Working Paper

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Coastal Capital: Belize
The Economic Contribution of Belize's Coral Reefs and Mangroves

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Executive Summary

Coastal and marine ecosystems provide vitally important goods and services to Belize. The country's coral reefs and mangrove-lined coasts provide critical protection against erosion and wave-induced damages from tropical storms. They have supported artisanal fishing communities for generations, and, more recently, they stand at the center of a vibrant tourism industry, drawing snorkelers, divers and sport fishermen from all over the world. Belize also boasts the longest barrier reef in the Western Hemisphere, part of the biologically rich Mesoamerican Reef complex, stretching from Mexico to Honduras.

Despite their importance, these benefits are frequently overlooked or underappreciated in coastal investment and policy decisions. Unchecked coastal development, over-fishing, and pressures from tourism threaten the country's reefs and mangroves. Additional threats of warming seas, fiercer storms, and other climate-related changes loom on the horizon. The government, NGOs, and private sector in Belize have begun to recognize the importance of coastal ecosystems to the economy. Nevertheless, as this paper demonstrates, the amount currently invested in protecting Belize's coral reefs and mangroves is very small when compared to the contribution of these resources to the national economy.

Economic valuation assigns a dollar value to the goods and services provided by ecosystems, giving policy makers an important tool with which to set priorities and improve decision-making around natural resources. This study assesses the economic contribution of just three out of the many culturally and economically valuable services provided by reef and mangrove ecosystems in Belize. Even within this narrowed scope, this study finds that the country's coastal resources are extremely valuable. Thousands of tourism and fishing jobs rely upon the health of reefs and mangroves, and millions of dollars in coastal property rely upon their invisible protection. Investing in the maintenance and enhancement of these benefits – or at least preventing their continuing rapid loss - is thus an important investment in the health and sustainability of Belize's economy.

The Value of Marine Protected Areas

Working with local partners, WRI also assessed the economic contribution of several of Belize's Marine Protected Areas (MPAs). The country's MPAs system, widely hailed as an example of forward thinking in marine conservation, consists of 18 protected areas managed primarily by the Fisheries and Forestry Departments in collaboration with local non-governmental organizations (NGOs). The parks are an important draw for divers, snorkelers, and sport fishermen, and contain no-fishing areas that, when well-protected, help to maintain stocks of key commercial species.

MPAs in Belize generate economic benefits well beyond the amount invested in their protection. Approximately 115,000 visitors were recorded by MPAs in 2007, spending an estimated US$17 million on accommodation, recreation, food, and other expenses on days that they visited a reserve. Actual spending may be up to 30 per cent higher as visitor numbers to most of the reserves is significantly under-recorded.

Our economic analysis indicates that reef-related tourism and fisheries at just one park - Glover's Reef Marine Reserve - contributed an estimated US$4.9 to $7.3 million per year to the national economy. By comparison, the Fisheries Department is allocated roughly US$100,000 per year for each of the MPAs that it manages. Management levels at most of Belize's marine parks fall well below those needed to keep reefs healthy and attractive to visitors over the long-term. The economic and environmental benefits provided by these parks may not prove sustainable without greater investment in management.

Key Findings:

In total, the value of reef- and mangrove-related fisheries, tourism, and shoreline protection services in Belize is 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 GDP totaled US$1.3 billion in 2007.

Tourism: In 2007, reef- and mangrove-associated tourists spent an estimated US$150–$196 million on accommodation, reef recreation, and other expenses (equal to 12–15 percent of GDP).

Sport fishing and diving – high-value industries that are heavily dependent upon reef and mangrove health – earned US$30–$37 million in 2007. Belize's cruise industry, by comparison, contributes only US$5.3–$6.4 million in reef- and mangrove-related taxes and revenues to the country per year. The negative environmental impacts of cruise tourism disproportionately affect coastal and marine areas, while these areas reap very little economic benefit from the industry.

Fisheries: Fishing is an important cultural tradition, as well as a source of food and livelihood for many coastal Belizeans. Economic benefits from reef- and mangrove-dependent commercial fisheries are estimated at between US$14–$16 million per year. Belize's fisheries are threatened by over-fishing, especially of desirable finfish such as grouper and snapper, as well as by the loss of healthy coral reef and mangrove habitat.

Shoreline Protection: Reefs and mangroves protect coastal properties from erosion and wave-induced damage. Emergent reefs, such as the Belize Barrier Reef, can mitigate over ¾ of wave energy. Belize's coral reefs provide an estimated US$120–$180 million in avoided damages per year. Coastal mangroves offer protection worth an additional US$111–$167 million per year.

Actions Needed:

As these resources become increasingly threatened, it is critical to recognize the value they provide, and to incorporate these values into decision-making. It is in the long-term economic interest of Belize to:

- **Invest in management, monitoring, and compliance.** The government has taken an important first step by reinstating the Coastal Zone Management Authority and Institute (CZMAI). Now, it needs to invest in CZMAI and other science-based efforts to expand monitoring activities and assess the state and use of coastal resources. Additional resources for tightening and enforcing fishing regulations are also badly needed.
- **Plan and implement development sensibly.** The government needs to enforce existing land-use and development regulations in the coastal zone. Minimizing the loss of mangroves along the shoreline will be increasingly important, as they provide critical habitat and protect the coast from storms. Longer-term tourism and development strategies should incorporate the ecosystem services provided by coral reefs and mangroves. For instance decisions on development permits, sewage and waste disposal regulations, and the balance between cruise and overnight tourism should all include consideration of potential impacts on the flow of benefits from coastal resources.
- **Increase support for Belize's MPA system.** Belize's MPA system is among the best in the world, but it is suffering from uneven funding and management. To avoid a continuing decline in the health of coral reefs and fish populations in MPAs, Belize should increase overall investment, improve fee collection, strengthen monitoring and enforcement efforts, and establish a permanent source of funding to support the valuable MPA system. Strategic planning at the system level is also needed to address disparities and gaps in the current structure.

1. Introduction

Coral reefs and mangroves provide a wide range of commercial and non-commercial benefits to human society. These benefits, or "ecosystem services" include: habitat for commercially valuable fish, recreation and tourism, and protection from coastal erosion and wave-induced damage. Coral reefs in particular also have high conservation and cultural value. They harbor vast biodiversity with unknown potential uses, and spark the imagination of millions of people who rarely visit them. Reefs, mangroves, and seagrasses are also part of an interconnected system, each playing a critical role in supporting the health of neighboring habitats, and of important fish species.

In the island nations of the Caribbean, many of these ecosystem services are of high value and critical importance to both local and national economies. In Belize and elsewhere, coral reefs and mangrove-lined coasts provide critical protection against erosion and wave-induced damages from tropical storms. They support artisanal fishing communities, and drive vibrant tourism industries, drawing snorkelers, divers and sport fishermen from all over the world.

Despite the varied and high value benefits that they provide, however, the region's coastal mangroves have been lost to development at an astonishing rate, while the extent and health of Caribbean coral reefs have declined dramatically in recent decades. Both habitats continue to be threatened by human activities, and the ecosystems benefits they provide remain overlooked or underappreciated in coastal investment and policy decisions. Threats include unchecked coastal development, over-fishing, and pressures from tourism. Climate related threats including warming seas and fiercer storms also loom on the horizon.

The decline of coral reefs and mangroves has led conservationists and, increasingly, policy-makers – in Belize and across the region - to look more closely at how the degradation of these resources will affect those who depend upon them. For example, fish populations, including commercially valuable sport-fishing species and colorful reef fish, will diminish if they lose mangrove nursery habitats. Coastal properties will become increasingly vulnerable to storms and erosion, and reef-related tourism will suffer.

This study is part of the World Resources Institute's *Coastal Capital* project in the Caribbean. The project aims to provide decision-makers with information and tools that link the health of coastal ecosystems with the attainment of economic and social goals. The shoreline protection valuation, for instance, evaluates potential avoided damages afforded by coral reef- and mangrove-related storm protection. It also serves as a tool for coastal planning by identifying coastal areas which are vulnerable to storm damage. WRI and its local partners use the results of these studies to identify and build support for policies that help ensure healthy coastal ecosystems and sustainable economies.

A. Belize's Coral Reefs and Mangroves: Status and Threats

Belize, home to only 300,000 people, is well known for its marine and terrestrial biological diversity. Sitting in the heart of Central America, this small country boasts the longest barrier reef in the Western Hemisphere, extending approximately 280 km along its Caribbean coast and covering approximately 1,400 km^2 (McField and Bood 2007). The barrier reef complex includes a variety of reef types (barrier reef, lagoon patch reefs, fringing reefs, and three off-shore atolls) and ecologically linked habitats including mangrove forests, seagrass beds, estuaries, and numerous small islands or cayes. Island and coastal mangroves (within 1 km of the coast) cover approximately 400 – 420 km^2 of the country.

Two of Belize's major industries—tourism and fisheries—rely heavily upon coastal mangroves and coral reefs, and the majority of its population and valuable real estate lies along coastal areas that are sheltered

by these habitats. These and other benefits to Belizeans make effective management of these resources a critical priority.

Belize's reefs and mangroves are facing a number of threats, including over-fishing, pollution, deforestation, sedimentation, increased population in coastal areas, and weak (or weakly enforced) inland and coastal development and management legislation. Extreme natural events, including hurricanes and coral bleaching events, have severely impacted the country's coral reefs. Recent studies suggest that Belize's reefs have not recovered from the synergistic impacts of 1998 when mass coral bleaching and damage from Hurricane Mitch led to losses in coral cover of 50 percent or more on some reefs (Kramer and Kramer 2000). A 2006 survey of 140 reefs throughout Belize found that live coral cover has declined from a level of 25 – 30 percent in the mid-1990's to an average of 11 percent (McField and Bood 2007).

More recently, coastal development has led to significant losses in mangrove cover, particularly near Placencia (Bood 2008) and Belize City on the mainland, as well as Ambergris Caye and other offshore cayes. Marine dredging in sensitive areas such as the Pelican Cayes has led to smothering of reefs and damage to nursery habitats in surrounding mangroves and seagrass beds (Melanie McField personal comm.). Belize's reefs are also increasingly facing some of the common problems of overuse. Overcrowded snorkel and dive boats and haphazardly thrown boat anchors can result in abrasion and breakage of coral, especially at highly visited sites.

Overfishing is also a growing problem. Little is known about how many fish are caught on Belize's reefs each year. Local sales outside of the Fishermen's Cooperatives go unrecorded, and many fish caught in Belize are landed and sold in neighboring countries. However, recent surveys as well as anecdotal evidence suggest that local fishermen are landing less desirable food fish, such as barracuda, in increasing numbers, suggesting that snapper and grouper numbers are dwindling. A recent study of fishing at Glovers Reef found that barracuda and parrotfish were the most frequently landed fish (Gibson and Hoare 2006). This represents an even more worrying trend, as parrotfish and other herbivores play a critical role regulating the growth of macroalgae. Algal growth, especially if fed by excess nutrients from the land, will out-compete corals for space on the reef when these grazers are not present.

Climate change represents a growing threat in terms of both human and ecological impacts. Rising sea temperatures have increased the frequency of mass bleaching events and disease incidence on reefs, resulting in significant coral mortality. Belize's reefs have already been considerably impacted by mass bleaching events in 1995 and 1998, both of which coincided with elevated sea temperatures and calm seas. Ocean acidification caused by rising atmospheric carbon dioxide levels may hinder coral growth and regeneration going forward (Orr et al. 2005). Sea level rise and increased storm intensity also pose a particular threat to coastal populations, which will make the buffering role played by coral reefs and mangroves increasingly important as climate change intensifies.

B. Marine Conservation in Belize

Marine Protected Area System - Marine conservation efforts and monitoring programs in Belize have grown significantly over the past two decades. The number of designated Marine Protected Areas (MPAs) has grown to 18, covering approximately 250,000 ha. of marine area (McField et al. 2008). MPAs are a useful tool for addressing a number of threats to coral reefs, particularly those related to tourism, development, and over-exploitation of commercial species. Unfortunately, some of Belize's MPAs remain paper parks, and the majority lack sufficient funding and staff to effectively enforce fishing regulations and monitor use of the reef. Greater and more reliable funding is needed for the system to function as it was intended.

Managing coastal development sustainably - While coastal development is an important part of economic growth, unchecked clearing of mangroves in recent years has led to serious concerns about the loss of services this habitat provides. In 2008, the newly elected government enacted a temporary moratorium on mangrove clearing inside MPAs. In another encouraging sign, discussions on how to revamp and enforce the national mangrove legislation were underway at the time of this study. These are important first steps in managing Belize's coastal environment, and—along with the re-instatement of the Coastal Zone Management Authority and Institute—suggest that Belize may soon move towards a comprehensive strategy for managing sustainable development in its coastal areas.

Fisheries Regulations – Overall, Belize has fairly strong fisheries regulations, including size limits and closed seasons for the most heavily exploited species. No-fishing zones in some MPAs also help to serve as replenishment areas. However, there is inadequate financial support to enforce these regulations effectively, and there has been a trend—hopefully soon to change—of *decreasing* government financial support to the Fisheries Department. Regulations to protect top predators as well as critically important herbivores (parrotfishes, tangs, and surgeonfish) are also needed, as over-fishing threatens the delicate ecological balance on the reef. Equipment bans on spear fishing in MPAs, and on shrimp trawling, would also help maintain the health of Belize's fisheries.

Science and monitoring - Belize has a strong history of marine research and monitoring, particularly compared to many other countries in the region. It also benefits from an active NGO community with considerable scientific expertise. Policymakers and regulatory agencies need biological and socioeconomic information on the status of coral reef and mangrove habitats, as well as the potential impacts of existing and future threats to their health. Further investment in monitoring and research to inform good management should be a priority.

