BELIZE COASTAL ZONE MANAGEMENT AUTHORITY & INSTITUTE

STATE OF THE BELIZE COASTAL ZONE

2003 - 2013

COASTAL ZONE MANAGEMENT AUTHORITY & INSTITUTE

MINISTRY OF FORESTRY, FISHERIES & SUSTAINABLE DEVELOPMENT

NICOLE AUIL GOMEZ, EDITOR

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Foreword by Honourable Lisel Alamilla, Minister of Forestry, Fisheries, and Sustainable Development

The first "State of the Coast" Report was published in 1995 and the last in 2003. This year, 2014, we are once again happy to reflect upon the state of the coastal zone as we present the "State of the Belize Coastal Zone Report 2003-2013". This Report describes how various actors in the field of coastal zone management have impacted upon the management of coastal resources in Belize.

The information provided in this Report represents the research outcomes and expert views held by a cross section of Belizeans researchers and their international counterparts residing or working in Belize. It represents an astonishing amount of work done by those persons who are dedicated to the process of guiding development within the coastal zone, in recognition of the relevance and importance of the coast to the lifestyle and livelihood of the people of Belize. Recognizing that engaging, coordinating and delivering information is critical to managing the coastal zone and the resources contained therein, 26 papers, representing the work of at least 34 research scientists/investigators, are presented. Topics center around six thematic areas, which I note strongly illustrates the challenges faced in coastal zone management, and particularly, that it requires multiple inputs from various scientific disciplines. The Ministry of Forestry, Fisheries, and Sustainable Development is very much aware of the efforts expended in this exercise as it is cognizant that policy options and management strategies formulated within the framework of coastal zone management must be founded on information on the ecosystems, the people within the communities using the resources and the established capacity of the environment to assimilate the changes. The publication of a report such as this, which generates the types of information needed, goes a long way towards the development of management strategies and policy options. Options and interventions which the Ministry seeks to apply in its effort to provide long lasting solutions to the complex issue of sustainably developing the coastal zone.

Finally, the Ministry is grateful to all those who were involved. The papers are well written and well presented. Stakeholder participation in the discussions and recommendations coming from them are practical and very robust. Special appreciation is given to the Staff of the Coastal Zone Authority and Institute for producing the Report. The Ministry is also appreciates the contributions of the Oak Foundation, Protected Areas Conservation Trust (PACT) and the Environmental Management Fund in financing various aspects of the Report.

The Ministry encourages you to look at the full report and to stay involved in the process through dialogue with the Coastal Zone Authority via their web site at www.coastalzonebelize.org or on their Facebook page.

Foreword by Mr. Vincent Gillett, CEO, CZMAI

In 1995, the Coastal Zone Management Project produced the first "State of the Coast" Report. The idea then, was to present to the Government and people of Belize a document which summarized the state of knowledge about the country's coastal resources and the threats posed to them by current usage and management efforts. That initial report was very comprehensive and hugely successful. So much so that the exercise was repeated by the newly formed Coastal Zone Management Authority and Institute (CZMAI) in 1999, 2000, 2001/2002 and 2003. This year, as part of the process of continuing to improve our population's understanding of the important contributions that the coastal zone makes to the environmental, economic, political, social and cultural fabric of the Nation of Belize and, perhaps more importantly, how human survival is linked to it, we present the "State of the Belize Coastal Zone" Report 2003-2013.

The 2003-2013 report presents the best parts of presentations made at a forum called the "State of the Coastal Zone Summit" held on June 7th 2012. The suggestion to hold the summit was proposed and organized by the former Director of the Coastal Zone Management Institute, Mr. Colin Gillett. All the papers presented at the Summit were prepared and delivered by Belizean experts or their contemporaries working in Belize. Over the course of the event, 26 presentations were made and 34 articles are actually published in this Report. As should be noted, this Report also covers those intervening years during which annual reports were not published.

In the context of our responsibility to actively support the allocation, sustainable use and planned development of our coastal resources, the State of the Belize Coastal Zone Report 2003 -2013 offers credible information which can inform on the issues of sustainable use of coastal resources. While this effort is commendable, the CZMAI recognizes that there is much more that can be done and that much more detailed studies should be done. But, as I have expressly articulated on several occasions, full recognition of the importance of creating a sustainable financing mechanism for the Authority would most certainly contribute to a continuing annual state of the coast report and consequently, the long term sustainability of our coastal resources.

This edition of the State of the Belize Coastal Zone 2003-2013 Report is the latest in the series to be produced by the Coastal Zone Management Authority and Institute. We believe that it contains very relevant information including the recurring demand and support for the preparation of a plan for coastal development and clarity in understanding the many terrestrial activities that have influence on the coastal zone. We encourage you to use the Report to get a sense of what state the coast is in. We also encourage you to freely send prescriptions and recommendations for improvements to us here at the Coastal Zone Management Authority and Institute so that we can have better outcomes from our management efforts.

Acknowledgements

The State of the Belize Coastal Zone Report 2003-2013 could not have been published without the thirty-four dedicated authors who took time from their busy schedules to write an essay on their work, following the guidelines for this Report.

These contributors are listed below.

Special acknowledgement to those who met the original December 2011 deadline: Faustino Chi & Fred Short, Ed Boles, and Steven Platt & Thomas Rainwater. Also, particular thanks to Tanya Williams, Patrick Gallagher and Jan Meerman, who provided papers at later requests.

Sincerest thanks to Judy Lumb, Jan Meerman, Janet Gibson, and John McGill who kindly critiqued this document in its entirety, prior to publication. Your suggestions most certainly augmented the Report.

Thanks also to all the CZMAI staff that helped in various ways towards the Report. CEO Vincent Gillett, Director Chantalle Clarke, and former CZMAI Director Colin Gillett. Monique Goldson and Maritza Canto who captured recommendations from the Summit. and Yamira Novelo who assisted with finalizing the document.

The artistic cover was produced by Samir Rosado.

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Contributors

Name	Affiliation	Email
Michael Arana	BTB	marana@travelbelize.org
Yvette Alonzo	APAMO[1]	yalonzo02@gmail.com
Nicole Auil Gomez, M.Sc.	SEA	nauilgomez@gmail.com
James Azueta	Fisheries Dept.	jamesazueta_bz@yahoo.com
Ed Boles, Ph.D.	New Mexico State University	bzboles@yahoo.com
Nadia Bood, M.Sc.	WWF	nbood@wwfca.org
Emil Cherrington, M.Sc.	CATHALAC	emil.cherrington@cathalac.org
Faustino Chi, Ph.D.	University of New Hampshire	tinochi@yahoo.com
Chantalle Clarke, M.E.M.	CZMAI	directorczmai@gmail.com
Robin Coleman, Ph.D.	WCS	rcoleman@wcs.org
Noreen Fairweather	NEMO	nemocoordinator@nemo.org.bz
Carlos Fuller, M.Sc.	CCCCC	cfuller@btl.net
Patrick Gallagher	Stanford University	pmg70@stanford.edu
Dennis Gonguez	Meteorological Dept.	dgonguez@hydromet.gov.bz
Candy Gonzalez, J.D.	BELPO	candybz@gmail.com
Mauro Gongora, M.Sc.	Fisheries Dept.	megongora@gmail.com
Ann Gordon	CCCCC	anngordon56@hotmail.com
Rachel T. Graham, Ph.D.	MarAlliance	rachel@maralliance.org
Lee Jones, Ph.D.	Consultant	lee_jones@att.net
Losita Lee	Consultant	lositalee@yahoo.com
Anthony Mai, MBA	DOE	antcayo@yahoo.com
Isaias Majil	Fisheries Dept.	isaiasmajil@yahoo.com
Melanie McField, Ph.D.	HRI	mcfield@healthyreefs.org
Jan Meerman	Belize Tropical Forest Studies	meerman@biological-diversity.info
George Myvett, M.Sc.	Fisheries Dept.	georgemyvett@yahoo.com
Steven G. Platt, Ph.D.	WCS	sgplatt@gmail.com
Roberto Pott, M.Sc.	HRI	pott@healthyreefs.org
Rigoberto Quintana	Fisheries Dept.	bertoquintana@gmail.com
Thomas R. Rainwater, Ph.D.	Medical University of South Carolina	trrainwater@gmail.com
Leandra Cho-Ricketts, Ph.D.	UB/ERI	lricketts@ub.edu.bz
Fred Short, Ph.D.	SeagrassNet, Washington Department of Natural Resources	fredtshort@gmail.com
Timothy Smith, M.Sc.	Brooksmith Consulting	t_brooksmith@hotmail.com
Armeid Thompson, M.Sc.	BTB	athompson@travelbelize.org
Tanya Williams, M.Sc.	Belize Coalition to Save Our Natural Heritage	coalitioncoordinator@belizecoalition.org

[1]Currently at Selva Maya Programme, GIZ, the German Society for International Cooperation

Abbreviations

APAMO	Association of Protected Areas Management Organizations
BAS	Belize Audubon Society
BAHA	Belize Agricultural Health Authority
BBR	Belize Barrier Reef
BELPO	Belize Institute for Environmental Law
BFCA	Belize Fishermen Co-operative Association
BFF	Belize Fishermen Federation
BTB	Belize Tourism Board
CATHALAC	Water Center for the Humid Tropics of Latin America and The Caribbean
CBO	Community Based Organization
CCCCC	Caribbean Community Climate Change Centre
CDB	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CZMAI	Coastal Zone Management Authority & Institute
CZMP	Coastal Zone Management Project (UNDP/GEF)
DOE	Department of the Environment
EIA	Environmental Impact Assessment
FoSC	Friends of Swallow Caye
FAO	Food and Agriculture Organization
GOB	Government of Belize
GPWSCMC	Gales Point Wildlife Sanctuary Community Management Committee
HRI	Healthy Reefs Initiative
ICZM	Integrated Coastal Zone Management
IMO	International Maritime Organisation
IUCN	International Union for the Conservation of Nature and Natural Resources
MARPOL	International Convention for the Prevention of Pollution from Ships
MFFSD	Ministry of Forestry, Fisheries and Sustainable Development
MPA	Marine Protected Area
NEMO	National Emergency Management Organization
NGO	Non-governmental Organization
OS	Oceanic Society
OSPESCA	Organization of Fisheries and Aquaculture in Central America
Ramsar	Convention on Wetlands of International Importance
S2SA	Sea to Shore Alliance
SACD	Sarteneja Alliance for Conservation and Development
SEA	Southern Environmental Association
SOLAS	International Convention for the Safety of Life at Sea
TIDE	Toledo Institute for Development and Environment
TNC	The Nature Conservancy
UB / ERI	University of Belize / Environmental Research Institute
WCS	Wildlife Conservation Society
WS	Wildlife Sanctuary
WWF	World Wildlife Fund

Introduction

The coastal zone encompasses the full extent of the area ranging from the open sea to the beaches and into the watersheds, and the diverse flora and flora that thrive in these systems, including *Homo sapiens*. There are many species, ecosystems, user groups, and economic, social and cultural interests in the coastal zone. Research and management therefore requires transdisciplinarity. It is with this in mind that The State of the Belize Coastal Zone Report 2003-2013 has been produced with input from a range of sectors.

The goal of this Report is to provide an update on the many activities, management roles, natural systems, and threats within the coastal zone of Belize. As the last Report dealt with activities in 2002 (Coastal Zone Management Authority and Institute 2003), this Report encompasses statistics from 2003 to 2013. Included are not only programs carried out by Coastal Zone Management Authority and Institute (CZMAI), but representatives of the disciplines that make up coastal zone subject matters, including protected areas, legislation, advocacy, and climate change.

This Report is a compilation of papers from experts in their respective disciplines. Each section was written as an independent report that includes a brief description of the topic, showing trends, detailing concerns and gaps, and concluding with tangible recommendations to improve the sector.

On June 7th and 8th CZMAI held the Coastal Zone Summit 2012. This was the second coastal forum hosted by CZMAI – in 2003, CZMAI held a National Coastal Symposium. The goal of the Summit was to publicly present the body of works that make up this Report. The presentations gave an overview of management, research, and policy related to various facets of the coastal zone. Special guest speaker, Honourable Lisel Alamilla, Minister of Forestry, Fisheries and Sustainable Development opened with support for integrated coastal zone management (ICZM), as long as it includes three pillars: Social Development, Economic Development, and Environmental Sustainability. This summation illustrates the challenge of coastal zone management, and emphasizes that it is an overarching discipline.

The Summit attendees made recommendations that supplemented the presentations and complement the essays in this document. The predominant message from the participants was the need to integrate climate change considerations and adaptation measures in coastal zone management actions, and in the ICZM Plan. Watersheds and littoral forests have been overlooked critical habitats in management and research activities. And development activities need a better system of evaluation, vetting, and monitoring.

The most pertinent recommendations are as follows[1]:

[1] The Summit 2012 presentations and recommendations can be found on the CZMAI website: www.coastalzonebelize.org

1. **Shift away from the strong focus on site management toward policy strengthening for the various sectors, e.g. coastal zone management, tourism management, fisheries management.**

2. **CZMAI should be mandated to not only coordinate the sustainable use of resources but also to regulate activities that occur within the coastal zone. Perhaps, CZMAI should be a permitting agency.**

3. **Prioritize the evaluation of cumulative development impacts - a comprehensive zoning scheme should allow for the assessment of cumulative impacts.**

4. **The ICZM Plan should address development in and the improved management of World Heritage Sites. Guidelines should be definitive for easy use by MPA managing committees.**

5. **Improve MPA management, from both the co-management (transparency) and government (overall support).**

6. **Complete a comprehensive Climate Change Policy; develop adaptation methods and recognize resiliency in systems.**

7. **Change the current government land distribution policy; haphazard leasing/sales of public land are potentially the biggest threat to the coast and marine areas.**

8. **Work towards determining the national populations of target fisheries species, to then afford comprehensive management for this commodity.**

The papers in this report bring forward recurring suggestions or themes, including the demand for a sustainable plan for coastal development, which is underway by CZMAI. There is a need to increase public involvement and awareness, strengthen collaborations, update laws, and improve management by regulating agencies. Also discussed is the effect of inland and/or upland activities on the coastal zone. Fires, alterations to hydrological features, agriculture actions and forest clearance all translate to changes in the system down the road or river to the coast. These are not understood, let alone studied. One paper looks at the terrestrial influence on the coastal zone, and recommends that special attention be given to critical areas, such as the Belize River watershed. While Belize's coastal zone is defined as extending to the limits of the territorial sea, this report does not include discussion on deep sea resources or threats, which are mostly unknown at this time.

Belize relies greatly on the resources from the coastal zone for economic benefit, primarily through the tourism and fisheries sectors. A sound understanding and management of these industries as commercial commodities, including resource stocks, pressures, controlling factors, and trends, are paramount to attaining long-term sustainability. Identifying existing research data, enhancing knowledge, and utilizing these to make informed decisions with stakeholder input, are the starting elements for success in integrated coastal zone management. It is hoped that this Report provides everyone with enough information to start asking more questions, getting involved, and championing Belize's resources.

The Report is an example of the Coastal Zone Management Authority & Institute fulfilling its mission and serving its constituencies. Coastal Zone's mission is to support the allocation, sustainable use and planned development of Belize's coastal resources through increased knowledge and the building of alliances for the benefit of all Belizeans and the global community.

Integrated Coastal Zone Management Plan

An integrated approach to Coastal Zone Management is needed for successful continuation of the use and enjoyment of an array of Belize's valued natural resources.

The Integrated Coastal Zone Management Plan for Belize will provide a straightforward blueprint for development activities, within nine coastal planning regions. Once endorsed by the CZMAI Board, the Executive (Cabinet) can formally adopt the Plan. The Plan will be the tool for all Government Departments to utilize, helping to ensure sustainable development of the coastal zone, benefiting Belizeans.

This Plan will serve as a global example of the advantage of foresight, to the extent which research, modeling and extensive consultations can produce.

A National Integrated Coastal Zone Management Plan for Belize: Creating a Blueprint for Sustainable Coastal Resources Use

Chantalle Clarke

Introduction

The coastal zone is one of Belize's greatest assets. Its complex and dynamic marine ecosystems support innumerable ecological processes and a vast array of marine life and habitats. In addition to these important ecosystem functions, the coastal zone is vital to the Belizean way of life. The highly productive coastal zone is the resource base for a broad range of economic activities. In fact, approximately 30% of Belize's gross domestic product is directly linked to commercial activities within the coastal zone (Cho 2005). The coastal zone has important social and cultural values to the Belizean people, especially to the approximately 40% of the population that reside on the coast and in offshore areas (Statistical Institute of Belize 2010).

Over the past decades, rapid economic development and population growth have taken place within the coastal zone and inland areas of Belize. These occurrences have led to increasing pressures on coastal and marine resources, with implications to the livelihoods of those that depend upon them. These anthropogenic threats stem from various developmental activities associated with tourism and recreational facilities, population growth and expansion, utility supply, dredging and minerals extraction, land clearance, pollution, waste disposal, fisheries and aquaculture. These threats are compounded by natural hazards, global warming and sea level rise, and the vulnerability of sensitive ecological systems to climate change. Thus, it is imperative now, more than ever, to ensure that the coastal zone is utilized in a manner that will continue to support important ecological functions, as well as social, cultural and economic prosperity for current and future generations.

ICZM as an Approach for Sustainable Resources Use

Many countries, including Belize, have recognized the deficiencies of sectoral planning for coastal zone management and have identified the need for a national cooperative approach for achieving ecologically-sustainable development. The need for an integrated approach to optimally manage Belize's coastal resources was made resoundingly clear at a historic meeting in 1989 when a wide cross-section of stakeholders from various sectors, including scientists, marine managers, private sector, and coastal communities converged in San Pedro, Ambergris Caye (Gibson 1989). The approach identified was integrated coastal zone management (ICZM) - an approach that brings together all decision-making agencies to resolve issues so as to ensure integration among their existing policies and plans to ultimately maintain, restore and improve the quality of coastal ecosystems and the communities they support (East Riding of Yorkshire Council 2002). The integrated approach also recognizes that many different players (i.e. government agencies, non-governmental organizations, industry, business, private sector, community groups, and Indigenous

communities) can make a difference in the long-term management of the coastal zone and aims to gain commitment from these key players to a common vision. The lead in promoting the integrated approach to coastal area management has come from the European Union, the outcome of which has informed plans such as the East Riding ICZM Plan (East Riding of Yorkshire Council 2002). The small-island developing state of St. Lucia is among one of few countries in the Wider Caribbean region that developed and implemented a functional ICZM Plan (UNEP 2012). Costa Rica was the first developing country in Central America to take the lead in ICZM approaches when its program was established in 1977 (Isager 2008). Belize also began the process of preparing an ICZM Plan by way of The National Integrated Coastal Zone Management Strategy for Belize produced by the Coastal Zone Management Authority and Institute (CZMAI 2003). The Strategy was the first step of the ICZM Plan; "*it provides the framework to guide development and future investment, while ensuring the protection of important natural habitats and existing human uses of coastal resources*"[1].

Institutional Arrangements for ICZM in Belize

In 1990, based on recommendations from the historic Ambergris Caye meeting, a small Coastal Zone Management Unit was set up within the Fisheries Department to take a multi-sectoral management approach to coastal resources management. A Technical Committee was formed, and the need for expansion to truly carry out the functions of integrated coastal zone management became clear. Subsequently in 1993, the United Nations Development Programme / Global Environmental Facility (UNDP/GEF) supported the creation of the Coastal Zone Management Project for Belize. The Project focused on data acquisition, management, and coastal planning through several program areas. Almost a decade after the Ambergris Caye meeting, Belize enacted the Coastal Zone Management Act (hereinafter referred to as the Act), the main function of which is to promote the sustainable development of coastal areas through coordination of existing legislation affecting coastal resources, and through building capacity and increased public participation to manage coastal resources. Through this visionary legislation (SI 52 of 1998), the Coastal Zone Management Authority and Institute (CZMAI) was created as the focal agency with responsibility for coordinating programs and activities related to integrated coastal zone management. Central to the mandate of the CZMAI, under the Act, is the preparation of a comprehensive coastal zone management plan. CZMAI established a coastal planning program as a strategy to ensure the attainment of its mandate.

Coastal Planning Initiatives

The National Integrated Coastal Zone Management Strategy (CZMAI 2003) outlined a clear-cut strategy for improving the management of Belize's coastal area. The Strategy, which underwent extensive public consultation, was endorsed by the House of Representatives and adopted as a national policy document in 2003. In addition, using the framework of the Cayes Development Policy (CZMAI 2001), CZMAI prepared development guidelines for the country's more than 300 cayes, including the three atolls by 2004. The development of both the national ICZM strategy and site-specific development guidelines for the cayes were the preparatory phases for the

[1] http://www.coastalzonebelize.org/?page_id=68

development of the ICZM Plan. However, as a result of considerable scaling back of financial resources in 2005, the CZMAI had to limit its activities and the substantial coastal area planning activities embarked upon pre-2005 were effectively abandoned. With the reinstitution of the CZMAI in 2008, and later the coastal planning program in 2010, the planning activities resumed, the main goal of which is to formulate the ICZM Plan.

It is noteworthy to mention that during the inactive years of CZMAI's coastal planning program, a key planning initiative was endorsed by Cabinet - the National Protected Areas Policy and Systems Plan (NPAPSP). The NPAPSP is a "*coherent approach to protected area establishment and management on a national scale that meets all obligations under international agreements to which Belize is a signatory*" (Meerman & Wilson 2005).

Other recent Government-commissioned national planning initiatives with implications for improved resource management include the National Sustainable Tourism Master Plan (BTB 2011), the National Land Use Policy and Integrated Planning Framework (Meerman et al. 2011), and the Horizon 2030 National Development Planning Framework (Barnett et al. 2012). The Sustainable Tourism Master Plan has been endorsed by the Cabinet.

Creating an Informed ICZM Plan

The National Integrated Coastal Zone Management Plan is a planning framework that calls for national action to facilitate the improved management of coastal and marine resources, so as to maintain their integrity while ensuring the delivery of ecosystem service benefits in perpetuity for present and future generations of Belizeans and the global community.

The process for the preparation of the plan is broadly defined in Section 23(2) of the Act (Coastal Zone Management Act, Laws of Belize, Revised Edition, 2000). The process outlines clear steps in respect of plan preparation, approval, implementation monitoring and revision. The planning process itself is intended to be continuous. The revision, as mandated by the Act, allows for the evaluation of the effectiveness of the proposed measures, and for adjustments and additions to be made every 4 years as new information, approaches and ideas come to light.

The pre-2005 activities undertaken by the then CZMAI coastal planning program represented pioneer work in coastal planning and management for the country. However, these activities were not without their limitations. For instance, the Cayes Development Guidelines (CZMAI 2004) focused primarily on land-use zoning of the cayes and did not integrate planning and management across the land-sea interface. This limitation has now been flagged by the CZMAI as an important gap that will be addressed in the formulation of the ICZM Plan.

Approaches

The approach taken by the CZMAI for the development of the national ICZM plan involved five key steps: literature review, data acquisition, stakeholder engagement, ecosystem assessments and marine spatial planning:

(i) Literature Review

A comprehensive review was undertaken of existing and relevant planning documents, in particular, planning legislation, initiatives and model ICZM plans with applicability to the Belizean context.

(ii) Data Acquisition

Significant research was undertaken to acquire information on the coastal zone and to create a data base to manage data, in addition to data layers for use in a geographic information system (GIS). CZMAI collaborated with several partner agencies, both nationally and internationally, to collect physiographic, oceanographic, climatological, biological, infrastructural, geopolitical, economic, cultural and social data related to the coastal and marine area of Belize.

(iii) Stakeholder Engagement

Throughout all the approaches, stakeholder participation has been critical, especially for the data acquisition, ecosystem assessments and marine spatial planning processes. Stakeholder consultations were held countrywide at strategic locations during the planning phase. These consultations included community level group meetings, interviews (face to face and telephone) with local experts in coastal zone management and key partners at the United States-based Natural Capital Project. These consultations have been crucial for identifying existing conflicts of interest in respect of resources use, and the vision of stakeholders as it pertains to maintaining a healthy coastal and marine environment that will continue to support livelihoods in the future.

To this extent, CZMAI has:

- Reformed 5 of 8 CACs
- Established working relationship with advisory committees in other 3 regions
- Hosted over 30 meetings in 9 planning regions
- Completed 2 rounds of stakeholder consultations

(iv) Ecosystem Assessment

The creation of a coastal and marine zoning scheme, which essentially spells out the recommended strategy for sustainable resource use over time, was informed as far as possible by the ecosystem approach within the limits of the best available information. Marine InVEST, a cutting-edge ecosystem assessment tool developed by the US-based Natural Capital Project, was employed to assess the impact of a variety of human activities that stress critical habitats (mangrove, coral and sea grass) and the consequential impacts on the delivery of ecosystem service benefits, such as coastal protection, fisheries and tourism opportunities (Fig. 1). The results of these assessments form the scientific foundation for the decision-making process. Based on the analyses of current and anticipated uses of the coastal and marine environment and using the outcomes from ecosystem risk assessments, a coastal and marine spatial plan was developed.

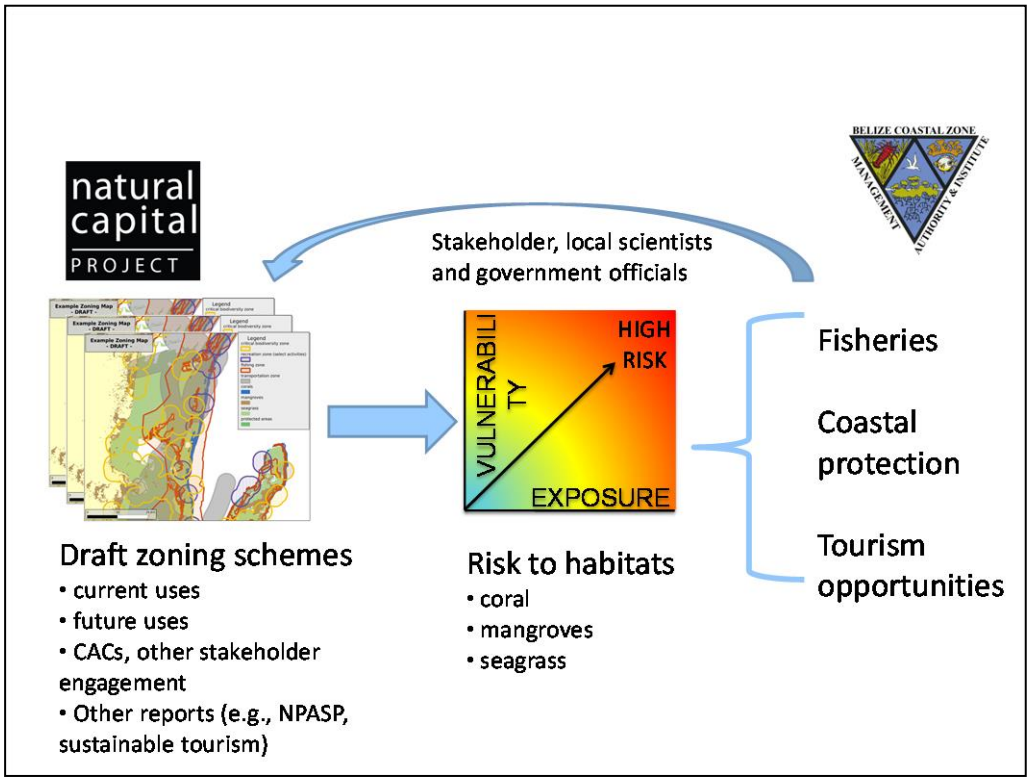

Figure 1. Modelling and valuation of ecosystem services

(v) Marine Spatial Planning

The marine spatial planning provided a process by which to identify areas most suitable for specific activities in an effort to reduce user conflicts and impacts, to preserve critical ecosystems and to guide the sustainable use of ecosystem services. The process, which can be replicated, included several iterative steps (Fig. 2).

Figure 2. Iterative coastal zone planning process.

Plan Structure

The ICZM Plan document is divided into two volumes. The first volume is strategic in nature and as such, contains very broad strategic narratives. It essentially highlights areas where a national, collaborative approach for management is not only better than sectoral planning but is actually required as in the case of addressing the issue of "coastal urbanization" and climate change adaptation strategies for coastal communities.

The ICZM framework is essentially laid out in Volume I (Fig. 3). It is intended to: (1) focus management activities that are already being undertaken to ensure these are integrated, and (2) highlight additional activities and actions that could be undertaken to help meet the challenge of ensuring a sustainable future for the coastal zone where healthy ecosystems support and are supported by thriving local communities and a vibrant economy.

On the other hand, Volume 2 of the Plan document is prescriptive and contains area-specific guidance for each of the nine coastal planning regions (Fig. 4). The guidance will be accompanied by a spatially explicit coastal and marine zoning scheme.

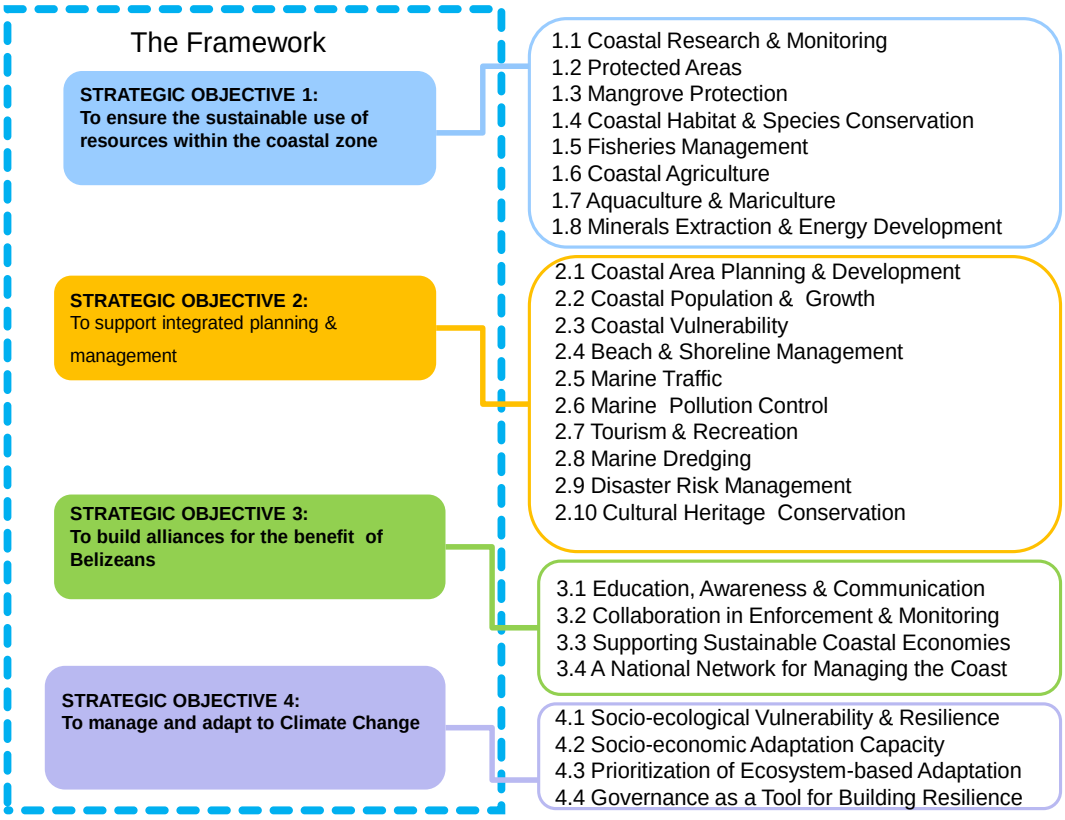

Figure 3. Planning framework for National ICZM Plan for Belize

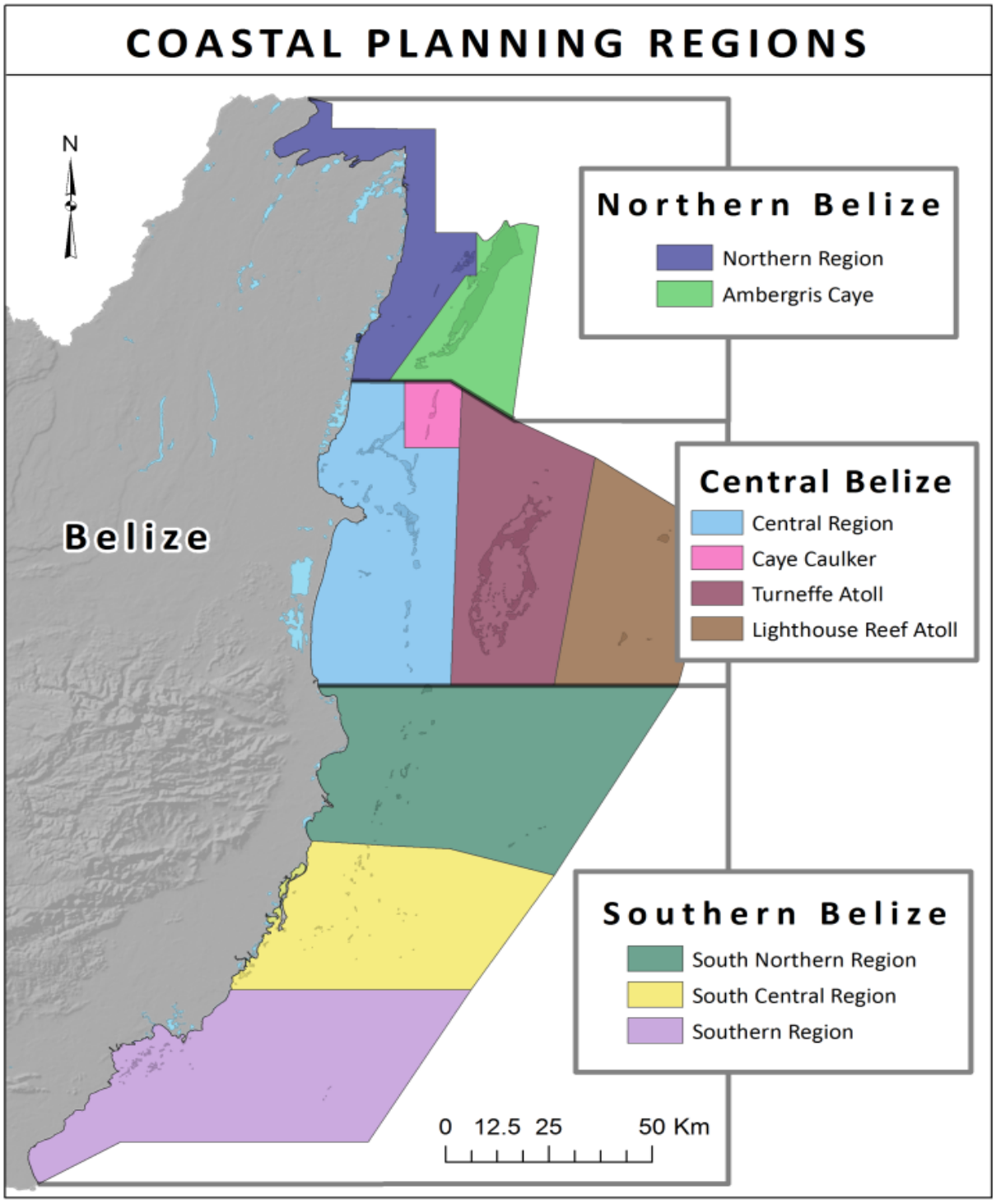

Figure 4. Coastal planning regions of Belize

Anticipated Outcomes

The integrated coastal zone management process will not end with the adoption of the Plan. It is anticipated that adoption of this plan will signal a continuous process by which decision making will remain open to involvement at all levels, and the work of all organizations with various jurisdictions over activities within the coastal zone will be integrated. Through the management framework laid out in the Plan, overall resource management within the coastal zone will be significantly improved. Furthermore, it is expected that the effectiveness of this plan to meet sustainable development objectives with respect to the coastal resources base will be measured and that key organizations charged with the implementing actions in the Plan will be held accountable. Stakeholder groups, such as coastal advisory committees, can provide the means for this public accountability.

Limitations

In preparing the first ever National ICZM Plan for Belize, the main factor that served as a limitation to the planning process was data availability and accessibility. Since CZMAI currently does not have the capacity to conduct primary research, it used older CZMAI datasets, relied heavily on the use of primary data collected by its partners, and in some instances secondary data collected by others. Complete data sets were not always readily available, such as climatological and oceanographic data for the country. In instances where Belize-specific data were unavailable, data were used from regions bearing similarity to Belize.

Recommendations

1. The successful implementation of the initial phase of the national integrated coastal zone management program hinges on the demonstrated commitment towards the vision of a sustainable coast by key partner organizations charged with the implementing actions in the Plan and as well as the general populace. Even though the Act recommends that the Plan be updated every four years, the review process could benefit from the production of annual progress reports to monitor and evaluate the effectiveness of the implementation actions. This report should ideally be completed in collaboration with the implementing organizations.

2. In order to aid dialogue and to strengthen inter-agency and public relationships, the CZMAI should ensure that meetings of the Coastal Zone Management Advisory Council (CZMAC) and regional Coastal Advisory Committees are (CACs) held on a regular basis. These meetings should facilitate discussions on the lessons learned from management activities subsequent to Plan effectuation so that they can inform the next phase of management.

3. The Coastal Zone Management Act, while it is visionary, was passed in 1998. Since the fourteen years it was enacted, the needs and circumstances of coastal area management and planning have definitely changed. Thus, the Act as it currently stands has inherent structural weaknesses in respect of enabling certain institutional arrangements to fully support an effective integrated coastal area management program. Within the four years immediately following the Plan effectuation, the Act should be amended to assure adequate implementation of the Plan.

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State of the Belize Coastal Zone

In the Coastal Zone Management Act, the coastal zone "includes the area bounded by the shoreline up to the mean highwater-mark on its landward side and by the outer limit of the territorial sea on its seaward side, including all coastal waters."

This "State of the Coast" section is an overview of the coastal zone ecosystems, from the habitats to the biota within them. Two sub-sections outline Habitats of concern and Species of concern. Also included are discussions on the effectiveness of the Marine Protected Areas network, from the point of view of both government and private managers.

Habitat

Habitats of the coastal zone include inland and offshore systems, which have degrees of interconnection. The functions and benefits of each habitat system are discussed, as well as research activities, management effectiveness and the health of the habitats. Recommendations are given to help improve their management.

This section presents papers on Coral Reefs, including the threat of Coral Bleaching, Coastal Mangroves, Seagrasses, and Watersheds, Estuaries & Wetlands.

Coral Reefs

Melanie McField and Roberto Pott

Introduction

Belize is well known for having the longest barrier reef in the western hemisphere. The barrier reef extends for approximately 250 km along the edge of the continental shelf and lies 13 to 48 km off the mainland coast. In addition, there are three off-shelf atolls, unusual inner-shelf rhomboid shoals, numerous patch and fringing reefs, extensive mangrove forests, sea grass beds and estuarine systems, and over 1000 islands or cayes (McField et al. 1996). The Belize barrier reef complex covers 1,400 km^2 and is the backbone of the Mesoamerican Barrier Reef Ecosystem. It includes seven sites declared as the Belize Barrier Reef Reserve World Heritage Sites by UNESCO. The reef complex entails a complex mosaic of reef zones, influenced by several important physical and ecological factors. Water movement, nutrients, light, sedimentation and predation are all key factors affecting this zonation. The atolls significantly modify waves approaching from the east creating a heterogeneous energy environment throughout the barrier reef and atolls. The predominant surface current inside the barrier reef is southerly, while east of the atolls the main oceanic circulation is to the north. However the circulation within the Gulf of Honduras is more complex, with influences by the counter-clockwise surface gyre between Roatán (Honduras) and Glovers Atoll (Heyman and Kjerfve 1999). The northerly Yucatan Current is a continuation of the currents moving west from Venezuela and ultimately from the Guiana Current that flows to the northwest from Brazil. These oceanic waters occasionally enter the Gulf of Honduras from the Caribbean further affecting the complex hydrology in this region.

Value of Belize's Coral Reefs

Belize's coral reef is a magnificent and valuable resource, internationally recognized for its biodiversity and beauty, while at home it is a critical feature of the national economy, food security, and cultural traditions. The reef also provides critical "ecosystem services" that include: providing a habitat for commercially valuable fish, offering opportunities for recreation and tourism, and providing protection from coastal erosion and hurricanes. The biodiversity of the reef has yet to be fully explored. While most of the 500 odd fish species found in Belize are also found in the wider Caribbean, Lobel and Lobel (2011) provide a preliminary estimate of at least 12 endemic fishes found only in the lagoonal area and another 8 species found on the outer barrier reef and the atolls. This diversity of species also harbours a vast treasure trove of potential medicinal compounds and provides an endless source of inspiration.

In 2008, the World Resources Institute completed an economic valuation of Belize's coral reef and mangroves, based on the value of reef- and mangrove-related fisheries, tourism, and shoreline protection services. The total annual value was estimated to be US$395–$559 million per year. Mangroves provide an estimated US$174–$249 million of this total, some independently, and some

through their supporting role for nearby coral reefs. As a reference point, Belize's Gross Domestic Product totalled US$1.3 billion in 2007(Cooper et. al. 2008)

Reef Management and Monitoring Efforts

Protection of Belize's marine resources is the shared responsibility of several governmental and non-governmental agencies. The Coastal Zone Management Authority and Institute (CZMAI) should be the focal point and coordinating body for marine conservation planning, monitoring and research for the various sectoral or regulatory government departments (Fisheries, Environment, Geology, Forestry, and Lands Departments). Established in 1998, the CZMAI served as a model of integrated coastal planning for other countries. CZMAI is now in the process of completing the National CZM Plan, which will be an integral component of the management of the reef system.

Most of the reef monitoring effort in Belize is focused within the marine protected areas (MPA) network which falls under the jurisdiction of the Fisheries and Forest Departments (now both housed in one new Ministry) and assisted by several NGOs providing co-management of these MPAs.

The Coral Reef Monitoring Network was initiated in 1994 as a Working Group under the coordination of the CZM Project. It functioned for several years and then went dormant for a number of years. The group was re-invigorated in 2008 under the chairmanship of the Fisheries Department and now has approximately 14 organizational members. The group meets regularly (4-6 times a year) and has developed a TOR, formal membership agreement, and coral beaching database within ERI (see section *Coral Bleaching*). There is a sub-committee dealing with lionfish and another one planned to review emergency response plans (such as ship grounding plans and oil spill contingency plans when they become available for review by the Department of Environment).

Belize recently succeeded in gaining two multimillion dollar court settlements for reef damages caused by two ship groundings. A coral reef CSI (Crime Scene Investigation) workshop was held in 2009, training rapid response damage assessments teams including various government departments, reef researchers and MPA managers to strengthen the response to such cases. The completion and funding of the national response plans is essential, while Belize's overarching legislation protecting reefs can still be strengthened. CZMA&I had coordinated planning and response, while relevant agencies handled prosecution. Recently, DOE has been leading the oil spill plan.

The Spawning Aggregation Working Group was initiated in 2001 and is chaired by ERI. It includes approximately 13 organizational members that meet regularly (4-6 times a year). It has a TOR, formal membership agreement, a website and spawning aggregation database, now housed within ERI.

Health of Belize's Reef

Prior to 1998, Belize's reefs were thought to be in relatively "good" condition and were considered some of the healthiest in the Caribbean (McField et al. 1996; Kramer, Kramer, Arias-Gonzalez and

McField 2000). However, escalating threats, including coral bleaching, disease and a major hurricane in 1998, adversely affected Belize's reefs, which experienced a 48% reduction in the live coral cover along Belize's forereefs (McField 2002). As of 2005 there had been no sign of reef recovery based on the analysis of six reef sites (Bood 2006). The average coral cover and fish abundance was slightly below the Caribbean average (Marks & Lang 2006).

The 2008 Report Card issued by the Healthy Reefs for Healthy People Initiative, a collaboration of over 30 international, regional, national and local organizations across the region, included the largest integrated reef survey undertaken in the Caribbean including 326 sites surveyed in 2005/6 throughout Belize, Mexico, Honduras and Guatemala. Reef health was assessed using seven indicators of reef health (coral cover, coral disease prevalence, coral recruitment, fleshy macroalgal index, herbivorous fish biomass, commercial fish biomass, and *Diadema* density). The regional findings were: no reefs in "very good" condition, 6% in "good" 41% in "fair", 47% in "poor", and 6% in "critical" condition. The 140 Belize reef sites were slightly below average with no reefs in "very good" condition, 3% in "good" 39% in "fair", 53% in "poor", and 5% in "critical" condition (HRI 2008).

The 2010 Report Card noted an overall decline in reef health, mainly due to reduced fish biomass and increased macroalgal cover. In this report, Belize's 66 reef sites within this sample had 1% in "very good" condition; 8% in "good" 26% in "fair", 38% in "poor", and 27% in "critical" condition. This is somewhat better than the regional average (130 sites in Mexico, Belize and Honduras) which found 1% in "very good" condition; 8% in "good" 21% in "fair", 40% in "poor", and an alarming 30% of reefs in "critical" condition. These results are based on evaluation of four indicators of reef health (coral cover, fleshy macroalgal cover, herbivorous fish biomass and commercial fish biomass), forming a "simplified" Reef Health Index (SIRHI) for data that were collected in 2009 (HRI 2010). Figure 2 provides the national averages for these for indicators for both sampling periods (2006 and 2009). Honduras has the highest live coral cover in 2009 but the lowest biomass of commercial fish species. Mexico has the highest biomass of commercial fish species, while Belize has the highest biomass of herbivorous species. Fleshy macroalgae is fairly consistent across all countries, with a slight increase in Honduras. The good news for 2009 was that there had been no major hurricane or coral bleaching events to dramatically affect coral cover, which actually increased almost 6% over this 3-4 year interval (HRI 2010).

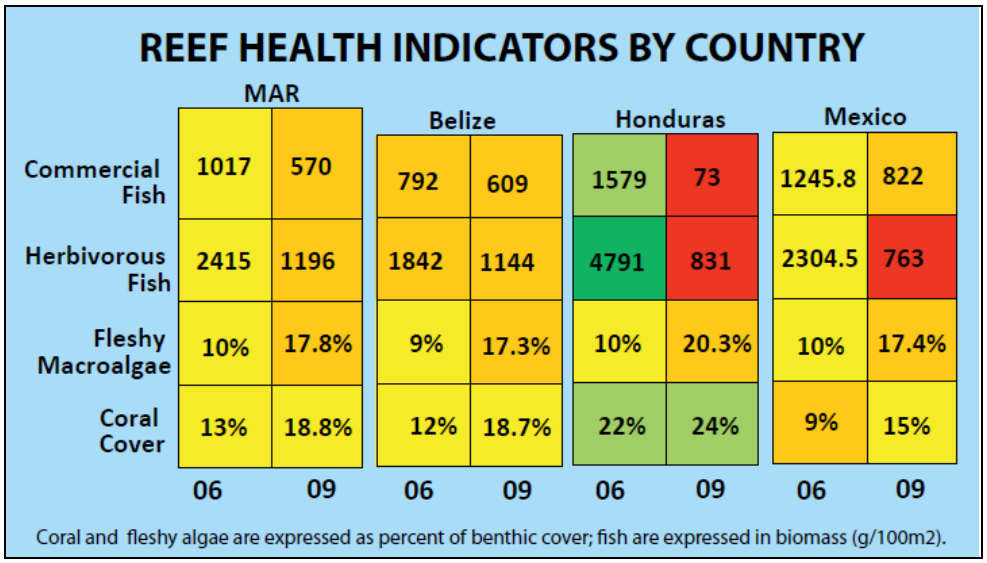

Figure 1. A comparison of Reef Health Indicators by country and between years 2006 and 2009.

Examining the four indicators of reef health for five sub-regions illustrates some differences within the Belize barrier reef complex and between sampling periods. Coral cover was somewhat higher on the barrier reef versus the atolls and increased between the two sampling periods. Fleshy macroalgae increased in all sub-regions, particularly in the southern barrier reef and Glover's reef, which also saw the largest increases. This may be associated with river run-off which is more influential in these southern reefs. Herbivorous fish biomass (which is the biomass of all parrotfish + Acanthurids) was highest on Glover's reef in 2006, but showed a dramatic decline by 2009. This corresponds to data collected by WCS in the marine reserve showing that parrotfish were one of the most caught species on the atoll during this time. The legislation protecting parrotfish was passed in 2009 about the same time these data were collected. Hopefully, subsequent sampling will demonstrate an increase in herbivore biomass. Finally, the biomass of commercial fish (snappers + groupers) also declined between 2006 and 2009, particularly in the Northern barrier reef and on Glover's reef. Note that the number of sites surveyed varies among sub-regions. These sites were randomly selected – stratified by habitat and do not consider MPA boundaries and zoning schemes.

