is by far the most important species in the fishery catches. Other species in the catches include small amounts of margined flyingfish (*Cypselurus cyanopterus*) as well as occasional catches of Atlantic flyingfish (*C. melanurus*), mirrorwing flyingfish (*H. speculiger*) and others (national reports included in Oxenford et al. 2007: ch 1-7).

Although *H. affinis* dominates the catch, there is some evidence that several other species may be equally or more abundant in the ecosystem although apparently less accessible to the fishery. In a flyingfish transect sighting survey conducted in 1988, the visually identified species composition for adults was 52% *Parexocoetus brachypterus* (sailfin flyingfish), 47% *H. affinis* and 1% *Cypselurus cyanopterus* (Oxenford et al. 1995a). In the same survey, a complementary sampling programme using dipnets and lights at night estimated juvenile species composition to be 50% *P. brachypterus*, 41% *Exocoetus volitans* (tropical two-wing flyingfish) and only 8% *H. affinis* (Oxenford et al. 1995b). The apparent disparity between relative abundance in the catch and that seen in the surveys most likely results from heightened availability of *H. affinis* to the fishing gear due to its spawning behaviour.

H. affinis is essentially an annual species, completing its lifecycle in approximately one year (Campana et al. 1993; Oxenford et al. 1994). Although there is some bimodality in the size composition and timing of catches, this does not appear to represent annual cohorts but rather variations in growth rate and spawning time within the single cohort (Hunte et al. 2007). The strong seasonal pattern in catches is likely due to a combination of the inter-cohort gap in adults and emigration from known fishing areas (Khokiattiwong et al. 2000).

Throughout their range, the various species of flyingfishes are an important prey group for a variety of large pelagic predators. Bigeye tuna, dolphinfish and large mesopelagic predators all take more than 15% of their diet from flyingfishes, while billfish, blackfin tuna and squid take more than 5% of their diet from flyingfishes (Heileman et al. 2008 and references therein). In the eastern Caribbean, various flyingfish species were estimated to make up more than 40% of the total diet of dolphinfish, *Coryphaena hippurus* (Oxenford and Hunte 1999). Although this is considerably higher than reported from other areas, this fraction seems feasible given the known concentrations of flyingfish relative to other prey in the area and the very close migratory timing of four-wing flyingfish and dolphinfish.

Flyingfish Fisheries

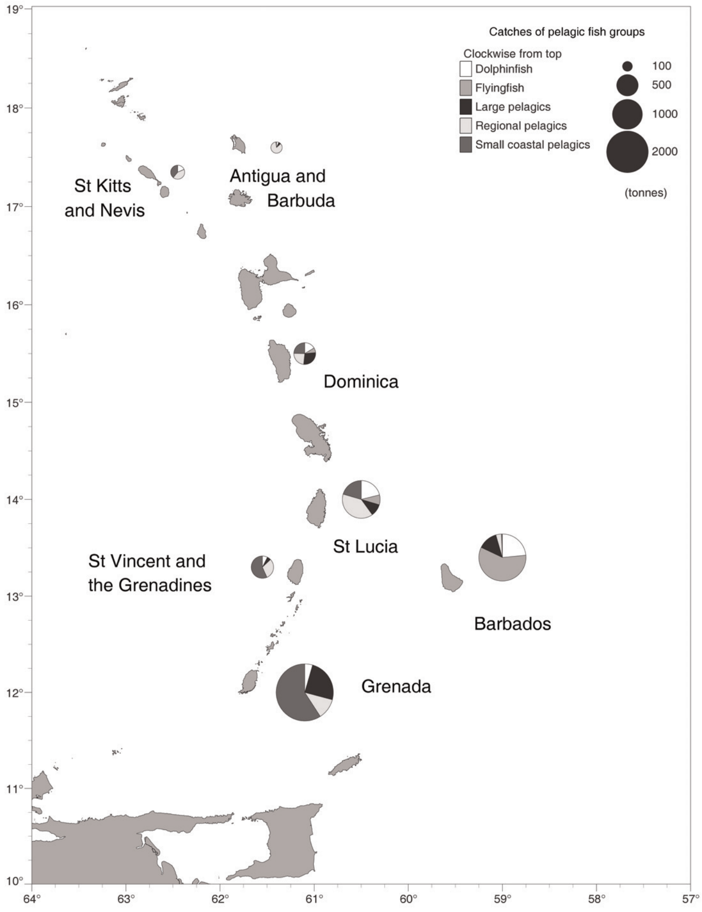
The fisheries for flyingfish are concentrated in the southern end of the Lesser Antilles chain, with important fisheries in Barbados, Grenada, Martinique, Saint Lucia and Tobago (Oxenford et al. 2007). Fishers in Dominica have complained that flyingfish have 'disappeared' from their grounds in recent times, but were previously important there (Grant 2008). In the northern parts of the island chain (Saint Kitts/Nevis, Antigua and Barbuda), flyingfish is rarely caught and has never been an important fishery species. This may simply reflect a traditional fisheries focus on the demersal resources of the relatively extensive shelf areas surrounding the northern islands.

Although there are small catches of species other than *H. affinis* in the flyingfish gear, to all intents and purposes the flyingfish fishery targets *H. affinis,* depending on their spawning behaviour to aggregate large schools around floating objects on which they deposit their sticky eggs to maintain bouyancy. Flyingfish fisheries today are primarily conducted with a combination of surface floating gillnets, handheld dip nets, and 'screelers' which are made of floating debris, usually palm fronds or sugarcane leaves and are attached to the gear. The spawning flyingfish become entangled in the gillnets beneath the screelers or are scooped up by dip nets when fish concentrations are very high.

The directed flyingfish fishery is part of a multi-species, multi-gear pelagic fishery. While travelling to and from port and while the gillnets are soaking, fishers use hook and line gear, either trolled or stationary, to fish for regional large pelagic species, primarily dolphinfish, but also wahoo (*Acanthocybium solandri*) and, in Barbados, ocean triggerfish (*Canthidermis spp*.). Flyingfish is used as the bait in the hook and line fishing. The economics of this fishery make the two activities largely inseparable, as neither is likely to be economically viable alone, and the major flyingfish catch comes from this troll/gillnet sector. Barbados has the largest flyingfish fishery and lands the majority (~ 65%) of the reported regional catch (Mohammed et al. 2008a). In Barbados it is a high value-added fishery, especially through sales in the tourism sector (Mahon et al. 2007a). Almost the entire catch, excluding that small amount used at sea for bait, is sold for human consumption. There are also important fisheries in Tobago, Martinique and Saint Lucia for human consumption, but these other islands do not realise the same degree of value-added benefit that Barbados does.

The multi-species nature of the pelagic fisheries taking flyingfish means that management measures must be adjusted to ensure adequate opportunity to fish for – and prevent overexploitation of – the associated target

Figure 16.2. Reported catches of pelagic species as reconstructed by the LAPE project. 'Large pelagics' includes large tuna species and billfishes; 'Regional pelagics' includes small tuna species, mackerels, and wahoo; and 'Small coastal pelagics' includes scads, herrings, anchovies and halfbeaks. These flyingfish catch data remain underestimates as catches from flyingfish fisheries known to exist in Grenada for bait, and in Tobago and Martinique for market sale, are not included.



species, primarily dolphinfish and wahoo. In addition, the regional distribution of these species will require multilateral management by the states involved. These and other management considerations are reviewed by Mahon et al. (2007b).

A fishery redirected at flyingfish specifically as bait instead of as a food fish has emerged in concert with the development and expansion of longlining in the region. This is particularly important in Grenada, and all countries except Barbados are following the same pattern. As the longline fishery initially developed, the commonly used bait was flyingfish. However, since flyingfish is highly seasonal, longliners adopted the use of small coastal pelagic species taken with local beach seines to augment bait supplies when flyingfish was seasonally unavailable. With the growing demand for longline bait, this supply has proved insufficient in many areas, and unless flyingfish was available, the longliners have been limited by bait supply. Barbados is an exception in this respect. Because of the absence of a local beach seine fishery for small coastal pelagics, and with the considerable expense of off-season storage of flyingfish for bait, the Barbados fishers adopted a combination of imported bait (mostly frozen squid) augmented with flyingfish when available. For Barbados, this strategy has proved more cost-effective and more reliable than attempting to freeze and store adequate supplies of locally caught flyingfish.

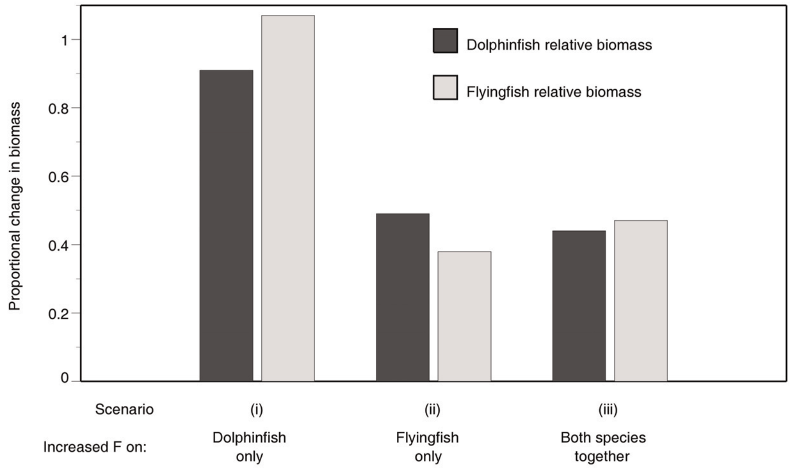
The catch statistics on flyingfish for the region are incomplete; for example, there are currently no landings records in Martinique although it is known that there is a significant flyingfish fishery still active there. Also, recorded flyingfish landings have dropped significantly in Barbados, although the fleet size has increased and the catch per trip has remained stable (Staskiewicz et al. 2008). Furthermore, flyingfish used for bait, whether incidentally or as a directed supply, are not recorded in any of the countries involved (FAO 2008b). As a result, there is no clear picture of actual flyingfish catches in the region. Recompiled estimates of regional pelagic catches (Figure 16.2) based on available national data sources (Mohammed et al. 2008a) still did not reflect a number of known flyingfish fisheries, e.g., Grenada, Martinique or Tobago. There is also a known issue of under-recording in other countries.

Issue: The Linkage Between Flyingfish and Dolphinfish

Dolphinfish and flyingfish, especially *Coryphaena hippurus* and *Hirundichthys affinis*, are tightly linked through trophic, technical and economic interactions. The strong trophic dependence of dolphinfish on flyingfish was investigated using an Ecopath with Ecosim (EwE) model of the Lesser Antilles pelagic ecosystem (LAPE) (Mohammed et al. 2008b). The EwE model was used in Figure 16.3 to show a range of plausible scenarios in which the biomass of dolphinfish is negatively affected by increased catches of flyingfish. Figure 16.3 compares the population biomass response (B20/B0) of each species over 20 simulated years, under three scenarios in which the instantaneous fishing mortality (F) was arbitrarily and substantially increased from the base level in the balanced model to F=1.0 yr^{-1}. The F was changed in scenario (i) for dolphinfish alone, in (ii) for flyingfish alone, and (iii) for both species.

The model indicates that both flyingfishes and dolphinfishes are relatively insensitive to increases in F on dolphinfishes alone (Figure 16.3, sce-

Figure 16.3. Ecopath with Ecosim (EwE) model simulations showing the expected change in population biomass separately for dolphinfishes (dark bars) and flyingfishes (light bars) in response to substantial increases in fishing mortality applied to (i) dolphinfishes alone, (ii) flyingfishes alone, and (iii) both species. Fishing mortalities applied in this simulation were F=1 for each species. This represents a substantial increase over the base levels in the balanced model of F=0.13 for dolphinfish and F=0.013 for flyingfish.



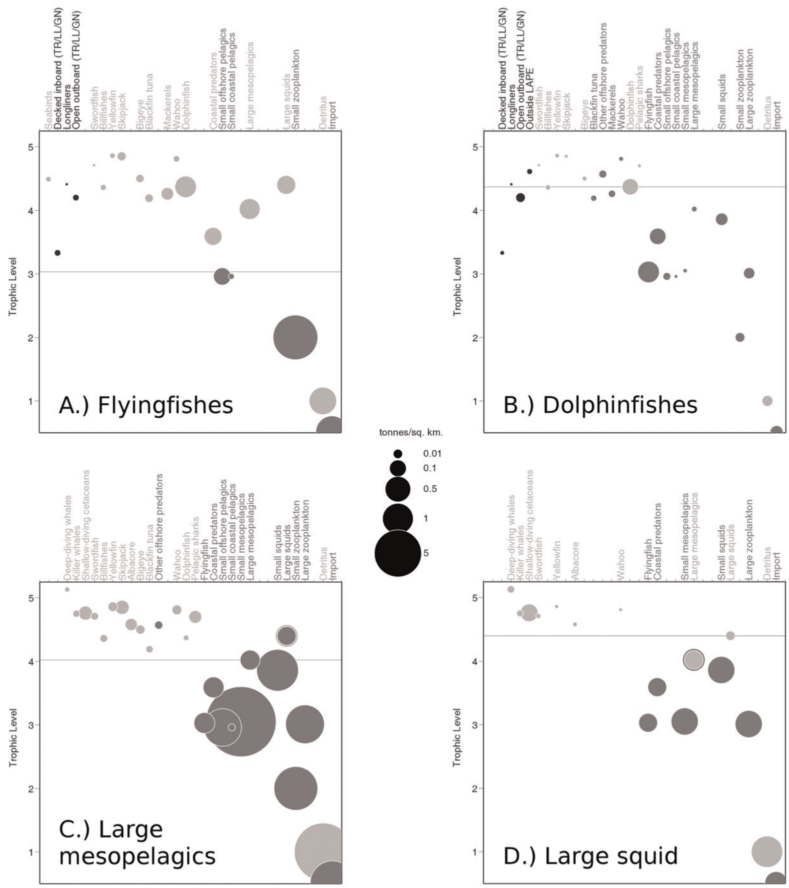
nario (i)). In this case, the dolphinfish population biomass decreases slightly from 1.0 to 0.91, whilst the flyingfish population biomass increases marginally to 1.07, consistent with a release from a slight degree of predator (top-down) control. In contrast, when the F on flyingfishes alone is increased significantly (Figure 16.3, scenario (ii)), the effect on dolphinfishes is marked (reduction to 0.49 of starting biomass), indicating a significant degree of donor (bottom-up) control. This tight linkage results from two factors. First, there is an exceptionally high proportion of flyingfishes in the dolphinfish diet reported in the eastern Caribbean (Lewis and Axelsen 1967; Oxenford and Hunte 1999) although the proportion is lower in dolphinfish diet studies from other areas in the western central Atlantic (Oxenford 1999) and in adjoining Atlantic waters (Júnior 2000; Manooch et al. 1983; Pimenta et al. 2001; Satoh et al. 2004). The strong regional dietary dependence on flyingfishes in the eastern Caribbean likely reflects regional concentrations of flyingfishes, particularly spawning groups of *Hirundichthys affinis*. Secondly, cannibalism is a significant fraction of the dolphinfish diet in all areas (see Oxenford 1999; Heileman et al. 2008), and any reduced availability of flyingfish prey is likely to be offset by increased cannibalism and resultant increases in predation mortality for dolphinfishes. The Ecopath model of Mohammed et al. (2008b) estimated the instantaneous predation mortality rate of dolphinfish cannibalism at 4.3 yr^{-1}, almost four times its rate of predation on flyingfishes. Thus increased effort on flyingfishes for bait, even without concomitant increases in dolphinfish catches, could result in declines in dolphinfish biomass.

When F on both species is increased simultaneously (Figure 16.3, scenario (iii)), the EwE model results are quite similar to increased F on the flyingfishes-alone scenario, with a decrease in biomass of both flyingfishes and dolphinfishes by around 40-50%. From these results, it is apparent that the impacts on flyingfish biomass in particular will depend on the balance between increased fishing and reduced predation. To date, the F on flyingfishes has been quite low, and predation mortality is far more important in the flyingfish stock dynamics.

The model results suggest that increasing fishing effort in the gillnet/troll fishery, which targets flyingfish, dolphinfish and wahoo, will almost certainly result in decreased biomass of dolphinfishes. However, the impact on flyingfishes could be positive, negative or neutral depending on the offsetting changes between increased fishing and reduced predation (Figure 16.3).

In addition to dolphinfishes, there are a number of other predators and predator groups that feed heavily on the flyingfish group that have been quantified in the Ecopath model by Mohammed et al. (2008b). The biomass flows involving flyingfishes are represented in Figure 16.4 (panel A) and its three primary predators, dolphinfishes (panel B), large mesopelagic fishes (panel C) and large squids (panel D). Unlike dolphinfishes and flyingfishes, these latter two groups are not made up of closely related species but rather are functional groups defined for modelling purposes as species sharing common trophic characteristics. Large mesopelagic fishes include species like snake mackerel (*Gempylus serpens*), longnose lancetfish (*Alepisaurus ferox*), oilfish (*Ruvettus pretiosus*) and Atlantic pomfret (*Brama brama*). Large squids include species with adult sizes greater than 50 cm mantle length from families such as hooked squids (Onychoteuthidae) and giant squids (Architeuthidae). It should be noted that both the large mesopelagic fish and the large squid functional groups display cannibalism; however, in multi-species functional groups this may indicate either intraspecific predation (the usual understanding of cannibalism) or inter-specific predation within the same group. Both types are likely present in these groups. Cannibalism is indicated in Figure 16.4 by the presence of a column for the captioned species eating itself, the circle in that case will always sit right on the line, aligned beneath its own name. In terms of total consumption of flyingfishes (Figure 16.4A), large mesopelagic fishes and large squids follow closely after dolphinfishes, however, neither of these two functional groups is as heavily dependent on flyingfishes in terms of the fraction of their diet (0.6% and 6.6% respectively). Furthermore, these groups, while cannibalistic to some degree, are much less so than dolphinfishes. Taken together, this means that these two groups are far less sensitive to changes in flyingfish availability than are dolphinfishes.

Figure 16.4. Selected biomass flows estimated in the Lesser Antilles pelagic ecosystem Ecopath model of Mohammed et al. (2008b). Shading indicates consumption by (dark grey), predation on (light grey), and fisheries catches from (black) the named group in each panel. The groups are as defined in Mohammed et al. (2008), including the 'import' group which represents feeding outside the model study area, either in demersal/reef areas within the Lesser Antilles or entirely outside the Lesser Antilles. TR/LL/GN refers to the troll, longline, and gillnet fisheries. Trophic level of the indicated group is marked by the horizontal line. The circles indicate the magnitude of the biomass flow (tonnes/km2/yr) using a constant log ratio scale on all panels. Overlapping circles in panels C and D indicate that large squid and large mesopelagic groups are each a predator and a prey of the other.



Technical and economic interactions arise from the fact that the majority of the catches of both flyingfish and dolphinfish are taken in a fishery that catches both species using different gears on the same trips. Furthermore, part of the flyingfish catch is utilised for bait on troll lines directed at dolphinfish and wahoo. This multi-species, multi-gear fishery is highly seasonal, as dolphinfish and flyingfish are closely synchronised in their presence in the region. It has long been assumed that the dolphinfish follow the flyingfish as they migrate and spawn.

The model results presented here may be revised in the future, but they are clearly indicative of the importance, strength and direction of ecological interactions involving flyingfishes. Further, they illustrate where technical and economic interactions between flyingfishes and other fisheries are likely to be strongest.

Issue: The Linkage Between Flyingfish Longlining and Beach Seining

The regional governments and fishing industry have spent considerable effort over the last 15-20 years to build the Caribbean region's capacity in large pelagic fisheries, especially through the development of longlining. There has been marked success, with several countries now operating significant numbers of medium and large longliners (7-15 m and >15 m). For example, Barbados has 37 registered longliners, Grenada over 200 and Trinidad has 17 (Mohammed et al. 2008a). There are also smaller numbers of longliners in Dominica, Saint Lucia, Saint Vincent and Guadeloupe. Longliners require a year-round supply of bait, thus growth in longlining has created a parallel growth in the demand for baitfish, namely flyingfish. This is augmented in the flyingfish 'off-season' with imported frozen squid (in the case of the Barbados fleet) and by locally available alternatives such as the small coastal pelagic species caught in beach seines (in the other eastern Caribbean longlining fleets). These primarily include scads (*Decapterus* sp.and *Selar crumenopthalmus*) known locally as robins and jacks respectively.

This high demand for bait has implications not only for the catch-monitoring systems of the region, but also for food security. Flyingfish and beach seine species caught for bait do not pass through the local markets and may not even be landed, thus bypassing the landings data collection systems. Furthermore, flyingfish and beach seine catches have traditionally been a source of relatively low-cost fish for food in rural areas and an important component of the protein available (Grant and Berkes 2007; Grant 2008). The increased demand for these species as bait in the longline fishery has resulted in increased prices and in some instances the bait sales have completely removed flyingfish and the small coastal pelagics from the local food supply (Phillip and Rennie 2007; Grant 2008). Grant (2008) also reported that fishers have been moving between islands to obtain the bait they require. Saint Vincent and the Grenadines had become a bait supply point for fishers from places such as Grenada, Tobago and even

Venezuela, resulting in the imposition of a temporary ban in Saint Vincent on exports of live baitfish in an attempt to protect the resource and maintain the local food supply (R. Ryan, CFO of Saint Vincent and the Grenadines, personal communication).

Interestingly, the longline fleet in Barbados has sought an alternative bait (imported frozen squid) to maintain the fishery year-round. This is no doubt partly because there is no significant beach seine fishery for coastal pelagics on the island and the cost of storing frozen flyingfish for use as bait is prohibitive. In addition, the high economic and social value of flyingfish for food in Barbados has precluded much increase in its use as bait.

However, the Barbadian longline fleet still depends on flyingfish as a key economic component of their landed catch. Annually, about 15% of the catch (by weight) sold from Barbados longliners is flyingfish, and another 10% is dolphinfish (Walcott et al. 2009). These two species are taken by directed effort during lengthy longline trips. At certain times, entire short trips may be made by longline vessels solely for these species in order to accumulate sufficient cash to fund the long trips directed at tunas and billfishes (A. Kinch, longliner owner and captain, Barbados, personal communication).

The regional statistical systems have little information on the magnitude and trends in the bait fisheries (FAO 2008b). At this point, it is likely that the flyingfish catches have already increased substantially to provide bait, but little or no quantitative information is available. The ability to monitor and to assess trends in the fishing mortality and sustainability of the flyingfish fisheries depends on developing new information sources on the bait fisheries and ensuring these catches are represented in the assessment process. This is equally true for the small coastal pelagic species used for bait. Like the biological data, information on the economic and social performance of the fisheries sector overall is largely lacking, and flyingfish fisheries are no exception in this regard. Although an expanded and active fisheries statistics system could provide significant information on the economic aspects of the fisheries, site-specific studies of a more academic nature – an example would be Grant and Berkes (2007) in Grenada and Walcott et al. (2009) in Barbados – would be needed to really understand the social role and performance of fisheries.

Conclusion

The flyingfish provides a good example of a species for which EAF management is highly appropriate, given that it is a well-studied and important forage fish in the tropical oceanic realm, and also because it supports a significant number of small-scale commercial fisheries in the eastern Caribbean. Here we have used an ecological model and touched upon various technical and economic interactions relevant to the flyingfish fishery within its ecosystem which demonstrate strong linkages and important differences in the management advice that may arise from an ecosystem approach as opposed to a single-species assessment.

Perhaps the most obvious linkages to consider under an ecosystem approach are ecological. Flyingfishes are a key component in the tropical pelagic ocean food web (Parin 1968), and their importance to the diet of other commercially important species is well recognised (Oxenford 1986; Heileman et al. 2008) but has never been quantified within the context of the ecosystem. The Ecopath with Ecosim model recently developed under the LAPE project (Mohammed et al. 2008b) can be used to model the likely outcome of increasing fishing mortality on any one or more species within the Lesser Antilles pelagic ecosystem. This model is used here to demonstrate a range of possible outcomes when fishing mortality is increased for flyingfishes and/or the closely linked dolphinfishes. Interestingly, the outcomes for flyingfishes are similar if fishing mortality is increased solely on flyingfishes or simultaneously on flyingfishes and dolphinfishes (as is more likely with the current technological linkages in the fishery). However, the outcome is very different if only dolphinfish mortality is increased. A similar disparity of outcomes is also apparent for dolphinfishes under these plausible scenarios. Of particular interest is the sensitivity of the dolphinfish stock to increases in flyingfish fishing mortality. Single-species assessments of these annual species, based on their life history parameters, have suggested that they can each withstand relatively high levels of fishing effort with little risk of stock collapse (Oxenford et al. 2007; FAO 2010). Considered one species at a time, this conclusion is supported here, but a quantitative consideration of their trophic linkages indicates that the dolphinfish population is highly sensitive to flyingfish biomass, and the dolphinfish fishery will become less likely to be sustainable with a marked decrease in flyingfish biomass.

Furthermore, there are strong economic and technical interactions involving flyingfish that link three regional fisheries sectors, namely the longliners, the beach seines and the traditional flyingfish (troll/gillnet) fishery. As such, management actions in any one of these fisheries may have significant consequences for the others and should therefore be considered under an ecosystem approach.

Although flyingfish stocks appear to be able to sustain the current levels of fishing, and perhaps may be able to sustain expanded fisheries, the linked stocks may not do so. The current direction towards expansion of the longline fisheries is creating demands on other sectors for bait. While expanding flyingfish catches solely for bait may be feasible, the current dominant mode of fishing flyingfish as part of a multi-species pelagic troll/gillnet fishery means that any increase in flyingfish catches will almost certainly involve increased catches of regional pelagic species, especially dolphinfish. Furthermore, since these other species are a critical component of the economic viability of the pelagic troll/gillnet fishery, fishers will not willingly avoid these species.

The increased use of imported bait, as is done in Barbados, may also not relieve fishing pressure on flyingfish entirely from the longline sector. A recent preliminary economic review of the Barbados longliners indicates that, in addition to the flyingfish used for bait, the flyingfish and dolphinfish that longliners catch and sell make up about 25% of their annual landings and are crucial to the economic viability of longlining (Walcott et al. 2009). In the Barbados processing sector, there is a heavy reliance on flyingfish to maintain the core activities and capacities of the processing sector, especially the human resources. Flyingfish provides a significant fraction of the fish processing employment and is a key element in the marketing of other seafood products as well (J. Morgan, seafood processor, Barbados, personal communication).

The need for comprehensive and timely statistics on all fisheries has been noted many times. The development of specialised bait fisheries, both for flyingfish and small coastal pelagics, has created a market avenue that is not recorded well, if at all, in the eastern Caribbean region. In many cases, the bait sales are made from boat to boat, with no landing of catch at all. In addition to improved recording on the traditional fisheries, special efforts to assess the magnitude and composition of bait sales are needed if a realistic assessment and management approach are to be applied to flyingfish or the small coastal pelagics also used for bait.

Any broader consideration of the linked fisheries under an ecosystem approach to management will certainly require increased efforts at understanding the quantitative nature of the linkages. For example, what is the economic contribution of flyingfish to the landed catches of the troll/gillnet fishery and the longline fishery? How sensitive are these fisheries to changes in the landings of flyingfish? How much flyingfish bait is used to support the current levels of longlining for large oceanic pelagic species? What is the cost and what are the logistics of storing and using frozen flyingfish for bait in the off-season, compared with using locally available coastal pelagics or frozen imported bait? These are basic economic questions and do not require ecosystem modelling to address, but answering them will allow us to assess realistically the ecological impacts of the changing fisheries of the eastern Caribbean.

The analyses discussed are based on an EwE model constructed from the most detailed data presently available for this region. An ongoing effort over the next five to ten years to improve the quality and quantity of catch data (for example, better species composition estimates and economic information) and to conduct basic biological research, especially diet studies, could provide the basis for a much more detailed model of the Lesser Antilles pelagic ecosystem and a means to assess ecosystem-level changes between now and that time.

17

Coastal Lagoons and Estuaries

The EBM Approach

Alejandro Yáñez-Arancibia, John W. Day, Bastiaan A. Knoppers and Jorge A. Jiménez

Abstract

Ecosystem-based management (EBM) is an appropriate approach for coastal lagoons and estuaries with high habitat heterogeneity and coupled gradients. From the standpoint of temporal and spatial scales and functional integration, we conclude that the drainage basin with respect to the continuum '*low river basin-wetlands-delta-coastal lagoon-estuary-estuarine plume on the sea shelf*' is the optimal ecosystem level for a successful EBM approach to coastal lagoons and estuaries as biocomplex systems. Because EBM is a tool for social and economic development, any such EBM programme should: a) reduce those market distortions that affect biological diversity, b) align incentives to promote biodiversity conservation and sustainable use, c) internalise costs and benefits in the ecosystem to the extent feasible, d) understand the habitat gradients concept in the coastal zone and how they apply to the EBM approach, and d) keep in mind that only management based on ecosystem integrity and functioning is sustainable.

Introduction

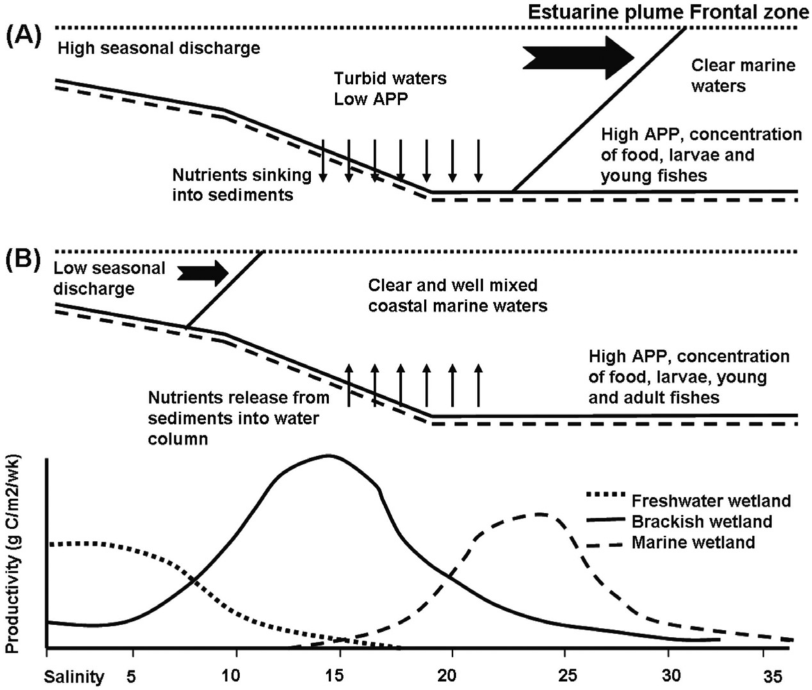
Coastal lagoons and estuaries are highly productive, highly vulnerable and, particularly for tropical coasts, highly diverse with respect to both species and habitats. These ecosystems support many valuable populations of fish and shellfish as well as birds and macrophytes. At the same time, a high proportion of the world's human population lives close to coastal lagoons and estuaries, which are therefore the recipients of many kinds of contaminants. The Caribbean region has an area of 15 million km^2, in which 1.9 million km^2 correspond to the continental shelf, with three main large marine ecosystems (LME); the Gulf of Mexico, the Caribbean Sea and the North Brazil Shelf. The coastal oceanography is complex due to the interactions between the Caribbean current, tropical hurricanes and the strong influence of major rivers such as the Amazon (200,000 m^3/s), the Orinoco (35,000 m^3/s), the Magdalena (7,800 m^3/s), the Rio Dulce (1,100 m^3/s), the Grijalva-Usumacinta (4,700 m^3/s) and the Mississippi (19,000 m^3/s). Deltaic systems, mangroves and integration of the LME with coastal zone management are a key concern for EBM of coastal lagoons and estuaries (Yáñez-Arancibia 2005; Yáñez-Arancibia and Day 2004a, 2004b; Day et al. 2008). In the coastal zone, lagoons and estuaries are synonymous with the estuarine environment. Estuarine environments are integrated with wetlands and wetlands reflect the river basin. The most important part of river basins with respect to coastal lagoons and estuaries is the coastal plain. Freshwater discharge results in estuarine conditions extending onto the continental shelf as the estuarine plume. All of these are structural components of the coastal zone. Moreover, this habitat gradient with its integrated functioning is a key concern for a comprehensive EBM approach in the Wider Caribbean Region.