C. Economic Valuation – A Brief Introduction

Many of the activities that damage marine ecosystems—over-fishing, dredging, and discharge of sewage near reefs, among others—occur because an individual or group seizes an immediate benefit, without considering the broader and longer-term consequences to society. Economic valuation analyses attempt to quantify the value of the array of goods and services provided by these ecosystems. By providing a clearer picture of the importance of these goods and services, and placing a dollar value—even a "rough" estimate—on them, economic valuation can help to facilitate more sensible, far-sighted decision-making. It can help policy-makers to understand (and publicize) the benefits of investing in conservation and enforcing development regulations. Valuation can also help these same decision-makers to identify winners and losers under current practices as well as from future management and development decisions. For example, a straightforward analysis shows the hotel industry to be a major beneficiary of healthy coastal ecosystems. However, in many areas, hotels also place major stresses on these resources. The environmental impacts of unsustainable tourism and development threaten both the livelihoods of local reef users and the future of reef-associated tourism itself. An economic valuation can lend support to efforts to require coastal hotels to compensate for mangrove clearing and commit to better sewage treatment. These and other efforts may help to protect a hotel's existing investment in coastal real estate.

There are many different methods for estimating the economic value of natural resources, many of them developed by academics for localized studies. However, economic valuation is increasingly being applied in the public sector, and with links to decision-making and policy applications in mind. Most famously in Bonaire (Dixon et al 1993), but also in other places with significant tourism, "willingness to pay" surveys

have been used to assess the value that tourists place on the experience of visiting coral reefs or other natural resources. The results of these surveys are often used to set visitor fees, helping to finance protected areas.

Valuation studies can attempt to estimate the Total Economic Value (TEV) of an ecosystem, or they can identify and evaluate only a subset of the goods and services that an ecosystem provides. Total Economic Value includes both *use* values—such as food production (consumptive), tourism (non-consumptive), and indirect services like shoreline protection (regulating)—and *non-use* values, such as the value humans place on the knowledge that a resource exists, even if they never use it (existence value).

All of the above approaches attempt to estimate the *value*, or wellbeing that society gains from an ecosystem. A more basic approach is to examine the amount of economic activity (or "impact") an ecosystem service generates in the local economy (Pendleton 2008). This involves looking at the revenues, taxes, and jobs generated by an activity - information that is especially useful for national and local decision-makers who are faced with questions around restricting development or investing in efforts to protect a threatened resource. These decisions are typically made without knowing the economic losses that could result from degradation of natural resources.

Although economic valuation is a useful and potentially powerful decision-making tool, users should always bear in mind the high degree of uncertainty in most valuation studies, and should pay attention to the methods used, assumptions made and the caveats attached to the results.[1]

2. Methods

This study is part of the World Resources Institute's *Coastal Capital* project in the Caribbean. The economic valuation method used is adapted from the methodology designed for this project and applied in two pilot sites, St. Lucia and Tobago. For a full description of the original method, see Burke et al. 2008. A copy of the detailed current methodology is available on the WRI website at: http://www.wri.org/project/valuation-caribbean-reefs.

We do not attempt to capture the Total Economic Value of coral reefs and mangroves, but instead focus on three critical goods and services provided by these resources in the Caribbean: tourism, fisheries, and shoreline protection. These services were chosen because they can be assessed using publicly available data, allowing the study to be repeated in the future by local NGOs or decision-makers. By limiting the analysis to three services, this study *underestimates* the total value of these resources. What it does provide is a snapshot of the economic activity generated by reef- and mangrove-dependent tourism and fisheries, and an estimate of losses in coastal property that could result if the protective function of these habitats declines. The results can be easily explained to policy makers and integrated into decision-making. It also leaves room for further studies to build on these estimates by assessing the value of other goods and services provided by coral reefs and mangroves.

We use 2007 as the base year for all prices, visitation, fish catch, and land value data in Belize.

A. Coral Reef- and Mangrove-associated Tourism

[1] For a more thorough discussion of economic valuation techniques, applications, and strengths and weaknesses, please refer to pages 3-6 in Burke et al. 2008.

The value of coral reef-and mangrove-associated tourism was calculated by estimating gross revenues and taxes from marine recreation as well as revenues from accommodation and other tourist spending on days spent using coralline beaches, reefs, or mangroves. This method assesses the current economic contribution of reef- and mangrove-related tourism in Belize.[2] This produces an *underestimate* of the tourism value of reefs and mangroves, because we omit consumer surplus (the additional welfare a consumer enjoys beyond what he or she has paid for the service). The focus of this study is the combined value of reef- and mangrove-associated tourism, rather than the independent contribution of each habitat. For a rough estimate of the reef/mangrove breakdown, see Box 1.

The most difficult step in the tourism analysis is determining what portion of total "tourist days" should be attributed to use of mangroves and coral reefs. In the Belize study, we use published accommodation statistics for each region of the country to tell us *where* tourists spend their time, and then use local expert opinion to estimate what percent of "tourist days" for each region should be attributed to marine recreation. For example, we estimate that one percent or fewer tourists visit reefs or coastal mangroves on days that they are staying in the inland district of Cayo. By comparison, we count 100 percent of tourism on Caye Caulker as reef- or mangrove-associated.

We calculate accommodation and "other spending" by tourists on reef and mangrove-associated days using published room rates and information on typical tourist spending patterns in Belize. Revenues from marine recreation and beach use are calculated separately based on estimates of tourist activities from the Belize Tourism Board (BTB 2007) and average activity prices for 2007. Finally, we calculate revenues from reef and mangrove use by cruise tourists, utilizing a similar "activity survey" to determine the number of cruise tourists that participate in marine recreation during their visit to Belize (BTB 2008a). For a full discussion of the data, assumptions, and calculations for all of the tourism components, please see Appendix 1a.

B. Coral Reef- and Mangrove-associated Fisheries

The value of coral reef- and mangrove-associated fisheries was calculated by estimating gross revenues from commercial fishing and processing activities. The valuation focuses on fisheries that depend directly on coral reefs or mangroves for at least a portion of their life-cycle, including snappers (*lutjanidae*), groupers (*serranidae*), parrotfish (*scaridae*), squirrelfish (*holocentridae*), and lobster (*panularius argus*). Positive or negative changes in coral reef health will impact fisheries productivity and total fisheries revenue as a result. Because these are highly interdependent habitats, our principal assessment looks at the total fisheries value associated with both reefs and mangroves in conjunction. For a rough estimate of the independent contributions of mangroves and coral reefs to the fisheries industry, see Box 1.

We break commercial fisheries revenues in Belize into three categories: a) export sales through the Fishermen's Cooperatives, b) local sales through the Fishermen's Cooperatives, and c) all other local fish sales (direct sales to restaurants, market sales, and subsistence use). The Fishermen's Co-ops provide data on all sales, making revenue estimates for the first two categories straightforward, but no one is collecting data on local sales outside of Co-ops at this time. As a result, we had to rely on other studies and local expert opinion to supply an estimate for the third category of fish sales (See Appendix 1, Section B).

[2] Gross revenue is used in this study for several reasons: We are interested in assessing the economic contribution of reefs and mangroves at the national level. At that scale, gross revenues serve as a good indicator of the economic activity generated by these resources. We were also limited by data availability: little-to-no information was available on operating costs for either the fisheries or tourism sectors in Belize. Gross revenue is still an underestimate of the total value of coral reefs and mangroves, because it does not include an estimate of consumer surplus. A survey-based assessment of consumer surplus from reef- and mangrove related tourism would be a useful compliment to this study.

In addition to fish production, or catch, we also estimate the value added through fish processing. In the case of exports, this value is included in the sale prices from Co-ops. A small amount of local fish cleaning at landing sites is also included in the estimate. This study examines the economic benefits accruing to Belize, so it does not count any revenues earned by people fishing in Belizean waters, but landing and selling their catch in neighboring countries. For a full discussion of the data, assumptions, and calculations for all of the fishery components, please see Appendix 1, section B.

Limitations

Both the fisheries and the tourism analyses are limited by the quality and availability of data for the study site. This methodology was designed to utilize existing data in order to increase its replicability and transparency. However, where data are poor or scarce, we have had to rely upon the grey literature and expert opinion to fill in the gaps; where there was uncertainty around particular variables, we applied a sensitivity analysis, typically using values between +/- 20 percent of the original estimates. Although these are relatively rough estimates, they do provide important insight into the often overlooked economic contribution of reefs and mangroves in the fisheries and tourism sectors.

It is also important to keep in mind that the analysis of the economic contribution of reef- and mangrove-associated fisheries and tourism is a snapshot of current levels of use. It does not take into account whether these resources are being used at a sustainable level and does not address the damage that overcrowded dive sites, inadequate waste treatment, and fishing at current levels may be doing to the reefs and mangroves. Similarly, this study does not assess the *potential value* of sites that are currently protected but not heavily used, especially for tourism. With an assessment of the sustainable level of visitors that a protected area or a dive site can support, it would be possible to conduct a similar analysis of the potential revenues the site could draw in the future.

Box 1: Distinguishing Reef and Mangrove Values

Coral reefs and mangroves are highly interconnected habitats, physically supporting each other and providing habitat for fish species. For example, mangroves filter sediment and pollutants from coastal runoff, supporting the clean water favored by corals. Many species important to fisheries and tourism rely upon both mangrove habitat and coral reefs for a portion of their life-cycle.

This study did not directly evaluate the independent contributions of mangrove and coral reef habitats to the fisheries and tourism sectors, but assessed their collective value. To produce a rough estimate of the breakdown by habitat, we examined the proximity of mangroves to coral reefs across Belize to estimate the portions of fisheries and tourism values that a) rely exclusively on coral reefs, b) rely exclusively on mangroves, and c) depend upon both. We estimate that US$60-78 million of Belize's annual tourism revenue stems from the presence of healthy mangroves. Approximately US$15 to $19 million of that total comes from tourist spending associated with mangrove-dependent activities, such as manatee tours and sport fishing, while the remaining $45 - $59 million is attributed to supporting services (including nursery habitat) provided by mangroves that grow in close proximity to reefs. Coral reef-associated tourism *not* supported by nearby mangroves earns an estimated US$90 - $117 million per year; in addition, reef-based tourism contributes $45 - $59 million that is supported by mangroves (mentioned above). The combined value of reef- and mangrove-associated tourism is approximately US$150 – 196 million per year (see the Results section, below); revenues are only counted once, regardless of whether they are associated with one or both habitats.

For the fisheries sector, we assessed which fish species were primarily reef dependent, mangrove dependent, or depended heavily on both habitats, and allocated fisheries revenues accordingly. We estimate that mangroves contribute approximately US$3 to $4 million in fisheries value per year, while reef-based fisheries provide US$13 to $14 million per year .The combined value of reef and mangrove-associated fisheries is US$14-16 million. Again, revenues are counted only once, even if a fish relies upon both habitats during its life cycle.

WRI's shoreline protection analysis differentiates between the protection provided by mangroves and reefs from the outset. Mangroves play an especially important role in buffering against storm surge and reducing erosion. We estimate that Belize's mangroves contribute US$111 - $167 million in avoided damages per year. Coral reefs provide $120 - $180 million in protection. These values are independent of one another, and can be added together for a combined value of US$231 - $347 million per year.

Estimated Coral Reef and Mangrove contributions to the economy (million USD)*			
	Coral Reefs	**Mangroves**	**Combined Contribution**
Tourism	135 - 176	60 - 78	150 - 196
Fisheries	13 – 14	3 – 4	14 – 16
Shoreline Protection	120 - 180	111 - 167	231 - 347
*Mangrove & reef fisheries and tourism values are **not** additive, as they include revenues that rely on both habitats.			

C. Shoreline Protection

A methodology for valuing the shoreline protection services provided by coral reefs was developed jointly by the Institute of Marine Affairs (IMA) in Trinidad and Tobago and WRI for application in the Eastern Caribbean. This method has been revised and adapted for application in Belize. In particular, the method has been modified to factor in the role of the atolls and the offshore barrier reef in mitigating wave energy, as well as to allow for explicit evaluation of the role of mangroves in protecting shorelines.

A modified "avoided damages" approach is used to estimate the value of this service along coastal segments protected by coral reefs or mangroves. This involves estimating the likely economic losses (in property value) to a coastal area from a given storm event, both with and without the reefs and mangroves present. This difference represents the "avoided damages" owed to the presence of reefs and mangroves. The approach developed by WRI and IMA has a geographic information system (GIS) analytical modeling component as well as an economic component. This method was selected because reliable estimates of the cost of replacement by manmade structures are limited, making estimation of value difficult. The avoided damages approach has the additional benefit of producing analytical results which support informed coastal planning and development.

The methodology involves five steps, which are implemented within a GIS:

- **Identify land which is vulnerable to wave-induced erosion and storm damage.** Vulnerable lands were defined as those within 1 km of the coast which are lower than the combined height of the storm surge and wave height expected during a 25 year storm event (5 m in the case of Belize).[3] Storm surges can easily intrude 1 km inland, so this distance is conservative. Storm surge and wave height estimates can be adjusted to include predictions of future sea level rise, or for changes related to projected changes in storm regime. "changes related to projected changes" is confusing. Can we re-phrase?