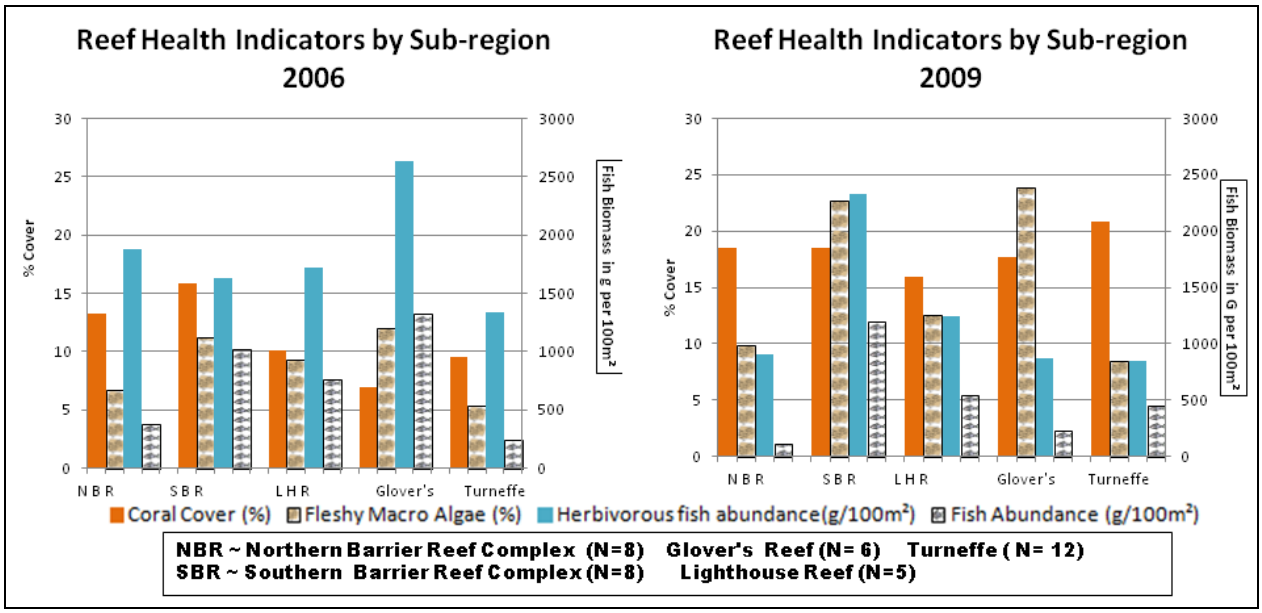

Figure 2. Comparison reef health indicators for Belize for years 2006 and 2009. For this, Belize is divided into five (5) sub-regions.

Recommendations

If Belize is committed to securing the health of its coral reef, it needs to recognize the critical importance of each incremental management and development decision that negatively impacts this irreplaceable national treasure. Completion and implementation of a comprehensive, legally binding integrated coastal zone management plan for Belize is paramount to securing the future of Belize's most prized national asset.

1. Currently only about 2% of marine territory is fully protected. The target is 20% and consistent incremental increases are needed in the amount of sea under full protection. Establishment of Turneffe as an MPA with an adequate amount in full protection would assist. Also, increasing the conservation areas in the MPAs with little full protection (such as Gladden Spit and Port Honduras marine reserves).

2. Increase the level of sewage treatment in coastal areas, particularly those in close proximity to coral reefs (Ambergris Caye and Caye Caulker) to improve declining water quality to achieve legal standards for Class I waters.

3. Implement all of the management measures detailed by UNESCO to remove the Belize Barrier Reef Reserve System from the "List of World Heritage in Danger" (including their protection from any offshore oil exploration or drilling activities).

4. Conservation and community based organizations need to promote reef awareness and outreach. Getting more average citizens out to visit the reef and develop their own personal connection with marine life will help give the reef the collective popular and political support it deserves.

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Coral Bleaching on the Belize Barrier Reef 2009-2011

Leandra Cho-Ricketts

The National Coral Reef Monitoring Network has been monitoring coral bleaching events on the Belize Barrier Reef since 2008. The network is made of up of 14 organizations including the Fisheries Department, the University of Belize and NGO co-managers. The coral bleaching data collected is uploaded to a national database that is administered by the Environmental Research Institute (ERI) of the University of Belize (UB). Bleaching data are collected using the weighted bar-drop method. Coral bleaching monitoring is conducted at thirteen different locations across the Belize Barrier Reef and from a total of 87 sites. During the period 2009-2011, 179 bleaching surveys were conducted spread over the three years (Table 1). Funding for the coral bleaching monitoring during 2009 was provided through a grant from PACT. The periods surveyed each year varied from year to year based on monitoring efforts and the availability of funds (Table 2). Fewer sites and months were surveyed in 2010 and 2011 than in 2009.

Table 1. List of locations surveyed and the total number of surveys in each location during 2009-2011.

LOCATIONS	TOTAL # OF SITES	TOTAL # OF SURVEYS	#SURVEYS 2009	#SURVEYS 2010	#SURVEYS 2011
Ambergris Caye	2	3		3	
Bacalar Chico	6	6	4	2	
Caye Caulker	8	8	8		
Gallows Caye	12	9	9	0	
Gladden Spit/Silk Cayes	6	13	7	6	
Glovers Reef	4	6	1	5	
Hol Chan	4	3	3		
Laughing Bird	6	22	13	9	
Lighthouse Reef	7	25	6		19
Port Honduras	6	18	6	12	
Sapodilla Cayes	7	13	7	6	
South Water Cayes	5	3	3		
Turneffe	14	50	2	29	19
TOTAL	**87**	**179**	**69**	**72**	**38**

Table 2. Time period data were collected for each year, Oct. 2009 – Nov. 2011

Year	
2009	January, February, March, July, August, September, October, November, December
2010	February, April, September, October, November
2011	January, April, July, September, October, November, December

Annual mean coral bleaching during 2009-2011 was low with less than 10% mean bleaching annually (Fig. 1). When bleaching trends were analyzed by location, some locations were found to be more susceptible to bleaching based on results over the three year period. The southern Barrier Reef seemed more susceptible to bleaching with areas such as Laughing Bird, Gladden Spit and Sapodilla Cayes having the highest bleaching over consecutive years (Fig. 2).

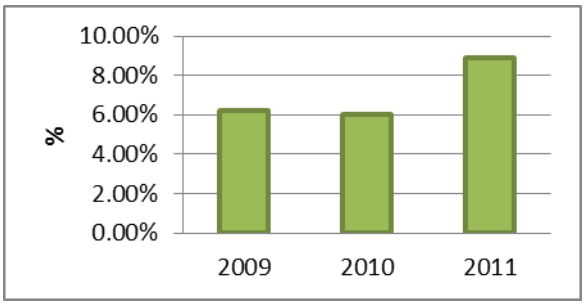

Figure 1. Mean annual bleaching on the Belize Barrier Reef for the period 2009-2011.

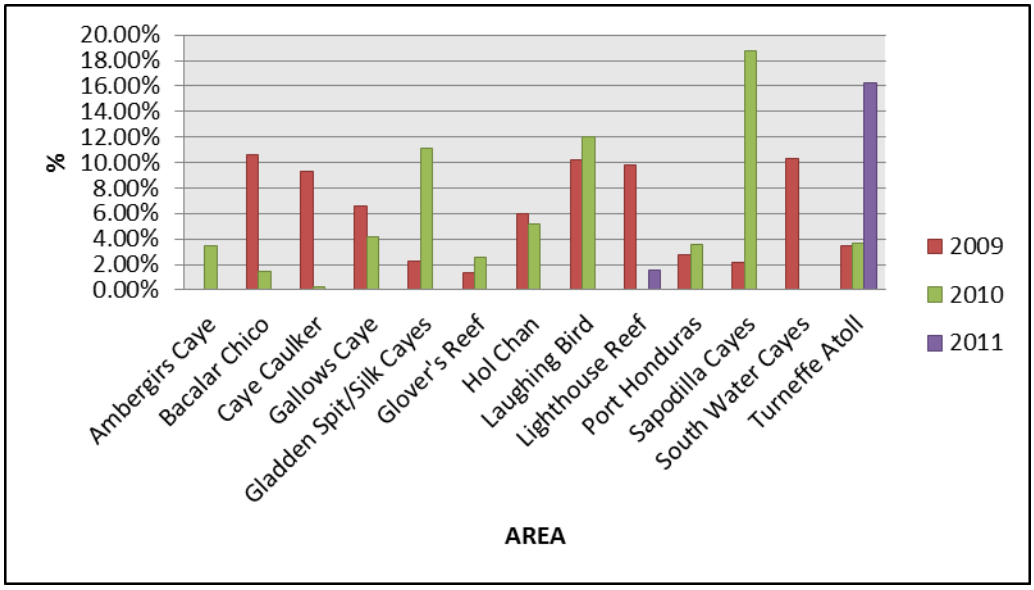

Figure 2. Mean bleaching occurrence by location for the period 2009-2011.

Monthly bleaching trends show that the highest levels of bleaching and paling occur in the latter months of the year during September through December (Fig. 3a-c). The data have shown that the Belize Barrier Reef did not suffer from significant levels of bleaching during 2010. This year was described as a major bleaching event. Only in localized areas of the Barrier Reef did bleaching exceed 10% but by no means was this widespread.

When bleaching data were analyzed at the site level across the Barrier Reef for 2009, bleaching ranged from low to medium with one site near Caye Chapel having high bleaching (Fig. 4). In 2010,

bleaching at sites across the Barrier Reef showed low to medium levels also (Fig. 5). In 2011, only sites at a few locations were monitored. Data for this year showed a slightly higher level of bleaching ranging from low to medium with two sites in the north showing high bleaching levels (Fig. 6). The National Coral Bleaching Monitoring Network will continue to monitor bleaching activity on the Barrier Reef during 2012 and regular updates on bleaching statistics are available on the ERI website under databases.

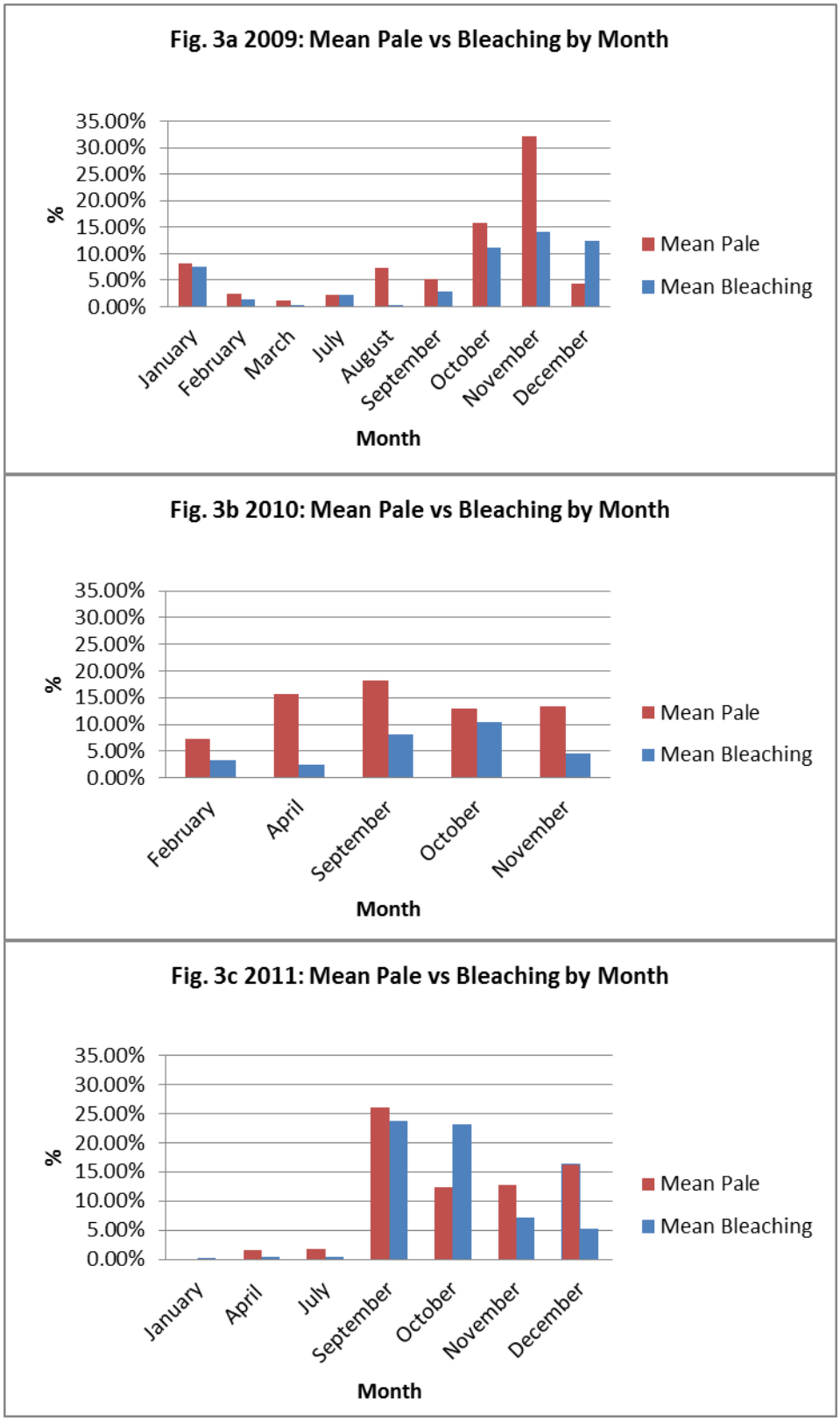

Figure 3a-c. Monthly bleaching levels on the Belize Barrier Reef

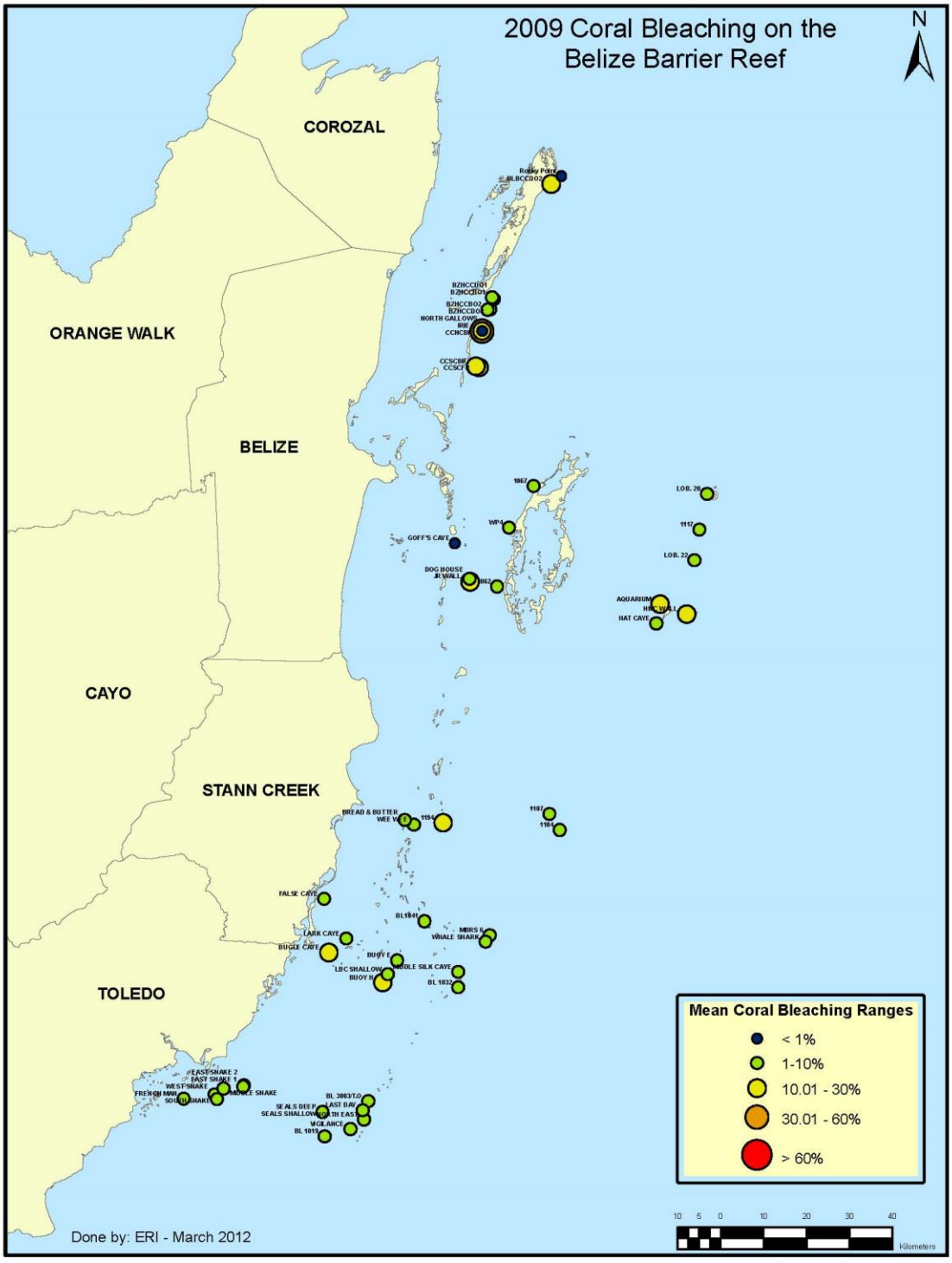

Figure 4. Bleaching at sites along the Belize Barrier Reef in 2009

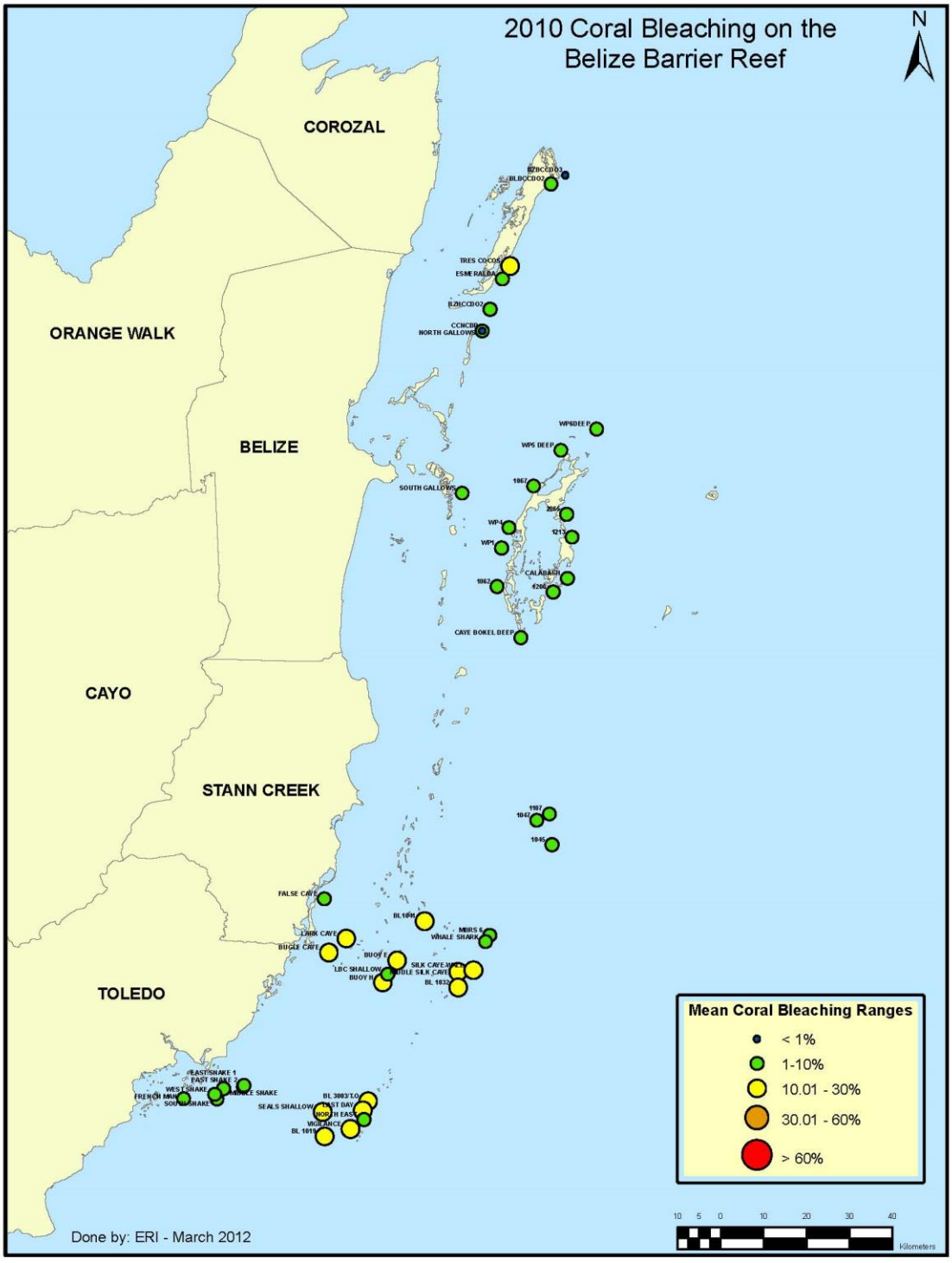

Figure 5. Bleaching at sites along the Belize Barrier Reef in 2010

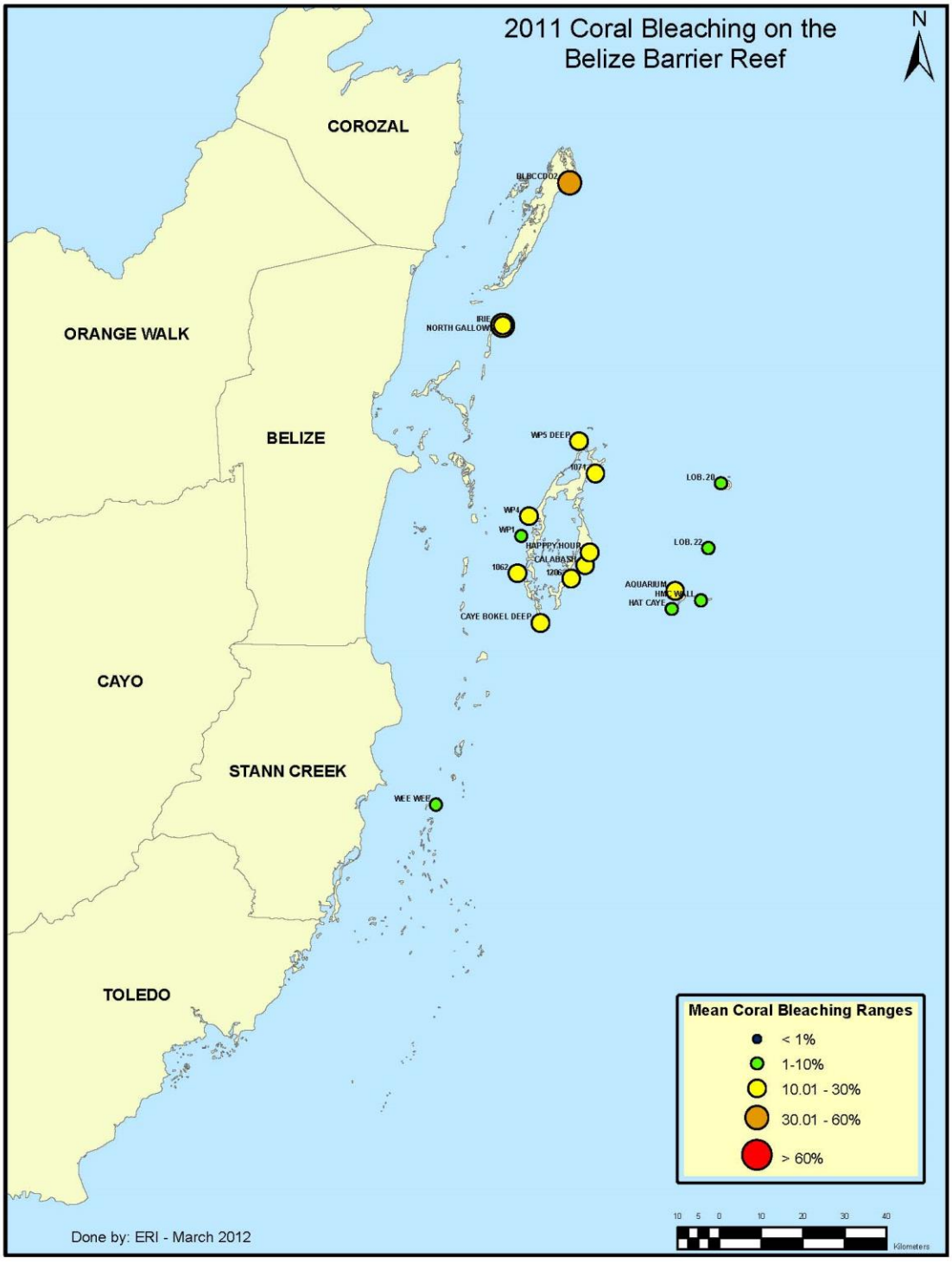

Figure 6. Bleaching at sites along the Belize Barrier Reef in 2011

Coastal Mangroves

Nadia Bood, Emil Cherrington, and Timothy Smith

Introduction

Vegetated coastal habitats such as mangrove forests have much in common with rain forests in that they are hot spots for biodiversity and provide important and valuable ecosystem functions. Mangroves grow in tropical and subtropical intertidal zones, which are generally inhospitable places for plants to grow since their root systems are frequently flushed or flooded by incoming tides. Mangroves are able to thrive under such harsh conditions and provide various ecosystem services such as helping to protect shorelines, mitigate storm surge, control erosion, sequester carbon, and provide nursery grounds for many estuarine and marine fish species. Mangrove forests also produce and export large amounts of detritus and nutrients to surrounding ecosystems (Mann 2000).

Of some 110 species of mangrove worldwide, the Caribbean region is home to three such species; red mangrove (*Rhizophora mangle*), black mangrove, (*Avicennia germinans*) and white mangrove (*Laguncularia racemosa*), as well as the mangrove associate buttonwood (*Conocarpus erectus*) that can often be found along the boundaries of wetlands, streams or swamps deeper inland (Hogarth 1999; Murray et al. 2003; Zisman 1998). Red mangroves dominate the shoreline from the upper subtidal to the lower intertidal zones (Odum and McIvor 1990; Zisman 1998), and are distinguished from other mangroves by networks of prop roots that originate in the trunk of the tree and grow downward towards the substratum. Black mangroves are typically found growing immediately inland of red mangroves, and white mangroves are more prominent in high marsh areas, typically growing upland of both red and black mangroves. Together, these plants help to create, hold and protect coastal land.

Mangrove forests or small mangrove swaths can be found along most of coastal Belize, from the upper Corozal Bay area southward to the Sarstoon River, Toledo where they exist as a narrow fringe (Murray et al. 2003). They can be found in a variety of settings—as coastal fringe, along some rivers and inland lagoons, and on most of Belize's cayes. Mangrove formations include sparse mangrove in open water, mangrove savannah, mixed mangrove forest, dwarf mangroves, and medium to tall mangroves forests (Table 1 and Fig. 1; FAO 2005a). Main geographical factors believed to control mangrove distribution in Belize are the presence of the barrier reef, a shallow coastal gradient and a narrow tidal range, but mangrove distribution is also influenced by local subsidence, drainage, quantity of soil inputs and hurricane events (Murray et al. 2003). Factors such as climate, salt tolerance, water level fluctuation, nutrient runoff, and wave energy also influence the composition, distribution, and extent of mangrove communities. Nevertheless, mangrove forests are also increasingly under pressure of deforestation due to varied development activities (WWF & Brooksmith Consulting 2011; Boles et al. 2011). Over all, it is felt that the extent

of Belize's future mangrove cover will largely depend on hurricane activity and human influence (Murray et al. 2003).

Table 1. Distribution of mangrove communities

Type	Area		
	Acres	Hectares	%
Sparse mangrove in open water	320	130	0.2
Mangrove in mixed forest	112	45	0.1
Mangrove savanna	29,695	12,017	16.5
Dwarf mangrove	98,821	39,992	55.0
Medium height mangrove	39,736	16,081	22.1
Tall mangrove	11,005	4,454	6.1
Total (2014)	**179,689**	**72,718**	**100**

Cherrington et al. (2014), unpublished –3 sets of updates (i.e. 2012, 2013, and 2014)

Importance of Mangroves to Belize

Belize's mangroves are a major contributor to safeguarding the coastal-marine environment. Since mangroves have the ability to thrive where no other trees can, they are able to make significant contributions, including provision of vital environmental and economic goods and services such as habitats and nurseries for sustaining many marine species of commercial importance and effectively functioning as pollution and shoreline protective buffers. Belize's mangroves aid stabilization of the coastal and insular shorelines, provide habitats for many diverse species of birds, mammals, crustaceans, and fish, and foster good water quality via their role as pollution reducers. From a coastal protection and pollution reduction viewpoint: mangroves' root systems provide a filtering system for run-off from the mainland and cayes, allowing sediments and other pollutants to be removed before entering open sea and smothering seagrass beds and coral reefs; they promote coastal accretion and serve as natural barriers against torrential storms (acting as natural wave and wind breaks), and in this manner, preserve the coastline, prevent shoreline erosion, and damage to properties and infrastructure.

Along those lines, a national economic valuation study carried out by World Resources Institute (WRI) found that Belize's mangroves annually contribute a value approximately equivalent to 25% of Belize's gross domestic product through the provision of nursery areas for fish and invertebrates, habitat for wildlife, and physical buffers against pollution, cyclonic storms and coastal erosion (Cooper et al. 2009). However, since mangroves grow along the mainland coast and on outer cayes, which are areas considered prime development locales, their domain has been greatly targeted for waterfront properties and other coastal development opportunities (World Wildlife Fund & Brooksmith Consulting 2011; HRI 2008; Boles et al. 2011).

Research

Except for a few mapping studies carried out over the past few decades, Belize lacks comprehensive national level information on its mangrove resources (Cherrington et al. 2010; McField & Kramer 2007), in turn hindering their effective conservation and management. Belize has some advantages in mangrove conservation though, in the form of mangrove legislation (SI N0. 52 of 1989), and local communities and civil society groups' taking proactive steps to try to conserve and even replant mangroves. Perhaps most importantly, the population density of Belize is quite low and the human footprint along the coast is still somewhat limited. However, development is currently moving ahead and much of it is concentrated in housing and resort developments along the coast (Healthy Reefs Initiative 2008; World Wildlife Fund & Brooksmith Consulting 2011; Boles et al. 2011).

In terms of data on the historical coverage of mangroves in Belize, the most comprehensive recent assessment was conducted by Zisman (1998), using satellite imagery and aerial photography for 1990. That data indicated Belize's mangrove cover to be approximately 78,511 ha, "*equivalent to 3.4% of the country's land area and approximately 2% of the mangrove remaining in the Americas. Through the examination of early aerial photos, historical records and ground conditions, it is estimated that about 98% of Belize's original mangrove cover (80,016 ha) remained at this time*" (Murray et al. 2003). Later mapping in 1992 of key areas such as Belize City, revealed further losses of roughly 519 ha due to direct clearance, bringing about a 0.7% reduction in national cover in a short two year span. According to Zisman (1998) and Murray et al. (2003), the low rate of clearance may be owed to low historical development pressures (stemming from a small population size) and the concentration of a significant percentage of the country's population in one centre—Belize City. More recent studies have indicated increased mangrove clearance near tourism "hot-spots" such as Ambergris Caye and the Placencia Peninsula, and at areas of municipal expansion such as in Belize City and northern Belize (Murray et al. 2003; Cherrington et al. 2010; Boles et al. 2011; Cherrington et al 2014; Table 2).

Table 2. Mangrove Change by Zone for 1980 -2014 (ordered from north to south)

No.	Zone	Change 1980-2014 (acres)	% of clearings
1	Corozal and northern Belize District	5,214	42.0
2	Ambergris Caye area	1,666	13.4
3	Caye Caulker and Caye Chapel	234	1.9
4	Belize City and nearby cayes	2,738	22.1
5	Far inland mangroves	70	0.6
6	Turneffe Atoll	629	5.1
7	Lighthouse Reef	0	0.0
8	Dangriga and nearby cayes	767	6.2
9	Placencia and nearby cayes	864	7.0
10	Pelican Cayes range	123	1.0
12	Punta Ycacos and Port Honduras	79	0.6
13	Sarstoon-Temash	21	0.2
	Total	**12,407**	**100**

Cherrington et al. (2014), unpublished –3 sets of updates (i.e. 2012, 2013, and 2014)

Regarding more recent data, in 2008, the Healthy Reefs Initiative in partnership with CATHALAC updated Zisman's data on mangrove cover, and this was expanded in 2010 through a partnership between the World Wildlife Fund and CATHALAC. The latter involved the assessment of mangrove cover change for the period 1980-2010 based on a remote sensing-based study utilizing satellite imagery for the years 1980, 1989, 1994, 2000, 2004, and 2010 (Cherrington et al. 2010). This 2010 national satellite-based mapping study reveals the current condition of Belize's mangroves, on a national basis, to be reasonably good, with less than 4% removal since 1980 (Table 3 and Fig. 2); compared to a total estimated global loss of 25% (TNC 2010). The study and more recent updates carried out by Cherrington et al 2014 "*indicates that from late 1980 through mid-2014, Belize's mangrove cover declined from less than 192,000 acres, or 98.7% of the original extent, to 179,690acres, or 92.4% of the original extent. These figures equate to a net loss of approximately 11,780 acres of mangrove cover over roughly 34 years, a loss of 6.3% of the 1980 mangrove cover.* A field validation of the 2010 satellite-based study was carried out by the University of Belize's Environmental Research Institute (ERI) and partners, for which mangrove cover at 5 locations (Corozal Bay, Belize City/Drown Cayes, Turneffe, Placencia and Port Honduras) was comprehensively assessed. Groundtruthing and statistical analysis by the ERI found the 2010 national mangrove map to be 90.7% accurate overall, which indicates that mangroves were mapped with a high level of accuracy from the satellite imagery (Environmental Research Institute 2011). The difference in accuracy is owed to the fact that the Zisman (1998) mangrove classification map was used as the baseline for the 2010 CATHALAC mapping study, and the field validation of these reveals some relative error for areas classified as non-mangrove areas by Zisman (1998). The majority of error was for areas having dwarf mangroves in shallow water, which Zisman (1998) classified as non-mangrove areas.

Table 3. Mangrove cover change from 1980 – 2014

Year	Area		% Mangrove cover	% Land cover
	Acres	Hectares		
Pre-1980	194,567	78,738	100	3.4
1980	192,097	77,739	98.7	3.4
1989	191,470	77,485	98.4	3.4
1994	190,827	77,225	98.1	3.4
2000	188,554	76,305	96.9	3.3
2004	182,445	73,833	93.8	3.2
2010	180,266	72,951	92.6	3.2
2012	179,812	72,767	92.4	3.2
2013	179,730	72,734	92.4	3.2
2014	179,690	72,718	92.4	3.2

Cherrington et al. (2014), unpublished –3 sets of updates (i.e. 2012, 2013, and 2014)

While the 2010 study indicated that mangrove loss in Belize is concentrated in certain "hot-spots", the low national average loss of mangrove cover may simply be due to a lack of opportunity to remove mangroves up to this point (e.g. due to the 2008 economic downturn). Nevertheless, of the mangroves that remain intact, approximately 70% are believed to be privately owned (Young 2008), which sets the stage for increased mangrove clearance in the future, but also offers an

opportunity to work in closer partnership with such private landowners to promote mangrove friendly development practices. The 2010 study reveals that sites where population density is high have, by far, the highest rates of mangrove removal in country. Most mangroves loss in Belize appears to result from real estate development and ecotourism, both of which now seem to be on the rise. Some of the locales identified as experiencing the greatest losses are – Ambergris Caye, Placencia Peninsula, Belize City, northern Belize and outer Cayes (See Table 2 and Fig. 2; Cherrington et al. 2010; Canto 2011).

A national economic valuation study carried out for Belize found that mangroves contribute some US $174-249 million per year to Belize's economy via tourism recreation, fisheries and shoreline protection; $60-78m, $3-4m and $111-167m respectively (Cooper et al. 2009). According to Cooper et al 2009, mangroves shelter about half of Belize's mainland coast and about 75% of the shoreline of the outer cayes, and where they exist, they contribute 10-35% of the stability of the shoreline (Fig. 3).

Strengths & Weaknesses of Mangrove Research & Management in Belize

Most national level mangrove research to date has been carried out via the use of satellite imagery and/or aerial photography. While these are undoubtedly great methods for rapidly assessing mangrove cover on a large-scale basis, it would be ideal, as a practice, to complement these with comprehensive field-based investigations which can provide added value in terms of improved accuracy. The validation of the 2010 mapping study has provided evidence of this, and as a result Belize now has more recent data on mangrove cover that can be used by resource managers and decision makers. Furthermore, taking into consideration a possible changing pattern in mangrove clearance, it would indeed be wise to carry out, at a minimum, biannual assessment of Belize's mangrove cover to ensure the availability of recent and updated records on the distribution and cover of mangroves.

Mangroves play an important role in the cultural and economic livelihoods of coastal communities, and provide risk reduction measures in combating vulnerability to natural threats (e.g. storms). However, to date there have been minimal studies focusing on determining their vulnerability and resilience potential to natural and human threats. The ability of mangroves to withstand a broad range of environmental conditions makes them crucial in adapting to climate change.

Many developers in Belize still reflexively clear land down to the shoreline, even though this activity often results in immediate loss of portions of their properties to erosion, which in turn can lead to hard coastal defences which accelerate neighbouring erosion. It is also of concern that regulations on mangrove removal have not always been enforced. Developments built on filled sites or even below sea level are still routinely approved with devastating effects on mangrove habitats as well as surrounding seagrass meadows that are dredged (Boles et al. 2011; Mangrove

Action Project[1]). In an era of rising sea levels and increasing storm intensity, this is a worrying trend.

Mangrove conservation efforts in Belize have focused on strengthening enforcement and legislation, raising awareness of the value of mangroves as nursery habitats and shoreline protectors, pointing out positive examples of development that have embraced the preservation of mangrove habitats, and promoting private reserves and other conservation and restoration measures (WWF and Brooksmith Consulting 2011). NGOs, local communities and civil society groups have played a significant role in these, focusing on positive, proactive measures to conserve Belize's mangroves, pointing out the value of this critical habitat and highlighting efforts to help it remain an integral part of both the natural and human-dominated landscapes of coastal Belize. With continued focus on this vital resource, there is reason to believe those accomplishments can carry forward into the future.

Regarding legislation, the 1989 Forest (Protection of Mangrove) Legislation is quite outdated and associated fines do not appropriately reflect the level of ecosystem services being provided to Belize, nor does it effectively emphasize areas/locations warranting protection based on interconnectivity of habitats, biodiversity safeguards, or coastal protection benefits. The conservation community in partnership with the Forest Department completed a revision in 2009, which was submitted to the Solicitor General's office for review and enactment. However, this apparently could not be enacted because of conflicts with the mother Forest Act (SI No. 16 of 1965), among which was the fines being proposed were much higher than those stipulated in the Forest Act.

Health of Belize's Mangroves Compared with Neighbouring Countries

Large expanses of highly diverse mangrove ecosystems can be found throughout Latin America and the Caribbean, but they are also affected by a variety of pressures, including logging for charcoal and construction material, pollution from urban, industrial and agricultural activities, direct destruction for urban growth, tourism infrastructure and coastal development, shrimp farms and agriculture as well as storm events (UNEP and CATHALAC 2010). Two of Belize's neighbours, Honduras and Mexico, have experienced large-scale loss of their mangrove cover over the years. Honduras' mangrove extent was recorded as 297,800 ha in 1965 but this is estimated to have been reduced to 54,300 ha by 2001 (FAO 2005b). Mexico has likewise seen large scale clearance of its coastal mangroves. Statistical data from Greenpeace Mexico and the Federal Ministry of the Environment and Natural Resources reveal that coastal mangrove cover has fallen from 1,041,267 ha in 1976 to 683,881ha in 2007. That country has since implemented a permanent moratorium on mangrove clearance to protect the remaining mangrove areas.

[1] http://mangroveactionproject.org/news/action-alerts/development-project-imperils-important-mangroves-marine-reserve-and-reef

Recommendations

Based on what is known about the current status of Belize's mangrove resources, the following recommendations are proposed to ensure their sustainable management:

1. Enact and enforce revised mangrove legislation, and create and implement coastal development guidelines aimed at minimizing impacts on mangroves.

2. Update existing data on Belize's mangrove cover on a bi-annual basis to ensure that Belize has recent information on the distribution and cover of mangroves on which to make planning and resource management decisions.

3. Carry out a remapping and classification of the national Belize mangrove cover map developed by Zisman in 1998, especially where dwarf mangroves are concerned since these were not appropriately accounted for in this original mangrove base map (*This map was used as the baseline for the 2010 CATHALAC mangrove mapping study, and the field validation of this 2010 study revealed some relative error for non-mangrove areas which is a result of the fact that the Zisman's 1998 study did not identify all mangrove areas in country. The majority of error was for areas that have dwarf mangroves in shallow water, which Zisman 1998 classified as non-mangrove areas*).

4. Complement the studies of mangrove cover with detailed field-based studies to properly inventory these critical ecosystems. Such field studies would shed light on ecosystem processes, such as their rates of growth, how nutrients are cycled, how carbon is being sequestered, and how such processes vary across Belize's geographic gradient, among other factors.

5. Carry out studies on mangrove vulnerability and resilience at finer levels of detail, taking into consideration field investigations on mangrove nursery functions, coastal protection levels, and how mangroves may be able to provide climate adaptation benefits.

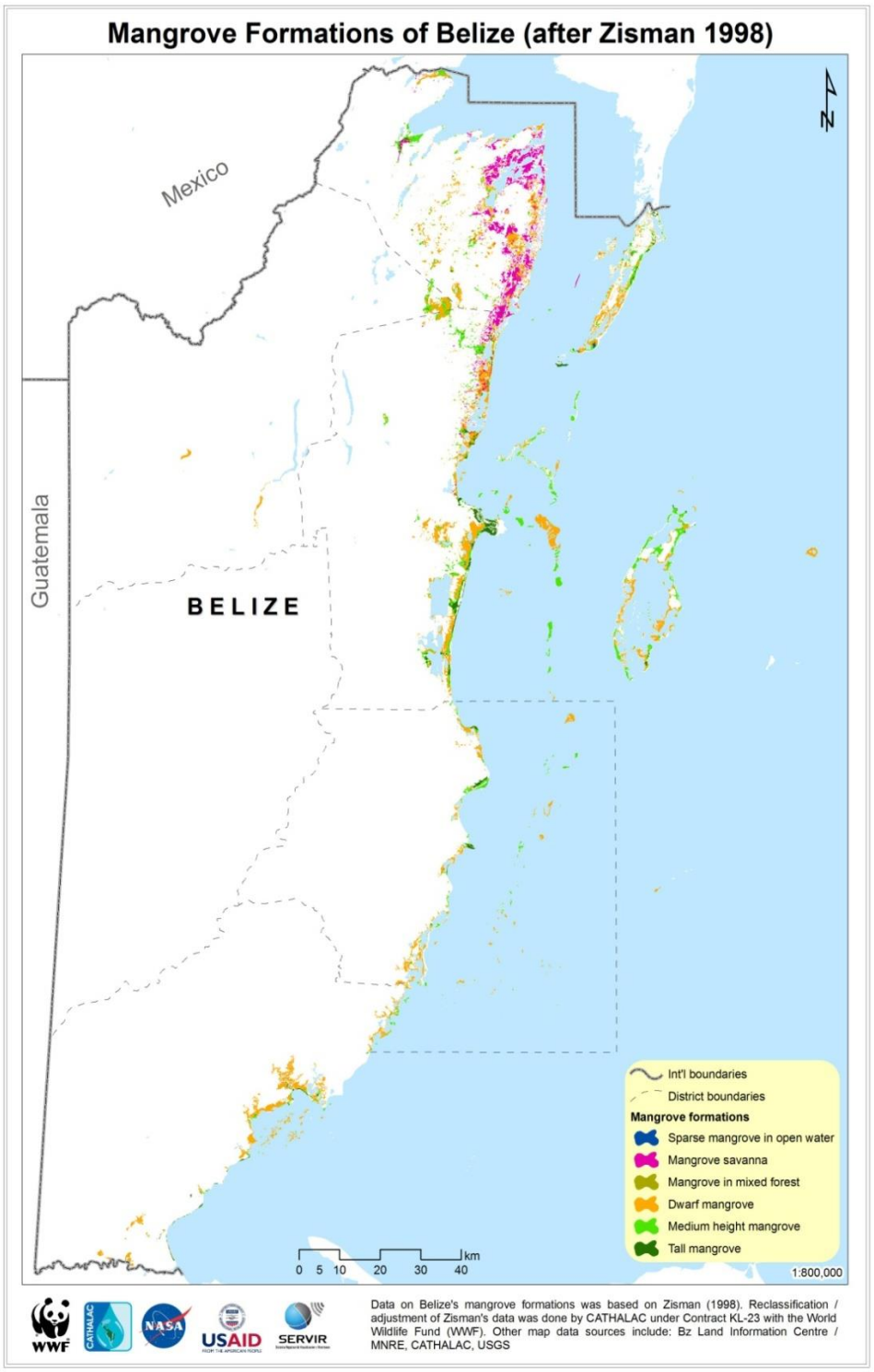

Figure 1. Mangrove formations of Belize.