Coastal Ecosystem Framework Towards EBM

For management purposes, the boundaries of the coastal zone should be defined by the area of relevant biophysical, ecological, economic and social interactions. Islands or small nations, of which there are many in the Caribbean, can be managed in their entirety. However, for most other countries, scale puts a practical limit on the extent of a manageable area. In these cases, there is rarely a clearly defined physical boundary, either landward or seaward, which incorporates all the relevant factors. In general, the coastal zone is taken to mean a broad eco-region with intense physical and biological interactions, where dynamic interchanges of energy and materials occur between land, fresh water, atmosphere and the adjacent sea. Typically, such areas include coastal plains, wetlands, low-river basins, mangroves, coastal dunes, coastal lagoons, estuaries and the adjacent ocean (Scura et al. 1992; Windevoxhel et al. 1999; Yáñez-Arancibia 1999, 2000, 2005; Schwartz 2005).

Coastal lagoons and estuaries mean estuarine environments. Fairbridge (1980) defined an estuary as an inlet of the sea reaching into a river valley as far as the upper limit of the tidal rise, usually being divisible into three sectors: a) a marine or lower estuary, in free connection with the open ocean, b) a middle estuary, subject to strong salt and freshwater mixing, and c) an upper or fluvial estuary, characterised by fresh water but subject to daily tidal action. Coastal lagoons are one of the most typical geomorphologic features in the coastal zone (Kjerfve 1994). Lankford (1977) defined a coastal lagoon as a coastal zone depression below mean high water, having permanent or ephemeral communication with the sea, but protected from the sea by some type of barrier. From an ecological point of view, coastal lagoons and estuaries are both typical estuarine ecosystems. Day and Yáñez-Arancibia (1982) and Day et al. (1989) distinguished the concept of a lagoon-estuarine ecosystem as a coastal ecotone, connected to the sea in a permanent or ephemeral manner; in these natural conditions,

Figure 17.1. Ecosystem Approach to Coastal Wetlands Functioning: (a) conceptual model of river delta system discharge and responses of the estuarine ecosystem. Fish larvae, juveniles and adults, and macro invertebrates use the open water system and the gradient of the frontal zone in the estuarine plume (as essential habitat), before and after movements towards mainland wetlands or open sea; (b) the physical, chemical and biological pulsing and gradients modulate the river delta system functioning and the positive effect of flood; the habitat switcher functions in terms of the effects of salinity on wetland habitat type; plant primary production is a function of salinity, and the diagram shows the salinity levels where habitat succession takes place in the model for three of the habitat types in deltaic system. The higher marsh productivity is in brackish wetlands.



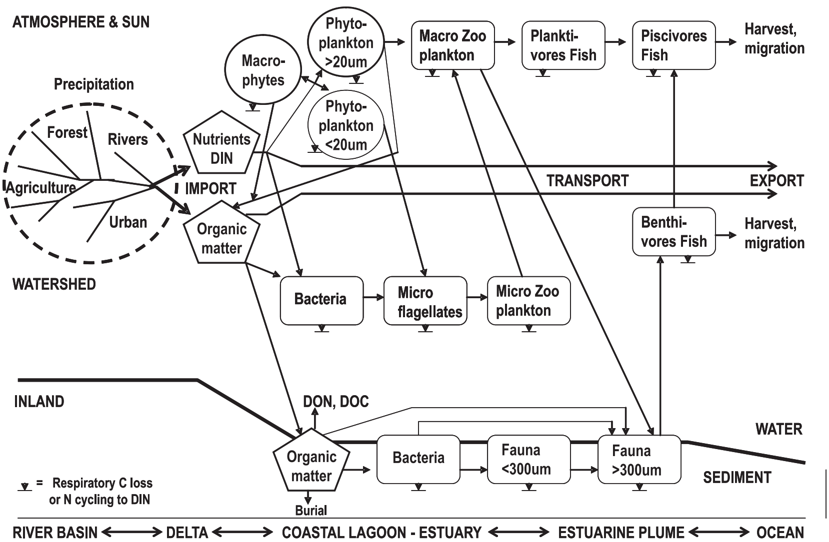
the lagoon-estuarine ecosystem incorporates a balanced network of: a) physical gradients, b) environmental pulsing, and c) biotic interrelationships.

The Ramsar Convention defines wetlands as: areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters, or 20 feet (Mitsch and Gosselink 2000; Dugan 2005). The biological interactions in wetlands allow them to provide goods such as healthy wildlife, fisheries and forest resources (Maltby et al. 1992; Mitsch and Gosselink

2000; Weinstein and Kreeger 2000; Dugan 2005). These functions and goods, together with the value placed upon biological diversity and the cultural values of certain wetlands, make these ecosystems invaluable to people worldwide (Figure 17.1).

Coastal plain is normally associated with low river basin geography, and its extent on the mainland is modulated by: a) lowland plain physiography, b) seasonal floods, and c) hydrophytic vegetation (Figure 17.2). This coastal subregion is characterised by: a) important wetlands, b) high ecodiversity of critical habitats and associated flora and fauna, c) areas of groundwater recharge, d) a gradient from freshwater to brackish wetlands that depends on tidal range and river discharge, e) a transition zone between the low river basin and the sea, f) filtration of incoming water that improves water quality and lessens eutrophication, and g) supporting important economic activities in the coastal zone (Deegan et al. 1994; Yáñez-Arancibia et al. 2007).

Figure 17.2. Conceptual model of nutrient flow in an estuarine ecosystem emphasising inputs of organic and inorganic nitrogen from uplands and the four major pelagic and benthic trophic pathways that lead to the production of top carnivores. DIN = dissolved inorganic nitrogen, DON = dissolved organic nitrogen, DOC = dissolved organic carbon, C = carbon. The main gradient is from the low river basin to deltaic and coastal lagoons and estuaries to estuarine plume and finally the open ocean. See text for more explanation.



The estuarine plume is the area where estuarine conditions extend to the sea over the continental shelf. The plume has salinities less than 35 parts/thousand, high turbidity, high particulate and dissolved organic matter concentrations, and in the frontal zone, the highest aquatic primary productivity in tropical coasts. Its magnitude and extension depends on: a) the width and dynamics of estuarine inlets, b) river discharge, c) tides, d) littoral currents, and e) seasonal winds (Figures 17.1 and 17.2). The estuarine plume is greatest when associated with deltaic systems and the primary productivity of the plume is an indicator of environmental sustainability of deltas and their correlation with demersal fish resources in tropical coasts. Freshwater discharge can be on the surface especially associated with large rivers in the Gulf of Mexico, or as groundwater discharge as in karstic zones typical in the Caribbean Sea (see Day et al. 1997; Cardoch et al. 2002; Sánchez-Gil et al. 2008; Yáñez-Arancibia et al. 2007, 2009a).

From an ecosystem functioning focus, Figures 17.1 and 17.2 represent the landscape and seascape universe for EBM of coastal lagoons and estuaries. Figure 17.2 shows a number of compartments of nutrient cycles (mainly nitrogen) in coastal lagoons and estuaries. Important processes and components include nutrient and organic matter dynamics, estuarine primary producers, phyto- and zooplankton, microbial dynamics, benthic and pelagic organisms, nutrient and organic matter transport, and export through estuarine inlets and the estuarine plume extension to the open ocean.

Essential and critical habitat has been defined by the U.S. Congress as those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity. The designation and conservation of essential fish habitat seeks to minimise adverse effects on habitat caused by fishing and non-fishing activities. Habitat destruction, especially lost and degraded estuarine wetlands, was responsible for as much as half of the depleted coastal fisheries in United States waters. The U.S. Congress added essential fish habitat provisions to the revision of the Magnuson Act of 1976 (Magnuson-Stevens Act 1996). We can define habitat as the range of environmental conditions in which a species/population/life-history stage can live (Baltz 1990). Because of this approach, some important points have emerged (Box 17.1) based on Yáñez-Arancibia et al. (1994).

Box 17.1. Animal Behaviour Responses to Complex Estuarine Habitat Gradients in the Gulf of Mexico and the Caribbean

The utilisation of estuaries, coastal lagoons and low land tidal wetland ecosystems is an integral part of the life cycle of numerous finfish and shellfish, particularly in the Gulf of Mexico and the Caribbean. These coastal ecosystems are mainly utilised by juveniles and young adults.

There is a greater number of fish species in the coastal zone of the Gulf of Mexico and the Caribbean than in comparable temperate or boreal systems in Northern and Southern America.

Second-order consumers are more abundant and diverse than first-order consumers or top carnivores. Second-order consumers are the most common commercial fish stocks, in contrast with the top carnivores, which are the most common sport fishing stocks.

Functional components in the fishery-ecosystem of coastal lagoons and estuaries in the Gulf of Mexico and the Caribbean are: (a) resident species, those that spend their entire life cycle within estuaries, lagoons or coastal wetlands, (b) seasonal migrants, those that enter the estuary during a more or less well-defined season from either the marine or the freshwater side and leave it during another season, and (c) occasional visitors, those that enter and leave the estuary and associated coastal wetlands without a clear pattern within and among years. To these, two other groups may be added: (d) marine estuarine-related species, those that spend their entire life cycle on the inner sea shelf under the estuarine plume influence, and (e) freshwater estuarine-related species, those that spend their entire life cycle in the fluvial-deltaic river zone, associated with the upper zone of the estuarine system.

The ecosystem approach, defined here as a strategy for management of land, water and living resources that promotes conservation and sustainable use in an equitable way, was adopted at the Second Conference of the Parties of the Convention on Biological Biodiversity (CBD) as the primary framework for action under the Convention (Smith and Maltby 2003). Day and Yáñez-Arancibia (1982) published an early paper dealing with the ecosystem approach of coastal lagoons and estuaries. The ecosystem approach provides a framework for planning and decision-making that balances the objectives of the CBD (De Fontaubert 1996). People are placed at the centre of biodiversity management. Capturing and optimising the functional benefits of ecosystems is emphasised. The importance of biodiversity management beyond the limits of protected areas is emphasised, while protected areas are recognised as being important for conservation. The flexibility of the approach with respect to scale and purpose makes it a versatile framework for biodiversity management. Transboundary biodiversity problems can be addressed using the ecosystem approach and regional political structures. The objectives of management of land, water and living resources are a matter of societal choice. Ecosystem management should consider the effects (actual or potential) of the activities on adjacent and other ecosystems. Recognising potential gains from management, there is usually a need to understand and manage the ecosystem in an economic context (Yáñez-Arancibia et al. 2009b). Therefore, the ecosystem approach is a major concern for dealing with EBM of coastal lagoons and estuaries in the wider Caribbean region.

Coastal zone management must be integrated with the EBM approach. A successful programme is based on a comprehensive and integrated planning process, which aims at harmonising cultural, economic, social and environmental values and regulations (CEP/UNEP, 1995). Management without an appropriate planning process tends to be neither integrated nor comprehensive, but rather a sectoral activity. (Chua and Pauly 1989; Vallega 1992; Clark 1996; Cicin-Sain and Knecht 1998; Yáñez-Arancibia 1999, 2000; Olsen 2003). Integrated coastal management is a dynamic process by which decisions are taken for the use, development and protection of coastal areas and resources to achieve goals established in cooperation with user groups and national, regional and local authorities. Integrated coastal management recognises the distinctive character of the coastal zone, is multi-use oriented, analyses implications of development, conflicting uses and interrelationships between physical processes and human activities, and promotes linkages and harmonisation between sectoral coastal and ocean activities (Knecht and Archer 1993). Understanding and managing coastal and estuarine systems for sustainability requires an integrated ecological economics approach, and this implies the recognition of the economy as a subsystem of the larger ecological life-support system (Costanza 1994).

Progressive concepts of ecosystem-based management emphasise four common principles: 1) integration, 2) sustainability, 3) precaution, and 4) adaptiveness (Boesch 2006; Day and Yáñez-Arancibia 2009). These principles have important implications for addressing the coastal environmental crises worldwide. Although frameworks exist for integration of management objectives in a number of regions, the technical capacity for quantitative assessments of stressors and strategies is still in an early stage of development, particularly concerning restoring major coastal ecosystems in the Gulf of Mexico and the Caribbean. Based on these experiences (Boesch et al. 2001; Boesch 2006; Day et al. 2004; Yáñez-Arancibia and Day 2004a; Day and Yáñez-Arancibia 2009; Yáñez-Arancibia et al. 2006), ecosystem-based management could be advanced by the approach summarised in Box 17.2.

Box 17.2. Ecosystem-Based Management Approach for the Gulf of Mexico and the Caribbean

– Orienting more scientific activity to providing the solutions needed for ecosystem restoration.
– Building bridges crossing scientific management barriers to more effectively integrate science and management.
– Directing more attention to understanding and predicting achievable restoration outcomes that consider possible state changes and ecosystem resilience.
– Improving the capacity of science to characterise and effectively communicate uncertainty.
– Fully integrating modeling, observations and research to facilitate more adaptive management.

After the actions described in Box 17.2, coastal wetlands rehabilitation in the Gulf of Mexico and the Caribbean must focus on a new paradigm based on seven principles necessary for a sustainable vision for the future of coastal cities, wetlands and coastal lagoons and estuaries (Costanza et al. 2006): 1) let the water decide, 2) avoid abrupt boundaries between deep-water systems and uplands, 3) restore natural capital, 4) use the resources of the river-delta system to rebuild the coast, changing the current systems that constrain the river between levees, 5) restore the built capital of urban culture to the highest standards of high-performance green building and a car-limited urban environment, with high mobility for everyone, 6) rebuild the social capital to 21st century standards of diversity, tolerance, fairness and justice, and 7) restore the river basin-deltaic system to minimise coastal pollution and the threats of river flooding. From an EBM approach, people are becoming increasingly aware of the loss of the services wetlands once provided free of charge, including: a) groundwater and flood control, b) stable shore and storm protection, c) sediment retention, d) nutrient retention and export, e) plant and animal resources, f) energy resources, and g) biological diversity, among others. Therefore, essential habitat protection and restoration is a major concern for sustainable coastal fish stocks in the Gulf of Mexico and the Caribbean (Day et al. 2007, 2009). Benefits of the ecosystem approach for restoring coastal wetlands include: 1) water quality improvement, 2) reduction of public health threats, 3) habitat creation and enhancing landscape, 4) flood mitigation that will accrue to the locations where restoration and/or rehabilitation occurs, and 5) saving a significant amount of money (Costanza et al. 1997).

Conclusions and Implications for Management

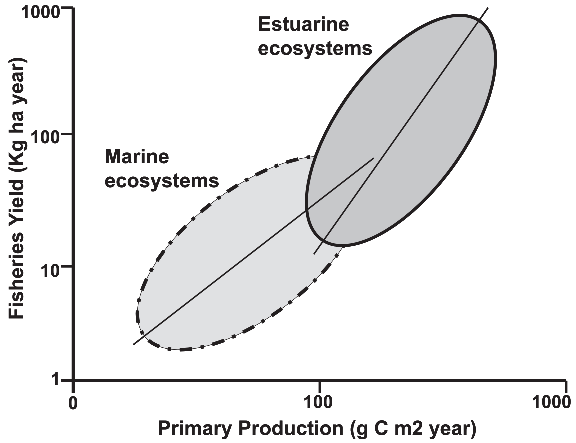
Why are Coastal Lagoons and Estuaries Highly Vulnerable?

Coastal lagoons and estuaries are dynamic open systems, which are dominated and subsidised by physical energies. A coastal ecosystem in such a physical environment reflects this dynamic open nature. In this section, we will present several ecosystem characteristics, which are a function of these features and a key concern for EMB. Coastal lagoons and estuaries are markedly different from most other coastal marine environments because they are the sites of interactions between freshwater discharge and the sea. If human impacts in the river basin change the quality of water entering the system, there will be consequences for the estuarine environment. Coastal lagoon and estuaries have the following general characteristics. If we do not understand this functioning, we will likely never achieve successful EBM of coastal ecosystems.

Coastal Lagoons and Estuaries are Highly Productive

These ecosystems are characterised by rates of primary and secondary production that are among the highest measured for natural ecosystems ((Rojas Galavíz et al. 1992; Mann 2000). In addition, high net ecosystem production allows a large economically valuable harvest of fish, oysters, shellfish, waterfowl, mammals, etc. Coastal lagoons and estuaries are so productive because they are subsidised ecosystems. Moving water is an important subsidy that is rich in nutrients. There are several types of primary producers and often there is year-round production (Rojas Galavíz et al. 1992). Physiological and behavioural adaptations (i.e., salinity tolerance and migration) allow much higher biomasses at certain times than could be supported on a year-round basis. We do not mean to imply here that coastal lagoons and estuaries are always very productive. Indeed, there are many instances where productivity is relatively low (i.e., under severe stress conditions, either natural or human induced). In general, these systems are much more productive than the adjacent continental shelf (Mann 2000).

Figure 17.3. Relationships between Aquatic Primary Productivity and Fisheries for Estuarine and Marine Systems, modified from Nixon (1982)



Oceanic primary productivity averages approximately 125 grams dry weight per square metre per year, compared with about 500 for upwelling zones, 300 for shelves, 2000 for estuarine environment, and 1000 for floodplains. Currently, estuarine fish production can reach 1000 kilograms/hectare/year, compared with 100 to 500 for shelves and less than 100 for open oceans (Figure 17.3). For example, the conceptual model presented in Figures 17.1, 17.2 and 17.3 predicts a shift in the focus of fish production from the benthic to the pelagic zone as nitrogen inputs change from low-quality organic matter to dissolved inorganic nitrogen. Total fish production predicted by the model of Figure 17.3 is not a simple function of dissolved inorganic nitrogen input. Benthic-pelagic coupling and nitrogen recycling combine to make fisheries production highest when there is an equal balance of nutrients and organic matter.

Coastal Lagoons and Estuaries are Ecologically Complex

From an ecological standpoint, complexity in tropical coasts can have several meanings. It can mean that there is a high diversity of species. It also can mean that there is a high diversity of environmental factors modulating biological processes, a high diversity of habitats, a high diversity of connections in the food web and complex linkages among the detritus benthic food web and the pelagic food web, and a high diversity of coupling both internally and with neighbouring systems (Figures 17.1 and 17.2). Coastal lagoons and estuaries have a relatively high environmental diversity. The diversity of important forcing functions is high (i.e., sun, wind, tide, rivers, rain, littoral currents and storms). There is also a high diversity of habitat types, of types of primary producers (i.e., marsh grasses, mangroves, sea grasses, macro algae, benthic and epiphytic algae, phytoplankton, terrestrial production and sea production) that are sources of organic matter. There is a high diversity of different types of life histories of estuarine organisms with many behavioural adaptations and physiological tolerances. Chemical cycling is also very complex (Day et al. 1989, 1997; Deegan et al. 1994; Hobbie 2000).

Coastal Lagoons and Estuaries are Ecologically Stable

As with the concept of complexity, stability can be considered in different ways: (1) systems achieving a steady state under constant conditions (i.e., tropical rain forest and coral reefs); (2) systems that evolve in variable environments and develop mechanisms to cope with the variability. Coastal lagoon and estuary ecosystems are of this latter type. Ecosystems of the former type are not very resistant to perturbations, while the latter are. Mechanisms to deal with variations include physiological and behavioural adaptations of different species as well as the development of alternative pathways and structures. Wide physiological tolerances, migrations, a highly connected food web, and complex chemical cycles are examples of these mechanisms. Thus, complexity increases the stability of coastal systems (Day et al. 1989; Mann 2000).

Coastal Lagoons and Estuaries Have Many Boundaries and are Open

Estuarine environments have many boundaries; both internal and external (see Figures 17.1 and 17.2). Externally, they are bound by marine, freshwater and terrestrial systems and the atmosphere. Internally, there are boundaries between water and bottom, aerobic and anaerobic, fresh and salt, wetlands and open waters, shallow and deep, different water masses, etc. Much of the reason that coastal lagoons and estuaries are productive, stable and complex is because of the nature and number of these boundaries. The existence of a boundary implies the existence of a gradient, and 'work' (in a thermodynamic sense) takes place when a gradient exists. Thus an ecosystem can be more productive (can do a greater amount of work) where there are many gradients. Hydrology is very important in maintaining these gradients. These boundaries also allow the development of many different habitats and increase both the stability and complexity of lagoon and estuaries (Day et al. 1989; Yáñez-Arancibia et al. 2007).

Coastal Lagoons and Estuaries are Heavily Used by Humans

Nutrient loading is frequently a practical problem for the management of coastal lagoons and estuaries. The addition of plant nutrients, especially nitrogen compounds, frequently leads to greatly increased planktonic primary production (see Figures 17.1, 17.2 and 17.3). That part of the primary production not taken by grazers then sinks to the bottom and decomposes, using oxygen and creating oxygen-deficient water masses where there is stratification. These can cause mass mortalities of bottom-dwelling organisms. High biomass of phytoplankton also blocks the penetration of light and causes death of submerged macrophytes. The long-term effect can be loss of productivity of fish and invertebrates and often loss of recreation potential as the water becomes turbid and dystrophic.

Reduction of nutrient input from cities and from agriculture is an expensive undertaking. There are several stages in the process. First, it is necessary to make the population aware of the nature of the problem. Second, it is necessary to obtain consensus on the details of the problem and of the steps needed to remedy it, taking into account the often-conflicting interests of various segments of the community. Only then can the political will be found to divert resources to the solution of the problem. The next stage is implementation of the solution, after which it is necessary to put in place a monitoring programme that will enable judgments to be made about the effectiveness of the steps taken. The heavy use of coastal lagoons and estuaries, coupled with the attendant detrimental effects, has led to environmental deterioration and thus a need for management so that there may be optimal use in the future. The consequence of this heavy use directly impacts the structure and function of these ecosystems. From an EBM approach, we present a synthesis of how humans affect system functioning (Box 17.3).

Box 17.3. Vulnerability of Coastal Lagoons and Estuaries From an EBM Perspective

The mechanisms that enable estuaries to be efficient nutrient traps also contribute to their ability to be pollutant traps.

Destruction of macrophytes such as marsh grasses or mangrove forests greatly lowers the productivity of an estuary, from food source and habitat perspectives, and directly limits its potential to produce finfish and shellfish.

Food chains in shallow coastal lagoons and estuaries are particularly susceptible to interference from man. Generally, the higher trophic levels depend upon a few key primary consumers that can utilise both micro algae and vascular plant detritus particles.

Many organisms from coastal lagoons and estuaries are living near the limit of their tolerance. These organisms may be excluded from an estuary by additional stresses such as those caused by low levels of pollution or by decreased oxygen concentration in the water resulting from dredging or mining.

Undisturbed and stabilised sediments are important in estuarine systems for normal nutrient cycling, to prevent excess turbidity in the water column, as a site for extensive plant growth, and as a habitat for benthic organisms.

Shallow coastal lagoons and estuaries normally exist in a state of natural eutrophication. For this reason they are vulnerable to any process that would lower the oxygen concentration of the water.

The most productive and valuable zone in many coastal lagoons and estuaries is the intertidal and shallow subtidal zone of wetlands. This boundary region is the area highly likely to be destroyed by changes in land use (i.e., construction of bulkheads, filling, dredging and agriculture).

Fresh water inflow is necessary for coastal ecosystems to function normally. The low salinity region of coastal lagoons and estuaries is important for the feeding and protection of juvenile fish and invertebrates and for the production of oysters. The salinity gradient appears essential in the life cycle of organisms that spawn outside the estuarine system.

Coastal Lagoons and Estuaries and Global Climate Change

Global warming is likely to have many consequences for coastal habitats (IPCC 2007). It is expected that sea surface temperatures will rise, with the largest changes at the highest latitudes. This increase will lead to greater evaporation near the equator and hence a more vigorous hydrological cycle. The mid-latitudes will have major increases in evaporation, whereas higher latitudes and some tropical latitudes (continental with mountain) will have major increases in precipitation, and in the tropical case associated with more frequent hurricane activity. As a result, the north-south coastal gradient in salinity may increase, creating fresher northern conditions and saltier tropical-subtropical conditions. The impact cited by UNCED Rio 1992 as requiring the most urgent action in the coastal zone was accelerated sea-level rise. The IPCC predicts a rise in sea level of about 40 cm by 2100 from thermal expansion of ocean water and melting land-based ice masses. In places where there is a natural environment adjacent to salt marshes, mangroves and so forth, the natural coastal communities may migrate inland with the rising waters, but if the migration is prevented by development it is likely that macrophytes will die as they are inundated beyond their flooding tolerance, leaving coasts exposed to storms and floods (Day et al. 2008). Under the scenario of a half-metre rise by the year 2100, it is estimated that the Caribbean islands will be under severe stress, and more than 4000 square miles of coastal wetlands could be lost in the United States. Some reports suggest that sea level will rise by one metre or more by 2100 (Rahmstorf 2007; Pfetter et al. 2008). Many human settlements will be threatened in the Gulf of Mexico (e.g., Tampa, Mobile, New Orleans, Galveston, Corpus Christi, Tuxpan, Panuco, Veracruz, Alvarado, Villa Hermosa, Ciudad del Carmen), especially by the increasing severity of episodic flooding associated with storm surges and with heavy rainfall. All of these cities are associated with coastal lagoons and estuaries. In the tropics, many low-lying areas currently used for human settlements will become uninhabitable. The degradation of coastal lagoon and estuarine habitats that has already occurred can only exacerbate these effects, and restoration of existing systems will help in coping with sea-level rise.

The discussion indicates a central point for EBM. Humans must think of management in terms of the whole ecosystem rather than of one species or population or activity. This is the case of humans using dynamic natural systems where disruption leads to decreased utility. From the standpoint of both temporal and spatial scales and functional integration, we conclude that the drainage basin in the coupled unit '*low river basin-wetlands-delta-coastal lagoon-estuary-estuarine plume onto the sea shelf*' is the optimal ecosystem level for a successful EBM approach of coastal lagoons and estuaries. Some principles that should guide EBM and conservation for sustainable development are: a) preserve basic structure and ecosystem functioning, b) utilise natural energy subsidies, c) live with the dynamic nature, d) define the long-term sustainable yield of renewable resources, and e) define medium-term climate change effects.

Part IV

Governance

Introduction

The chapters that comprise Part 4 focus on significant aspects of governance within the Wider Caribbean. In Chapter 18, Fanning and Mahon explore the effectiveness of regional institutional arrangements for ecosystem-based management of fisheries resources in the Caribbean, recognising that success will depend on understanding the connectivity between interactions with other sectors in the marine environment at multiple scales. The chapter highlights the complexity of governing current and future activities within the Caribbean and identifies both the strengths that exist among and between institutions for governance, as well as the challenges that arise from having such an abundance of institutions within the region.

Turning from the institutions to the legal framework for regional ocean governance, Haughton explains in Chapter 19 that while Caribbean states and territories appear committed to the application of principled ocean governance, as evidenced by their signing of many of the global multilateral environmental agreements, the legal basis for the ecosystem approach to fisheries is not adequately reflected in domestic legislation. In fact, within the region, he concludes that the concept is found primarily in non-binding instruments, and he therefore highlights the need for Caribbean states and territories to address these deficiencies to ensure the existence of a robust foundation for pursuing principled ocean governance at the national and regional levels.

In Chapter 20, Butler, Boudreau, LeBlanc and Baldwin emphasise an often overlooked component to effective governance, namely shared information. They stress the importance of having access to the best available information as a prerequisite for sustainable ocean governance success within the Wider Caribbean and highlight the opportunities available to share knowledge using current advances in information technologies. However, these authors caution that while the technical tool might be available, the provision of available information requires interest in sharing the knowledge. This requires trust and participation in information sharing while recognising that no one person or agency has, or can control, all of the information required to adequately manage coastal and marine ecosystems.

The final chapter, by Potter and Parsram, returns to the notion that effective governance in the region will require the involvement of non-state actors, particularly the current suite of non-governmental organisations (NGOs) that populate the Caribbean region. By fully implementing the principle of participation, the authors suggest that NGOs can provide a variety of resources and capabilities to support EBM functions. These range from networking, public awareness and education, and project management to scientific research, advocacy and funding. However, they caution that care and attention must be paid to understanding the capacities of the different types of NGOs within the region and the factors underlying their willingness and ability to support ecosystem-based management strategies in the Caribbean.

18

An Overview and Assessment of Regional Institutional Arrangements for Marine EBM of Fisheries Resources in the Wider Caribbean

Lucia Fanning and Robin Mahon

Abstract

This chapter explores the effectiveness of regional institutional arrangements for ecosystem-based management (EBM) of fisheries resources in the Caribbean, recognising that success will depend on understanding the connectivity between interactions with other sectors in the marine environment at multiple scales. The emphasis on fisheries resources is based on the priority assigned to the sustainable management of these shared resources by participating member countries in the pan-Caribbean Large Marine Ecosystem (CLME) project and the tractability of dealing with a single sector first, in the light of the complexity of the region. Given the existing suite of institutional arrangements in the region, the chapter highlights areas for improvement, with the authors recommending two potential options for institutional reform to facilitate EBM implementation for fisheries resources based on a Caribbean-derived large marine ecosystem (LME) governance framework. It concludes with an identification of the major challenges confronting the region as it attempts to implement options to facilitate an EBM approach to managing fisheries resources in the Caribbean.

Introduction

Ecosystem-based management recognises that an ecosystem is comprised of both a natural component and a human component. The natural subsystem is that part of the ecosystem that consists of the physical environment, the natural processes occurring within that environment and the biological resources that inhabit it. The human subsystem consists of those who use the natural component of the ecosystem for a variety of purposes (e.g., economic, social, cultural, research-related, conservation and/or spiritual) as well as those who are responsible for governing how these differing demands on the resources are to be met.

EBM seeks to integrate and balance the differing ecological, social and economic goals set by the human component of the ecosystem, recognising that success in one cannot be sustained without success in the others. It also takes into account the differing scales at which natural processes occur, often extending across political boundaries and connected to land, air and sea. Equally importantly for implementing EBM is to have in place institutional arrangements that engages multiple stakeholders in a collaborative process to define problems and seek equitable solutions, using adaptive management approaches that can respond to the uncertainties and risks inherent in these complex ecosystems (Christie et al. 2007).

This chapter will explore the effectiveness of regional institutional arrangements for EBM of fisheries resources in the Caribbean, recognising that success will depend on understanding the connectivity between interactions with other sectors in the marine environment that occur at multiple scales.

What are Institutional Arrangements?

As noted by McConney and Salas (Chapter 7), there tends to be some confusion between the terms institutions and organisations. For the purposes of this chapter, institutions are defined as the customary, socially prescribed norms, rules and modes of interactions that people develop in order to function effectively (Ostrom 2005). As such, an institution may include formally mandated rules and procedures (such as legislation and regulations) as well as the informal and voluntary but agreed-upon norms and customary practices (such as signing a deal with a handshake). Given this understanding of institutions, institutional arrangements can be thought of as the mechanisms or processes that have arisen as a result of the rules (formal and informal) that have been established to guide interactions between and among different people and organisations. Successful marine EBM will depend on the suitability of the chosen institutional arrangements to effectively achieve the stated EBM objectives. These arrangements are needed at multiple levels, and their effectiveness to implement EBM within a given sector and across sectors has been shown to be strengthened when interactions occur at the same level (local, national, regional or international) as well as between different levels (Fanning et al. 2007).