- **Identify coastline which is protected by coral reefs or by mangroves.** In general, the methodology defines coastal land as "protected" by coral reefs if it lies within 100m of a fringing reef, or is enclosed by a barrier reef. In Belize, where the barrier reef and coral atolls occur far from the

[3] Data on predicted storm surge and wave height come form: Organization of American States (OAS). 2002. *Atlas of Probable Storm Effects in the Caribbean Sea*. Online at: http://www.oas.org/CDMP/document/reglstrm/index.htm.

mainland coast, these reef structures still provide some attenuation of waves reaching the mainland. These features also protect the many cayes found within the barrier reef. Shoreline with windward facing coast, in areas enclosed by the barrier reef or in the "wind shadow" of a reef or atoll, is classified as "protected" by coral reef. Shoreline within 50 meters of mapped mangrove is classified as protected by mangrove.

- **Estimate the relative stability of the shoreline based on a range of physical factors.** The relative stability (resistance to erosion) of each shoreline segment was evaluated based on the integration of up to nine physical factors.[4] The factors are: coastal geomorphology; geology; coastal protection (such as protection by an atoll or a sea wall); a coral reef index (which integrates reef type, continuity and distance from shore); [5] wave energy; frequency of hurricane events (by category); coastal elevation; coastal vegetation; and presence of damaging anthropogenic activities, such as sand mining. Each individual factor can range in value from 0 to 4 (with 4 being the highest stability). The nine factors and their associated values are provided in Appendix 1c, Table 2. The relative stability of the shoreline is calculated by taking the average of all factors for which data are available for the entire study area.[6] The sum of these factors (FACTOR_SUM) is used as the basis for comparison of the relative contribution of coral reefs and mangroves to shoreline stability.

- **Determine the share of shoreline stability which is attributed to coral reefs or to mangroves.** The share of shoreline stability contributed by coral reefs or mangroves was estimated by virtually "removing" the coral reef or the mangrove from the map and recalculating the sum of factors contributing to the stability of the shoreline.[7] The sum of the factors from the shoreline stability estimation (above) is compared to the similar sum with mangroves or reefs removed and the percentage difference is calculated. For example, if the seven factors for which data area available sum to 24, but only sum to 18 with mangroves "removed", mangroves contribute a 25 percent share to the protection of that segment of shoreline.

- **Estimate the "damages avoided" due to the presence of coral reefs (or mangroves) based on the value of property (land and built structures) in vulnerable land protected by coral reefs (or mangroves).** Property values for both undeveloped and developed properties in vulnerable areas across the study area are needed. Average property values for distinct locations are required (ideally differentiated between land adjacent to the coast - within 100m - and further inland). Values are summed as follows (once for coral reefs and once for mangroves):
  - The average property value in areas classified as vulnerable (based on the 25 year storm event), and classified as protected by a coral reef are multiplied by the share of coastal protection attributed to coral reefs (for the nearest shoreline segment).

[4] As comprehensive data are not always available for all nine factors, one should include as many factors as possible (above a bare minimum of 5).

[5] Within the coral reef index, higher protection values are associated with reefs which are close to shore, reefs which are continuous rather than interrupted, and with emergent reefs such as the barrier reef or the windward side of an atoll as compared with patch reefs. A nomogram developed by Chris Houser of Texas A&M University was used to establish the critical thresholds for reef distance offshore. The nomogram links wave heights with wind speed and fetch length (distance wind blows over open water) to allow estimation of the wave heights possible given the reefs proximity to the shore. (See Appendix 1c, figure 3).

[6] Where data are missing for some locations, data can be filled in based on best assumptions for the area, as to not have to drop the entire factor from the analysis.

[7] In the case of coral reefs, the coral reef index variable is reset to one. Where mangrove covered atolls are present, the factor reflecting coastal protection structures is halved, reflecting the possibility that some mangrove-covered cayes could persist for some period even without the coral reefs (a generous, conservative assumption). Mangroves are similarly "removed" by resetting the coastal geomorphology factor (from 2 for mangrove) to the category of the nearest non-mangrove category, and resetting the coastal vegetation factor (from 4 for mangrove) to the average value for all other coastal vegetation (1.2, which is between the wetland and shrub categories). See the factor table (Table 2) in Appendix 1c.

- The sum of these values is then multiplied by 4 percent (the probability of the 25 year storm event occurring in a given year). This reflects the "damages avoided" due to the presence of coral reefs in an average year.

Notes and Limitations

This innovative methodology provides a useful means for evaluating potential avoided damages afforded by coral reefs and mangroves, as well as providing an aid to coastal planning by identifying coastal areas which are vulnerable to storm damage. This method can also support planning for adaptation to climate change by considering future scenarios of sea level rise, storm regime changes, and associated changes in storm surge and wave heights. These scenarios can be introduced by adjusting the elevation used to define "vulnerable lands."

Implementation of the shoreline protection valuation requires detailed data on coral reef and mangrove locations and coastal elevation (these are the most important), a variety of data sets on coastal characteristics, as well as expertise in GIS. The method compares wave-induced damage with and without coral reefs / mangroves present. It does not estimate the protection value which might be lost during the gradual degradation of a coral reef. Such a nuanced analysis would require scenarios of reef degradation over time, coupled with estimates of the reduced wave mitigation associated with the reef at different stages of degradation.

There are inevitably uncertainties associated with a multi-stage modeling approach designed to emulate complex physical processes. In addition, few data are available specifically on wave-induced storm damage, making the calibration of the model difficult. To reflect the uncertainty surrounding these estimates, ranges (such as +/- 20 percent) were established around the central estimates.

3. Results

A. Coastal Tourism Profile

Belize is a major ecotourism destination, particularly in comparison to other countries in the Caribbean. A large percentage of visitors seek out and value healthy ecosystems, and—as this study shows—almost two-thirds of these visitors come to see the country's mangroves, reefs, and coralline beaches.

Belize is renowned as one of the premier dive destinations in the region. It boasts the largest barrier reef in the hemisphere, as well as the world famous Blue Hole and other well-known dives off of three coral atolls. The lucrative yachting and liveaboard sector depends heavily on divers, and thousands of tourists flock to Placencia each spring to dive and snorkel with the whale sharks that come to feed on reef fish spawning aggregations off Gladden Spit. The Belize Tourism Board's *Visitor Expenditure and Motivation Survey* (VEMS) from 2006 found that 27 percent of visitors to Belize went diving at least once. In terms of sheer volume, snorkeling dwarfs every other visitor activity in Belize (BTB 2007).The same survey found that 59 percent of overnight visitors snorkeled at least once during their stay. Finally, Belize is famous for its sport fishing, an activity that relies upon the health and delicate relationship between mangroves, seagrass beds, and coral reefs along the country's coast. A recent study estimated that recreational fishing for bonefish, permit, and tarpon contributes US$25 million a year in direct spending to the Belizean economy (Fedler 2008).

In addition to underwater activities, kayaking and wildlife tours are also popular with tourists. Birders come to see the red-footed boobies, egrets, spoonbills, and other birds native to Belize's coastal

mangroves, and thousands of tourists take manatee tours each year. Kayak rentals and trips have become increasingly popular.

Belize has also been more successful than other countries in the region at creating local jobs through the tourism industry. Jobs in tourism account for roughly 15 percent of the workforce (Statistical Institute of Belize 2008), while the wider "tourism economy"—sectors that directly or indirectly support tourism—employs 29,000 people, or 26.6 percent of the workforce (WTTC 2008). Many local fishermen work part-time as fishing guides, helping to provide alternative employment during the closed seasons for lobster and conch; others have switched to leading wildlife tours or dive and snorkel trips full time (Deidrich 2006). Belize has very few of the all-inclusive resorts that dominate the tourism industry in places like St. Lucia and the Dominican Republic. As a result, tourists eat, visit, and buy souvenirs from primarily Belizean-run establishments. In the coastal areas, reef- and mangrove-related tourism is the lifeblood of much of the local economy.

Belize's diving and sport fishing industries in particular attract tourists who are willing to spend considerable sums, and are far more sensitive than the average tourist to the condition of coastal and marine habitats. If the permit, bonefish, and other prized fishing targets disappear, the anglers who spend thousands of dollars for catch-and-release fishing in Belize's waters will go elsewhere. So will divers who choose Belize over other Caribbean countries because of the quality of its reefs. Unfortunately, Belize's reputation as a premier destination for these coastal recreation activities is threatened by the rapid decline of reef health in the past decade and the clearing of coastal mangroves in sensitive areas. It is a critical time to take stock of the benefits that these resources bring to the economy and to protect the tourism industry by taking steps to maintain their health.

Tourism Valuation Results

Accommodation

Approximately 250,000 overnight tourists visit Belize each year, staying for eight days on average (BTB 2008b). Many spend time both inland and on the coasts. Using BTB's accommodation statistics and local expert opinion, we estimate that roughly 64 percent of all "tourist days" can be attributed to visitors using coral reefs, coralline beaches, or mangroves during their stay (see Appendix 1 for more detail). In addition to tourists on land, this total includes 6,800 – 10,000 people who charter yachts or stay on liveaboard boats for most of their stay (BTB 2008d). In total, tourists spend between $56.3 and $75.4 million on accommodation per year for reef- and mangrove-associated nights.

Reef and Mangrove Recreation

Some visitors come to Belize exclusively to dive or fish, and many others will participate in more than one marine recreation activity during their stay. With very little information available on the number of dives, snorkel trips, and other reef- and mangrove-related activities engaged in by tourists in an average year, we used the Belize Tourism Board's 2006 *Visitor Expenditure and Motivation Survey (VEMS)* to estimate the percent of visitors that participated in these activities at least once during their stay. To account for uncertainty in the estimates of reef-and mangrove recreation, and to produce a more conservative estimate of reef use, we vary visitor recreation estimates by 20 percent, using the VEMS figures as the high end of ranges in participation. For example, we estimate that between 22 and 27 percent of visitors dive, and 47 to 59 percent snorkel. We then use expert opinion and other studies of marine recreation in Belize to produce rough estimates of the average number of dive, snorkel, fishing,

and wildlife viewing trips taken per person, keeping in mind that many visitors go on only one trip, while others spend a full week in the water. In total, reef- and mangrove-associated recreation earns an estimated $37.5 to $46.5 million per year in gross revenues (see Appendix 1 for more detail).

Coralline Beaches

Coral reefs and mangroves play an important supporting role in building and maintaining the white sand beaches that line the cayes and parts of the coast of Belize. Reefs are important not only as a source of sand, but also for their role in reducing wave energy and creating calm waters desirable for swimming. A beach represents a dynamic equilibrium between accreting and eroding processes, and the protection afforded by a reef is an important part of this dynamic.

The value of beaches is included indirectly in this study in that we consider beaches an important part of the attraction for major coastal destinations such as Placencia and San Pedro. White sand beaches play an important role in the decision of many tourists to stay in these locations, and most coastal tourists spend at least some time at the beach. We count accommodation and other spending of all tourists in these locations, even though they may not be directly visiting the reef every day.

Other Spending

In addition to accommodation costs and direct spending on marine recreation, we count "other tourist spending" on reef- and mangrove-related days as revenue associated with the use of these resources. This study estimates that reef- and mangrove-associated tourists spend $31.8 to $44.7 million per year on expenses such as food, transport, and non-reef-related entertainment (See Appendix 1 for further detail on this calculation).

Cruise Tourism

Belize has a significant cruise tourism industry. Although cruise visitation has leveled off over the last few years, construction of a new docking terminal has begun, so this figure could rise again in the future. In 2007, there were over 620,000 cruise visitors to Belize. Of these, only a very small portion engaged in coastal recreation. The vast majority of cruise tourists head inland for tours of the rainforest, cave tubing, and Mayan ruins—attractions that most other cruise stops do not offer (BTB 2008a). As a result, of the relatively small amount of revenue per person that comes into the country from cruise tourism, an even smaller portion flows to coastal communities.

Only 10 percent of cruise visitors engage in reef- or mangrove-related activities (including snorkeling, diving, wildlife viewing, etc.) (BTB 2008a), bringing an estimated $4.6 to $5.7 million in revenues and another $0.6 to $0.8 million in head and sales taxes to the country. Hence, while the negative impacts of cruise tourism affect coastal and marine areas disproportionately, these areas reap very little economic benefit from the industry.

Taxes, Fees, and Service Charges

For the purposes of this analysis, we consider taxes on reef- and mangrove-based tourism to be a benefit to the economy and the country of Belize. Taxes have been deducted from gross revenue where necessary in the sectors above, but we add them back into the estimate of reef and mangrove tourism value.

This study finds that between $11.6 and $15.2 million in General Sales Tax was collected on reef- and mangrove-associated spending in 2007. Another $6.0 million in departure tax and cruise head taxes were collected from reef- and mangrove-associated tourists, as well as $1.2 million in Marine Protected Area (MPA) fees. We also conservatively estimate $0.7 to $0.9 million in service charges, typically a 10 percent charge added at some of the higher-end hotels.

Value of Reef- and Mangrove-associated Tourism

Total tourist spending associated with coral reefs and mangroves in Belize is estimated at approximately $150 - $196 million per year (see Table 1 below). In addition to direct economic impacts in the tourism sector, there are additional impacts on the economy from spending by reef- and mangrove-associated visitors (see Box 2). These "indirect" impacts are not included in an economic valuation, but would be included in an economic impact assessment.