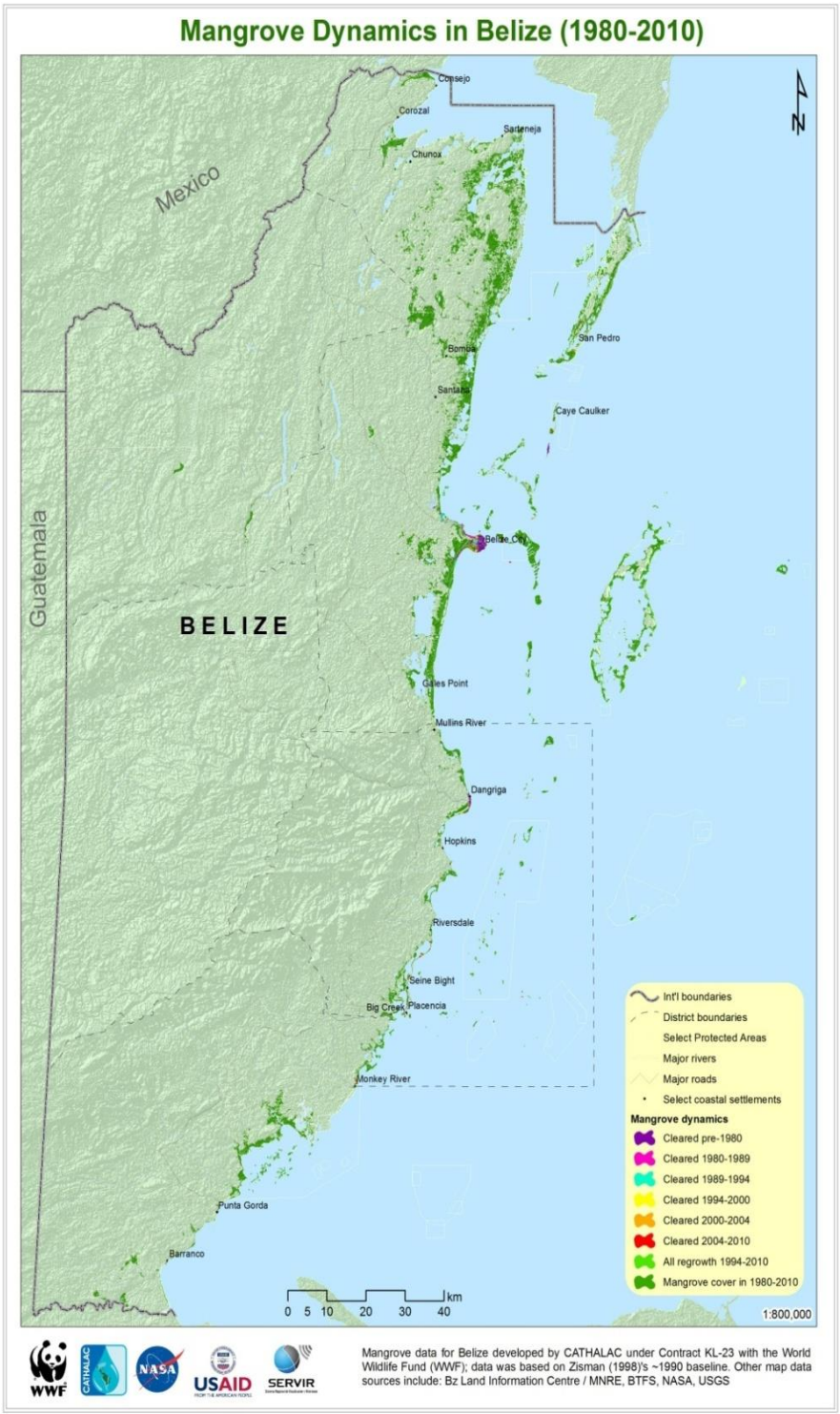

Figure 2. Mangrove dynamics in Belize

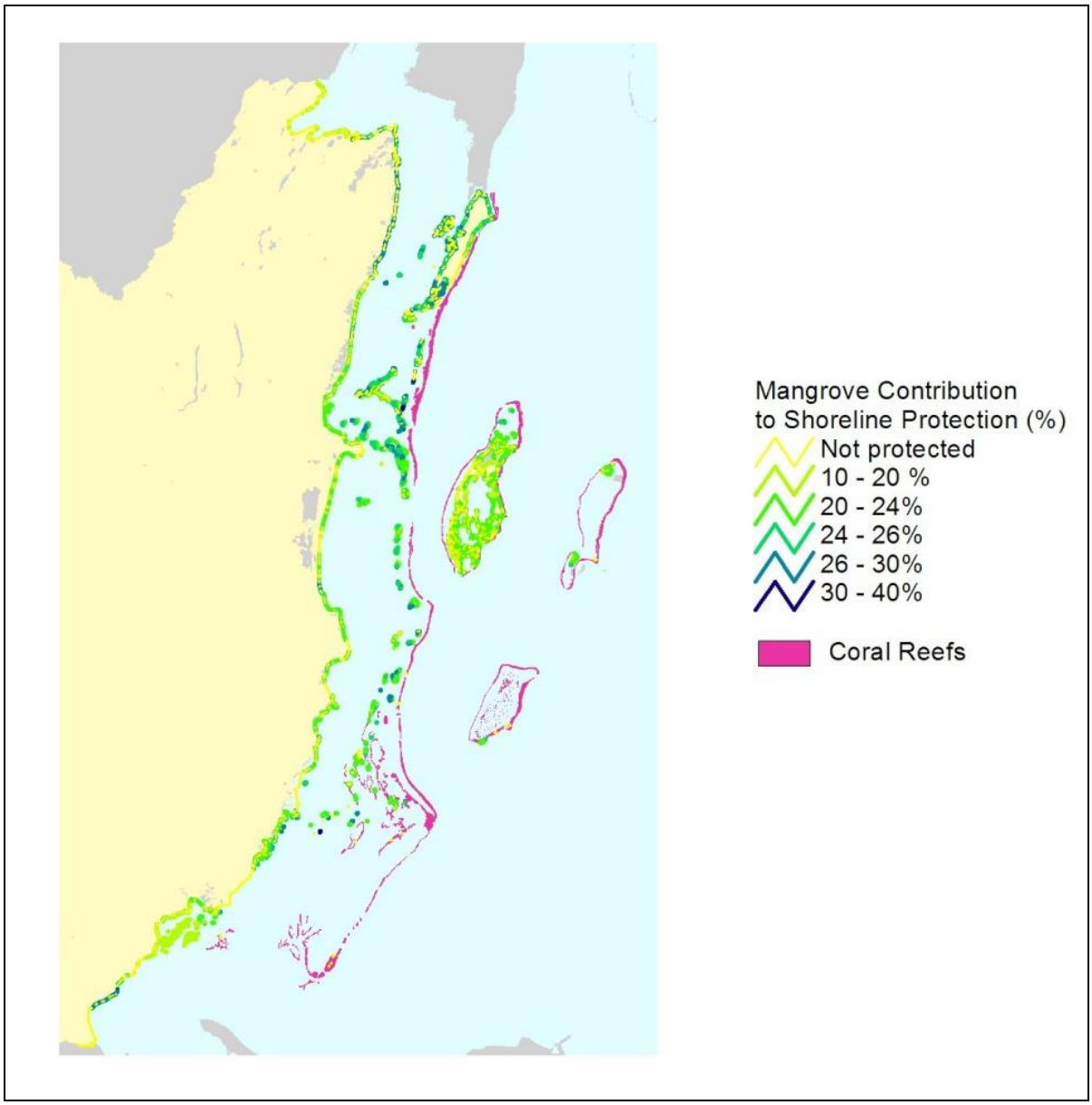

Figure 3. Shoreline protection by mangroves (Source: Cooper et al 2009)

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Seagrass

Fred Short and Faustino Chi

Introduction

Seagrasses are productive marine and estuarine flowering plants that root in the coastal parts of the world's oceans. Found in the waters of every continent except Antarctica, sea grass habitat is linked to mangroves and coral reefs in tropical oceans by both geographic proximity and trophic interaction (Hemminga & Duarte 2000; Larkum et al. 2006). In the coastal waters of Belize, seagrasses are prolific and occur in mixed species stands along the coastline and barrier reef system. Belize has six species of sea grass: *Thalassia testudinum*, *Syringodium filiforme*, *Halodule wrightii*, *Ruppia maritima*, *Halophila baillonii* and *Halophila decipiens*. These species represent a typical mix for the Tropical Atlantic bioregion (Short et al. 2007). One of these, *Halophila baillonii*, is considered vulnerable by the International Union for the Conservation of Nature Red List species assessment process and is found only in the Caribbean; the largest known population of *H. baillonii* is in Placencia Lagoon in Belize, where it has declined dramatically over the past few years (Short et al. 2010).

The IUCN Red Listed 'Vulnerable' seagrass species Halophila baillonii in Placencia Lagoon, Belize.

The people of Belize, to a large extent, depend on food that has a link to sea grass beds, which act as nurseries and refuges for fish and shellfish (Heck et al. 2003). Seagrasses are, themselves, part of the food chain and are directly consumed by fish, manatee, and turtles. Previous State of the Coast Reports have not included a sea grass component, but it is the important "third habitat", along with coral reefs and mangroves, in the barrier reef and coastal system of Belize. Because seagrasses are submerged, they are easily overlooked. They are rooted to the bottom and they depend on clear waters to grow and maintain their habitat and its many contributions to the coastal ocean. Tourists may not come to Belize to view the seagrasses, but both tourism and fisheries depend on sea grass health.

Seagrass Functions and Values

Seagrass provides a high value, per hectare, of ecosystem services (Costanza et al. 1997), and it contributes to a healthy coastal marine environment throughout the Tropical Atlantic region. It provides habitat for commercially and recreationally important fish and shellfish species, and is a nursery for young marine creatures. The fish that are caught in reef areas have often spent their early life in a sea grass bed. Moreover, manatees and sea turtles eat sea grass, leaving feeding trails along the bottom in the sea grass beds. Some fish and birds also consume sea grass, and as dead sea

grass breaks down, it becomes part of the coastal food web. Seagrasses are classic ecosystem engineers, which transform relatively monotonous sediment bottoms into structurally complex, diverse, and highly productive habitats. In addition to the seagrasses themselves, sea grass beds often recruit macroalgae, sponges, corals, large bivalves, and other sessile invertebrates that are rare or absent on unvegetated substrate (Duffy 2006). Seagrass ecosystems have also been identified as a globally significant carbon stock (Fourqurean et al. 2012).

The Seagrass - Mangrove – Reef Connection

Seagrasses, mangroves, and coral reefs form a three-part marine coastal ecosystem, and each part contributes to a healthy ocean. Mangroves filter the water coming off the land and create a stable shoreline. Furthermore, seagrasses filter runoff, sediments and pollution (Short & Short 1984; Freeman et al. 2008) and are nursery areas for many of the fish that live in coral reefs as adults. Seagrass, as it dies and decomposes, provides a link in the food web essential to coral reef fauna. Together, healthy seagrasses, mangroves, and coral reefs create a coastal resource for both fisheries and tourism, essential to the people and economy of Belize. Furthermore, Belize's low lying coastal areas are prone to disturbance from storms, and therefore are dependent on the buffering effects from these ecosystems. Sediments rendered unstable by removal of seagrasses can be shifted by currents or storms and may have a deleterious impact on adjacent sea grass beds, mangroves, coral reefs, beaches or navigational channels. The sea grass root mat creates coastal stability, and sea grass leaves lessen the impact of wave energy on the shoreline.

Adjacent habitats: seagrass and coral

Threats to Seagrasses in Belize

Dredging of seagrass beds and mangrove deforestation at Stake Bank, east of Belize City in 2008.

Shoreline development, increasing human population, industrial and residential runoff pollution, and damaging fishing and aquaculture practices all contribute to losses of sea grass worldwide and in Belize (Short & Wyllie-Echeverria 1996; Spalding et al. 2003). As human population grows and the country becomes more developed, impacts on sea grass increase. Nutrient pollution can already be seen to impact seagrasses in rapidly developing areas such as Placencia (Ledwin 2010). Too much nitrogen encourages macroalgae, which overtake seagrasses and phytoplankton which in turn cloud the water, causing

the seagrasses to receive less than optimal amounts of light. The deep edges of sea grass beds are the first to go, receding due to light limitation – but this loss is often overlooked. Destruction of the mangrove habitat affects adjacent sea grass meadows by allowing greater sedimentation and runoff to reach the sea grass beds. Seagrass responds closely to its ocean environment, acting as an indicator of trends in water clarity as well as temperature, direct human impacts and storm frequency (Orth & Moore 1983; Dennison et al. 1993). By monitoring these habitats, early detection of coastal environmental degradation can be made and corrective measures can be taken before coastal ecosystems experience irreparable loss.

Seagrass Research in Belize

Worldwide, there is insufficient assessment of marine and estuarine habitat resources, particularly evaluation of long-term trends based on scientific monitoring of critical habitats. There has been little or no consistent information on the sea grass habitat prior to 2000 (Short & Coles 2001). SeagrassNet is a scientific monitoring program for sea grass habitat and was first put into place at sites across the Western Pacific in 2001. SeagrassNet arrived in Belize in 2003 with Oak Foundation support with two sites in Placencia and one at Glover's Reef (Fig. 1).

The aim of SeagrassNet is to establish scientific sea grass monitoring worldwide, tracking the status of seagrasses as a measure of the trends in coastal environmental health, using a standard protocol (Short et al. 2006). The program is an international effort that empowers participants in host countries with both scientific knowledge and environmental awareness. SeagrassNet teams worldwide now monitor 124 sites in 34 countries. In Belize, the number of sites has expanded to 21 and Belize is the first country in the world to have a country-wide network of SeagrassNet sites. The habitat is monitored by a local SeagrassNet Team four times a year, using the same consistent protocol, designed to scientifically and rapidly reveal habitat trends with quarterly, repeated analysis of a series of specific parameters at permanent locations across a sea grass meadow providing evidence of change in the sea grass environment. SeagrassNet also monitors environmental information about light and temperature conditions. The current management indicator for sea grass trends is its percent cover of sea grass at monitoring sites and change in that percent cover over time (Fig. 2). Many of the SeagrassNet monitoring locations have paired sites: one is called a "reference site" and is the least impacted site available at that location. The other site, the "impact site," is located to reveal the ongoing stressors from human activity typical of the area. It is identified by the SeagrassNet Team as an area of concern where sea grass indicator data will be useful to capture trends and scientifically determine possible losses in the coastal zone.

At each monitoring site, a SeagrassNet Team trained by the Belize country coordinator (F. Chi) conducts monitoring four times a year and sends the data to the University of New Hampshire, world headquarters of SeagrassNet, for incorporation into the online database. Across Belize the SeagrassNet sites are operated by a suite of NGOs, the University of Belize (UB) and the Belize Department of Fisheries (Table 1, Fig. 1). Together these sites now form a monitoring network that represents most of Belize's Marine Protected Areas. SeagrassNet is working with resource managers to help implement management plans that take sea grass health into account, both as an indicator and as a goal.

Much of Belize remains quite un-impacted, especially the areas removed from human development and tourism. The percent cover levels (Table 1) represent all sea grass species combined (see www.SeagrassNet.org).

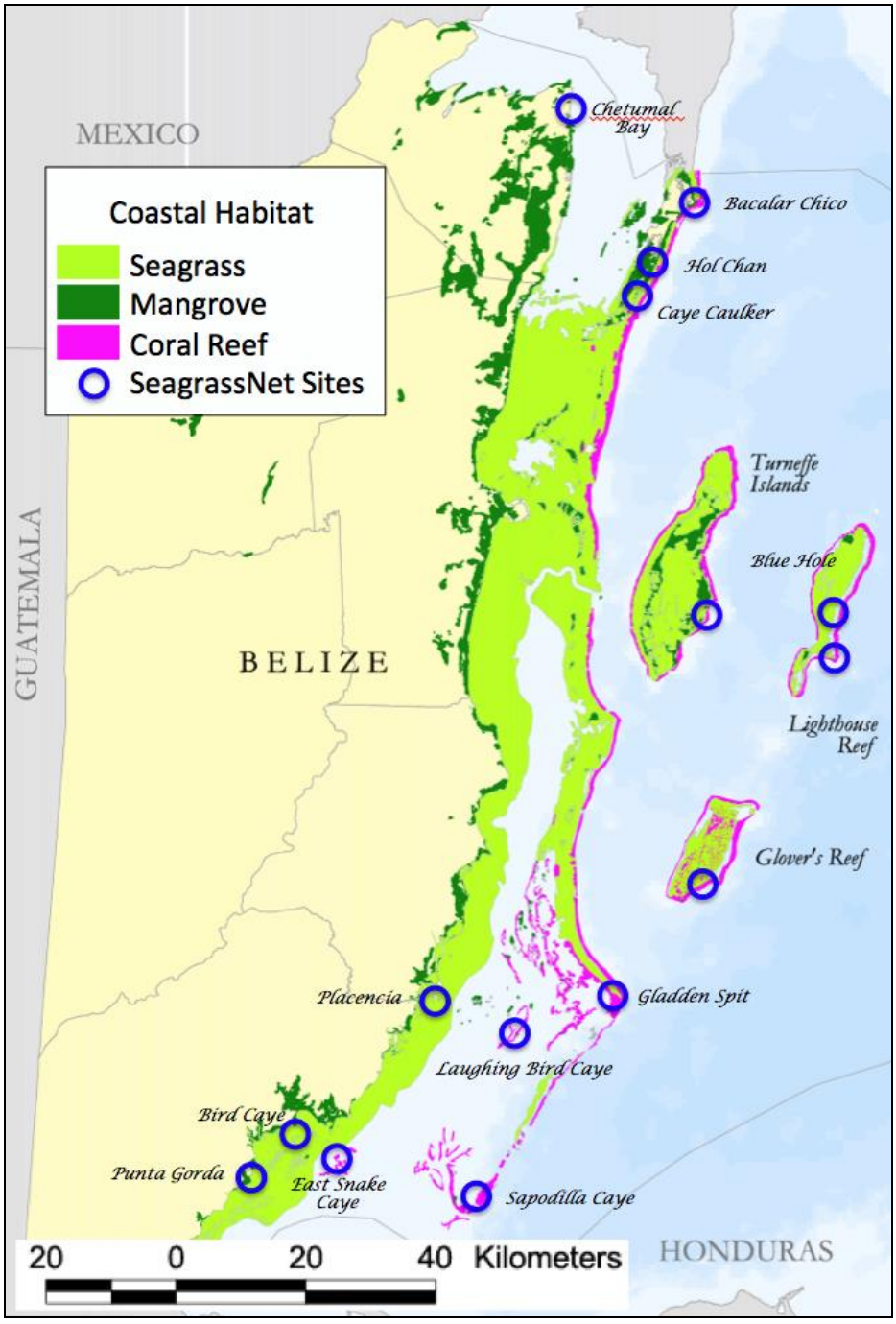

Figure 1. SeagrassNet network in Belize. Many locations have two monitoring sites (see Table 1). Base map from the *Belize Coastal Threat Atlas* (2005) created by the *Reefs at Risk in Belize* project implemented by the World Resources Institute with other partner organizations in Belize.

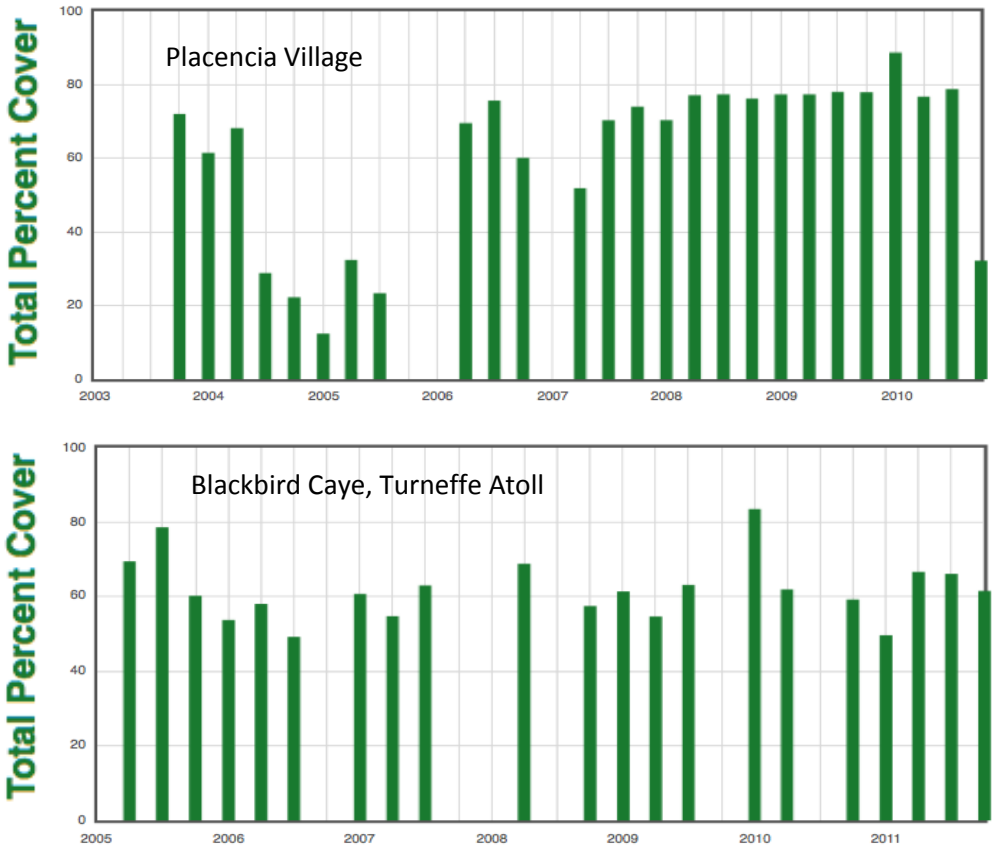

Figure 2. Seagrass total percent cover at two SeagrassNet sites over time. Placencia Village experienced a sea grass decline in 2004-05 followed by recovery. Blackbird Caye shows stable sea grass cover.

Table 1. SeagrassNet sites in Belize with start date and trends.

Location/Site	Start of Monitoring	Active Site	Trend
Bacalar Chico, Ambergris Caye/MR no-take zone [R]	2010	✓	
Bacalar Chico, Ambergris Caye/MR public use zone [I]	2010	✓	
Ambergris Caye/Hol Chan MR [R]	2010	✓	Stable seagrass cover - 45%
Ambergris Caye/San Pedro Town [I]	2010	✓	Stable seagrass cover - 65%
Caye Caulker/Marine Reserve [R]	2010	✓	
Caye Caulker/Village [I]	2010	✓	
Corozal/Corozal Bay	2007	☒	
Lighthouse Reef Atoll/Blue Hole [R]	2006	✓	
Lighthouse Reef Atoll/Half Moon Caye [I]	2006	✓	
Turneffe Islands Atoll/Calabash Caye [R]	2005	✓	Variable pattern but no trend of loss, cover ranging from ~30 - 75%
Turneffe Islands Atoll/Blackbird Caye [I]	2005	✓	Variable pattern but no trend of loss, cover ranging from ~50 - 85%
Glover's Reef Atoll/Middle Caye	2003	☒	
Placencia/Bugle Caye [R]	2003	✓	Stable seagrass cover, cover ranging from ~40 - 45%
Placencia/Village [I]	2003	✓	Dramatic decline between 2004 - 2005; stable seagrass cover of ~75% 2005-2008; worrisome decline to ~30% in October 2010
Placencia/Laughing Bird Caye	2011	✓	
Placencia/Gladden Spit & Silk Cayes	2011	✓	
Placencia/Sapodilla Cayes	2011	✓	
Punta Gorda/East Snake Caye [R]	2007	✓	Since October 2010 decline from ~40% to ~10%
Punta Gorda/Joe Taylor Creek [I]	2005	☒	Steady decline in seagrass cover since 2008; monitoring suspended due to poor visibility
Punta Gorda/Bird Caye [I]	2011	✓	

MR = Marine reserve, R = Reference site, I = Impacted site. Sites without a note on trend: monitoring in progress but insufficient data to make trend statements. At Glover's Reef Atoll and Corozal, monitoring expected to re-start in 2012-13.

Conclusions & Recommendations

Seagrass in Belize is abundant, widespread, and crucial to the health of the country's coastal oceans. Healthy sea grass supports both the fisheries resource (commercial, recreational and artisanal) and the clear marine waters that make Belize a tourist destination. Seagrass is an overall indicator of coastal ecosystem health and monitoring the sea grass status and trends is therefore important. Overall, seagrasses are fairly stable and healthy, with only a few sites showing concerning negative trends. The major threats are coastal pollution (primarily nitrogen loading), sediment inputs from upland deforestation and mangrove removal, onshore coastal development, agriculture and aquaculture, and direct dredging and hardening in the coastal zone. Also, in some areas, there are tourist impacts from boating and trampling that may be an issue locally. With monitoring and careful management, along with increased awareness of the value of sea grass habitat to the country's economy, seagrasses in Belize can persist and thrive.

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Estuaries, Wetlands, & Watersheds

Ed Boles

Introduction

Belize has sixteen major watersheds, five of which are shared with neighbouring countries (Lee & Stednick 1995) (Fig. 1). The Rio Hondo watershed begins within Mexico and Guatemala and the river forms the northern border of Belize. The Mopan River flows out of Peten, Guatemala, crosses the western border of Belize and joins the Macal River to form the Belize River. The Moho, Temash and Sarstoon watersheds are shared with Guatemala to the west and south of Belize. There are also many small coastal stream catchments scattered along the coastline between major rivers. Each watershed has associated ponds, karst lakes, oxbow lakes, lagoons and freshwater wetlands of one type or another, from swamp forests to coastal savannas and patches of bulrush and cattail marshes (Esselman & Boles 2001). Most of the wetland acreage is found in northern Belize and includes Crooked Tree Lagoon - a Ramsar site and largest wetland in Belize. Southern Belize has two Ramsar sites - Aguacaliente Swamp and Sarstoon-Temash National Park, and also Punta Ycacos Lagoon. Three reservoirs, the largest being the Chalillo Reservoir, have been created by damming the Macal River, within the Cayo District, to produce hydroelectricity. Coastal areas throughout the country include many brackish marshes, swamps and lagoons.

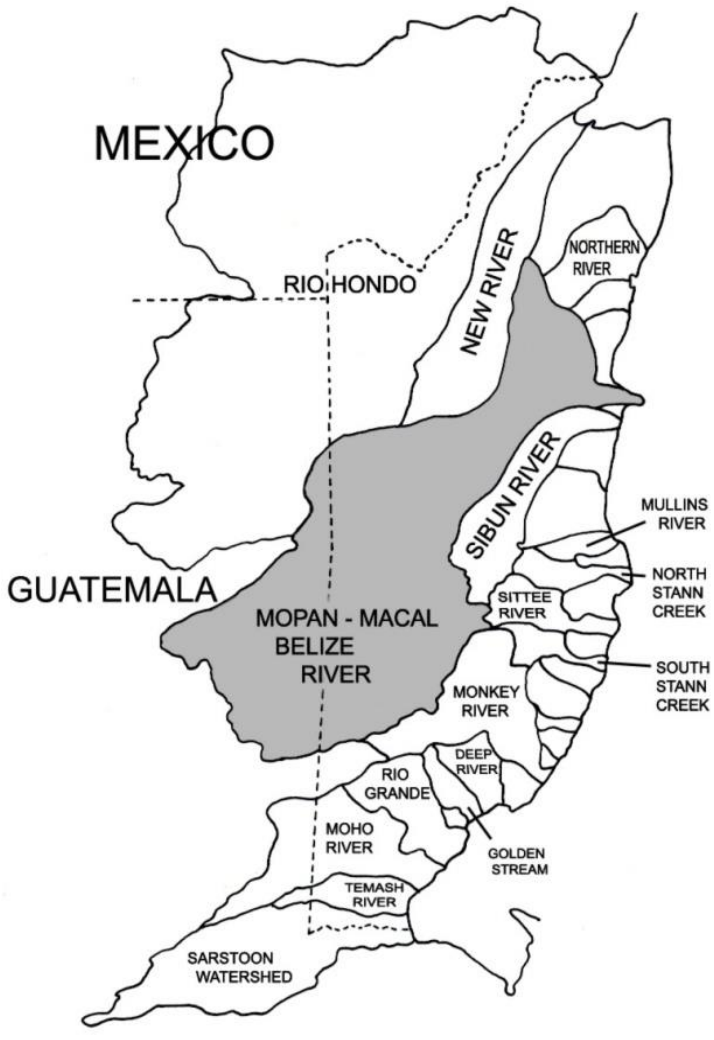

Figure 1. Watersheds of Belize.

All of these watershed systems, with their many aquatic components, discharge into and help create estuaries, including mangrove estuaries that define the Belize coastal zone. They make up the central portion of the Mesoamerican Barrier Reef System drainage network, running from the karst hills of southern Mexico and eastern Guatemala and the Maya Mountains of southern Belize and discharging into the coastal lagoons and inner channel between the shoreline and the barrier reef. These flowing water networks collect, store, process, transport and deliver the nutrients, sediments, dissolved minerals, organic material and fresh water vital to the maintenance and production of marine coastal ecosystems. Because of this interconnectivity between land, freshwater, brackish water, and marine ecosystems, effective management of watersheds and associated wetlands is essential to effectively manage the coastal and marine natural resources, a concept promoted in several key studies (Nunny et al. 2001; Esselman et al. 2006; Bailey et al. 2007; Buck et al. 2008).

Research and Management

A moderate level of research, assessment and planning activities within freshwater and wetland systems in Belize have been on-going throughout the past decade. Increased research activity is needed, particularly the type of studies that contribute to management and conservation efforts.

Several regional initiatives have been developed that have implications for Belize freshwater and estuarine resources, including the Central American Eco-regional Plan (Calderon et al. 2004) and Las Selvas Maya, Zoque and Olmeca Ecoregional Plan (Secaira & Maldonado 2006). Several large scale, multiple watershed management schemes have been promoted within Belize, including the Maya Mountains Massif Conservation Action Plan (Walker & Walker 2008) and the Maya Mountains Marine Corridor Conservation Action Plan (Meerman & Salas 2008), both funded through The Nature Conservancy. Two modelling efforts focused on watersheds draining to the waters of the Mesoamerican Reef compared potential impacts of different watershed systems and promoted watershed management priorities that would benefit marine management objectives. These included the ICRAN-MAR Modelling of Discharge into MBRS (Burke & Sugg 2006) and the Rapid Assessment of Transboundary Watersheds (Bailey et al. 2007). The Global Water Partnership is working closely with water management professionals throughout Belize and the region to help promote local to regional integrated water resource management (R. Frutos, personal communication).

At the national level, the Belize National Protected Areas System Plan (NPASP) gives a country-wide assessment of the Belize protected areas system and discusses freshwater issues to some extent (Meerman & Wilson 2005). Efforts have been underway to establish a Belize national land use policy and efforts have been made to develop strategies to control land-based pollution sources affecting coastal ecosystems (Department of the Environment, MNRE 2008). A National Integrated Water Resource Management Policy has been developed for Belize that includes considerations for the effects of climate change (BEST 2008).

Results of a variety of research efforts have been published since 2003. Rejmánková et al. (2004) investigated the cyanobacteria within inland marshes of northern Belize. A floristic study of threatened riverine vegetation was conducted on the Macal River (Urban et al. 2006). A longitudinal connectivity study of native fishes was carried out within the Monkey River watershed (Esselman et al. 2006) and a trophic relationship study in this same watershed (Alison et al. 2006; Cochran-Biederman & Winemiller 2010). A north-eastern Mesoamerica freshwater fishes survey documented diversity, ranges and distribution for the inland fishes, assessed the extent of the range occupied by the invasive tilapias, and recommended freshwater fish conservation areas that should be protected (Esselman et al. 2006; Esselman 2009). Over the past decade, there has been active involvement of ECOSUR, Chetumal, Mexico and officials within Belize to address issues related to the Rio Hondo, with a report being made available soon. There are also efforts underway to develop standardized biological assessment protocols for flowing waters involving all Central American states and Mexico that are being facilitated through the University of Costa Rica and supported by the Mexican Embassy. Researchers are surveying aquatic macroinvertebrate communities in the Cayo, Belize and Toledo Districts that support that initiative.

DiFiore (2002) conducted a remote imagery analysis to rapidly assess changes in changes in riparian forest cover along the Belize River. Several unpublished surveys involving global positioning unit (GPS) mapping and rapid assessment techniques have been conducted of other aquatic systems through the University of Belize Natural Resource Management Program, including Crooked Tree wetland (Boles 2003), Punta Negra Lagoon (Boles et al. 2004), Five Blues Lake (Boles 2005) and North Stann Creek Watershed (Boles 2011). Other aquatic systems where similar projects have been conducted include the Belize River (Karper & Boles 2006; Boles & Requena 2009), the Monkey River (Esselman & Buck 2007), and the Temash River (Karper & Boles 2004). All of these projects pull together physical, chemical, biological, and geographical (riparian forest mapping) information about specific aquatic systems for community groups and NGOs involved in management and conservation activities.

An initial study of the upper Belize River Valley, conducted with assistance from CATIE (Centro Agronómico Tropical de Investigación y Enseñanza) in Turrialba, Costa Rica, identified the major issues impacting the river within this agricultural landscape and propose potential solutions that would implement solutions through farmers and community groups during the second phase (Boles et al. 2010). An atlas of the Mopan-Macal-Belize River Watershed was compiled through the Friends of Conservation and Development for distribution to community leaders within watershed communities to better inform them about general watershed ecology and specific environmental issues (Boles & Boles 2010).

Several administrative documents produced include a synthesis of freshwater research and conservation in Belize, listing and briefly describing all Government, international NGOs, local NGOs and other institutions involved (Boles et al. 2008). This same team also produced a companion document that described the general status of freshwater issues in Belize, identified research and management needs and proposed a way forward (Buck et al. 2008). An adaptation strategy and action plan for the water sector of Belize was developed to address challenges of climate change (BEST 2008). The main recommendation made was to place water control responsibilities,

currently scattered throughout many different ministries and departments, under one agency. This was conducted in conjunction with the development of the National Water Policy in accordance with the Water Industry Act of 2003 (CAP 222) in the Ministry of Natural Resources.

NGOs are involved in management of aquatic systems. The Belize Audubon Society co-manages Crooked Tree Wildlife Sanctuary that includes the lagoon and wetland system. The Toledo Institute for Development and the Environment is involved in monitoring the Rio Grande watershed and has been working with local communities to replant damaged riparian areas (Toledo Institute for Development and the Environment 2002). Ya'axhe staff and associated researchers are monitoring Golden Stream and Deep River and other systems within the Maya Mountain Marine Transect connecting the Maya Mountains to the Port of Honduras, with a focus on aquatic microinvertebrate assessment. SATIIM is working on the Moho River and Sarstoon River watersheds. The Hydromet Office and Japan International Cooperation Agency technical volunteers are working together to install gauging stations on the Belize River at Santa Familia, Banana Bank, Big Falls, and Isabella Bank, assisting in developing an early flood warning system.

A few foreign universities have participated in monitoring projects over cycles of several years through field course programs. Working through the Steadfast Tourism and Conservation Association, University of Arkansas faculty and students installed a gravel and sand filtration system for the community water supply coming from Billy Barquedier Creek, a tributary of North Stann Creek, and helped promote management of Billy Barquedier National Park. University of Florida faculty and students have conducted assessment studies on Monkey River and Golden Stream. Also, the University of the West Indies is involved in testing water quality and flow in the Bladen, Swazey and Monkey River, gauging stream discharge at stations above Red Bank above and below bridges crossing the stream, upstream, and downstream of the confluence of the Swazey and Bladen Rivers that join to form the Monkey River.

Nationally, the University of Belize's Natural Resource Management Program houses a reference collection of aquatic macroinvertebrates that have been collected over several years by Boles and students. Several student projects have been conducted over the past six years, including botanical surveys of select riparian forests, assessments of Mount Pleasant Creek and associated communities, and an assessment of macroinvertebrates and seeds associated with detritus mats on the upper Belize River.

The need to coordinate research and management activities is recognised and serious efforts are being made to collaborate among a diverse group of water-focused stakeholders, managers and conservationists. However, many of the activities in different areas of Belize are still conducted piece-meal without guidance from an overarching research and management strategy based on threats to freshwater resources and growing demands for fresh water from farmers, industries and households. Many of these research and survey efforts provide needed background information on specific river systems that are useful for management applications. Freshwater studies in Belize have lagged far behind marine studies, but are slowly growing in numbers of participants and organizations involved. However, there has been a serious lack of investigation into groundwater

resources. Currently, the nation's freshwater resources are deteriorating faster than conservation initiatives can be put into place.

Environmental Conditions

Sibun River road through riparian forest.

Belize was regionally recognized for its abundant and high quality fresh water, extensive and relatively pristine watersheds and large expanses of wetlands and estuaries, especially compared to neighbouring countries where population pressures have severely degraded water resources (CCAD 1998; Olson et al. 1998; Frutos 2003). However, lacking effective enforcement of land use and water management legislation, those pristine resources of the last decade are being lost. Based on a sophisticated computer simulation model created and run through the Caribbean Community Climate Change Centre, projections for Belize indicate the occurrence of a drier and hotter climate in Belize (Vergara et al. 2007), meaning that the country will have overall less water.

Belize is undergoing a rapid and poorly planned development surge that includes agriculture and tourism expansion. Many land developers, along with river bank residents, are clearing the riparian forests throughout Belize at an estimated rate of over 10% per year outside of protected areas, according to a recent unpublished assessment. Essentially the filtration system for the landscape is being rapidly stripped out, resulting in increased siltation of marine habitats, more direct introduction of pollutants, including growing numbers of pesticides, fertilizers, heavy metals, hydrocarbons, faecal material from livestock and sewage from towns, villages, tourist facilities and riverside homes. Surveys of crocodile populations in Belize for presence of several heavy metals, as well as organochloride pesticides indicate that the bioaccumulation of toxic materials in aquatic food webs is becoming more prevalent (Rainwater et al. 2007). Solid waste disposal in streams and rivers is also increasing.

Backhoe in Sibun River.

In-stream gravel mining continues in an effort to keep up with the demand of development, particularly within the tourism sector. Increasing numbers of access roads are being built to river gravel bars and low water crossings, cutting through riparian forests and sometimes natural levees, opening the river to gravel miners, livestock, fishers (heavy gill net use) and hunters. Many development projects are being installed within the sixty-six foot buffer of rivers and streams, as defined in the National Lands Act and the Land Utilization Act as protected. Water extraction is on the increase as the population grows and more homes,

businesses and tourist facilities tie into water systems and as more farmers turn to irrigation agriculture. In 2005 an engineering firm presented a concept to the government of Belize to extract and export 360 billion gallons of water per year, roughly about a fourth of the total estimated annual river discharge (Imagine Engineering Research and Development Corporation 2005). Although this project was rejected, given that there are only very crude estimates of the annual water budget for the country, there is growing interest in the commercialization of the water resources by international corporations. Presently there are no minimal flow standards adopted for Belize and no assessment of the potential cumulative impacts of excessive extraction of water from river systems.

The Belize River is now a regulated river, its main tributary, the Macal River supporting three dams that control the flow of the river for the production of hydroelectricity and secondarily for flood control. The ecology of the system has changed significantly, with high flows being reduced for the water holding capacity of the reservoirs, resulting in the build-up of fine silt sediments in the lower Belize River. The mud substrate of the larger Chalillo Reservoir contains heavy amounts of organic material from the inundated forests and is very anaerobic. Bacteria within these oxygen-deprived sediments capture elemental mercury leached out of the Maya Mountains. This natural background mercury that normally flushes through the river system without issue is now transformed by anaerobic bacteria into methyl mercury that becomes incorporated into the food chain. Consequently, river fish, particularly predatory fish, now contain significant levels of mercury and people are now advised not to eat fish regularly.

Deforestation for agricultural activity in wetland area.

General environmental degradation due to the unsustainable use of both land and water resources accounts for much of the impacts to freshwater systems. A national survey of land degradation in Belize using satellite images revealed many practices that contribute to land degradation and, subsequently, freshwater and coastal; zone degradation in Belize, including soil erosion, habitat conversion, riparian deforestation, and pollution runoff. Those activities contributing to negative impacts are steep slope farming, cultivating agriculturally marginal lands, extensive use of fires and occurrence of wildfires, slash and burn agriculture (especially on river banks), overgrazing by livestock, mining of lands for aggregates, timber removal and introduction of invasive plants (Meerman & Cherrington 2005). Furthermore, commercial petroleum production by foreign-owned and funded companies just started in Belize during 2006. This industry has a high potential to damage and impair water resources during extraction, processing, storage and transport of bulk petroleum products.

Recommendations

1. Work with farmers and other watershed stakeholders to maintain, recuperate and protect riparian and wetland forests.
2. Promote use of low-cost, low-maintenance and appropriate bioremediation systems to treat wastewater from households, businesses, hotels and other facilities.

3. Address solid waste disposal in rivers with community and household consultation and promote appropriate household solid waste management.
4. Encourage and assist communities and schools to become involved in monitoring the health of their home watersheds.
5. Collaboratively work with the Central American Network to develop an appropriate set of biological assessment protocols for the region based on country-wide surveys and field research results.
6. Assess the geography, yield capacity, and recharge of aquifers throughout the country.

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Sentinel Species

Sentinel species can be considered the indicators of an ecosystem's health, and consequently give us a clue of how well we are overseeing these systems.

This section discusses five major groups of animals found in the coastal zone. They are primarily threatened species, and some are charismatic megafauna that get much public attention. All the animals selected are vertebrates and the species represent mammalian, reptilian and avian groups.

The Sentinel Species included are Marine Mammals, Sea Turtles, Crocodiles, Sharks, and Coastal Birds.

Marine Mammals

Nicole Auil Gomez

Introduction

Marine mammals have captured the hearts and imagination of people around the world. Humans can get a close and personal glimpse of them, if even only for a moment as they break the water surface for air. Many marine mammals are cosmopolitan, found around the globe. They can be seen from the arctic to tropical waters, and some have even become established in rivers and lakes. There are three orders of marine mammals: Sirenia (manatees and the dugong), Cetacea (dolphins, whales and porpoises) and Carnivora (the polar bear, pinnipeds, and marine otter). Belize has marine mammals of the orders Sirenia and Cetacea.

Of the three species of Sirenia, Belize harbours the Antillean manatee (*Trichechus manatus manatus*), which is a subspecies of the West Indian (WI) manatee (*Trichechus manatus*). Belize has the largest number of the endangered (Self-Sullivan & Mignucci-Giannoni 2008) Antillean manatee in the world (O'Shea & Salisbury 1991; UNEP 2010), and shared with Mexico and Guatemala, they can be found from the Rio Hondo border in the north to the Sarstoon River border in the south (Auil 1998; Auil 2004). The WI manatee can be considered the most important marine mammal of the Wider Caribbean (WC) because it is the only marine mammal that exclusively resides in the Caribbean basin, from Florida to the northern countries of South America. The extinct Caribbean monk seal (*Monachus tropicalis*) (Kovacs 2008) was the only other regionally endemic marine mammal in the WC.

Sperm whale sighting in southern Belize. Aerial survey 2012, N. A. Gomez; courtesy of Lighthawk.

Several species of Cetacea are found in the inner reef lagoon and beyond the reef; but a systematic inventory has not been done. The common bottlenose dolphin (*Tursiops truncatus*) is what most persons on the water encounter from the north to the southern most parts of Belize. They can even been seen in the head of rivers, such as the Belize River where they are spotted a couple miles upriver. Many other dolphin species [Family Delphinidae] are distributed throughout national waters - there are confirmed sightings of those in bold print: the **Atlantic spotted dolphin** (*Stenella frontalis*), Pantropical spotted dolphin (*S. attenuata*), **spinner dolphin** (*S. longirostris*), **clymene dolphin** (*S. clymene*), striped dolphin (*S. coeruleoalba)*, **roughtooth dolphin** (*Steno bredanensis*), **Fraser's dolphin** (*Lagenodelphis hosei*), Rizzo's dolphin (*Grampus griseus*), melon-head whale (*Peponocephala electra*), pygmy killer whale (*Feresa attenuate),* **short-finned pilot whale** (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*), possibly tucuxi / Guiana dolphin (*Sotalia*

fluviatilis guianensis), and the most widely-ranging mammal, second only to humans, the **killer whale** (*Orcinus orca*). Great whales' whose ranges include Belize's waters are Bryde's whale (*Balaenoptera edeni*), Cuvier's beaked whale (*Ziphius cavirostris*), blue whale (*Balaenoptera musculus*), **pygmy sperm whale** (*Kogia breviceps*), dwarf sperm whale (*Kogia sima*), **humpback whale** (*Megaptera novaeangeliae*), **fin whale** (*Balaenoptera physalus*) and the **sperm whale** (*Physeter macrocephalus*).

Management

The Forest Department has the legal mandate for marine mammals in Belize, under the Wildlife Protection Act of 1981. They, however, do not carry out active management of marine mammals, either through presence at the relevant wildlife sanctuaries nor though national strategic species planning. If an infraction of the Act occurs, the logistics of acquiring information and evidence is difficult, and is often left to the Fisheries Department who has coastal enforcement presence. Prosecution very rarely occurs.

The Coastal Zone Management Project (CZMP) and the subsequent statutory body Coastal Zone Management Authority and Institute (CZMAI) was the lead agency that dealt with marine mammal conservation issues on a national scale, between 1996 and 2004. Manatees were the primary species of concern. Under the CZMP, the National Manatee Working Group was created in 1996 as a body made up of government, NGOs, and scientists to advise the national manatee research project. While the group no longer directs a national project, members now meet at least twice per year to discuss their activities and plans related to manatee management, research, and education activities. This enables organizations and researchers to collaborate on projects and provides a platform for group initiatives. However, lack of funds has stalled well-meaning concepts, including training. Between 2004 and 2009, the international NGO Wildlife Trust carried out much of the manatee research and conservation activities, picking up from where CZMAI left off. Since 2009, the national manatee conservation project has been a collaborative effort between CZMAI and the international NGO Sea to Shore Alliance (S2SA).

Manatees in Belize utilize the coast, many lagoons, cayes, and all the river systems; they have been seen far inland in systems such as New River Lagoon, and one was even seen as far offshore as Glover's Reef southeastern outer edge in 2007 (WCS – A. Carr pers. comm.). The three most important manatee areas, based on manatee presence and habitat suitability (freshwater availability, storm / wave protection, and vegetation) are Belize City Cayes and Rivers (Belize River and Sibun River), Southern Lagoon, and Placencia Lagoon to Indian Hill Lagoon / Sennis; the Corozal Bay and Port Honduras are also critical manatee areas River (Auil 1998). Of these sites, three are protected with some level of management under the National Parks System Act or Fisheries Act (Table 1).

Table 1. Status of protected areas important for manatees in Belize, listed north to south.

Protected Area	Corozal Bay WS	Swallow Caye WS	Gales Point (WI Manatee WS)	Port Honduras MR
Date Designated	May 1998	September 2002	August 1998	January 2000
Size (acres)	180,508	8970	9096	102,400
Management Group	SACD	FoSC	GPWSCMC	TIDE
Co-management	Yes	Yes	No	Yes
Grant Funded	Yes	Yes	No	Yes
Project Focus	•Sustainable Fisheries •Alternative Livelihoods •CBO Strengthening •Conservation targets data	•Onsite research •Public outreach •Surveillance / Enforcement •Membership	• Marine turtle conservation •Education	•Resource protection & zoning •Education •Resource monitoring •Sustainability
Management Plan	Draft	Draft	Draft	2012 - 2017
Management	Active	Active	Not Active	Active

Research

Manatees are the most studied marine mammal in Belize's waters. Research projects are both national and localized in scope, and goes back to 1977 (Bengston & Magor 1979). Longitudinal studies very, but include 18 national aerial surveys; strandings consistently recorded since 1996; and health assessments of 144 randomly captured individuals between 1997 and 2011.

Aerial survey data were gathered and analyzed primarily between 1994 and 2002 (Gibson 1995; Morales Vela et al. 2000; Auil 2004). While found along the entire coastal zone, manatees utilize inland systems, i.e. rivers and lagoons, greater than expected by chance, and the population trend between 1997 and 2002 indicated a stable to declining number (Auil 2004). Low counts were made in 2006 and 2007, and the last survey in April 2012, had 507 manatees with 10% of them being calves (Auil unpublished data), which is encouraging. This is the highest count recorded for Belize. Some key areas were in and around the Belize River; the river itself had 12 manatees; the Turneffe Atoll had 14 manatees (the highest count recorded), Placencia Lagoon had 31 individuals, and the Southern Lagoon WS had a remarkable 52 animals. The count is a minimum population size, as for every animal seen, others present are missed.

Between 2003 and 2011, 46 manatees have been fitted with satellite and radio (VHF) or only VHF telemetry tags, captured between Southern Lagoon, Belize City cayes area and Placencia Lagoon. Based on telemetry data, it has been learned that manatees generally spend most time where they were captured (Fig. 1), but some travel between sites and even to Mexico (Auil et al. 2007; Castelblanco-Martínez et al. 2012). Manatees from Belize and from Mexico have travelled between the countries, and the popular stopping locations are Belize River area and Southern Lagoon (Fig. 2).