Lessons on Implementing EBM

The arguments supporting the adoption of an ecosystem approach to the management of living marine resources – be they extractive fisheries resources or non-extractive resources such as coral reefs or endangered species – have been made for some time now and in numerous fora (FAO 2003; Rosenberg 2006). These arguments draw on the recognised and well-publicised global failure of single-sector approaches to effectively identify cumulative impacts and manage the tradeoffs among competing demands for coastal and ocean uses and space. Referring specifically to fisheries as an example, Christie et al. (2007) suggest that the overwhelming evidence of unsustainable fisheries is a clear demonstration of the lack of the institutional arrangements necessary to implement an ecosystem approach to fisheries. In other words, the interactions, or lack thereof, between actors are such that they do not allow an ecosystem-based approach to fisheries to be achieved.

The Caribbean Context for EBM

The Caribbean region has been described as the most geographically and politically diverse and complex region in the world (Mahon et al. 2009). At this time, there is a great deal of ongoing work examining the implications of complexity for effective ocean governance. However, the findings need to be interpreted and applied in the Caribbean context, particularly when attempting to address priority transboundary areas of concern within the region. These priority areas, as identified during the project development phase of the CLME Project, were: unsustainable exploitation of fish and other living marine resources, habitat and community degradation, and pollution of the marine environment (CLME 2007). Focusing solely on a preliminary analysis of the causes responsible for unsustainable fishing practices, the research identified as contributing factors a lack of alternative sources of employment, pressures from the tourism sector and export demands, the lucrative nature of the lobster fishery, existing cultural norms, lack of appropriate and adequate management tools, and weak governance mechanisms. Given the transboundary nature of fish and other living marine resources at different stages of their life cycle, the effectiveness of any management initiative will necessarily depend on collaborative and cooperative actions at the regional level.

Existing Institutional Arrangements in the Caribbean

A number of regional initiatives and organisations already exist, and the need for attention to the governance of shared marine resources in the Wider Caribbean is well documented (Chakalall et al. 2007; Fanning et al. 2007; McConney et al. 2007; Mahon et al. 2009). From the early 1980s, it has been a major subject for discussion by the Western Central Atlantic Fisheries Commission (WECAFC), with agreement reached on the need for a coordinated regional effort at many other fora.

Similarly, an array of regional and global binding and non-binding agreements exists, which seek to address the social, economic and governance issues related to shared marine living resource management. These include the UN Convention on the Law of the Sea (UNCLOS), the UN Fish Stocks Agreement, the United Nations Food and Agriculture Organization (FAO) Compliance Agreement and the FAO Code of Conduct for Responsible Fisheries. The national-level implications of several of these are being explored by the Caribbean countries. These implications include: (a) the need for capacity building at the national level to take part in international and regional level management of shared resources; (b) the need for strengthening and expanding the scope of regional institutions to undertake this function; and (c) developing linkages among these arrangements and organisations.

Arrangements Specific to Transboundary Living Marine Resources

Institutional arrangements for the management of transboundary living marine resources in the Caribbean region have been emerging *de facto* from the ongoing efforts of various institutions (Chakalall et al. 2007). These include extra-regional, regional and subregional fisheries management organisations such as WECAFC of the FAO, the International Commission for the Conservation of Atlantic Tuna (ICCAT), the Caribbean Community Regional Fisheries Mechanism (CRFM), the Caribbean Fishery Management Council (CFMC) and other subregional arrangements such as the Latin American Organisation for Fishery Development (OLDEPESCA) and the Central American Organisation for the Fisheries and Aquaculture Sector (OSPESCA). In addition, multilateral political arrangements at the regional and subregional level have decision-making mandates that influence the rules affecting the use of shared living marine resources. These arrangements include the Association of Caribbean States (ACS), the Organization of American States (OAS), the Caribbean Community (CARICOM), the Central American Integration System (SICA) and the Organisation of Eastern Caribbean States (OECS).

With regards to managing shared living marine resources, the emerging arrangements are flexible and involve networking and adaptation of existing institutions. This approach has been endorsed by the countries of the region at two meetings of the WECAFC in 1999 and 2001. The arrangements involve a number of fledgling initiatives for various types of resources. For example, in the case of conch (Appeldoorn et al. Chapter 12), the Caribbean Fishery Management Council has taken the lead in approaching regional management. Efforts are underway for the WECAFC to lead in the management of shrimp and groundfish resources (Phillips et al. Chapter 15) and flyingfish (Fanning and Oxenford Chapter 16). The CRFM has undertaken to lead efforts aimed at other regional pelagics, and

OSPESCA is to lead in the management of lobster resources (Ehrhardt et al. Chapter 11).

From an institutional perspective, a major constraint affecting the effectiveness of these arrangements to implement EBM for the fisheries sector is the varying membership of Caribbean countries in each of these different bodies. Currently, all of the fisheries arrangements lack a pan-Caribbean mandate while at the political level, decisions by Spanish-speaking and English-speaking countries are still primarily made in isolation of each other. This shortcoming is being addressed through the increasing participation of all member states in the ACS and OAS, where the opportunity can be seized to implement decisions that reflect an understanding of the integrated nature of managing the shared resources of the Caribbean Sea. However, given the limited resources among member states, increasing participation to influence institutional arrangements, particularly at the extra-regional level such as ICCAT, will require innovative solutions that build on sub-regional and regional level efforts.

Non-Specific Arrangements Affecting EBM of Transboundary Living Marine Resources

Other important institutions affecting marine EBM in the Caribbean include the Revised Treaty of Chaguaramas and its associated rules and policies affecting the Caribbean Single Market and Economy, and the Common Fisheries Policy, as discussed by Haughton (Chapter 19). In addition, subregional rules, policies and norms affecting Central American countries will no doubt influence available institutional arrangements in a manner considerably different from those arising from the St. George's Declaration for the Eastern Caribbean States (OECS).

It is also worth noting that the regional environmental legislative regime comprises different international conventions that are related to marine and coastal resource management. For the Caribbean region in particular, the United Nations Environment Programme (UNEP) has played a leading role in the establishment of a number of conventions, protocols and action plans. These include the Caribbean Action Plan, adopted in 1981 to provide assistance to all countries of the region, recognising the special situation of the smaller islands. The 1983 Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (also known as the Cartagena Convention) and its three protocols (Cooperation in Combating Oil Spills, Specially Protected Areas and Wildlife, and Pollution from Land-Based Sources and Activities) are also significant institution-setting instruments.

At the international level, conventions relating to the sustainable management of transboundary living marine resources and marine environmental protection in the Caribbean region include: the Convention on Biological Diversity (CBD); the Convention on International Trade in

Endangered Species (CITES); the United Nations Framework Convention on Climate Change (UNFCCC); the Convention on Wetlands (the Ramsar Convention); and the International Convention for the Prevention of Pollution from Ships (MARPOL).

In 1991, the Marine Environment Protection Committee of the International Maritime Organisation designated the Wider Caribbean Region and the Gulf of Mexico as a Special Area under Annex V of the MARPOL Convention. More recently, on 20 December 2006, the UN General Assembly adopted a non-binding resolution entitled "Towards the Sustainable Development of the Caribbean Sea for present and future generations". This resolution is a significant step in the ongoing efforts begun almost a decade ago – led by the Association of Caribbean States – to secure the recognition by the international community of the Caribbean Sea as a special area in the context of sustainable development (CLME 2007).

Despite the existence of these regional and international initiatives, implementing the rules, norms and practices necessary to give effect to marine EBM is an ongoing challenge. Most countries lack the capacity, and there is seldom a clear mandate by any national, sub-regional or regional institution for management policies that address integration among sectors.

Building Institutional Arrangements to Address Unsustainable Exploitation of Fisheries

As discussed above, implementing an EBM approach needs to recognise the impacts of linkages within a given sector as well as having mechanisms in place that take into account the interconnectivity of decisions across the sectors to influence the goals of any single sector. However, given the seemingly intractable task of focusing effort on all sectors immediately, coupled with the emphasis on managing shared living marine resources in a sustainable manner in the pan-Caribbean CLME project, this chapter will limit its discussion to institutional arrangements to facilitate EBM implementation for fisheries resources. This focus does not in any way minimise the importance of the need to ultimately address intersectoral integration and cross-scale governance in the implementation of marine EBM in the Caribbean Sea.

In part, the array of overlapping and nested organisations within the Caribbean with varying mandates and responsibilities described above reflects the fact that the Caribbean fisheries is made up of a diversity of primarily small to medium-scale fisheries. As such, unlike other regions where valuable lucrative fisheries support regional management organisations such as the tuna fishery in the Western Central Pacific and the groundfish stocks in the North Atlantic, the Caribbean region does not have any major fish stocks attracting large commercial fleets from which revenues can be expected to support a single regional fisheries management institution. The emerging approach in the Caribbean seems more suited to the large diversity of resources that are already mostly exploited by indigenous fleets so that the issues relate primarily to conservation, optimisation and intra-regional equity (Mahon et al. 2009).

The Large Marine Ecosystem (LME) Governance Framework

In response to the particular characteristics of the Caribbean, an LME governance framework has been developed to address aspects of living marine resource governance in the Wider Caribbean Region (Fanning et al. 2007). As illustrated in Figure 18.1, the framework focuses on policy cycles that are complete – where processes are in place to ensure appropriate data collection leads to analysis and advice that informs decision-making, which then gets implemented and subsequently monitored and evaluated to determine the effectiveness of the decisions. The content of the common structure of these cycles may vary in nature at various levels (e.g., the decision-making process at a national governmental agency may be considerably more complex than a similar process occurring at a local fisher folk organisation). However, each policy cycle must be complete in order for there to be effective governance at the level or location in question. As illustrated by the vertical and horizontal lines connecting policy cycles (represented as ovals) in Figure 18.2, cycles must also be linked horizontally at each of the local, national, subregional, regional and international levels and vertically between these levels with two-way flows. It is also important for linkages between different policy cycles to be established, ensuring advice is available to inform the decision-making stages of the various cycles.

Figure 18.1. The complete policy cycle with linkages between each stage to ensure an effective decision-making

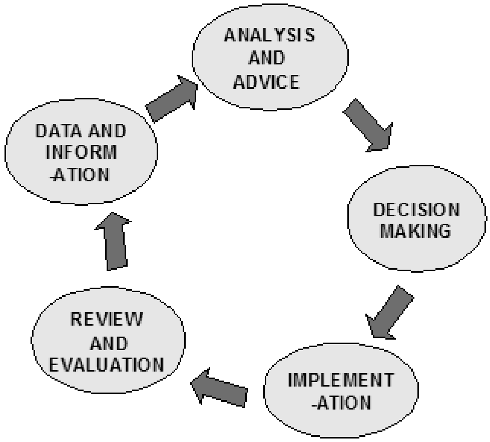
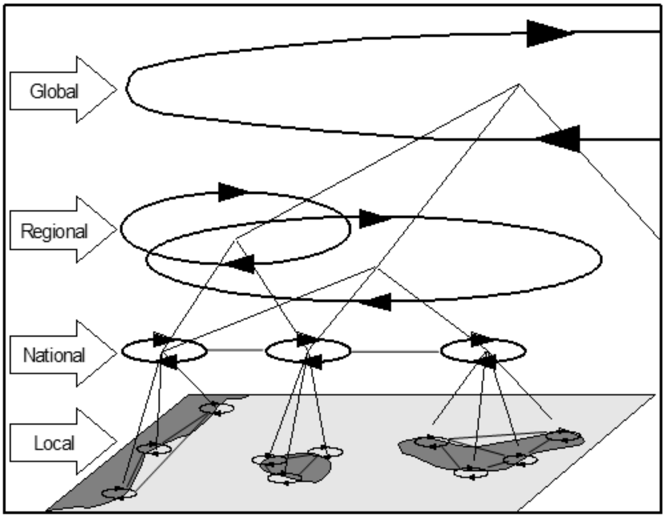


Figure 18.2. The multi-level component of the LME governance framework with vertical and horizontal linkages among the different policy cycles at multiple levels



Options Facilitating EBM of Fishery Resources

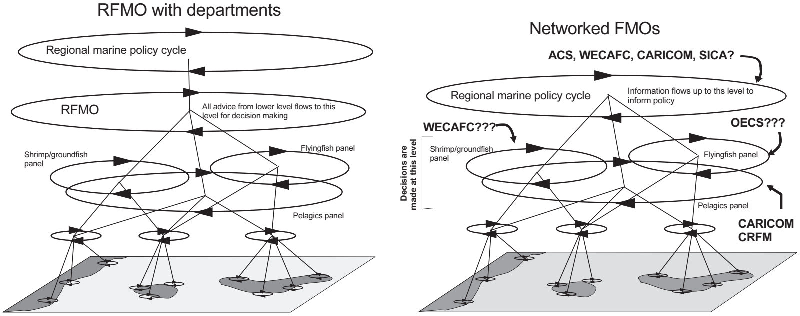
Research conducted for the CLME Project has suggested that major change is required in the institutional arrangements for an ecosystem approach to managing transboundary fisheries resources in the Caribbean (Parsons 2007). Chakalall et al. (2007) summarised the problems with the existing fisheries management arrangements thus:

> Essentially the array of organizations with interest in fisheries management is a mix of political and technical entities at a variety of geographic scales with affiliations at a variety of organizational scales. These arrangements were not originally oriented towards regional level cooperation in governance. However, they do provide some basis for achieving it. Their current weaknesses are often scale related; their geographic scope is inadequate; their small size is limiting; the capacity is limited, often comprising only a small Secretariat, and is often further diluted by a wide range of responsibilities. Equally problematic is that a value system (tradition/culture) for cooperation and integration is lacking.

The Networked Option

Options for improving effective governance of transboundary fisheries have been discussed and, given the contextual aspects of the region and the nature of the fisheries, it seems likely that a coordinated networked approach may be appropriate (Parsons 2007). This concept envisages principled ocean governance being achieved through a network of formal and informal multilateral agreements for the various resources/regions of interest to particular countries (Figure 18.3, right). The network would seek to establish common principles and practices where appropriate, with a nested suite of decisions being informed and made at each level of authority (regional, subregional, national and local). Application of the governance framework would allow for voluntary compliance with some of the decisions taken, while other decisions could require more formal compliance mechanisms to be established. It would also require the fisheries suite of policy cycles to be linked vertically to the broader region-wide marine policy cycle where issues connecting the different marine sectors – such as between fishing, conservation, tourism and oil and gas extraction – can be discussed prior to sector-focused decision-making.

Figure 18.3. The Fisheries EBM Departments/Panels Option (left) and the Networked Option (right)



The Coordinating RFMO Option

A variation of the networked approached could be a coordinating regional fisheries management organisation (RFMO) with departments/panels for various subsets of regions or resources (Figure 18.3, left). This would allow for different arrangements to be implemented for different species groups or regions. In essence, these departments/panels could be semi-autonomous entities operating under the umbrella of the overall RFMO. One major advantage of such an arrangement would be flexibility within an overall framework of principles and practices. The flexibility could extend to financing arrangements, with the countries being able to opt in or out of the sub-mechanisms, depending on their interest in and the perceived benefit of participating in the various components. Departments/panels could be assigned in such a way as to best address issues of geography, ecosystem, resource type and expertise available. As with the networked option, the suite of policy cycles focusing on fisheries resources must be linked vertically to the region-wide marine policy cycles, where intersectoral issues can be discussed prior to sector-focused decision-making.

Key Challenges

Given the priority for a regional approach to managing transboundary living marine resources in the CLME Project, the current array of institutional arrangements in place and the previously discussed complexity within the region, it seems logical to focus efforts on an EBM approach to fisheries resources. However, the full implementation of an EBM approach to fisheries resources and to other marine sectors using the LME governance framework in the Caribbean can be expected to be a highly dynamic process, taking several decades and requiring regular review and adaptation. It will require that existing organisations be willing to rationalise their current mandates and roles in the context of the framework, taking on the new responsibilities that will be essential for transboundary governance in the Caribbean. For example, the Association of Caribbean States, through its Caribbean Sea Commission and other intergovernmental organisations will need to incorporate processes for review of and decision-making on Caribbean Sea issues. This will require additional time and will incur additional transaction costs to ensure fully functional policy cycles are developed and appropriately linked horizontally and vertically.

Communication and networking will be key elements of implementing the framework. Electronic means now make this easier than ever, but care must be taken to ensure that access to technology, and the capacity to use it, do not introduce disabling inequities, especially at national and lower levels.

Differences in size and capacity among the countries of the region present particular challenges in many areas. To engage effectively, smaller countries often require subregional organisations to provide technical support and collective representation. This can lead to issues of sovereignty that must be considered in strengthening policy cycles at subregional levels. At the technical level, data and expertise are highly aggregated in a few of the larger countries. The capacity to access and use the data and to interact with the expertise is likely to be a key challenge in building an equitable framework.

The cultural diversity in the region also presents challenges. The development of shared principles and values, appreciation of the diversity of approaches that may be culture-based and the ability to communicate across language barriers are challenges that face all aspects of regional development and will be present in Caribbean Sea LME governance.

The socio-economic dependence of the countries in the Wider Caribbean, particularly small island developing states (SIDS), on the living and non-living resources provided by the Caribbean LME presents a considerable challenge for implementation of EBM. Sectoral decision-making at the governmental level that seeks to enhance economic gain in one sector can often conflict with the achievement of environmental, economic and social goals set in other sectors. At the same time, many key stakeholders from the private sector, including resource users, and civil society whose actions can support or undermine governmental level policy decisions are not fully engaged in the policy cycle process. The reasons for this may include lack of capacity, lack of institutional structures by some of these stakeholders, lack of resources to participate, and existing governance mechanisms that ignore the contributions these stakeholders can make to the policy process.

Conclusion

The strengthening of the LME Governance Framework in the Caribbean is seen as the most reasonable direction for building institutional arrangements that support EBM in the immediate future. It reflects to a large extent how governance has been developing in the region and builds on that knowledge (McConney et al. 2007). It is consistent with and uses emerging ideas on governance of complex socio-ecological systems. It can accommodate full participation and should enhance resilience of the entire system and all its parts.

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International Environmental Instruments and the Ecosystem Approach to Fisheries in CARICOM States

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Abstract

The ecosystem approach to fisheries and ocean governance has gradually emerged as an attractive addition to, or alternative to, traditional management approaches which have not produced the desired outcomes in respect of sustainable use and conservation of the resource systems. Caribbean states are committed to principled ocean governance and have been exploring the application of ecosystem-based management approaches. This chapter looks at the international instruments that establish the legal and institutional basis for ecosystem-based fisheries management, and examines their transposition in regional and domestic policy and law. It finds that whereas the legal basis for the ecosystem approach is well established in international law, the concept is found mainly in non-binding instruments. Furthermore, within the region, although the underlying principles are to be found in both regional agreements and domestic laws, the concept has not been explicitly provided for in these instruments. Caribbean states, therefore, need to address these deficiencies to ensure the existence of a robust foundation for pursuing ecosystem-based management and principled ocean governance.

Introduction and Background

The Caribbean region's coastal and marine ecosystems and their biological diversity are complex and dynamic natural systems, and valuable national and regional assets. They have been providing the countries with countless benefits in the form of food, employment, transportation, information, culture and recreation. If these assets are used and managed well, they can make a sustained contribution to a broad range of economic, social, cultural and nutritional goals.

Today, however, numerous challenges such as global warming and sea level rise, marine pollution, overfishing, population growth, increasing food prices and the continuing degradation of the coastal and marine environment are compelling us to develop and implement policies to more effectively protect and conserve these resources for sustainable development.

The doctrine of permanent sovereignty of states over their natural resources (UNGA 1962, 1986, 1992a) has dominated the use and conservation of marine fish stocks in areas under the sovereignty or jurisdiction of coastal states. However, since the 1980s when the crisis in global fisheries became evident, there has been a gradual shifting and refocusing of attention away from the doctrine of permanent sovereignty and the rights of states to exploit the resources, towards the responsibilities associated with their use.

Greater weight is now being given to the principle that the "right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources" (FAO 1995A, Principle 6.1). In other words, attention has been shifting towards improved governance of fisheries and ocean resources. There has also been a refocusing of attention on how to improve the effectiveness of international environmental laws to achieve sustainable resource use by, *inter alia*, identifying and addressing gaps in the existing legal framework, developing technical rules for enhanced implementation, and promoting synergies among instruments and agencies involved in implementation.

In this connection, the concept of principled ocean governance, whereby activities are regulated to ensure sustainable resource use and protection of the ecosystem, taking account of the needs of present and future stakeholders, through an integrated, interdisciplinary and intersectoral approach, has evolved and strengthened over the last 40 years. It is an attempt to use a holistic and systematic approach giving more attention to maintaining the productivity, health and integrity of the entire ecosystem in tackling the difficult challenges of ocean and coastal resource use and conservation.

The purpose of this chapter, however, is to consider the concept of ecosystem-based management or the ecosystem approach to fisheries and, more specifically, the extent to which multilateral environmental agreements (MEAs) and other international instruments can be relied on to support the application of this approach in the Caribbean Community (CARICOM) region.[1] The chapter does not attempt to consider all the MEAs and international documents that may support the concept but rather will consider a sample of the key ones dealing with the subject. It may be argued that the ecosystem approach is implicit in the concepts of conservation of natural resources, that is, use of the resource in a manner that does not compromise the long-term health or productivity of the ecosystem or any component of it. The International Union for the Conservation of Nature (IUCN) defines conservation as "the management of human use of organisms or ecosystems to ensure such use is sustainable. Beside sustainable use, conservation includes protection, maintenance, rehabilitation, restoration, and enhancement of population and ecosystems" (IUCN 1980). Before examining the treatment of the ecosystem approach within various agreements, it is useful to provide a brief overview of multilateral environmental agreements and the ecosystem approach concept.

Multilateral Environmental Agreements

A multilateral environmental agreement (MEA) is a legally binding treaty[2] between several states concerning environmental matters. Some are global in scope, while others are hemispheric or regional. The basic goal of MEAs is the achievement of a peaceful, sustainable, equitable and harmonious future for humankind and the planet by regulating the way man interacts with the natural world, whether directly or indirectly. The states that are party to an MEA must perform their obligations in good faith, and are prohibited from invoking the provisions of their own domestic law to justify any failure to comply with any obligation arising from the MEA (Vienna Convention 1969, Articles 26 27).

A distinction is often made between MEAs, which are described as "hard law", and those that are "soft law" depending on the nature of the agreement. The terminology of hard law describes an agreement containing specific and legally binding obligations, whereas soft law describes an agreement which is either not legally binding or the obligations are flexible or lack specificity. Although treaty provisions are generally binding on all parties to the treaty, some treaties may be written in broad language with considerable flexibility. For example, the provisions may be no more than an exhortation or an expression of intent, with no clear standard for compliance, and with considerable room for interpretation and discretion.

The value of non-binding international instruments should not, however, be underestimated, as they still carry the weight of political and good faith obligation, and are important in terms of the progressive development of the law. The soft-law approach is often the preferred option for environmental issues not simply because they are easier and quicker to negotiate but, perhaps more importantly, because they encourage broader participation and collective action. This is especially the case where framework agreements are concerned, since the fundamental purpose of these agreements is to provide an inclusive discussion and decision-making forum for addressing the subject at issue (University of Joensuu 2007).

It is important to note in passing that most CARICOM states adopt the dualist approach rather than the monist approach to international law. This means that international treaties, including MEAs, are not self-executing and are effective only when national legislation has been enacted to give effect to the provisions of the agreement.

The Ecosystem Approach

Ecosystem-based management is essentially an approach to management that considers the entire ecosystem, including human activities. The goal of ecosystem-based management is to maintain an ecosystem in a healthy, productive and resilient condition so that it can provide the services to both humans and the planet on a sustainable basis. Ecosystem-based management is different from traditional approaches, which tend to concentrate on the management of a single species, sector, activity or concern; it embraces an integrated holistic approach and the impacts of different sectors and activities. Specifically, ecosystem-based management:

- Emphasises the protection of ecosystem structure, functioning and key processes;
- Is place-based in focusing on a specific ecosystem and the range of activities affecting it;
- Explicitly accounts for the interconnectedness within systems, recognising the importance of interactions between many target species or key services and other non-target species;
- Acknowledges interconnectedness among systems, such as between air, land and sea and integrates ecological, social, economic and institutional perspectives, recognising their strong interdependences.

The ecosystem approach to fisheries management seeks to apply the general ecosystem-based concept within the fisheries context. It therefore recognises the need for fisheries management policies and rules to consider the broader impact of fisheries on the ecosystem as a whole and also the impact of the ecosystem, and other users of the ecosystem, on fisheries. The overall goal of the ecosystem approach to fisheries is to achieve sustainable use of the whole system, not just of the targeted fish species. The FAO defines the concept in these words: "... an ecosystem approach to fisheries (EAF) strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties of biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" (FAO 2003a).

The ecosystem approach concept in its various formulations has been supported, implicitly or expressly, by the rapidly developing legal framework regulating the use and conservation of natural resources, including the 1972 Stockholm Declaration, the 1982 UN Convention on the Law of the Sea, the 1992 Rio Declaration, the 2002 World Summit on Sustainable Development Plan of Implementation and others.

International Multilateral Environmental Agreements

The Ramsar Convention

A useful starting point in considering the development of the modern concept of the ecosystem-based approach is the Ramsar Convention (1971). This convention is an intergovernmental treaty that provides a framework for national action and international co-operation for the conservation and wise use of wetland ecosystems and their resources. Its provisions are relevant for present purposes as it seeks, *inter alia*, to preserve the fundamental ecological functions of wetland ecosystems as regulators of the water regime and as habitats supporting a characteristic flora and fauna (Preamble). Each contracting party is obliged to designate suitable wetlands within its territory for inclusion in a list of wetlands of international importance (Article 2.1). The contracting parties are also required to formulate and implement national legislation to promote conservation of their wetlands. Although fisheries managers do not rely heavily on the Ramsar Convention as a policy tool, it is nevertheless a treaty that can lend support to the ecosystem approach to management of aquatic resources, albeit within wetland ecosystems in the coastal zone. As of 13 January 2010, 159 states are party to the Convention, including eight CARICOM member states (Ramsar 2010).

World Heritage Convention

The Convention Concerning the Protection of the World Cultural and Natural Heritage (1972) links together in a single instrument the concepts of nature conservation and the preservation of cultural properties. The preamble recognises "that the cultural heritage and the natural heritage are increasingly threatened with destruction not only by the traditional causes of decay, but also by changing social and economic conditions which aggravate the situation with even more formidable phenomena of damage or destruction".

The convention establishes a body called the World Heritage Commission, which is responsible for the protection of natural heritage (Article 8). For the purposes of the Convention, the term "natural heritage"[3] has been given a wide meaning, which could include identified coastal and marine ecosystems. For example, the Belize Barrier Reef Reserve System, consisting of 96,300 ha of coastal space, was declared a natural heritage site under the Convention in 1996 (WHC 2009a). Each state party to the convention has the "duty of ensuring the identification, protection, conservation, presentation and transmission to future generations of the cultural and natural heritage" within its territory (Article 4). Further, to ensure that "effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage on its territory, each State Party" (Article 5) is mandated, "so far as possible, and as appropriate", *inter alia*, to adopt a general policy to give the cultural and natural heritage a function in the life of the community and to integrate its protection into comprehensive planning programmes (Article 5(1)), and to take the appropriate legal, scientific, technical, administrative and financial measures necessary for the identification, protection, conservation, presentation and rehabilitation of this heritage (Article 5(4)).

The Heritage Convention does not expressly address the concept of the ecosystem approach to management, nor is it a popular instrument in the tool box of fisheries managers, but as with the Ramsar Convention, it is yet another treaty that is capable of providing support for the ecosystem approach to conservation and protection of coastal and marine ecosystems and their resources falling within the definition of a natural heritage. There are 186 states party to the Convention as of 16 April 2009, including all the CARICOM states (WHC 2009b).

Convention on the Conservation of Antarctic Marine Living Resources

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR 1980) is a wide-ranging conservation convention that addresses not only the direct effects of harvesting specific organisms but also the indirect effects of exploitation on other species. This approach to management of the marine living resources was adopted out of concern that unregulated fishing, particularly for krill, could result in irreversible damage to the populations of other non-target species in the ecosystem. The preamble speaks to the importance of safeguarding the environment and protecting the integrity of the ecosystem of the seas surrounding Antarctica. Although the Convention is limited in geographic scope to Antarctica, CCAMLR is of interest for two main reasons. Firstly, it is one of the first treaties to expressly adopt the ecosystem-based management approach in respect of ocean resources, and secondly, it is considered one of the more successful MEAs. There are, however, two significant limitations on the ecosystem approach as practiced by CCAMLR that are worth highlighting (Churchill and Lowe 1999). Firstly, marine mammals fall outside of CCAMLR's competence and are regulated by other organisations. Secondly, the lack of scientific knowledge of the Antarctic ecosystem imposes practical difficulties in applying the concept in reality. We will return to the issue of science and the ecosystem approach below because it is an approach that relies on scientific knowledge.

UN Convention on the Law of the Sea

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) is a legally binding treaty that lays down the rights and obligations of states and provides the legal basis upon which to pursue the protection and sustainable development of the marine and coastal environment and its living resources. The preamble speaks of a desire to establish "a legal order for the seas and oceans which will facilitate international communication, and will promote the peaceful uses of the seas and oceans, the equitable and efficient utilisation of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment". The preamble also recognised the need for an integrated, holistic approach and, by implication, the ecosystem approach, to ocean governance. It says "the problems of ocean space are closely inter-related and need to be considered as a whole".

Within the exclusive economic zone (EEZ), the coastal state has "sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living" (Article 56 (1)). These rights are subjected to a number of duties. Firstly, the coastal state must give "due regard" to the rights and duties of other states (Article 56(2)). Secondly, it must take into account the best scientific evidence available in developing conservation and management (Article 61(2)). Thirdly, such measures must ensure that the "maintenance of the living resources ... is not endangered by over-exploitation", and that "such stocks are maintained at or restored to levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, ... and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global" (Article 61(3)). Fourthly, the coastal state must "take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened" (Article 61(4)).

UNCLOS also addresses the issue of protection and preservation of the marine environment. Firstly, states party to the convention are obliged to "take, individually or jointly as appropriate, all measures ... that are necessary to prevent, reduce and control pollution of the marine environment from any source" (Article 194(1)). Secondly, they must take all measures necessary to ensure that activities are so conducted as not to cause damage by pollution to other states and their environment, and that pollution arising from incidents or activities under their jurisdiction or control does not spread beyond the areas where they exercise sovereign rights (Article 194 (2)).

The Convention does not expressly provide for the use of ecosystem-based management or the ecosystem approach to fisheries. A strong argument can, nevertheless, be made that the underlying principles and objectives of this approach, and the basic components of it, are provided for in the standards and rules governing resource use and conservation. These include: commitment to sustainable resource use; taking into account the best available science; taking into account economic and environmental factors; consideration of the effect on associated species; the need to protect and preserve the marine environment and collaboration with interested regional and international organisations. It should also be recalled that the concepts of sustainable use and conservation themselves already imply some commitment to the ecosystem approach. If this proposition is accepted, then one can say the Convention implicitly supports the ecosystem approach to fisheries.

On the other hand, it should be noted that the duties imposed on the coastal states lack specificity, as they are formulated in very wide and general terms, giving the coastal states broad discretion in respect of their conservation and management obligations (Churchill and Lowe 1999). Furthermore, states are required merely to "take account of" environmental and economic factors and to "take into account" the interdependence of fish stocks as part of their conservation and management duties. While these provisions empower states to take account of ecosystem consideration when managing fisheries resources, the commitment is less than wholehearted. It is facilitative only rather than mandatory. These considerations would naturally diminish the strength of any implicit commitment to the undefined concept of the ecosystem approach to fisheries management in the Convention. There are 160 states party to the Convention as of 8 January 2010, including all CARICOM member states (UNDOALOS 2010).