Table 1: Economic Contribution of Reef- and Mangrove-associated Tourism

Tourist Expenditure Categories	**Gross Revenues ($US million/year)**
Reef/Mangrove-associated Accommodation	$56.3 – 75.4
Reef/Mangrove Recreation	
Diving	$20.1 – 25.1
Snorkeling	$10.1 – 12.6
Sport Fishing	$7.2 – 8.5
Other	$0.2 – 0.3
Other Visitor Expenses	$31.8 – 44.7
Cruise Tourism	$4.6 – 5.7
Taxes and Fees	$19.6 – 23.4
Total Direct Impact	**$149.9 - 195.7**

Box 2: Indirect Economic Impact of Reef- and Mangrove-associated Tourism

Impacts on the wider economy from spending by reef- and mangrove-associated visitors include a variety of factors such as food purchased by visitors may be sourced from local farmers and fuel used for transportation purchased from local fuel distributors. In an economic impact assessment, it is possible to estimate the magnitude of these *indirect* (or "secondary") impacts using a tourism multiplier. A multiplier of 1.6, for example, represents 60 cents of additional impact for every $1 in direct tourist expenditure. The size of the multiplier is influenced by the portion of goods and services used in the tourism sector that is produced domestically, such as linen, beverages, food, dive equipment, and construction materials. If no published multiplier exists for the study site, a multiplier (or range) from a similar economy can be used to get a ballpark figure, but these estimates should be treated with caution.

We do not assess indirect economic impacts in the economic valuation results, but are including a ballpark estimate here. It is important to recognize the wider ripple effects in the economy of the ecosystem services provided by coral reefs and mangroves, even if precise numbers are not available. We were not able to find either a general economy or sector-specific multipliers published for Belize, and instead relied upon rough multipliers used in the recent literature (see Appendix 1). Because of the large amount of uncertainty in creating and applying multipliers as well as the lack of a reliable estimate for Belize, we chose to go with a very conservative multiplier, which may underestimate indirect impacts considerably.

By applying a multiplier range of 1.2 to 1.4 to total reef- and mangrove-related tourist expenditure we estimate between **US$26.1 and $68.9 million per year in indirect economic impacts**. When added to direct tourist expenditures, this sums to a **total economic impact of $175.9 to $264.6 million for 2007.**

An economic valuation attempts to capture the value society places on an ecosystem service (also known as 'willingness to pay'); this can be approximated by measuring gross or net revenues associated with a service, or broadened to include consumer surplus as well (see footnote and text on page 5 or the full methodology at http://www.wri.org/project/valuation-caribbean-reefs). The concept of 'value' does not, however, include secondary impacts on the economy. As a result, indirect impacts are mentioned here, but not included in the final valuation results.

B. Commercial Fisheries Profile

Belize's commercial fisheries sector is primarily made up of small-scale artisanal fishers. Almost all fishing is done in the shallow waters off the barrier reef and the three atolls (FAO 2005). All of the major commercial species rely on reefs, mangroves, or the sandy flats and seagrasses of the lagoon protected by the outer reef. Seafood products remain one of Belize's primary exports, with lobster and conch representing the bulk of wild exports, both in production and revenues. Belize had over 2,000 licensed fishers and 650 registered boats in 2006, and fishing continues to play a significant role not only economically, but as a food source and part of the culture in coastal communities. Approximately 300 fishermen—representing 15 percent of the country's licensed fishermen, and a larger proportion of active, full-time fishermen—come from the northern village of Sarteneja. Here the majority of adult men are full-time fishermen, spending weeks at a time fishing sites up and down the Belize coast. In Sarteneja, fishing remains a family-oriented activity, where boys begin working on the family boat straight from school (Kishore et al. 2006).

Over-Exploitation

There are a number of indications that the major finfish species are overexploited in Belize. A 2007 study found a drop in catch per unit effort and landings per boat for the mutton snapper fishery at Gladden Spit (Graham et al. 2007). All the fishermen interviewed for the study described a decline in catch and fish size over the past decade. Another study, of fish catch in Glover's Reef Marine Reserve during 2007, found that barracuda and parrotfish were the most frequently landed species (WCS 2008). The more desirable snapper and grouper species fell much further down on the list, suggesting that populations of these key commercial species are declining in this area. Lobster and conch production, after dropping from peaks in the early 1980s, have held relatively steady at between 0.4 and 0.7 million pounds for both species in recent years (FAO 2005, Belize Fisheries Department 2008). Some researchers argue that this may be primarily a result of increases in total effort and the expanded reach of the industry, and that declining yields of individual fishers as well as decreasing size of conch and lobster suggest that these stocks are also overexploited (Huitric 2005). Belize has a five month closed season for lobster, lasting from February through June of each year, and a three month closed season for conch, beginning in July. Although the Fishermen's Cooperatives will not accept out of season or undersized catch, the common practice of selling directly to restaurants and hotels (or over the border in Honduras and Guatemala) provides an easy market for illegal catch (Heyman and Graham 2000, Vernon 2007). The fisheries department is also insufficiently funded to enforce fishing regulations effectively across Belize's entire marine area.

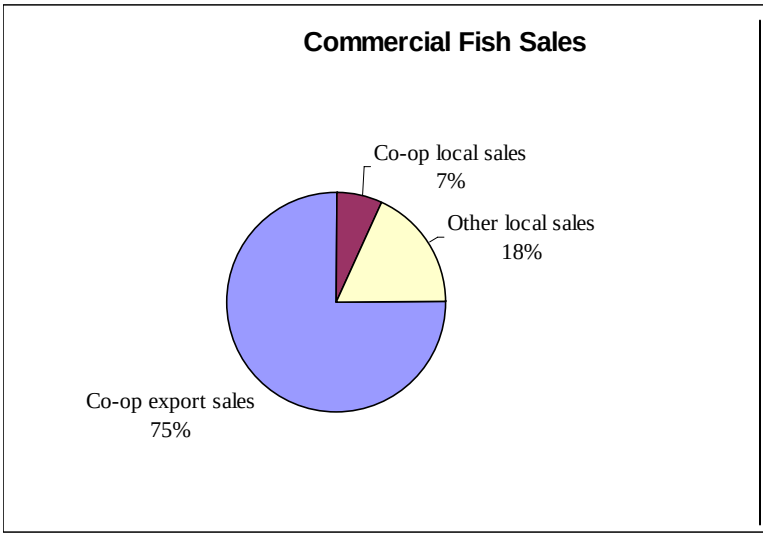
The official catch numbers reported to FAO each year come through the five Fishermen's Cooperatives. Because all local sales outside the Co-ops go unrecorded, fisheries experts in Belize estimate that total

fish catch may far exceed recorded catch (Gillett 2003). Finfish sales are almost entirely unrecorded, since they are almost exclusively sold in local markets (the Co-ops did not find them profitable to process). The discrepancy may have become more pronounced as coastal tourism has grown over the past fifteen years, dramatically increasing the number of coastal hotels and restaurants that fishermen can choose to sell to directly.

Fisheries Valuation Results

The Fisheries Department does not systematically collect catch or landings data for the country at this time. The best available information comes from the Fishermen's Cooperatives. The Co-ops provide data to the Fisheries Department on total catch, total exports, and total export revenue by major fish type. Using this information as a starting point, we divided the fisheries sector into three categories: (1) export sales through cooperatives, (2) local sales through cooperatives, and (3) all other local sales (further divisible into local market sales and direct sales to hotels and restaurants). Export sales are the biggest source of revenue for the fisheries industry (see Figure 1). We believe that the Co-op data on exports and local sales are relatively good, but have little to no information on local sales outside of the cooperatives.

Figure 1: Breakdown of Commercial Fish Sales in Belize



Exports and Local Sales by Cooperatives

Using the data provided by the fisheries department, we divided Co-op sales into exports and domestic sales. Export revenues were reported at $11.3 million for 2007. Less than 20 percent of the fish and shellfish processed by the Cooperatives is sold domestically; lobster head meat and conch fillet are sold domestically in relatively small amounts, and around 60,000 pounds of fish fillet are sold locally through the Co-ops. We use a rough estimate of average local sale price per pound (broken down by lobster, conch, finfish) to estimate that domestic Co-op sales earned approximately $1.0 million in 2007. Total Co-op sales (local and export) for 2007 are estimated at $12.3 million (see Appendix 1b, Table 11). This total includes the value added from any processing done at the cooperative plants. It was difficult to accurately separate out production and processing revenues in Belize, so the two are presented together as total revenue.

Other Local Sales

As noted above, Co-op sales represent only a portion of total fish sales in the country. Many fishermen sell a portion of their catch to local markets, directly to hotels and restaurants, and to family and friends. There is very little information currently available on these sales, so we relied on expert opinion and published surveys of local fishermen to estimate that, averaged across the country, fishermen sell 15 percent of lobster, 5 percent of conch, and 95 percent of the finfish they catch to buyers outside of cooperatives (i.e. to local markets, restaurants, etc.). Using the average local sale price for 2007 (averaged across the year), we estimate that local sales of reef- and mangrove-associated fish earn $1.9 to $3.5 million in gross revenues per year.

Fish Cleaning

On-site fish cleaning plays a very small role in Belize's fisheries industry; most of the fish sold outside of Cooperatives are sold unprocessed or are processed by fishermen for a minimal fee. The value of cleaning and processing of fish for export and local sale through the Cooperatives is captured in the Co-op sale prices, above. To estimate the value of local fish cleaning, we designed a survey with WWF-Belize to gather information on average earnings and hours worked by fish cleaners at four major landing sites. We very conservatively estimate that local fish cleaning (cleaning outside of the Cooperatives) brings in $80,000 to $120,000 in gross revenues per year (see Appendix 1b for more details).

Value of Reef- and Mangrove-associated Fisheries

We estimate that total revenues from the fisheries industry (production and processing) fall between $14.2 and $15.9 million per year. Of this total, $11.2 million comes from exports, and the remainder from in-country sales through Co-ops, local markets, restaurants, and informal sales.

Table 2: Economic Contribution of Reef- and Mangrove-associated Fisheries

Fisheries Sector Categories	Gross Revenues ($US million per year)
Co-op Sales	
Exports	$11.2
Local Sales	$1.0
Other Local Sales	$1.9 - $3.5
Local fish cleaning	$.08 to $.12
Total Direct Impact	**$14.2 - $15.9**

Limitations

This assessment of the economic contribution of Belize's fisheries sector understates the actual value of Belize's reefs and mangroves for two key reasons:

1. Revenues from fish that are caught in Belize's waters but landed and sold in other countries are not counted as an economic benefit to Belize.
2. Limited information is available on the extent of local fish sales, especially to restaurants and hotels in Belize. Some of these sales also include illegal and out-of-season catch that is sold under the radar. The decline in catch for most species in recent years also makes this number difficult to

estimate using historical catch levels. This study produces a ballpark estimate that is purposefully conservative in order to avoid inflating the valuation results.

In addition to these limitations, it is important to note that this assessment provides a "snapshot" of fisheries revenues at the current level of extraction. There are many indications that this level of use may not be sustainable, in which case future value may be less due to declining yields. Better collection of local catch and sales data is essential to monitor and inform the sustainable management of Belize's fisheries.

C. Shoreline Protection

The "damages avoided" due to reductions in wave-induced erosion and storm damage attributable to coral reefs and mangroves was evaluated using the five-step process described in the methodology section (see pages 7-9). Technical details and data sources are included in Appendix 1, section C.

1) **Identify land which is vulnerable to wave-induced erosion and storm damage.** Land vulnerable to wave-induced erosion and storm damage was defined as any land within 1km of the coast which has an elevation of 5 m or less. This elevation was selected based on the wave height and storm surge predicted for a 25 year storm event. Using this definition, 693 sq km of land was classified as vulnerable. This constitutes about 3 percent of the total land area in Belize, and 87 percent of land within 1 km of the coast.

2) **Identify coastline which is protected by coral reefs or by mangroves.**
   a) **Coral Reefs.** Coral reef location, fetch (the distance wind blows over open water) and shoreline orientation were considered in defining the shoreline protected by coral reefs. Shoreline on the windward facing coast, which is enclosed by the barrier reef or the "wind shadow" of a reef or atoll, was classified as "protected" by coral reef. About 70 percent of the coastline of Belize—66 percent of the mainland coast and 72 percent of the cayes—was classified as protected by coral reefs.
   b) **Mangroves.** Data on the current extent of mangroves in Belize are imperfect. This analysis made use of three data sets on mangroves in Belize (see technical notes) and focuses on land within 1km of the coast. We estimate there are between 400 and 420 sq. km of mangrove within 1km of the coastline of Belize (including all cayes). Coastline segments within 50m of a mangrove were classified as protected by mangrove. Using this definition, half of the mainland coast is sheltered by mangroves, as are three-quarters of the offshore islands (cayes).
   c) **Combined.** Over 35 percent of the mainland coast is sheltered by both reefs and mangroves, as is over half of the shoreline of the cayes (see table 3 below).