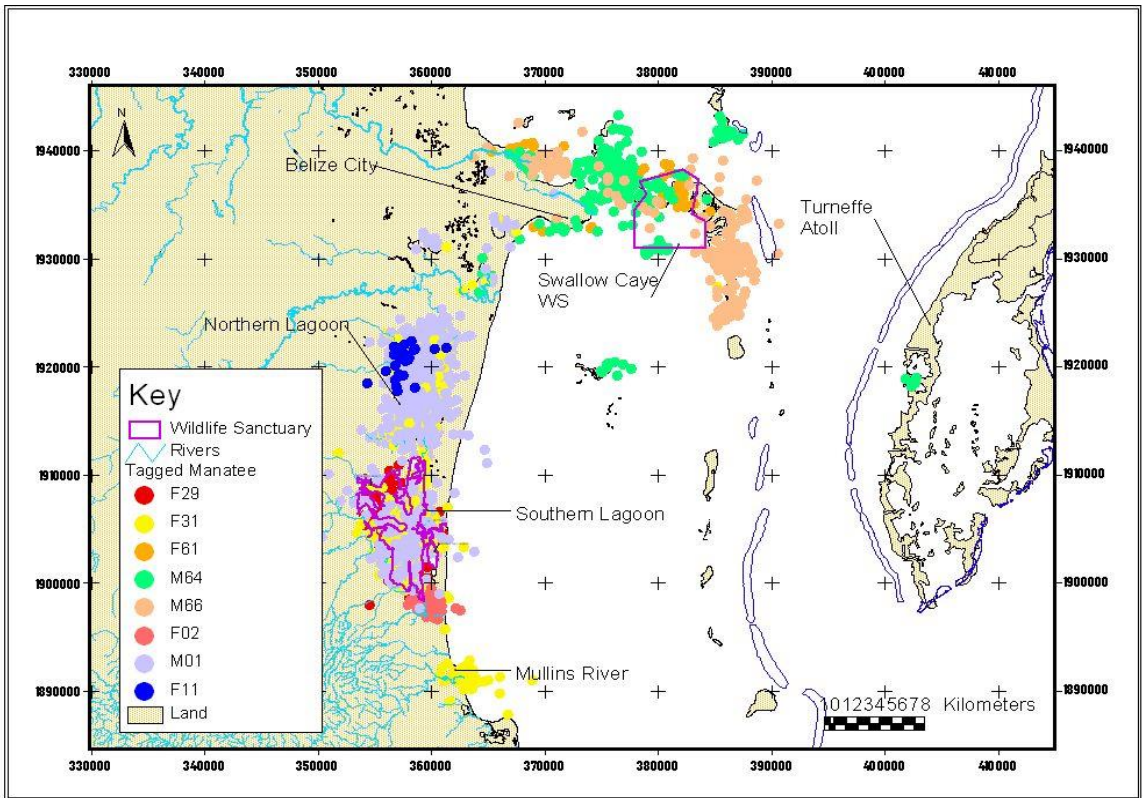

Figure 1. Satellite points of eight manatees tracked between 2002 and 2005. Five tagged in Southern Lagoon and three in Belize City cayes (F61, M64 & M66).

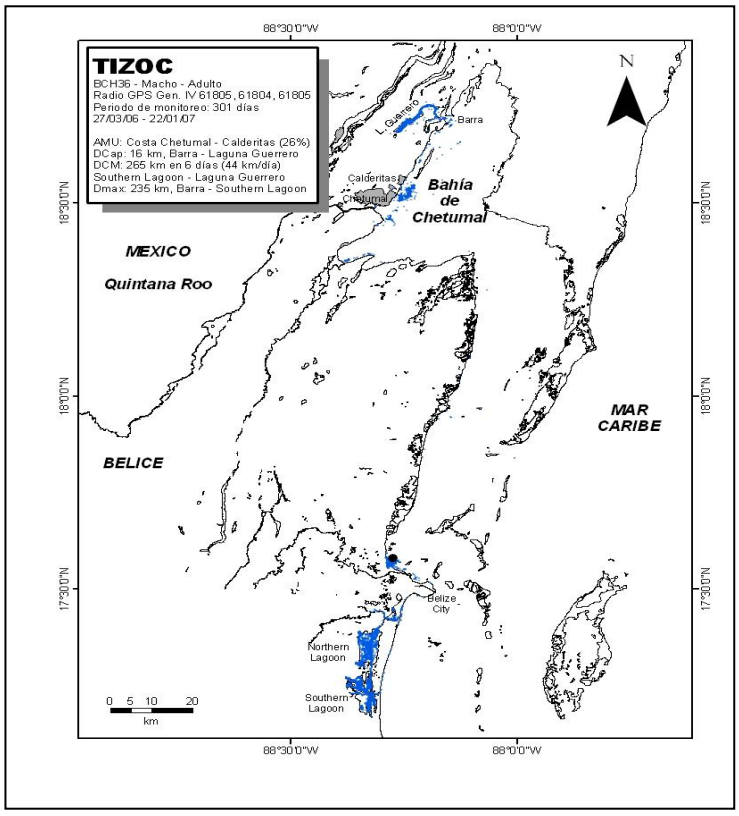

Figure 2. Male manatee captured by ECOSUR research team in Chetumal Bay and tracked (blue dots) with a GPS tag between March 2006 and January 2007. It was randomly caught by S2SA in the Southern Lagoon in 2011. *Map provided by B. Morales-Vela.*

As each animal captured is implanted with a passive integrated transponder (PIT) tag, mark-recapture analysis can be done to determine survivability. Additionally, manatee health assessments were carried out for each animal captured, which has have given information on genetics, parasite loading, nutritional condition, and has improved tools for detection of diseases and inflammatory processes in manatees (Wong et al. 2012). With genetic material collected, more has been learned about the population dynamics, including identifying discrete populations, and relationships between individuals. Nuclear DNA genetic samples from manatees in Belize were compared to populations from both Florida and Puerto Rico and very distinct evolutionary separation was detected between these populations (Hunter et al. 2010). This information was also supported by feeding ecology studies that examined stable isotopes (Alves-Stanley et al. 2010). Preliminary results of detailed fine scale population structure in Belize also revealed significant separation between individuals when compared to habitat types, suggesting offshore and inshore subpopulations (Hunter et al. 2010), which the preliminary analysis of tracking data also suggest. However, there is very low genetic diversity in the Belize population, which corresponds to the low population size and long-term exploitation (Hunter et al. 2010).

Regarding cetaceans, there has not been a concerted national effort to determine the diversity of species, distribution, relative abundance, or threats. However, dolphins, particularly the bottlenose dolphin, have been studied by the Oceanic Society (OS) since 1990. They began research doing photo-identification at Turneffe Atoll (TA) from 1992-1995 and 2001 to the present. From 1996 to 2002 research was also conducted at the Drowned Cayes. While OS primarily works in the TA, photo-identification work has also been conducted off the coasts of Punta Gorda and Placencia. In the Turneffe Atoll, there is a small year-round population of coastal bottlenose dolphins. Preliminary estimations of the population (216 bottlenose dolphins), and density (0.749 dolphins/km^2), were determined by distance sampling protocol using boat line transects (Dick & Hines 2011). Additionally, dolphins were observed closer to mangrove cayes and atoll openings than expected by chance; therefore minimizing mangrove removal and development at atoll openings is recommended (Dick & Hines 2011). Kerr et al. (2005) estimated the population of bottlenose dolphins in the Drowned Cayes at 122 using mark-recapture methods. The difference between the two studies is due to the research question and methods, but both results confirm small dolphin estimations.

Cetacean aerial surveys were conducted for the first time in April 2012, and extended between 10 and 50 miles from the coast. The Oceanic Society surveyed east and west of TA and CZMAI surveyed from the southern end of TA to the end of the barrier reef. The survey team searched for cetaceans such as rough-tooth dolphins, killer whales, pilot whales, and sperm whales which have been seen in Belize's waters. Two sperm whale southern end of the barrier reef, northeast of Sapodilla Cayes; they were swimming southward, towards the Gulf of Honduras. This was not the first recording of sperm whales in Belize, but very little is known of their ecology here. Other species spotted during the 2012 aerial surveys were 33 dolphins.

While reports of large whale sightings or pods of dolphins are not consistently made, there have been sightings of interest and anecdotal reports. Pilot whales and sperm whales have been seen predominantly between Turneffe and Lighthouse Reef. For instance, in December 2011, a pod of about 40 pilot whales were observed near Caye Bokel (R. Pott, pers. comm.) Killer whales have also been identified around Turneffe Atoll (Walker 2012).

Strandings

Stranding data provides much information on species that is often difficult to ascertain in the open sea, including species presence (Morales-Vela et al. 2011). The Belize Marine Mammal Stranding Network (BMMSN) continues to collect information on marine mammal strandings throughout Belize, particularly in the Belize District as there are more coastal residents making reports (Galves 2012). Stranding data continues to show watercraft as the primary cause of known manatee death in Belize, either directly or indirectly, i.e. a dependent calf being orphaned due to a boat killing its mother. Between 2003 and 2011 there were 132 manatee strandings (Fig. 3). Between 2003 and 2011, there were less than ten reports of cetacean strandings. Cetacean strandings are rare, but are usually small bottlenose dolphins. In 2009, there was a dead pygmy sperm whale at Blackbird Cay, TA (OS stranding report). In general, most marine mammal carcasses are difficult to get to, and most often are not given a complete examination due to inaccessibility or advanced state of decomposition, therefore cause of death is unverified (not confirmed by BMMSN member) or undetermined (unable to determine reason for death).

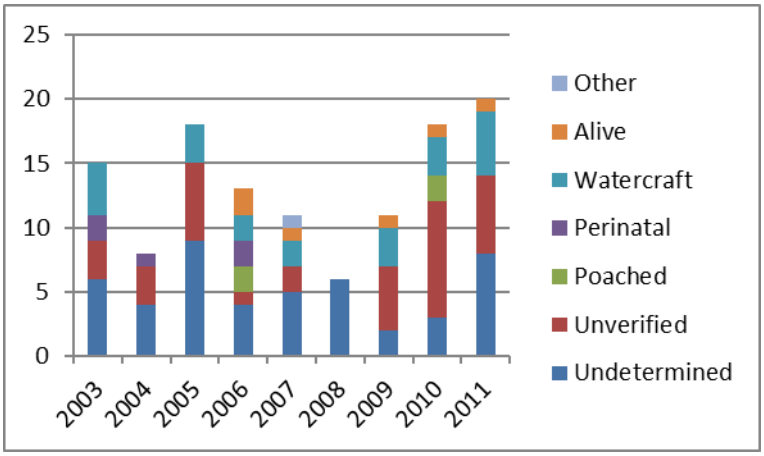

Figure 3. Manatee strandings per year, by cause.

Dead manatees are mostly found by chance, and it is possible that when a dead dolphin is identified, it may not be reported and the data then is not complied into the national database. Only the Belize District has a dedicated manatee researcher; other districts rely on volunteers or biologists from NGOs to respond to strandings. Lack of funds and trained persons allocated to do the work has resulted in low responses to strandings, thereby losing information for the country.

Health of Marine Mammals in Belize

Marine mammals' greatest threat, both historically and today, is man - they are vulnerable to population decline through anthropogenic activities such as intentional hunting, commercial fishing, and shipping activities. Also, changes in their environment such as prey decline, pollution, and even climate change can be stressful for individuals or populations. For example, pollution has

reduced sea grass beds, manatees' food source, in the Placencia Lagoon (Ledwin 2010); habitat alternation is burgeoning due to coastal tourism projects; and fish stocks, cetaceans' food source, have declined due to overexploitation (Graham et al. 2008). Today, the sea and lagoons are vulnerable to contamination by industrial runoff (Ledwin 2010) including agricides, organic compounds, and heavy metals. Researchers are just beginning to monitor various contaminants in marine mammals in Belize, and baseline levels are being studied (Ramey 2010; Siegal-Willott et al. in press; Sulzner in prep.[1]). The threats are certainly compounding, and it is difficult to determine marine mammals' abilities to recognize and or avoid individual or cumulative threats (Auil 2011; Hines 2011).

The marine mammals found in Belize are probably populations that use the waters of neighbouring Mexico, Guatemala, and Honduras, and most likely cetaceans in particular travel beyond. Belize may be a transit area for the great whales, and a residence site for pods of dolphins and individual manatees. The certainty is that management of coastal waters and the open sea is important, and collaborative conservation and research initiatives would be beneficial for marine mammals to thrive in Belize's waters.

Recommendations

1. An annual allocation of funds [$10,000] towards the BMMSN to be used for transport, equipment, and personnel to efficiently respond to strandings nationally.

2. The enforcement agency, Forestry Department, taking an active role in day-to-day sanctuary management would be a huge forward step in species conservation. This could be achieved by having a staff member present on site and as a part of the sanctuary management team, which are formally or informally established CBOs.

3. Concerted effort to consolidate data on Cetacea sightings for Belize.

4. Update and implement the Belize Manatee Recovery Plan, and include updated protocol for rehabilitation and reintroductions.

5. Standardize data collection methods, where applicable, to have comparative results. Training in implementation should be done beforehand.

6. The declaration of the Turneffe Atoll, including the deep waters outside of the atoll as a multiuse biosphere reserve.

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Marine Turtles

Robin Coleman and Isaias Majil

Introduction

Three species of sea turtles - hawksbill (*Eretmochelys imbricata)*, green (*Chelonia mydas)* and loggerhead (*Caretta caretta)* - are known to nest on over 30 cayes and a few coastal mainland areas in Belize (Smith et al. 1992). With the longest coral reef system in the Western Hemisphere, Belize also provides extensive foraging and developmental habitat for these three species of sea turtles and very rarely, leatherbacks (*Dermochelys coriacea*), Kemp's Ridley (*Lepidochelys kempii*), and Olive Ridley (*Lepidochelys olivacea)* have been observed within Belizean waters (Smith et al. 1992; Belize Fisheries Department personal communication).

For decades sea turtles were an important commodity in the Belize fishing industry (Smith et al. 1992), but due to overexploitation sea turtle populations in Belize have been severely depleted, as in many other Caribbean countries (IAC 2009). Globally, the International Union for the Conservation of Nature (IUCN) classifies the loggerhead and green sea turtle as Endangered and the hawksbill as Critically Endangered.

During the 1990's, surveys of the 30 nesting sites indicated that Belize may support 200-250 hawksbill nests, 70 loggerhead nests, and 18 green nests per year (Smith et al. 1992). The most important of these nesting sites was Manatee Bar, Gales Point with 150 nests, making it one of the few sites in the Caribbean where over 100 hawksbill nests could be found on one beach (Smith et al. 1992). These estimates are now out-dated and more recent beach surveys suggest that at the regionally important Manatee Bar nesting site, the number of nests reported in a season has now decreased to less than 50% of the 1990's estimates (Wildtracks 2007). The other two main nesting sites included Sapodilla Cayes and Ambergris Caye (Smith et al. 1992).

While the Belize Barrier Reef is the focus of much conservation attention and Belize has pioneered the use of marine protected areas (MPAs) to conserve high-priority marine ecosystems, sea turtle conservation is still in its early stages in the country. In 1992, the Sea Turtle Recovery Action Plan for Belize (Smith et al. 1992) was developed and outlined the management needs. To date, one priority area addressed is the strengthening of sea turtle legislation (Chapter 210, 1977) with amendments in 1993 (SI No. 55) and in 2002 (SI No. 66), the latter providing full protective status to all sea turtle species in Belize's territorial waters. The most recent Statutory Instrument 10 of 2011, effective 4th February, 2011, completely bans trawling in the waters of Belize, thereby providing further protection of sea turtles by mitigating incidental captures.

Belize also participates in international sea turtle conservation efforts, another priority area identified in the Action Plan, by becoming one of fifteen contracting parties to the Inter-American Convention for the Protection and Conservation Sea Turtles (IAC) in February, 2003. The IAC is an intergovernmental treaty which provides the legal framework for countries in the American

Continent to take action to benefit these species by promoting the protection, conservation and recovery of sea turtle populations and the habitats on which they depend, based on the best available scientific evidence and taking into account the environmental, socio-economic, and cultural characteristics of the Parties. Belize's representation on the IAC is the Belize Fisheries Department (BFD) as focal point and the Wildlife Conservation Society (WCS) as the representative on the Scientific Committee.

Despite the implementation of protection measures, sea turtle nesting and foraging populations in Belize continue to face numerous threats. The principal direct threat is the alteration and destruction of coastal habitats used by sea turtles for nesting from coastal development. These include the construction of buildings and seawalls, pollution associated with sewage and waste disposal, the removal or alteration of vegetation creating unnatural sandy areas on nesting beaches, and increasing beach erosion. Climate change may also exacerbate beach erosion as sea level rises and also alter the sex ratios of turtle eggs, which depend on the temperature of the sand. Some nesting populations, in particular the Manatee Bar nesting site, are also seriously threatened by excessive mammalian predation, and the presence of dogs on many of the cayes where turtles generally nest (Smith et al. 1992, Wildtracks 2007). In addition, sea turtles are threatened by ongoing fisheries, particularly the use of gillnets, throughout their foraging habitats in Belize and elsewhere.

The Belize Barrier Reef Reserve System is the centrepiece of a national emphasis on marine conservation and therefore has a strong national network of MPAs which work well together with a very active and well-trained corps of marine professionals representing government, non-government, and community entities. The MPAs have as part of their objectives the conservation and protection of the areas' biodiversity, which incorporates sea turtles. This includes enforcement of sea turtle Fisheries regulations, research, monitoring, and environmental education for local communities and stakeholders. As a result, many of the important nesting beaches that fall within protected areas such as Bacalar Chico Marine Reserve, Sapodilla Cayes Marine Reserve, Port Honduras Marine Reserve, and Half Moon Caye Natural Monument are afforded extra protection. The Manatee Bar at Gales Point falls outside the boundaries of the Gales Point Wildlife Sanctuary, but is still included within the management plan given its importance (Wildtracks 2007). The sea turtle conservation programs also complement other projects geared towards the sustainable management of the fishing and tourism industries, which may have an impact on sea turtles. The Integrated Coastal Zone Management Plan (CZMAI in prep.) also serves as an important mechanism to control and mitigate the impact of coastal development.

Research and Monitoring

Nesting Beach Monitoring

There are several ongoing efforts to collect data on sea turtle nesting beaches in Belize. The Belize Fisheries Department's marine reserve staff conducts monitoring annually during the months of June to November at several nesting sites located within the Bacalar Chico, South Water Caye, Hol Chan, and Glover's Reef Marine Reserves. During the nesting season, non-government organizations

(NGOs) and community groups also monitor beaches within their respective management areas. These include the following: Gales Point Wildlife Sanctuary Management Committee – Manatee Bar; Belize Audubon Society - Half Moon Caye Natural Monument; Southern Environmental Association - Laughing Bird Caye National Park, Sapodilla Cayes Marine Reserve, and Gladden Spit and Silk Cayes Marine Reserve; and the Toledo Institute for Development and Environment - Port Honduras Marine Reserve. More recent initiatives include the Environmental Research Institute's establishment of a sea turtle nesting monitoring program at Calabash Caye, Turneffe Atoll in conjunction with the Belize Sea Turtle Conservation Network (UB ERI 2011). The Oceanic Society also conducts nesting beach monitoring at Turneffe Atoll. As part of the nesting beach monitoring, a few studies have also incorporated satellite transmitters which aim to understand the migratory behaviour of sea turtles (ECOMARa 2011).

Foraging Ground Surveys

Anecdotal reports of turtle sightings in Belize have suggested that some areas may be important foraging areas for sea turtles. Since 2002, several in-water studies have been conducted to identify key foraging sites in Belize.) Robinson Point is an important foraging area for green turtles and site studies and the dietary requirements of green turtles have been conducted in this area (Searle 2003). Since 2009, ECOMAR has been conducting in-water surveys to assess sea turtle abundance and diversity at Gallow's Point (ECOMARa).

In 2007, the Wildlife Conservation Society (WCS) launched its marine turtle work in partnership with the Belize Fisheries Department, by initiating an annual long term in water sea turtle monitoring program at Glover's Reef Atoll (GRA). The findings suggest that GRMR is an important developmental and foraging habitat, particularly for juvenile and sub-adult hawksbills which represented 84.1% of the 679 turtles sighted to date (WCS 2011). The results of the genetic analyses conducted as part of the study suggest that the rookeries of Cuba and Costa Rica are the primary source of the GRA hawksbills, with lesser contributions from Barbados and US Virgin Islands (WCS 2011).

Turtle captured by hand during in-water surveys at Glover's Reef Atoll.

The Lighthouse Reef Atoll (LRA) has also been a study site for sea turtle research. Studies conducted on the hawksbill populations of LRA have found that the area may be an important feeding ground for juvenile hawksbills and that active acoustic telemetry could prove to be an important tool in understanding habitat use, behavior, and fine-scale movement of turtles in their foraging grounds (Jackson 2010; Jackson et al. 2010). Scales et al.'s (2011a, 2011b) study at LRA provided further support for the findings of Jackson (2010) and Jackson et al. (2010) that LRA constitutes a critical

developmental habitat, supporting the juvenile life stage of the regional population of hawksbill turtles.

In 2011, ECOMAR, with the support of members of the Belize Sea Turtle Conservation Network (BSTCN) and MPA managers conducted an assessment of seven foraging sites: Port Honduras, Caye Caulker, South Water Caye, Hol Chan and Bacalar Chico Marine Reserves; Turneffe Atoll and Gallow's Point. A total of 63 turtles were observed from the 29 surveys conducted, of which 37 were hawksbills, 16 greens, and 10 loggerheads (ECOMARb 2011).

There is a growing interest in sea turtle conservation and management in Belize, which has resulted in several ongoing efforts to collect data on sea turtle nesting beaches and foraging sites. Despite these efforts, the national status of nesting and foraging sea turtle populations remains unknown. Sea turtles have long-life spans and wide-ranging migrations which make them difficult to monitor, and for the most part, the data being collected are not adequately informing managers. There is a need for well-coordinated surveys of nesting and foraging marine turtles. Additionally, training of data collectors, standardization of data collection protocols, and creating a centralized database management system would greatly enhance the country's efforts.

Green turtles foraging on seagrass *Thalassia testudinum.*

Belize Sea Turtle Conservation Network

Many of the protected areas are co-managed by the Belize Fisheries Department (BFD) with local partner NGOs, and provide an excellent opportunity for information exchange and capacity building. One entity that demonstrates this is the Belize Sea Turtle Conservation Network, a volunteer organization made up of representatives of NGOs as well as the Belize Fisheries Department and leaders of communities near important nesting beaches. In addition to the various members helping to fill knowledge gaps by conducting nesting beach surveys, in-water surveys, and migratory studies, the BSTCN is also active in public awareness efforts. The BSTCN has hosted three Sea Turtle Expos countrywide and members such as SEA, TIDE, BFD, in particular Hol Chan Marine Reserve, are very active in public outreach efforts. In 2011, ECOMAR launched a Belize Turtle Watch Program with the goal of determining if climate change is impacting sea turtles in Belize. The program includes activities such as a Sea Turtle Census, which consists of the in-water and nesting beach observation programs that encourage marine guides and coastal property owners to record their observations of sea turtles; an Adopt a Reef and Adopt a Beach program; and the creation of a Stranded Sea Turtle Online Reporting System which allows for immediate reports of strandings to the BFD (ECOMARa 2011).

By fostering partnerships with regional networks such as the Wider Caribbean Sea Turtle Network (WIDECAST), which serves as a gateway for information exchange, and with regional and international educational institutions, turtle conservation efforts have been greatly enhanced through capacity building in the areas of necropsies, beach characterization, and studies on genetics.

Although progress has been made, current conservation measures are inadequate and need to be strengthened in order to improve the survival outlook for sea turtles in Belize and the region. To do so requires continued building of technical capacity and collecting much needed baseline data on sea turtles nesting and foraging in Belize. These efforts, combined with increasing public awareness, will provide the support and information management authorities need to mitigate threats and aid in the recovery of sea turtles in the area.

Recommendations

To improve sea turtle conservation efforts, the following recommendations are being made:

1. Strengthen the Belize Sea Turtle Conservation network, including setting objectives.

2. Build the capacity of stakeholders to collect accurate, reliable, and standardized data from nesting and foraging index sites that decision makers can use to better understand the status and threats to sea turtles in Belize and make informed decisions regarding their conservation and management needs.

3. Compile and disseminate national nesting data on an annual basis.

4. Develop area-specific management action plans, addressing nesting beaches and foraging areas.

5. Increase public support for sea turtle conservation through a campaign to raise awareness about sea turtle conservation needs.

6. Implement management of the largest nesting beach in Belize, the Gales Point Manatee Bar, with regular data collection. Co-management of this site between the Gales Point Wildlife Sanctuary Committee and a larger national organization would be an asset.

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Crocodiles

Steven G. Platt and Thomas R. Rainwater

Background

The American crocodile (*Crocodylus acutus*) is widely distributed throughout the northern Neotropics, ranging from the southern tip of Florida, USA, the Caribbean islands of Cuba, Jamaica, and Hispaniola, along the Atlantic and Pacific coasts of Mexico and Central America, to coastal South America from northern Peru to eastern Venezuela (Platt & Thorbjarnarson 2000a; Thorbjarnarson et al. 2006). Although primarily inhabiting coastal lagoons and estuaries, the American crocodile also occurs on offshore cayes (islands) and atolls, and in some parts of its range is found inland, particularly along major rivers and land-locked lakes of varying salinities (Platt and Thorbjarnarson 2000a; Thorbjarnarson et al. 2006).

From 1920 to 1970, the American crocodile was widely hunted for its skin, and over-harvesting significantly depleted populations throughout its historical range (Thorbjarnarson et al. 2006). By the 1970s, population declines intensified owing to the development of coastal areas and subsequent loss of crocodile habitat (Thorbjarnarson et al. 2006). In 1973, the American crocodile was listed as endangered under the U.S. Endangered Species Act and in 1979 was listed on Appendix I of the CITES (Groombridge 1987; Platt & Thorbjarnarson 2000a) where it remains today. Since that time, national and international trade restrictions and the availability of skins from other crocodilian species from ranching and farming programs have significantly reduced the commercial hunting of the American crocodile, leading to the recovery of populations in many regions within its range (Thorbjarnarson et al. 2006). Today, while some deliberate killing persists, habitat loss and fragmentation are recognized as the primary factors affecting the survival of American crocodile populations (Platt & Thorbjarnarson 2000a; Thorbjarnarson et al. 2006), although additional factors such as accidental drowning in fishing nets and exposure to environmental pollution may also present a subtle yet significant long-term risk to populations (Platt & Thorbjarnarson 1997; Wu et al., 2000; Rainwater et al. 2007, 2011). Currently, the American crocodile is recognized as "vulnerable" by IUCN and considered threatened by the Belize Department of Fisheries (McField et al. 1996; Platt & Thorbjarnarson 2000a). The two species of crocodiles are protected from hunting under the Belize Wildlife Protection Act (SI No. 4 of 1981).

In the early 1990s, owing to a lack of reliable population estimates, surveys of the American crocodile in Belize were accorded high priority by the IUCN Crocodile Specialist Group (Thorbjarnarson 1992; Ross 1998). Preliminary surveys of offshore cayes and atolls were initiated in 1994 and 1995 (Platt & Thorbjarnarson 1996), and a country-wide survey of offshore and mainland habitats was completed in 1997 (Platt & Thornjarnarson 1997, 2000a; Platt et al. 1999b; Platt et al. 2004). Survey results suggested that fewer than 1000 non-hatchling American crocodiles inhabit Belize, and that the largest American crocodile population (ca. 200-300 non-hatchlings, 15-25 breeding females) and the highest concentration of nesting activity occurs on Turneffe Atoll, approximately 35 km from the mainland (Platt et al. 1999a; Platt & Thorbjarnarson 2000a,b; Platt

et al. 2004). In addition, Turneffe Atoll is thought to serve as source population for the American crocodile elsewhere in the coastal zone of Belize, and therefore believed to play a critical role in regional metapopulation dynamics (Platt & Thorbjarnarson 2000a; Platt et al. 2004). Reproduction of the American crocodile in Turneffe Atoll is highly dependent on elevated beach ridges composed of coarse sand, and owing to a combination of natural and human-related factors suitable nesting beaches are rare in the atoll (Meerman 2006; Platt & Thorbjarnarson 2000a; Platt et al. 2004). Because nesting beaches are increasingly threatened by development (Meerman 2006), Platt and Thorbjarnarson (2000a) concluded that the conservation status of the American crocodile in Turneffe Atoll should be considered tenuous at best, and recommended a long-term monitoring program based on spotlight surveys and nest counts to determine population trends (Platt et al. 2004).

Research

Since the completion of the country-wide survey in 1997, American crocodile population assessments have been conducted in Turneffe Atoll in 2002, 2004, and 2008-2010 (Platt et al. 2004; Rainwater 2008; Rainwater & Platt 2009, 2010). Increased crocodile encounter rates (number of crocodiles observed per kilometre of shoreline, using spotlights at night) and numbers of nests found during 2002 and 2004 suggested a possible population increase since 1997 (Table 1, Fig. 1) (Platt et al., 2004). However, the lowest encounter rates in 2008, in conjunction with the development of some known crocodile nesting beaches, suggested a possible decline in the Turneffe Atoll crocodile population (Rainwater & Platt 2009). Overall, encounter rates since 2008 remained low compared to numbers in the 1990s and early 2000s (Table 1, Fig. 1). Conversely, the number of crocodile nests found in 2010 was almost double the number found in 2009, and was the highest since 2004 (Table 2, Fig. 2). This was largely driven by a marked increase in nesting activity on Calabash Caye. Nesting on Northern Caye, the most critical American crocodile nesting locality in Belize, remained consistent since 2008 but reduced compared to previous years. The overall increase in crocodile nesting in Turneffe Atoll observed in 2010 is encouraging, but continued long-term monitoring is essential to determine if this increase simply reflects annual variation in nesting effort.

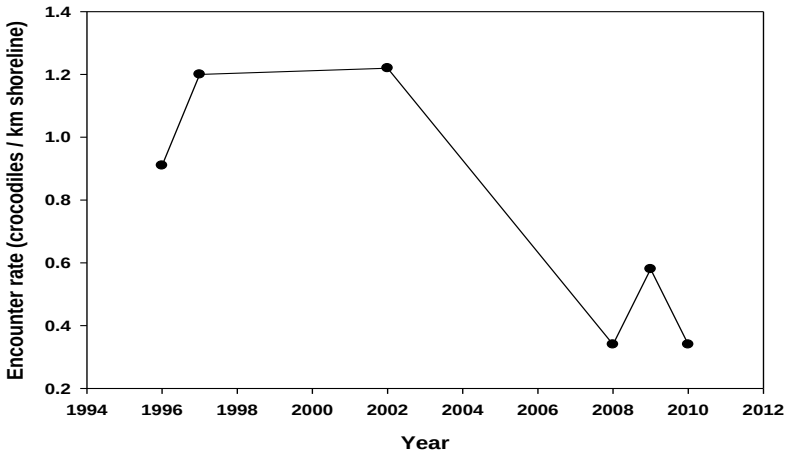

Figure 1. Encounter rates (crocodiles / km shoreline) of American crocodiles along Blackbird Cay and Calabash Cay (Turneffe Atoll, Belize) during spotlight surveys conducted in 1996, 1997, 2002, 2008, 2009 and 2010.

Table 1. Spotlight survey data for American crocodiles by location in Turneffe Atoll, Belize, 1996-2010.[a]

Location	Date	Season[b]	Distance surveyed (km)	Crocodiles encountered	Encounter rate (crocodiles/km)
Blackbird Caye (Eastern shore)	Nov-96	wet	2.7	7	2.6
	Feb-97	dry	2.7	11	4.07
	Apr-97	dry	2.7	6	2.22
	May-08	dry	10.5	5	0.48
	Jun/Jul-08	wet	9.2	0	0
	Jul-09	wet	8.6	10	1.16
	Jul-10	wet	9.7	4	0.41
Blackbird Caye (Western shore)	Nov-96	wet	15.7	6	0.38
	Feb-97	dry	15.7	7	0.45
	Apr-97	dry	15.7	11	0.7
	May-08	dry	30.4	14	0.46
	Jun/Jul-08	wet	24.1	6	0.23
	Jul-09	wet	29.2	12	0.41
	Jul-10	wet	29.7	12	0.4
Calabash Caye	Nov-96	wet	2.4	6	2.5
	Feb-97	dry	2.4	8	3.3
	Apr-97	dry	2.4	7	2.91
	May-08	dry	5.7	4	0.7
	Jun/Jul-08	wet	12	2	0.17
	Jul-09	wet	19	11	0.58
	Jul-10	wet	15.8	3	0.19
Turneffe Atoll (Sites combined)	1996	wet	20.8	19	0.91
	1997	dry	41.6	50	1.2
	2002	wet	40.1	49	1.22
	2008	dry, wet	91.9	31	0.34
	2009	wet	56.8	33	0.58
	2010	wet	55.2	19	0.34

[a]Data from Platt and Thorbjarnarson, 1997; Platt et al., 2004; Rainwater and Platt, 2009; Rainwater and Platt, 2010.

[b]A pronounced wet season occurs in Belize from mid-June through late November, followed by the dry season which peaks in April and May.

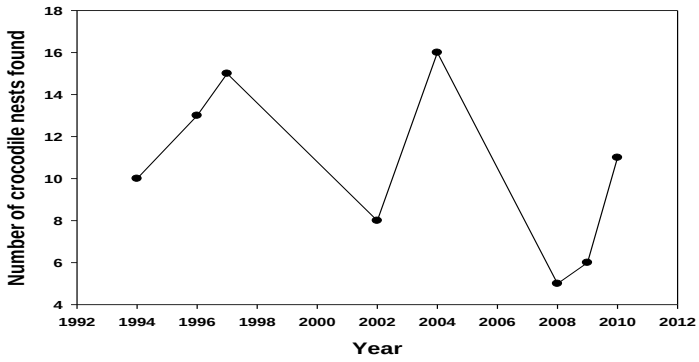

Figure 2. Number of American Crocodile nests found during nest counts conducted on Blackbird Cay and Calabash Cay (Turneffe Atoll, Belize) in 1994, 1996, 1997, 2002, 2008, 2009 and 2010.

Table 2. Counts of American crocodile nests at various beaches in Turneffe Atoll surveyed from 1994 to 2010[a]. Numbers in 2008 have been adjusted to include three nests that were excavated in 2008 following the completion of surveys and were found later in 2008 or in 2009. Note that 1995 counts are based on incomplete survey data.

Location	1994	1995	1996	1997	2002	2004	2008	2009	2010
Calabash Caye	0	NA[b]	0	0	1	2	1	1	5
Blackbird Caye (south)	0	NA	5	3	1	3	1	1	2
Blackbird Caye (west)	2	1	1	2	0	0	0	0	0
Northern Caye	8	NA	7	10	6	11	3	4	4
Total	10	1	13	15	8	16	5	6	11

[a]Data are from Platt and Thorbjarnarson (1997), Platt et al. (2004), Rainwater and Platt (2009), Rainwater and Platt (2010), and the present study.
[b]NA = Not available.

Conservation Questions

1) Is the American Crocodile population in Turneffe Atoll stable? Yes. However, the stability of the Turneffe crocodile population is highly threatened by the loss of nesting habitat as a result of increasing development of beach land on the atoll. The loss of even one nesting beach could result in a spiralling decline in the population.

2) What is the greatest threat to this crocodile population? Beach development - the destruction of nesting beaches and associated nursery habitat is the greatest threat to continued survival of American crocodile populations in Turneffe Atoll, and Belize in general. Elevated beach ridges, where most nesting occurs, are extremely limited and under increasing pressure for development. Consequently, these ridges and associated plant communities are considered the most endangered habitat in the coastal zone (McField et al. 1996). Furthermore, lagoons and freshwater pools adjacent to beach ridges are critical for the survival of hatchling and juvenile crocodiles. Without

suitable nursery habitat, neonates may experience osmotic stress and ultimately die due to prolonged exposure to salt water.

3) Are there habitats that require urgent protection for the survival of the species? Yes. The preservation of nesting and nursery habitat is crucial for long-term population viability, and the most important element of any conservation plan. It is imperative to protect known nesting sites through zoning or incorporation into existing protected areas. Also, proposed developments must be evaluated with regards to potential nesting habitat before building permits are issued.

4) How does the American crocodile population compare with those in neighbouring Mexico and Honduras? American crocodile populations along the Caribbean coasts of Mexico and Honduras are similar to those in Belize: most animals are confined to offshore cayes (islands) and atolls and have limited breeding habitat (Platt & Thorbjarnarson 2000a; Kaiser et al., 2001; Machkour-M'Rabet et al. 2009). Unlike Belize and Mexico, a substantial population of American crocodiles exists in inland Honduras, in the El Cajon Reservoir (Espinal & Escobedo-Galván 2011). In Belize and Mexico, American crocodiles are largely competitively excluded from inland, fresh water habitats by the sympatric Morelet's crocodile (Platt & Thorbjarnarson 2000a; Machkour-M'Rabet et al. 2009).

Recommendations

The low population densities found in the Belize coastal zone, coupled with the loss of nesting and nursery habitat warrant the continued protection and classification of the American crocodile as a critically threatened species in Belize. Population recovery is dependent upon the implementation of appropriate conservation strategies, such as those listed below.

1. Full protection of known crocodile nesting beaches and nursery habitat. Beaches in Turneffe Atoll including Blackbird, Deadman's, Calabash, and Northern Cayes / Cockroach Cayes should be protected to provide critical nesting habitat for crocodiles. It is absolutely imperative that the nesting beach on Northern Caye (Turneffe Atoll) be granted national protection immediately to prevent development. In addition, given the high level of nesting activity observed in 2010, national protection for the two nesting beaches on Calabash Caye is warranted and should also be pursued. Moreover, crocodile nesting habitat is also found on Ambergris Caye, Caye Caulker, Long Caye, Mapps Caye, Southern Lagoon, and Northern Caye (Lighthouse Atoll), and should be considered for protection.

2. It is recommended that Turneffe Atoll be incorporated into the national protected areas system. This would afford maximum protection to the most critical crocodile nesting areas.

3. Protection of mangrove habitats, particularly those adjacent to or near nesting beaches. Mangroves provide nursery habitat for hatchling crocodiles as well as foraging areas and cover for all crocodile size classes.

4. Maintaining a ban on the use of monofilament fishing nets in all protected areas of the atoll and the Belize coastal zone as a whole. The greatest source of mortality of American crocodiles in Belize appears to be the incidental drowning of crocodiles in monofilament fishing nets. While it is impossible to quantify mortality from these sources, the loss of even a few crocodiles, especially adult females, from small populations such as those in Belize, can have a significant negative impact.

5. Reduce opportunistic killing of crocodiles. Although commercial poaching no longer appears to be a threat to American crocodiles in Belize, opportunistic killing of crocodiles is commonplace. Most animals are shot near fishing camps or resorts, a problem exacerbated by careless waste disposal practices, which tend to attract crocodiles.

6. Enact and enforce laws prohibiting the feeding of wild crocodiles. When humans feed crocodiles, crocodiles learn to associate humans with food. This results in an increase in human-crocodile conflicts, including attacks. In addition to serious injury or fatality to humans, this in turn results in the killing of adult crocodiles, the most ecologically important segment of the population (animals capable of breeding). This is a major problem on Ambergris Caye, where locals routinely feed crocodiles in ponds and lagoons, and attacks on humans have recently been documented.

7. Promote crocodiles as an ecotourism attraction. Small-scale ecotourism has been a preferred option in past development plans (McField et al., 1996), and coastal residents (e.g. tour operators and guides) whose livelihoods depend on the continued survival of American crocodiles can be expected to support future conservation efforts.

8. Last, we continue to recommend the implementation of nesting beach restoration efforts by clearing brush and vegetation from known or potential nesting beaches.

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Coastal Birds

Lee Jones

Belize has 240 miles of coastline and the longest barrier reef in the Western Hemisphere, so it should come as no surprise that the coastal zone has one of the most diverse assemblages of birds in the western Caribbean. Among these are several species of terns and gulls that nest on its outer cayes, and colonies of storks, herons, ibises, spoonbills, frigatebirds, boobies, cormorants and pelicans that inhabit the inner cayes and coastal lagoons. Add to this the impressive numbers of Neotropical migrants that migrate along the coast and through the cayes, and the Yucatán endemics that populate the northern half of the country, and one begins to understand the critical role of the coastal zone in supporting a large segment of the region's avifauna.

But this internationally important resource is under grave threat on a variety of fronts. The few remaining breeding seabird and other colonial waterbird populations are under siege by unregulated development, poaching, habitat destruction, over-exploitation of fish and other marine resources, non-native pests, and pollution of its tidal and offshore waters. Natural disasters exacerbate these threats, making it increasingly difficult for populations to recover during the intervening years between hurricanes and other extreme climate events.

Great blue heron feeding in a seagrass (*Halodule wrightii*) bed, Glovers Reef, Belize.

Seabirds (terns and gulls), waders (storks, herons, egrets, ibises and spoonbills), and totipalmates (frigatebirds, boobies, cormorants and pelicans) play an important role in maintaining healthy coastal and marine ecosystems. Most of the seabird and totipalmate species in Belize prey on small to medium-sized fish, and to a lesser extent on arthropods, molluscs, and other invertebrates. Seabirds and totipalmates cull smaller and younger fish from schools, thereby reducing competition for limited resources and allowing more fish to attain larger size – a benefit to sport and commercial fisheries that too many modern fishermen fail to recognize. At least in some cases, they are predictors of stocks of important fisheries (Cairns 1992, Roth et al. 2007). Additionally, waders and totipalmates nest colonially in mangroves and littoral forest, where they enrich shallow-water fish nurseries with their excrement, or guano.

The benefits derived from resident and migrant landbirds are less apparent but equally important. Through their diet of arthropods, grains, and fruit, these smaller species help maintain the complex and often delicate interrelationships between arthropod and plant populations that comprise the ecosystems they in turn depend on. Migratory birds that breed in North America and winter in Central America are most vulnerable during migration, primarily through predation and starvation (Klaassen 1996; Mehlman et al. 2005). Birds that migrate along the major flyway that takes them across the Gulf of Mexico are especially vulnerable to starvation. These birds stop in coastal Yucatán

and Belize to replenish their fat reserves (Duncan et al. 2002; Bayly & Gomez 2008), either in preparation for their 12- to 15-hour non-stop flight across the Gulf of Mexico in spring or after crossing the Gulf on their southward fall migration when fat reserves are critically low.

Research

The first CZMAI report with a section devoted to the state of birds in the coastal zone was published 18 years ago (McField et al. 1996). In Section 3.2.4 of that report, Ellen McRae examined the then current status and perceived threats to birds that nest in the coastal zone. Since that publication, interest in Belize's birds has increased exponentially. Ecotourism, and birding tours in particular, has also increased significantly. In 1995, tour companies that specialize in birding had only recently "discovered" Belize. Now the number of birding tour groups coming to Belize rivals that of Costa Rica, arguably the most popular destination for birders in the American tropics.

Largely because of the increasing popularity of Central America as a birding destination, in 2000 the journal *North American Birds* expanded its coverage beyond the United States and Canada to include Mexico and Central America. It provides virtual real-time documentation of seasonal and distributional trends in bird populations and is the only publication that provides regular updates on bird populations in Belize.

Yet, with this increase in the number of birders visiting Belize and the concomitant increase in the number of birding tour guides, the amount of research on coastal birds has remained stagnant. Two recent papers, however, stand out, both focused on birds in the north-eastern corner of the country. Annick Morgenthaler (2003) reported on the ecology and status of the near-threatened black catbird (*Melanoptila glabrirostris*) at the Shipstern Nature Reserve, and Nicholas Bayly and Camila Gomez (2008) studied the role north-eastern Belize plays as a stepping stone for Neotropical migrants.

Belize has five Annual Christmas Bird Counts (CBCs), three that lie partially within the coastal zone. Though the counts are informal and have limited usefulness, they have a value in their longevity. Long-standing CBCs have been used successfully for detecting long-term changes in populations of certain easily recognizable species as long as coverage and effort have remained reasonably consistent over time.

Threats

Despite the paucity of original research on avian populations in the coastal zone in recent decades, it is clear from informal studies (e.g., Schreiber 2007) that many, if not most, of the colonial waterbirds nesting in Belize are in serious decline and some are either recently extirpated or on the verge of being lost. While landbirds are generally faring better, uncontrolled conversion of critical habitat for these species in the coastal zone is depriving them of food supplies and sheltering opportunities vital to successful reproduction and migration to and from breeding and wintering grounds. No bird better illustrates the effects of these threats than the black catbird. Based on recent research (see, for instance, Johnson and Haight 2011), the IUCN is now considering uplisting

the black catbird from Near Threatened to Vulnerable. Through personal interviews and analysis of the literature dating as far back as 1862, Jones and Balderamos (2011) detailed the precipitous declines and continuing threats to most colonial waterbirds nesting among the cayes and along the shoreline. They expressed an urgent need to curtail these threats and, in some cases, implement recovery plans for those species already extirpated or on the verge of being eliminated.

McRae (in McField et al. 1996) identified the following threats to birds in the coastal zone as of 1995: (1) destruction of critical nesting habitat; (2) pollution; (3) introduction of exotic species; (4) disturbance due to human visitation; (5) hunting; (6) natural disasters; and (7) global climate change.

With the possible exception of hunting, all of these threats remain. Critical habitat continues to be destroyed despite environmental regulations, with large-scale developments moving forward with little enforceable mitigation for environmental impacts. Most of the habitable cayes not protected now have resorts or private developments or have been largely cleared of native vegetation in anticipation of development. Many of these actions have taken place without permits or other government approval. Nearly all of the smaller cayes, so critical to nesting seabirds, have been occupied by makeshift fishing camps – some of these recently removed, however, through the establishment of marine reserves (Wildtracks 2007, 2009, 2010a, 2010b).

Pollution comes primarily from agricultural run-off, industrial effluents, and domestic wastes. These sources of water pollution continue largely unabated, although the nature and extent of direct adverse impacts on coastal zone birds have not been adequately documented.

Exotic species, especially rats and less so cats and dogs, continue as a problem. Rats have long been suspected of contributing to the decline of the red-footed booby population on Half Moon Caye (Miller & Miller 2006; Wildtracks 2006), yet little attention has been paid to this potentially devastating problem. Cats and dogs accompany fishermen on the smaller cayes where terns and gulls nest, and have contributed to the extirpation of seabirds from some of these cayes. Other disturbances include unregulated tourism, recreational boaters and fishermen, and even well-meaning biologists intruding on tern colonies during the egg-laying and early incubation phases.

Egg poaching and shooting in seabird and wader colonies has largely abated thanks to nationwide educational programmes conducted by environmental NGOs, the Belize Zoo and Tropical Education Centre, schools, and community groups. Despite these efforts, however, few cayes with nesting seabirds and other waterbirds are patrolled regularly. Poisoning of pelicans and cormorants by fishermen who mistakenly believe that these birds are eating "their" fish is also suspected.

Natural disasters play a role in decimating waterbird populations, but populations invariably recover within a few years. However, populations already low or under stress from continued persecution can no longer recover sufficiently between extreme climatic events.

The effects of global climate change are much more gradual, long-term, and not well understood. Rising sea level may ultimately inundate low-lying cayes where seabirds nest just above the high-tide mark. Climate change has also been implicated as a cause of greater frequency and intensity of hurricanes.

Management

Half Moon Caye has seen an apparently dramatic decline in the boobies since first studied by Verner (1959) in 1958. Techniques for estimating the population since 1958 have varied widely, most being mere "guestimates". Also, little attempt has been made to correlate population fluctuations with the effects of hurricanes, and no studies have been undertaken to determine the role that rats may have played. The island is managed by the Belize Audubon Society, which provides a full-time warden to manage use of the island. However, wardens are not trained biologists and have little or no experience in standard methodologies used to monitor the booby and frigatebird colonies.

Laughing Bird Caye National Park was established in part to protect the laughing gulls that once nested there. However, none were nesting there when Jones visited the caye in 1998, nor had any nested there for several years prior to that. The caye and surrounding waters are used primarily by divers and there is now a permanent structure on the caye, so it would not be practical to attempt to re-establish a laughing gull colony at the present time.

The Glovers Reef Marine Reserve is a World Heritage Site and most of the original native terrestrial habitats on undeveloped Middle Caye have since been restored. Glovers Reef may have been the last outpost for the black noddy (*Anous minutus*) which was last recorded breeding in Belize on Northeast Caye in 1907, and the brown noddy (*Anous stolidus*) which nested on Southwest Caye at least as late as 1990 (Poole 1990). The latter may also have nested as late as 2002 on Tobacco Caye (Jones 2002), and a few pairs may still breed on the Silk Cayes. Although neither noddy has been recorded in historical times breeding on Middle Caye, now that it is protected and has been restored, efforts to attract noddies to this caye are worth pursuing.

Jones found a few bridled terns (*Onychoprion anaethetus*), sandwich terns (*Thalasseus sandvicensis*), and laughing gulls (*Leucophaeus atricilla*) nesting on shoals within what is now the Gladden Spit and Silk Cayes Marine Reserve in 1998, but fishing camps were threatening their continued presence. Since the establishment of the marine reserve two years later, the camps are gone and there are unconfirmed reports that terns of one or more species and laughing gulls still nest there. Yet, until we understand what species are breeding there, in what numbers, and what threats may still exist, we cannot develop an effective management plan.