Convention on Biological Diversity

The 1992 Convention on Biological Diversity (CBD) is a binding treaty that seeks to conserve and promote sustainable utilisation of biological diversity. The stated objective of the Convention is "the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources" (Article 1).

The preamble of the Convention identifies in situ "conservation of ecosystem and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings" as a fundamental requirement for the conservation of biological diversity. The legal principles and rules for in-situ protection of ecosystems and natural habitats are dealt with in Article 8. There are provisions addressing general mechanisms for planning, habitat protection and the protection of biological diversity at both national and regional levels. In respect of the coastal and marine environment, contracting parties are encouraged to promote the integrated marine and coastal area management approach, which is a participatory process for decision-making to prevent, control or mitigate adverse impacts from human activities, and to contribute to the restoration of degraded coastal areas.

There are provisions that can be used to support holistic planning for sustainable use and conservation of ecosystem resources. The Convention says that contracting parties must "as far as possible and as appropriate" prepare national plans (Article 6(a)), integrate conservation and sustainable use into plans and policies (Article 6(b)), and identify and monitor components of biological diversity important for conservation and sustainable use (Article 7). Contracting parties are also required to prepare environmental impact assessments for projects that are likely to have a significant adverse impact on biological diversity (Article 14).

There are also provisions that address protection of the ecosystem more directly. Contracting parties must, "as far as possible and as appropriate", protect ecosystems, habitat and minimum viable populations of species in their natural surroundings (Article 8(d)). Parties are further required to establish protected areas and develop management guidelines for these areas to conserve biological diversity (Article 8(a b)). They are also required to manage resources within and without these areas to ensure their sustainable use and conservation (Article 8(c)); restore degraded ecosystems and promote the recovery of threatened species (Article 8 (f)); prevent the introduction of, control or eradicate alien species that threaten ecosystems, habitats or species (Article 8(h)); and develop or maintain laws for the protection of threatened species and populations (Article 8 (k)). Parties are further required to recognise and respect the rights and traditional uses of biological resources by indigenous and local communities when developing measures to conserve and protect biodiversity (Articles 8(j) and 10(c)).

The Jakarta Mandate (1995) develops the ecosystem approach adopted by the CBD.[4] The Jakarta Mandate encourages the use of integrated marine and coastal area management as the most suitable framework for addressing human impacts on marine and coastal biological diversity and for promoting conservation and sustainable use of this biodiversity. It also encourages parties to establish or strengthen, where appropriate, institutional, administrative and legislative arrangements for the development of integrated management of marine and coastal ecosystems, plans and strategies for marine and coastal areas, and their integration within national development plans.

The Conference of Parties (COP) of the Biodiversity Convention defines the ecosystem approach as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way, and embraces it as the primary framework for action under the Convention (CBD 2000). The seventh meeting of the COP went further by agreeing that the priority at this time should be on facilitating implementation of the ecosystem approach and welcomed additional guidelines to this effect (CBD 2004).

Healthy, well-functioning and resilient ecosystems are possible only if biological diversity is conserved and maintained. Loss of biological diversity undermines and compromises the integrity of an ecosystem. Maintenance and conservation of biodiversity is thus a critical component of ecosystem-based management. While the CBD contains general provisions that can be used to support the sustainable use and conservation of coastal and marine ecosystems, including application of ecosystem-based management, there are troubling limitations within this convention. The fundamental problem is that the extent of the contracting parties' obligations is uncertain and ambiguous owing to the vague and imprecise language used to qualify these obligations (Wold 2002). For example, as noted above, the conservation obligations are said to be "as far as possible" and "as appropriate", thus allowing the contracting parties substantial flexibility and discretion in carrying out these obligations. These broad qualifications diminish and create difficulties in determining the limits of the parties' obligations and bring the commitments closer to being unenforceable soft law. Notwithstanding these concerns, the CBD is perhaps the most powerful international MEA supporting the ecosystem approach. There are presently 193 states party to the Convention, including all CARICOM member states (CBD 2010).

UN Fish Stocks Agreement

The objective of the UN Fish Stocks Agreement (1995), a legally binding treaty, is to ensure the conservation and management of straddling and highly migratory fish stocks (Article 2). Its purpose is essentially to clarify, add content to, and implement the duties imposed on states by UNCLOS (1982) to conserve and manage straddling and highly migratory stocks (see Articles 63(2), 64, and 116-120). This implementing agreement lays down the principles that should govern the conservation and management of the stocks in question by the coastal state within its EEZ and by the coastal state and other states operating on the high seas. The UN Fish Stocks Agreement is significant for its support for the general proposition that the rights and freedom of fishing must be subject to the duty to manage and conserve stocks, including the obligation to co-operate in order to achieve this objective.

The basic principles and standards concerning conservation and management of the resources are set out in Articles 5, 6 and 7. These rules are clearly inspired by the call for new approaches and informed by the sustainable development principles agreed by the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil, between 3 and 14 June 1992 (Anderson 1996). They are the most detailed principles and rules of their kind in any binding international agreement (Churchill and Lowe 1999) and are arguably implicitly based on the underlying concepts of the ecosystem-based approach and the precautionary principle[5] agreed to by UNCED. States must adopt conservation measures designed to ensure the long-term sustainability of fish stocks, which is consistent with the principle of sustainable development adopted in Agenda 21 (see below), based on the best scientific evidence available, taking into account fishing patterns and the interdependence of stocks. The conservation measures adopted must take account of the effect on species belonging to the same ecosystem or dependent on or associated with the target stocks, and maintain or restore populations at levels that can produce maximum sustainable yields, in keeping with the ecosystem approach. This means that states must adopt measures such as the use of selective, environmentally-safe and cost-effective fishing gear and techniques that will effectively minimise discards and bycatch, and reduce other negative impacts on target and non-target species and the ecosystem. States are further required to preserve biodiversity in species of fish (Article 5).

The commitment to the precautionary approach (Article 6) is new and innovative to the extent that it provides detailed rules for the application of the precautionary principle to fishing for straddling and migratory fish stocks. The precautionary approach is especially relevant in circumstances where data is inadequate and there is uncertainty regarding the impact of planned activity. For these reasons, it is particularly relevant to the Caribbean experience. Annex II contains Guidelines for Application of Precautionary Reference Points, which are based on sound science. Target or non-target fish stocks that become the subject of concerns must be more carefully monitored. If a natural event, such as a change in ocean currents like El Ninõ, adversely affects the status of stocks, states are required under Article 6, paragraph 7 to adopt temporary emergency measures in order to avoid worsening the situation by overfishing an affected stock (Anderson 1996). The precautionary approach is obviously closely linked to the ecosystem approach and reinforces the commitment to conservation and sustainable use. The main limitation with this treaty is that its application is concerned primarily with straddling and highly migratory stocks. As of 8 January 2010, 77 states were party to the UN Fish Stocks Agreement, including five CARICOM member states: Belize, the Bahamas, Barbados, Saint Lucia, and Trinidad and Tobago (UNDOALOS 2010).

Non-Binding International Instruments

Stockholm Declaration

The influential 1972 UN Conference on Human Development is an important instrument in the development of international law on protection of the natural environment as a means of promoting human development. Principles 2 and 6 of the Stockholm Declaration (1972) speak explicitly of the need to protect the natural ecosystem as an important component of the overall effort to preserve and enhance the human environment.[6] The Declaration is, however, soft law and does not impose any binding obligations on states.

Chapter 17 of Agenda 21

UNCED was undoubtedly a watershed in the growth and acceptance of the principles of sustainable development. It was also a significant event in respect of the development of the ecosystem approach to fisheries. Chapter 17 of Agenda 21 (UNGA 1992b) deals with the protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas, and the protection, rational use and development of their living resources. It calls for an ecosystem approach to ocean and coastal management. States are required to adopt "new approaches to marine and coastal area management and development, at the national, sub-regional, regional and global levels, approaches that are integrated in content and are precautionary and anticipatory in ambit" (paragraph 17.1). It provides a framework for integrated management and the sustainable development of coastal areas (Programme A), marine environmental protection (Programme B), sustainable use and conservation of marine living resources in the high seas (Programme C), and in areas under national jurisdiction (Programme D). Chapter 17 also addresses uncertainties related to natural variability of the marine environment and climate change (Programme E).

In respect of fisheries, there is a call for improved management, with emphasis given to "multi-species management and other approaches that take into account the relationships among species, especially in addressing depleted species" (see paragraphs 17.45 and 17.70). States committed themselves to the conservation and sustainable use of marine living resources and more specifically, *inter alia*, to take account of nutritional needs, as well as social, economic and development goals; to take account of traditional knowledge and interests of local communities, artisanal fisheries and indigenous peoples; to maintain or restore species at levels that can produce the maximum sustainable yield; to promote the use of selective fishing gear and practices that minimise waste and bycatch of non-target species; to protect endangered species; to preserve ecosystems, habitats and other ecologically sensitive areas; and to promote research (paragraphs 17.46 and 17.74).

States are further asked to identify ecosystems with high levels of biodiversity and other critical habitat and designate them as protected areas, giving priority to: coral reef ecosystems; estuaries; wetlands, including mangroves; seagrass beds; and other spawning and nursery areas (paragraph 17.85). Finally there is a general call for improved collaboration and co-operation at bilateral, sub-regional, regional and global levels to improve the sustainable use and conservation of coastal and ocean resources.

FAO Code of Conduct for Responsible Fisheries

The FAO Code of Conduct for Responsible Fisheries (FAO 1995a) is a comprehensive and detailed, non-binding global agreement setting out principles and standards for responsible practices "with a view to ensuring the effective conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity" (Introduction). The Code of Conduct provides a synthesis of the requirements for the ecosystem approach to fisheries found in several international instruments and provides the conceptual basis and institutional requirement for its application (Garcia et al. 2003).

The objectives of the Code of Conduct include, *inter alia*, establishing principles for responsible fisheries taking into account relevant biological, technological, economic, social, environmental and commercial aspects (Article 2(a)); protection of the living resources and their environments and coastal areas (Article 2(g)); and research on fisheries as well as on associated ecosystems and relevant environmental factors (Article 2(i)).

The general principles of the Code include several provisions that are relevant for present purposes in that they speak to the application of the ecosystem approach to fisheries management. The principles provide, *inter alia*, that aquatic ecosystems should be conserved (Article 6.1); fisheries management should maintain the quality, diversity and availability of fishery resources in sufficient quantities for present and future generations and ensure the conservation of target species and other species belonging to the same ecosystem or associated with or dependent upon the target species (Article 6.2); prevent overfishing and excess fishing capacity, and rehabilitate degraded populations (Article 6.3); use of the best scientific evidence available, including traditional knowledge and relevant environmental, economic and social factors (Article 6.4); and encourage bilateral and multilateral co-operation in fisheries research.

The general principles also call on states to use the precautionary approach (Article 6.5); develop and use selective and environmentally safe fishing gear and practices; minimise waste, catch of non-target species, and negative impacts of fishing on associated or dependent species (Article 6.6); and protect or rehabilitate critical fisheries habitats and ecosystems from destruction, degradation, pollution and other impacts resulting from human activities that threaten the health and viability of the fishery resources (Article 6.8). Provisions are also made for integrating fisheries into coastal area management, planning and development (Article 6.9) and co-operation at sub-regional, regional and global levels through fisheries management organisations, or other international agreements, to ensure effective conservation and protection of the resources throughout their range of distribution, taking into account the need for compatible measures in areas within and beyond national jurisdiction (Article 6.10).

The ecosystem approach to fisheries has been further developed in the FAO technical guidelines for responsible fisheries, which supplement the

Code (FAO 2003a). The Guidelines provide operational procedures for the ecosystem approach. They provide suggestions on how to translate the economic, social and ecological policy goals of sustainable development into operational objectives, indicators and performance measures. The Guidelines also recognise the need for a flexible and adaptable approach that can meet the needs of the particular physical, social and economic conditions of a management area, however defined.

The Code, taken together with the technical guidelines, is the most comprehensive instrument based on the concept of ecosystem approach to fisheries. The FAO is required to monitor and report on progress in implementing the provisions of the Code of Conduct at each meeting of the FAO Committee on Fisheries (COFI). A recent FAO report on the implementation of the Code acknowledges, not surprisingly, that “fundamental changes in the fisheries sector since the adoption of the Code in 1995 remain limited” (FAO 2009). The report also acknowledges that world fishing fleets remain largely in an overcapacity situation, global resource rent is negative, and overall stock status trends have continued to deteriorate. The paper goes on to say that in technically complex areas such as the implementation of the ecosystem approach to fisheries, the Code’s impact has been diffuse and progress has been slow.

Reykjavik Declaration on Responsible Fisheries

The Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem, held in Reykjavik, Iceland between 1 and 4 October 2001, was a significant event in respect of the development of the ecosystem approach to fisheries. The conference reviewed the available scientific knowledge on marine fisheries and ecosystem issues and produced the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem (FAO 2002). The Conference sought to establish a means by which ecosystem considerations could become more prominent in capture fisheries management, and to identify future challenges and strategies to facilitate implementation of the ecosystem approach.

The Reykjavik Declaration’s preamble confirms that the aim of including ecosystem considerations in fisheries management is to contribute to long-term food security and human development, as well as effective conservation and sustainable use of the ecosystem and its resources. It states that including ecosystem considerations provides a framework to enhance management performance, and affirms that these considerations imply more effective conservation of the ecosystem, increased attention to interactions such as predator-prey relationships among different stocks and species, and a better understanding of the impact of human activities on the ecosystem.

The preamble also recognises the need to strengthen and sustain management capacity to incorporate ecosystem considerations, and stresses the need for further development of scientific knowledge on the ecosystem and the ecological impacts of fishing. It recognises further that certain non-fishery land- and sea-based activities have an impact on the marine ecosystem and therefore have consequences for fisheries management.

The Reykjavik Declaration itself states that, in an effort to reinforce responsible and sustainable fisheries in the marine ecosystem, "we will individually and collectively work on incorporating ecosystem considerations into that management to that aim".

It also speaks of a need to immediately introduce effective management plans that encourage responsible fisheries and sustainable use of marine ecosystems (Clause 2); the importance of strengthening or establishing regional fisheries management organisations that incorporate ecosystem considerations (Clause 3); the prevention of adverse effects of non-fisheries activities on marine ecosystems (Clause 4); and the need to monitor the interaction between aquaculture in the marine environment and capture fisheries (Clause 6).

The Reykjavik Declaration notes that scientific knowledge required to apply the ecosystem approach needs to be advanced in several areas, including: sustainable management strategies that incorporate ecosystem considerations; characteristics of marine ecosystems, diet composition and food webs, species interactions and predator-prey relationships, and the role of habitat and factors affecting ecosystem stability and resilience; systematic monitoring of natural variability, and its effect on ecosystem productivity; monitoring of bycatch and discards in all fisheries; fishing gear and practices; and the adverse human impacts of non-fisheries activities (Clause 5).

It further emphasises the need to strengthen international co-operation to support developing countries in incorporating ecosystem considerations into fisheries management (Clause 7).

The Declaration highlights the importance of the ecosystem approach to fisheries and calls for its incorporation in fisheries management as a means of achieving sustainable and responsible use of fisheries and marine ecosystems.

Johannesburg Plan of Implementation

The Plan of Implementation of the World Summit on Sustainable Development (WSSD 2002) clarifies and echoes the call made in previous instruments for the application of the ecosystem approach to the management and conservation of living marine resources. It recognises that "oceans, seas, islands and coastal areas form an integrated and essential component of the earth's ecosystem and are critical for global food security and for sustaining economic prosperity and the well-being of many national economies, particularly in developing countries". It also recognises that "sustainable development of the oceans requires effective co-ordination and co-operation, including at the global and regional levels, between relevant bodies, and actions at all levels…" (paragraph 30).

The Plan of Implementation exhorts states to "promote integrated, multidisciplinary and multisectoral coastal and ocean management at the national level and encourage and assist coastal States in developing ocean policies and mechanisms on integrated coastal management" (paragraph 30(e)). It also calls for the implementation of Agenda 21 (paragraph 30(c)) and supports the Reykjavik Declaration by encouraging "the application by 2010 of the ecosystem approach, noting the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem and decision V/6 of the Conference of Parties to the Convention on Biological Diversity" (paragraph 30 (d)). It further calls for "the use of diverse approaches and tools, including the ecosystem approach, the elimination of destructive fishing practices, the establishment of marine protected areas… by 2012" (paragraph 32(c)). States are also required to take action to maintain or restore stocks to levels that can produce the maximum sustainable yield with the aim of achieving these goals for depleted stocks by 2015 where possible (paragraph 31(a)), and to maintain the productivity and biodiversity of important and vulnerable marine and coastal areas (paragraph 32(a)).

The WSSD Plan of Implementation thus reinforces and adds urgency to the call made in previous instruments for states to adopt and use the ecosystem approach to fisheries.

Regional Agreements

In additional to the international MEAs and documents, there are several agreements with more limited geographical scope that are relevant for present purposes.

The 1940 Convention on Nature Protection

The Convention on Nature Protection and Wild Life Preservation in the Western Hemisphere (1940) is a hemispheric treaty that calls on parties to protect wildlife by establishing various categories of protected areas (Article 1) where there would be no exploitation of the resources. The preamble speaks of a desire "to protect and preserve in their natural habitat representatives of all species and genera of their native flora and fauna, including migratory birds, in sufficient numbers and over areas extensive enough to assure them from becoming extinct through any agency within man's control". Parties are not obliged to create protected areas, but are required to "explore at once the possibility of establishing" them (Article II (1)). These protected areas could be national parks, national reserves, nature monuments or strict wilderness reserves. However, if a party decides to establish a national park or strict wilderness reserve pursuant to the treaty, it must prohibit the exploitation of wildlife and other resources within the protected area (Articles III IV).

While this treaty does not speak explicitly of the ecosystem approach, it is another legal instrument that can be used to support the implementation of regional and domestic policies and laws to give effect to ecosystem-based management. However, at present there are only three CARICOM states that are party to the Convention: Haiti, Suriname, and Trinidad and Tobago (OAS 2009).

The Cartagena Convention

The 1983 Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, also known as the Cartagena Convention, is a legally binding treaty for the protection and development of the marine environment of the Wider Caribbean Region (Article 2(1)).[7] The Convention requires the adoption of measures aimed at preventing, reducing and controlling pollution from various sources. It also requires parties to take appropriate measures to protect and preserve rare or fragile ecosystems, as well as the habitat of depleted, threatened or endangered species and to develop technical and other guidelines for the planning and environmental impact assessments of important development projects in order to prevent or reduce harmful impacts on ecosystems. It provides the legal framework for co-operative regional and national actions to meet its objectives, and is supplemented by three protocols: the Oil Spills Protocol (1983), the Specially Protected Areas and Wildlife Protocol or SPAW Protocol (1990), and the Land-based Pollution Protocol or LBS Protocol (1999). The Convention has been ratified by 23 states in the Wider Caribbean Region, including 11 CARICOM member states (CEP 2010). The Bahamas, Guyana, Haiti and Suriname are not party to the Convention.

The SPAW Protocol entered into force fairly recently (18 June 2000) and is highly relevant for the present review. The general objective of the SPAW Protocol is to protect rare and fragile ecosystems and habitats, thereby protecting the endangered and threatened species residing therein. It is a comprehensive agreement with detailed and specific provisions for realising its objectives. The preamble highlights the special hydrographic, biotic and ecological characteristics of the Wider Caribbean Region; the grave threat to the integrity of the marine and coastal environment posed by ill-conceived development; and the overwhelming ecological, economic, aesthetic, scientific, cultural, nutritional and recreational value of rare or fragile ecosystems and native flora and fauna to the region. It also recognises that the Caribbean is made up of an interconnected group of ecosystems in which an environmental threat in one part represents a potential threat in other parts, and that protection and maintenance of the environment are essential to sustainable development within the region. The preamble further emphasises "the importance of establishing regional co-operation to protect and, as appropriate, to restore and improve the state of ecosystems, as well as threatened and endangered species and their habitats".

Each party to the SPAW Protocol is obliged to "take the necessary measures to protect, preserve and manage in a sustainable way, … areas that require protection to safeguard their special value; and threatened or endangered species of flora and fauna" under their sovereignty or jurisdiction (Article 3(1)). Parties must also "regulate and, where necessary, prohibit activities having adverse effects on these areas and species" (Article 3 (2)) and "to the extent possible … manage species of fauna and flora with the objective of preventing species from becoming endangered or threatened" (Article 3(3)). It should be noted, however, that it does not say when the prohibitions will be necessary.

Parties to the SPAW Protocol are obliged to establish and manage protected areas unilaterally and co-operatively. It provides that, "when necessary", parties must unilaterally "establish protected areas in areas … with a view to sustaining the natural resources … and encouraging ecologically sound and appropriate use, understanding and enjoyment of these areas" (Article 4(1)). Parties are also obliged to collectively establish co-operative programmes to establish and manage protected areas and advance the objectives of the agreement (Article 7). The Protocol does not say when such action will be necessary. Presumably it is left to the discretion of the state to make a determination, individually or co-operatively, on whether to establish a protected area. If, however, a party decides to establish a protected area, it must satisfy certain basic requirements designed to conserve, maintain and restore biodiversity and the ecosystem (Article 4(2)).

In addition to the establishment of protected areas, parties are under an obligation to take unilateral actions to prevent species from becoming endangered or threatened, and to identify and protect species that may be threatened or endangered. Once identified, states must "regulate and prohibit … activities having adverse effects on such species or their habitats and ecosystems, and carry out species recovery, management, planning and other measures to effect the survival of such species" (Article 10(1)). Additionally, for protected flora, which presumably would include seagrass beds, states must "regulate, and where appropriate, prohibit all forms of destruction and disturbance, including the picking, collecting, cutting, uprooting or possession of, or commercial trade in" such protected species (Article 10(2)). For protected fauna, states likewise "must regulate, and where appropriate, prohibit: the taking, possession or killing or commercial trade in such species or their parts or products; and to the extent possible, the disturbance of wild fauna, particularly during the period of breeding, incubation, estivation or migration, as well as other periods of biological stress" (Article 10(3)). Note that here the obligation to "regulate" is unqualified so that once identified as threatened or endangered it must be regulated, whereas the obligation to "prohibit" certain activities is qualified by “where appropriate”, thus giving the state some amount of flexibility.

Parties are further obliged to take co-operative action to ensure the protection and recovery of endangered and threatened species that they list in Annexes I, II and III of the SPAW Protocol (Article 11(1)). The Protocol calls for measures to ensure total “protection and recovery” for species listed in Annexes I and II. There is a complete ban on the taking, possession or killing or commercial trade in such species, their eggs, parts or products, and “to the extent possible” states must also prohibit disturbance to such species (Article 11(1)(b)). These are much more stringent provisions allowing less discretion and flexibility to states.

Although the SPAW Protocol does not expressly call for the application of the ecosystem approach to fisheries or ecosystem-based management, it is written in specific and strong language covering conservation and protection of species, habitats and ecosystems, and includes the basic principles and rules for application of the ecosystem approach. It is clearly a powerful but underutilised instrument for the sustainable use and protection of coastal and marine resources in the Caribbean using the ecosystem approach. The Protocol has been ratified by twelve states, including five CARICOM member states: Barbados, Belize, Saint Lucia, Saint Vincent and the Grenadines, and Trinidad and Tobago (CEP 2010). To fully realise the benefits of the Convention, including the protocols, more states need to come on board.

Revised Treaty of Chaguaramas

The objective of the Revised Treaty of Chaguaramas (2001) establishing the Caribbean Community, including the CARICOM Single Market and Economy (CSME), is to promote economic and social development through regional co-operation and integration of the economies. The Treaty provisions address natural resource management and fisheries. CARICOM has an obligation to adopt effective measures to assist member states in the management of their natural resources (Article 58(1)). More specifically, CARICOM must adopt measures for the effective management of the soil, air and all water resources, the EEZ, and all other maritime areas under the national jurisdiction of the member states; and for the conservation of biological diversity and the sustainable use of biological resources of the member states (Article 58(2)). In respect of fisheries, the Treaty requires the Community, in collaboration with national, regional and international organisations, to promote the development, management and conservation of the fisheries resources in and among the member states on a sustainable basis (Article 60(1)). The Community is required to achieve this objective by, *inter alia*, enhancing the institutional capabilities and providing assistance to the member states; establishing development programmes for aquaculture; and encouraging the establishment of protected aquatic habitats and associated terrestrial areas and fish populations (Article 60(2)). The Treaty also requires the Community to promote the establishment of a regime for the effective management, conservation and utilisation of the living resources of the EEZs of the member states (Article 60(4)). While the Revised Treaty of Charaguamas does not specifically address the concept of an ecosystem approach, it is another instrument that can be used to support its use in the CARICOM region.

The CRFM Agreement

The Agreement establishing the Caribbean Regional Fisheries Mechanism (CRFM) is a legally binding treaty that was signed and entered into force on 4 February 2002. The objective of the CRFM Agreement is to establish a regional fisheries body to promote co-operation in the sustainable use and management of the fisheries of the states party to the agreement, which are the CARICOM member states plus Anguilla and the Turks and Caicos Islands. Article 4 sets out the objectives of the CRFM as follows:

> the efficient management and sustainable development of marine and other aquatic resources within the jurisdictions of Member States; the promotion and establishment of co-operative arrangements among interested States for the efficient management of shared, straddling or highly migratory marine and other aquatic resources; and the provision of technical advisory and consultative services to fisheries divisions of Member States in the development, management and conservation of their marine and other aquatic resources.

The CRFM's work must be guided by a number of general principles including, *inter alia*, maintaining marine biodiversity, managing fishing capacity and fishing methods so as to facilitate resource sustainability, and use of the precautionary approach (Article 5). In addition, the CRFM is required to "promote the protection and rehabilitation of fisheries habitats and the environment generally" (Article 9). This is one of the functions of the Forum, which is comprised of the Chief Fisheries Officers of the states. The Agreement does not speak explicitly of the ecosystem approach to fisheries, but it is yet another instrument that can provide support for its application in the Wider Caribbean Region.

UN Resolution 59/230 on the Caribbean Sea

The UN General Assembly resolution promoting an integrated management approach to the Caribbean Sea (UNGA 2005) encourages the promotion of an integrated management approach in accordance with, *inter alia*, Agenda 21, the Johannesburg Plan of Implementation, and UNCLOS (paragraph 4). It also calls on states to develop national, regional and international programmes for halting the loss of marine biodiversity in the Caribbean Sea, in particular fragile ecosystems such as coral reefs (paragraph 14).

Common Fisheries Policy

The CARICOM countries have committed themselves to the development and implementation of a Common Fisheries Policy and Regime as an instrument to achieve their fisheries development objectives. The Policy will set out the goals to be achieved in respect of fisheries and associated ecosystems, including the desired improvements in social and economic conditions, and the desired targets in respect of conservation and protection of ecosystems. It will also set out, in a comprehensive framework, the basic principles, standards and rules to be followed to ensure good governance, fairness and equity in the utilisation and management of the fisheries resources. Although the agreement is still being negotiated, it expressly provides for the use and application of the ecosystem approach to fisheries as a fundamental principle of the Policy.

Domestic Law

Domestic laws regarding management and conservation of fisheries in CARICOM member states do not explicitly address the ecosystem approach, as the concept is relatively new. The fisheries laws generally reflect the rights and obligations assumed under UNCLOS in respect of sustainable use and conservation of fisheries. Antigua and Barbuda, Dominica, Grenada, Montserrat, Saint Lucia, Saint Kitts and Nevis, and Saint Vincent and the Grenadines have harmonised their fisheries laws. Barbados and Guyana have followed the general scheme of the harmonised fisheries laws of the eastern Caribbean states.[8] The principal fisheries acts and subsidiary legislations lay down the legal rules for development and management of the fisheries resources including, *inter alia*, the rules governing the conservation and management of fisheries and ecosystems.[9] The ministers responsible for fisheries are generally given broad powers to "take such measures as he thinks fit"[10] to promote the management and development of fisheries to ensure optimum utilisation of the resources. Guyana's Fisheries Act (2002) goes further than the other CARICOM states in calling for use of the precautionary approach to fisheries management, as well as the need to conserve fisheries resources for future generations.[11] The powers given to the ministers appear broad enough to embrace the ecosystem approach and other recent principles aimed at the protection and conservation of fisheries and their ecosystems.

Conclusion

Healthy, well-functioning marine ecosystems are necessary prerequisites for a sustainable supply of fish from the seas and oceans to meet human food and nutritional needs. Today, however, marine ecosystems are under severe stress from, *inter alia*, fishing and ineffective fisheries management, degradation of the environment, and climate change.

The ecosystem approach to fisheries management is an emerging, promising, yet problematic legal concept owing to practical difficulties in defining and implementing the integrated, holistic, cross-sectoral measures needed to give effect to the concept and to manage the ecosystem as a whole. While the concept has been gaining support among policy makers, fisheries managers and scientists, there are continuing difficulties in establishing the appropriate measures and techniques for operationalising it and achieving marine ecosystem management and protection.

A challenge with the ecosystem approach is that the ecosystem is not only affected by the specific international and domestic legal rules that target them for protection and conservation, but by the entire suite of laws and practices adopted by a state, and by neighbouring states in some cases, aimed at regulating human activities whether environmental, economic, social, cultural or technological.

Another underlying problem is that the ecosystem-based management concept is an ideal rather than a specific practice and would not, *prima facie*, have binding effect in international law. As such, states are unlikely to be legally bound to use the ecosystem approach. Agreements that explicitly call for the use of ecosystem-based management or the ecosystem approach to fisheries are almost exclusively non-binding instruments, such as the Code of Conduct for Responsible Fisheries, the Reykjavik Declaration and the Johannesburg Plan of Implementation. On the other hand, the strength of its expression in these more recent non-binding instruments and the general shift towards responsible ocean governance and protection of the marine environment mean that the concept can be taken into account when interpreting or implementing the binding treaties such as UNCLOS, the UN Fish Stocks Agreement or the Cartagena Convention.

Notwithstanding the above, there are legally binding treaties such as the Convention on Biological Diversity that provide support for ecosystem-based management. The problem is that the language used tends to be vague and hortatory, giving states a wide degree of flexibility and discretion about whether and how to act. For these reasons, the concept may not be given full binding force. This vagueness and uncertainty arises because the ecosystem approach is not yet sufficiently developed to the point where there are clear rules and modalities for applying it in a practical context to manage fisheries and to conserve the ocean ecosystem and its resources. Overcoming this constraint is not going to be easy because it requires advances in scientific knowledge and further development of interdisciplinary policies, laws and institutional frameworks to translate the theories into practice.

A further problem is that the ecosystem approach by its nature is based heavily on scientific knowledge of the complex structure and functioning of the ecosystem, including the impacts of human activities, whether direct or indirect. While the growing interest in the concept is linked to advances in scientific knowledge, the extent to which it can be usefully applied in any given situation is also limited by the available scientific knowledge of the ecosystem in question. Such limitations are particularly relevant in the Caribbean context due to the region's limited human and institutional capacity for research, planning and management, and the paucity of scientific data and information.

Notwithstanding the limitations of existing international instruments as a legal basis for applying the ecosystem approach, they nevertheless carry the weight of political, good-faith obligations. They have created heightened awareness of the potential benefits and value of using the ecosystem approach, and have called for its use by states as a way of achieving sustainable fisheries.

The CARICOM states can therefore rely on these instruments in developing and implementing the ecosystem approach regionally and in areas under national jurisdiction. However, implementation remains a major challenge, as regional and national laws and policies have not kept pace with developments in science and law at the international level in explicitly incorporating the ecosystem approach.