Table 3: Extent of Reef or Mangrove Protected Shoreline

Location	Coastline length (km)	Reef-protected coast (km)	Percent protected by reefs	Mangrove-protected coast (km)	Percent protected by mangroves	Reef and mangrove-protected coast (km)	Percent protected by both
Mainland	**518**	**342**	**66%**	**260**	**50%**	**189**	**37%**
Offshore	1,288	928	72%	972	75%	690	54%
Total	1,805	1,270	70%	1,232	68%	879	49%

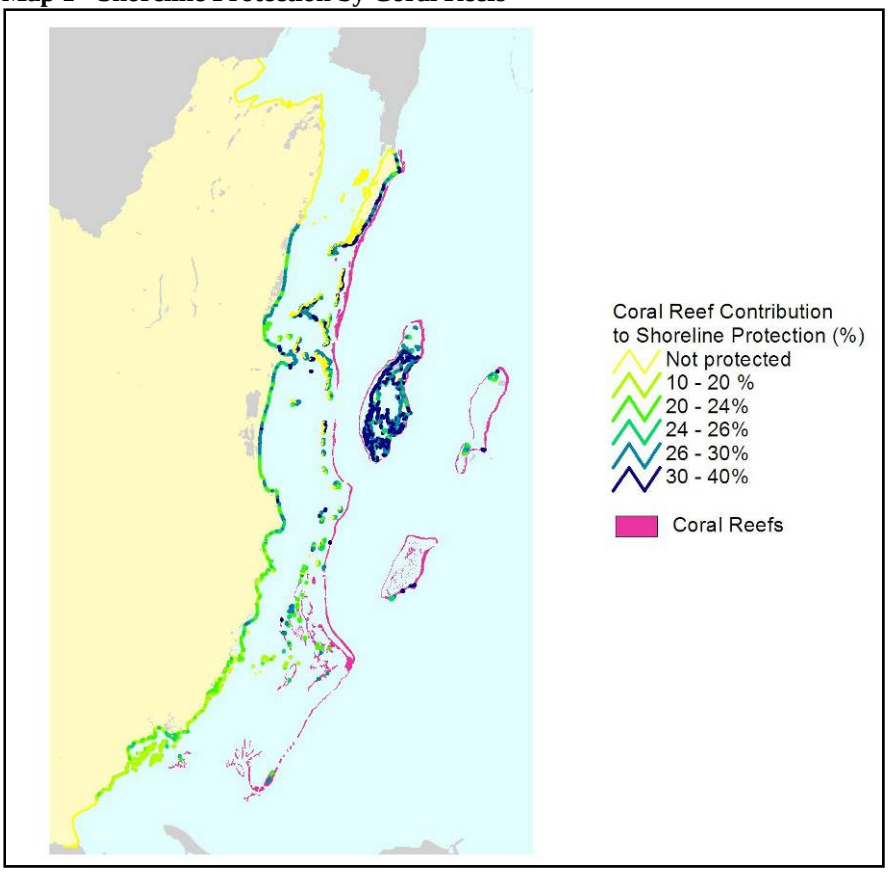
Note: Coastline is very detailed, so the analysis may exaggerate the coastline of cayes.

3) Estimate the relative stability of the shoreline. Data were available for seven of the nine factors which influence the relative stability of the shoreline: coastal geomorphology, geology, coastal protection by structures (atolls or sea walls), the coral reef index (reef proximity, type, and continuity), hurricane frequency, coastal elevation, and coastal vegetation. Data were not available for wave energy or presence of damaging activities, such as sand mining. Data sources and details on the analysis can be found in Appendix 1, section C.

The seven factors influence the stability of the shoreline over different scales. Coastal geomorphology, geography, and storm regime operate over broad scales (i.e. do not vary much over short distances). Coral reefs and atolls protect broad swaths of the coastline, but this protection varies with the reef characteristics, including distance from shore. Mangroves offer vital protection in the fairly localized areas where they are present. This results in a patchwork of relative stability of the shoreline. Relative shoreline stability is high in areas with mangroves and coral reefs close to the shore, such as in Turneffe Atoll. It is also high in areas well protected by multiple lines of defense, such as an atoll and the Belize Barrier Reef off some cayes.

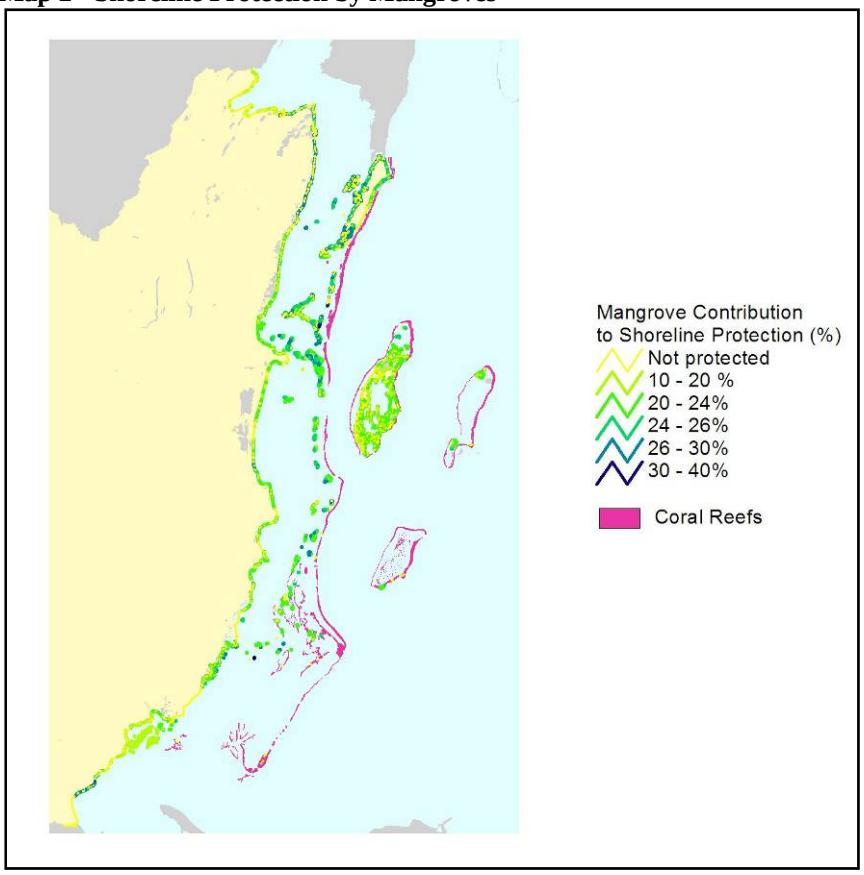
4) Determine the share of shoreline stability attributed to coral reefs or mangroves. By evaluating the relative shoreline stability both with and without reefs present, we are able to isolate the share of shoreline stability contributed by coral reefs. Where reefs protect the shoreline, they can contribute between 12 and 40 percent of the shoreline stability. The share is very high along all of the cayes in the outlying atolls, such as Turneffe Atoll, and along Ambergris Caye (See map 1 below).

Map 1 - Shoreline Protection by Coral Reefs



A similar approach is used to evaluate the role of mangroves in protecting the shoreline. Where mangroves are present, they contribute between 10 and 32 percent of shoreline stability (see map 2). Mangroves are vitally important to the stability of the shoreline of cayes throughout Belize, as well as along many segments of the mainland coast.

Map 2 - Shoreline Protection by Mangroves



5) **Estimate the average annual "damages avoided" due to the presence of coral reefs or mangroves, based on the value of property in vulnerable land protected by coral reefs or mangroves.** Property values were collected through internet searches for both developed and undeveloped properties in Belize during 2007 and 2008. These were differentiated based on whether they were adjacent to the coast (first 100 m inland) or further inland, and based on locale to arrive at these average property values. Coastal property values in US$ per sq ft ranged from US$22 for San Pedro to US$15-16 for Caye Caulker and Placencia, to US$2 for properties along the coast in remote areas. Properties more than 100 m from the shore were often about half the value of properties right on the shore. The values reflect average values for land and built structures (when present).

Avoided damages were calculated separately for coral reefs and mangroves. For each area mapped as "vulnerable" (based on the 25 year storm event), the property value for that area was combined with the degree of shoreline stability provided by coral reefs (or mangroves) for the nearest coastal segment to estimate the potentially avoided damages due to the presence of the coral reef (or mangrove). The sum of these values was then multiplied by 4 percent (the probability of the 25 year storm event occurring in a given year) to arrive at an average annual value. A range of +/- 20 percent was incorporated to reflect uncertainty around these estimates.

The shoreline protection services from coral reefs in Belize are valued at between US$120 – 180 million per year in potentially avoided damages through reduced erosion and storm damage.

Mangroves within 1 km of the shoreline are estimated to contribute between US$111 – 167 million per year in potentially avoided damages. Mangroves within 1 km of the coast[8] provide shoreline protection services with an average annual value of US$2,775 – $4,000 per ha per year (US$1,125 – 1,600 per acre per year).

Table 4: Annual Value of Shoreline Protection Services Provided by Coral Reefs and Mangroves

	Central Estimate	Range (reflects uncertainty)
Coral Reefs	US$150 million	US$120 – 180 million
Mangroves	US$139 million	US$111 – 167 million

Summary of Results

Table 5: Economic Contribution of Coral Reefs and Mangroves to Belize: Summary of Results (millions USD per annum)

All figures are for 2007

Reef- and Mangrove-associated Tourism	
Accommodation	56.3 – 75.4
Recreation	$37.5 – 46.5
Other Spending	$31.8 – 44.7
Taxes and Fees	$19.6 – 23.4
Cruise Tourism	$4.6 – 5.7
Tourism Value	**$149.9 - 195.7**
Reef- and Mangrove-associated Fisheries	
Co-op sales (lobster, conch, finfish)	$12.3
Local sales (est.)	$1.9 - 3.5
Fish Cleaning	$.08 to 0.12
Fisheries Value	**$14.2 - 15.9**
Shoreline Protection	
Annual value of protection by coral reefs	$120 – 180
Annual value of protection by mangroves	$111 – 167
Potentially Avoided Damages	**$231 – 347**
Annual value of the three goods and services combined	**$395 – 559**

[8] Our mapping suggests that there are between 400 and 420 sq km of mangroves within 1 km of the coast.

4. Policy Application: Marine Protected Areas

The Marine Protected Area (MPA) system of Belize is well known and widely hailed as an example of forward thinking in marine conservation. The system consists of 18 protected areas managed primarily by the Fisheries and Forestry Departments in collaboration with local NGOs. Belize's MPAs are an important draw for divers, snorkelers and sport fishermen, and contain no-fishing areas that, when well-protected, help to maintain stocks of key commercial species.

In 2007, Belize's MPAs recorded approximately 115,000 visitors. Even accounting for some repeat visitors, this is a remarkable share of Belize's total 250,000 overnight visitors for that year (very few MPA visitors come from the cruise lines). In addition, MPA managers note that a significant portion—sometimes as much as 30 percent —of visitation goes unrecorded. Using our reef- and mangrove-associated tourism findings, above, we estimate that the average reef-related visitor spends approximately US$150 a day. This translates into approximately $17 million in tourist spending on accommodation, food, and other expenses on days that people visited a reserve. Indirect economic impacts, such as tourist spending on transportation and food, contributed an additional $3.5 to $6.9 million to the economy. By comparison, the Fisheries Department allocates roughly US$600,000 per year to its five co-managed reserves, while the Forestry Department uses mainly MPA fees to fund marine park management (See Appendix 3).

Unfortunately, the current financing situation is not sustainable. At most MPAs, management levels fall well below what is needed to keep reefs healthy and attractive to visitors over the long-term. Visitation, investment, and management levels vary widely across the system. Many MPAs rely heavily on grant-based funding that may not be reliable from year to year. Staff, fuel, and equipment limitations make it difficult to curb illegal fishing and monitor visitation in most of the reserves. If the condition of the reefs and mangroves protected by the system continues to decline and their importance as refuges for key species diminishes, visitors may decide MPAs are no longer worth the trip,. This is especially true for some of the most fragile sites, such as the rare mangrove and reef habitats in the Pelican Cayes in South Water Caye Marine Reserve, and Glover's Reef (assessed below). Belize's MPAs provide benefits well beyond what can be measured in economic terms alone. Even with an increase in government support, they should continue to be an extraordinarily "good deal" — long into the future.

As a first step towards sustainable financing of MPAs in Belize, WRI and WWF interviewed MPA managers to compile their understanding of the current financing situation. The responses from MPA mangers on the details of visitation levels, fee collection, expenditures, and financial needs are included in the table in Appendix 3. This snapshot of MPA management demonstrates, among other things, a need for coordination and record keeping at the MPA system level. Inconsistencies, gaps in data, and vast differences in the availability of funding make it difficult to assess the current level of investment, total fees collected, or even total MPA visitation with accuracy. The available information suggests that fees, government spending, and funding by co-managing organizations (largely grant based) bring total spending on MPA management in Belize to roughly US$1.6 million per year.

WRI has also adapted the national level valuation method for reef- and mangrove-associated tourism and fisheries for Marine Protected Areas in Belize.9 Preliminary assessments of the fisheries and tourism value of several MPAs were produced in collaboration with protected area co-managers, such as TASTE, TIDE, and the Belize Audubon Society, and will be available in a separate document. The results of a valuation of the tourism and fisheries benefits of Glover's Reef Marine Reserve are included in Box 3.

[9] This valuation method, both at the national and the MPA level, captures only *current use* of resources. For underutilized MPAs, an assessment of "potential" tourism value may be a more useful estimate. For this application and others, it will be important to conduct assessments of tourist carrying capacity at one or more marine tourism sites in Belize.

Box 3: Glover's Reef Marine Reserve

The Glover's Reef Marine Reserve (GRMR) was established in 1993 and became a World Heritage Site in 1996. Located 45 kilometers east of the Belize mainland, Glover's Reef Atoll contains over 800 patch reefs and six sand cayes (Wildtracks / WCS 2007). It supports critical habitat areas for commercial fish species, including lobster and conch, and protects a Nassau grouper spawning site at its northeastern end. Glover's Reef is distanced from most land-based sources of pollution, but exposed to many other threats, including storms, coral bleaching, and overfishing, as well as tourism impacts such as anchor damage from boats and waste disposal by on-site hotels.

Glover's is not only an important tourism and fishing destination, but an important marine research site, housing the Wildlife Conservation Society's marine research station. The atoll has a small number of permanent residents and supports several small resorts. It is also a highly touted dive destination, drawing serious divers to the on-site resorts as well as independent dive operators from the towns and high-end resorts on the mainland. Fishermen from several mainland communities rely on Glover's Reef for at least a portion of their livelihood, with boats visiting regularly from Sarteneja, Belize City, Dangriga and Hopkins.