South Water Caye Marine Reserve includes the Man-O'-War Caye Bird Sanctuary, which has a long-established and relatively stable colony of magnificent frigatebirds (*Fregata magnificens*) and brown pelicans (*Pelecanus occidentalis*); however, bridled tern and brown noddy colonies that once nested on South Water Caye and nearby Carrie Bow and Curlew cayes (Jones and Balderamos 2011) are now gone. Any efforts to restore and protect some of the undeveloped cayes and shoals in the marine reserve are unknown to the author.

As with the other marine reserves, the focus in the Sapodilla Cayes MR has been the protection and management of its marine resources. Less effort has been devoted to terrestrial resources. Nevertheless, small numbers of laughing gulls, and perhaps bridled and roseate terns, have nested or attempted to nest in recent years on Seal and Ragged cayes. Privately leased Tom Owens Caye is rumoured to still support a few nesting terns despite the recent construction of a small resort that

dominates this small caye. Tiny Ragged Caye, if managed appropriately should be an ideal setting for small tern and gull colonies.

Poole (1990) was the last to report on the status of nesting long-legged waders in Belize, although the BAS published periodic accounts of waders nesting on mangrove cayes along the west side of Ambergris Caye as late as the mid-1990s. These cayes are not protected and may no longer support viable populations of waders (Schreiber 2007), although surveys over the course of a full nesting cycle may be necessary to determine what species may still nest there. Other cayes, such as those in Shipstern Lagoon, are protected and still have healthy populations of wood stork (*Mycteria americana*) (Meerman 1994), tricolored heron (*Egretta tricolor*), reddish egret (*Egretta rufescens*), white ibis (*Eudocimus albus*), and roseate spoonbill (*Platalea ajaja*). The current status of long-legged wader populations occupying other cayes that were reported by Poole are not known to the author.

A few reserves have been set aside within Belize's coastal zone to protect littoral forest, mangroves, and other coastal woodland communities, and thus the landbirds that reside within them. These include the Bacalar Chico Marine Reserve and National Park, the Caye Caulker Forest and Marine Reserve, and Gra and Sarstoon-Temash national parks.

Recommendations

We clearly need to know more about the current status of colonial waterbirds, especially the tern and gull colonies that once flourished on the outer cayes and the long-legged waders that nest on mangrove cayes closer to shore, before we can begin to understand the nature of threats to their continued presence, the efforts needed to protect them and stabilize their populations, and the best strategies for their recovery. The following recommendations are proposed:

1. A comprehensive inventory of all the cayes likely to support colonial waterbirds is a mandatory first step.

2. Increased enforcement in existing protected areas is also critical in order to protect existing populations. Even innocent trespass into a colony during the early stages of nesting can result in the entire colony being abandoned for the season.

3. Educational programmes in schools, along with community-based programmes, should be intensified and expanded. Without the benefit of environmental awareness programs in the schools and college-level programs, the cycle of misinformation and ignorance of environmental issues will only continue.

4. Belize has a solid foundation in environmental regulation, and the infrastructure for public participation in the environmental review process has been in place for many years. But past performance on potentially destructive developments has demonstrated that the system of environmental review and regulation can be broken. The mechanisms for implementing and enforcing these environmental safeguards must be strengthened for them to be meaningful. But a public that is ignorant of, or easily misled on, environmental issues will never support these steps, another reason that environmental education is so crucial to Belize's future.

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Sharks and Rays

Rachel T. Graham

Introduction

Sharks, rays, skates and chimeras, collectively known as Chondrichthyans, are vital components of healthy and functional marine ecosystems and play key roles in structuring fish communities and fostering reef resilience (Newman et al. 2006). Their populations, however, are in global decline due to fishing pressure (Stevens et al. 2000; Baum et al. 2003; Baum & Myers 2004). Coupled with chondrichthyans life history characteristics of slow growth, late maturity and low fecundity, chondrichthyans are vulnerable to overexploitation and in dire need of management (Camhi et al. 1997; Musick et al. 2000). Poorly controlled developments of coastal and marine habitats are further impacting chondrichthyans' nursery habitats. Belize is no exception to the global decline in chondrichthyans and coastal habitats. Increased market demand for shark products from the neighbouring countries of Guatemala, Honduras and Mexico, as well as Asia, coupled with a lack of shark specific regulations have led to population declines and distributional shifts of Belize's chondrichthyans (Graham 2007a).

Information on chondrichthyans diversity, abundance, distribution, current exploitation levels, habitat use, and movement throughout their lifecycle has increased considerably in Belize over the past decade. Key findings from scientific studies on sharks and rays conducted to 2010 are summarized in this report. Following an assessment of the Caribbean region is believed to host 151 species of chondrichthyans (Kyne et al. 2012) of which Belize hosts at least 42 species of which six are listed as threatened with extinction per the Red List assessment by the International Union for the Conservation of Nature (IUCN) initiated in 2004. Threatened species include the great and scalloped hammerheads (*Sphyrna mokarran* and *S. lewini* respectively) Red Listed as "Endangered". The whale shark (*Rhincodon typus*) is listed as "Vulnerable" and the Caribbean electric ray (*Narcine bancroftii*) is so rare that it is now listed as "Critically Endangered". Most dramatically of all, two species of sawfish that were formerly abundant in Belize, *Pristis perotteti* and *P. pectinata*, are both Red Listed by IUCN as "Critically Endangered". Now considered ecologically extinct, and possibly regionally extinct, there have been no verifiable sightings in over 18 years, with nets cited as the cause of their demise (Graham 2012).

Chondrichthyans can be encountered throughout the coastal and estuarine, lagoon, coral reef and deep-water habitats of Belize. The most abundant species of chondrichthyans based on landings surveys and fisheries-independent surveys combined include the Caribbean reef shark (*Carcharhinus perezi*), the Caribbean sharpnose shark (*Rhizoprionodon porosus*), the nurse shark (*Ginglymostoma cirratum*) and the southern stingray (*Dasyatis americana*). While Belize still possesses much of the habitat considered essential for these species, results from field and fisher surveys and comparisons with historical literature indicate that sharks are now scarce where they were once abundant, with nets cited as the primary gear used for shark fishing followed by longlines (Graham 2007a).

Management of chondrichthyans in Belize has relied primarily on general fisheries management measures of gear regulation, such as the restriction in the number of nets and sized mesh, and prohibition of longlines and nets within the network of Belize's 13 marine protected areas. Marine protected areas are widely recognized as a primary means of stemming the decline of commercial fish species (Roberts 1995), and an increasing body of work is demonstrating that MPAs can have a protective effect for sharks. Monitoring of shark populations at Glover's Reef Atoll has suggested that small MPAs may be helpful as a tool for conservation of certain shark species notably the Caribbean reef shark and the nurse shark (Chapman et al. 2005), whereas connected networks might be required for very large and highly migratory species such as the whale shark (Graham 2007b). Of the 14 MPAs, eight further include management actions that focus on sharks and rays with the Gladden Spit and Silk Cayes Marine Reserve enforcing MPA-specific regulations related to the critical feeding habitat and management of whale shark in particular. Assessment of the use of MPAs by sharks in areas where shark fishing is still relatively low thus becomes particularly important in understanding whether MPAs are effective shark conservation tools.

Belize has passed shark-specific legislation with whale sharks declared a protected species in 2003 (GoB 2003; Graham 2007b) followed by the nurse sharks in 2011. Belize has now established a closed season for shark fishing between 1 August and 31 October (GoB 2011), which coincides with the peak storm and hurricane season. The wasteful practice of finning, whereby the shark's fins are cut off and the animal discarded – often alive, has been banned in Belize and in Belize-registered high seas vessels in 2011 (GoB 2011). Belize recently proposed to the International Commission to Conserve Atlantic Tuna (ICCAT) a finning-ban for shark fisheries in the Atlantic, requiring landing of sharks with fins fully or partially attached. Although unsuccessful in 2011, ICCAT countries, including Belize, agreed to no retention of bigeye thresher sharks (*Alopias superciliosis*) and supported an agreement for no exports of products from hammerheads (*Sphyrna* spp.) captured commercially. In November 2011, Central American countries including Belize, agreed to a regional finning ban (OSPESCA 2011).

Research Activities 2003-2010

Belize is fortunate to have a strong research focus on sharks compared to its Central American and Caribbean neighbours. Research has been led by The University of York, The University of Exeter and the Wildlife Conservation Society (WCS) who have focused on Coastal Belize including the Barrier Reef, Turneffe Atoll and Lighthouse Reef, and Stony Brook University (SBU) who have conducted their studies primarily at Glover's Reef and Turneffe Atoll. Primary partners include the Department of Fisheries and the University of Belize and in-country NGOs co-managing MPAs. Research on sharks and rays only began in the late 1990s with a focus on whale shark at Gladden Spit (1998-present), Glover's Reef Atoll (2000-present) and throughout the country's barrier reef and coast (2004-present). Whale shark research conducted by Graham while at the University of York, focused on population demographics, site fidelity and migratory behaviour of animals in relation to a predictable pulse of food. Glover's Reef Atoll research, initially conducted by Pikitch and Chapman while at WCS and transitioned to the Pew Institute for Ocean Sciences (PIOS) and then to SBU, has focused on the population and behaviour of Caribbean reef sharks and nurse sharks as well as the importance of the marine protected area to the shark population. Coastal and

barrier reef research was instigated by WCS in 2006 with a broad Southern Belize assessment that included Southwater Caye Marine Reserve (MR), Gladden Spit and the Silk Cayes MR, Sapodilla Cayes MR, Port Honduras MR and the Sartsoon Temash National Park (NP) and the Paynes Creek NP. In 2007, WCS expanded shark research eastwards to Lighthouse Reef Atoll and northwards to the region encompassing Corozal Bay Wildlife Sanctuary, Bacalar Chico MR, Hol Chan and Shark Ray Alley MR, and Caye Caulker MR. Both SBU and WCS are working at Turneffe Atoll and Southwater Caye MR. MarAlliance, a new NGO, is currently leading shark and ray research in Belize.

Whale shark research initiated at Gladden Spit in 1998 led to the documentation of a unique phenomenon of sharks feeding on snapper spawn (Heyman et al. 2001) that has not been documented elsewhere to date. A comprehensive study undertaken by the University of York from 1999 to 2004 yielded new insights into the population, site fidelity, spatial ecology, and behaviour of whale sharks (Graham 2003). At least 521 whale shark encounters were recorded from the research inception to April 2003 yielding a total of 106 identified animals. Of these 86% were sexed as juvenile males. The lack of females was supported by the sighting of only eight individuals during the study period. From 1999 to 2002, 70 sharks were tagged with marker tags. The mean total length (TL) of marker tagged whale sharks was 6.0 m ± 1.6 SD, also composed predominantly of juvenile males (Graham & Roberts 2007).

The use of acoustic tags revealed strong intra-seasonal and inter-annual site fidelity of tagged whale shark to Gladden Spit. The timing of visitation coincided with the lunar-entrained spawning of the dog and cubera snappers (*Lutjanus jocu* and *L. cyanopterus*). Satellite pop-up archival tags (PSATs) deployed from 2000-2002 and smart satellite position only tags (SPOTs) deployed in 2003 and again in 2010 revealed movements away from the spawning aggregation site to other sites on the Belize Barrier Reef and atolls with occasional transboundary movements to other feeding sites in Mexico and Honduras (Fig. 1) (Graham 2007b; Graham et al. 2007). Time spent by acoustically-tagged sharks at other locations in Belize, including six other documented spawning aggregation sites, suggests that Gladden Spit is the only spawning site where whale shark aggregate for significant amount of time in relation to spawning fish (Graham 2003). PSAT tags revealed deep diving behavior in whale sharks, to over 1500 m, withstanding temperatures of 4.6^{0}C as well as strong circalunar (about a lunar month), circadian (about a day), and ultradian (within a day) rhythms associated with diving (Graham et al. 2006a).

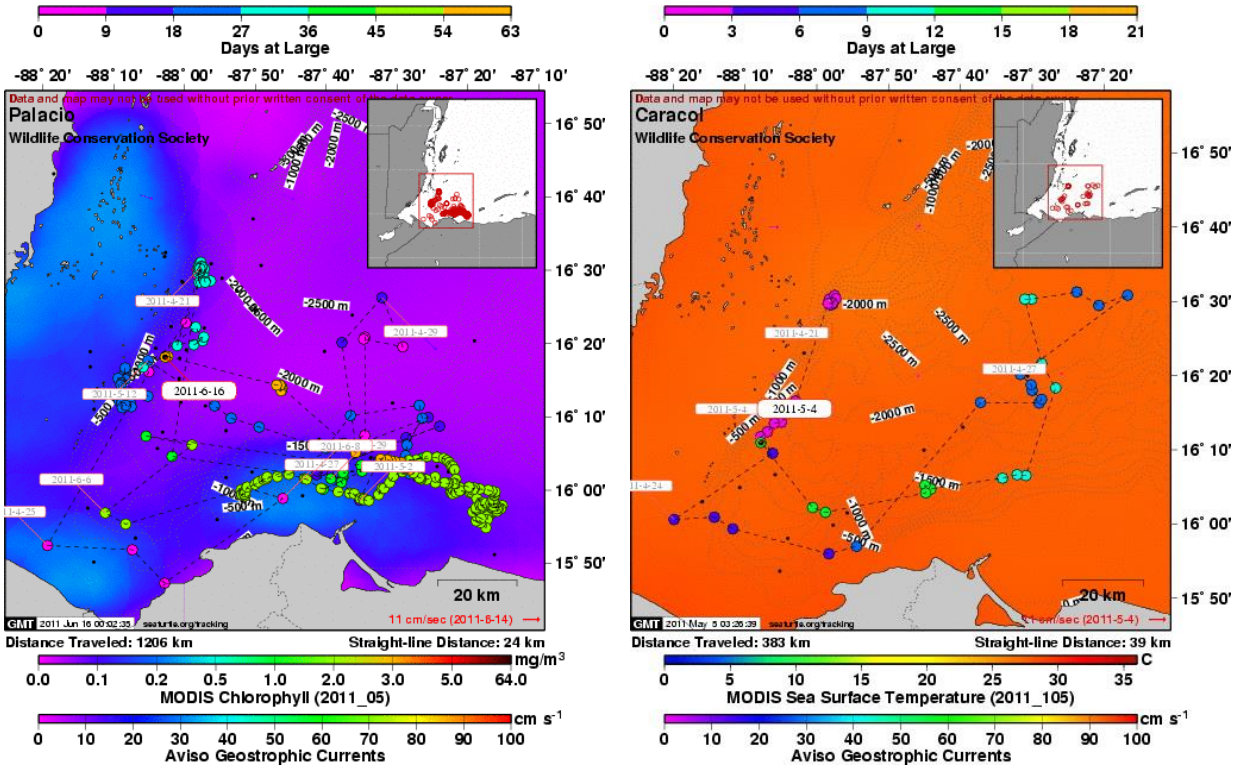

Figure 1. Map of movements for the whale shark "Palacio" (1.A.) and "Caracol" (1.B.) tagged by Graham with a SPOT5 tethered tags. Both sharks spent several days at Gladden Spit, moved to another feeding site near the Sapodilla Cayes before foraging broadly throughout the Gulf of Honduras in the territorial waters of Guatemala and Honduras, and then returning to Belize.

Fisheries-Independent Chondrichthyan Surveys

The first reef-associated chondrichthyan surveys conducted in Belize took place at Glover's Reef Atoll from 2000 onwards. Annual surveys conducted between 2000 and 2005 yielded 12 species of chondrichthyans with Caribbean reef sharks dominating the fore-reef areas and nurse sharks dominating deep and shallow lagoon habitats. Male Caribbean reef sharks were found to mature between 150 to 170 cm and nurse sharks between 185 to 200 cm total length, respectively (Pikitch et al. 2005). Chapman (2007) documented diving behaviour in Caribbean reef sharks at Glover's reef with satellite pop-up archival tag deployments of 7 to 20 days duration. Larger individuals spent more time above 40m depth at night and descended to deeper depths (356 m) withstanding a broad temperature range between 31 to 12.4°C. A five month passive acoustic tracking study conducted with five Caribbean reef sharks and 25 nurse sharks at Glover's revealed smaller distances travelled and partial site fidelity of nurse sharks to the atoll's protected Conservation Zone as compared to larger distances and broader roaming patterns demonstrated by Caribbean reef sharks (Chapman et al. 2005).

Chondrichthyan surveys subsequently conducted throughout Southern Belize by WCS from Tobacco Caye south of Dangriga to the Guatemalan border yielded 11 species of chondrichthyans (8 sharks and 3 rays) and lower catch per unit effort than at Glover's or at Lighthouse Reef Atoll.

Spatial differences in catch levels of blacktip sharks (*C. limbatus*), nurse sharks, Caribbean sharpnose sharks and Caribbean reef sharks provided insights into habitat partitioning by these species (Graham 2007). This study also demonstrated a significantly higher catch per unit effort inside of marine protected areas suggesting that marine protected areas provide a degree of protection for chondrichthyans regardless of enforcement levels.

At Lighthouse Reef Atoll, shark surveys conducted between 2007 and 2010 show that the population of captured sharks is dominated by small size classes or juvenile animals. The dominant small size class (81-100 cm) suggests strong recruitment and survivorship of neonates and young of the year (YOY) animals (Fig. 2). The standardized annual longline surveys conducted throughout the atoll over the course of four years shows an increase in catch per unit effort of chondrichthyans between 2007 and 2010, from less than 0.2 to 0.4 sharks 100 hks^{-1} hr^{-1}. This suggests that sharks are slowly recovering at the atoll, and that work conducted with the Belize Audubon Society rangers, as well as greater awareness and vigilance by guides has led to a decrease in fishing pressure for sharks especially by transboundary fishers.

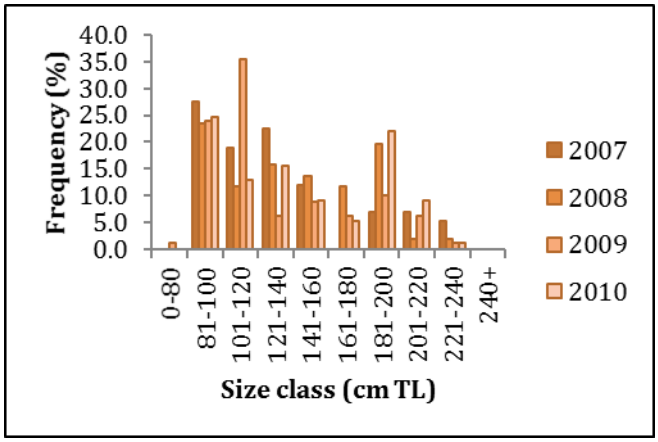

Figure 2. Size frequency of Caribbean reef sharks captured at Lighthouse Reef Atoll during annual surveys, between 2007 and 2010.

The diversity, abundance and distribution of rays in Belize is poorly known despite an increase in fisheries pressures and these species' vulnerability to bottom set nets. Belize hosts at least 11 species of rays belonging to six families. The smalltooth and largetooth sawfish belonging to the family Pristidae, were once abundant throughout Belize and are now considered ecologically if not fully extinct and were never sighted or captured during surveys throughout Belize. Captured as part of annual shark assessments, the four most commonly encountered species of ray include the widely distributed and highly abundant southern stingray, the yellow spotted ray (*Urobatis jamaicensis*), the IUCN Red List "Data Deficient" Caribbean whiptail stingray (*Himantura schmardae*) (Fig. 3), and the coastally constrained and estuarine longnose stingray (*D. guttata*). Specific studies on their populations, behaviour and habitat or environmental preferences were not implemented until 2009 in Glover's Reef Atoll (WCS/University of Bangor), Lighthouse Reef Atoll,

Figure 3. Researching one of the region's largest rays. The Caribbean whiptail stingray can reach up to 2 m in disc width.

and the Barrier Reef (WCS/University of Exeter). Results from the Coast and Barrier Reef as well as Turneffe Atoll are forthcoming. The Lighthouse Reef Atoll hosts all stages of these four species' life cycle (pup to mature and reproducing adults). Repeated in-water transect surveys revealed higher abundances on western fore-reef habitat (CPUE 2.1 rays person^{-1} hr $^{-1}$), that provides a mixture of sand and coral providing suitable, sheltered habitat. The lowest abundance was found on the eastern fore-reef, which provides less suitable sandy habitat (Fig. 5). Results are pending for the country-wide survey of rays conducted by WCS/University of Exeter in 2012.

Mercury Contamination in Sharks

Tissue samples from sharks landed through the fishery in Southern Belize, Belize City, and Lighthouse Reef Atoll revealed that at least 87% of 11 species of sharks sampled throughout Belize (n=172, Fig. 4) exceeded 0.3 ug/g wet weight of mercury in the muscle tissues in lab analyses conducted by WCS working with NOAA, the University of Connecticut and the Biodiversity Research Institute (USA). This level represents the USEPA maximum recommended amount of mercury to be ingested by adults. However, this amount also exceeds the recommended 0.12 parts per million recommended for pregnant women and children. Lighthouse Reef Atoll, Belize's most remote reef site, yielded above the USEPA level of mercury in 39 of the 42 sharks (93%) sampled across five species (Fig. 8). Surprisingly, the levels of mercury in nurse sharks, a mid-level predator with a major draw for tourism and listed as a protected species in Belize in 2011, were also above USEPA acceptable levels and therefore unsafe to eat. Mercury levels also correlated in some species (blacktip and nurse sharks) with increasing shark size (n=165, r=0.687, P<0.001) (Evers et al. 2008). Ascertaining point sources of mercury and whether these are anthropogenic or natural in nature (or both) will provide the necessary information to develop mitigation measures if the sources are anthropogenic, and avoidance measures if natural. Meanwhile, study results and the impact of mercury in sharks to consumer have been televised in Belize through the medium of the documentary "Where have our Sharks gone?[1]" to raise awareness of the issue and help people make conscious food choices and preferably avoid shark meat.

[1] *Where Have Our Sharks Gone?* Produced by Carol & Richard Foster and Rachel Graham - view on YouTube or Vimeo at stations named "BelizeSharks" or "MarAlliance".

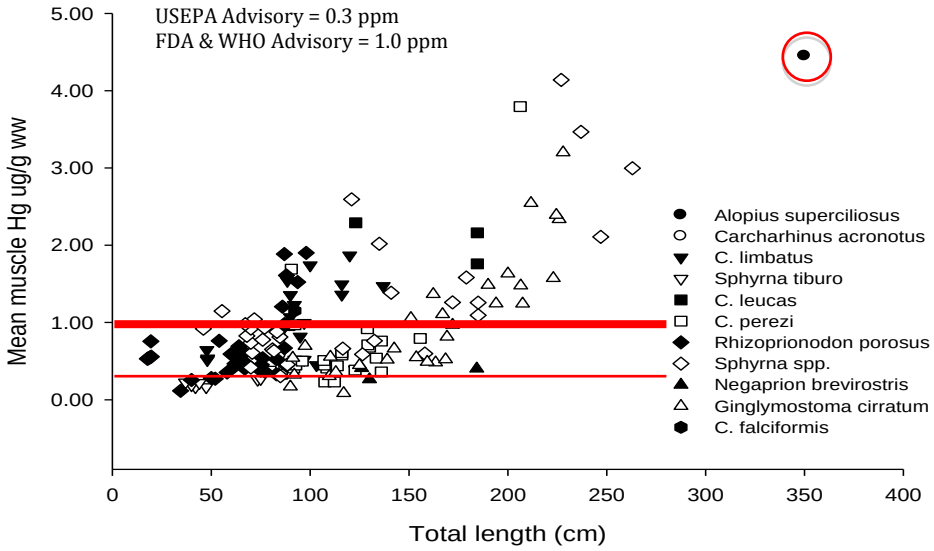

Figure 4. Mercury levels recorded in 172 chondrichthyans of 11 species sampled throughout Belize. The outlier circled in red is the bigeye thresher shark captured on the BBR and brought to the Belize Vernon Street Market in February 2008. This animal registered an order of magnitude greater level of methyl mercury than the majority of the samples. The red lines indicate the two mercury advisory levels, USEPA (thin line) and FDA/WHO (thick line).

Although alarming, the results are not wholly unsurprising as sharks are apex predators that biomagnify toxins including heavy metals such as mercury due to the many food chain linkages existing in the marine environment. Absorption of large pulses of mercury and continued ingestion above the advisory levels impacts cognitive abilities, memory, depresses serotonin levels leading to depression and aggression and can severely impact foetal development. Affected foetuses suffer permanent damage to brain cells leading to, on the least problematic scale, future problems associated with learning, weakened attention spans and anger management among others[2]. FDA advisories suggest that pregnant women should avoid eating fish such as shark, king mackerel and not eat more than two meals of fish or shellfish of lower mercury content a week (no more than 12 ounces)[3]. However, these advisories are considered too high for pregnant women and young children with suggestions that 0.12ppm would be the acceptable threshold for these groups. Additional samples are currently under analysis to determine the breadth of the mercury contamination throughout the trophic levels. We hope to identify point sources of mercury, either anthropogenic or natural, if these exist. With these data in hand we will be well placed to develop advisory levels on fish consumption on a species basis for Belize. Meanwhile it is advisable to not eat shark meat, a suggestion that mirrors the FDA's advice for the Gulf of Mexico.

[2] For rapid facts on mercury exposure and impacts, visit: http://www.mercuryexposure.org/
[3] For more information on recommended consumption levels for certain species of fish visit: http://www.cfsan.fda.gov/~dms/admehg3.html

Shark and Ray Tourism

Chondrichthyans constitute an important component of marine tourism in Belize. A survey conducted in 2002 with visitors to the Gladden Spit and Silk Cayes MR and its world-renowned whale shark aggregation yielded a value of US$3.7 million in income to Belize for a six week whale shark season (Graham 2003; Graham 2004). Belize's whale shark tourism is now managed by the Southern Environment Association (SEA), the co-managers of Gladden Spit. Due to the transboundary and thus shared nature of the whale shark population, guidelines and/or management of the tourism activities have been implemented in Mexico and Honduras (Graham and Bustamante 2007). More recently, combined receipts from the visitation of Hol Chan's Shark Ray Alley and Lighthouse Reef Atoll's Blue Hole, also known for predictable encounters with Caribbean reef sharks, topped US$1 million based on 2008 Belize Tourism Board figures with total revenue based on tour and travel costs expected to yield significantly more income for Belize. By comparison, the Bahamas, with its well-developed shark tourism and recently declared protection for sharks, generates over US$73 million in tourism from shark dives (Gallagher and Hammerschlag 2011). This would indicate that sharks and rays are considerably more valuable to Belize as a tourism attraction and for promoting coral reef resilience than as a fishery. With effective protection for sharks and rays, Belize could easily become the Caribbean's premier shark-diving destination.

Strengths & Weaknesses of Research & Management in Belize

Belize has a relatively well-developed chondrichthyan research program compared to other Caribbean-facing Central American countries and neighbouring Mexico's Quintana Roo. As several of the species of sharks studied to date are highly migratory, development of a standardized research protocol throughout the region would help to monitor populations and compare country conservation performance in relation to established management and legislation. General awareness for shark management and conservation in Belize has increased over the past decade and MPA managers have been responsive through the integration of shark specific measures in site management plans. However, marine reserve staff continues to struggle to deliver effective enforcement, as netting and longlining conducted principally by fishers from neighbouring countries continue to infringe MPA boundaries. Management of chondrichthyans and strengthening of the species bans e.g., nurse sharks (GoB 2011), could be strengthened through a decrease in fishing pressure, greater enforcement of MPAs and regulations and prohibition of destructive gear types (nets and longlines). These measures combined will help to stem and ultimately reverse shark population declines.

Iterative updating of management measures by the non-governmental organization SEA have effectively kept whale shark tourism in check at Gladden Spit in light of the species' variable seasonal visitation. Results from research conducted at Gladden Spit, Glover's Reef Atoll and seven other marine reserves have been integrated into management plans and national legislation. A National Plan of Action for Sharks exists and will likely be revised to integrate the research results gleaned over the past six years. Internationally, Belize is party to the Convention on the International Trade in Endangered Species (CITES), and party to several Regional Fisheries

Management Organisations (RFMOs) including the Inter-American Tuna Commission (IATC), the International Commission for the Conservation of Atlantic Tuna (ICCAT) and the Indian Ocean Tuna Commission (IOTC). Continued support for shark-friendly legislation at RFMO meetings and application of laws to its high seas vessels will reduce shark bycatch and illegal, unregulated and unreported (IUU) fishing of sharks. Belize flagged high seas vessels have been repeatedly accused of IUU fishing and in several instances apprehended illegally landing fins or finned sharks, thereby attempting to circumvent finning bans and landings legislation[4].

Effectiveness of Related Working Groups

A Shark Advisory Working Group (SAWG) formed by The Department of Fisheries in 2005, met twice to review the draft National Plan of Action for Sharks in Belize. The group encompassed three representatives from the Fisheries Department, one representative from Northern Fishermans' Cooperative, and one NGO representative. Despite their value for tourism, fish, and reef resilience, chondrichthyans are not a clear priority for the Department of Fisheries whose domestic focus remains fixed on commercial stocks such as conch and lobsters. The SAWG has not met since 2006. A newly constituted SAWG is now needed to encompass more stakeholder groups, update the National Plan of Action, and implement activities in a coherent, effective, and timely manner.

Health of Belize's Shark Populations Compared with Neighbours

There are no comparable studies conducted on sharks and rays in the region, particularly along the Caribbean coast. Fishers originating from Guatemala, Honduras and Mexico regularly fish in Belizean waters with a focus on shark capture during the pre-Lenten season prior to Easter, suggesting that shark stocks have significantly declined in these countries' territorial waters. However, fishers surveyed on perception of shark abundance have indicated that sharks are not only more scarce but also smaller in size (Graham et al. 2006b), suggesting that even in Belize the shark stocks have declined considerably since abundance estimations stated in historical reports (Thompson 1944; Dres 1964). A Caribbean-wide diver-based survey suggests that the region, including Belize, possesses a very low abundance of sharks with the exception of the Bahamas (Ward-Paige et al. 2010).

[4] http://news.co.cr/shark-fin-poaching-in-costa-rica-results-in-hefty-fine-for -captain/5701/

Recommendations

To rebuild shark populations in Belize, a combination of chondrichthyan-specific regulations coupled with gear bans will be necessary. Specifically, we recommend the following:

1. Establish a viable and effective Belize-based shark working-group that encompasses representatives of all stakeholder groups including fisheries, tourism, academia, conservation groups.

2. Prohibit the use of nets and longlines throughout Belize and prohibit the capture and sale of chondrichthyans and their products.

3. Rescind shark fishing permits and limit or suspend the number of export licenses for salted fish.

4. Harmonize shark laws with neighbouring countries to help regulate transboundary trade and foster collaborative and standardized research.

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Effectiveness of the Marine Protected Area System

IUCN's defines a protected area as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural value."

Belize augments the management of fisheries stocks, other marine creatures, and reef habitats through a system of marine protected areas, and the Belize Barrier Reef Reserve System is globally recognized as a World Heritage Site represented by seven reserves.

MPA management is largely under the Fisheries Department, although a few are managed under the Forest Department. Most marine protected areas are managed with a partner agency. The following section looks at the Government and Co-management perspectives of MPAs.

Effectiveness of Marine Protected Areas - Fisheries Department Perspective

James Azueta

The concept of protected areas is not new to the Caribbean Region. Various categories have existed for over 200 years, such as *nature preserves* and *natural monuments*. The categorization depends on various criteria including management objectives, preservation of endangered species, protection of watersheds etc. Under the World Conservation Union (IUCN) classification there are eight categories of protected areas: i) Strict Nature Reserve/Scientific Reserve, ii) National Park, iii) Natural Monument/Natural Landmark, iv) Managed Nature Reserve/Wildlife Sanctuary, v) Protected Landscapes and Seascapes, vi) Resource Reserve, vii) Anthropological Reserve/Natural Biotic Area, viii) Multiple Use Management Area/Managed Resource Area.

The Legislative authority to declare MPAs in Belize falls under two ministries: the Ministry of Forestry, Fisheries and Sustainable Development and the Ministry of Tourism. Depending on what category an area will be classified under will determine if the Forest Department, the Fisheries Department or the Archaeological Department will enact the legislation. The Forest Department is responsible for the National Park System Act and the Forest Act which encompass national parks, natural monuments, wildlife sanctuaries, nature reserves, and forest reserves. The Fisheries Department implements the Fisheries Act which declares marine reserves; and the Archaeology Department has the Antiquities Act which can declare marine archaeological sites, though none have been declared to date. The legislation that is used to declare MPAs is an extension of Forestry laws, Fishery laws, and the integration of new multiple-use concepts for marine reserves.

The marine protected area network in Belize is composed of marine reserves, national parks, natural monuments and sanctuaries. These areas, and the addition of the proposed Turneffe Atoll Marine Reserve and Ambergris Caye Marine Reserves Cluster, will cover about 20% of Belize's entire maritime area. The most common marine protected area in Belize is the marine reserve which is multi use. The general-use zone commonly consists of about 80%, with the conservation zone consisting of 15% and preservation zone 5% - some exceptions include the Port Honduras MR, Gladden Spit MR and Sapodilla Cayes MR. Figure 1 shows all coastal and marine protected areas in Belize as of 2011.

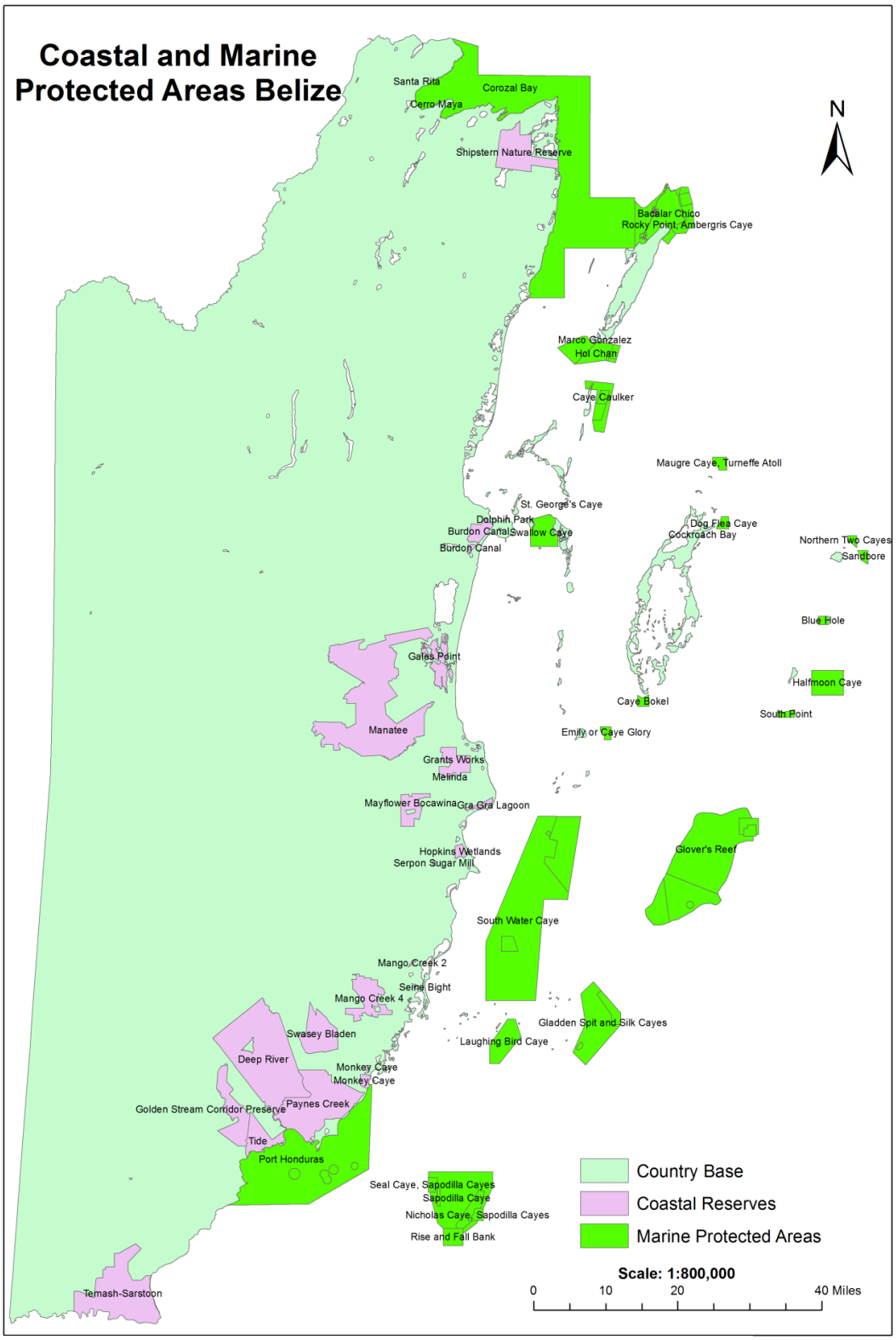

Figure 1 Marine and coastal protected areas of Belize

The benefits of protected areas are many and have been documented, particularly in the fisheries sector. Some benefits are increased spawning stock biomass that provides greater fauna replenishment, spill-over that enhances local catches, insurance against uncertainty, increased

predictability of catches, reduced problems of multi-species management, easier enforcement, greater equity among fishers, and greater public understanding of management. In Belize marine protected areas are proven to perform well and have shown rapid build-up of fish biomass with larger fish than those outside the protected areas to produce more offspring. The most valuable species tend to respond strongly to marine protection. For example, conch and lobster densities were found to be higher in the Hol Chan Marine Reserve than the non-protected area of Mexico Rocks that has similar habitat types (Fig. 2).

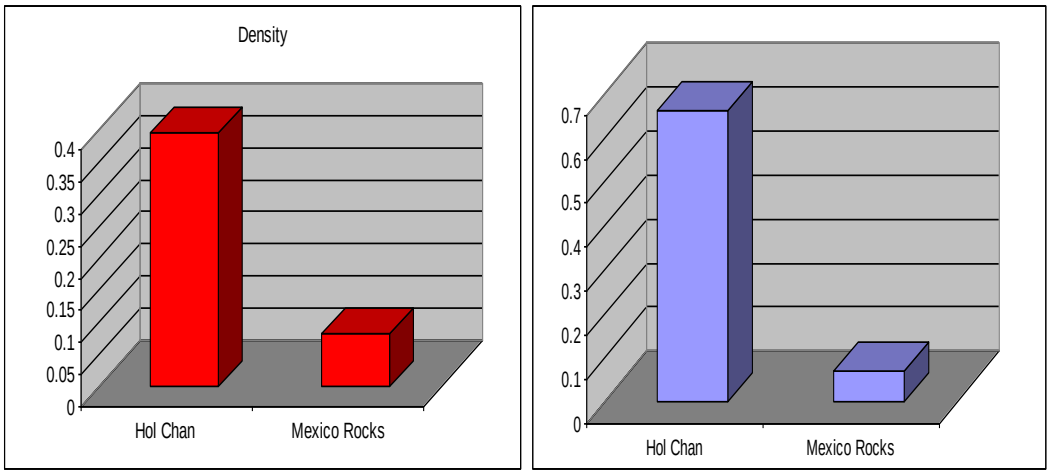

Figure 2. Conch (red) and lobster (blue) density (number per square meter) inside an MPA (Hol Chan MR) and outside an MPA (Mexico Rocks).

MPAs address tourism impacts such as anchor damage, physical damage to ecosystems (corals), garbage production, and specimen collections. They further address unregulated coastal development that includes illegal dredging, illegal cutting of mangroves and destruction of habitats, although these activities have occurred in MPAs. MPA management can curb illegal fishing and overfishing, and through Fisheries legislations, shifting fishing targets to other species, and reducing overfishing of algae grazers.

Marine protected areas also encourage the monitoring of sources of pollution such as sewerage, nitrates from fertilizers, toxins from pesticides, chemicals from agricultural practices, and sedimentation from land use practices, and furthermore, monitoring the effects of climate change. Rising temperature causes ice deposits to melt thus increasing sea level, which will in turn result in coastal flooding, salt water intrusion into aquifers, and the displacement of species. Rising carbon dioxide levels cause acidification of oceans and rising temperatures increase the incidence of hurricanes, cause coral bleaching and promote coral disease. MPAs promote global, regional, and functional protection.

What do we have in Belize? Globally, Belize is recognized as a "leader" in MPA establishment and management. Management effectiveness was ranked "moderately satisfactory" as was stated in

2000 study of four MPAs. From that study, further recommendations were implemented and management effectiveness in 2008 showed that Hol Chan, as an example, was "highly satisfactory". There are several organizations and individuals that evaluate Belize MPAs; there have been evaluations by the University of the West Indies' Centre for Research Management and Environmental Studies (CERMES), the University of Rhode Island, and the Association of Protected Areas Management Organization (APAMO). These studies showed that MPAs are properly managed and are meeting their objectives.

The success of marine protected areas in Belize depends on existence and implementation of legal frameworks, general support by local people through education and participation and an effective and well-supported management system (Parker 1986). The Government of Belize cannot by itself finance the machinery it is creating to implement long-term management and monitoring of the use of MPAs, and co-management has therefore been an important management strategy. The operation of this machinery is crucial and depends on continued training of management staff, adequate equipment for surveillance and monitoring, regular monitoring of tourists and their impacts, implementation of environmental educational aspects, provision of maintenance of facilities and services, enforcement of regulations, and periodic reviews of management plans.

Recommendations

1. Full implementation of the National Protected Areas Systems Plan.

2. Finalize the rationalization of the marine protected areas.

3. Work towards sustainability of the marine protected areas.

4. Implement more needed legislation.

5. Increase the training of protected areas staff.

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Acknowledgement

Thanks to Miss Yamira Novelo who transcribed this report from Azueta's presentation at the State of the Coastal Zone Summit 2012.

Effective Management of the Belize MPA System - NGO Co-Management Perspective

Association of Protected Areas Management Organizations

Introduction

Historically, conservation efforts in Belize have been primarily led by civil society and grass root movements. The Government has encouraged a co-management approach with local NGOs and community based organizations (CBOs) primarily as a result of human and budgetary constraints. However, rather than a true partnership with the NGOs and CBOs, Government's limited support and in some cases lack of support, resulted in more of a delegated management rather than a true co-management of protected areas.

Marine Protected Areas (MPAs) play a key role in Belize's marine conservation efforts. They are part of a broader conservation planning process currently underway to develop a national protected areas system. In 2005, Government reaffirmed its commitment to co-management as the preferred protected areas management option through its endorsement of the Belize National Protected Areas Policy and System Plan (Meerman 2005) that provides support to a co-management framework.

Local NGOs and CBOs provide the much needed services in the financing and management functions of nine out of thirteen MPAs (Table 1). They have contributed to increased stakeholder participation and support for the protected areas system, as well as increased access to international funding sources, not available to state agencies. Over the past three decades, MPA management has become a major employer in Belize providing a broad and growing range of local employment. It is especially notable that many young persons are attracted and committed to working in protecting the marine heritage of Belize with no shortage of new entrants to the workplace every year (personal observation M. Vega).

A recent assessment of the management effectiveness of protected areas in Belize, led by the Association of Protected Areas Management Organizations (APAMO), demonstrated that co-management increases the probability of improved management effectiveness. Of the nine co-managed MPAs three are rated very good with scores of above "3", while only one out of four under Departmental management has a similar rating (Table 2). This reflects the investment in human resources and equipment, and management processes established within the co-managers regime. Overall, the MPAs of Belize averaged a score of 2.52 (63.0% - GOOD) for ecological integrity and the remainder of the MPAs scored above 2 (2-3 MODERATE) for management effectiveness (APAMO 2009).

One of the main problems facing the effective management of MPAs is the lack of adequate resources for proper enforcement. Funding is greatly needed to develop adequate zoning plans, cover operational costs, secure necessary technical and human resources for enforcement,

implement monitoring and research programs to track the health of the ecosystems, and "building up" of education and awareness of both visitors and local communities alike.

Table 1. List of Marine Protected Areas in Belize[a]

No	Managing Organization	Co-managed	Protected Areas (PAs)	Size in Acres
1	Belize Fisheries Department	No	Bacalar Chico Marine Reserve	15,766
2	Belize Audubon Society	Yes	Blue Hole Natural Monument	1,023.10
3	Forest and Marine Reserve Association of Caye Caulker	Yes	Caye Caulker Marine Reserve	9,670.20
4	Sarteneja Alliance for Conservation & Development	Yes	Corozal Bay Wildlife Sanctuary	180,510
5	Southern Environmental Association	Yes	Gladden Spit and Silk Cayes Marine Reserves	25,978
6	Belize Fisheries Department	No	Glover's Reef Marine Reserve	86,653
7	Belize Audubon Society	Yes	Half Moon Caye Marine Reserve	9,771
8	Belize Fisheries Department	No	Hol Chan Marine Reserve	3,813
9	Southern Environmental Association	Yes	Laughing Bird Caye National Park	10,119
10	Toledo Institute for Development and Environment	Yes	Port Honduras Marine Reserve	100,000
11	Southern Environmental Association	Yes	Sapodilla Cayes Marine Reserve	38,594
12	Belize Fisheries Department	No	South Water Caye Marine Reserve	117,875
13	Friends of Swallow Caye	Yes	Swallow Caye Wildlife Sanctuary	8,972
	Total area under protection			**608,744.30**
	Total area under co-management			**384,637.30**
	% of PAs in co-management			**63%**

[a] APAMO 2009

Strengths and Weaknesses of Research and Management of MPAs in Belize

Government's delegated management rather than genuine co-management with the NGOs and CBOs has resulted in fundamental gaps in MPA management such as lack of consistent and effective patrolling and enforcement of regulations. Indicators show that surveillance and enforcement units of the marine protected areas, in partnership with the Belize Coast Guard, are stretched in their role of ensuring sustainable use of Belize's marine resources, with fishermen not yet fully engaged in the management of the marine fisheries sector (APAMO, 2009). In 2003, Pomeroy, R.S. and T. Goetze noted that the weaknesses in MPA management can also be attributed to Government's seemingly lack of commitment to MPAs as illustrated by the small budget allocated to the National Protected Areas Program, resulting in a lack of capacity of key government agencies responsible for management and co-management of MPAs, almost a decade later, this continues to be the case.

Nevertheless, despite a less than enabling environment a number of NGOs have made considerable strides. They have obtained funding and begun to take steps towards the effective management of the protected areas. NGOs have also helped to promote research and monitoring of site specific threats. Many of the larger NGOs such as SEA, TIDE and BAS contribute to national and regional scientific databases. In the assessment carried out by APAMO, marine reserves have the highest score in terms of resource information due to the fact that many of the marine reserves have up-to-date management plans and ongoing monitoring programs, providing information for effective management. Several marine reserves have also been included in system level planning initiatives, with identification and rigorous assessment of conservation targets and threats. Managers of the marine protected areas have developed good capacity in the areas of applied research and monitoring for biodiversity conservation (APAMO 2009). However, there is still significant room for improvement.

NGOs and CBOs have also played a key role in working with surrounding communities and resource users in providing the necessary awareness and environmental education at the community level. In some cases considerable efforts have been made to connect with specific resource users in a structured way that embodies co-management ideals. A case in point is TIDE's effort made to involve the fishers, tour guides, and other stakeholders in the management of MPAs through their stewardship program for the protection of the Port Honduras Marine Reserve.

In general, the older and well established APAMO members such as BAS, SEA and TIDE have ranger stations on site to facilitate the day to day operations such as patrolling, surveillance, research and monitoring, and visitor guide and management. Their research programs are established and incorporated into their respective management plans. However, while many of the research programs had data collection for ten years or more, less progress has been made in the analysis of this data to inform management decisions.

With the establishment of the Environmental Research Institute under the University of Belize, there is now a centralized data base collection and analysis system for the assimilation of field results with the aim to inform both site and system level management decisions. NGOs such as SEA and TIDE have strengthened their data base collection with the assistance of community researchers. The benefits of involving community researchers are paramount for much of the

marine protected area management. This strategy not only builds capacity at the community level but also provides an alternative source of income for community members in the tourism and fishing off seasons. As the community members work and learn through first-hand experience, they serve as local ambassadors for conservation work, and have better understanding and teaching skills through their laymen terms that are suitable for their respective communities. Two of the large NGOs are staffed with doctoral degree researchers. Although their tenure is generally short term, they fill a huge gap in human resource needs.