Further work is therefore needed to translate the ecosystem approach into regional and domestic policies and laws in order to close the gap between the international framework and the situation in the Wider Caribbean Region. Not all CARICOM states have ratified or acceded to the various agreements mentioned above that can support the ecosystem approach. Special mention must be made of the SPAW Protocol, as it provides a powerful legal and policy framework that can support the ecosystem approach in the Wider Caribbean Region. A first step therefore is for states, individually and collectively, to review regional and national priorities and to sign and ratify or accede to those instruments that can help advance their interests. But application of the ecosystem approach will not only require further development of the legal framework, it will also require institutional and administrative reforms regionally and at the national level to be able to generate the interdisciplinary information, and to develop and apply the cross-sectoral and transboundary measures needed to monitor and regulate fisheries and the health of their ecosystems. Implementing the ecosystem approach is much more challenging than implementing a single-species approach to managing the region's fish stocks. It nevertheless remains attractive, at least in theory, as an approach that can produce sustainable fisheries and protect the marine ecosystems in the region.

Notes

1. The member states of the Caribbean Community (CARICOM) are Antigua and Barbuda, the Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, and Trinidad and Tobago. There are also five associate members of CARICOM: Anguilla, Bermuda, British Virgin Islands, Cayman Islands, and Turks and Caicos Islands. All the member states of CARICOM, with the exception of the Bahamas and Montserrat, are also members of the CARICOM Single Market and Economy.
2. The general definition of a treaty in the Vienna Convention on the Law of Treaties adopted in 1969 (Vienna Convention 1969), Article 2(1)(a) is: "an international agreement concluded between States in written form and governed by international law, whether embodied in a single instrument or in two or more related instruments and whatever its particular designation".
3. Article 2 defines natural heritage as "natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the aesthetic or scientific point of view; geological and physiographical formations and precisely delineated areas which constitute the habitat of threatened species of animals and plants of outstanding universal value from the point of view of science or conservation; natural sites or precisely delineated natural areas of outstanding universal value from the point of view of science, conservation or natural beauty".
4. The Biodiversity Convention contains no specific article on marine and coastal biodiversity. The 1995 Conference of the Parties dealt with these issues in two decisions: Decision (II10) was a policy decision and is now known as the Jakarta Mandate on the Conservation and Sustainable Use of Marine and Coastal Biological Diversity containing basic principles and thematic areas; and Decision (IV5) implements these provisions through a multi-year programme of work.
5. Principle 15 of the Rio Declaration says "In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation".
6. Principle 2 says, "[t]he natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate". Principle 6 says, "[t]he discharge of toxic substances or of other substances ..., in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems".
7. Under the Cartagena Convention, the Wider Caribbean is defined as the marine environment of the Gulf of Mexico, the Caribbean Sea and the areas of the Atlantic Ocean adjacent thereto, south of 30 degrees north latitude and within 200 nautical miles of the Atlantic coasts of the states referred to in Article 25 of the Convention.
8. Examples of the fisheries acts are the 1983 Antigua and Barbuda Fisheries Act; the 1993 Barbados Fisheries Act; the 2000 Belize Fisheries Act; the 1975 Jamaica Fishing Industry Act; and the 2002 Guyana Fisheries Act. These primary

legislations are implemented by subsidiary legislations containing detailed rules; see for example, Antigua and Barbuda's 1990 Fisheries Regulations, Grenada's 1987 Fisheries Regulations and Saint Lucia's Fisheries Regulations of 1994.

9. See for example ss. 4 and 5, and Part III (Marine Reserves and Conservation Measures) Grenada Fisheries Act 1986 and Part VI (Fishery Conservation Measures), Grenada Fisheries Regulations 1987.
10. See for example s. 3(1) Fisheries Act 1986, Grenada; s 3(1) Fisheries Act 1986, Saint Vincent and the Grenadines; s. 3 Fisheries Act 2002, Guyana.
11. Section 3, Fisheries Act 2002 Guyana says "The Minister or the Chief Fisheries Officer, as the case may be, may take such measures as he thinks fit to promote the management and sustainable development of fisheries so as to ensure the optimum utilisation of fisheries resources in the fisheries waters for the benefit of Guyana, and in so doing shall promote precautionary approaches to fisheries management, as well as the need to conserve fisheries resources for future generations".

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Spatial Data Infrastructures in Support of EBM and the Ecosystem Approach to Fisheries in the Caribbean

Michael J. A. Butler, Paul R. Boudreau, Claudette LeBlanc and Kim Baldwin

Abstract

To be successful, ecosystem-based management (EBM) and the ecosystem approach to fisheries (EAF), as with any environmental management effort, require the best available information. The required information includes all forms of hard copy and electronic information. Whereas hard copy documents have a long history of management and use through libraries, the management and use of electronic information is still evolving. With the existing Internet capability, coastal and fisheries managers have the potential to search, find, access and use an incredible amount of information online. In this lies the challenge of having appropriate access to the salient pieces of information within an ever-expanding plethora of information. Technology is quickly evolving to facilitate access to available knowledge. However, the need for human interest, trust and participation in data sharing is also key to providing natural resource managers with access to the various kinds of information required for their decision-making process, be it EBM or EAF. No one person or agency has, or can control, all of the information required to adequately manage coastal and marine ecosystems. This chapter will attempt to demonstrate the necessary balance between personnel and technology in a modern-day spatial data infrastructure (SDI).

Introduction

To quote Gillespie et al. (2000), "In order for data or information to be useful for coastal management, or any other application, it must be both comprehensive and accessible. A major challenge for anyone involved in the management of coastal areas is simple access to data and information in a timely fashion." Gillespie et al. are referring to both geospatial and non-geospatial data and information. With regard to the former, the associated spatial data infrastructures – SDIs (also known as geospatial information infrastructures) – are vital to supply the data and information on which to base complex decision-making associated with sustainable resource management and development. The challenges of ecosystem-based management and the ecosystem approach to fisheries – and integrated coastal and ocean management (ICOM) in general – were recently documented by Sale et al. (2008). They state that there is a need to improve the flow of information among management agencies, the quality of the information and its subsequent analysis.

What is an SDI?

The concept of SDIs was developed in the early 1980s before the existence of the World Wide Web. According to Coleman and McLaughlin (1998), a "(geo)spatial data infrastructure encompasses all of the data sources, systems, network linkages, standards and institutional policies required to deliver geospatial data and information from many different sources to the widest possible group of potential users".

Blake et al. (2008) define an SDI as an inter-sectoral, inter-institutional strategy to ensure that data and information are available to people who need them, when they need them, and in a form that they can use to make decisions. They further state that an SDI encompasses the technologies, policies and people necessary to promote the sharing of geospatial data.

Longhorn recently commented on the SDI presentations made at the 10th Global SDI Conference (25-29 February 2008 in St. Augustine, Trinidad). He particularly noted that:

> SDIs are composed of too many disparate elements – technical, legal, political, societal – to ever be conveniently herded into a single block on a diagram... those implementing organizations which stand the best chance of implementing an SDI are those which have recognized that SDI is a process, not a thing, comprising many disparate elements, which will be implemented in different ways, at different speeds, different cost (and benefits), and with different impacts. (2008)

The main principles that should guide the development, operation and maintenance of an SDI include:

- Encouraging distributed information networks that link users with the most up-to-date, closest-to-source, authoritative data and information;
- Promoting the use of common standards to discover, acquire, access, publish, process and view geospatial data;
- Creating, through policy and best practices, a culture of data sharing by reducing barriers associated with ownership, privacy, cost and data sensitivity (GeoConnections 2008).

Some countries such as Canada actively create and make freely available key national data such as roads, place names and satellite imagery as important foundational layers for online mapping in support of good management practices, e.g., GeoGratis (http://geogratis.cgdi.gc.ca).

SDIs in the Caribbean

SDIs, or components thereof, have been the subject of numerous papers presented over the past 25 years in the Caribbean (Butler et al. 1985; Butler and LeBlanc 1989; Butler and LeBlanc 1992; IDRC 1989). The International Development Research Centre (IDRC) (1989) outlined the proposals for a regional information system strategy resulting from a project undertaken by the Caribbean Community (CARICOM) Secretariat and the United Nations Economic Commission for Latin America and the Caribbean (ECLAC) Sub-regional Headquarters for the Caribbean.

More recently, the subject of SDIs in the context of sustainable development in the Caribbean was considered at the 10th Global SDI Conference. According to a paper by Blake et al. (2008) presented at this conference, the forces driving the need for SDIs include socio-economic and environmental benefits; community expectations for online services; globalisation; technological innovation; changing societal priorities; and the need to address issues such as environmental degradation and natural resource depletion. Inhibitors include: immature relationships between users and data providers; poor spatial data quality of online map services; inconsistent spatial data policies; incomplete knowledge about spatial data; and lack of best practice guidance in the use of enabling technologies. Based on the results of a survey, the authors conclude that only a quarter of the countries in the region are addressing the national SDI challenge. Of these countries, Jamaica, Cuba and Cayman have made significant progress in the areas of SDI policy development, the establishment of institutional structures, capacity development and the creation of fundamental datasets (Blake et al. 2008).

Also presented at the SDI Conference was an evaluation of the SDIs in eleven countries in the Caribbean (Fernández and Crompvoets 2008). They used an SDI readiness index supported by the methodology of Delgado et al. (2005), which uses a fuzzy-compensatory model to interrelate the following factors: organisation, information, human resources, technological issues and financial resources. Consistent with the results of Blake et al. (2008), their conclusion is that the development of SDIs in the region is still in an infancy stage, and the capacity for their development varies across the region due to different social, economic and institutional conditions. According to Fernández and Crompvoets (2008), Jamaica and Cuba, the most advanced, could lead the development of a regional data infrastructure in the Caribbean and by so doing strengthen the situation in the other less developed countries in the region. Even though the results depict low national preparedness to undertake SDIs, a coordinated effort to build regional SDIs could contribute not only to the development of a Caribbean SDI, but would also strengthen national capacities. However, co-operation between and within nations is an obvious prerequisite.

The Canadian Experience

The development of coastal and ocean SDIs in Canada has been both complex and lengthy, primarily because of the inertia and overlapping jurisdiction of the three levels of government (federal, provincial and municipal) and the plethora of associated departments. Some initial steps towards developing a Coastal and Ocean Information Network (COIN), an important component of an SDI, began in the late 1980s (Butler et al. 1988) before the existence of the World Wide Web. Gillespie et al. (2000) further documented the challenges of implementing a marine geospatial data infrastructure.

The history of SDI development in Canada was recently documented (Canessa et al. 2007). The authors describe the evolution of the Canadian information infrastructure through numerous projects and programmes over a thirty-year period and the eventual establishment of the Canadian Geospatial Data Infrastructure (CGDI) (http://www.cgdi.ca). The implementation of this SDI is currently the responsibility of GeoConnections (http://geoconnections.ca), a nationwide programme of the federal Department of Natural Resources.

Atlantic Coastal Zone Information Steering Committee (ACZISC)

Experience in Canada has shown that the key to the establishment of a successful and sustainable COIN is a network of people and organisations that are willing, able and interested in developing a common pool of shared information. In Atlantic Canada, the Atlantic Coastal Zone Information Steering Committee (ACZISC) (http://aczisc.dal.ca) has responded to the challenge of supporting such a network (ACZISC Secretariat 2009).

The ACZISC was established in 1992 under the aegis of a regional government body, the former Council of Maritime Premiers, and has since evolved into an independent non-governmental organisation (NGO) headquartered on the campus of Dalhousie University in Halifax, Nova Scotia. ACZISC members represent organisations and agencies that have a mandate for, and can contribute to, the development and co-ordination of a regional coastal zone information infrastructure and the promotion of ICOM initiatives, including EBM and EAF. Members of the ACZISC currently represent the four Atlantic provincial governments, eleven federal departments/agencies, community organisations, NGOs, the private sector and academia. Members are responsible for a wide range of management issues including fisheries, aquaculture, marine planning, water quality, security and others. Experience has also shown that broad representation is essential to foster cooperation in all aspects of ICOM, including the development of the associated SDI.

The ACZISC functions as a 'horizontal mechanism', i.e., it works collaboratively across organisational boundaries to implement its mandate of fostering co-operation in integrated coastal and ocean management, coastal mapping and geomatics in Atlantic Canada. It was highlighted as a successful case study in two reports published by the Government of Canada (Canadian Centre for Management Development 2002, Treasury Board of Canada Secretariat 2003) to document the challenges of operating successful horizontal and collaborative initiatives.

In 2008, the ACZISC launched COINAtlantic, the Coastal and Ocean Information Network for Atlantic Canada (http://COINAtlantic.ca), as an important component of Canada's SDI, in collaboration with GeoConnections, Fisheries and Oceans Canada, and other partners.

The ACZISC is making progress towards implementing COINAtlantic, a coastal and ocean information network for the western North Atlantic, composed of people, information and technology. The ACZISC is working with partners to encourage them to publish their best available data and to register them in the national metadata catalogue. A search engine has been implemented through an Internet browser application. The COINAtlantic experience may provide a number of valuable lessons that could be considered by Caribbean nations for the establishment of national and regional SDIs in support of EBM and EAF.

Coastal and Ocean Information Networks

The work of the ACZISC has identified four main components that are required for a successful SDI: (1) online access to data using recognised standards; (2) metadata catalogues that can be used to search for geospatial information; (3) a web interface that allows users to search, access and retrieve the best available information from the most reliable sources; and (4) active participation of data providers and data users to ensure that the right data are available to contribute to more effective decision-making. Each of these components will now be described in more detail.

Online Data Sources

With the existence of the Internet, and the associated Web standards, there is a large amount of data available online from numerous sources. These can be in the form of databases, spreadsheets, electronic documents, or maps. All are of interest to the EBM/EAF manager.

It is essential that data contributors to coastal and ocean information networks (COIN) have the will and the ability to post their information online to enable access to these datasets. Several government departments and agencies in the Caribbean have the resources to make their information available online for access by the public. Nevertheless, government policies can often stand in the way of providing reasonable access. This may be particularly true when individuals feel that they have 'ownership' of the data and are unwilling to share. This has been observed in the scientific community when individuals claim that early release of information will jeopardise their ability to publish. Proper accreditation is essential.

A large amount of information can also be found in what is referred to as grey literature. This class of information is made up of reports and documents that have not gone through the peer-review process. Although their content may be considered somewhat suspect in regards to their accuracy and authoritativeness, it is important that managers are aware of their content. Often this information is catalogued locally in an agency's internal library and is not easily accessible. Even when easily accessible, these reports may not include the sources of their information. COINAtlantic is working with an NGO in Atlantic Canada to develop improved methods for searching and finding such grey literature, particularly through the use of geographic searching (MacDonald et al. 2009).

Difficult to achieve but important goals include: the continued provision of information online by the data providers, the identification of the potential benefits and limitations of any information, and the limitations of current Internet text and spatial search engines.

Metadata Catalogues

Metadata is data about data. Online metadata facilitates the effective searching for relevant information, particularly in non-text-based information sources such as maps and images. For all data types, metadata can document a wide variety of useful information about the data such as the time collected, the owner, the format, the method of access, the spatial and thematic quality, and other attributes. Metadata answer the fundamental questions of who, what, why, when and where about the data.

Maps, graphics and geographic information system (GIS) layers rarely contain sufficient text to allow for effective searching, i.e., the only information in textual form are cryptic short titles of the data source or of the data layers. Additional information must be provided to allow users to find and select data of relevance.

Fortunately there are a number of metadata catalogues available online. COINAtlantic has particularly focused on the Canadian GeoConnections Discovery Portal (GDP) (http://geodiscover.cgdi.ca), a component of the CGDI. The GDP also contains data of use to Caribbean EBM/EAF because of its interaction with spatial data infrastructures and services around the world. The National Aeronautics and Space Administration (NASA) Global Change Master Directory (GCMD) is another major source of Caribbean references (http://gcmd.nasa.gov).

Web Interface

Combining the functionalities of searching textual descriptive metadata and the geospatial extent in a single query allows users to easily identify all registered information of interest. The user can then focus on the selection and analysis of appropriate and relevant information. COINAtlantic has developed a Web interface to provide this combined functionality using standard Internet browser technology.

This interface connects with the numerous online mapping websites – e.g., the Geoscience Data Repository of Natural Resources Canada (http://gdr.nrcan.gc.ca) – that are most often associated with a specific project, issue and/or database and provides a tool to easily overlay information from multiple sources as is most often required for integrated coastal and ocean management.

Through a simple Web interface between the user and the numerous disparate data sources (Figure 20.1), COINAtlantic provides the functions of searching, finding and accessing the information. Once the data have been retrieved, it is expected that users will have additional GIS capabilities to analyse the data and information for their particular requirements.

Participant Commitment and Support

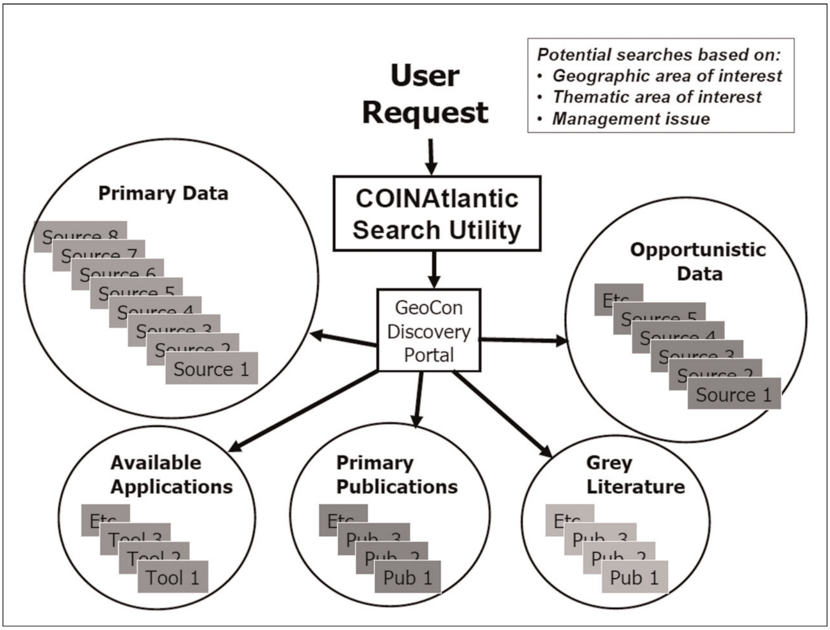
The WWW permits the sharing of, and access to, data and information around the world at very low cost. However, the active participation of individuals, agencies and organisations are a prerequisite for the success of any coastal and ocean information network.

The ACZISC experience has shown that the trust necessary for the establishment of a COIN is most effectively achieved by face-to-face interactions over significant periods of time, as one would expect (Butler and LeBlanc 2009). Whereas policy and legal frameworks can guarantee the participation of government agencies, the creation and acceptance of a COIN are always driven by individuals who have an understanding of the need to share information.

Implications and Insights Regarding a Caribbean SDI

EBM and EAF involve issues on a broad geographic scale. While one can imagine the management of a particular watershed, small island, estuary or bay, in reality most management challenges involve interactions with

Figure 20.1. Schematic diagram of the planned COINAtlantic search functionality



adjacent watersheds, islands and so on. To effectively manage complex, interdependent systems, it is essential to access diverse information (e.g., environmental, economic, social, cultural) over various geographic regions and at various scales. This is required for routine planning and management of coastal and ocean resources and, in particular, fisheries that may cover wide geographic areas and provide a range of socio-economic benefits. In addition, some issues such as climate change require planning and managing and therefore data and information at global scales.

An effective coastal and ocean information network for the Caribbean (e. g., a COINCaribbean) would be invaluable in responding to the multiple management objectives of fishery production, marine protected area planning, coastal hazard mitigation, biodiversity conservation, etc. It would also be invaluable in responding to catastrophic events, such as pervasive hurricanes. These events are difficult to predict and require fast and effective response at a time when resources may be scarce or in disrepair and personnel distracted. A COINCaribbean, with established relationships amongst individuals, agencies and countries, could facilitate information flow to assist in an understanding of the situation and the formulation of an appropriate and rapid response. The establishment and use of a COINCaribbean and associated SDIs would also minimise the inadvertent duplication of effort by virtue of increased data and information dissemination, thus resulting in optimal use of funding and other resources.

In order to establish an effective COINCaribbean, it will be necessary to further develop SDIs, both national and regional, in the Caribbean region. The efficient development and sustainability of any SDI will require economic growth (hence funds), human resource development and organisational re-engineering within and between the Caribbean states.

From a regional perspective, the obvious Caribbean government bodies with a collaborative mandate and in a position to consider the implementation of a regional SDI include: CARICOM, the Association of Caribbean States and the Organisation of Eastern Caribbean States. United Nations bodies with sustainable development roles, informatics expertise and the capability of supporting such SDI initiatives include the United Nations Environment Programme in the Caribbean, the United Nations Development Programme in the Caribbean and the Global Environment Fund-Integrating Watershed and Coastal Areas Management in Caribbean Small Island Developing States (GEF/IWCAM) Project (Fernández and Crompvoets 2008).

As in all complex endeavours, the establishment of a sustainable COIN-Caribbean/SDI will need champions, both individual and organisational, at the local, national and regional levels. Their continuous efforts will be required to achieve the 'dream' of building and maintaining a spatial data infrastructure.

21

Roles for Non-Governmental Organisations in EBM of Marine and Coastal Areas of the Wider Caribbean

Bruce Potter and Kemraj Parsram

Abstract

This chapter briefly reviews the range of environmental non-governmental organisations (NGOs) and their potential roles to support ecosystem-based management (EBM) strategies for fisheries resource managers in the Caribbean. This is done according to the local, national, regional and international geographic scales that dominate the governance of the Caribbean Large Marine Ecosystem. NGOs can provide a variety of resources and capabilities to support EBM functions. These range from networking, public awareness and education, and project management, to scientific research, advocacy and funding. We also discuss some pertinent *caveats* or constraints that fisheries and marine resource programme managers need to anticipate with regards to their relations with NGO and their involvement in fisheries management.

Introduction

This chapter briefly examines the range of environmental NGOs that might be able to provide support to EBM strategies for fisheries resource managers in the Caribbean. For a somewhat wider perspective on this issue, we urge you to consult Angulo-Valdes (2008). In addition, for an overview of organisations and their roles in the Caribbean Large Marine Ecosystem, see Parsram (2007).

The thumbnail definition of ecosystem-based management that we have used for this chapter is that offered by Dan Dorfman in the EBM Tools website www.ebmtools.org (accessed March 2008):

- Accounting for triple bottom line: environmental, social equity, economical interests in a balanced or integrated fashion;
- Incorporates ecosystem processes and ecosystem services both ecological and relating to human uses;

– Is based on ecological reasoning of functional integrated ecosystems as a basis for management and decision-making;
– Employs adaptive management where results are monitored and management is adjusted to meet objectives;
– Accounting for uncertainty is based on the precautionary principle which suggests that in the case of uncertain knowledge, long-term risk should be minimised;
– Engages multiple stakeholders to participate in a collaborative decision-making process.

From this definition it is obvious there are many opportunities for NGOs to provide useful support for fisheries and other marine and coastal resource managers seeking to implement EBM policies. These capabilities tend to concentrate on the last three items in Dorfman's list of functions (paraphrased):

1. Providing monitoring and assessment inputs to support adaptive ecosystem-based management;
2. Providing community-based feedback on the range of long-term risk factors to be considered for application of the precautionary principle;
3. Providing networks and community spaces for multiple stakeholders to participate in the collaborative EBM decision-making processes.

Activities to support these EBM functions range from surveying and assessing community attitudes to concepts and practices of EBM, to providing the highest level of international technical assistance and up-to-date scientific expertise and communications networks to national and regional EBM programme activities. NGOs and similar community-based organisations also provide an independent voice on key development policies that may not be well represented in national governmental or commercial organisations.

NGO Resources and Capabilities

NGOs are legally constituted organisations made up of private organisations or individuals with no government representation or participation. In cases where governments provide financial support to an NGO, according to United Nations policy, the organisation retains its NGO status as long as it excludes government representatives from membership.

According to *Wikipedia*, "The number of internationally operating NGOs is estimated at 40,000. National numbers are even higher: Russia has 277,000 NGOs. India is estimated to have between 1 million and 2 million NGOs." en.wikipedia.org/wiki/Non-governmental_organization>. A few years ago we saw one estimate that Costa Rica had over 400 *environmental* NGOs.

There are many different taxonomies for NGOs. For this short paper we will divide NGOs into the basic geographic scales that will dominate the governance of the Caribbean Large Marine Ecosystem: local, national, regional and international (or global). Especially in the [very] small island states where we mostly work (in Island Resources Foundation and the University of the West Indies), there is overlap and concatenation of these categories. For purposes of the discussion we will consider many of the behaviours of large island national NGOs to be equivalent to regional (Caribbean-wide) organisations; similarly, community-based NGOs on large islands are equivalent to small island national NGOs. Table 21.1 provides a summary of different roles for NGOs, depending on the scale of NGO operations and typical capabilities.

Local NGOs and Related Community-Based Organisations

About 15 years ago, Island Resources Foundation updated its directory of environmental NGOs in the Eastern Caribbean by visiting each island and interviewing everyone we could find to talk to about NGOs. In the course of those interviews we asked our subjects to assess the institutional viability of the NGOs they belonged to, or knew about, and what standard they suggested we use to assess that delicate subject. One friend, a retired civil servant in St. Vincent from the former British colonial service, provided a standard that we find really useful: “An NGO is probably viable if it has a desk, a telephone number and someone to answer the phone.”

Fast-forward fifteen years, and add a computer and a web page, and you still have a reasonable description of the resource base for a large number of the community-based NGOs. This small size and capital resource base should not be mistaken, however, for a lack of persistence or resilience. The list in Table 21.2 includes all of the local or community-based environmental NGOs surveyed in the early 1990s. Most of them still exist and some have prospered. Island Resources Foundation is not familiar with any directory of local environmental NGOs since publication of the 1995 edition of our directory. There is a Worldwide NGO Directory online at www.wango.com, which lists 452 NGOs in the Caribbean, but only 79 of these are [self-]identified as “environmental” NGOs, nine of which are in the non-Hispanic Caribbean including, for example, the Christian Children’s Fund of Dominica.

Table 21.1. Summary of NGO and Ecosystem Based Management Issues

Scale	– Local NGO (can be island-wide for small islands)	– Regional (or National for large islands and continental states)	– International
Typical Capabilities Relevant to EBM	– Local Networking – Public Awareness & Education – Local Site or Project Management – Monitoring Results & reporting phenomena	– Adaptation of technologies to regional or national conditions – Regional Project Management – Ambassador to political or opinion leader groups	– Scientific research – Regional and global databases – Publicity and funds distribution
Examples	– Nevis Historic and Conservation Society – Barbados Marine Trust – Environmental Awareness Group of A B (EAG)	– Caribbean Conservation Association (CCA) – CANARI – Island Resources Foundation – Society for the Conservation and Study of Caribbean Birds (SCSCB)	– The Nature Conservancy – WIDECAST – World Wildlife Fund – World Conservation Society
Typical Risks Relevant to EBM in the Caribbean	– Limited institutional capacities – both technical and administrative. – Under-budgeting for full costs? – Lack of leverage by NGO on national policy making process – Possibly inadequate representation of community interests (i.e. may represent the interests of a subset of local stakeholders)	– Inadequate or restricted financial resources for long-term sustainability? – Lack of capacity limits scale of implementation (i.e. are more active in select countries) – Lack of interest (by community, NGOs, local governments) at the local implementation sites leading to project failure	– May have strong, independent agenda – Tendency to ignore local and national decision-making processes. – Program objectives at times are not in sync with local goals and/ or perceived threats – Rigorous project and finance reporting beyond the bureaucratic skills of many local implementing agencies and may not be adequately backstopped by International NGO.

Table 21.2. Local or community-based environmental NGO's surveyed in the early 1990's in the Lesser Antilles

ANGUILLA Anguilla Archaeological and Historical Society Anguilla National Trust	DOMINICA ACT – Dominica Dominica Conservation Association Social Partners for Action and Transformation	ST. KITTS Beautiful Basseterre Brimstone Hill Fortress National Park Society St. Christopher Heritage Society
ANTIGUA-BARBUDA Betty's Hope Trust Environmental Awareness Group Gilbert Agricultural and Rural Development Center Historical and Archaeological Society Something You Need	GRENADA A Group of Concerned Women Agency for Rural Transformation Carriacou Historical Society Friends of the Earth Grassroots Ecological Citizens Association National Trust and Historical Society Willie Redhead Foundation	ST. LUCIA Archaeological and Historical Society Folk Research Center National Research and Development Foundation Soufriere Regional Development Foundation St. Lucia National Trust St. Lucia Naturalists' Society
BARBADOS Barbados Environmental Society Barbados Environmental Youth Programme Barbados Museum and Historical Society Barbados National Trust Barbados Marine Trust	MONTSERRAT Environmental Education Committee Montserrat National Trust St. Peter's Community Group	ST. VINCENT Bequia Heritage Foundation JEMS Environment Management Services St. Vincent National Trust
BRITISH VIRGIN ISLANDS Botanic Society Historical Society Jost Van Dyke Preservation Society National Parks Trust	NEVIS Hamilton Estate Trust Nevis Environmental Education Committee Nevis Historical and Conservation Society	U.S. VIRGIN ISLANDS Environmental Association of St. Thomas-St. John Friends of the Virgin Islands National Park St. Croix Environmental Association VI Conservation Society (VICS)

The Special Case of Fisheries Cooperatives or Associations

Fishers are famously independent and hard to organise, so ordinarily one would not expect many NGOs involving communities of fishers. In recent years, however, concern for coastal and reef fisheries on the one hand, and funding (largely from the Japanese government) to support fish processing facilities have stimulated the creation of various types of fishers' associations. Some of these may represent real opportunities for collaboration on ecosystem-based fisheries management issues, and these avenues of cooperation should be among the first to pursue in the design of partnerships with local groups. The Caribbean Regional Fisheries Mechanism (CRFM) has implemented several activities/projects geared towards strengthening fisher folk organisations within CARICOM member states. Several key output documents of these various interventions presented or described the range of fisherfolk organisations and/or some of their characteristics. We urge readers to consult CRFM (2004, 2005, 2007) and McConney (2007).

National or Regional NGOs

In the 1995 Directory of Environmental NGOs in the Eastern Caribbean, Island Resources Foundation listed the following groups ordered in terms of our impression of the current level of activity by these regional NGOs:
- Caribbean Natural Resources Institute (CANARI)
- Island Resources Foundation (IRF)
- Caribbean Conservation Association (CCA)
- Museums Association of the Caribbean (MAC)
- Caribbean Network for Integrated Rural Development (CNIRD)
- Partners of the Americas
- Caribbean People's Development Agency
- East Caribbean Organisation of Development Foundations

Another regional group, perhaps the largest and most diverse in terms of the numbers of islands involved, is the Society for the Conservation and Study of Caribbean Birds (SCSCB, originally the Society for Caribbean Ornithology), with an extensive network of local bird-watching groups (such as the Virgin Islands Audubon Society), and regional and international links to groups such as Partners in Flight (PiF), the American Bird Conservancy (ABC), Birdlife International and the Royal Society for the Preservation of Birds (RSPB). (Readers are cautioned that this description is focused only on the insular Caribbean. Resources and organisations for many of the continental countries around the Caribbean dwarf those described here. For example, Fundación ProAves of Colombia has a reported 60 staff members, 21 reserves under active management, and their own affiliate in the United Kingdom.

In the course of preparing this paper on Caribbean environmental NGOs, we have been surprised by the rate of attrition of environmental NGOs in general, and especially by the deteriorating condition of regional groups. To a certain degree the regional NGOs have been displaced from 'below' by increasing numbers and capabilities of local and national environmental NGOs, and from 'above' by increased direct participation at the national and local level by international environmental NGOs.