Using information collected by the Wildlife Conservation Society (WCS) and the Belize Fisheries Department, we assessed the economic contribution of fisheries and tourism activities associated with Glover's Reef (see Appendix 2 for technical notes and sources).

Valuation Results

The total economic contribution of tourism and fisheries associated with Glover's Reef Atoll is estimated at US$4.9 to $7.4 million per year.

Table 6: Tourism and Fishing Revenues Associated with Glover's Reef Marine Reserve

	Total Revenues (USD)
MPA-associated accommodation	$3,158,243 – $4,737,344
MPA-associated recreation (outside of all-inclusives)	$291,123 - $586,671
Other tourist spending on MPA-associated days	$37,287 - $55,914
Taxes and Fees (including MPA fees)	$345,028 - $506,722
Total Tourism Value	**$3,931,680 - $5,886,652**
Lobster revenue	$457,951 - $686,926
Conch revenue	$500,803 - $751,205
Finfish revenue	$18,850 - $28,276
Total Fisheries Value	**$977,604 - $1,466,407**
Total Tourism and Fisheries Value, Glover's Reef	**$4,909,285 - $7,353,058**

Tourism

Total reef- and mangrove-associated tourism in the Glover's Reef Marine Reserve is estimated to be worth **US$3.9 - $5.9 million per year**. This includes:

a) MPA-associated accommodation revenues – for example, tourists staying at hotels inside the MPA, nights on chartered yachts visiting the MPA, and one night of accommodation for each day-trip visitor;

b) spending on reef-related recreation, including diving, snorkeling, kayaking, and recreational fishing trips to the MPA;
c) other expenditures (on food, transportation, etc.) on days that tourists visit the MPA; and
d) all fees and tax revenues from tourist spending associated with the reserve ($0.3 - $0.5 million).

Since there are several all-inclusive resorts inside the MPA, some of the revenues from categories (b) and (c) are captured in the accommodation sector. For a further breakdown of this estimate and details on calculations and data sources, please see Appendix 2.

Fisheries

Glovers Reef Atoll is an important site for commercial fishing in Belize, with fishermen from Sarteneja, Dangriga, and Hopkins regularly using the general use zone of the reserve to catch lobster, conch, and finfish. We use data from WCS's Fisheries Catch Data Collection Program to estimate total fish catch and revenues associated with the MPA for 2007 (see Appendix 2 for more detail on these calculations).

A total of 41 boats with approximately 200 crew members visited the reserve in 2007. Fishermen from Dangriga and Hopkins fish in the reserve for 1- 4 days, while sailboats from Sarteneja typically stay for a week at a time. Fishermen sell roughly 85 percent of lobster, 95 percent of conch and 5 percent of finfish caught inside the reserve to Cooperatives, while the remainder is sold to restaurants, hotels, and markets in the local area (Gibson, pers. communication). Using national average fish prices for 2007, we estimate that commercial fisheries in Glover's Reef Atoll earned $1.0 to $1.5 million in revenues for that year.

There are signs that current fishing pressure in the MPA is not sustainable. A recent study found a decline in catch per unit effort for finfish since 2004, and found barracuda and parrotfish have become the most frequently landed fish (Gibson and Hoare 2006; WCS 2008). Catch of the more desirable (and heavily fished) snapper and grouper species fell much further down the list, suggesting that these populations may be overexploited.

Summary: Under-Investment in a Key Asset

The total economic contribution of tourism and fisheries associated with Glover's Reef is estimated at US$4.9 to $7.3 million per year. By comparison, the government spends roughly US$100,000 per year to manage the reserve. This amount covers staff, fuel, and other non-capital expenditures, and is roughly the same for all MPAs co-managed by the Fisheries Department, regardless of size.

Glover's Reef Marine Reserve is almost 87,000 acres in area (Hol Chan, by comparison, covers approximately 3,800 acres), making it an extremely large reserve to manage. Current funding covers only one boat and enough fuel to patrol once a day. Bringing someone to Belize City for a fishing violation can quickly exhaust most of the fuel allotment for the month. The small reserve staff focuses primarily on fisheries patrols, relying upon hotels to report accurately on visitation and collect MPA fees.

The Fisheries Department has not reported official visitation numbers for the reserve in several years. A recent Financial Sustainability Report for Glover's Reef estimates that 7,500 tourists visit Glover's each year (Denby et al. 2007). Our study arrives at a similar estimate of between 6,300 and 8,000 annual visitors, using on-site occupancy rates and estimates of day-trip visitors from nearby towns. In 2006, the reserve collected BZ$42,810 in MPA fees. It is not clear what proportion came from weeklong visitors (BZ$30 fee) versus day trip visitors (BZ$10), but the total can only account for between 1,427 and 4,281 visitors (probably less than half of total visitors) for the year.

Glover's Reef remains one of the crown jewels of Belize's MPA system, but it lacks the resources to protect effectively the natural ecosystems that draw thousands of tourists a year and support local fishing communities.

Recommendations

Glover's Reef Marine Reserve would benefit greatly from collecting the fees it is currently not capturing. Potential solutions include changing fee collection practices to increase transparency and better capture day-trip visitors, and /or seeking support from Protected Area Conservation Trust (PACT) to collect fees. Better information on MPA user numbers will help to improve management and to quantify the full benefits of maintaining the health of the reserve. It will also be important to ensure that fees are directed back efficiently into managing the MPA, and that this can be demonstrated to the visitors, tour operators, and hotels that use the reserve.

To improve management effectiveness, Denby et al (2007) recommend adding an additional boat, ranger, and fuel for patrolling the MPA. Currently, only one boat is available to patrol, leaving the reserve uncovered whenever the rangers have to leave to bring someone to the mainland for prosecution, change shifts, or carry out repairs. The financing study recommends raising fees for day-trip visitors to $15 and establishing a permanent source of annual funding beyond the small amount allocated by the government each year. Additional government funding would be an important first step, as would the creation of a permanent trust fund to support this and other MPAs in Belize. The Fisheries Department is currently managing the MPA on its own, and appointing an NGO as a formal co-manager could also benefit many aspects of reserve management.

5. Conclusions and Recommendations

The valuation findings underline the extent to which coastal and marine ecosystems provide vitally important goods and services to Belize's economy. The protection they furnish from erosion and wave damage from coastal storms, valued at US$231 – 347 million in avoided damages per year, is especially notable, and highlights the importance of protecting coral reefs and mangroves for their less visible services as well as for the more obvious benefits of fisheries and marine tourism. As these resources become increasingly threatened, it is critical to recognize the value they provide, and to incorporate them into decision-making. It is in the long-term economic interest of Belize to:

1. **Invest in scientific assessment, monitoring, and compliance.** The government has taken an important first step by reinstating the Coastal Zone Management Authority and Institute (CZMAI). Now, it needs to invest in CZMAI and other science-based efforts to expand monitoring activities and assess the state and use of coastal resources. Next steps should include:
    a. Allocating additional resources to enforce fishing regulations and work with local fishermen, restaurants, and hotels to improve compliance with existing laws;
    b. Collecting data at a national level on how many tourists are using reefs and mangroves and visiting MPAs each year. This is critical information for evaluating the importance of these resources, managing them sustainably, and planning for their future use.
    c. Climate change is a growing threat. Current monitoring and conservation efforts should expand to include identification of reefs that will be resilient to climate change.

2. **Plan and implement development sensibly.** The government needs to enforce existing land-use and development regulations in the coastal zone. Longer-term tourism and development strategies should incorporate the ecosystem services provided by coral reefs and mangroves. For instance decisions on development permits, sewage and waste disposal regulations, and the balance between cruise and

overnight tourism should consider the potential impacts on the flow of benefits from coastal resources. Key areas of focus should include:

a. Minimizing the loss of mangroves along the shoreline and outer cayes, as they provide critical habitat and protect the coast from storms;
b. Incorporating ecosystem services into Environmental Impact Assessments and subsequent compliance plans for development in sensitive coastal areas, such as the cayes;
c. Conducting threat hazard assessment/mapping as part of any proposed development along Belize's mainland and insular coast;
d. Engaging developers proactively to find ways to protect mangrove habitat, manage construction impacts and sewage treatment, and incorporate other sustainable practices into the sector; and
e. In planning a long-term tourism strategy, weighing revenues from a growing cruise industry against potential losses to the overnight sector from environmental impacts.

3. **Increase support for Belize's MPA system.** Belize's MPA system is among the best in the world, but it is suffering from uneven funding and management. To avoid a continuing decline in the health of coral reefs and fish populations in MPAs, Belize should: increase overall investment; improve fee collection in order to capture missing revenue; improve collection of basic indicators of human use (e.g. visitation, recreation, and fisheries data); strengthen monitoring and enforcement efforts, and establish a permanent source of funding to support the MPA system. Strategic planning at the system level is also needed to address disparities and gaps in the current structure, and to incorporate climate-related threats into planning for the future.

Further research: Belize's reefs and mangroves provide many benefits not assessed in this study. Not the least of these is the previously described "consumer surplus" of divers, anglers, and snorkelers – the enjoyment they receive above what they have paid for their experiences. A useful follow-up to this study would be to estimate this value in order to provide a fuller picture of the tourism value of Belize's reefs and mangroves, including some of the intangible elements that draw tourists to the country. This information could also be used to set MPA fees, sport fishing taxes, and other fees to support better marine and coastal management.

This study demonstrates that the links between healthy coastal and marine ecosystems and Belize's economy are too important to ignore. Coral reefs and mangroves are an extremely important part of Belize's ecological and economic wealth. The value of three economically vital services provided by these ecosystems amounts to **US$395 – 559 million** per year. This is an especially large sum relative to Belize's GDP of US$1.3 billion, and underlines the importance of protecting and managing these resources so that they can continue to provide these benefits. Many of Belize's reefs and mangroves are already under threat from unsustainable development, overfishing, and natural threats such as storms. Climate change threatens to worsen these effects. It is critical for Belize's government and citizens to work now to protect their coastal resources, or risk losing these benefits in the not-so-distant future.

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Appendix 1: Technical Notes and Data Sources

Note: All prices and revenue estimates are in US dollars.

A. Reef- and Mangrove-Related Tourism

Belize is a major ecotourism destination, and attracts visitors both for its coastal and marine attractions and for inland sights such as rainforests and Mayan ruins. A critical step in evaluating the economic impact from reef- and mangrove-related tourism is thus to determine the percentage of total "tourist nights" that are spent by visitors engaged in marine activities. The Belize Tourism Board (BTB) collects accommodation statistics (including number of hotel rooms and occupancy rates) by district. WRI held an expert workshop in Belize in March 2008 to solicit feedback on the data, assumptions, and methods used in the analysis. Among the key outputs of the workshop was an estimate of the percentage of tourists engaging in coral reef or mangrove-related activities on any given day for each of BTB's accommodation districts (these include the six political districts plus major offshore islands and tourist towns). If a tourist visits the reef to dive or snorkel, sits on a coralline beach, or fishes for mangrove-dependent fish, we count that day as reef or mangrove associated. We applied this "reefuser" estimate to BTB's data on total rooms and occupancy rates, concluding that an estimated 64 percent of visitor nights in Belize can be attributed to days spent using reefs, mangroves, or coralline beaches (see Table 1).

Table A1: Reef and Mangrove Visitation by District 2007

District	Total # rooms [a]	Occupancy rate [a]	Avg. # of occupied rooms / night	% of visitor days spent using reefs, mangroves, beaches [b]	Avg. # rooms occupied by "reef users" / night
Belize District	966	49.1%	474	30%	142
Ambergris	1443	49.5%	714	100%	714
Caye Caulker	580	39.6%	230	100%	230
Cayo	942	43.4%	409	1%	4
Corozal	283	19.7%	56	1%	1
Orange Walk	237	38.6%	91	1%	1
Stann Creek	495	43.6%	216	90%	194
Placencia	689	39.2%	270	90%	243
Toledo	265	32.2%	85	50%	43
Other Islands	300	44.6%	134	100%	134
Total	6200	44.3%	2679	NA	1706
Estimated % of visitor nights attributed to the reef					64%

[a] Source: BTB 2008c (Accommodation Statistics)
[b] Source: WRI estimate, based on expert opinion

Accommodation

Hotels

We use BTB's published accommodation statistics to estimate annual hotel revenues generated by reef-associated tourists. In doing this, we found that there was a major disparity between total reported hotel revenues for 2007 ($64.1 million) and the rough estimate that can be produced by multiplying together the data on total rooms, average occupancy rates, and average room rates for each district ($99.7 million). There are uncertainties in both estimates. Underreporting of revenues could cause the first figure to be low; higher occupancy rates at the low end of the price scale and/or a large number of hotel rooms sold at discounted rates would lead to an overestimate using room and occupancy rates. We use BTB's figure on total tourist spending in 2007 ($257.8 million for overnight visitors) (BTB 2008c) as an additional reference point. Reported hotel revenues for 2007come to less than 25% of the total spending figure. In comparison, expert opinion in Belize suggests that 40 – 50% (or more) of visitor expenditures tend to go toward accommodation.

We try to estimate a range for reef- and mangrove-related accommodation revenue in 2007 that takes these uncertainties into account. For the low end of the range, we apply our estimates of reef-related visitor days to *reported hotel revenue* to arrive at an estimate of $46.7 million in reef-related accommodation revenue per year. For the high end of the range, we use the rough revenue calculation from above, and reduce average room rates by 15 percent, to account for uneven distribution of room sales, discounts, etc. We multiply this total by estimated reef-related visitor days to arrive at an estimate of $61.2 million per year, a difference of about 24 percent (see Table 2 below).