Across the board, a weakness in the system is a lack of funding for management implementation, including core costs and research activities. Without a robust funding mechanism, all the NGOs and CBOs fall short in the continuity of research work, expansion of research activities, hiring and retaining experienced and trained staff, staff capacity building, expertise in analyzing data and publishing results either for in-house use or general dissemination amongst organizations. Additionally, there is a need for equipment for research monitoring and site management such as surveillance and patrols, and for fuel - a very costly commodity without which all organizations will not be able to conduct their management activities. The CBOs lack the necessary facilities and rigorous management structures; however, efforts are being made to strengthen their capacities.

Table 2. Average scores for management effectiveness based on seven criteria[a]

	Protected Areas Co-managed	Overall Score for Management Effectiveness[b]
1	Bacalar Chico Marine Reserve	2.89
2	Blue Hole Natural Monument	3.39
3	Caye Caulker Marine Reserve	2.79
4	Corozal Bay Wildlife Sanctuary	2.17
5	Gladden Spit and Silk Cayes Marine Reserve	2.74
6	Glover's Reef Marine Reserve	2.95
7	Half Moon Caye Natural Monument	3.39
8	Hol Chan Marine Reserves	3.68
9	Laughing Bird Caye National Park	2.78
10	Port Honduras Marine Reserve	3.04
11	Sapodilla Cayes Marine Reserve	2.6
12	South Water Caye Marine Reserve	2.65
13	Swallow Caye Wildlife Sanctuary	2.01

[a]APAMO 2009
[b]Scoring Key: Poor: ≤ 1, Fair: > 1.00 – 2, Moderate: > 2.00 – 3.00, Very Good: > 3.00

Recommendations

Belize's MPA system is suffering from uneven funding and management. Government must play a more active role in co-management and provide support to protected area co-managers who are providing a critical service, on behalf of the government and people of Belize, in managing and safeguarding the integrity and diversity of Belize's protected areas. Greater investment in management of marine protected areas is necessary if the economic, social and environmental benefits provided by these parks are to be sustained. Further investment in monitoring and research to inform good management should also be a priority (Cooper et al. 2009).

1. Prioritize Protected Areas Management in national planning.
   - Practice sustainable development especially with regard to MPA's;
   - Strengthen independent institutions for integrated planning e.g. CZMAI;
   - Develop adequate zoning plans to aid in planning and development;
   - Enforce existing land-use and development regulations in the coastal zone.

2. Establish a framework to support the financial sustainability of the MPA system
   - Restructure PACT to provide direct funding for core costs to protected areas managers;
   - Implement a robust revenue collection system including a distribution process including but not limited to entrance fees, permits and license fees;
   - Subsidize and/or allow MPA managers to acquire fuel at a discounted rate or tax free;
   - Provide greater national investment in system-level support, provide greater fund allocation to the MPAs, and more fund allocation to the Government Agency (Fisheries Department) so that they can provide more enforcement, monitoring, and support to the co-managers. This is especially critical in the southern areas where there are issues of illegal fishing activities by fishers from the neighbouring countries.

3. Strengthen the capacity of the smaller and less experienced co-managers for effective management and project implementation, and strengthen the capacities of the Forest and Fisheries Departments to coordinate with and support the co-managers.

4. Invest in patrolling, compliance and enforcement of regulations.

5. Invest in monitoring and research programs to track the health of the ecosystems as well as in the "building up" of education and awareness of both visitors and local communities alike.
   - Invest in CZMAI, ERI and other science-based efforts to expand monitoring activities and assess the state and use of coastal resources.

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Climatic Events

Today planning schemes have to take into consideration stochastic events. While there are models for weather patterns, climatic events are unpredictable and can be devastating to coastal systems. Climate change adaptation is an emergent concept being examined for inclusion in Belize's management planning.

Unfortunately, extreme weather events such as hurricanes or drought are expected to increase in frequency and intensity, given future climate change models. This section examines Climate Change and Extreme Weather Events and their relation to the coastal zone.

Climate Change and the Coastal Zone

Carlos Fuller, Ann Gordon, and Nadia Bood

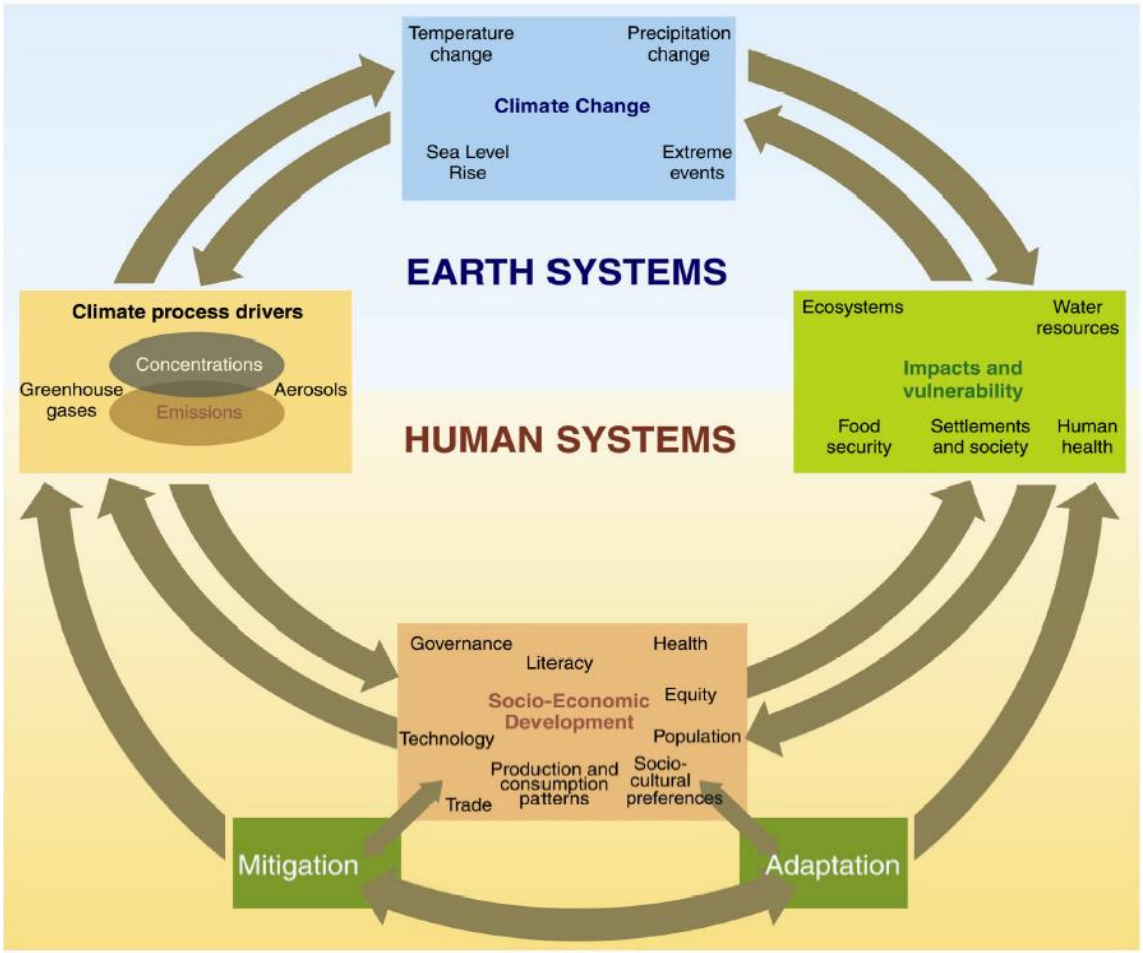
Background

The American Meteorological Society's Glossary of Meteorology defines climate change as "*Any systematic change in the long-term statistics of climate elements (such as temperature, pressure or winds) sustained over several decades or longer. Climate change may be due to natural external forces such as changes in solar emission or slow changes in the earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing*." Meteorologists have long recognized that climate is not static. As a result the climate of a region is always derived from the weather data of the past 30 years. As the definition indicates, climate change may be natural or anthropogenic. Anthropogenic forcing refers to the emission of greenhouse gases into the atmosphere caused by human activities such as the use of fossil fuels, agriculture, industrial processes and land use change. Natural climate change is produced by changes in the radiation emitted by the sun, changes in the orbit of the earth around the sun, changes in the tilt of the earth's axis, wobbling in the spin of the earth about its axis, and the internal processes by which the atmosphere/earth/water systems exchange energy.

Since 1850 or the advent of the industrial revolution, average global air temperatures have risen by approximately 0.7°C. This rise in temperature is unprecedented and has been attributed primarily to anthropogenic forcing, as categorized by the Intergovernmental Panel on Climate Change (IPCC), the authoritative body established by the international community to provide scientific assessments of climate change. The Fourth Assessment Report of the IPCC published in 2007 (IPCC 2007) and that garnered the Nobel Peace Prize for the IPCC, notes that climate change is changing the global weather patterns, producing more extreme and severe weather events, producing warmer seas, and causing sea level rise (Fig. 1).

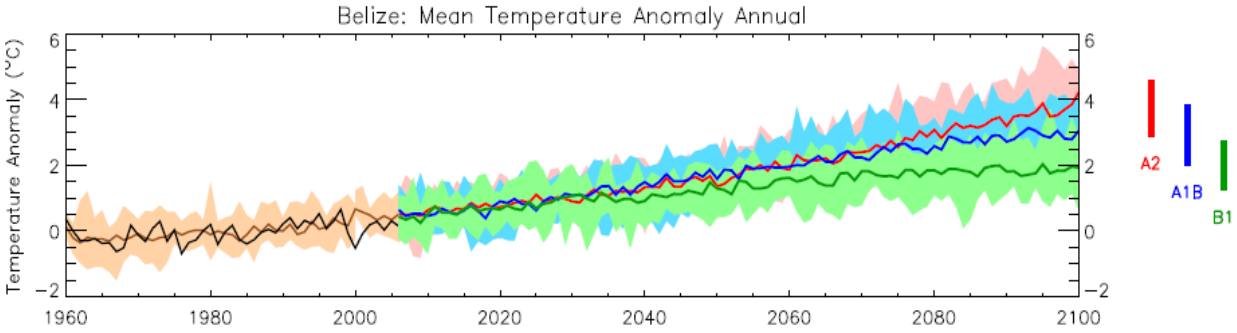
Analyses by the Belize National Meteorological Service shows that air temperatures in Belize have risen by approximately 1°C from 1960 to 2006 (Fig. 2). Most of the increase in temperatures has occurred during the night, i.e. the minimum temperatures are higher than they were forty years ago. While the maximum temperature has also risen, the rise is not as significant. Changes in precipitation have also occurred. However, it has increased in some locations and fallen in others. Sea surface temperatures in recent years have also been increasing, surpassing maximum monthly mean temperatures and are particularly evident during the summer months (Fig. 3). There are not enough data to quantify any changes in sea level offshore Belize.

Figure 1. Impact of human actions on global climate change



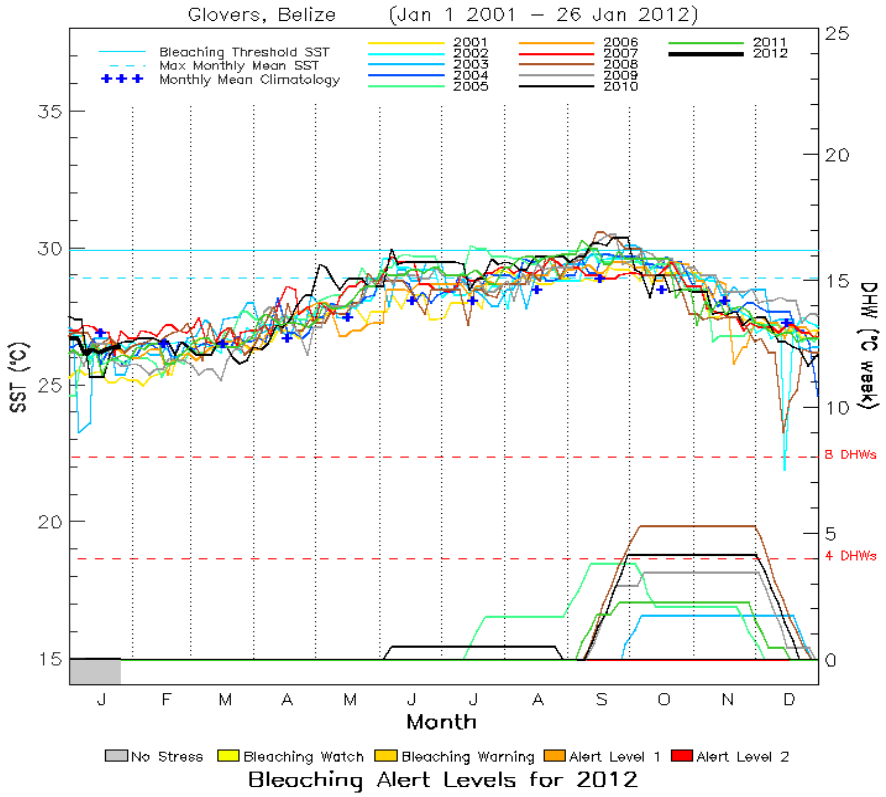
Source IPCC 4th Assessment Report – November 2007

Figure 2. Trends in annual mean temperature for the recent past and projected future. All values shown are anomalies, relative to the 1970-1999 mean climate. Black curves show the mean of observed data from 1960 to 2006, brown curves show the median (solid line) and range (shading) of model simulations of recent climate across an ensemble of 15 models. Colour lines from 2006 onwards show the median (solid line) and range (shading) of the ensemble projections of climate under three emissions scenarios. Colour bars on the right-hand side of the projections summarize the range of mean 2090-2100 climates simulated by the 15 models for each emissions scenario.



Source: UNDP Climate Profile Report for Belize (2008)

Figure 3. Multi-annual sea temperature variation at NOAA Satellite monitoring station offshore Belize.



Source: NOAA Coral Bleach Watch Satellite Monitoring
(http://www.osdpd.noaa.gov/data/cb/time_series/vs_multiyear_Glovers.png)

Importance of Belize's Coastal Zone to Climate Change

The coastal zone acts as a buffer between the sea and the mainland. Extending along its entire 150+ mile eastern boundary and several miles inland, especially in the north because of its low elevation, the coastal zone of Belize is quite extensive, and is home to the second longest barrier reef in the Western Hemisphere, swaths of mangrove and sea grass ecosystems, among others.

Belize's barrier reef breaks wave swells coming in from the Caribbean, thereby providing considerable protection to coastal beaches and the flora and fauna living on beaches, as well as offering physical protection to coastal communities, properties and infrastructure. Mangrove forests absorb carbon dioxide, stabilize the shoreline, and buffer impacts from waves that survived passage through the barrier reef and those waves generated by local weather. Seagrass beds reduce the albedo (proportion of reflected light) of the sea floor, enabling the grass to absorb solar radiation and mitigate some of the effects of climate change while also intercepting the movement of sediments. On the mainland, the coastal zone acts as a transition zone between fresh and salt water interfaces, both of which are highly important and in so doing creates an environment conducive for its own ecosystems, such as wetlands and estuaries. The coastal zone also acts as a moderating factor between the maritime climate and the more extreme continental climate of the Yucatan Peninsula.

Vulnerability of Belize's Coastal Zone to Climate Change

Coral reefs are very sensitive to changes in sea temperatures. Warm sea surface temperatures produce coral bleaching which can only be reversed if the sea temperature returns to normal fairly quickly. Sea surface temperatures nearing corals' threshold level of 30°C (and prolonged) often result in mass coral bleaching (McField et al. 2007; Figure 3). Several episodes of coral bleaching have occurred in Belize in the past few decades: 1995, 1998, 2005, 2008 and 2009 with varied impacts to reefs. Until the 1990s, Belize reefs were fairly healthy and had not been affected by mass bleaching events that were occurring in many areas of the Caribbean. The first mass bleaching event occurred in 1995 and was followed by two events in 1997 and 1998. The second bleaching event coincided with further destruction from Hurricane Mitch. The 1998 event resulted in a 48% reduction in live coral. Both events coincided with times of high sea temperatures, calm weather and increased solar radiation. Impacts of mass bleaching incidences on reefs since the 1998 event have been negligible (McField & Bood 2007; McField et al. 2007).

Warmer sea temperatures will result in more coral bleaching episodes and a deterioration of the marine environment. Prolonged and frequent bleaching episodes could result in large-scale reef die-off. Endemic reef fish species will migrate to cooler more favourable environments for their survival.

Sea level rise is already causing salt water intrusion in coastal aquifers and remedial measures to provide freshwater have had to be implemented in Ambergris Caye, Caye Caulker and the Placencia Peninsula. Further sea level rise will compromise other sources of fresh water including the systems serving Belize City and Dangriga. If the entire Greenland Icepack melted – the worst case scenario - a resulting five meter sea level rise would affect almost all of Belize's wetlands (The Impact of Sea Level Rise on Developing Countries: A Comparative Analysis, February 2007).

Heavy rainfall episodes have produced frequent and intense floods resulting in huge quantities of silt flowing into the sea and extending out to the reef. This sedimentation has been exacerbated by deforestation along the coast and on uphill areas in the interior of the country.

Ocean acidification is another foreseeable impact for the coastal zone, particularly for the coral reef ecosystem. Increasing amount of carbon dioxide in oceans and seas could result in reactions that change the chemistry of the oceans/seas. This can have a negative impact on marine organisms such as hard corals, clams and crabs that create calcium carbonate shells and skeletons. Excess carbon dioxide in the oceans/sea causes a lowered pH and more acidic condition of the oceans/seas, thereby compromising the availability of material for and ability of these organisms to create their shells and skeletons. Increase in ocean acidification could make it increasingly difficult for corals and other marine animals to strengthen existing structures and build new ones, and in certain cases may cause shells and skeletons to dissolve. In the case of Belize, it could compromise the physical protective role provided by the barrier reef. Sufficient data are not available to ascertain overall effect of ocean acidification on Belize's reef system and marine organisms to date.

Management and Research Related to Climate Change in Belize

Belize has made a strong political commitment to address climate change. It hosts and provides support to the regional intergovernmental specialized agency, the Caribbean Community Climate Change Centre, established by CARICOM Heads of Government to coordinate the region's response to climate change. Cabinet approved the multi-disciplinary National Climate Change Committee to advise government on all aspects of climate change. The committee has established several sub-committees and expert working groups. In addition the Ministry of Agriculture has established an Agriculture Climate Change Committee. The National Meteorological Service maintains a national climate monitoring network. Nevertheless, the country has no systematic programme for research on climate change, although the University of Belize's Environmental Research Institute (ERI) has flagged key climate change related research as part of a national research agenda for Belize. Research is usually conducted when funding is made available through regional projects and in the process of preparing national reports such as National Communications to the United Nations Framework Convention on Climate Change (UNFCCC). Some climate change research is also being carried out by a few non-governmental agencies (such as the World Wildlife Fund, The Nature Conservancy, among others) with the aim of identifying climate adaptation measures for the coastal zone (Devisscher et al. 2010; Bood 2008).

Some of the initiatives taken in the past few years to address the impacts of climate change on the coastal zone include: coral reef monitoring programmes, public awareness programmes, establishment of coral reef nurseries, mangrove mapping, restoration and preservation, and vulnerability assessment of the coastal zone, fisheries, tourism, and agriculture sectors.

The institutions managing climate change in Belize are: 1.) Focal Point to the UNFCCC – Mrs. Ann Gordon, Ministry of Forestry, Fisheries and Sustainable Development; 2.) Focal Point to the IPCC – Mr. Dennis Gonguez, National Meteorological Service; 3.) Chairman of the Belize National Climate Change Committee – Dr. Wendel Parham, CEO, Ministry of Forestry, Fisheries and Sustainable Development; 4.) Chairman of the Agriculture Climate Change Committee – Ministry of Agriculture.

Recommendations

1. The monitoring network for the coastal zone should be strengthened and should examine sea level, sea temperature, water quality, and ecosystems.

2. Quantitative vulnerability studies of the coastal zone should be undertaken to include: erosion, salt water intrusion, ocean acidification, and impacts on coral reef, fish species, mangroves, sea grass beds, etc.

3. Based on the results of these studies, policy recommendations should be developed to ameliorate the projected impacts.

4. Pressures on the marine environment from land based activities should be reduced.

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Extreme Weather Events

P. Noreen Fairweather

Background and Belize's Climate Trends

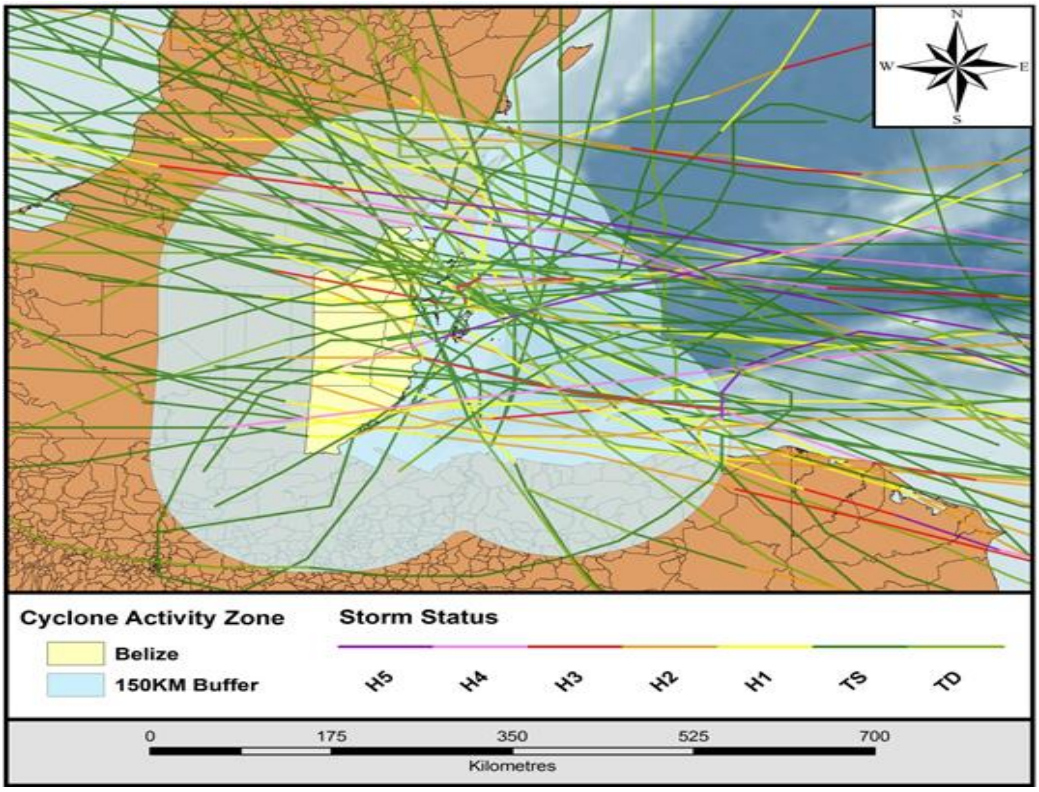
Situated between Latitude 16° - 18°, the general climate of Belize is sub-tropical. The seasonal change are primarily a "rainy season" (May to October) and "dry season" (November to April). Annual mean temperature is 79°F, the warmer months generally between May and October. During this time, temperature can rise up to 95°F (or higher). In the higher western parts of the country, temperatures can fall as low as 45°F.

The country diverse terrain includes a long coastline on the Caribbean Sea, a broad coastal plain, and hills and mountains towards the interior. Like most of the Central America and the Caribbean, Belize is exposed to Tropical Cyclones unfortunately from both the Atlantic Ocean/Caribbean Sea and the Pacific Ocean. These events pose a significant threat to the coastal areas, and potentially can result in damage from wind, storm surge, flooding and coastal wave impacts. Flooding from heavy rains also threatens the coastal and inland areas.

This distribution of hazards is important, as much economic activity is concentrated in the low lying coastal areas around Belize City, which is most exposed to hydro-meteorological hazards. The major economic sector drivers for Belize are tourism contributing 33% of GDP and agriculture contributing 13% of GDP (CIA Factbook, 2012). Tropical cyclones pose a risk to coastal tourism, which is vital part of the country's economy. Within the coastal zone, the agriculture sector is less exposed than the rest of the economy, however agriculture is exposed to other aspects of hydro-meteorological hazards, particularly heavy rainfall, flooding and land slippages.

It has been suggested that the Caribbean region may experience an increase in temperature by up to 2-3°C, and annual rainfall may decrease by as much as 20-30 % over the next seventy five years. If this situation does in fact materialize, the region can expect an increase in the intensity of hazards such a flooding, erosion and drought.

The Belize coast is subject to the south-easterly Trade Winds which average between 10-13 knots. The Atlantic Hurricane Season is June to November, and the country lies in the "hurricane belt". Over the past decades Belize has experienced a number of significant impacts from Atlantic tropical cyclonic events. These events are usually accompanied by heavy rainfall and strong winds. The map below shows cyclonic activity within 150km of Belize since 1851.

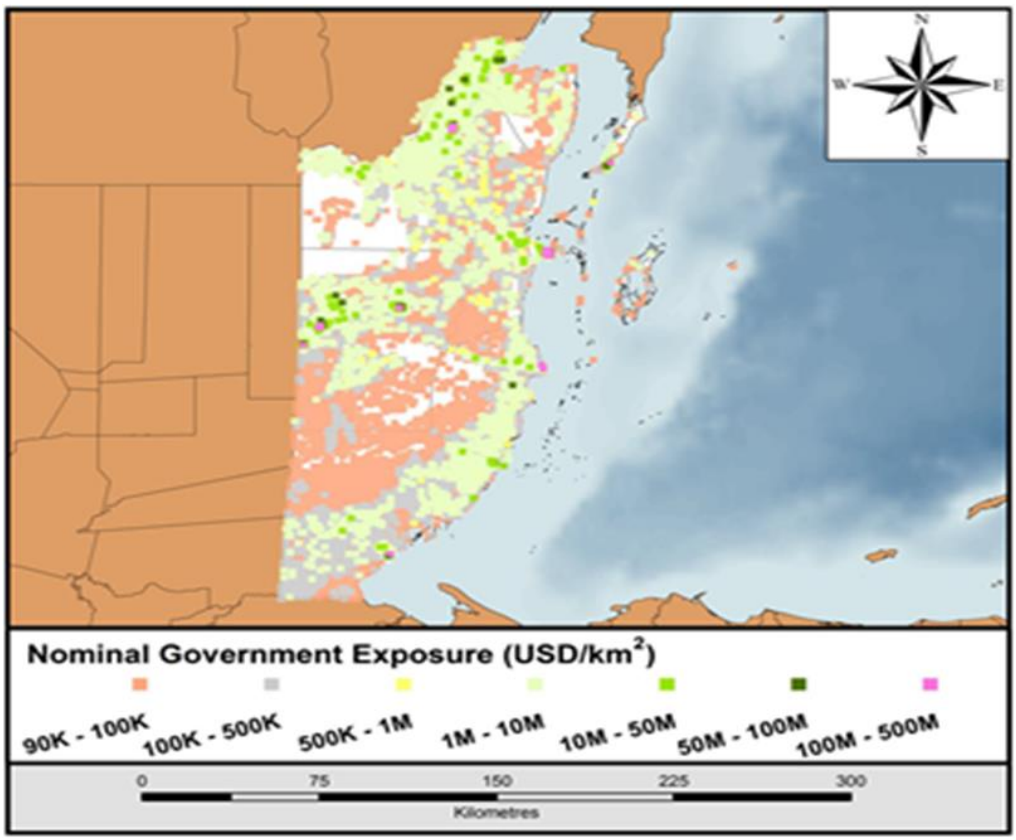


Tracks of Tropical Cyclones moving within 150km of Belize since 1851.
Source: Belize Country Risk Profile 2012

Vulnerability of Belize's coastal zone to extreme weather events

The nature and severity of impacts from extreme weather events depend not only on the intensity of the events, but also on exposure and vulnerability. When these impacts result in widespread damage they become disasters causing critical changes to how communities operate.

Settlement patterns and changes in socioeconomic conditions have both influenced trends in exposure and vulnerability to extreme weather events. Belize's coastal settlements in particular, are exposed and vulnerable to extreme weather events. Five major population centres lie along the coast, along with tourist resorts selling the much-desired sun, sand and sea packages. These activities also contribute to increased vulnerability. Adjusted for population density and assuming that GDP is relatively constant across the country the following map shows the distribution of exposure for Belize.



Exposure Map of Belize as used in CCRIF
Source: Belize Country Risk Profile 2012

Coastal erosion – over time

During the past decade there have been considerable environmental impacts along the coastal and immediate inland areas. Coastal erosion, uprooting of seagrass and damage to the reef system as a result of storm surge and wave action have occurred at varying degrees with each event. In addition, sediment plumes from the flooding runoffs also impact the reef system.

Major Historical Events

On 21 August 2007, Dean was a Category 5 Hurricane which made landfall 30 miles north of the Belize/Mexico border with sustained winds of approximately 165 mph (266 km/h). The estimated value of the destroyed structures was US$6.78 million and the value of damaged structures was estimated at US$3 million. The total direct value of houses destroyed and damaged was estimated at approximately US$10 million. The need for replacement and rehabilitation of houses was estimated at US$10 million (NEMO, 2007).

The Corozal and Orange Walk Districts, the hub of the sugarcane and papaya industries, were significantly affected. There was also significant damage to corn, vegetables, tree-crops and subsistence crops, with some damage to livestock. The high loss to the agriculture sector is attributed to the strong winds which accompanied Dean. The Government of Belize confirmed that the cost of reconstruction as a result of this storm was about US$100 million. The major damages recorded were to the agriculture and housing sectors. (NEMO DANA Report 2007).

Subsequent to the passage of Hurricane Dean in 2007, coastal erosion was significant only in the northern part of the country. An estimated 15-25% of the beach was lost along the coastline. It was noteworthy that most of these areas were those that had lost vegetation previously due to Hurricane Keith in 2000. The direct and indirect losses due to erosion in 2007 have not been quantified. Approximately 60% of the standing vegetation near the Corozal Town and Consejo areas was either severely damaged or completely toppled. The villages closest to Corozal Town or within the town itself saw 40-60% of their trees uprooted or sustained some type of damage. Although 70% of the north-western dry forests were left standing, these were either wind scorched or denuded of the leaves. Twenty percent of Caye Caulker and San Pedro mangroves were affected (Hurricane Dean DANA Report).

On 16 October 2008, Tropical Depression 16 threatened the countries of Honduras, Guatemala and Belize and made landfall in northern Honduras. However, the outer bands of the system dumped a large amount of rainfall as it passed over Belize, which resulted in life threatening floods to communities situated in close proximity to the Mopan, Macal and Belize Rivers (NEMO Damage and Needs Assessment Report, 2008). Four fatalities were reported as a result of this event with approximately 60 communities which comprised of over 10,000 persons being severely affected.

The agricultural sector sustained the most damage as a result of the passage of this event and it was reported that the impact accounted for 25% of agricultural GDP, with total damage estimated to be US$14.17 million. The tourism sector experienced damage in the amount of US$584,500 and losses in the amount of US$1,391,896, which could be attributed to loss of tourists through cancellations, loss of revenue earned by tour operators and guides for a period of approximately two weeks during and following the event. Total damage and losses were estimated at US$27 million (ECLAC)

On 24 October 2010, Hurricane Richard made landfall and caused some damage in central and southern Belize as a Category 1 storm with winds as high as 90 mph (145 km/h) with recorded gusts of 115 mph (185 km/h) and torrential rains for a period of eight hours.

Approximately 830 homes were damaged or completely destroyed across 55 communities during the passage of this system. Agriculture suffered significant damage with over 1,500 acres of citrus estimated at over US$ 19.2 million. Tourism sector US$ 3.7 million. The total damage as a result of Hurricane Richard was estimated to be approximately US$24.6 million. The cost for immediate emergency response and relief efforts was estimated at US$1.5 million

Coastal areas and the reef system are very diverse; being home and spawning/nesting area to more species than any other ecosystem except the rain forest. Additionally, mangrove forests have proven to be exceptional protective against storm surge and coastal erosion; it is therefore critically important that we ensure the sustainability of these systems.

Disaster Risk Management (DRM) and mitigation focuses on reducing exposure and vulnerability and increasing resilience to potentially adverse impacts of weather events. There is a high probability that locations currently experiencing adverse impacts, such as coastal erosion and inundation, will continue to do so in the future due to the rise in sea level and the effects of extreme events. Mean sea level rise, in addition to the likely increase in tropical cyclone maximum wind speed, is a major concern for coastal communities. An emphasis on, and the prioritizing of DRM activities is therefore of paramount importance.

Disaster Management, Mitigation and Response

Table 1. Major Natural Disasters Impacting Belize 2003 -2013
See Appendix 1 for more details prepared by the National Meteorological Service.

Year	Events
2003	Extreme Temperatures: Belize experienced a severe dry season. Heat waves in April and May resulted in degraded pastures which affected the livestock and poultry (5000 chickens died) and caused widespread bush fires.
2004	Hurricane activity was well above normal with 16 named storms forming in the North Atlantic Basin. However, the only hurricane that posed a threat to Belize was Ivan, which came within 326 miles NE of Belize City in September.
2005	Tropical Cyclones: Atlantic hurricane season was one of the most active on record. • 7 tropical storms and 1 subtropical storm occurred. 15 became hurricanes, and 7 of these became major hurricanes. Additionally, there were 2 tropical depressions and 1 subtropical depression. Numerous records for single-season activity were set, including most storms, most hurricanes, and highest accumulated cyclone energy index. This was the year of Hurricane Katrina, the deadliest U.S.A. hurricane since 1928. The storm also caused well over $100 billion in damages and approximately 1500 deaths in the United States alone, making 2005 the costliest hurricane season of record. Hurricane Wilma threaten Belize with no significant damage reported.
2006	Floods: Belize experienced significant flooding events. ● January, flooding in the Belmopan area caused major disruption in traffic as the Western Highway just outside the city being washed out. ● May, 18.6 inches of rain fell in the Stann Creek District, flooding the Pomona and Melinda area. ● June the Western and Hummingbird Highway junction was submerged, over 22.83 inches of rainfall was record.
2007	Hurricane Dean: 21 August 2007, Category 5 Hurricane which made landfall 30 miles north of the Belize/Mexico border with sustained winds of approximately 165 mph (266 km/h). Extreme Temperatures: This year saw the "end" of the extreme temperatures which started out in 2003. • Three major forest fires in the Mountain Pine Ridge, resulting in some 20,000 acres of natural and regenerating pine trees destroyed. • More than 2000 chickens died.
2008	Tropical Cyclones: Tropical Storm Arthur impacted over 36,500 people (5 deaths); Damage/Loss Approx. $80 million. Tropical Depression No. 16; Damage $27Million Earthquake: Southern Belize; Damage $0.6 million. Fire: Waste Disposal Site Belize (30acres); Damage $0.35 million.
2009	Floods: Belize experienced significant flooding events. • uly, flooding in the Toledo District • eptember, 18.6 inches of rain fell in the Stann Creek District, flooding the Pomona and Melinda area.
2010	Floods: Belize experienced five major flooding events. There were four tropical storms and one hurricane, Richard. On 24 October 2010, Hurricane Richard made landfall and caused some damage in central and southern Belize as a Category 1 storm with winds as high as 90 mph (145 km/h) with recorded gusts of 115 mph (185 km/h).

Activities in the Coastal Zone

Over 60% of the world's population lives or works within 100 miles of a coast[1]. For Belize, that estimation includes the entire mainland. People are attracted to the coast where it is cool, fun, relaxing, and opportunities are diverse. To be here, commodities are needed and job opportunities are necessary. Secure infrastructure, healthcare, education, recreation, access to fresh food, and conservation are some needs that have to be balanced.

This section looks at some activities within the coastal zone: land and sea development, capture fisheries, aquaculture, and tourism.

The opening essay touches on the complexities of coastal management and research by outlining how activities inland impact the coastal zone – a link often overlooked.

[1]*Hinrichsen, D. 1998. Coastal waters of the world: trends, threats, and strategies. Washington D.C. Island Press.*

Terrestrial Impacts on the Coastal Zone

Jan Meerman

Introduction

For some time now, there has been a realization that proper coastal zone management is not possible without taking terrestrial influences into account. While activities such as fishing and recreation in the marine environment itself are easy to observe and quantify, land-based activities often have a more insidious relationship to what happens to the reef and beyond. Natural processes, and above all human activities, on the land ultimately may influence coastal zone processes through siltation, nitrification and toxification. Tied in to this are factors such as natural vegetation cover, land use, population density, and socio-economic aspects (MBRS 2007).

In spite of this realization, there is still insufficient understanding of and attention to terrestrial activities that affect the coastal zone. This can be demonstrated without any doubt using a few recent events in the terrestrial realm that have impacted the coastal zone, but which have essentially slipped under the radar, leaving no one any the wiser of their quantitative and qualitative impacts on the marine environment.

Terrestrial events with potential impact on the marine environment

One such event was in August 2009, when BECOL released large amounts of sediment from the bottom of the Chalillo hydro lake[1]. As a result, the turbidity in the Macal and Belize Rivers rose to such an extent that both rivers turned to the colour of chocolate milk. This release of silt continued for a couple of weeks and the resulting plume of silt eventually reached the sea, where it discoloured the water of the coast in front of the Buttonwood Bay area. The effects of the siltation on the riverine environment were never assessed, neither was it investigated whether there might have been an impact on, for example, the sea grass beds in front of Belize City.

A similar event took place in April and May of 2011 when, as the result of forest damage caused by Hurricane Richard in October 2010 and in combination with an unusually strong dry season, there developed a large number of wildfires in Central Belize. These fires raged for nearly two months, affecting approximately 86,400 ha / 213,500 acres of broadleaf forest, this being in addition to the "usual" savannah and pine forest fires[2] (Fig. 1). Once the rainy season started, much of the ash washed away and with the bulk of the fires being centred in the Belize River Valley, much of this nutrient rich ash must have been washed into the Belize River.

In May of the same year, reports started to appear of a large algae bloom in Southern Belize waters[3]. Algae blooms are typically a result of sudden nutrient inputs in the marine environment and some people suggested that the nutrient input caused by the fires in the Belize River Valley might have been to blame, but the actual link was never investigated.

[1] http://www.7newsbelize.com/sstory.php?nid=14760&frmsrch=1
[2] http://biological-diversity.info/Hurricane_Richard.htm
[3] http://www.scubaboard.com/forums/marine-life-ecosystems/385082-heavy-phytoplankton-bloom-belize.html

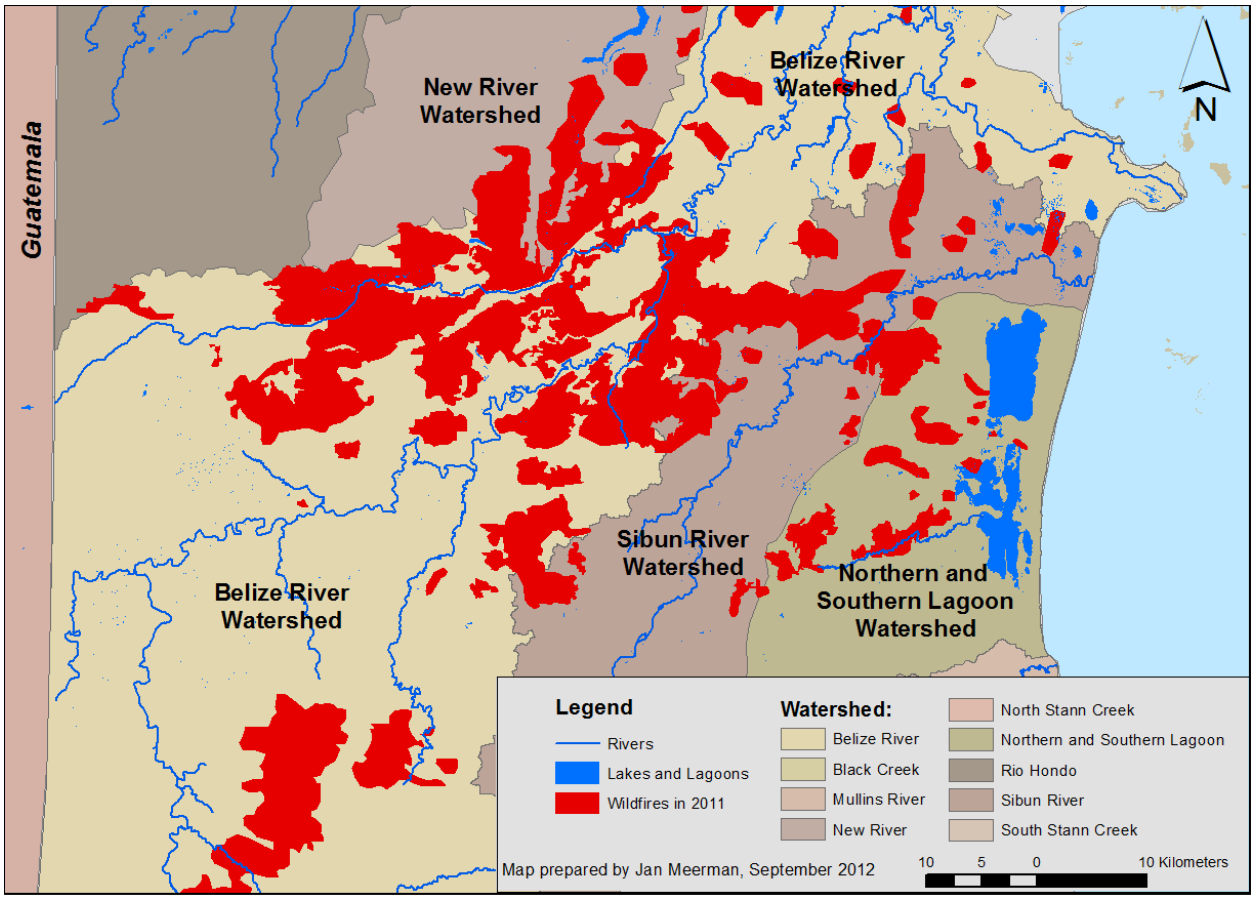


Figure 1. Dry season 2011 wildfires in central Belize. Source: 2011 LANCE FIRMS Fire data and 2012 Landsat tm images.

While the previous examples represent unique events, there are land use trends that should be monitored for their potential to affect the marine environment. For example, over the years the area under agriculture has been expanding steadily in Belize. When analyzing this trend, it appears that between 1998 and 2012 agricultural expansion (and thereby deforestation) has been most prominent in Northern Belize. Within this region, there are very distinct areas where this expansion has been taking place, notably, the Rio Hondo Watershed, the New River Watershed, the Shipstern Lagoon Watershed and the Belize River Watershed (Fig. 2 and note that this does not take into consideration agricultural expansion within shared cross boundary watersheds - See Karper & Boles 2003). Further analysis reveals that there is also a trend towards large scale, export focussed, mechanized agriculture. Because of the increased global interest in agricultural commodities such as corn, sugarcane and beef, this trend can be expected to accelerate even more. With the agricultural expansion comes not only deforestation, but also increased risk of siltation, eutrophication, and pollution with pesticides.

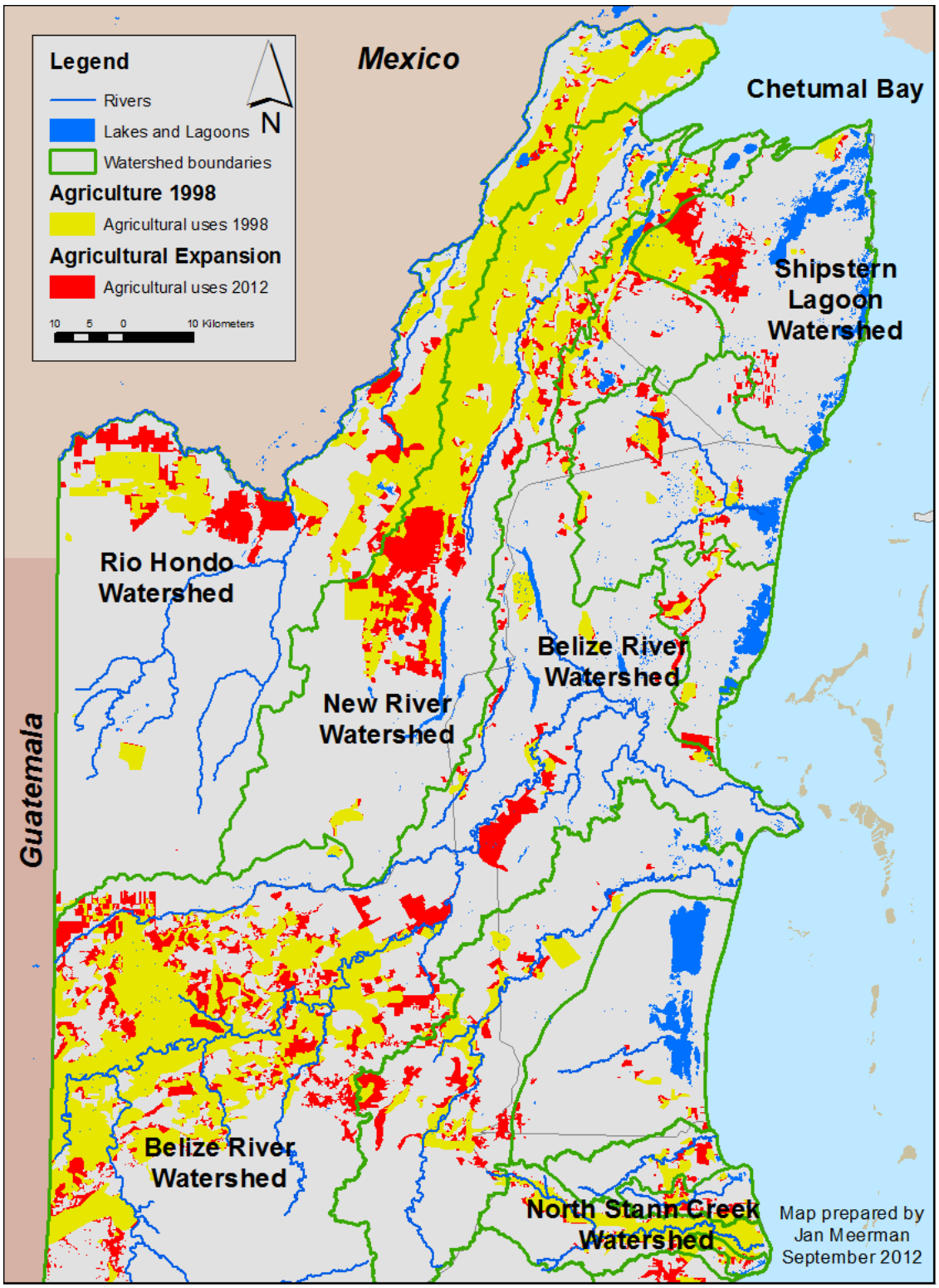


Figure 2. Extent of agriculture in Northern Belize, with agricultural expansion since 1998 indicated in red. Sources: Landsat tm images of 1998 and 2012.

Recommendations

Activities and events in the terrestrial realm have the potential to affect the coastal zone. Constant vigilance and monitoring of activities are essential if we want to pre-empt serious impacts. The Belize River is a principal concern, but also the northern watersheds are increasingly coming under pressure and thereby affecting Chetumal Bay particularly, which also receives effluents from the Mexican side. Sustained water quality monitoring processes should be established in all these rivers and a mechanism should be put in place to enable responses to unexpected events, whether monitoring or corrective measures. In addition, the EIA mechanism should be strengthened and used to evaluate all developments, marine and terrestrial, and their impacts on the marine environment.