We have not had the resources to investigate the causes or detailed components of this decrease in environmental management capacities of civil society in the insular Caribbean in detail, and we are sceptical of casual analyses using aggregate data, but it is our informed judgment that real dollar resources available to support the environment in the insular Caribbean have decreased about 40% since the high-water mark at the time of the Rio Summit – the United Nations Conference on Environment and Development (UNCED) – in 1992.

International Environmental NGOs Working in the Caribbean Sub-Region

The following list is organised in order of our perceptions of current levels of activity in the region:

- The Nature Conservancy (TNC)
- Wider Caribbean Sea Turtle Conservation Network (WIDECAST)
- World Conservation Society (WCS)
- World Wildlife Fund US or World Wildlife Fund International
- Fauna and Flora International (FFI); (especially active in species recovery for the Antiguan Racer, together with the Environmental Awareness Group of Antigua-Barbuda.)

The Nature Conservancy has been a long-time presence in the region with varying levels of activity. Much of TNC's programme has revolved around the Parks in Peril programme of USAID, but over the past five to eight years this has been supplemented by direct TNC activities to map insular natural resources and recently to promote the "Caribbean Initiative" as a major new input to the Global Island Partnership (GLISPA), to which TNC has committed a total of US$ 10 million in long-term support.

Managing Relations With NGOs

This section is intended to provide a preliminary list of caveats or special opportunities which may need to be considered when dealing with environmental NGOs, especially at the regional, national and local levels.

NGOs frequently operate in a multi-objective environment that can be difficult to reconcile with narrowly focused memoranda of understanding (MoUs) or contractual agreements. Fisheries resource managers and others seeking partnerships with environmental NGOs are well advised to plan on spending the extra time necessary to become fully aware of the complexities these issues can create. For example, Island Resources Foundation's non-profit status with the US Government as a research and education organisation requires the Foundation to take special efforts to ensure that its products are available to the public. As part of that obligation, when we produce technical studies or environmental characterisations for public or private clients, we negotiate specific terms governing when our reports will eventually be made available directly to the public. If this issue was not known and discussed in advance, our NGO behaviour might be seen as unethical for some other form of private enterprise.

Local Non-Governmental or Community-Based Organisations

The Build-It-Yourself Option

The NGO organisational process itself offers many advantages in terms of enlisting a community of interest from the wider population. An NGO framework is useful for securing the informal participation of a number of different public and private organisations with less need for detailed MoUs and other political steps requiring protracted negotiations among various governing authorities. The organised NGO then provides a series of instruments to stimulate community awareness, advocacy, educational activities and resource recruitment and distribution. This process is frequently employed by international NGOs seeking local partners, or enhancing the capabilities of existing local affiliates, and it has been employed in many other situations. For example, the Sustainable Grenadines Project has many of the attributes of an NGO.

Avoid Over-Programming NGOs

As multi-objective organisations, NGOs already are involved in a complex policy management environment. For example, we have quoted below the list of objectives on the website for the well-known Soufriere Marine Management Area. The SMMA concerns itself with a range of activities that include:

- Scientific research on the natural resources of the area;
- Regular monitoring of coral reefs, water quality and other environmental factors and resources;
- Public information and sensitisation;
- Provision of facilities for users of the SMMA, e.g. moorings;
- Coordination of economic activities related to the SMMA and its resources;
- Promotion of technologies that are appropriate and linked with local environmental, social and cultural aspects of the SMMA;
- Surveillance and enforcement of rules and regulations;
- Conflict resolution among the various user groups whenever necessary;
- Maintenance of the principles of ongoing participation and public consultation.

With such an ambitious agenda as background, it is appropriate to keep the objectives of new projects simple and direct.

Plan to Pay for All Costs

As mentioned previously, small NGOs and community-based organisations seldom have the experience or institutional infrastructure (e.g., non-profit 'fund accounting-based' bookkeeping systems) to be able to calculate and charge for the full range of overhead and indirect costs that they incur in a project. There are several ways that this problem can be addressed, including special training and technical assistance activities by the donor to upgrade the institutional capacity of the NGO, but for most small projects, the simplest way to proceed is to set up the MoU or contract as a firm, fixed-price agreement at a level that both parties feel will cover all costs.

A straightforward way to achieve this is to clearly define the anticipated products, budget the direct costs of producing those products, and then double the amount. This is a generally conservative estimate of overhead and indirect costs. Extra costs should be added if the tasks are based on some special NGO capability, such as a photo archive or library made up of uniquely collected sources useful to the project.

Some Other Caveats

- Improve partnerships and linkages with other NGOs, research institutions and government agencies. They provide a knowledge base (especially other NGOs with past experience and successes) and skills to improve on the project design and implementation.
- During the design phase, ensure the consideration of post-implementation goals to provide sustainability of outputs and outcomes. Also attempt to account for uncertainties (natural disasters and loss of support) and plan accordingly.
- Provide planning resources that will enable NGOs to garner broad-based community support. Informed community supporters are the greatest asset to any NGO-driven activity. Participation will increase the available capacity, even for such technical activities as monitoring and evaluation. Community supporters are also essential for effective advocacy when political support is low (votes influence policy). It will also increase the likelihood of project success through increased awareness, compliance and participation.
- Conduct adequate research on the environmental and social conditions and relationships of the project area (especially on how stakeholders interact with the resource).
- The use of a pilot or small-scale project not only 'tests the waters' but also increases project publicity and can increase internal (within the

agency) and external (community, government, potential funders) confidence and support for future project development.

More caveats can be found in e.g. the GEF Lessons Learned toolkit (http://www.reefbase.org/gefll/default.aspx)

National and Regional NGOs

In general, national and regional NGOs should be able to provide better institutional capacity and depth of specialised technical skills than local NGOs. Fisheries management officials should verify, however, that the support they seek is being provided by qualified individuals (staff or consultants to the NGO) for the term of the agreement. As with many small- to medium-sized organisations, technical capabilities are more often embedded in the people, rather than being a technology controlled by the organisation.

Some regional NGOs are still driven by volunteer-staffed organisations, such as the Society for the Conservation and Study of Caribbean Birds (SCSCB). When arranging an agreement with such groups, fisheries resource managers should ensure that sufficient full-time administrative support is built into the project to be able to meet recordkeeping and logistics requirements for all of the project activities.

International NGOs

International NGOs, especially the largest groups such as The Nature Conservancy and the World Wildlife Fund, have independent agendas that can sometimes influence the support that they provide to a project. In addition, it is more difficult to know who the internal experts are on given subject matter areas, and it is unlikely that large NGOs will agree to commit specific personnel to specific tasks as part of an agreement.

On the other hand, large international NGOs are well known to most funding sources, and the depth of experience they have amassed with previous projects means that donor agencies are generally more comfortable with agreements with large international NGOs than they are with less known groups. This advantage is a variant of the old saying, "No one ever got fired for hiring IBM."

Conclusion

NGOs can provide a variety of resources and capabilities that support important elements of natural resource management programmes and projects. They can often provide these resources more efficiently and less costly than commercial sources and contractors, especially in the general arena of public awareness, education, and monitoring and assessment. The advantages of NGO activities, however, also include certain *caveats* or constraints that fisheries and marine resource programme managers need to anticipate. These special conditions vary from NGO to NGO, but they are also influenced by the scale of NGO operations and the communities in which they work.

Part V

Synthesis

Introduction

Part five outlines the consensus of experts from throughout the Caribbean region and beyond regarding a shared vision for ecosystem-based management (EBM) and provides guidance for the strategic directions and activities to be implemented in order to achieve the vision. The first four chapters reflect the shared thinking on a vision for EBM for specific reef, pelagic and continental shelf ecosystems, as well as the governance regime needed to move towards the vision. To achieve this consensus, symposium participants were placed into each of the four working groups and were asked to reflect on the question "*What do you see in place in 10 years' time when EBM/EAF has become a reality in the Caribbean?*". The diversity among the participants in each group provided for a fruitful and comprehensive visioning process that generated the key vision elements and their subcomponents for each of the fisheries ecosystems and governance themes as well as the level of priority assigned to each of the vision elements.

Working with the assistance of facilitators, each of the four working groups proceeded to evaluate current factors within the Caribbean that could facilitate the achievement of the vision elements and those that could serve to impede them. The group then categorised the assisting factors into current strengths within the region and potential opportunities to be seized. Similarly, resisting factors were collectively categorised into those relating to existing weaknesses and potential threats. Following this exercise, groups used the World Café process to explore the strategic directions needed to implement the vision by identifying specific actions to be undertaken for each of the vision elements. The findings from this process for each of the four working groups are provided in Chapters 22 (reef fisheries ecosystem), Chapter 23 (pelagic fisheries ecosystem), Chapter 24 (Continental Shelf fisheries ecosystem) and Chapter 25 (governance).

The fifth chapter (26) synthesises the findings from the previous four chapters into an overarching vision for marine EBM within the Caribbean Region and serves as the concluding chapter for the book. The combined vision was identified as: "Healthy marine systems that are fully valued and protected through strong institutions at local national and regional levels providing effective governance that involves everyone, is fully understood and supported by the public and enhances livelihoods and human well-being".

The network of strategies that emerged as being needed to arrive at this shared vision is not comprehensive, nor is it to be expected, given the limited time available for discussion in the groups. However, it is believed to reflect the strategies that the symposium participants thought were most critical for moving towards marine EBM in the Caribbean. Most notable is the strong focus on the human aspects of EBM in its broader context where it approximates the ecosystem approach to fisheries of the FAO. Stakeholder involvement, social justice, livelihoods, institutions and regional collaboration all appear to be the areas where most people would focus attention in order to achieve marine EBM in the Caribbean. Some may be concerned about the relatively low emphasis on science and ecosystem research at the LME scale. This should not be taken to mean that they are not seen as important, but rather that the institutional and social aspects were at the fore in this particular gathering of diverse stakeholders.

22

The Vision for EBM of Coral Reef Ecosystems in the Wider Caribbean

Robin Mahon, Sharon Almerigi, Richard Appeldoorn, Kim Baldwin, Georgina Bustamante, Jeff Cramer, Nelson Ehrhardt, David Gill, Caroline Gooding, Winston Hobson, Phil Kramer, Mitchell Lay, Adolfo Lopez, Sergio Martinez, Judith Mendes, Armando Ramirez, Silvia Salas, Vincent Sweeny and Beverley Wade

Introduction

Coral reef ecosystems have great importance for the countries of the Wider Caribbean Region in terms of both use and non-use values and services. Several of the contributors to this symposium attest to their importance for fisheries and biodiversity (see Ehrhardt et al. in Chapter 11; Appeldoorn in Chapter 10; Appeldoorn et al. in Chapter 12; Horrocks et al. in Chapter 9). Coral reef ecosystems support livelihoods (see McConney and Salas in Chapter 7) and provide critical ecosystem services (Schuhmann et al. in Chapter 8) including for tourism, although this aspect of their value is not developed in detail in Chapter 8. Caribbean coral reef ecosystems have been degraded by many human impacts of both marine and land-based origin (see Sweeney and Corbin in Chapter 4; Gil and Wells in Chapter 5; Yáñez-Arancibia et al. in Chapter 17). They are among the most complex and biologically diverse marine ecosystems, and will require a holistic ecosystem-based approach for their conservation and sustainable use.

This synthesis chapter presents the outputs of a group process aimed at developing a vision and way ahead for ecosystem-based management (EBM) for coral reef ecosystems in the Wider Caribbean, using the methods described earlier (Fanning et al. in Chapter 1). The chapter first describes a vision for coral reef EBM and reports on the priorities assigned to the identified vision elements. It then discusses how the vision might be achieved by taking into account assisting factors (those that facilitate achievement) and resisting factors (those that inhibit achievement). The chapter concludes with guidance on the strategic direction needed to implement the vision, identifying specific actions to be undertaken for each of the vision elements.

Table 22.1. A vision for ecosystem based management for coral reef ecosystems in the Wider Caribbean

FOCUS QUESTION: *What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?*

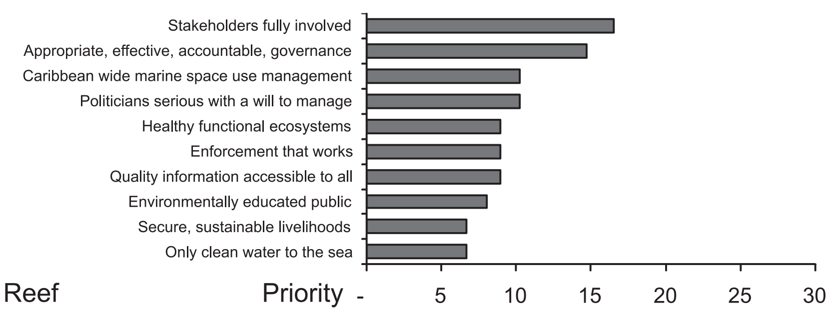
The Caribbean region - a model for reef management in the world

Strengthened knowledge base		Good governance				Healthy reefs sustaining people		
Environmentally educated public	Quality information accessible to all	Serious politicians with a will to manage	Appropriate effective accountable governance	Enforcement that works	Stakeholders fully involved	Healthy functional ecosystem	Secure and sustainable livelihoods	Caribbean-wide marine space use management
– EBM in education curricula – Reef conservation in curriculum – Public environmental awareness	– Easy access Caribbean SDI – Good information available to everyone – Accessible information system – Regular data collection	– Political accountability for sustainability – Reefs high on political agenda – Greater political will by government – More money for management – Full value of reefs recognized	– Regional EBM legislation in place – Harmonized and fully integrated management and legislation among countries – Binding agreements for EBM – International agreements become national laws – Integration of fisheries and CZM regulations – Cross-sectoral agency communication – Adequate capacity to manage reefs – Fishing capacity adjusted to sustainable practices – Elimination of resource disputes	– Enforcement is functional and effective – Functional enforcement – All activities in reefs are well regulated	– Stakeholders fully involved in management and decision-making – Local & scientific knowledge used – Fisher/community rights to manage reefs resources – Active stakeholder participation in governance	– Critical coastal habitats restored – Limits to coastal development – EBM compatible coastal development – Conch off the CITES list – Reefs, seagrass and mangroves with plenty of fish Only clean water to the sea – All waste-water treated before entering marine environment – Watershed-based focus to management – Only clean freshwater entering the sea	– Alternative livelihoods – Improve fisher-folk standard of living – Grow coral for income and restoration – Organized equitable market structure	– Network of no-take reserves – Integrated protected areas networks (30%) – Caribbean-wide space-use plan – More no-take reserves – Reefs managed at scales of the resource

The Vision

The occupational breakdown of members of the Coral Reef Ecosystems Working Group reflected the diversity of affiliations present at the EBM Symposium and included governmental, intergovernmental, academic, non-governmental and private sector (fishers and fishing industry and consulting) representatives. With guidance provided by the facilitator, this diverse group of participants was asked to first address the question of "*What do you see in place in 10 years' time when EBM/EAF has become a reality in the Caribbean?*" This diversity provided for a fruitful and comprehensive visioning process, the results of which are summarised in Table 22.1, in terms of the key vision elements and their subcomponents, and in Figure 22.1, which illustrates the level of priority assigned to each of the vision elements.

Figure 22.1. The Priorities Assigned by the Group to the Elements of Their Vision As Shown in Table 22.1



Vision Elements and Their Subcomponents

Ten key vision elements were considered essential by the Coral Reef Ecosystems Working Group in order to achieve effective EBM for coral reef ecosystems in the Wider Caribbean, and these were grouped under three themes (Table 22.1). In the first theme – 'strengthened knowledge base' – there were two vision elements, *environmentally educated public* and *quality information accessible to all,* with a focus on the need to promote environmental awareness in schools and for the public, in part through better access to information. The second theme – 'good governance' – included four vision elements: *1) serious politicians with a will to manage; 2) appropriate effective accountable governance; 3) enforcement that works; and 4) stakeholders fully involved*. Here there was a wide range of ideas relating to engendering political will for reef conservation and management, including the recognition of the full value of the goods and services that they provide. Attention to institutional arrangements and capacity for reef governance was also prominent here, with enforcement being highlighted as a critical factor. Finally in this theme, there was emphasis on the potentially important role of stakeholders and their knowledge. The third theme – 'healthy reef sustaining people' – also had four vision elements: *1) healthy functional ecosystem; 2) secure and sustainable livelihoods; 3) Caribbean-wide marine space use management; and 4) only clean water to the sea*. The emphasis in this theme was in two main areas. The first was the restoration of reef habitats and the reduction of land-based sources of pollution. The second was on livelihoods and the well-being of reef resource users. After much discussion, the group included the vision element on *Caribbean-wide marine space-use management* because of its connection with marine protected areas (MPAs), which were also seen as having connections to livelihoods. However, the group noted that this element was also strongly connected with the second theme of 'good governance'.

Prioritisation of Vision Elements

Following the identification and discussion of the ten vision elements, the working group members were asked to prioritise the elements based on which ones they considered to be the three most important. The assigned ranking is presented in Figure 22.1 and the results illustrate the overall significance of all of the vision elements to the members, despite their occupational diversity. However, two elements – *stakeholders fully involved* and *appropriate, effective, accountable governance* – received appreciably more votes than the remaining eight.

Achieving the Vision

Working with the assistance of the facilitator, the working group members proceeded to evaluate current factors within the Caribbean that could facilitate the achievement of the vision elements and those that could serve to impede them. The members subsequently worked collectively to categorise the assisting factors into current strengths within the region and potential opportunities to be seized. Similarly, resisting factors were collectively categorised into those relating to existing weaknesses and potential threats. Following this exercise, members provided guidance on the strategic direction needed to implement the vision by identifying specific actions to be undertaken for each of the vision elements.

Assisting and Resisting Factors

The suite of assisting and resisting factors identified by the Coral Reef Ecosystems Working Group is presented in Table 22.2. The list of 15 assisting factors, which combines both strengths and opportunities, is diverse, ranging from factors relating to capacity, advances in information exchange and stakeholder will for action in Caribbean countries to external factors such as possible beneficial effects of climate change and the advent of a new president in the US. Resisting factors were divided into threats and weaknesses. Most threats were external and not easily addressed by those responsible for EBM. In contrast, many items in the list of weaknesses were thought to be ones that could be addressed in the strategic direction that followed. The list includes many items that have frequently been identified as characteristic of the Wider Caribbean and indeed developing regions worldwide. Enigmatically, both open and closed access fisheries were seen as weaknesses, reflecting the complex nature of the topic and the tradeoffs that characterise management of natural resources.

Table 22.2. Assisting and Resisting Factors Affecting a Vision for EBM for coral reef ecosystems in the Wider Caribbean Region

Assisting Factors	Resisting Factors
Impacts of climate change	*Threats*
Science and information technology	Poverty
Information and education	Climate change
Political understanding and will	Uncontrolled investment in coastal development
Fisher and stakeholder participation	Pollution
Internet	Increased demand in market
Ecotourism /green industry	Invasive species
Tourism sector participation	Dams – water flows
Disappearance of fish resources	Oil Infrastructure
Favorable market forces	Farming practices
New president in USA	Over-population
Education in schools	
Multi-lateral funding	*Weakness*
Committed players	Stakeholders manipulating political system
Recovering rent from natural resources	Small size of countries
(economics)	Ineffective administration systems
	Lack of information sharing
	Limited resources
	Highly complex geo-political mosaic – think as country NOT region
	Chronic corruption
	Lack of capacity
	Open access to fisheries
	Closed access to fisheries

Strategic Directions

The final facilitated process undertaken by the Coral Reef Ecosystems Working Group was aimed at identifying key actions that could provide guidance on the strategic direction to be followed by decision-makers within the region. These are provided for each of the vision elements below.

Vision Element 1: Environmentally Educated Public

Key actions:
- Introduce changes to the school curriculum:
  - Assess current level of environmental education in school curricula.
  - Environmental education must be a formal part of the programme, becoming increasingly complex and integrated throughout the school curriculum.
  - Promote buy-in of Departments of Education:
    - Develop teaching materials with a local emphasis and train teachers to use them.
    - Convince Departments of Education of the need for environmental education, possibly through regional meeting of education ministers.
    - Make wider use of Caribbean Conservation Association *People and Corals* book in primary schools.
- Improve public education:
  - Make more use of the media (radio, talk shows, TV, newspapers).
  - Maintain a continued presence for the public and for politicians.
  - Find out how to organise public awareness initiatives in every country according to the local socioeconomic context, and utilise community groups that are most active, whether geographical community or community of interest (e.g., churches and service groups).
  - There is a wide variety of Caribbean-specific reef educational material available for the public, but cost of production and dissemination are prohibitive. NGOs are not inclined to spend money on these kinds of materials and need to be encouraged to do so. They need to be encouraged to spend money on distribution to make these resources available to everyone.

Vision Element 2: Quality Information

Key actions:
- There is already a lot of information out there that needs to be made available through effective information systems. Many topic-specific systems are already developed or under development throughout the region. These need to be integrated at the level of metadata systems.

  - Including getting older data into digital formats.
  - Metadata requirements (source, collection, date, etc.).
- There is also the need to gather new information to add to these systems.
  - Review regional and national data needs to serve EBM and collect only data that are needed.
- Increase the capacity for data collection and processing of environmental and fisheries data.
  - Make better use of people in field to capture fisheries data including local NGOs and fishers co-operatives.
- Promote trust in sharing data.
  - Clarify where it is going and how it is to be used.
  - Fishers will not share until they know its importance and how it will be used.
- Make data more spatially related and visual for greater impact.

Vision Element 3: Politicians Serious about the Environment with a Will to Manage

Key actions:

- Most politicians do not have knowledge of the areas that they are responsible for governing.
  - Promote the establishment of environmental advisory panels comprising scientists, fishers, technical officers and public to advise politicians and to provide them with a transparent basis for their decisions.
  - Influence politicians through peer pressure and through more effective lobbying.
  - Empower civil society to pressure politicians:
    - This is linked closely to public awareness.
    - Provide politicians with trips that will expose them to environmental issues.
    - Conduct polls on the environment ahead of the elections.
    - Concerned entities should publish an environmental agenda before each election and ask contesting parties to address the issues in their manifestos (this can be a shared NGO action).
    - Pursue valuation to put the environment in 'financial' terms.
    - Utilise persons with access to political inner circles to influence politicians.

Vision Element 4: Appropriate Effective Accountable Governance

Key actions:

- Strong and participating NGOs to help alert people through media and to empower them to stand up for what they believe in.
- More advocacy forces government to listen; there is strength in numbers.
- Get people to be 'issue' focused and to dissociate from party level politics.
- Use formal multi-sectoral groups as a way of bringing issues into the open. It is difficult to ignore formally established groups and also provides a way that responsibility for a decision can be placed on the group.
- Promote formal cross-communication between agencies that are responsible for EBM to develop regulatory mechanisms and legislation/ tap into legal systems (e.g., US Coral Reef Task Force).
- Pursue international agreements and accountability to implement nationally within a specified timeframe.

Vision Element 5: Enforcement that Works

Key actions:

- Review and update legislation, especially in regards to fines that are often too small.
- Place emphasis on building social capital for compliance (less on enforcers). This must include programmes that address root causes of infractions. Note that compliance is cross-linked with public awareness and participation.
- Address low allocation of resources, training, capacity of enforcers.
- Pursue means of changing the low priority given to environment and fisheries on national agendas for enforcement.
  - Funding for enforcement and for training of enforcers is an issue.
  - The judiciary (including prosecutors) often does not take these matters seriously; there is a need for them to be trained and encouraged to do so.
  - Streamline judiciary process for rapid effective prosecution such as through dedicated prosecutors attached to fisheries and environment departments (e.g., Belize).
  - Get all people 'on the water' involved and make it easy for people on the sea to be the eyes and ears for enforcement through simple direct anonymous reporting mechanisms.
  - Enforcement is more timely and fair.
- Ensure proper interaction among functional arms of management and enforcement agencies at appropriate levels. This includes decentralising authority so that they can interact directly in the field without needing to go up the chain for interaction. This will ensure maximisation of

resources, (e.g., Belize Joint Interagency Coordinating Committee). Interagency collaboration and interaction for enforcement should be formal and should include regular meetings. It may even be through a legally constituted body such as the Belize JICC.
- Education is essential especially in fishing communities and for fishers so there is peer pressure. This needs to cover not only fisheries regulations but also environmental regulations.
- Create demonstration sites in protected areas where enforcement is effective and can then be expanded.

Vision Element 6: Stakeholders Fully Involved

Key actions:
- Conduct stakeholder assessments to identify and understand stakeholders. Define stakeholder relationships with each other and with the resource.
- Strengthen and support better stakeholder participation communication, education and information, as well-organised stakeholders will participate better. Build stakeholder capacity to promote cooperation and empower them for management of the resources (e.g., Punta Allen, Mexico, where fisher co-ops are now advisors, are well-organised, and own and manage the area). This entails involvement at multiple levels, local to regional.
- Support regional fisher association networks to build capacity and engage fishers in policymaking at the regional level. Build on existing structures (fishing organisations) for regional networking.
- Pursue mechanisms that will facilitate equitable but limited access to resources, and that sees them as a commodity for the benefit of users and the public.
- Promote mechanisms to give stakeholders rights and ownership of resources, and develop fishing co-ops to allow them to participate effectively.
- Pursue proper integration of regional markets to increase opportunities for fishers and ensure that benefits from fisheries resources are equitably distributed.

Vision Element 7: Only Clean Water to the Sea

Key actions:
- Vigorously pursue national signing and implementation of Land Based Sources of Pollution (LBS) Protocol to the Cartagena Convention:
  - Identify point and non-point sources of pollution.
  - Implement watershed management practices throughout the region.

  - Promote best land- and water-use practices for domestic, forestry, agricultural users.
- Install and/or upgrade sewage systems and identify alternative solutions for current treatment practices.
- Contain sedimentation and nutrient flows through improved building codes.
- Integrate land and marine space-use planning.
- Improve capacity of countries – e.g., infrastructure – to combat pollution.
- Promote agricultural and forestry land use that reduces pollution (e.g., organic agriculture).

Vision Element 8: Healthy Functional Ecosystems

Key actions:
- Healthy functional ecosystems require legislation that is effectively enforced.
- Promote the collection and analysis of scientific information that can form baselines on reef functionality.
- Adopt a healthy reef indicator framework which is made public regularly.
- Pursue advanced modeling of multi-species, predator/prey climate and species/habitat interaction developed to accomplish management learning towards healthy functioning ecosystems.
- Formulate and implement integrated coastal zone management plans.
- Promote the adoption of building codes that are appropriate to sustain coastal habitats.
- Implement coral reef restoration projects, starting with surveys for identification of critical areas for restoration; target marine management areas.

Vision Element 9: Secure and Sustainable Livelihoods

Key actions:
- Develop new livelihood activities that either add value to existing products or make new non-extractive use of marine ecosystems:
  - New livelihood alternatives should utilise existing skills as far as possible.
  - Assist communities to obtain small loans and capacity building for new livelihoods.
- Promote the concepts of 'best fishing practices' and of increased 'sustainable' efficiency in fishing through better technology that is more efficient but does not lead to overfishing.

– Assist fisher co-ops and associations to empower them to promote policy changes, obtain improved infrastructure and secure more equitable and reliable markets.
– Pursue better control of dive activities that lead to conflicts with fishers.

Vision Element 10: Caribbean-Wide Marine Space-Use Management

Key actions:
– Promote the assignment of spatial areas to organised stakeholder groups. This may also lead to passive reduction of fishing capacity (attrition process) as groups seek to maximise benefits from their areas.
– Promote networks of persons or groups involved in spatial management with a view to making it more widely understood and accepted, including providing information and principles on spatial management and information on 'how to do it'.
– Facilitate cooperation of neighbouring countries to share responsibility for resource management.
– Network existing marine management areas to scale up, allowing for larger-scale resource management in the region.
– Implement the programmes of work of the Convention on Biological Diversity and Specially Protected Areas and Wildlife Protocol of the Cartagena Convention.
– Pursue resolution of maritime boundary delimitation issues.

Conclusion

The members of the Coral Reef Ecosystems Working Group were particularly conscious of the time constraints on the discussion, noting that it was a very broad topic. They noted the need to broaden the discussion even further to include the tourism sector which, although present at the symposium, was not prominent in numbers. The group, however, felt that their work provided valuable insights and a consensus in terms of the key elements and implementation actions needed to achieve a vision for EBM for coral reef ecosystems in the Caribbean. The output of this working group, in conjunction with those of the other three working groups discussed in Chapters 23, 24 and 25, provides an important starting point for all stakeholders in the region to move toward an ecosystem-based approach for regional decision-making. The outputs of all four working groups are synthesised in Chapter 26.

23

The Vision for EBM of Pelagic Ecosystems in the Wider Caribbean

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Introduction

Pelagic ecosystems and their fisheries are of particular economic and social importance to the countries and territories of the Wider Caribbean for various reasons. In some countries (e.g. Barbados, Grenada) commercial pelagic fisheries already contribute significantly to total landings and seafood export foreign exchange earnings. Ports and postharvest facilities service the vessels, ranging from artisanal canoes to industrial longliners, and their catch which often reaches tourists as well as locals (Mahon and McConney 2004). In other places where the focus has previously been on inshore and demersal fisheries (e.g. Antigua and Barbuda, Belize) there is growing interest in the potential of pelagic fisheries development. This potential lies not only in commercial fisheries, but also in the high-revenue and conservation-aware recreational fisheries well established in a few locations (e.g. Puerto Rico, Costa Rica) and undertaken at a lower level in many others.

Underlying all of this is the complexity due to many of the valued pelagics being migratory or highly migratory shared and straddling stocks falling under the 1995 United Nations Fish Stocks Agreement and subject to several international instruments and management regimes, such as those of the International Commission for the Conservation of Atlantic Tunas (ICCAT). The web of linkages across Caribbean marine jurisdictions and organizations is complex (McConney et al. 2007). The related issues call for an ecosystem approach (McConney and Salas Chapter 7; Schuhmann et al. Chapter 8) and some progress has already been made at multiple levels (Fanning and Oxenford Chapter 16; Singh-Renton et al. Chapter 14).

This synthesis chapter presents the outputs of facilitated symposium sessions specifically related to achieving and implementing a shared vision for the pelagic ecosystem in marine ecosystem based management (EBM) in the Wider Caribbean. The methodology was described in Chapter 1 of

Table 23.1. A vision for ecosystem based management for the pelagic ecosystem in the Wider Caribbean

FOCUS QUESTION: *What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?*

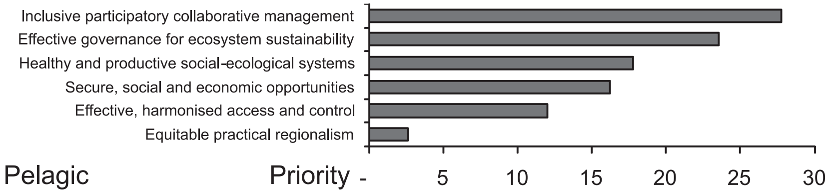
Inclusive and participatory collaborative management	Equitable practical regionalism	Healthy and productive social-ecological systems	Effective, harmonized access and control	Effective & responsible governance for ecosystem sustainability	Secure, social and economic opportunities
– NGOs are stronger and their values listened to – Effective participation of fishers in fisheries conservation and management issues – Fishers take over the industry – Delegation of management to fishers – Recognize and pay full cost of fish – Fisherfolk and government in harmony at decision making level – Education: Listening, understanding challenges and trade-offs – Industry contribution to research	– National interests give way to Regional interest	– More abundant fish resources in the region – Return of great whales to Barbados – Make friends with the sharks – Minimize impacts on the environment – Policy is put in place to protect the different species – Harvesting practices changed and improved	– Eradication of IUU Fishing – Effective Caribbean legislation and successful enforcement – Medium-scale boats legally mobile among CARICOM	– Responsible usage management and networking – Sustainable utilization of fisheries resources – Management decisions based on biological realities of exploited species – Harmonized governance for ecosystem well being and human well being – Transparent commercial operations which incentivize sustainable pelagic fisheries	– Most proud of: Equitability and stability of livelihoods; Health of CLME – Children perceive fishing as a reputable career – Profitable- high standard of living for fisherfolk – Secure access so harvesters can plan a secure future – Contribution of the fishing industry to greater economic development

this volume. This chapter first describes a vision for the pelagic ecosystem and reports on the priorities assigned to the identified vision elements. It then addresses how the vision might be achieved by taking into account assisting factors (those that facilitate achievement) and resisting factors (those that inhibit achievement). The chapter concludes with guidance on the strategic direction needed to implement the vision, identifying specific actions to be undertaken for each of the vision elements.