Table A2: Reef- and Mangrove-Related Hotel Revenue 2007 (USD)

District	Total number of rooms [a]	Average occupancy rate [a]	Occupied room nights / year [b]	Percent of visitor days spent using the reef [c]	Reef related room nights / year [b]	Reported hotel revenue (USD)[a]	Reef-related accom. revenue (b) using reported revenue [b]	Average room rate (USD) reduced by 15%	Reef-related accom. revenue (a) using room and occ rates [b]
Belize District	966	49.1%	173,122	30%	51,937	$ 8,524,479	$ 2,557,344	$ 59.86	$ 3,108,763
Ambergris	1,443	49.5%	260,714	100%	260,714	$26,983,501	$ 26,983,501	$122.23	$ 31,867,075
Caye Caulker	580	39.6%	83,833	100%	83,833	$ 3,076,504	$ 3,076,504	$ 43.32	$ 3,632,031
Cayo	942	43.4%	149,222	1%	1,492	$ 7,883,541	$ 78,835	$ 72.66	$ 108,428
Corozal	283	19.7%	20,349	1%	203	$ 897,314	$ 8,973	$ 54.52	$ 11,094
Orange Walk	237	38.6%	33,391	1%	334	$ 1,281,877	$ 12,819	$ 55.91	$ 18,670
Stann Creek	495	43.6%	78,774	90%	70,897	$ 4,614,756	$ 4,153,280	$ 87.58	$ 6,209,431
Placencia	689	39.2%	98,582	90%	88,724	$ 8,011,728	$ 7,210,556	$131.17	$ 11,637,715
Toledo	265	32.2%	31,145	50%	15,573	$ 576,844	$ 288,422	$ 39.53	$ 615,644
Other Islands	300	44.6%	48,837	100%	48,837	$ 2,307,378	$ 2,307,378	$ 81.74	$ 3,991,949
Total	6,200	44.3%	977,970	64%	622,544	$ 64,093,827	**$46,677,612**	$ 83.96	**$ 61,200,802**

[a] Source: BTB 2008c (Accommodation Statistics)
[b] Source: WRI calculation using BTB 2008c
[c] Source: WRI estimate, based on expert opinion

As a further check, we found that the high end of this range ($61.2 million) was fairly close to $66 million – the figure that results from taking 64 percent (reef related) of 40 percent (percent of visitor spending that usually goes toward accommodation) of BTB's estimate of total overnight visitor spending ($257.8 million).

Liveaboards

In addition to revenues from hotels on land, there is a small but active liveaboard and yachting industry in Belize. The liveaboard sector primarily attracts tourists who are interested in spending the week diving, fishing, anc visiting beaches maintained by the reefs. As a result, we chose to count 100% of liveaboard and yachting revenue as reef-associated. With the help of BTB and local experts, we estimate that between 6,800 and 10,000 tourists visit the reefs on yachts or liveaboards per year. The average length of a trip in 2007 was 7.2 days, and the average price of

chartering a yacht was estimated at $197 per person per night (from research on prices, weighted by volume per company). Using these figures, we estimate revenue from liveaboard guests at between $9.6 and $14.2 million for 2007.

Table A3: Liveaboard Revenue from 2007 (USD)

# of liveaboard tourists (range)	Avg. trip duration	Avg. price pp / per night in 2007	Estimated Liveaboard Revenue
6,800	7.2 days	197.21	**$ 9,655,342**
10,000	7.2 days	197.21	**$14,199,033**

Source: BTB 2008d

Reef and Mangrove Recreation

There is no centralized and publicly available estimate of annual revenue from reef- and mangrove-based recreation such as diving, snorkeling, and sport fishing in Belize. It is clear that these sports are popular with visitors, and they provide an important source of employment and revenue to coastal communities. We do not have enough information to estimate how many people come to the country *because* these activities are available; however, BTB's 2006 *Visitor Expenditure and Motivation Survey* (VEMS) does produce estimates of the percent of total visitors who engage in different activities during their stay, including marine activities such as diving and snorkeling. The VEMS results indicate that 27 percent of visitors to Belize dive, 59 percent snorkel, and 16.5 percent fish (BTB 2007). Since no centralized data were available, we used these figures as a starting point for the analysis. At an expert workshop held in March 2008, we solicited feedback on available reef recreation data, and on the assumptions and adjustments used to incorporate these data into the analysis.

Finally, recognizing that many all-inclusive resorts advertise room prices that include reef-related activities, we wanted to be sure to avoid double-counting revenue already recorded in the accommodation sector. According to BTB, the published room rates and revenues for hotels represent the *accommodation portion* only for all-inclusive resorts. This should avoid most double-counting concerns in this sector.

Diving

Dive tourism is a lucrative industry in Belize, and the barrier reef draws a large number of both serious and novice divers to the country. Diving is a relatively expensive sport, and it is likely that divers spend more in the local economy, on average, than most other tourists. It is also an industry that is likely to suffer if the quality of Belize's reefs continues to decline relative to other dive destinations.

To estimate annual revenue from dive tourism, we researched dive prices at shops across the country, and used expert opinion to estimate the distribution of 1, 2, and 3 tank dive trips sold (2 tank dives being by far the most popular option). The VEMS exit survey indicates that as many as 27 percent of visitors dive, but not how many dive trips these visitors tend to purchase; some people will come for a whole week of concentrated diving, while others may go out only once (BTB 2007). We consulted experts at the workshop and elsewhere to arrive at a conservative estimate of an average four dives per "diving visitor". Web research showed dive prices to be slightly higher in the south, in part due to longer distances per trip. Because the north is more heavily visited, we weight the northern prices more heavily, producing the average prices per trip listed in the table below. We conservatively estimate that 60 percent of divers rent equipment, averaging US$22 per rental.

Through our own research and input from participants at the expert workshop, we determined that the VEMS figure was a reasonable estimate of the number of divers per year, likely falling at the high end of a probable range. In an effort to remain conservative in our estimate, we treat 27 percent participation as the high end of a range. For a low-end estimate, we use a 20 percent lower figure for percent of visitors who dive (22 percent of all visitors).

The revenue figures we have calculated below include taxes, which we need to separate out from gross revenue. We subtract the 10% General Sales Tax (GST) from the totals to arrive at an estimated range of $20 million to $25 million in gross revenue from diving for 2007.

Table A4: Estimated Dive Revenue, 2007 (all figures in USD)

Dive type	Distribution of dives sold	# of divers (est. 27% of visitors dive)	# of dive trips (avg. 4 trips per diver)	Avg. price of trip	Dive revenue (high estimate)	Rental revenue (high estimate)	Dive revenue (20% fewer divers)	Rental revenue (20% fewer divers)
1 tank dive	10%	6,845	27,380	$55.25	$1,512,755		$1,206,867	
2 tank dive	72%	49,284	197,137	$79.06	$15,585,671		$12,434,156	
3 tank dive	10%	6,845	27,380	$119.25	$3,265,086		$2,604,866	
long distance	8%	5,476	21,904	$167.50	$3,668,943		$2,927,061	
Total	**100%**	**68,450**	**273,802**	**NA**	**$24,032,454**	**$3,614,183**	**$19,172,950**	**$2,883,374**
Revenue minus GST					**$21,847,685**	**$3,285,621**	**$17,429,955**	**$2,621,249**
Total Dive and Rental Revenue					**$25,133,306**		**$20,051204**	

Snorkeling

We calculated revenue from snorkeling in Belize using the same approach used for diving, above. The VEMS survey results suggest that 59 percent of visitors to Belize snorkel at least once. We estimated that these visitors average 1.5 snorkel trips per visit, and consulted local experts to estimate the distribution of half day, full day and long-distance trips sold. We researched snorkel operator prices and weighted them towards the more heavily visited northern destinations. We estimate that 90 percent of snorkelers rent equipment and 70 percent of shops charge extra for rentals at $5 per trip.

The VEMS estimate of snorkeling volume seemed reasonable to local experts, but because there is a high degree of uncertainty in the figure, we again used a 20 percent lower estimate of snorkelers (47 percent of all visitors) to create a range. To remain conservative, we assume GST is included in all trip prices, and subtract it from the total to arrive at an estimate of $10.1 million to $12.6 million in gross snorkeling revenue for 2007.

Table A5: Estimated Snorkel Revenue, 2007 (all figures in USD)

Snorkel trip	Distribution of snorkel trips sold	# of snorkelers (est. 59% of visitors)	# of snorkel trips (1.5 trips per snorkeler)	Avg. price of trip	Snorkel revenue (high est.)	Rental revenue (high est.)	Snorkel revenue w/ 20% fewer snorkelers	Rental revenue w/ 20% fewer snorkelers
1/2 day trip	55%	81,247	121,871	$40.00	$4,874,828		$3,903,185	
full day trip	35%	51,703	77,554	$67.00	$5,196,124		$4,160,440	
long distance	10%	14,772	22,158	$140.00	$3,102,164		$2,483,845	
Total		147,722	221,583		**$13,173,116**	**$697,987**	**$10,547,469**	**$558,865**
Total revenue minus GST					**$11,975,560**	**$634,533**	**$9,588,608**	**$508,059**

Kayaking/Canoeing

The VEMS survey suggests that 15.7 percent of visitors to Belize canoe or kayak. We again use this figure as the upper end of a range; at the lower end we estimate that 11 percent of visitors canoe or kayak (a 30 percent reduction). We conservatively estimate that the average canoeing or kayaking trip costs $7.50 (or $5 per hour, with half of visitors going out for two hours, half for one). Using these figures, we arrive at estimated gross revenues of $207,000 to $296,000 per year.

Sport Fishing

Recreational or "sport" fishing is an extremely high-value industry per visitor, and an important source of income for fishermen in Belize. Nevertheless, it is very difficult to estimate the number of participants or even the number of guides in the country based on publicly available data. Belize is home to the "Big Three" sport fishing species – Permit, Tarpon, and Bonefish. These three species are dependent upon mangrove and seagrass habitats, many of which are threatened by development along the country's coastline and outer cayes. A recent study (Fedler 2008) estimates that the wider economic impact of recreational fishing for these three species could be as high as $25 million in direct impact and $56 million in direct and indirect impact combined[10]. These estimates do not translate directly into our study, but the field research in the report is helpful for refining our estimates, particularly in terms of getting a sense of the total number of recreational fishers that come to Belize each year.

The VEMS results indicate that 16.5 percent of visitors to the country engage in fishing during their trip. Information on the total number of fishing guides in Belize is limited—local experts suggest that the list of registered guides is an underestimate—but based on an estimate of the number of guides in the country, it did not seem that the industry could support quite this volume of recreational fishermen.[11] We decided to look for additional sources, including Fedler's study, to arrive at a more conservative range. We conservatively estimate that 90% of all sport fishing in Belize is reef- or mangrove-based (experts suggested that there is a very small amount of deep sea fishing). In addition to relatively serious anglers staying at all-inclusive lodges or hiring guides for multiple days to fish for the Big Three, there are tourists who hire party boats for a day or two of casual fishing on the reef.

To arrive at a low-end estimate of recreational fishermen, we use Fedler's estimate that 7,261 anglers come to fish for the Big Three each year (roughly 1/3 of them staying at all-inclusives and 2/3 fishing with independent guides). He estimates that guests at all-inclusive lodges fish for six days on average, and fishermen using independent guides spend an average of 3.5 days fishing (Fedler 2008). We researched lodge prices and estimated an average price of $461 per night per person at a fishing lodge. Experts at BTB confirmed that it is reasonable to assume that 50% of an all-inclusive rate goes toward accommodation, so we count $230.50 per day as the price of fishing at a lodge, and subtract out the remainder to avoid double counting the accommodation portion. Prices for fishing with independent guides are estimated at $167 per person, per day, assuming an average of 1.8 anglers per boat, at $300 per boat. To estimate the number of "party boat" fishermen that visit Belize in addition to the serious anglers, we take (90%) x (9%) x (total visitors in 2007 (251,656)) and subtract the Big Three fishermen counted above. This cuts the VEMS estimate of visitors that fish almost in half, to 9 percent. We estimate an average of five people per "party boat" and an average trip price of $250, or $50 a head. All of these figures are included in Table 6 below.

The greatest amount of uncertainty in this estimate is around a) the number of fishermen who come to the country in a given year, and b) the number who participate in each type of fishing. Local experts suggested that Fedler's estimate of Big Three anglers is very conservative and we could easily assume that a higher number of serious fishermen visit Belize each year. Based on information on the number of guides and local expert opinion we use 25 percent higher visitation by Big Three anglers, as well as a slightly higher number of sport fishermen overall (12% of visitors or 75% of the VEMS results) as the high estimate of sport fishermen. As was done above, we assume the less serious fishermen engage in one day of fishing with a larger party. We do not subtract GST from the recreational fishing totals, since research suggested that the majority of fishing guides do not include tax in their

[10] Fedler looks at total spending by sport fishermen, including accommodation and other spending by anglers on days they are not fishing. We capture some of this spending (if it is reef related) in our separate accommodation and 'other spending' categories.

[11] The number of people coming to sport fish likely fluctuates with the time of year, and it is possible that the survey results were collected during the high season for some of the target species in Belize, skewing the numbers slightly high.

advertised rates; we also normalize lodge prices at "before GST". We estimate that revenues from sport fishing in Belize fall between $7.2 and $8.5 million per year.