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Coastal Development and Environmental Impact Assessments Zone

Anthony Mai

The Department of the Environmental and its Regulatory Mandate

The Department of the Environment (DoE) is a department within the Ministry of Natural Resources and the Environment that is responsible for environmental protection in Belize. In 1992, with the enactment of the Environmental Protection Act (EPA), the DoE was given a broad mandate to protect and ensure the prudent use of Belize's natural resources (both terrestrial and marine). Since then, the Department has developed considerably; it has effected several important Regulations under the EPA, such as the Environmental Impact Assessment Regulations in 1995 and its Amendment in 2007[4]. These legislative instruments were opportune as around this time global recognition of Belize as a tourism destination was becoming apparent. The world was looking at Belize as an ecotourism mecca for its pristine state and strict environmental laws.

Tourism was the new focus, and consequentially investment and infrastructure grew rapidly along coastal areas to accommodate global visitors and expatriates. Mangrove clearance, dredging and filling, alteration of shoreline, disruption of marine habitats, along with water pollution, are some of the adverse impacts that resulted from the rampant coastal development. In addition, as the demand for coastal land and islands increased, their value experienced a parallel increase.

The DoE was instrumental in mitigating the adverse impacts stated above. This was accomplished by requiring all projects judged as likely to have a significant impact on the environment to be screened by the DoE to determine if an Environmental Impact Assessment (EIA) is required. EIAs are effective tools that alert both developers and decision makers to potential adverse environmental impacts and suggest mitigative measures to reduce such impacts.

Since Belize is committed to sustainable development principles, EIAs are needed to assist the implementation of development projects and programs in a pragmatic and sustainable manner. In addition, the EIA is fundamentally a process used to achieve protection and management of the environment, consistent with national policies and laws, and in compliance with commitment to international conventions addressing climate change, biodiversity conservation, ecosystems and environmental services, environmental flows, and environmental health (e.g. MARPOL, SOLAS, IMO, and CBD).

EIAs within the Coastal and Marine Zone

Since 2003, the DoE has received over 30 EIAs for projects specifically within coastal areas. Most of the projects are tourism related, a few are aquaculture related, and others are more development related, such as the establishment of marinas, port improvement, installation of fibre optic cable

[4] See amendments at www.doe.gov.bz

line, and electrical power line from Belize City to San Pedro, just to name a few. Tourism projects are mostly resorts, subdivisions, golf courses and marinas. Aquaculture projects are terrestrial or marine cage farming.

While the magnitude and scope of these projects vary, their locations are still in sensitive coastal areas, marine protected areas, and the World Heritage Sites (Fig. 1). For example[5]:

- The Stake Bank and Ocean Grand View projects are proposed for the Stake Bank and Northern Drown Caye offshore Belize City. Together these projects consisted of a causeway to connect Belize City with Stake Bank and Northern Drowned Caye, and hotels, casino, etc. to accommodate cruise tourism visitors. This proposed development abuts the Swallow Caye Wildlife Sanctuary.

- The Ara Macaw Project is a tourism related development that includes a golf course, resort, marina and more near Riversdale Village, Stann Creek District.

- The South Beach Project is a development proposed for south Ambergris Caye where several tourism attractions including homes, marina, casino and more would be available.

- More recently, the Placencia Marina, a 35-acre marina incorporated into two shoreline based developments (the Placencia and Copal Beach) in the Placencia Village area, was submitted to the DoE for environmental clearance.

- Yum Balisi Sustainable Luxury Resort, Chrysalis, and Bellcan Eco-resort San Pedro are three projects located within marine protected areas and the World Heritage Sites. These projects include all amenities mentioned above including helipads and airstrips.

These projects are similar "high-end tourism destinations" that have been the development trend for the tourism sector. All the projects mentioned above received environmental clearance though were controversial and caused significant public outcry. Through the EIA process and the mandatory public consultations for these projects, large issues were dealt with, compromises were hammered out, and the DoE is satisfied that the integrity of the environment is still intact and the sustainable development of Belize continues.

[5] EIAs available online at http://www.doe.gov.bz/EIAs.html

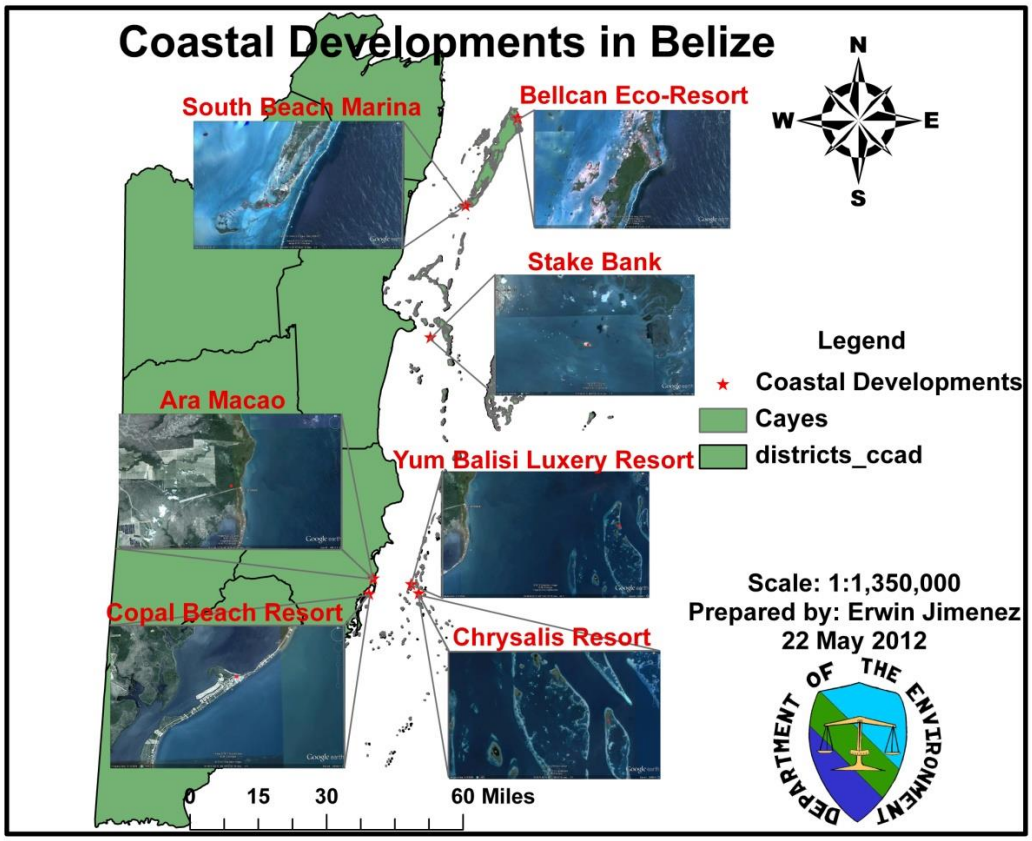

Figure 1. Coastal Developments in Belize

Other Projects, Policies, and Guidelines

Apart from projects that go through the EIA process, there are other coastal projects, smaller in scope and magnitude that are processed within the DoE on a daily basis. Once environmental clearance is granted to these projects, the proponent is required to sign an Environmental Compliance Plan (ECP), which is a legally binding contract that contains conditions, restrictions and guidelines that ultimately mitigate the adverse effect of a project. ECPs are project specific and must be agreed upon and signed before environmental clearance is granted. The ECP is one of the most effective tools that ensure environmental protection in Belize and unlike the rest of the Caribbean nations, the ECP is non-transferrable, and is only valid for one year after signing by the DoE.

In addition to the ECP, the DoE has developed guidelines such as the Overwater Structure Guidelines (DOE 2010), Marina Guidelines (DOE 2009) and Shoal Development Guidelines (DOE 2010) that ensures further protection of the Belizean coastal and marine areas. These guidelines and investment friendly processes separate Belize from the region and make it a leader in striking the balance needed for sustainable development. The DoE has also required all coastal development to install package treatment plants to treat liquid wastes. These plants must be able to treat liquid

waste to meet or exceed the standards of the Third Schedule of the Environmental Protection (Effluent Limitations) (Amendment) Regulations, 2009 for discharges into Class I Waters. Recognizing the need for a more comprehensive approach, the DoE has conducted a sewage needs assessment on Caye Caulker Island and also fully supports the Ambergris Caye Sewer Expansion Project and the Placencia Sanitation Project.

The DoE is committed to continue being progressive to lead the way in environmental management especially along the coast of Belize and a trendsetter in sustainable development in the Caribbean region. With so many coastal development types, the DoE must now be more vigilant and concerned about coastal degradation. The DoE is dedicated to maintaining the balance between the environment and development through continued education outreach, proponent dialogue and advancements in research, monitoring and enforcement.

Recommendations

1. Conduct an evaluation of the EIA process with a view to ameliorate the effectiveness and efficiency of the process, leading to better environmental management.

2. Environmental consultants need to conduct more technical and scientific oceanography data as part of their EIA. This way more realistic impact matrices can be prepared and better mitigation measures suggested in EIA documents.

3. Create a database that would include the physical and biological data that is collected for EIAs, so this information can be used by other parties.

4. Environmental scoping must consider environmental resiliency, critical and sensitive habitats or areas, carry capacities and improve section on cumulative impacts.

5. The DoE, in its capacity as regulatory managers of the coastal zone should develop and legislate a Marine Pollution Act that incorporates point and non-point sources of pollution, among others.

6. With the advent of offshore petroleum exploration and exploitation being considered, the DoE must now build capacity to deal with this type of development and must ensure that the proper legislations are in place to respond to this future industry.

Capture Fisheries

Mauro Gongora

The Capture Fisheries Unit is a principal technical arm of the Belize Fisheries Department and its work is geared towards the conservation and sustainable use of fishery resources. Total fishery export earnings increased by 20% in 2011 from BZ$21.59 million in 2010 to $25.95 million in 2011. Lobster continued as the most important fishery commodity, followed by conch and finfish.

Fisherman's catch of lobster and conch.

Management

The Capture Fisheries Unit (CFU) is directly charged with the responsibility of providing technical and scientific advice to the Fisheries Administrator on matters relating to the sustainable use, conservation and management of wild fishery resources of commercial importance including marine and inland species. This responsibility is executed mainly through field research, fishery-dependent, and fisher-independent catch data of exploited fish species. The data gathered is subsequently utilized in the development of appropriate management measures for the different exploited species.

In 2011, a new licensing system has been implemented, which requires fishermen to provide socio-economic information that is recorded in a custom-built database. Fishermen need to show proof of residency in Belize and evidence of sale of fishery products in Belize. Also, the CFU team assisted in the introduction of a Managed Access/Catch Shares Program that has been successfully implemented in the Glovers Reef and Port Honduras Marine Reserves. Over 200 fishermen are currently participating in the program. Preliminary data show slight increases in fisheries production in these areas as a result of improved management, data collection and law enforcement activities.

Also, consultations on the proposed finfish regulations were carried out in the major coastal fishing communities including Dangriga and Punta Gorda, and fishermen supported the introduction of new regulations to ensure sustainability of the fishery. However, they also recommended that additional resources should be made available for monitoring and law enforcement in the fishing areas.

Another major activity in 2011 was the passing of legislation for sharks, which among other provisions includes a 3-month closed fishing season from August to October each year and complete protection of three species namely; great hammerhead shark (*Sphyrna mokarran*), bonnethead shark (*Sphyrna tiburo*) and nurse shark (*Ginglymostoma cirratum*). Of particular importance to the tourism sector is the protection of the nurse shark. In recent years the nurse shark has shown a significant increase in presence at selected sites such as Shark and Ray Alley

[located on the Belize Barrier Reef between San Pedro Town and Caye Caulker] where tourism activity is very high.

This year, the CFU also led the work in the preparation of legislation for gill nets, which was enacted to establish the gill net regulations, and addresses issues such as registration of gill nets, areas where gillnets are not to be placed, the number of nets, and length of gillnets. These regulations, once implemented, will help address some of the concerns of the Belizean public and the fishing community with regards to the use of gill nets in Belizean waters.

Development of Deep Slope Fishery

Over the past 60 years, lobster and conch have been the principal fishery commodities that fishermen have targeted for commercial fishing. During this time the conch fishery has shown some resiliency and slight growth, but the lobster fishery has shown some decline, despite an increase in fishing effort (number of active fishermen). Both fisheries are considered mature at present and no further expansion in fishing effort is being recommended for the lobster fishery, since this would lead to a collapse of the fishery. For this reason, the CFU has proposed to develop the deep-slope fishery to target under and un-utilized finfish species such as deepwater snappers and groupers. In order to develop this fishery, it has been proposed to first conduct exploratory deepwater fishing using high-tech fishing equipment and gears to gather baseline data on species, fishing grounds, abundance, and distribution of finfish species of commercial importance. The results of the project will then be shared with commercial fishermen. The plan includes the identification of suitable fishing grounds (based on knowledge and experience of deep-slope commercial fishermen) and will initiate fishing trials in 2012.

Fisheries by Species

Lobster Recruitment Monitoring Program

The spiny lobster (*Panulirus argus*) is the most important fishery commodity fished in Belize. In 2011, lobster aggregation structures were deployed in five marine reserves to monitor the species. Data gathered indicate that northern Belize is an important nursery ground where the youngest lobsters are normally found - 80-85% of lobsters sampled are considered juvenile lobsters (1-2 year olds) (Gongora 2010). These lobsters prefer the shallow sea grass beds of *Thallasia testudinum* and *Syringodium filiforme* in the reef lagoon area found between the barrier reef and the mainland. It is therefore extremely important that additional and more concrete efforts be made to ensure the viability and sustainability of the lobster fishery in northern Belize. More resources should be

dedicated to additional data gathering (fishery dependent and fisher-independent), monitoring and control and enforcement of the fisheries regulations.

Total lobster tails landings increased by 22% in 2011 (in 2010 landings increased by 7.7% and reached 500,650 lbs) totalling 611,160 pounds. It is noted that in the past 25 years, lobster production volume has generally stabilized, so there is a possibility of decline of the fishery if additional fishing effort continues (Fig. 1). A decline in production, coupled with any decrease in prices in the international markets, could have dire effects on the fishing community and other sectors that depend on this fishery.

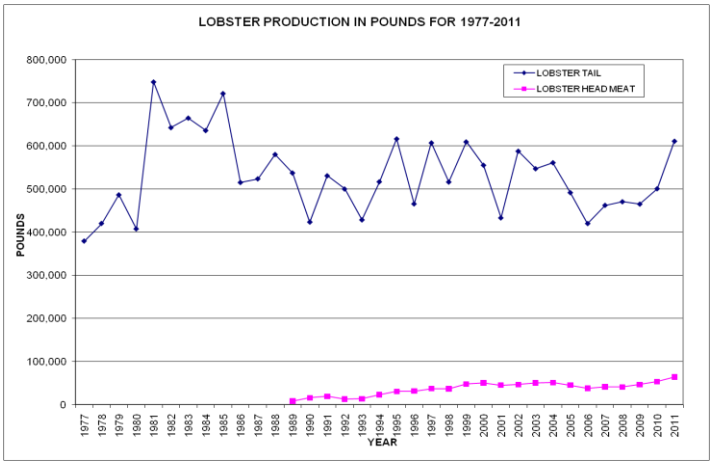

Figure 1. Lobster production performance during the period 1977 to 2011.

Lobster tail exports also increased by 28.4% from 433,960 lbs in 2010 to 557,320 pounds in 2011. The export earnings increased significantly by 29.72% from $12.98 million in 2010 to $16.85 million in 2011 (Fig. 2). The increase in export earnings is attributed mainly to the large volume exported and not necessarily because of better market prices in the USA where the bulk of Belize's lobster tails are exported. Conservatively, lobster export selling price is estimated at US$15/pound of lobster tails.

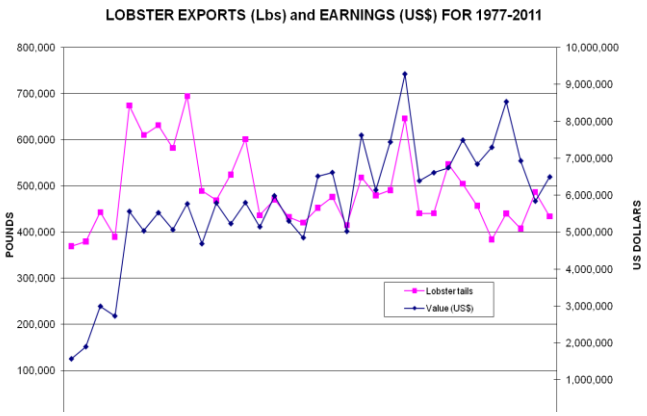

Figure 2. Lobster tails (pink) and export earnings (blue) during the period 1977 to 2011.

No assessment of the status of the lobster stock in Belize was carried out in 2011. Lobster fishing continues to be a major economic activity, but as a declining trend in lobster catches was identified during the period 1999 to 2009 while fishing effort (assuming number of fishermen is taken as a measurement of fishing effort) gradually increased, the catch landings reported by the fishermen cooperatives in 2011 was surprising. While there have been some peaks and troughs in the volume of lobster production, in the last two decades lobster production has remained generally stable averaging around 700 tons per year (live weight). One interpretation is that the lobster stock has reached its Maximum Sustainable Yield and cannot produce additional biomass despite the high fishing effort being applied. No additional fishing effort should be applied to this fishery and real efforts should be made to control and/or reduce the number of fishermen involved in this fishery.

Conch Fishery

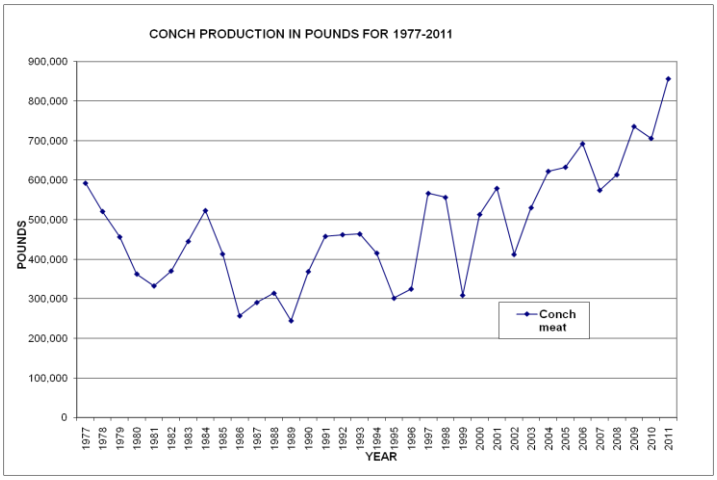

Figure 3. Conch production volume during the period 1996 to 2011.

The Queen conch was the second most important fishery commodity for 2011. Conch meat landings increased by 21.3% from 705,775 lbs in 2010 to 856,425 lbs in 2011. Conch meat export volume increased by 9% from 726,050 lbs in 2010 to 791,350 lbs in 2011. Figure 3 shows annual conch production volume for the period 1977 to 2011.

Furthermore, conch meat export earnings increased by 2.44% from $7.98 million in 2010 to $8.18 million in 2011 (Fig. 4). The growth in earnings is in response to increased sales and not necessarily to improved conch price in the US market.

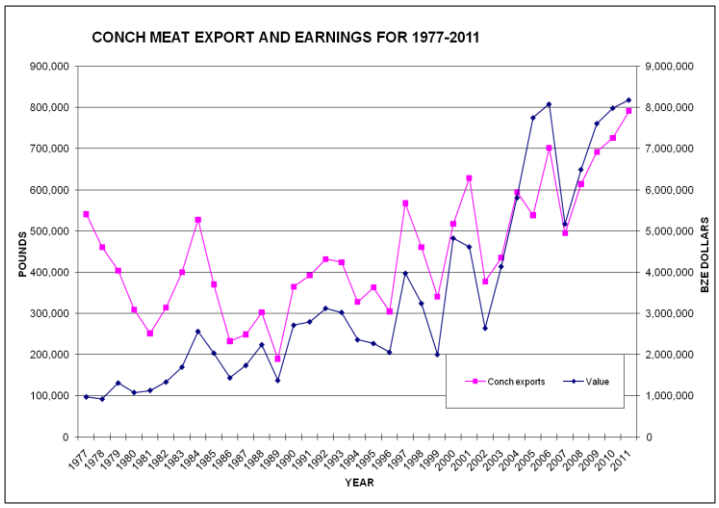

Figure 4. Conch meat export (pink) and export earnings (blue) from 1977 to 2011.

The fact that conch production volume has shown a consistently increasing pattern since 1989, together with a major leap of more than 150,000 pounds in 2011 corresponding to increasing fishing effort (a measurement used is the number of fishermen) levels indicates that this fishery is continuing to grow. In fact, conch production in 1977 (600,000 pounds, when fishing effort was much lower), was only surpassed in 2004, and since then it was only in 2007 that production volume fell slightly below the 1977 figure. However, continuation of the persistently high effort of this fishery is not recommended. Ways and means of curbing the current increasing trend in fishing effort need to be identified and applied as soon as possible to ensure the conservation and sustainability of the conch fishery.

Finfish Fishery

Finfish production volume (export only) once again increased significantly by 115% from 124,772 lbs in 2010 to 268,340 lbs in 2011 (Fig. 5) and export earnings were estimated at $805,020. Thirty finfish species are being caught commercially in Belize. These include ocean jack, Jimmy hind, goliath grouper, snook, squirrel fish, hog fish, shad, king fish, cubera snapper, school master, drummer fish, mullet, black grouper, French grunt, Spanish girl, stone boss, queen snapper, red hind, yellow-fin grouper, lane snapper, crevalle jack, mutton snapper, red grouper, grouper, amber jack, pork fish, black snapper, silk snapper, porgy, mackerel, dog snapper, white grunt, grunt, jack and yellow-tail snapper. The main species harvested by production volume (with over 1500 lbs per month) included yellow tail snapper, jack, grunt, white grunt, dog snapper, mackerel, porgy, silk snapper, black snapper, pork fish, grouper, red grouper, mutton snapper and crevalle jack, in order of importance.

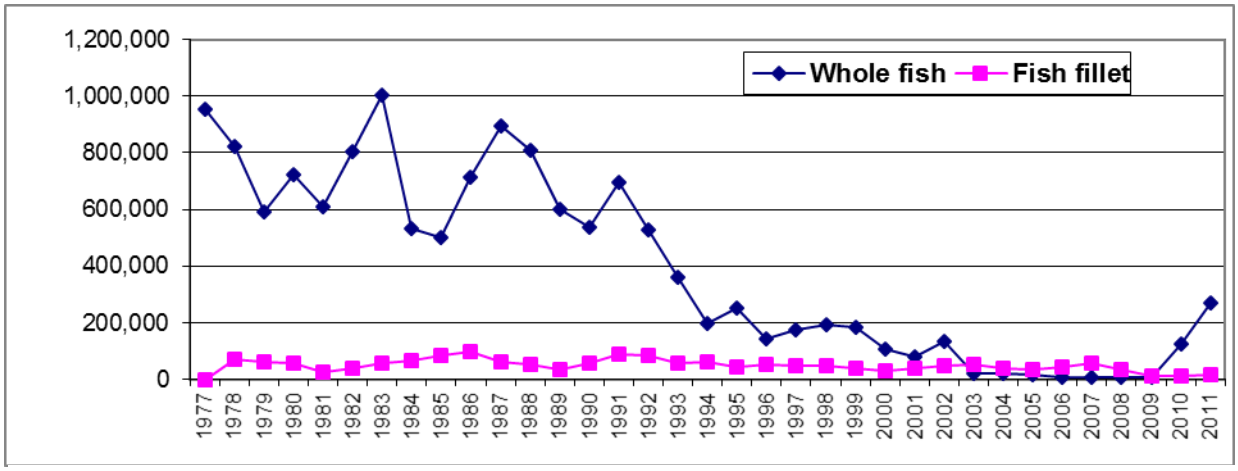

Figure 5. Finfish production volume (pounds), 1977 to 2011.

Total finfish landings for local consumption at the municipal markets in Corozal, Dangriga, Punta Gorda and Belize City were estimated at 335,400 lbs in 2011 and generated an estimated income of $1,341,600 (assuming whole fish is sold at average price of $4/pound). This volume of fish is consumed both by Belizeans and tourist. The Vernon Street Fish Market in Belize City is by far the most important fish market in the country where fish landings were estimated at 288,000 pounds per year. The second most important fish market is the Dangriga Market with an estimated volume of 19,400 pounds of fish per year. The Punta Gorda Market is the third most important fish landing site with an estimated production of 16,000 pounds per year. The Corozal Fish Market deals in approximately 12,000 pounds of fish per year. Consumers generally purchase fish at the municipal fish markets directly from fishermen at an average retail price per pound of fish is BZ$4 to $5. This price per fish is twice the amount paid to fishermen by exporting businesses.

The principal fishing grounds for finfish in terms of volume of fish harvested consist of 26 fishing areas, which contributed to 92.2% of total catches in 2011. The most important fishing ground is south of Punta Gorda Town, which accounted for 20,000 lbs of fish, followed by Ranguana Caye

with 16,000 lbs of fish, Silk Caye, Pompion Caye, and Sapodilla Cayes each accounted for just over 10,000 lbs of fish. Ranguana Caye and Pompion Caye were the two fishing areas with the highest number of fishermen carrying out commercial fishing activities. Silk Caye, Sapodilla Caye and Harvest Caye are also important fishing grounds to fishers. Ranguana Caye, Pompion Caye, Reef area, and Silk Caye are the areas where the fishermen spent most time engaged in fishing. This trend was observed by catches per area and with number of fishermen per area. It clearly shows that these areas are not randomly fished but are targeted by fishermen.

Rainforest Seafood Limited is by far the most important finfish exporter with nearly 224 thousand pounds in 2011 (Table 1). The parent company for Rainforest Seafoods Ltd (Belize) is based in Jamaica, and most exports go to Jamaica. Fish fillet production volume increased by 50% from 11,393 lbs in 2010 to 17,090 in 2011. This considerable increase in finfish production volume and subsequent export is directly attributable to the work of Rainforest Seafood Company, which is involved in the purchasing and packaging of fish in Independence in southern Belize. The average price paid to fishermen is $2.50 per pound of fish. The yellow tail snapper, which is the most prized fish in Jamaica, fetches around $3.00 per pound.

Table 1. Finfish exports (in pounds) by establishment.

PLACENCIA	NORTHERN	RIO GRANDE	RAINFOREST	BRIFRA	PG FISHING CO.	TOTAL
6,837	2,395	4,087	223,988	9,033	22,000	268,340

Shrimp Fishery

No shrimp trawling was carried out in 2011. In early 2011 when shrimp trawling was still legal in Belize, Northern Fishermen Cooperative, which owned the only two shrimp trawlers in the country did not carry out fishing operations mainly because of mechanical problems and also because they were in negotiations with OCEANA (a conservation advocacy group) to sell the vessels. The cooperative agreed to support the banning of shrimp trawling and in exchange OCEANA would purchase the shrimp trawlers from the cooperative at an agreed price. A purchase agreement was finalized in early 2011 and the government passed a Statutory Instrument banning all forms of trawling (including shrimp trawling) in Belize's waters.

Sea Cucumber Fishery

In 2011, the sea cucumber fishery remained strong and viable. The two main species of commercial importance were still donkey dung sea cucumbers (*Holothuria mexicana*) and three-rowed sea cucumbers (*Isostichopus badionotus*). Some 50,000 pounds of dried and salted sea cucumber were exported by four authorized exporters. Rio Grande Fishermen Cooperative was the largest exporter with 23,500 pounds. Exports go to Guatemala, Mexico and the United States. The management measures implemented in 2011 were as follows:

- The number of fishermen that participated in the sea cucumber fishery was restricted to 75 persons.

- The sea cucumber catch limit (CL) for the 2011 fishing season was set at 182,750 pounds (wet weight).
- The fishing season remained for six months only (January to June).
- Fishermen were required to provide catch data at the end of June 2011 to the Fisheries Department or would not qualify the following year for a special sea cucumber license.
- Harvesting of sea cucumbers was expanded to other fishing zones.
- Sea cucumber exporters were required to provide export data to the Fisheries Department on a monthly basis. Failure to furnish export data will disqualify the exporter from obtaining an export license for the next year.

Shark Fishery

The shark fishery continued as a small scale and artisanal fishery in 2011. The most common shark species landed in 2011 did not vary much compared to 2010. These included blacktip shark (*Carcharhinus limbatus*), bonnethead shark (*Sphyrna tiburo*), and bull shark (*Carcharhinus leucas*).

Development of Crab Fishery

Crab fishing has been done in Belize for many years at a small-scale artisanal level. In the 1990's crab was harvested mainly in northern Belize and sold to the fishing cooperatives, which in turn exported it to the United States. In the following years, fishers' interest in crab production slowly declined until commercial production halted, and currently crab production is mostly sold on the local market.

The principal crab species of commercial importance in Belize include the Florida stone crab (*Minippe mercenaria*) and channel cling crab (*Mithrax spinosissimus*). The Florida stone crab, also locally known as king crab, is the most important in terms of market demand and production volume, which is estimated at 20,000 lbs per year with earnings amounting to $60,000.00. The development of the crab fishery was launched in December 2010 when the First Fisheries Forum was organized by the FD. The objective of the program is to diversify the fishing industry, to create additional employment opportunities, and to improve the standard of living of fishermen. The positive response from the fishing community confirms the high interest of fishermen in the crab fishery.

Fishermen & Boats

Figure 6 shows that in just five to six years the number of fishermen has increased by 27%, from 2026 fishers in 2005 to 2582 in 2011. In a similar fashion, the number of licensed boats increased by 26.8%, from 593 in 2007 to 752 in 2011.

Figure 6. Number of fishermen (pink) and boats (blue) employed in the fishing industry, 1996 to 2011.

The large number of fishermen and boats employed in the fishing industry is a direct result of the "open access" nature of Belize's fisheries sector. The increase in number of fishermen and boats observed in 2011 translates into even higher fishing effort applied to the only 2 commercially important fishery resources; lobster and queen conch. The increases in the number of fishermen are again attributed to more Belizeans becoming fishermen due to unavailability of job opportunities and economic difficulties in other productive sectors, such as the sugar cane industry in northern Belize. It is noted that annual increases in the number of fishermen and boats involved in the fishing industry (Table 2) is unsustainable, especially in the case of the lobster fishery where the production trend shows that the Maximum Sustainable Yield (MSY) has already been reached at around 6000,000 lbs. Historical production figures clearly show that the 2011 lobster production volume (611,160 lbs) is not much higher than what was produced in 1995 (616,520 lbs), 1997 (607,226 lbs) and 1999 (609,523 lbs). However, it is important to note that in these years the fishing effort was surely much lower than in 2011 and therefore no additional fishing effort put into the fishery will produce significant increases in lobster production volume in the near future under the current lobster fishing practices.

Table 2. Fishers and boat licenses issued by the Fisheries Department, 2000-2011.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
# Fishers	1872	1707	1947	2009	1731	2026	2131	2110	2267	2759	2472	2582
# Boats	750	608	708	689	621	652	653	593	643	628	703	752

Conclusions and Recommendations

1. Control and reduction of fishing effort in the lobster and conch fisheries is strongly recommended in 2012. This can be done through various ways, as a result of the nation-wide consultations carried out on the National Plan of Action for the Management of Fishing Capacity (NPOA- Fishing Capacity) fishermen strongly supported the introduction legislation to establish limits or "ceilings" to the number of fishermen than can participate in the lobster and conch fisheries. Of course, this would certainly require the agreement of the major fishing cooperatives and other bodies such as Belize Fishermen Co-operative Association (BFCA) and Belize Fishermen Federation (BFF).

2. The license requirements established in 2011, which required fishermen to show proof of residency and the sale of fishing products in Belize, has already started producing good results as catch landings in the south (Mango Creek Receiving Station – Northern Fishermen Cooperative) have increased due to the fact that more fishermen are delivering their fishery product to the cooperative. The license system (including hardware and software programs) should be improved and strengthened and fully enforced by the licensing personnel.

3. The data collection resulting from the implementation of the Managed Access/Catch Shares program in Glovers Reef and Port Honduras Marine Reserve in 2011 has produced excellent results. The preliminary data analysis is showing that the enhanced fishery resources management and fisheries enforcement is helping participating fisheries to obtain bigger catches and is therefore leaving more money into the fishermen's pockets. More educational programs and awareness of the benefits of Catch Shares is strongly recommended. The implementation of the program at South Water Caye Marine Reserve and Sapodilla Caye Marine Reserve in 2012 is also strongly recommended.

4. A conch stock assessment will be carried out before the opening of the 2012 fishing season. The results on the abundance and estimated MSY should continue to be used as the basis to establish the Total Allowable catch (TAC) for Belize. It is expected that conch production volume will either increase slightly or remain at the same level as observed in 2011 but it does not mean that more fishing effort should be incorporated in the fishery. The monitoring of the individual cooperative quotas should be strengthened to ensure full compliance by all parties, and fisheries law enforcement should be increased and improved especially in areas where known conch nursery areas are located.

5. The finfish production volume is expected to increase significantly in 2012 and therefore additional resources should be made available to permit increased monitoring and data collection at the various landing sites along the coast of Belize. The finfish regulations that have been prepared have gone through the consultation process and should be implemented in 2012. The proposed management measures will help in the sustainability and conservation of commercially important species.

6. The sea cucumber fishery should continue to be monitored closely and the management strategy developed for 2011 should be adhered to. A joint sea cucumber national assessment along with the University of Belize (since it has indicated its desire to do a joint project) should be done in December 2012 to determine the size of the stock, spatial and temporal distribution of the resource before the opening of the fishing season in January 2013. The results of this study should guide the development of improved management measures to ensure sustainability of the fishery and conservation of the species.

7. Enact the Aquatic Living Resources Bill.

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Status of Aquaculture

Rigoberto Quintana and George Myvett

Introduction

Development trends in aquaculture in Belize date back to the last thirty years. In the early 1980's, the first commercial trials were conducted with the Pacific white shrimp (*Litopenaeus vanammei*) which led to rapid expansion in production with a total of 16 farms established by the end of 2005 with a total production area of 6,888 acres. In 2002, the species portfolio was expanded to the production of the grey tilapia (*Oreochromis niloticus*), namely by Fresh Catch Belize Limited (FCB), and subsequently in 2006 the establishment of cobia (*Rachycentron canadum*) in grow-out cages by Marine Farms Belize Limited (MFB) near Robinson Point Cayes. Most recently, hatchery trials by MFB are also underway with the Florida pompano (*Trachinotus carolinus*) as well as the cultivation of seaweed (*Euchuma isoforme* and *Gracelaria* spp.) by fishermen of the Placencia Fishing Cooperative. Another project for the grow-out trial of the red drum (*Sciaenops ocellatus*) is currently under the permitting process to establish experimental grow-out cages near Stake Bank Caye. In terms of other species of commercial interest, some investors have expressed an interest in farming sea cucumber, oyster, octopus, and common snook.

Current Status

Shrimp: Although shrimp aquaculture was successful and promising in terms of investment, the industry has met some failure due to significant declines in the world market prices, as well as the impacts due to disease problems for the period 1995 to 2000. The economic losses sustained by the industry and the unfavourable market prices since then have resulted in major closure of more than 60% of the production area, especially those farms that had loan commitments with the commercial lending institutions. To date, the successful farms have been able to cope with the crisis and increase profit margins by adopting better husbandry strategies and supplying most of the products to the Mexican market. In 2012, there are a total of nine farms operational with a total area of 2,673 acres of production units. In 2011, a total of 9.8 million pounds were exported which generated a total of BZ $20.15 million in export revenues.

Tilapia: Apart from shrimp farming, the first commercial tilapia operation (FCB) was established near La Democracia in 2002. Since its inception, the farm has expanded to a total of 300 acres of production ponds with another 100 acres partially constructed. First exports of tilapia fillets to the US market were initiated in 2004. The farm's production peaked in 2008 to 1865 MT, and then production contracted to 455.8 MT in 2010. During this period however, the farm infrastructure was significantly impacted by Hurricane Richard, and compounded by the economic losses caused by the hurricane, the farm also experienced financial problems with the inability to meet its financial obligations. Subsequently, the farm ceased operation and was taken into bank

receivership. The receivership is now seeking potential buyers / investors to take over the aquaculture facility.

In addition to the commercial production of tilapia by FCB, over the past five years the Government of Belize has prioritized the development of small scale tilapia production through the establishment of a Technical Unit within the Fisheries Department to focus on developing the sector. Most recently, in 2012, this mandate has been transferred to the Department of Agriculture, Ministry of Natural Resources and Agriculture, which is now responsible for land-based aquaculture only.

There are currently 65 small-scale tilapia producers with an approximate production area of 20 acres. In an effort to support the current production systems and to expand this sector, the Government of the Republic of China (Taiwan), along with the GOB, is in the process of establishing a tilapia hatchery with a capacity to produce one million fingerlings annually at Central Farm - hatchery design and engineering are currently underway. Through a five-year development plan to be prepared by the GOB, the various issues of the high cost of imported feeds, low-credit financing, markets and marketing would be some of the priority areas that would need to be addressed if the sector were to move forward.

Cobia: The other species that was commercially developed was the cobia by MFB near Robinson Point Cayes with its first exports commencing in 2006. The highest production of cobia was in 2009 with a total of 500 MT pounds produced. Again, the farm infrastructure was extremely damaged by Hurricane Richard in 2010. The most affected were the grow-out cages, which suffered almost 80% of fish mortality as a result of damages caused to the physical structure of the nets and the anchoring system.

In 2009, MFB also established a hatchery for the production of cobia seedstocks near Dangriga. Hatchery production did not meet expectations and the farm was unable to sustain the grow-out operations. Since the cage production site by Robinson Point closed down operations in 2010, MFB dedicated efforts to improving hatchery production capacity and to diversifying the species portfolio. To date, the hatchery has proven capacity to mass produce cobia fingerlings and has breeding stocks of the Florida pompano for breeding trials. By the end of 2012, MFB investors will take a decision as to the future investment in grow-out operation at the Robinson Point Cayes production site.

Other Species of Interest: One of the most promising species as a means of an alternative economic opportunity for fishermen is the farming of seaweed. A group of fishermen from the Placencia Fishermen Cooperative has pioneered this initiative. Fishermen, through a grant from the UNDP, have been able to establish a commercial trial which has proven successful. The participants are now focusing on expanding the production area and have developed a business and marketing plan that will enable them to export seaweed both in the unprocessed form as well as a value-added commodity. The Cooperative is also seeking an investor and grant funding to expand production infrastructure so as to sustain constant marketing of the product.

Much interest has been expressed in Belize by various investors, either in purchasing shrimp farms that have been lying fallow, or in investing in new farms. One company, Blue Water International Belize Limited, has recently received approval to establish a pilot project to test the grow-out performance of the red drum. The production of this species has been attempted in the mid-1990's by Cherax Belize Limited which was later discontinued as the farm became bankrupt.

Regionally, much interest has been expressed in developing other species with aquaculture potential. The Organization of Fisheries and Aquaculture in Central America (OSPESCA) has been exploring alternative aquaculture species in the region such as the farming of sea cucumber, oysters, seaweed, octopus and the saltwater snook. To date, various exchange programs have been undertaken with countries that have developed the technology, such as Mexico which is currently producing the majority of these species. A regional forum has been proposed in June 2012 by OSPESCA at which aquaculture projects should be identified and prioritized for funding and implementation, especially for those emerging species.

The Food and Agriculture Organization (FAO) has recently published proceedings a workshop held in late 2010 to identify and assess the needs of establishing a "Regional Mollusk / Shellfish Hatchery for the Wider Caribbean". The project concept is still underway and participating countries would need to take this initiative forward by jointly accessing support and identifying donor agencies to establish the regional centre and conceptualize projects.

Management of Aquaculture in Belize

Regulatory Governance

There are various institutions involved in regulation of the aquaculture industry in Belize, indicating the level of GOB commitment. These institutions can be divided into two major: those directly associated with assisting the production process and those obliquely or indirectly associated with this process.

Although there is a general enabling environment for aquaculture, the sector, especially shrimp aquaculture, has developed with limited regulatory oversight. The major interaction between the private sector and the GOB has been in the form of lobbying for development incentives which would include the exemption of import duties on feed, fuel and farm equipment and machinery. The only institutions that are actively involved in monitoring of farms are the Belize Agricultural Heath Authority (BAHA) for sanitary aspects, and the Department of the Environment (DOE) with monthly water quality reporting and monitoring.

Recognizing the need for regulatory oversight for the industry, the Fisheries Department, in collaboration with the Coastal Zone Management Authority developed in 2002 a "National Aquaculture Policy & Zoning Plan for Aquaculture in Belize". Subsequently, in 2004, the Fisheries Department developed the "Aquaculture Regulations" with stakeholder participation – this has yet to be enacted. Alternatively, there was a proposed Aquaculture Bill by the Shrimp Growers Association, which had strong political support. The proposed bill was skewed towards self-

regulation with limited or no GOB oversight and the exemption from all forms of taxation. However, with strong opposition by the regulatory agencies and the NGO's, the GOB's interest eroded.

To date, there is an urgent need to put in place a regulatory framework for aquaculture given Belize's obligations to comply with certain regulatory requirements, especially for commodities destined for the export market and the on-going auditing by the importing countries. In Latin America, Belize is on the list of countries that need to advance the policy and regulatory regime for the sustainable aquaculture development.

Permitting Agencies & Roles

Recent (2012) Cabinet directives have divided responsibilities for the management of aquaculture in Belize. The Department of Agriculture has the responsibility for land-based aquaculture, with major focus on developing freshwater aquaculture in Belize. The Fisheries Department retains the other functions of mariculture and any other activities within the coastal waters. With regards to the derivation of national policy and legislation to guide the development of the sector, the GOB needs to make its decision on which institution has primary responsibility.

With regards to the labelling and certification of aquaculture produce, the mandate lies within the BAHA. BAHA is responsible for issuing export permits as well as the Hazard Analysis and Critical Control Point (HACCP) certification and inspection of aquaculture facilities in Belize. In general, BAHA is responsible for quality assurance, food safety and aquatic animal health.

The Department of the Environment (DOE) has been charged with the regulatory leadership of the EIA process, and is mandated to safeguard and sustain the integrity of the environment.

The Lands and Survey Department of the Ministry of Natural Resources is charged with the oversight responsibility for land tenureship. This includes the leasing of National Lands, and enacting and enforcing legislation governing land tenure.

The GOB institutions that are indirectly involved in managing aquaculture production process include the Departments of Petroleum and Geology, and the Ministry of Economic Development. The Offices of Petroleum and Geology have extended their mandate to include "earth movement" in regard to pond construction. This department has in effect become a permitting agency, since there is a need for aquaculture operations to obtain either a Quarry Permit or a Mining License before they can proceed with pond construction activities. The Ministry of Economic Development is involved with the permitting process with regard to applications for development incentives. This includes provisions for the exemption of import duties and taxes under the Fiscal Incentives Act, (Chapter 54, 2000), as well as the Export Processing Zone Act (Chapter 280, 2000).

Recommendations

1. The GOB needs to play a leading role in stewarding the sustainable development of aquaculture in Belize. There is a need to define the roles of the institutions involved in aquaculture with a view to revisiting the Fisheries Department-led aquaculture policy and regulations. The incentives program accorded to investors also needs careful review and, where necessary, expansion of those benefits whereby small farmers have participation.

2. The planning of aquaculture and lobbying with the GOB needs to be championed by an Aquaculture Steering Committee that would have the participation of both the GOB and private sector. The committee would have a better capacity to negotiate with government.

3. Reporting on the progress of the industry in terms of its annual performance has become a major challenge. The Statistical Institute of Belize needs to make it mandatory for operational farms to provide an annual report.

4. Put in place a regulatory framework for aquaculture given Belize's obligations to comply with regulatory requirements, especially for traded commodities.

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Tourism

Belize Tourism Board

Introduction

The Belize Tourism Board has a long history of guiding and enabling the development of sustainable tourism in Belize. Over the past decade, tourism has emerged as an integral pillar of the Belize economy. Tourism expenditure represents about 22% of the GDP and one in every seven jobs is related to or driven by tourism. The health of the tourism industry is a key economic driver and vital contributor to the quality of life for all Belizeans.

The Tourism Industry has become the largest revenue generator for Belize, directly and indirectly involving the greatest proportion of the labour force, and affecting all other sectors. An assessment of the tourism sector of Belize highlighted several areas of supply and demand-based economic vulnerability to climate change, including the risks to coastal land and infrastructure, exposure to resource damage (such as coral bleaching), and an associated reduction in demand because of resource changes or risks to personal health and safety. A preliminary assessment of Belize's tourism sector suggests that it is highly vulnerable to the effects of climate change through both its exposure to climate impacts and its capacity for adaptation.

Studies have examined the impact of a changing climate on the economy most recently the Caribbean Carbon Neutral Tourism Program in conjunction with the Caribbean Community Climate Change Centre (CCCCC). Adaptation measures that reflect these specific sources of vulnerability should be considered in light of the country's limited capacity to moderate the harmful effects of climate change. Such measures include diversifying the portfolio of tourism offerings to emphasize inland attractions, planning for coastal development with greater caution as reflected in the Sustainable Tourism Plan master plan, and also considering the feasibility of artificial reefs as underwater attractions to alleviate some of the existing pressures on Marine Protected Areas.

Vulnerability and Adaptation Assessment of the Tourism Sector

Undoubtedly, the Caribbean region faces numerous threats to its tourism industry due to climate change. However it is refreshing to know that Belize has developed a policy on adaptation to global climate change with each Ministry tasked with specific targets aimed at mitigation and adaptation strategies. The recent Carbon Neutral Tourism Programme (CCNTP) implemented by the CCCCC sets the precedent by assisting the Caribbean region to respond to climate change by devising ways of attracting new sources of financing for: (i) the scaling-up of low carbon investments in the tourism sector; and (ii) reducing the sector's vulnerability to climate change.

The nature-based tourism that is promoted in Belize is entirely dependent on the integrity of the natural resources. It is estimated that 80% of overnight tourists visit destinations within the coastal zone, and approximately 60% of income is derived directly from coastal and marine activities.

A recent Climate Change Risk Atlas for Belize implemented by the CARIBSAVE mentioned that, "*Based on present spending levels, it is estimated that 45% to 70% of the tourism sector is highly vulnerable to the effects of climate change. At current spending levels, this corresponds to BZ $180 to BZ $280 million (or US $90 to $140 million) and is related to the proportion of tourism that is centred on the cayes, atolls and coastal zones.*" (CARIBSAVE Climate Change Community Risk Atlas). According to available statistics Belize is emitting lower levels of CO^2 than the global annual average of 4.3 t CO^2 per capita (3.1 t CO^2).

In Belize, a 1 m seal level rise (SLR) places 73% of the major tourism properties at risk, with 86% at risk with a 2 m SLR. It is important to note that critical beach assets would be affected much earlier than the SLR induced erosion damages to tourism infrastructure. With projected 50 m erosion, 95% of all major tourism properties in Belize would be at risk, with all (100%) at risk with 100 m of erosion. Such impacts would transform coastal tourism in Belize, with implications for property values, insurance costs, destination competitiveness, marketing and wider issues of local employment and economic well-being of thousands of employees. Belize relies on its tourist industry for much of its national income and therefore the economic effects of SLR and storm-induced erosions are very significant.

If action is not taken to protect the coastline of Belize, current and projected vulnerability of the tourism sector to SLR, include coastal inundation and increased beach erosion, which will result in significant economic losses for the country and its people. Adaptation to minimize vulnerabilities in Belize needs to involve revisions to development plans and major investment decisions.

In real terms, the threats posed to the region's development prospects are severe and it is now accepted that adaptation will require a sizeable and sustained investment of resources. Over the last decade alone, damage from intense climatic conditions has cost the region in excess of half a trillion US dollars (CCCCC, 2009).

Climate variability affects operations and management practices in tourism and its related sectors such as agriculture, water resources, health and biodiversity. Extreme weather events can also impact energy supply and distribution. Belize is already experiencing some of the effects of climate variability through damage from severe weather systems and the decline of some coastal tourism attractions (Caribbean risk atlas, 78).

According to the Government of Belize, the major issues of climate change in Belize are SLR, the likelihood of more intense weather systems and loss of biodiversity. With its high-density development along the coast, the tourism sector is particularly vulnerable to climate change and SLR. Belize is one of the Caribbean's most important tourism destinations where the threat of SLR has been identified as a particular concern in both the short and long-term. Belize relies on its tourist industry for much of its national income and therefore the economic effects of SLR and storm induced erosions are very significant.