The vision

The members of the Pelagic Ecosystem Working Group reflected the diverse affiliations present at the EBM Symposium, including governments, intergovernmental organisations, academic institutions, non-governmental organisations and private sector (fishing industry and consulting). With guidance provided by the facilitator, this diverse group of participants was asked to first address the question of "*What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?"* The various occupational perspectives provided for a fruitful and comprehensive visioning process the results of which are summarized in Table 23.1, in terms of the key vision elements and their subcomponents, and in Figure 23.1, which illustrates the level of priority assigned to each of the vision elements.

Figure 23.1. The priorities assigned by the groups to the elements of their vision as shown in Table 23.1



Vision elements and their subcomponents

Six key vision elements were considered essential by the group in order to achieve effective governance for EBM in the Wider Caribbean (Table 23.1). These elements are described below.

The group elaborated upon *inclusive and participatory collaborative management* as the importance of effective stakeholder participation, mainly of fisherfolk through their NGOs, and especially fishers who they saw as being able to "take over the industry" (assume leadership, management responsibility and ownership of assets). Collaboration with government at decision making levels came with a better understanding of fishery challenges and trade-offs. An industry contribution to research was thought important and linked to the value of pelagic fisheries.

Also recognised as essential *was equitable practical regionalism* given the many shared pelagic stocks. The single key point here was the need for national interests to give way to regional interests. This spoke of ending insularity in outlook and action, in favour of encouraging collectivism.

Next, *healthy and productive social-ecological systems* concerned a vision for more abundant fishery resources in the region indicated perhaps by a return of great whales to Barbados and more sensitivity to marine ecosystems that would minimize human impacts on the environment and put more appropriate policies in place for species protection as well as use. For example, harvesting practices would be changed and improved.

Another element reflecting shared stocks was *effective, harmonized access and control*. Eradication of IUU fishing coupled with effective Caribbean-wide legislation and successful enforcement were important. However, within this regime, medium-scale boats needed to be legally mobile among CARICOM countries (at least) in order to follow the fish and improve returns on investment for sustainable livelihoods.

The *effective and responsible governance for ecosystem sustainability* was dealt with in more detail in the Governance Working Group, but the pelagic emphasis was on responsible and sustainable fisheries resource use via management authority networking. Management decisions needed to be based on the biological realities of exploited species so that harmonized governance led to ecosystem well-being as well as human well-being. Good governance would be exemplified by transparent commercial operations which incentivize sustainable pelagic fisheries.

Finally, the *secure, social and economic opportunities* concerned intergenerational and equity perspectives on the pelagic ecosystem. Stability of livelihoods, children perceiving fishing as a reputable career and a profitably high standard of living for fisher folk were seen as contributing to securing resource access so harvesters could plan for a more secure future. Group members expected that the contribution of the fishing industry to economic development in the Caribbean would be greater in the future.

Prioritisation of vision elements

Following the identification and discussion of the six vision elements, Working Group members were asked to prioritise the elements based on which ones they considered to be the three most important. The assigned ranking is presented in Figure 23.1 and the results illustrate the overall significance of all of the vision elements to the members, despite their occupational diversity. As shown in Figure 23.1, the spread between the element receiving the greatest number of votes (i*nclusive and participatory collaborative management*) and the one receiving the lowest number of votes (e*quitable practical regionalism)* was fairly wide with a clear order in the preferences.

Achieving the vision

Working with the assistance of the facilitator, the Working Group members proceeded to evaluate current factors within the Caribbean that could facilitate the achievement of the vision elements and those that could serve to impede them. The members subsequently worked collectively to categorize the assisting factors into current strengths within the region and potential opportunities to be seized. Similarly, resisting factors were collectively categorized into those relating to existing weaknesses and potential threats. Following this exercise, members provided guidance on the strategic direction needed to implement the vision by identifying specific actions to be undertaken for each of the vision elements.

Assisting and resisting factors

The suite of assisting and resisting factors identified by the Pelagic Ecosystem Working Group is presented in Table 23.2.

In terms of the assisting factors identified as current strengths, the group listed more regional integration of projects, harmonized legislation (particularly in the OECS countries), good research institutions and people staffing them that could be networked for effective governance. Political will was seen as strengthening as heads of government were showing support for the development of RFOs in several sub-regional country groups. Fisherfolk organisations were growing.

Opportunities highlighted included governments commitment to the CARICOM Common Fisheries Policy and the Caribbean Sea Initiative/ Commission, more CARICOM members being interested in ICCAT such as via the CLME project, more research on governance for EBM in progress, growing consumer demand for fair trade products and sustainable ecotourism.

The few resisting factors identified as threats were potential negative climate change impacts, the declining world economy with limited resources, and the propensity to seek short term solutions to economic development needs especially through government action.

Strategic directions

The final facilitated process undertaken by the Pelagic Ecosystems Working Group was aimed at identifying key actions that could provide gui-

Table 23.2. Assisting and Resisting Factors Affecting a Vision for Governance that is Ecosystem Based in the Wider Caribbean

Assisting Factors	Resisting Factors
Strengths	*Threats*
More regional integration of projects in Marine Science	Negative climate change impacts
Harmonized legislation	Declining world economy-limited resources
Responsible people	Short term solutions to economic development needs
Existing regional institutions to facilitate research. Some very good, capable human resources. Knowledge of ecosystem health. Caribbean Regional Fisheries Mechanism (CRFM)	Government actions look at short term
UWI for research	
Greater awareness and knowledge of issues	
Existing relevant organizations that can be networked for effective governance	
Collaboration	
Public awareness and consultation	
Harmony	
Regional heads are supporting the development of the RFO for the purpose of strengthening the industry	
Improved regional and international collaboration (at least among scientist)	
Caribbean Fisherfolk monuments	
Education	
Existing regional institutions CERMES & CRFM. Strengthening of fisherfolk organization to participate in decision making and management	
Opportunities	
Regional government commitment to Common Fisheries Policy and Regime.	
More CARICOM members are interested in ICCAT CLME project	
More research on Governance for EBM in Progress	
Growing consumer demand for organic and fair trade products	
Declining catches	
Caribbean integration	
Caribbean Sea Initiative/Commission	
Necessity- Observed decline in stocks and profits	
Government has taken more interest in the development of the fishing industry	
CARICOM Common Fisheries Policy	
Financial Institutions	
Growing demand for sustainable ecotourism	
Market forces (Eco-labeling)	
Proposed Collaboration with ICCAT	

dance on the strategic direction to be followed by decision- makers within the region. These are provided for each of the vision elements below.

Vision element 1: Inclusive and participatory collaborative management

Key actions:

- Identify stakeholders and representatives – across sectors (national level).
- Educate stakeholders on purpose of EBM and invite their views:
  - Establish mechanism for dialogue/communication.
  - Identify and prioritize issues/concerns/challenges.
- Establish coordinating committee (national level) and representation across sectors:
  - Include decision makers or representatives for continuity and participation.
- Effective communication for coordinator mechanism (strengthen skills) and decision making:
  - National fisheries organization to be strengthened.
  - Communication among countries – ministers are key communicators.
  - Networking various government levels – must also be inter-sectoral.
  - Common policy- legislation- enforcement (regional level, collaboration among countries).
- Ministers to be convinced of initiative to advance EBM:
  - Free and open discussion – solicit involvement of ministers.
  - Role of technology in communication – meeting dates etc. shared electronically.
  - Strong and effective fisher folk organizations – politicians respond to the electorate.
  - >90% of vessels owned by non-fishers – professionals' lack of stewardship by these.
- Political intervention to drive the collaboration scaling up from national to regional.

Who?:

- Caribbean Sea Commission (Multi - sectoral) - Caribbean Sea initiative (possesses large scale of collaboration required for pelagics in region).
- CLME project.
- National fisheries authorities.
- CRFM and other regional organizations.
- Community Based Organizations.

Some steps:
- During the creation of a Caribbean/Common Fisheries Policy and a Caribbean Marine Ecosystem Framework Agreement the principles of inclusive participatory collaborative management would be enshrined; then national authorities would work in a top-down fashion institutionalized collaborative management approach in all fisheries activities and programmes.
- National authorities would assess best practices and lessons learnt, and effectively communicate these to others through documentation, internet, advertisements and participatory events.
- Regional fisher folk network, currently in progress by CRFM is needed for effective participation.
- Expand over time to involve Spanish, French and Dutch speaking Caribbean in pelagics EBM.
- CRFM requires a communication strategy and plan covering all types of communication.
- Broaden to rest of Caribbean and include focal points (national and subregional for pelagic issues).
- Include EBM in international trade and postharvest sector in trade talks.
- Need bottom-up and top-down. Use ACS Caribbean Sea Commission as a possible framework.
- Serious use of documentary film as an information tool to reach fishers, general public, politicians.

Vision element 2: Equitable practical regionalism

Key actions:
- Strengthen linkages between WECAFC and CRFM.
- Weaknesses in human capacity within the Fisheries Divisions need to be addressed.
- Need change in attitude (more pro-regional) to take Common Fisheries Policy forward.
- Need more practical experience of fisheries authorities working together .... Learning by doing rather than talking at meetings.
- Make use of ACS (Caribbean Sea Commission needs to be absolutely inclusive of all Caribbean) as a regional body for broader issues of EBM.
- Need much more focus on land-based activities affecting water quality/ or transshipment of hazardous waste.
- Equity would mean considering compensation or perhaps exemption when a regional policy impacts one or more nations negatively.
- Practical – refers to sub-regional bodies scaled according to issues at stake.

- Consider portioning of pelagic resources in the Caribbean – and value resources at different trophic levels. Examine alternative uses for pelagic resources (e.g. commercial versus recreational fishing).
- Use all fora to push regional perspective after defining region(s) and sub-region(s) and how they fit into or adjacent to each other.
- Establish management partnership with ICCAT to cover part or whole Western Atlantic; CRFM perhaps currently moving towards this.

Who?:
- Stakeholders are at various levels. Two main levels are:
  - National level
    - Fisher folk organizations
    - Fisheries departments
    - Investors in the fishing industry
    - Other stakeholders
  - Regional level
    - CARICOM countries
    - Non-CARICOM countries
    - Must include Venezuela and Latin American countries who share the LME resources as well as Martinique, Guadeloupe, Cuba, Puerto Rico, etc
- Also international level – ICCAT

Vision element 3: Effective harmonized access and control

Key actions:
- Common Fisheries Policy. It contains key elements to be addressed (elements of the vision).
  - Complete the creation of the Fisheries Policy in order to achieve this, but it is now a political mine field.
  - Points below are examples of the components that the policy would address, but note that there are others covered now and a draft is publicly available.
  - Recognize that it is now only for certain countries, so need to expand to non- CRFM countries, need to define region and sub-regions, and how they relate to each other.
  - Need to understand how political decisions are made and infiltrate the process.
- Consider including as components of Common Fisheries Policy:
  1. Licensing regimes
  2. Regional fishing boat registry
  3. Pay for license
  4. Quota allocation
  5. Capacity building – data collection information system CLME
  6. Enforcement measures work with drugs and enforcement agencies

7. Complementing education and sensitization
8. Observer programmes – bycatch – what constitutes bycatch?
9. Vessel monitoring, satellite tracking
10. Uniform gear agreement – enforcement - fines including for gear lost
11. Foreign fleet policy

Who?:
- CRFM (Caribbean Regional Fisheries Mechanism) + non-CRFM CLME (Spanish, Dutch, French)
- ICCAT
  - Atlantic wide stocks (tunas, etc) decisions rest with ICCAT.
  - ICCAT is not in full EAF management mode at the moment although moving towards it However, RFMO and/or regional management arrangement oversees management of small tunas and tuna-like species. Example blackfin, dolphin and wahoo.
  - RFMO should use EAF for all pelagics. Although management for smaller tunas will be entirely in their mandate provided stocks are within region only.
  - Advice based from EAF approach of RFMO level will be used and presented in the ICCAT for larger pelagics as well.
  - Although this approach only deals with large pelagics it will feed into all other wider ecosystem management.

Vision element 4: Healthy and productive social-ecological systems

Key actions:
- Partnerships for regional and Australian-styled assessments include links to the Caribbean Sea Commission for monitoring and reporting (CLME project).
- Change harvesting practices, e.g. FADs need management and more thought on whether or not they are good.
- Concern about a need to change harvesting practices is also an issue of the need to limit access and harvest.
- More attention needs to be placed on the release of undersized fish through legislation and against bringing undersized fish to market.
- Assess possible problem with lost and discarded gear.
- By-catch wastage: extensive research to identify if there is a problem.

Who?:
- National fisheries departments - CRFM and through various other regional fisheries organizations such as ICCAT, Association of Caribbean States, OSPECA, etc.
- Note that in some countries some stakeholders are not fishers but investors in the industry. They have other means of income; therefore do

not particularly care about health of ecosystem. They can always move to main source of income.

Vision element 5: Effective and responsible governance for ecosystem sustainability

Key actions:
- Create a Caribbean Ecosystem Framework Agreement.
- Use existing guiding principles like:
  - Cartagena Convention – Specially Protected Area and Wildlife (SPAW)
  - Inter American Convention (IAC) on Sea Turtles (guiding principles)
  - IMO

Who?:
- Caribbean Sea Commission (of ACS)
- IOCARIBE UNESCO e.g. via CLME project

Vision element 6: Secure, social and economic opportunities

Key actions:
- A Common Fisheries Policy and a Caribbean Marine Ecosystem Framework Agreement would CONTRIBUTE TO securing and protecting pelagic resources (i.e., necessary but not sufficient)
- Education and sensitization to change the mindset of all stakeholders
- Fisheries and the sea no longer a "free for all" inclusive, stakeholder consultation and participation

Who?:
- Regional implementing agency, presently CRFM, with the need to extend to a broader agency in the near future, for example WECAFC as first step

Conclusion

The Pelagic Ecosystem Working Group provided valuable insights and reached consensus in terms of the key elements and implementation actions needed to achieve a vision for pelagic EBM/EAF in the Wider Caribbean. The output of this Working Group, in conjunction with those of the other three Working Groups (Fanning et al. Chapter 25; Mahon et al. Chapters 22 and 24) provide an important starting point for all stakeholders in the region to move toward an ecosystem based approach for regional decision making.

24

The Vision for EBM of Continental Shelf Ecosystems in the Wider Caribbean

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Introduction

Continental shelf ecosystems have high importance for the continental countries of the Wider Caribbean Region. They support important shrimp and groundfish fisheries (Phillips et al. Chapter 15) and snapper fisheries on their outer slopes (Heileman Chapter 13). There are also important linkages between the former fisheries and the many coastal and estuarine lagoons and wetlands that occur in these countries (Yáñez-Arancibia et al. Chapter 17). They support livelihoods (McConney and Salas Chapter 7) and provide critical ecosystem services (Schuhmann et al. Chapter 8). Continental shelf ecosystems have been degraded by many human impacts of both marine and land-based origin (Sweeney and Corbin Chapter 4; Gil and Wells Chapter 5).

This synthesis chapter presents the outputs of a group process aimed at developing a vision and way ahead for ecosystem based management (EBM) for continental shelf ecosystems in the Wider Caribbean, using the methods described earlier (Fanning et al. Chapter 1). In terms of structure, the chapter first describes a vision for continental shelf EBM and reports on the priorities assigned to the identified vision elements. It then discusses how the vision might be achieved by taking into account assisting factors (those that facilitate achievement) and resisting factors (those that inhibit achievement). The chapter concludes with guidance on the strategic direction needed to implement the vision, identifying specific actions to be undertaken for each of the vision elements.

The vision

The occupational breakdown of members of the Continental Shelf Ecosystems Working Group reflected the diversity of affiliations present at the

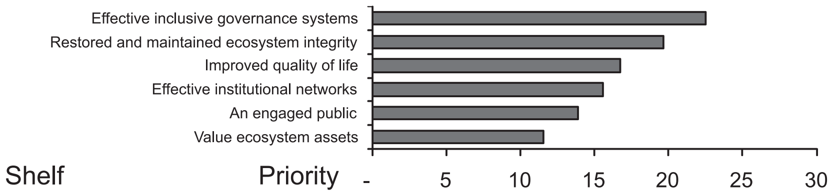
Table 24.1. A vision for ecosystem based management for continental shelf ecosystems in the Wider Caribbean

FOCUS QUESTION: *What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?*

Improved quality of life	Effective inclusive governance systems	Restored and maintained ecosystem integrity	Effective institutional networks	Value ecosystem assets	An engaged public
– Secured livelihoods- happy faces – Improved quality of life for stakeholders – Healthy use of the ecosystem that benefits all users – Balanced usage of freshwater including the coastal zone – Sustainable benefits from ecosystem goods and services	– Harmonized inclusive policy on EBM – Harmonized governance – Subsidiarity in decision making and management – Well developed legal framework – Adequate enforcement measures – Wider Caribbean coordinating body established	– Native marine biota very close to natural numbers – Ecosystem integrity being maintained – Quantify habitats under extinction risk – Climate change mitigation and adaptation measures	– Capacity in place to deliver EAF/EBM – A well managed co-coordinated ecosystem – Improved trans-boundary linkages/information sharing	– Ecosystem recognized and treated as natural and regional assets	– Informed educated citizens – Public awareness of the concept

EBM Symposium and included governmental, intergovernmental, academic, non-governmental and private sector (fishers and fishing industry and consulting) representatives. With guidance provided by the facilitator, this diverse group of participants was asked to first address the question of "*What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?"* This diversity provided for a fruitful and comprehensive discussion which is summarized in Table 24.1, in terms of the key vision elements and their subcomponents, and in Figure 24.1, which illustrates the level of priority assigned to each of the vision elements.

Figure 24.1. The priorities assigned by the continental shelf ecosystems group to the elements of their vision as shown in Table 24.1



Vision elements and their subcomponents

Six key vision elements were considered essential by the group in order to achieve effective EBM for shelf ecosystems in the Wider Caribbean (Table 24.1). With regard to i*mproved quality of life,* the emphasis was on livelihood security and sustainability of benefits flowing to stakeholders. *Effective inclusive governance systems* comprised a number of ideas relating to the need for integrated policy, legislation and implementation. It addressed the need for regional collaboration which also emerged in *effective institutional networks*. Under *restored and maintained ecosystem integrity,* participants envisaged the rehabilitation of ecosystems to levels that could produce sustainable benefits and cope with the uncertainty associated with climate change. The vision element *value ecosystem assets* contained a single idea related to the full recognition of the value of the ecosystems. Finally, the group saw a*n engaged public* with informed and aware citizens playing a role in resource management as a key element.

Prioritisation of vision elements

Following the identification and discussion of the six vision elements, Working Group members were asked to priorise the elements based on which ones they considered to be the three most important. The assigned ranking is presented in Figure 24.1 and the results illustrate the overall significance of all of the vision elements to the members, despite their

Table 24.2. Assisting and resisting factors affecting a vision for EBM for continental shelf ecosystems in the Wider Caribbean Region

Assisting Factors	Resisting Factors
Strengths and opportunities	*Threats*
Study cases	Poverty
Legislation	Jurisdictional issues
Science and technology	
Experienced human resource base	*Weaknesses*
Knowledge of what is required	Resource constraints
Regional co-ordination	Inadequate money ($$)
Commonality of issues	Resistance to change
Existing government frameworks	Anti-intellectual culture in decision-making
Existing institutions	Inadequate knowledge of EBM
Agreement among some key stakeholders	Perception that this is a pipe dream
Convergence of concerns	Unsupportive government policy
Schools, universities, education systems	Inadequate awareness
Information technology (communication, information management)	Ad hoc decision-making
	Politics (Bureaucratic impediments)
Civil society engaged	Command and control
	Both threats and weaknesses
	Ineffective governance
	Diversity-insularity

occupational diversity. The element receiving the greatest number of votes was *effective inclusive governance systems* emphasising the emerging symposium focus on this aspect of EBM. However, the one receiving the lowest number of votes (*value ecosystem assets)* was still well supported given that it represented a single yet complex idea.

Achieving the vision

Working with the assistance of the facilitator, the Working Group members proceeded to evaluate current factors within the Caribbean that could facilitate the achievement of the vision elements and those that could serve to impede them. The members subsequently worked collectively to categorize the assisting factors into current strengths within the region and potential opportunities to be seized. Similarly, resisting factors were collectively categorized into those relating to existing weaknesses and potential threats. Following this exercise, members provided guidance on the strategic direction needed to implement the vision by identifying specific actions to be undertaken for each of the vision elements.

Assisting and resisting factors

The suite of assisting and resisting factors identified by the Continental Shelf Ecosystems Working Group is presented in Table 24.2. In terms of the assisting factors both strengths and opportunities were combined. These focused on the existing capacity in terms of science, technology and institutions for cooperation. This was seen as being supported by good educational systems. The idea that there are common issues throughout the region and some convergence in views regarding what they are and what needs to be done was also flagged. Finally, the fact that civil society is becoming engaged was noted as important.

Resisting factors categorized as threats were poverty, the significance of which extends beyond living marine resource use, and jurisdictional issues relating to disputes over marine space. The weaknesses identified were well-known to members of the Working Group as many participants have published works identifying the challenges facing the region. These included a lack of resources needed for effective governance to the lack of policy support. Lack of awareness of EBM and sustainability issues were also flagged.

Strategic directions

The final activity undertaken by the Continental Shelf Ecosystems Working Group was to further flesh out key actions that could provide guidance on the strategic direction to be followed by decision makers within the region. These are provided for each of the vision elements below.

Vision element 1: Improved quality of life

Key actions:
- Pursue a phased multi-sectoral approach to development, utilising existing support systems (governance)
- Focus on waste water treatment, beginning with restoration of water quality (national policy)
- Look into alternative livelihoods
- Limit access to fisheries
- Provide support through technical and/or financial means the development of businesses at the community level
- Develop and share success stories
- Resolve the user conflicts

Vision element 2: Effective inclusive government systems

Key actions:
- Develop mechanisms to allow equitable access to the resources and benefits
- Empower local organizations through tools including mentoring
- Comprehensive stakeholder engagement
- Foster good management at all levels, particularly at the lower levels
- Provide fundamental education to all groups
- Put value on ecosystem services i.e. through environmental economics
- Established coordinated regional and sub-regional policy to resolve common challenges
- Enforcement
- Ensure that the precautionary approach is always utilized
- Utilize inter-sectoral committees with decision-making mechanisms
- Establish institutional arrangements with adequate funding
- Management plans should identify and evaluate tradeoffs
- Ratification and implementation of existing agreements

Vision element 3: Restored and maintained ecosystem integrity

Key actions:
- 100% treatment of water discharged into the coastal and marine environment
- Increased scientific monitoring
- Establish baseline values and indicators
- Improve information sharing and maintenance of information and data to acceptable standards
- Fundamental education at all levels and help develop incentives for their participation thereafter
- Increased surveillance and enforcement, including support of self monitoring and enforcement
- Utilisation of best practices by all sectors
- Establishment of protected areas (MPAs)
- Integration of coastal zone and land use planning
- Reef and mangrove restoration

Vision element 4: Effective institutional networks

Key actions:
- Need for a clear understanding of the role of institutions
- Rationalize the roles of different organisations for efficiency and effectiveness

- Need for linkages of institutions at various levels - CLME efforts can be used as a governance model for networking at a local, national and regional level
- Build on existing institutional networks (example CRFM)
- Institutional arrangement at sectoral level
- Establish credibility of institutions via transparency and accountability mechanisms
- More effort on decision-making versus science and technology at institutional level
- Databases for different levels of users and different territories, to facilitate dissemination of information widely across stakeholders, decision-makers, etc.
- Education and information to address resistance to change
- Reallocation of resources towards education and sectoral level institutions
- Identify champions nationally and regionally to promote causes to attend to political challenges
- Generate demand for change at the local level
- Undertake more in-depth social and economic analyses
- Establish benefits for the sustainability of networks

Vision element 5: Value ecosystem assets

Key actions:

- Utilise resource economics to put a value on ecosystem goods
- Build on existing knowledge especially on social and economic analysis
- Use data from resource institutions as well as traditional groups like fisher folk
- Undertake comparative analyses (re: tradeoffs)
- Identify and quantify different goods and processing by-products of the industry (example what might be considered waste presently)
- Use economic information to develop policy and legislation support for EBM
- Promote awareness of these issues in the public

Vision element 6: An engaged public

Key actions:
- Incorporate EBM principles in the curriculum at all levels of the educational system
- Utilise experts and technology to communicate to the public to engage them (example Facebook EBM site)
- Provide wide access to information and knowledge
- Build on the convergence of EBM concern
- Use language that is suitable to the stakeholders
- Explore divers communication means
- Create conditions for engagement

Conclusion

Although limited in terms of the length of time and fullness of members, the members of the Governance Working Group provided valuable insights and reached consensus in terms of the key elements and implementation actions needed to achieve a vision for EBM governance in the Caribbean. The output of this Working Group, in conjunction with those of the other three Working Groups discussed in Chapters 22, 23 and 25 provide an important starting point for all stakeholders in the region to move toward an ecosystem based approach for regional decision making. These outputs are synthesised in Chapter 26.

25

Developing the Vision for EBM Governance in the Wider Caribbean

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Introduction

Countries of the Wider Caribbean have committed to principled ocean governance through several multilateral environmental and fisheries agreements at both the regional (e.g., the Cartagena Convention SPAW Protocol) and international level (e.g., the Convention on Biological Diversity, the United Nations Fish Stocks Agreement, the FAO Code of Conduct for Responsible Fishing). They have also committed to the 2002 World Summit on Sustainable Development (WSSD) targets for fisheries and biodiversity conservation. However, the ongoing challenge is to put in place the measures required to give effect to these principles at the local, national and regional levels (Fanning et al. 2009). While not minimising the important role of science in an ecosystem approach to managing the living marine resources of the Wider Caribbean Region, the chapters in this book serve to highlight the importance that regional experts have placed on the role of governance to address the problems in the region.

This synthesis chapter presents the outputs of a discussion specifically relating to the role of governance in achieving and implementing a shared vision for ecosystem-based management (EBM) in the Wider Caribbean, using the process described in Chapter 1. In terms of structure, the chapter first describes a vision for governance and reports on the priorities assigned to the identified vision elements. It then discusses how the vision might be achieved by taking into account assisting factors (those that facilitate achievement) and resisting factors (those that inhibit achievement). The chapter concludes with guidance on the strategic direction needed to implement the vision, identifying specific actions to be undertaken for each of the vision elements.

Table 25.1. A vision for governance that is ecosystem based in the Wider Caribbean

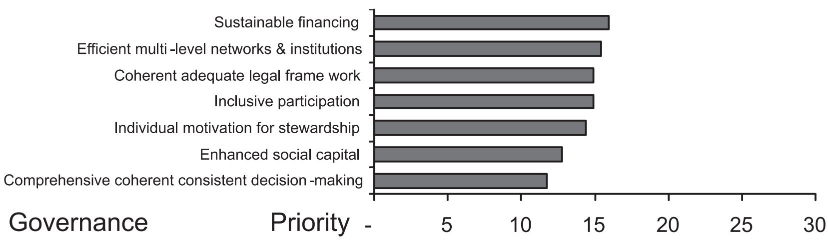
FOCUS QUESTION: *What do you see in place in 10 years time when EBM/EAF has become a reality in the Caribbean?*

Sustainable financing	Inclusive participation	Comprehensive coherent consistent decision-making	Coherent adequate legal frame work	Individual motivation for stewardship	Efficient multi-level networks & institutions	Enhanced social capital
– Adequate funding – Financial support for education and information sharing – Full economic valuation of Caribbean coastal and marine goods and services	– Interdisciplinary communication will be standard – World view that encompasses participation and collaboration – More effective and empowered stakeholder participation – Equitable – Access to information – Opportunities to participate are equitable – Inform and involve stakeholders in decision-making at all levels – Managing the source not resource in equitable manner. One person, one vote	– Openness, transparency, accountability – Clear and adequate decisions – Dynamic interaction in decision-making process – Accountability and transparency of all participating stakeholders – Governance of EBM needs to consider the complexity of ecological and social systems – Higher levels of co-operation and collaboration, interdependence, trust, and confidence – Governance must focus attention on management for resilience and building adaptive capacity	– Clear and adequate laws – Clearly defined rationalized legal frameworks – Compliance and enforcement – Inclusion/application of sustainable principles at all governance levels – Governance regime for conservation of biodiversity in areas beyond national jurisdiction	– Incentive-based governance – Environment seen as an enabling factor for development, not a 'burden' – Awareness and appreciations for ecosystem and the linkages – Incentives for individuals to be good stewards – People placing a higher value on marine resources – Greater efficiency in resource utilization	– Creation of ocean governance networks – Better linkages, networks and collaboration in EBM at all levels/scale – Stream-lined multi-level governance networks – Networking and sharing of Information – Clearly defined rationalized institutional frameworks	– Poverty levels reduced – Implementation of social and intergenerational equity – Social and cultural values fully recognized and developed – Improved quality of life and welfare

The Vision

The occupational breakdown of members of the Governance Working Group reflected the diversity of affiliations present at the EBM Symposium and included governmental, intergovernmental, academic, non-governmental and private sector (fishers and fishing industry and consulting) representatives. With guidance provided by the facilitator, this diverse grouping of participants was asked to first address the question: "*What do you see in place in 10 years' time when EBM/EAF has become a reality in the Caribbean?*". This diversity provided for a fruitful and comprehensive visioning process, the results of which are summarised in Table 25.1, in terms of the key vision elements and their subcomponents, and in Figure 25.1, which illustrates the level of priority assigned to each of the vision elements.

Figure 25.1. Priority Ranking for the Governance Working Group Vision Elements



Vision Elements and Their Subcomponents

Seven key vision elements were considered essential by the group in order to achieve effective governance for EBM in the Wider Caribbean (Table 1). These elements were identified as: sustainable financing; inclusive participation; comprehensive, coherent, consistent decision-making; coherent adequate legal framework; individual motivation for stewardship; efficient multilevel networks and institutions; and enhanced social capital.

With regards to meeting the need for sustainable financing, group members elaborated on the importance of securing adequate funding. This was seen as essential for both acquiring and disseminating information on the importance of coastal and marine resources to the well-being of the region. Particular attention was paid to having a good understanding of the economic value of Caribbean ecosystem goods and services, as the lack of this information by decision-makers and the general public was considered to be a key driver in the ongoing decline of these resources.

Inclusive participation was recognised as an essential principle if sustainable ocean governance is to be achieved. Group members stressed the need to engage stakeholders at all levels of the decision-making process and to ensure that a process is put in place that allows equitable access to information and participation. It was also determined that more effective and empowered stakeholder participation would benefit from information sharing that takes a holistic and interdisciplinary perspective of the ecosystem, rather than one in which decisions are made in sectoral "silos". Such a change would serve to manage the human component of the ecosystem from the perspective of the entire suite of ecosystem goods and services, allowing for more robust and sustainable decisions to be made.

Building on the notion of promoting integrated coastal and ocean policy, the element of comprehensive, coherent and consistent decision-making was identified. This element was underpinned by a focus on principles of openness, transparency and accountability. It was coupled with a recognition that EBM governance needs to consider the interdependence and complexity (and as such uncertainty) inherent in both the natural and human subsystems of the region. To reflect this effective form of governance, management decisions must support promoting resilience and building adaptive capacity.