Carbon Credits and Carbon Neutral Recommendations

Extensive sea grass beds are found along the entire length of Belize. The main species are turtle grass (*Thalassia testudinum*) and manatee grass (*Syringodium filiforme*). These sea grass beds play an important role as primary producers in the food chain of the reef community producing more than 4000 g C/m^2/yr. They also provide habitat, feeding, breeding, and recruitment and nursery grounds for many marine animals including the major commercial species. Seagrass beds also support large populations of manatees, which are an important eco-tourism attraction in the tourism centres of San Pedro, Caye Caulker and Placencia. Seagrass beds also help reduce sediment movement in near-shore waters and stabilize the coastline during storms. These ecosystems are generally distributed along the coast in shallow water where sunlight penetration is adequate to allow photosynthesis. Their location leaves them highly susceptible to run-off from land-based activities and to stressors arising from water sports activities. Belize can benefit from Carbon Neutral, or "blue carbon" programmes by focusing on its natural resources in a sustainable manner while encouraging tourists to play an active part in supporting initiatives aimed at low carbon development.[1]

"*The potential for the world's seagrasses to be used as carbon offset credits is an initiative referred to as Blue Carbon. The idea is simple. A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one ton of carbon dioxide. Carbon credits are part of national and international efforts to mitigate the growth of greenhouse gases by capping emissions and allowing regulated sources that emit greenhouse gases to buy credits for emissions. That money is used to preserve the world's resources that naturally store carbon dioxide. Seagrass meadows are capable of storing as much carbon dioxide as any forest. Currently, there could be as much as 73 billion metric tons of carbon dioxide already being stored in the world's sea grass meadows."*[2]

Recommendations

- Reduce energy use
- Improve energy efficiency
- Increase use of renewable energy
- Sequester carbon through sinks
- Complete a focused analysis of the vulnerability of the secondary and tertiary economic impacts of damages to the tourism sector due to SLR.
- Assess the adaptive capacity of the tourism sector to SLR.
- Commence coastal protection adaptation planning early, e.g. by conserving the remaining mangrove areas.
- Integrate SLR into the design of all coastal structures.
- Integrate SLR into government insurance policies

[1] http://phys.org/news/2012-05-seagrasses-carbon-forests.html
[2] http://phys.org/news/2012-05-marine-scientist-champions-blue-carbon.html

Knowledge Management System Overview – San Pedro Case Study

San Pedro town on Ambergris Caye is the tourism industry's largest revenue generator, accounting for over 40% of total revenue produced in the accommodation sector. Tourism development on Ambergris Caye has sometimes occurred in an unrestrained and haphazard manner, and this trend is not sustainable over the long term. It has become clear that in order to understand the true cost of managing a tourism destination sustainably, a system would have to be developed that is tailored to produce certain required results. The concept is to create an instrument that correlates economic, social and environmental data, thereby illustrating the effects of tourism expansion and development on the growth and advancement of San Pedro as a destination and as a community. This project is being called a "Knowledge Management System" (KMS). KMS is being designed to serve as a decision making tool that will guide municipal leaders in issues of destination management and influence national leaders in matters related to tourism policy development for the island.

The concept of the KMS was envisioned by Megan Epler Wood (Planeterra Foundation) after discussion with San Pedro's mayor Elsa Paz. The mayor outlined some of the challenges faced, particularly in dealing with sustainable development of the island. Insufficient finances are currently provided to manage a destination that has been allowed to expand in the absence of governmental vigilance. While the needs of destination managers in San Pedro had always been articulated, the tools to help address these problems had never been conceptualized, until now.

The Knowledge Management System project is a partnership between the BTB, Planeterra Foundation, and Cornell University's Centre for Global Sustainable Enterprise. Dr. Mark Milstein, professor of Cornell University, leads a team of three students from Cornell University's Johnson Graduate School of Management and the College of Architecture. The students developed a prototype for the KMS system and collected economic, social, and environmental data on San Pedro by consulting with numerous stakeholders on the island. The overall objective was to establish data tracking points for the KMS, specifically those that can be populated or updated over time. Some concerns raised during stakeholder interviews included: i) development is occurring in environmentally sensitive areas, ii) marine species are being depleted because of development and over-fishing, iii) not all *de facto* hotels are licensed, iv) there are not enough police officers to prevent major crimes against tourists, and v) hotels need to turn down visitors with minor health concerns. KMS used 19 key Topic Areas: air quality, land use, biodiversity land coverage, crime & safety local economy, demographics, municipal solid waste, education, real estate development, electricity, sewage, fishing, town council, health, water, hotel industry, water-based tourism, and road infrastructure. These topic areas were chosen because they affect or are affected by tourism on the island. Overall, KMS is meant to: increase participation, increase knowledge-sharing, increase accessibility to data, decrease hearsay, have longevity and be replicable, and finally to provide analysis options.

The long term goal of the KMS project is to create a model that can be used to construct similar systems in other destinations across the country. If the KMS is successfully deployed, it would be

the first of its kind in this region. Its development will signal a real shift towards sustainable tourism planning and development for Belize, and will further illustrate BTB's commitment to achieving the goals set forth in the two year Action Plan.

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Authority

The business of coastal zone management has important components that steer its direction. These are considered here as 'authorities', as they establish a framework in which stakeholders operate.

The most weighted authority is discussed in this section: Legislation.

Advocacy is included as public response has a very meaningful impact on direct management activities, and can have legislative consequences.

Finally, public valuing of the natural resources is a considerable driving force in the success of managing the coastal zone.

Legislation for the Coastal Zone

Candy Gonzalez, J. D.

Introduction - Status of Belizean Approach to Environmental Law

Over the past twenty years, Belize has seen continuous expansion of on-shore and offshore coastal development including tourism, agriculture, aquaculture, and infrastructure development. Unfortunately, much of this coastal development has been arbitrary, indiscriminate and largely unsustainable because Belize has no national land use policy or plan, much less a plan focusing on coastal development. The legal and institutional framework for the management of the coastal zone is inconsistent and incomplete.

It was expected that The Coastal Zone Management Authority and Institute would bring some order into the chaos of coastal management. It was anticipated that the Advisory Council, made up of the many different departments and ministries as well as civil society, would bring all the parts together. Unfortunately, it did not.

Now, offshore oil exploration and drilling, and cruise ship tourism, among other things, are following the same haphazard and uncontrolled path blazed by general coastal development. At issue is the direction to be pursued, whether it is better to: (i) seek new legislation; (ii) amend existing laws and regulations; (iii) repeal redundant statutes; or (iv) consolidate existing laws and regulations into a more coherent package.

Strengths & Weaknesses of Relevant Laws Related to the Coastal Zone in Belize

While many of the existing laws, regulations, and guidelines are relevant to the management of the coastal zone and its resources, many others are outdated and/or redundant. The strength of the relevant laws related to the coastal zone is that they exist. They indicate a commitment to work for sustainable development and a desire to use natural resources in a sensible manner. Another strength is the public's growing awareness of the importance of protecting and preserving the coastal zone and using its resources in such a way as to make them last for future generations.

The weakness of the relevant laws related to the coastal zone is that they are inadequate to meet the task. This is due to a number of reasons including the lack of a coordinated scheme or plan for the coastal zone and, the difficulty in enforcing the laws related to uncontrolled development, pollution, and overfishing, etc. These problems are exacerbated by the misuse of the discretionary powers of the ministers and by corruption.

Effectiveness of Relevant Legal or Policy Related Working Groups

Often an Act will include the creation of a committee or authority to handle and/or oversee the implementation and functioning of that law. Below are a few examples of such bodies.
The Environmental Protection Act calls for the creation of the National Environmental Appraisal Committee (NEAC) to vet all environmental impact assessments (EIAs). The NEAC, in reviewing an EIA, is to take into consideration the comments of the public, though this rarely happens. The NEAC is composed of people with expertise in various areas; their decision on granting environmental clearance for a project is only advisory. The Minister does not have to take its advice. In addition, the majority of the members of NEAC work for government and there is a lot of pressure on them to approve projects. This impacts its effectiveness. NEAC is functioning and the chair is the Chief Environmental Officer.

The Land Utilization Act requires the establishment of the Land Subdivision and Utilization Authority composed of representatives from relevant government departments, ministries, as well as local authorities when appropriate, and the Chief Engineer or representative. It is tasked to review all private subdivision applications and makes recommendations to the Minister on granting approval. It operates in an advisory capacity and the Minister has the final say. This may suffer the same problems as NEAC as to effectiveness. The Authority is functioning and the chairman is the Commissioner of Lands and Survey.

The Housing and City Planning Act established the Central Housing and Planning Authority made up of persons nominated by the Minister. Its members include representatives from the Health Department, Public Works, Lands and Surveys Department, and NEMO. Other members may include the Agricultural Department when appropriate; a planning officer or architect when zoning, site planning, or building is under consideration; and any specialist officer who may be available when the advice of such specialist officer is considered desirable. Also included are representatives from local authorities when appropriate and a representative from the Education Department when the matter concerns any school. The Authority has only advisory capacity, and though it exists, has not functioned for several years.

The Petroleum Act states that the Minister shall appoint the Environmental Pollution Control Board to ensure that all petroleum operations comply with the requirements of environmental standards and the relevant laws of Belize. No Board has been designated.

Key Legislation & Policies that Affect CZM – 2003-2010

There is a plethora of legislation relating to the coastal zone enacted through different ministries and departments. The key pieces of legislation are the Coastal Zone Management Act, the Environmental Protection Act and the Land Utilization Act.

The Coastal Zone Management Act establishes the Coastal Zone Management Authority and Institute to oversee and coordinate activities in the coastal zone. Its goal is to control the use of coastal resources by the development of an integrated coastal zone management process, to bring

together all the different agencies and interests, governmental and private, for the overall preservation and good of the coastal zone. In order to achieve that mandate, the coastal zone and coastal waters are defined and mechanisms were established to monitor a variety of activities within these areas. While the *Cayes Development Policy 2003*, drafted by CZMAI, expounds the provisions of a Coastal Zone Management Strategy and coastal development guidelines were developed for the offshore coastal region, none have been officially approved. The Cayes Development Policy is a solid foundation toward developing a coastal zone plan.

The Land Utilization Act allows for the Minister of Natural Resources to make regulations to prohibit clearing of vegetation, to demarcate areas as special development areas (SDAs) and to stipulate the type of development that will be permitted and for clearing of any forest or cutting of any tree within these areas. The objective of SDAs was to fill gaps that exist through the absence of zoning and land use management laws.

The Environmental Protection Act creates the Department of Environment (DOE) with the goal of providing for comprehensive environmental protection. Some relevant functions, duties and powers of the Act are: to *ensure the protection and rational use of natural resources for the benefit of the present and future generations;* to *undertake investigations and inspections to ensure compliance;* to *play a major role in providing the direction for long-term sustainable development based on the promotion or incorporation of ecological concerns in the economic development process.* The Act is supported by Regulations that establish guidelines and procedures for implementing the law.

The Environmental Impact Assessment Regulations require that anyone intending to undertake any project, program or activity that may significantly alter the environment is required to do an EIA indicating the effects of the proposed activity on humans, fauna, flora, soil, water, air, climatic conditions, etc. The activities that must have an EIA are listed in Schedule I of the Regulations (as amended) and include:

- *"8(h) – Construction of hotels, resort facilities and golf courses within or in close proximity of the boundaries of a protected area or a World Heritage Site. . ."*
- *"9(a) – Dredging for land reclamation and/or creation of projects utilizing a volume of material or more than 50,000 cubic yards along the coast, cayes and ecologically sensitive waterways. .."*
- *"9(b) – Any land reclamation or creation project in excess of ten acres along the coast or within a wetland. . . "*
- *"10(c) Any large-scale mining of minerals. . . "*
- *"14(h) Clearing of more than 10 acres of mangroves in ecologically sensitive areas."*

The activities that ***may*** need an EIA are listed in Schedule II of the Regulations; DOE decides which of the activities on Schedule II need an EIA. The pertinent ones are:

- *"9(e) – Clearing of fringing mangrove vegetation on islands or adjacent to marine or forest reserves for industrial, housing or agricultural use. . ."*
- *"14(b) Extracting of minerals such as marble, sand, gravel…"*
- *"17(b) – Development of tourist or recreational facilities or adjacent to national parks or protected areas. . . "*

- *"17(c) – Development of tourist or recreational facilities on cayes or islands…"*

Although the above three pieces of legislation are the main ones impacting the coastal zone, it is important to have a little insight into four other laws/regulations that are relevant.

The Housing and Town Planning Act is a major legislation for land use planning, though it has never been extensively used for that purpose; its lack of implementing regulations and orders make it a "paper tiger". It has potential to fill many gaps.

The Forest (Protection of Mangrove) Regulations deal with mangroves on public and private land. Management of the coastal zone cannot be discussed without addressing the protection of mangroves. There are many problems with the existing regulations. In 2008, a Mangrove Task Force was formed to draft an amendment to the regulations. It was completed but never enacted into law.

The Mines and Minerals Act governs mining activities. Dredging is defined as a form of underwater mining in the Act. Dredging is a major problem within the coastal zone and these can be dealt with through this Act.

The Petroleum Act is relevant because of the oil concessions that have been meted out by government for oil exploration in the coastal zone. The Act needs much work in order to map out a regime of regulations that would begin to address this type of activity.

Global CZM Laws

Many countries are dealing with coastal zoning problems. Some have made more advances than others.

In India the coastal zone is defined and divided into four zones, with different levels of protection for each zone. The new CZ regulations, of January 2011, have introduced a concept of hazard line restrictions when it comes to the setting up and expansion of industries, operations or processes, and the like in the said coastal zone. Additionally, the Supreme Court ruled that giving power to relax rules and give concessions in the Coastal Regulation Zone (CRZ) amounts to the same thing as giving the Government arbitrary, unguided power; this may result in serious ecological degradations and make the "No Development Zone" ineffective. [Union of India vs. Chennai Metropolitan Development Authority. 2006 (4) KLT.SN.117. P. 84:2006(4) CTC 460. P].

In Australia, responsibility for coastal protection is divided between the state and local governments. The Minister for Planning has a general responsibility for coastal areas, and often has an ongoing role in regards to proposed developments. Coastal Panels constituted under the Coastal Protection Act 1979 have consultative and approval functions for proposed developments in the coastal zone. The Act gives the Environmental Minister broad powers to regulate development in the coastal zone. Of particular interest to Belize is that in Australia, offshore petroleum exploration is regulated at the State and Commonwealth level.

Jamaica has an overabundance of legislation relating to the coastline and marine areas and several authorities with jurisdiction over these areas, as does Belize. Unlike Belize, Jamaica has no definition of the coastal zone. It has a Beach Control Act that regulates the foreshore, which is defined as the area between the low and high tide mark. The area inland beyond the foreshore is not generally regulated unless it falls within a marine park or is considered a wetland. In the former case, there are regulations that restrict the kinds of activities that may take place. In the latter case and also for the foreshore, a permit or license is required for modifications. There is a Council on Ocean and Coastal Zone Management that seeks to coordinate the activities of the various authorities responsible for the coast and marine areas.

Mexico, like Jamaica, does not have a law that defines the coastal zone or an authority in charge of the conservation and sustainable development in this area. Mexico has developed policies for coastal development that focus on the coordination of the different authorities, but does not have an authority that analyzes the situation and needs, overall, and make the decisions to coordinate the other authorities.

Key International Treaties/ Conventions Signed by Belize

- Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) 1983
- Convention on the Prevention of Marine Pollution from ships, 1973, 1978 (MARPOL)
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990 enforced 1995
- UNESCO Convention Concerning the Protection of the World Cultural and natural Heritage 1972 (Heritage)
- United Nations Convention on the Law of the Sea, 1982 (UNCLOS)
- United Nations Framework Convention on Climate Change, 1992 (UNFCC)

The important international treaties/conventions that Belize should ratify are:

- International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001, enforced 2008
- International Convention on Civil Liability for Oil Pollution Damage, 1992 (CLC 92)
- International Convention on the establishment of an International Fund for Compensation for Oil
- United Nations Convention against Corruption (UNCAC)

Recommendations

1. Curtailing ministerial discretion as demonstrated in the discussion on the Authorities and Committees established under key legislation. Giving the Minister broad discretionary powers without any provisions for meaningful public consultation and participation makes the laws ineffective. See above, in the case of India, how a court decision is paving the way to make such changes.

2. Need for a comprehensive coastal zone plan that integrates physical, institutional and economic considerations with broad based representation as well as multiple-use zoning regulations.

3. Legislation to address the different needs for effective development control in the coastal zone, legislation that guides the implementation and enforcement of such laws as well as a clear delineation of who is in control to make the decisions and follow up.

4. In 2004, the Belize National Planning Bill was drafted with the purpose of making provisions for land use planning and sustainable development and replacing development plans and other related instruments. It did not define zones or zoning. A new piece of legislation needs to be drafted rather than trying to revise or amend that Bill.

5. All decisions related to coastal issues must allow for public input and participation.

6. There must be a demonstration of political will in the form of added personnel and funds for the purpose of monitoring and enforcing of laws; this must include better inter-departmental communication that will aid enforcement and monitoring efforts and be more cost effective.

7. Suitable amendments and regulations for various laws relevant to the coastal zone.

a. Amend the Coastal Zone Management Act to give substance to this Authority so it can develop an overall theme and better manage development of areas. There is no separate legislation specific to marine and coastal areas. Amend the Act to give this Authority to CZMAI.

b. Amend the Environmental Impact Assessment Regulations to remove the discretionary power of DOE to decide whether a project needs an EIA, by including public/stakeholder input as a requirement for any decisions; by putting "oil exploration activities" back into Schedule I; by strengthening the requirements and criteria for mandatory and meaningful consultation with legitimate and other local interests.

c. Amend the Petroleum Act to give it meaningful powers for the protection of the people and resources of Belize and include, along with NEMO, provisions for effective response programs for worst-case scenarios.

d. Amend the Protection of Mangrove Regulations to define areas that need a license as well as increasing fines when there is illegal activity.

e. Amend the Mines and Minerals Act as it relates to dredging activities, including an increase in fines.

f. The Land Utilization Act must develop Regulations to control land utilization overall.

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- Chapter 188 & 188s Land Utilization Act RE 2000
- Chapter 191 National Lands Act RE 2000
- Chapter 210 & 210s Fisheries Act & Regulations RE 2000
- Chapter 213 & 213s The Forest Act and Regulations RE 2000
- Chapter 225 Petroleum Act RE 2000
- Chapter 226 & 226s The Mines and Minerals Act
- Chapter 328 & 328s Environment Protection Act RE 2000 (revised 2009)
- Chapter 329 Coastal Zone Management Act RE 2000

State of Belize's Environmental Advocacy

Tanya Williams

Introduction

Belize's Coastal Zone is critical to the economy of Belize as industries within the coastal zone contributed BZD700 million to Belize's economy in 2006. In addition, 38% of the Belize's population calls the coastal zone home (Neal et al. 2008). With its high value, the coastal zone also faces competition for resources use. There is continued need to ensure balance among the multiple uses and resource users while protecting the environment these industries depend on.

Environmental advocacy has played an important role in campaigning for policies and management strategies that focus on balancing the needs of various industries and sustaining the health of the coastal zone. This is reflective of the general role of advocacy which can be defined as "influencing public policy in social, economic, political, and cultural spheres in order to bring about justice and positive change in human rights and environmental issues" (Retrieved from http://environmentalprograms.net). Notably, environmental advocacy has advanced where campaigns embrace partnerships from business, grassroots organizations, government, etc. Generally, environmental advocacy is implemented by non-governmental organizations in Belize, but there is also some degree of environmental advocacy within Government ministries.

Historical Perspective

The establishment of marine protected areas and the protection of the reef system have been central themes for environmental advocacy campaigns in Belize. A historical perspective of environmental advocacy with direct impact on the coastal zone traces to the declaration of Belize's first marine protected area in 1982 – the Halfmoon Caye Natural Monument. The Belize Audubon Society (BAS), a non-governmental environmental organization, was at the forefront of the advocacy efforts, which was significant as it came one year after Belize's independence and was the first marine protected area in Central America.

Another important milestone for environmental advocacy in Belize was the declaration of the Belize Barrier Reef Reserve System (BBRS) being inscribed as a World Heritage Site in 1996. The nomination for World Heritage status emanated from the Global Environment Facility/United Nations Development Programme (GEF/UNDP) Coastal Zone Management Project. World Heritage inscription was significant for coastal zone management as the declaration of the BBRS being as a World Heritage Site – a feature of "outstanding universal value" – was boosted by Government's commitment to establish a management regime for activities within the property, namely the Coastal Zone Management Authority (Gibson 2011). The World Heritage inscription also provided an extra layer of support for sustainable management of Belize's coastal zone. In addition, the actual nomination process drove the declaration of four new marine protected areas as the BBRS World

Heritage Site is a serial site consisting of 7 marine protected areas (Gibson 2011). Notably, Belize had to address concerns over the potential for oil exploration and drilling offshore prior to the declaration (Gibson 2011) - a concern which has re-emerged with the existence of oil exploration concessions within the BBRS and the offshore system.

Significant Advocacy Campaigns 2003 – 2011

Strategic environmental advocacy in Belize has resulted in the development of significant strategies, polices and legislation. Indicated here are environmental advocacy campaigns for the period 2003 – 2010, which have achieved measureable success.

Development of a National Protected Areas System Policy and Plan

Belize has 26% of its territory under protection. The Belize Barrier Reef Reserve World Heritage Site is comprised of seven marine protected areas. However, Belize's protected areas were managed without an overarching policy and plan, resulting in disjointed management.

After years of advocacy by non-governmental organizations, the Government of Belize finally received funding and implemented a consultative process to develop a protected areas system policy and plan which concluded in 2005. Implementation of the plan is ongoing.

Assessing Climate Change Vulnerability and Identifying Adaptation Measures

As a country with low-lying areas, coastal communities and significant dependency on its coastal resources for economic development, Belize is extremely vulnerable to climate change. The World Wildlife Fund (WWF) has been the leading non-governmental organization partnering with Government and other NGOs to identify climate change vulnerability and making recommendations for adaptation and resilience.

Working on a local and national level, WWF has been able to get communities, stakeholders and Government to identify vulnerability and risks of climate change threats and plan development while taking these threats into consideration (Bood 2008). In addition, vulnerability assessments at key tourism hotspots have been developed and WWF has partnered with CZMAI to update the San Pedro Master Development Plan and has also worked with BTIA-Placencia in the 2020 Development Vision for the Peninsula (N. Bood pers. comm.).

Banning Overfishing of parrot fish and spear fishing in protected areas

Parrotfish and other grazers are critical to the health of the reef in controlling algae growth and the parrotfish and surgeon fish is listed on the "IUCN Red list due to overfishing throughout the Caribbean" (Hance 2009**)**. Historically, fisherfolks were less inclined to capture parrotfish for commercial sale. However, overfishing of commercial species such as groupers and snappers supported an increasing drive to capture any saleable fish, including parrotfish, which resulted in a declining population for this important "reef cleaner".

Partnering with Wildlife Conservation Society, the Healthy Reefs Initiative (HRI) was successful in its advocacy campaign to get legislation passed to protect the parrotfish and sturgeon fish. The strategic partnership and campaigns resulted in not only legislation to protect the parrotfish, but also enabled legislation enacted to ban spearfishing in marine reserves. An education and awareness campaign spearheaded by HRI titled "Real Men" (M. McField, pers. comm.) coupled with years of research by both partners and engagement of key stakeholders underpinned the success from campaign to legislation.

BBRS on World Heritage in Danger List

The environmental community persistently advocated and lobbied Government to restrict the permitting of development within the Belize Barrier Reef Reserve System World Heritage property. However, development continued unabated including the issuing of offshore oil concessions within the property and development within the Pelican Cayes range which is well-known for its high biodiversity. The aforementioned issues propelled Belize's environmental community to seek the inscription of the BBRS on the list of World Heritage in Danger. In 2009, the environmental community was successful in getting the Belize Barrier Reef Reserve System inscribed on the World Heritage in Danger list.

As a result of the inscription on the World Heritage in Danger list, the Government has been asked to implement corrective actions including cancellation of oil concessions. At the recent meeting of the World Heritage Committee in June 2012, it was decided that the BBRS would remain on the World Heritage in Danger list as the necessary corrective actions have not been made.

Banning Shrimp Trawling

Shrimp trawling has been identified as a destructive fishing practice due to its high bycatch rate. For several years achieving a ban on shrimp trawling has been at the top of the advocacy list with little movement from advocacy to legislation. A strategically- timed campaign and innovative partnership by Oceana in Belize in 2010 resulted in the ban being achieved.

The approach used by Oceana was to advocate and lobby Government and the fishing cooperatives who owned the shrimp trawlers and to provide an incentive to the fishing cooperatives to relinquish use of the shrimp trawlers. The partnership resulted in a ban on shrimp trawling and an agreement whereby Oceana purchased the shrimp trawlers and donated them to two organizations for educational use and providing a one-time funding for assistance to the cooperatives.

Banning Oil Exploration and Drilling in Belize's offshore

In 2010 Belizeans were informed that almost all of the country including the offshore and protected areas had been parcelled off into oil concession blocks. The issuing of oil concessions in the offshore area, which includes the Belize Barrier Reef, was a catalyst for one of the most significant environmental advocacy movements that saw collaboration amongst unlikely partners: environmental, business, trade union, and social/grassroots organizations. The end result was a coalition called the Belize Coalition to Save our Natural Heritage which focused on sustainable

development of Belize's petroleum industry, which includes achieving a ban on oil exploration in the offshore and protected areas.

To achieve a ban on oil exploration in the offshore area, the Coalition engaged the public through awareness and education and in a bold move, sought to trigger a national referendum through petitioning under the Referendum Act on the issue of offshore oil exploration and drilling. When the national referendum was frustrated through an administrative decision by the Elections and Boundaries Department to disqualify 40% of the petition signatures, the Coalition held a People's Referendum which saw over 29,000 Belizeans come out to vote on whether Belize should allow offshore oil exploration. Ninety-six percent of those who participated in the people's referendum voted "no" to offshore oil exploration and drilling.

Historically, Belizeans have not been engaged in natural resources management; however, the issue of oil and the reef has motivated the Belizean citizenry to become engaged. This is an ongoing campaign.

Strengths and Weakness

Environmental advocacy campaigns and approaches are metamorphosing, pushing environmental /natural resources issues higher on the national agenda.

Strengths

- Increase in national and regional scientific research and access to research
- Advocacy approach is collective – Coalition / Network approach
- Infusion of social justice/grassroots organizations
- Campaigns are more strategic in approaches (timing, etc.)
- Recognition of the importance of speaking $$$, human rights and social justice along with the appreciation of nature.

However, old attitudes and strategies still derail the successful movement of environmental/natural resources issues to a higher rung on the national agenda.

Weaknesses

- Piecemeal approach to campaigns and inability to implement sustained campaigns
- Implementing the same old strategies and expecting different results
- Failure to establish and maintain credibility with public – making public relations an organizational priority and implementing prior to advocacy campaigns
- "Lone wolf" approach of some organizations on national issues that in reality require collaboration for success.
- Not evaluating advocacy work nor the policies or legislative changes achieved.

Recommendations

1. Belizeans generally have stewardship for the sea, however, to get the public engaged and actively involved, organizations doing environmental advocacy must commit to building visibility (public relations). Generally, people do not follow or support what they do not know about.

2. The analogy of the "lone wolf" which can only feed on small animals or scavenge and the "wolf pack" that can bring mammoths to the dinner table; the former could become strong from being independent while the latter could also turn on each other. This is a good analogy for the approach to environmental advocacy, as organizations need to decide when an issue requires a collaborative approach or when an independent approach is more effective.

3. Successful environmental advocacy requires the recognition that to change a policy maker's position and enable policy change, strategies must scare them at their constituency level, i.e. their constituents must be engaged in the issue.

4. Collaboration with non-environmental or natural resources organizations is helpful by including and engaging populations previously unreachable by environmental and natural resources organizations.

5. Avoid politicizing advocacy campaigns.

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The Emotional Nature of Value in the Belize Barrier Reef

Patrick Gallagher

Background

Over the past decade, the Belize Barrier Reef and the broader Mesoamerican Reef system, has become an increasingly prominent site of conservation concern. This period of heightened interest in the conservation value of the Belize Barrier Reef has coincided with a significant cultural shift in the practice of environmental conservation towards market-based methods and metaphors for managing and conceptualizing natural resources (Robertson 2004; Sullivan 2011). This shift includes the move towards the use of ecosystem services and natural capital, concepts that imagine nature as an economically valuable producer of ecological services that are useful to people and expensive to re-create through conventional built capital (Daily 1997; Paruelo et al. 1997).

As a result of this coincidence of interest in the Belize Barrier Reef and a notable global shift in conservation practice, the reef has become a critical test site for the implementation and evaluation of new conservation practices—in several cases acting as a demonstration site for potentially global new techniques and technologies of environmental management. This has included, among other projects: multiple efforts at valuing the reef system at a variety of scales (e.g., Cooper et al. 2009), projects aimed at modelling the flows of ecosystem services (e.g., Patel et al. 2011), and educational and advocacy efforts geared towards producing new relationships of responsibility between people and coastal resources that link ridge to reef both socially and ecologically (e.g., Kramer and Kramer 2002).

As a cultural and environmental anthropologist, these shifts are of interest in two ways. First, I am interested in these changes as a locally situated example of a broader shift in the philosophy and methodology of environmental conservation—a shift towards more economic, and especially capitalistic and neoliberal, conceptions of nature. The Belize Barrier Reef then has been a compelling site for considering how global shifts in conservation practice are carried out in the culturally and ecologically specific context of Belize. It has been an especially compelling site for understanding the emerging role of spatial conservation technologies (such as GIS) in making broad new social connections to natural resources where frequently no social relationship to a resource previously existed (e.g., the linking of inland agricultural practices to the health of coastal ecosystems).

Second, Belize provides an important site for considering the social impacts of these shifts in conservation practice—for considering how new social relationships of responsibility are produced and how people respond socially and emotionally to the idea of nature as an object of economic production and as a source of monetary value in need of protective intervention.

In this research project, ethnographic work with international scientists, global and in-country conservation organizations, general community members, and members of national and local policy

and governmental communities has yielded a relatively broad-ranging sense for these changes in conservation practice in Belize and for their social and cultural implications.

Introduction

The hypothesis entering this anthropological research project was that this emergent globally significant way of thinking about nature was fundamentally changing the way that conservation operated as a professional, political, and social field of action in Belize. In making new ways of *thinking* about nature (new metaphors for how nature worked and how we valued it), we were simultaneously making new ways of seeing, analyzing and representing it, and significantly reworking the relationship between the domains of nature and culture in that process.

Analyses and critiques of these changes in conservation practice in other contexts have argued that such shifts lead to a more rationalistic, calculating form of conservation where nature merely becomes one more valuable, tradable commodity among others—that the realm of nature becomes incorporated into the realm of the market. Under this argument, subjects of environmental conservation projects either begin to adopt and naturalize this calculating logic or push back strenuously thereby highlighting their fundamental local opposition.

Findings

In the context of Belize at least, these analyses risk being socially and politically simplistic and underplaying some of the more nuanced and surprising ways in which ideological changes in conservation have manifested themselves politically and socially in the country. For purposes of this relatively brief report, I want to highlight two more surprising findings of this research project that run somewhat counter to the received wisdom on the social consequences of market-based conservation and consider their implications for the practice of conservation in the coastal zone of Belize and its connected ecosystems.

The Emotional Nature of Value

First, and perhaps most surprising, is the finding is that the response to efforts at monetary valuation are frequently deeply emotional rather than coldly calculative, and that the emotional nature of valuation is at least partially linked to the fact that the monetary value of ecosystems is often actualized through exercises that imagine their destruction or disappearance. Second, anxiety often arises out of the scale at which value is imagined. Frequently, the conservation rhetoric of ecosystem services utilizes messages that convey a personal or community responsibility for forms of value that are made at a much broader eco-regional scale thereby creating a disconnect between the scale of ecological and economic value and the desired scale of social action or change.

The argument made very effectively in other contexts by some social scientists (e.g. Robertson 2006; Hayden 2003) is that the project of ecosystem service science, and market-based conservation in general (whether in actual market methods or simply in a metaphorical language of markets), is to make a nature that capital can see—that nature instead of being a space situated in opposition to economic capital becomes one of interest for capital investment.

But in speaking with many people in the conservation industry in Belize, the project of identifying, visualizing, and valuing ecosystem services has been as much about making a nature that capitalists can *feel*, as it has been about making a calculative space that capital can see.

Informants have suggested that their work is more concerned with giving people the powerful emotional-ethical sensation of calculation than it is with giving people the actual technical capacity to calculate in dollars and cents (often readily conceding that the object of concern is largely incalculable to begin with).

In interviews, people outside of the conservation, policy and government communities in Belize have repeatedly told me that finding out that they are potentially damaging the reef's economic value makes them "*feel* bad", "*feel* guilty" or "*feel* responsible." The emergence of ecosystem service thinking in Belize hasn't caused much calculation on the part of everyday Belizeans. Rather, it's made people *feel* differently.

What conservation professionals in Belize have told me repeatedly is that by highlighting the economic value of nature, they hope to better connect people to the importance of its preservation, to produce a sense of "ownership" in these ecosystems.

Anthropologist Alex Golub (2007) has characterized "ownership" in the context of its usage in environmental projects in Papua New Guinea as "the internalization of a certain emotional disposition." His definition highlights the fact that the language of property and finance that drives "natural capital" and "ecosystem service' conservation" often ends up being more about achieving certain affective changes—reorientations of social relations—than it is about creating a currency of value that resides somehow outside of those relations. The language of finance capitalism here doesn't disentangle nature, and its valuation, from the complexity of the social relations which produce it. Rather, it is more often being deployed, here in Belize at least, as a strategic rhetorical device aimed at significantly reorienting social relations that conservationists feel do not channel societal effort and value properly.

The emotional nature of "ownership" when it comes to "natural capital" and "ecosystem services", and the frequent disconnect between ethical ownership (a responsibility for something) and simple property ownership (rights to that something) is critical. Because it is here that I think part of the anxiety around the valuation of ecosystem services or natural capital in Belize has been rooted. Through language that ecologically connects the social practices of people in Belize to the reef, people are emotionally vested with responsibility (and this can, of course, be a good thing) and that responsibility is talked about in monetary terms. But, individual actors within Belize rarely feel that they have the capacity to act towards protecting or capitalizing upon actual economic value of the reef in their everyday lives.

Of course, in an important sense regular people do access this value in their everyday lives. However, my experience in observing ecosystem service-based conservation projects and in reading the emerging scientific literature on the subject is that there has been a not always explicitly acknowledged slippage in usage of the term from a rhetorically potent metaphor to a reified economic object (for a good discussion of the shift in usage see: Gómez-Baggethun et al. 2009 and Norgaard 2010). In this slippage ecosystem services, even when not being explicitly monetized, come to be talked about as fungible, exchangeable, priceable, buyable objects. The sense then is that these objects should be attainable, consumable, and potentially profitable in much the same way as other capitalist economic objects. While some economists and ecologists might argue that this is in fact the case, in the far more common instances where it is not, the subjects of environmental conservation come to feel that they are being made responsible for a form of massive economic value to which they do not have meaningful access—that they are responsible for generating a form of value, that once produced, must be flowing elsewhere (because they sense profoundly that it is not flowing to them).

The scale of the public

The second factor in the production of anxiety around ecosystem services, and a secondary factor in creating the sense that people do not directly access the "value" of ecosystem services as they are imagined, is the issue of scale. Frequently, in Belize and elsewhere, the mechanisms for ecosystem service valuation have worked at a broad eco-regional scale, but that is not necessarily the scale at which the environmental conservation community has envisioned human behavioural change or at which imagined calculative actors can affect change.

Despite rhetoric of empowerment and value production, many regular citizens outside of the scientific and political process of conservation often make reference to this newly imagined value with a deep sense of distress. There is the feeling that a sense of responsibility and opportunity is being promoted to regular citizens, but that value exists in a scale and sphere of influence at which they do not actually participate in their everyday lives; it is a scale in which they lack agency. They are left with the emotional baggage of social and economic "responsibility," but without the sense that they can benefit at the individual, family or even community scale from accessing these new economic objects and the monetary value that they now feel should circulate with them.

Social scientists have argued that in other cases, this scaling up of the public sphere (in this case to the eco-region) is intentional, that is the making of what anthropologist Cori Hayden has called "the safe publics of *non*-community resources" (Hayden 2003: 47, see also Tsing 2005). It is the production of a certain kind of public, one whose members are pre-selected, and who have the agency and power to act within the same scale as the eco-political region that has been made the central concern.

Conclusion

In my observations in Belize, the ideas of ecosystem services and natural capital have been very powerfully introduced into public discourse (and often with remarkable effectiveness). The valuations and models of nature produced increasingly shape both professional and casual discourse about the reef and its protection. But, in terms of behaviour or policy there simply have not been the mechanisms or processes put into place that would allow these ideas to be particularly influential in either realm (though the current Integrated Coastal Zone Management Plan may be a meaningful move in that direction). The challenge going forward then is to hopefully produce mechanisms for a broader public to engage with, access and communicate the value, in its varied forms, of a resource that exists across scales, and which in its complex ecology—social and biological—calls into question the very idea that this can or should be governed exclusively at any single scale.

An exciting observation has been the keen interest among conservation practitioners in Belize in notions of scale. My caution from ethnographic experience, however, is to avoid the impulse to focus on scaling up and to instead consider how different forms of value are made and come into being at different scales. Scaling up then isn't simply a process of aggregating the value of lower scales, but it is a process that actually produces an entirely new kind of value and a new kind of public, and it is a process that changes who that value has meaning for (and what kinds of value can be communicated). In Belize, and elsewhere, the ecosystem service concept would benefit from considering ways in which it might be scaled down, to engage more active publics and to make more diverse forms of value visible and worthy of protection.

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Appendix I

Extreme Weather Events (2003 to 2010)

Dennis Gonguez

Tropical Cyclones and Flooding Events

Hydro-meteorological hazards pose the greatest natural threat to Belize. These are basically tropical cyclones and floods. These hazards have caused the greatest natural devastation throughout Belize's history. During the seven year period from 2003 to 2010 the country has seen four tropical storms and one hurricane make landfall on Belizean territory. The Atlantic hurricane basin is presently going through a phase of heightened activity. This makes Belize particularly vulnerable each hurricane season.

Hurricane Dean[1]

Hurricane Dean made landfall on Tuesday, 21st August, 2007 as a Category 5 hurricane about 43 miles northeast of Corozal Town near Majahual, a coastal community in Quintana Roo, Mexico. At the time of landfall Dean had maximum sustained winds of 165 miles per hour. Close to 2,000 persons were left homeless, with the bulk of them residing in rural Corozal. Two hundred and seventy five houses were completely destroyed with at least 451 partially destroyed. The village of Chunox was the hardest hit with 115 homes destroyed and 273 damaged. Roughly 1,650 persons were reportedly homeless in the Corozal district. Housing losses totalled US$2.94 million. Further south in Orange Walk town, 800 homes were affected with losses estimated to be US$1.75 million. About 260 persons were left homeless in that town. Villages such as San Jose and San Pablo suffered significant damage to houses.

In all US$10 million would be required to replace and repair the houses that were totally or partially destroyed. In addition, there were substantial agricultural losses associated with Hurricane Dean. US$15 million was lost in the papaya industry, as plants were levelled to the ground. Fruta Bomba which is a papaya production company in the Corozal district, lost half of its 1,200 acres of papaya. About 6,000 acres of sugarcane were affected. The losses in the industry were valued at US$1.8 million. Production loss of 10 to 15 % equates to US$5.5 million in foreign exchange in 2007[2]. (NEMO Damage Assessment and Needs Analysis Report, Hurricane Dean, 1st August 2007).

Tropical Storm Arthur[3]

Tropical storm Arthur with winds sustained at only 40 miles per hour but with torrential rainfall was a major destructive force in the Stann Creek district on the night of the 31st May 2008. Ten inches of rain in less than two days resulted in flash flooding on the north Stann Creek River near Hope Creek, causing the loss of 7 lives.

River crossing where the Kendall Bridge once spanned the Sittee River (1). ITVET building near Melinda inundated (2). Flooding and destruction in the Stann Creek Valley (3 & 4).

Tropical Depression #16[4]

The remains of tropical depression 16 of 15th October 2008 produced the most memorable flood event in recent history across the country. During the life of TD#16 and its remnant low pressure system from 13th to 20th October the Belize River and Sibun watersheds received the bulk of the rainfall with some recording stations recording in excess of 20 inches. The Macal River at San Ignacio town rose to 20 feet above the temporary bridge. The Mopan branch of the Belize River near Benque Viejo fed by runoff from rainfall in the eastern Guatemala portion of the watershed caused unprecedented flooding of that branch. As the flood waters travelled down the Belize River it inundated farmlands on its banks. The natural reservoirs in central Belize River Valley were filled to capacity. Levels at Crooked Tree rose some six and a half feet above the causeway.

Other areas affected included the Sibun River and Sittee River where the temporary causeway was washed out twice. Even in the north flooding was reported in the Rio Hondo and New River watersheds.

Flooding on the Mopan and Macal branches of the Belize river at Benque Viejo (1) and San Ignacio (2). The Belize River at Roaring Creek (3) and at the lower Belize river Valley area (4).

Tropical Storm Alex[5]

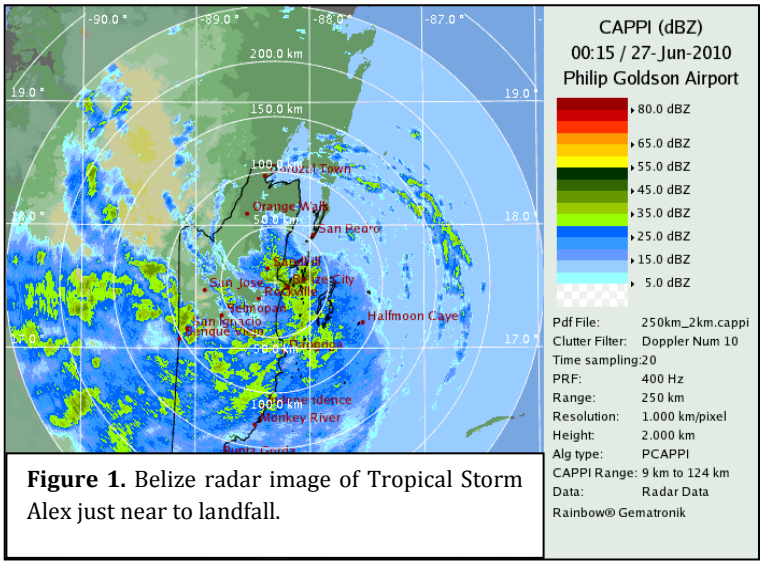

Figure 1. Belize radar image of Tropical Storm Alex just near to landfall.

Tropical Storm Alex made landfall just to the north of Belize City at around 6:00 p.m. local time on the 26th June 2010 (Fig. 1). The storm, with a small pocket of 65 miles per hour winds and rainfall accumulations of 6 inches, did very little damage across the country.

Tropical Storm Karl[6]

Tropical Storm Karl made landfall along the southern coast of Yucatan, Mexico on 15th September, 2010 at about 6:45 am local time about 53 miles northeast of Corozal Town (Fig. 2). Sometime just before 9:00 am local time, the centre reached its closest proximity to northern Belize- about 18 miles northeast of Corozal Town. Maximum sustained winds were near 60 miles per hour at landfall.

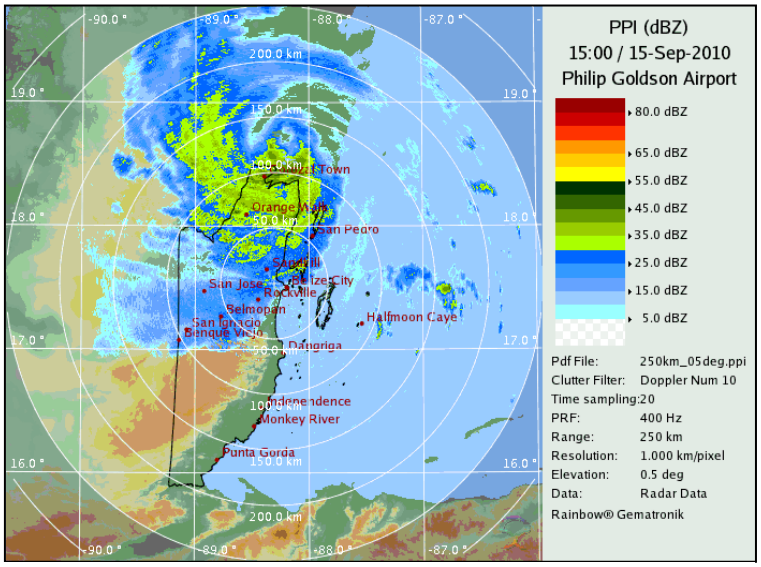

Figure 2. Belize radar image of Tropical Storm Karl at landfall.

A report from the Free Zone in Corozal Town indicated that increased wind speeds on 15th September, at 9:00 am local time, prompted the closure of the zone. Besides minor roof damage no significant damage was reported in the north.

Tropical Storm Matthew[7]

Tropical storm Matthew made landfall on 25th September, 2010 at about 9:30 a.m. near Monkey River Village. At landfall Matthew had maximum sustained winds of 40 miles per hour. Matthew was more of a rain event and produced no significant damages in any sector.[7]

Hurricane Richard

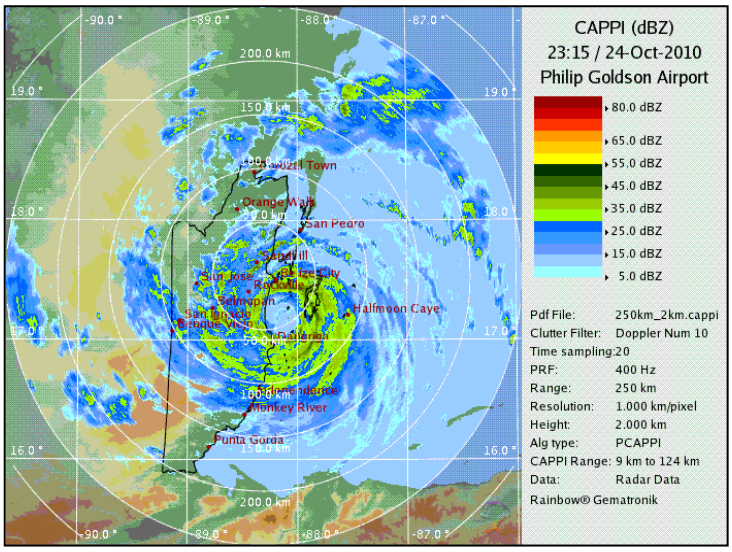

Figure 3. Radar image of Hurricane Richard at 5:15 p.m. 24th October 2010.

Hurricane Richard made landfall about 30 miles south of Belize City near Gales Point, Manatee at about 6:30 p.m. on the 24th October 2010 (Fig. 3). Richard traversed the entire width of the country exiting Belizean territory shortly after midnight. At landfall Hurricane Richard had maximum sustained winds of 90 miles per hour with no major drop in intensity as it crossed the mainland. Measured storm surge heights at landfall were some 4.5 ft. in the Belize City area. Total estimated losses attributed to Richard were in the order of BZ$49.2 million with the agricultural sector and forest being the largest impacted.[8]

Other Events

Besides these large scale events there were other occurrences of localized events that had profound short term impacts. These included the flooding of Belize City and nearby locations on the 29th August 2007. On that day a deluge of 7.7 inches of rainfall flooded the entire city and crippling commercial activities for the day. Water damage to household properties was extensive and many vehicles were stalled on the streets. The City was practically shut down for the greater portion of the day creating considerable inconvenience.

Belize City flooding on North Front Street (left) and corner Cleghorn and Mapp streets (right).

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BELIZE COASTAL ZONE MANAGEMENT AUTHORITY & INSTITUTE

For more information on this document, please contact us at:

Coastal Zone Management Authority & Institute
Princess Margaret Drive
P.O. Box 1884
Belize City, Belize

Tel: 223-0719 or 223-5739
Fax: 223-5738
Email: czmaibelize@gmail.com
Web: www.coastalzonebelize.org