A coherent adequate legal framework that provides a clear rationale for the rules governing the allocation of space and use of coastal and marine goods and services was considered essential to achieve the vision of EBM governance for the Caribbean. Underpinning the laws and rules governing use and space was the explicit adoption of legal and sustainability principles, nested across all jurisdictional levels. Effective compliance and enforcement mechanisms that ensured the ongoing provision of ecosystem goods and services both within and beyond national jurisdiction were also highlighted by the working group members.

The fifth vision element focused on the important role that individuals can play in promoting stewardship of the natural environment. Group members suggested that individual motivation for stewardship is likely when there is a clear understanding of the direct linkage between socio-economic well-being and environmental well-being. In this case, the latter is seen as an "enabling" factor that is necessary for development, not a 'burden' and certainly not a luxury. This increased awareness leads to higher appreciation of the overall value of ecosystem goods and services among individuals and provides incentives for stewardship and good governance, leading to greater efficiency in sustainable resource utilisation.

Recognising that living marine resources management in the Wider Caribbean Region is typified by a broad array of institutions (Fanning and Mahon, this volume), encouraging efficient multilevel networks and institutions was deemed critical to achieving EBM governance in the region. The efficiencies to be gained in building on the existing strengths of many of these institutions, coupled with a reorganising of mandates and activities where appropriate, were seen as opportunities to be seized. Additional recommendations included encouraging better linkages and multilevel collaboration in EBM across sectors and scales where they currently do not exist, as well as streamlining existing multilevel networks.

The final vision element identified by the Governance Working Group reflected the importance of securing a desired quality of life for the people of the Wider Caribbean and centred on enhanced social capital. Subcomponents under this element recognised the need to adopt principles of sustainable development pertaining to intergenerational equity and the goal of poverty reduction. Group members also highlighted the need to pay attention to the diversity of cultural and social values prevalent within the region.

Prioritisation of Vision Elements

Following the identification and discussion of the seven vision elements, Working Group members were asked to prioritise the elements based on which ones they considered to be the three most important. The assigned ranking is presented in Figure 25.1. The results illustrate the overall significance of all of the vision elements to the members, despite their occupational diversity.

As shown in Figure 25.1,the spread between the element receiving the greatest number of votes (*sustainable financing*) and the one receiving the lowest number of votes (c*omprehensive, coherent and consistent decision-making)* was less than four votes. In reporting to plenary, surprise was expressed at how quickly members of a given group reached consensus, leading some to question whether the appropriate level of debate was achieved. However, others observed that given the regional expertise and representativeness of the participants, the importance of the identified vision elements in terms of how to meaningfully achieve EBM/EAF in the Caribbean should not be underestimated.

Achieving the Vision

Working with the assistance of the facilitator, the Working Group members proceeded to evaluate current factors within the Caribbean that could facilitate the achievement of the vision elements and those that could serve to impede them. The members subsequently worked collectively to categorise the assisting factors into current strengths within the region and potential opportunities to be seized. Similarly, resisting factors were collectively categorised into those relating to existing weaknesses and potential threats. Following this exercise, members provided guidance on the strategic direction needed to implement the vision by identifying specific actions to be undertaken for each of the vision elements.

Assisting and Resisting Factors

The suite of assisting and resisting factors identified by the Governance Working Group is presented in Table 25.2. In terms of the assisting factors

Table 25.2. Assisting and Resisting Factors Affecting a Vision for Governance that is Ecosystem Based in the Wider Caribbean

Assisting Factors	Resisting Factors
Strengths	*Weaknesses*
Existing institutions	Outdated and overlapping laws and regulations
Motivated stakeholders	Weak mechanisms and logistics for monitoring, control and surveillance
Commitment to the rule of law	Budgetary constrains for implementation of actions
Human resources and experiences	IUU fishing takes place
Existing donors and partners	High rate of poverty and dependence on marine resources
Existing mechanisms for trade negotiations (bi/multi lateral) now include environment	Caribbean states find it difficult to control overexploitation of resources
Internal and external capacity and capability.	Multicultural and Multilanguage culture makes it costly for effective communication
CERMES, Nippon, GEF, FAO etc…	Vulnerable to Climate change
Pride in Caribbean culture	Small vulnerable economies
High investment in climate change adaptation / DRR can be leveraged for EBM	Lack of political will
Strength in numbers (# of nation can create political leverage)	Mismanagement of watersheds
Participation enshrined in national law/commitments to MEAs (CBB etc.)	High levels of poverty and inequality
Clear dependence on the Sea (tourism, livelihoods) makes action easier to sell	Coastal pollution urbanization
Higher awareness of many stake holder groups of need for EBM	Weak culture of participation and information sharing
	Ineffective, limited communication between scientists and decision-makers
Opportunities	Lack of data
Open access to environment information	Multiple levels of diversity poses challenges
Regional economic , political, integration can enhance external negotiating power	Limiting fishing will threaten livelihoods and social safety net
MEAs	Lack of capacity and resources for full participation at all levels
Open Access to knowledge/ information/ data	Conflicting national interests
Dependence of Caribbean economic activity on healthy natural resources (driver of change)	Lack of education
Sustainability assessments of nation legal frameworks	Limited political commitment to ecological sustainability
Existing organizations can be built upon	Limited incorporation of sustainability principles into domestic law
Technology exists and can be easily imported	Inadequate sanctions for beach regulations
Education	Small vulnerable economies and limited revenue inflows
Inclusion of 'soft' laws into domestic law	Inadequate community involvement in Decision-making
	Brain drain
	Excessive legislative back log
	Small over-worked, understaffed government departments
	Threats
	Drug trafficking – affecting social capital, alternative livelihoods
	Increasing global demand for seafood
	Negative impacts of developed country policies, e.g. US EPA
	Global warming climate change
	IUU fishing
	War and conflict

identified as current strengths, the previously discussed presence of a wide range of institutions and their mandates in the region, as well as qualified and motivated individuals, to facilitate the vision of sustainable ocean governance was seen as instrumental to achieving success. Additionally, given the high percentage of small island developing states, the Caribbean region has received considerable support from multiple donor agencies in recognition of the importance of the coastal and marine resources to the well-being of the region and in adapting to the impacts of climate change. Additional strengths worthy to highlight include the pride in Caribbean culture that is shared throughout the region and the commitment to the rule of law.

Opportunities highlighted included the willingness of Caribbean states to be party to multilateral environmental agreements and the potential to use national laws to implement both "soft" and "hard" international commitments. In addition, a culture of open access to data, information and knowledge and the potential to move sustainable development matters onto the agendas of existing regional and sub-regional institutions (for economic and political integration) can serve to enhance the negotiating power of the region at international fora.

Resisting factors categorised as weaknesses were well known to members of the Working Group, as many participants have published works identifying the challenges facing the region. These included a lack of effective laws and mechanisms for compliance and enforcement, coupled with a range of unsustainable coastal and marine-related practices. Other weaknesses include the level of poverty throughout the region, and dependence on marine resources, leading Caribbean states to find it difficult to control overexploitation of resources. When coupled with the abundance of small vulnerable economies, exacerbated by the threats posed from climate change, there is an obvious lack of financial resources to implement desired actions, driven by a lack of political will. Lastly, the existence of many cultures and languages, while contributing significant strengths in the region, also makes it costly for effective communication.

Significant threats that need to be minimised include the high incidence of drug trafficking in the region which affects social capital and presents a lucrative, albeit illegal, form of alternative livelihoods for many of the region's younger demographic. Additionally, the periodic outbreaks of war and conflict in parts of the region threaten the stability of the entire region. As well, external threats such as increasing global demand for seafood threaten the sustainability of fish stocks, while climate-change-induced threats have the potential to destabilise the well-being of the region.

Strategic Directions

The final facilitated process undertaken by the Governance Working Group was aimed at identifying key actions that could provide guidance on the strategic direction to be followed by decision-makers within the region. These are provided for each of the vision elements below.

Vision Element 1: Sustainable Financing

Key actions:
- Develop consensual, coherent long and medium-term sustainable financing strategies through regular donor/ministerial fora, including finance ministers and those responsible for ocean and coastal resources (the current biennial World Bank forum with a selected group of the region's decision-makers could be the basis for this by adding additional decision-makers from the natural resources/environmental ministries);
- Identify problems and set priorities for comprehensive planning;
- Specifically target priority funding proposals to donors and other financial sources that best matches their objectives to enhance chances of a "good fit". This requires building relationships with these providers so as to achieve that "fit";
- Ensure approved programmes have self-financing mechanisms built in (where appropriate);
- Increase the understanding and build support among stakeholders and decision-makers of the long-term linkages between ecological and economic values;
- Strengthen laws to ensure transparent use of funds and accountability, promoting more efficient use of funds;
- Establish a forum of relevant ministers, technical agencies and donors driven by Caribbean champions;
- Include EBM in national budgetary process using meaningful valuation of ecosystem goods and services;
- Build capacity to undertake environmental valuation;
- Explore and, where appropriate, establish user fees that are specifically collected and allocated for supporting EBM, i.e., not going into general revenues.

Vision Element 2: Inclusive Participation

Key actions:
- Promote comprehensive public education programmes in the school curricula and to the general public;
- Target participatory workshops at the community level;
- Integrate coastal zone issues in school curriculum;
- Build and implement co-management relationships where appropriate;

- Develop information clearing house(s) to provide easy access and availability of information to multi-targeted stakeholders at different levels and capacities;
- Ensure education programmes related to understanding EBM are a key component in long-term strategic planning;
- Adopt integrated coastal/ocean management approach by government and other stakeholders;
- Establish a legal requirement for governments to engage in meaningful public participation;
- Promote capacity development for public participation through education and awareness;
- Build and promote multilingual communication;
- Ensure cost of participating in decision-making processes does not generate an additional burden to stakeholders, particularly the disadvantaged poor and vulnerable such as some resource users and rural/coastal community members;
- Build capacity among stakeholders in how to effectively engage in the participatory process and recognise the value of trained facilitators.

Vision Element 3: Comprehensive, Coherent and Consistent Decision-Making

Key actions:

- Provide decision-makers with access to understandable interdisciplinary knowledge that includes scientific findings, traditional ecological knowledge (TEK), socio-economics and environmental law;
- Conduct stakeholder identification and analysis, and provide clear guidance on avenues of involvement;
- Implement transparent, documented decision-making processes;
- Provide and agree on clear understanding of each stakeholders' roles and responsibilities;
- Conduct regular monitoring and evaluation;
- Build human and institutional capacity;
- Impose adequate sanction for breaches of agreed-upon rules so as to serve as an effective deterrent;
- Establish models for multi-stakeholder collaboration that have legislative backing and adopts integrated coastal and ocean planning.

Vision Element 4: Coherent Adequate Legal Framework

Key actions:

- Expand law drafting capacity that recognises and reflects linkages between the social, economic and environmental pillars of sustainability;

- Evaluate, update, integrate and consolidate laws at regional and national levels;
- Use/develop the appropriate science needed to support the addressing of legal loopholes;
- Apply and enforce existing laws;
- Establish environmental public advocacy programmes;
- Harmonise law and policy in support of integrated marine planning;
- Incorporate sustainability in domestic laws;
- Introduce new models of compliance and enforcement based on social norms, incentives and alternative livelihoods, rather than only focusing on punitive measures;
- Conduct gap analysis of science needs and legal regulations;
- Design legal and regulation suite that matches EBM goals and principles;
- Review best practices of other regions;
- Conduct gap analysis – adoption and adaption of other models.

Vision Element 5: Individual Motivation for Stewardship

Key actions:
- Incorporate 'polluter pays' principle in environmental legislation;
- Conduct meaningful valuation of coastal and marine goods and services and link the outputs to education and awareness;
- Seek partnerships with other sectors in the assessment and management of risks, e.g., insurance, real estate involvement;
- Provide subsidies for conservation, tax concessions, green taxation;
- Expand environmental educational awareness in schools;
- Ensure secure property rights in land and marine resources;
- Ensure mechanisms in place for full public participation;
- Promote community based/co-management;
- Identify cultural values;
- Introduced free/subsidised education programmes.

Vision Element 6: Efficient Multi-Level Networks and Institutions

Key actions:
- Support use of available technology to improve communication through funding for more IT use – hardware, education, awareness;
- Build regional collaboration between and among initiatives that support EBM;
- Establish an international ocean governance network of academic and training programmes;
- Support data/information sharing through regional nodes;

- Use CLME Project as a platform to build networks and data/information sharing;
- Document success stories/case studies to provide support for multi-level collaboration;
- Create incentives for projects to share data;
- Collect and disseminate success stories on data/information sharing;
- Reduce redundancy through greater coherence between donors and technical agencies.

Vision Element 7: Enhanced Social Capital

Key actions:
- Implement community-directed job creation, retraining for example in enforcement, tourism;
- Establish community fora for information sharing;
- Establish programmes for sustainable enterprises (e.g., revolving funds mechanism);
- Provide education and awareness programmes on rights and opportunities;
- Legally require social equity and intergenerational equity;
- Enhance quality of education to show importance of social capital to economic well-being and ecological integrity;
- Provide and implement appropriate and feasible job-creation programmes;
- Legally require projects to conduct comprehensive social and environmental impact assessment;
- Adopt inter-sectoral planning;
- Require clear demonstration of social benefits from projects to be implemented;
- Promote diversification in goods and services and add value to them;
- Implement and adopt national sustainable development strategies;
- Develop and implement strategies for ensuring equity in distribution of wealth from resource exploitation;
- Mainstream gender issues in decision-making, policies and plans.

Conclusion

Although limited in terms of the length of time and fullness of members, the members of the Governance Working Group provided valuable insights and reached consensus in terms of the key elements and implementation actions needed to achieve a vision for EBM governance in the Caribbean. The output of this Working Group, in conjunction with those of the other three Working Groups discussed in Chapters 22, 23 and 24 provide an important starting point for all stakeholders in the region to move toward an ecosystem-based approach for regional decision-making.

26

Overall Synthesis and Future Directions for Marine EBM in the Wider Caribbean

Lucia Fanning, Robin Mahon and Patrick McConney

Introduction

This chapter provides an overall synthesis of the findings of the four working groups – Reef Fisheries Ecosystems, Pelagic Fisheries Ecosystems, Continental Shelf Fisheries Ecosystems, and Governance – on a shared vision and implementation of ecosystem-based management (EBM) in the Wider Caribbean. Drawing on the outputs from each of the working groups (Chapters 22-25), a combined vision and network of strategic directions was identified that was underpinned by a suite of agreed principles that would serve as a guide for decision-making. The fact that these were developed through group processes using methods that allowed all participants to make an input is an important aspect of these outputs. In this regard they are thought to reflect the combined inputs of the full range of expertise and experience that was present at the symposium.

Principles

The importance of placing principles at the forefront of discussions about EBM was emphasised throughout the symposium. It was noted that making these explicit will ensure that all who are working in EBM/EAF in the Caribbean will be working from a common set of principles, or at least have a reference set against which to compare their working principles. Table 26.1 presents the relationship of the top 10 principles identified by the symposium participants at the beginning of the process (Chapter 2) to the vision elements emerging from the visioning process carried out with the four working groups. What is clear from Table 26.1 is that all top 10 principles are integral to the visions that emerged. Thus achieving EBM will require careful checking and rechecking of principles to ensure that there is adherence to them and that there is a balance among them.

Table 26.1. Principles embodied in the group visions for marine EBM in the Wider Caribbean

Vision elements	Participation	Use of Science	Equity	Empower-ment	Sustain-ability	Precaution	Conservation	Account-ability	Adaptive-ness	Integration
Continental Shelf Ecosystem group										
Improved Quality of Life			✓	✓	✓					
Effective inclusive governance systems	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Restored and maintained ecosystem integrity		✓			✓	✓	✓		✓	✓
Effective institutional networks	✓	✓							✓	✓
Value ecosystem assets		✓	✓	✓	✓	✓	✓	✓		
An engaged public	✓	✓	✓	✓	✓				✓	✓
Offshore Pelagic Ecosystem group										
Inclusive and participatory collaborative management	✓	✓	✓	✓						✓
Equitable practical regionalism	✓		✓							✓
Healthy and productive social-ecological systems		✓	✓		✓	✓	✓		✓	
Effective, harmonized access and control	✓					✓	✓	✓		
Effective Coral Reef Ecosystem group										
Environmentally educated public		✓		✓			✓			
Quality information accessible to all	✓	✓		✓						
Serious politicians with a will to manage	✓			✓				✓		
Appropriate effective accountable governance	✓		✓	✓	✓	✓	✓	✓	✓	
Enforcement that works	✓			✓	✓			✓		
Stakeholders fully involved	✓	✓	✓	✓						
Healthy functional ecosystems		✓			✓		✓			✓
Only clean water to the sea		✓			✓		✓			✓

Vision elements	Participation	Use of Science	Equity	Empower-ment	Sustain-ability	Precaution	Conservation	Account-ability	Adaptive-ness	Integration
Secure & sustainable livelihoods	✓		✓	✓	✓		✓		✓	
Caribbean wide marine space use management	✓	✓				✓	✓			✓
Governance group										
Sustainable financing	✓	✓	✓	✓	✓			✓	✓	✓
Inclusive participation	✓		✓	✓		✓	✓	✓	✓	✓
Comprehensive coherent consistent decision-making	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Coherent adequate legal frame work	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Individual motivation for stewardship	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Efficient multi-level networks & institutions	✓	✓	✓	✓	✓		✓	✓	✓	✓
Enhanced social capital	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 26.2. Combined Vision for EBM/EAF for the Wider Caribbean Region. The vision elements from the separate working groups appear in the first four columns and are interpreted in the fifth column which can be read from top to bottom to give the overall vision

The elements that make up of our vision from the four groups				Our overall vision
Governance	**Reef ecosystems**	**Pelagic ecosystems**	**Continental shelf ecosystems**	
	• Only clean water to the sea • Healthy functional ecosystems	• Healthy and productive social-ecological systems	• Restored and maintained ecosystem integrity ➡	**Healthy marine ecosystems in the Wider Caribbean**
• Sustainable financing			• Value ecosystem assets ➡	**that are fully valued**
• Comprehensive coherent consistent decision-making • Coherent adequate legal frame work • Efficient multi-level networks & institutions	• Politicians serious about environment and with a will to manage • Appropriate effective accountable governance • Enforcement that works • Caribbean wide marine space use management	• Effective and responsible governance for ecosystem sustainability • Effective, harmonized access and control • Equitable practical regionalism	• Effective institutional networks ➡	**and protected through strong institutions at local national and regional levels providing effective governance**
• Inclusive participation	• Stakeholders fully involved • Quality information accessible to all	• Inclusive and participatory collaborative management	• Effective Inclusive governance systems ➡	**that involves everyone**
• Individual motivation for stewardship	Environmentally educated public		• An Engaged Public ➡	**is fully understood and supported by the public**
• Enhanced social capital	• Secure and sustainable livelihoods	• Secure, social and economic opportunities	• Improved quality of Life ➡	**and enhances livelihoods and human well being**

The Combined Vision

The vision elements for EBM/EAF for the Wider Caribbean from each of the four groups was combined into an overall vision, as illustrated in the final column of Table 26.2. By incorporating the essential elements from each group as reflected in the first four columns of the table, the agreed vision was identified as: "Healthy marine systems that are fully valued and protected through strong institutions at local national and regional levels providing effective governance that involves everyone, is fully understood and supported by the public and enhances livelihoods and human well-being."

Not surprising, the vision elements relating to healthy marine ecosystems were discussed principally by members of the three fisheries ecosystems working groups, while all four of the working groups emphasised elements relating to the need for strong institutions at multiple levels and the application of the principle of participation to facilitate effective governance. The need for enhancing public awareness was highlighted by the Governance, Reef Fisheries Ecosystems and Continental Shelf Ecosystems working groups while the Governance and Continental Shelf Ecosystems working groups specifically addressed the need for a valuation of the ecosystem goods and service and a mechanism for sustainable financing.

Achieving the Vision

The actions documented by the four groups in the World Café sessions and discussed at the workshop closing were further organised and synthesised by the workshop organisers to highlight the network of strategic directions that emerged from the symposium. The strategies were derived by noting keywords from each of the (some 260) action ideas and sub-ideas emerging from the groups (Chapters 22-25). The keywords were grouped into the 29 strategic directions shown in Table 26.3, where the number of dots indicates, in three levels, the frequency of occurrence of the strategic direction for each discussion group and overall. The most prominent strategies tended to occur across all four discussion groups. It is clear also from examining them that there are many linkages among them and at times progressions of strategies where some contribute to others.

The network diagram in Figure 26.1 displays some key relationships among the 29 strategic directions. The size of the font indicates the overall degree of prominence in the discussions according to the three levels in Table 26.3. The strategies have also been grouped to correspond to the key elements of the overall vision presented above.

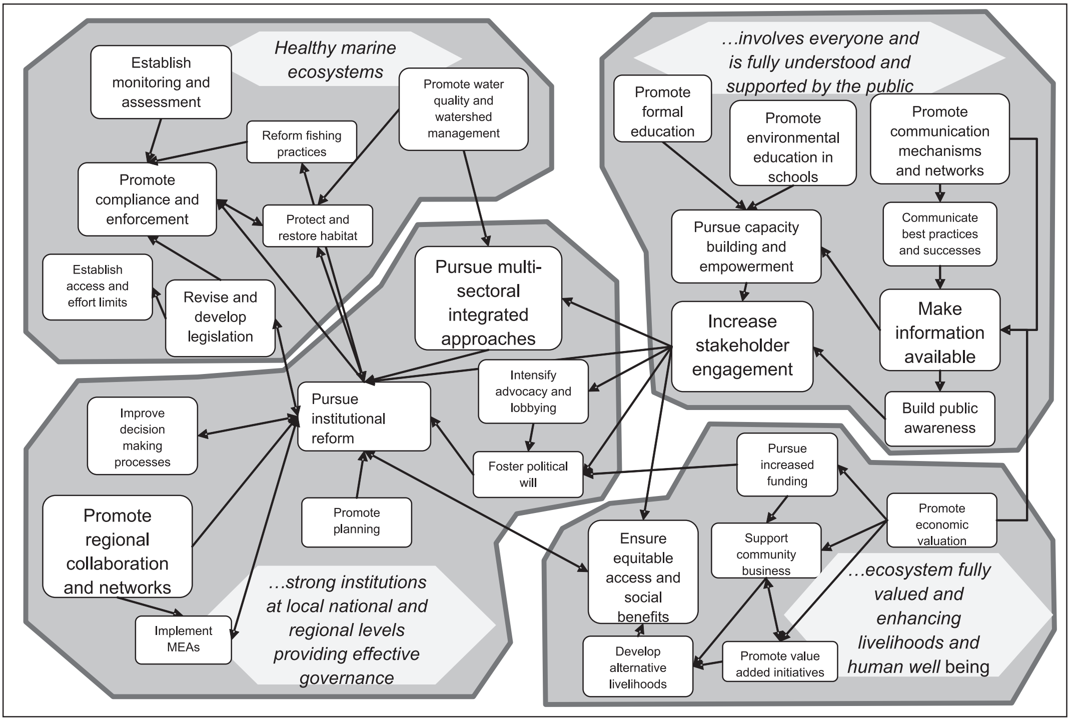
Table 26.3. Identified strategies for accomplishing the vision for marine EBM in the Wider Caribbean. (These are ordered according to the frequency with which they were featured in discussions, as represented by the number of dots assigned.)

Strategic component	Governance	Pelagic	Reef	Shelf	Overall
Increase stakeholder engagement	•••	•••	•••	•	•••
Promote regional collaboration and networks	••	•••	•	•	•••
Make information available	•••		•••	••	•••
Pursue multi-sectoral integrated approaches	•••	••	•••	••	•••
Establish monitoring and assessment	••	•	••	••	••
Build public awareness	••	••	••	•	••
Promote compliance and enforcement	••		•••	•	••
Pursue capacity building and empowerment	•	•	•••	•	••
Pursue institutional reform	••	•	•	••	••
Promote communication mechanisms and networks	•	••	•	•	••
Revise and develop legislation	•••	•	•		••
Ensure equitable access and social benefits	••	•	••	•	••
Promote environmental education in schools	••		••	•	••
Promote formal education	••	•	•	••	••
Improve decision making processes	•	•	••	•	•
Promote water quality and watershed management		•	••	•	•
Promote economic valuation	••		•	•	•
Pursue increased funding	••			•	•
Communicate best practices and successes	•	•	•	•	•
Intensify advocacy and lobbying	•	•	•	•	•
Promote planning	•	•		•	•
Implement MEAs		•	•	•	•
Reform fishing practices		••	•		•
Establish access and effort limits		•	•	•	•
Develop alternative livelihoods	•		•	•	•
Foster political will			••		•
Promote value added initiatives	•	•	•	•	•
Protect and restore habitat			•	•	•
Support community business	•		•	•	•

In the top left zone of the diagram are strategies relating to the vision of achieving healthy marine ecosystems. These include aspects of conventional fisheries management, showing that ideas for EBM in the Wider Caribbean are closely related and interwoven with ongoing efforts to improve fisheries governance. Here, also, we see the emerging emphasis on land-sea linkages that are critical for coastal ecosystem health.

In the top right zone of the diagram is a suite of strategies relating to formal education, training and empowerment of stakeholders. Here, also, are strategies relating to communication and networking leading to better

Figure 26.1. The Network of Strategic Directions that Emerged from the World Café Groups (font size indicates prominence in the discussions in three levels)



information and ultimately to an increase in stakeholder engagement. In the bottom right zone, economic valuation links to strategies that support alternative livelihoods as well as equitability in access to benefits.

At the bottom left and also extending into a central position are strategic directions that relate to improved institutions and governance through multi-sectoral approaches and other institutional reforms. These are both supported by and support many other strategies as indicated by two-way arrows. The strategic direction of improving regional cooperation stands out strongly and although it has few linkages, the reality is that most of the other strategic directions can be pursued at multiple levels including the regional level, which has emerged as a prominent feature (Chapters 18, 22, 23, 24 and 25).

The network that emerges in the above analysis is not comprehensive, as is to be expected, given the limited time available for discussion in the groups. However, it is believed to reflect the strategies that the symposium participants thought were most critical for moving towards marine EBM in the Caribbean. Most notable is the strong focus on the human aspects of EBM in its broader context where it approximates the EAF of the FAO. Stakeholder involvement, social justice, livelihoods, institutions and regional collaboration all appear to be the areas where most participants would focus attention in order to achieve marine EBM in the Caribbean. Some may be concerned about the relatively low emphasis on science at the LME scale and ecosystem research. This should not be taken to mean that they are not seen as important, but rather that the institutional and social aspects were at the fore in this particular gathering of diverse stakeholders.

Reflections on the Symposium

In this section we present some of the key themes that emerged from the final plenary discussion. There was a general sense that the process followed was useful and fostered a high degree of interaction that was valuable in addressing the needs and potential actions required to adopt and implement an ecosystem-based approach to the management of the Caribbean Sea. However, there was some degree of frustration expressed at not being able to move beyond the list of actions that was already well known to establishing priorities and setting the strategic direction needed to get to the root causes of the problems and to tackle these.

Insightful ideas that emerged from the process included a clear need to focus on issues of governance as a root cause of the challenges confronting EBM adoption in the region and in that regard, to strengthen efforts to provide advice to policymakers in a clear and consistent manner, incorporating knowledge from both stakeholders and scientists in the advice given. This focus on governance was reached despite the fact that the symposium commenced with presentations based on scientific findings, illustrating the point that it was not scientific information or a lack thereof that was of primary concern. It was also mentioned that while fisheries was an important sector in efforts aimed at EBM, an inter-sectoral approach that includes key marine sectors that impact the marine environment – particularly tourism, shipping, and oil and gas – should be included. Similarly, linkages to significant issues such as climate change and disaster mitigation and relief would ensure a comprehensive and coherent approach to these interrelated matters and establish closer ties with finance and development planning agencies in government.

A strong focus on the need to provide policymakers, stakeholders and the public at large with reliable economic data on the value of ecosystem goods and services also emerged as a new idea that could contribute significantly to building the case for EBM among decision-makers. On deciding on the means to move forward, participants suggested that the gathering of experts at the symposium represented a core group of knowledgeable, like-minded actors that had a responsibility to advance the progress achieved at the symposium. It was noted that the gathered experts had a degree of validity that could be instrumental in advancing EBM efforts to the forefront in the region, although it was acknowledged that they were not the only ones who should assume this responsibility.

Participants also focused attention on the need for a shared vision statement that could mobilise all sectors of society to pursue a shared goal, thereby facilitating the implementation of EBM in the region. It was suggested that lessons could be learned from others who have been successful in mobilising forces to achieve a common goal, including terrorist networks that operate separately but share a common belief and mantra to guide their independent actions, and successful businesses such as IBM, Nike and Xerox. It was agreed that the message from the symposium should: 1) build on what is common to all in the region, 2) be easily understood, 3) be identified with by all, and 4) be compelling. It needs to be repeated throughout the region and should engage the creative arts community. The message must resonate with fishers, politicians, tourists and the public equally and be visible across the region. While some attempts were made to suggest potential slogans, it was clear that crafting such a mantra would require more thought and professional assistance.

Future Direction and Next Steps

The Caribbean Regional Symposium entitled *Marine Ecosystem-Based Management in the Caribbean: An Essential Component of Principled Ocean Governance* provides an important milestone in the efforts of the countries of the Wider Caribbean to implement an ecosystem approach to managing the living marine resources of the region. As a key output of the symposium, this volume incorporates the thinking of leading experts within and beyond the region and provides decision-makers and all interested stakeholders with guidance on how to achieve the shared vision for marine EBM.

The timing and outputs of this important symposium were structured so as to directly contribute to the design and implementation of a number of key initiatives relating to the sustainable management of the Wider Caribbean Region. Two of the more important efforts for the region include the Caribbean Large Marine Ecosystem (CLME) Project and the development of the Caribbean Sea Commission, under the auspices of the Association of Caribbean States (ACS).

The activities of the CLME Project commenced in mid-2009 and have been endorsed by most of the twenty-six member countries of the Wider Caribbean. The goal of the project is "the sustainable management of the shared living marine resources of the Caribbean LME and Adjacent areas through an integrated management approach that will meet WSSD targets for sustainable fisheries". As such, having an understanding of the current status regarding EBM in the region and guidance on a way forward regarding implementation, based on an agreed suite of ocean governance principles, provides an important and valuable contribution for success.

The ACS has been pursuing the Caribbean Sea Initiative since 1998 through the promotion of the UN Resolution 'Towards the sustainable development of the Caribbean Sea for present and future generations' at the

UN General Assembly. An outcome of this process was the establishment of the Caribbean Sea Commission (CSC) in 2008 as a body to promote and oversee the sustainable use of the Caribbean Sea. Since its establishment, the CSC has been working towards developing an appropriate structure and arrangements for its work. This structure has been described and is now adopted by the CSC. The next steps are to operationalise these arrangements. This is envisaged as being initiated through a first phase of four years (2010-2014), with a focus on living marine resources of the Wider Caribbean, including their linkages with productive sectors such as fisheries and tourism, and with reference to the threats posed by climate change. As with the CLME project, the work of the CSC is aimed at sustainable regional ocean governance in the Wider Caribbean Region (ACS region) through the adoption of the multilevel LME governance framework.

The aim of the PROGOVNET symposium on marine EBM/EAF in the Caribbean was to produce a body of background work on EBM/EAF in various Caribbean situations and to synthesise these ideas under strategic headings that could provide guidance to the CLME Project, the Caribbean Sea Commission and other initiatives and their stakeholders in marine resource use with an interest in moving in this direction. We believe that this volume aptly demonstrates that the symposium met and exceeded its objectives.

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