Table A6: Revenue from recreational fishing in 2007

	Low Est.	High Est.
# Big 3 anglers / year	7,261	9,125
# Anglers using independents	4,804	5,900
Avg. # days fishing pp	3.5	3.5
Avg. price pp / day	$167	$167
Revenue from independents	$2,807,938	$3,441,667
# Anglers at all-inclusives	2,457	3,225
Avg. # days fishing pp	6	6
Avg. price pp / day	$429	$429
Revenue from all-inclusives	$7,378,371	$8,301,150
Fishing portion of all-inclusive revenue	$3,689,186	$4,150,575
# Visitors who do other reef-based fishing	13,123	18,054
Avg. # anglers / boat	5	5
Avg. # trips taken pp	1	1
Avg. price per party boat trip	$250	$250
Revenue from party boats	$769,402	$1,083,885
Total Revenue (USD)	**$7,153,280**	**$8,494,934**

Other Spending by Tourists Using Reefs and Mangroves

In addition to direct spending on reef and mangrove recreation, our methodology counts other spending by tourists on days they are using these resources as revenues that stem from the presence of healthy reefs and mangroves. To estimate "other spending", we rely upon expert opinion on the percent of total spending that the average tourist puts toward accommodation versus everything else (food, transport, entertainment). We estimate that 40 percent of tourist spending goes to accommodation, and work backwards to estimate $77.5 to $101.5 million in non-accommodation spending, including taxes.[12] We subtract out spending on reef and mangrove recreation to arrive at a range of $31.8 to $44.7 million in "other spending" by reef- and mangrove-related tourists in 2007, with an additional $3.2 to $4.5 million in GST.

Cruise Tourism

BTB conducts exit surveys of cruise passengers, and has a very good record of cruise visitor activities. We use their survey results from 2007, which cover almost all cruise visitors from that year (BTB 2007b). Using percent participation from that study, we scale up the estimates just slightly to cover the total number of cruise visitors in 2007 (see Table 7). To estimate revenues from reef- and mangrove-related cruise tourism, we researched average prices charged to cruise tourists for each of these activities. To keep things simple, we assume that most of these activities include tax in the advertised price. Using participation and price, we arrive at estimated revenues of $5.1 million from coastal and marine recreation by cruise tourists. Because there is some uncertainty around the number

[12] To avoid double counting, we subtract spending on liveaboards from this total before calculating Other Spending (most of the expenses of liveaboard tourists are likely included in trip prices).

of cruise participants and the prices over the course of a year, we varied the final revenue estimate by +/- 10 percent, producing a range of US$4.6 to $5.7 million per year.

Table A7:Revenue from reef- and mangrove-based cruise visitor recreation, 2007 (all figures in USD)

Reef- and mangrove-related activities	% of total cruise visitors participating	# of cruise visitors participating	Avg. price of activity (for cruise tourists) USD	Reef-related cruise tourism revenue	Revenue minus GST	Taxes
Snorkeling	5.8 %	36,052	$65.00	$2,343,380	$2,130,346	$213,035
Diving	2.6 %		$143.00	$2,325,973	$2,114,521	$211,452
Kayaking	0.2 %		$55.70	$55,952	$50,865	$5,078
Water-based wildlife (incl. dolphins)	1.3 %	8,083	$60.50	$489,019	$444,562	$44,456
Fishing	0.3 %	2,140	$206.11	$441,120	$401,018	$40,102
Reef & mangrove total	10.2 %	63,545		**$5,846,079**	**$5,141,312**	**$514,131**

Taxes and Service Charges

For the purposes of this analysis, we consider taxes on reef- and mangrove-based tourism to be a benefit to the economy and the country of Belize. Taxes have been deducted from gross revenue where necessary in the sectors above, but we add them back into the estimate of total economic contribution.

In estimating taxes and service charges associated with reef- and mangrove-based tourism, we only consider taxes on direct spending by tourists. To keep the analysis relatively simple and consistent between study countries, we have limited the scope to sales and departure taxes. Although there is not complete consistency within the different industries, we had to make a general assumption for each industry as to whether taxes and service charges are generally included in published rates. For the accommodation sector, we assume that taxes are not included in the advertised rate for the majority of hotels. We calculate taxes collected through Belize's nine percent hotel tax, as well as a 10 percent service charge for 15 percent of the rooms (not all hotels add a service charge, so this is a conservative estimate of the total number of rooms at hotels that do add a charge). For all other spending by tourists, including most spending on reef recreation, we conservatively assume that the 10 percent General Sales Tax *is* included in the advertised rates (sport fishing is the exception). We subtract the 10 percent tax from all of the revenues calculated for reef recreation and other tourist spending, and count those tax revenues here. We also count MPA fees as revenue that benefits the country. Finally, we count departure taxes from all overnight visitors who spend at least a portion of their time using the reef. For all of these totals, please see Table 8 below.

For cruise tourists, we count both the GST from reef recreation and $3.00 of the $7.00 per head cruise tax as benefits to the economy (we do not count the $4.00 that go to the cruise line-owned tourist village (CESD 2006:30)).

Table A8: Taxes on Coastal & Marine Tourism (all figures in USD)

	Low Estimate	High Estimate
Accommodation (hotel tax)	$4,268,790	$5,575,877
Accommodation (service charges)	$700,164	$918,012
Reef Recreation	$3,730,115	$4,623,833
MPA fees	$1,244,514	$1,244,514
Other tourist Spending	$3,180,604	$4,467,185
Cruise Reef Recreation	$462,718	$565,544
Portion of the Cruise Head Tax	$171,572	$209,699
Departure Tax	$5,826,466	$5,826,466
TOTAL	**$19,584,943**	**$23,431,130**

Total Direct Impact

The direct economic impact of reef- and mangrove-related tourism and recreation is estimated at US$149.8 - $195.7 million per year (See Table 9, below).

Table A9: Reef- and Mangrove-Based Tourism and Recreation: Direct Economic Impact (USD)

Reef- and mangrove-associated accommodation	$ 56.3 - 75.4 million
Reef- and mangrove-associated recreation	$ 37.5 - 46.5 million
Other spending by reef- and mangrove-associated tourists	$ 31.8 - 44.7 million
Spending by reef- and mangrove-associated cruise tourists	$ 4.6 - 5.7 million
Taxes and service charges	$ 19.6 - 23.4 million
Total Direct Impact (revenues + taxes and service charges)*	**$149.8 - 195.7 million**

*Totals may not sum correctly due to rounding

Indirect Impacts

In addition to direct benefits in the tourism sector, there are benefits to the wider economy from spending by reef- and mangrove-associated visitors. For example, food purchased by visitors may be sourced from local farmers; fuel used for transportation is purchased from local fuel distributors, etc. The most common way to estimate the magnitude of these indirect or secondary impacts to use a multiplier. A multiplier of 1.6, for example, represents 60 cents of additional impact for every $1 in direct tourist expenditure. The size of the multiplier is influenced by the portion of goods and services required by tourism operators that is produced domestically, such as linen, beverages, food, dive equipment, construction materials, etc.

We were not able to find either a general economy or sector-specific multipliers published for Belize, and instead relied upon rough multipliers used in the recent literature.[13] Because of the large amount of uncertainty in creating and applying multipliers as well as the lack of a reliable multiplier for Belize, we chose to go with a very conservative multiplier, and may underestimate indirect impacts considerably. We applied a multiplier of 1.2 to 1.4 to total reef- and mangrove-related tourist expenditure in Belize to arrive at a range of US$26.1 to $68.9 million per year in indirect economic impacts.

Table A10: Total Economic Impact of Reef- and Mangrove- Related Tourism (USD)

Total Direct Impact	$149.8 - 195.7 million
Total Indirect Impact	$26.1 – 68.9 million
Total Impact (Dir. & Indirect)	$175.9 – 264.6 million

[13] Fedler 2008 uses a tourism multiplier of 1.22; 1.8 was cited by local experts as a general economy multiplier that has been used in the past, but we were not able to find documented evidence.

Appendix 1B: Technical Notes and Data Sources - Commercial Fisheries

Belize's commercial fisheries sector is dominated by small-scale artisanal fishers, and is entirely dependent upon reef- and mangrove-related species. The fisheries department does not systematically collect catch or landings data for the country at this time. The best available catch information comes from the Fishermen's Cooperatives. The Co-ops provide data to the Fisheries Department on total catch, total exports, and total export revenue by major fish type. Using this information as a starting point, we divided the fisheries sector into three categories – (1) exports through cooperatives, (2) local sales through cooperatives, and (3) all other local sales (further divisible into local market sales and direct sales to hotels and restaurants). Export sales are the biggest source of revenue for the fisheries industry. We expect that the Co-op data on exports and local sales are relatively good, but have little to no information on local sales outside of the cooperatives.

Co-op Sales Revenues

Using data provided by the fisheries department, we divided Co-op sales into exports and domestic sales. Export revenues were reported at $11.2 million for 2007. Using a rough estimate of average local sale price per pound (broken down by lobster, conch, finfish) we estimated total revenues from domestic Co-op sales at $1 million. Total Co-op sales (local and export) for 2007 are estimated at $12.2 million (see Table 1). This total includes the value added from any processing done at the cooperative plants. It was difficult to accurately separate out production and processing revenues in Belize, so the two are presented together as total revenue.

Table B1: Domestic and Export sales by Cooperatives, 2007 (USD)

Fish type	Total Co-op Production (lbs)[a]	Catch exported (lbs)[a]	% of Co-op catch exported	Export sales[a]	Catch sold locally (lbs)[a]	Local sale price/lb[b]	Local sales	Total Co-op revenues
Lobster tails	462,152	440,080	95.2%	$8,531,400	22,072	$8.75	$193,130	$8,724,530
Lobster meat	41,294	23,450	56.8%	$84,600	17,844	$3.75	$66,915	$151,515
Conch	480,154	429,650	89.5%	$2,259,750	50,504	$5.00	$252,520	$2,512,270
Conch fillet	83,468	54,300	65.1%	$325,800	29,168	$5.00	$145,840	$471,640
Shrimp	26,351	750	2.8%	$3,000	25,601	$3.75	$96,004	$99,004
Salted fish	13,500	13,500	100.0%	$8,438	0		$0	$8,438
Crab claws	2,360	2,360	100.0%	$21,505	0		$0	$21,505
Whole fish	9,534		0.0%	$0	9,534	$1.50	$14,301	$14,301
Fish fillet	59,587	2,000	3.4%	$10,000	57,587	$4.00	$230,348	$240,348
Total	1,178,400	966,090	82.0%	**$11,244,493**	212,310		**$999,058**	**$12,243,550**

a: Source: Belize Fisheries Department, 2008.
b: source: WRI / WWF primary research

Local Sales Revenues

The Fisheries Department has begun to collect data at local markets and may look at restaurant and hotel sales in the future—these data will be critical for getting an accurate picture of total catch in Belize. In the meantime, we have looked to several different sources to come up with a plausible estimate for local sales. Using several different surveys of fishermen as well as expert opinion, we estimate that, averaged across the country, fishermen sell 15% of lobster, 5% of conch, and 95% of the finfish they catch to buyers outside of cooperatives (i.e. to local markets, restaurants, etc.). Using these percentages, we worked backwards from total Co-op production to estimate local sales (see Table 2). We used an average local sale price (see Table 1 above) to estimate total revenue from these sales, but did not have enough information to break down revenue estimates by destination (markets, restaurants, etc.). Local experts suggested that the price of fish varies over the course of the year, but does not vary widely between these different sale destinations. Hence, we felt reasonably comfortable estimating local sales at this aggregated level. Finally, we value fish given to family and friends using the local market price, since these can be considered an in-kind substitute for a local purchase.

Table B2: Local Fish Sales, 2007

	Total Co-op production (lbs)	Co-op production as % total catch	local market, restaurant, and personal sales (lbs)	local market, restaurant, and personal sales revenues (USD)
Total Lobster*	503,446	85%	88,843	$599,693
Total Conch	563,622	95%	29,664	$ 148,322
Total Finfish	69,121	5%	1,313,299	$ 1,969,949
Subtotal	1,136,189		1,431,807	**$ 2,717,963**

*We did not have information on the breakdown of local tail / head meat sales for lobster; we assume 40% head meat and 60% tail meat sold, which we hope to be a conservative breakdown (tails are more expensive). Much more tail meat is exported.

Total local sales for 2007 are estimated at $2.7 million. Given the many uncertainties in this calculation, this should be considered a very rough estimate. Varying estimated local catch by + / - 30 percent, we arrive at a range of $1.9 to $3.5 million in local (non Co-op) sales. Total fisheries revenue for 2007 is estimated at US$14.1 to $15.8 million.

Fish cleaning

Fish cleaning plays a very small role in the fisheries industry, as most local fish is sold unprocessed, or is processed by the fishermen for a minimal fee. Industrial processing for export is captured in the export figures, above. We surveyed fish cleaners at four of the major landing sites in Belize to get an idea of the number of people who work at the sites cleaning fish and their average earnings. There are eleven landing sites across Belize, with an average of three cleaners per site. Work days range from 3 – 10 hours per day, and cleaners earn an average of BZ$4.17 per hour. We used this information to estimate that local fish cleaning brings in about BZ$200,000 or US$100,000 per year. This estimate is sensitive to assumptions about time spent by cleaners and prices charged, which may vary over the course of the year. We varied the estimate by +/- 20 percent to arrive at a range of US$80,000 to $120,000 in revenues from local fish cleaning per year.

Total Direct Impact

We estimate total annual revenues from the fisheries industry (production and processing) at between US$14.2 and $15.8 million. Of this total, $11.2 million comes from exports, and the remainder from in-country sales through Co-ops, local markets, restaurants, etc.

Indirect Impact

Indirect impacts for the fisheries sector are calculated by applying a multiplier range of 1.2 to 1.4 to gross revenues from commercial fishing and cleaning (for a full discussion of multipliers and indirect impacts, see the section under Tourism, above). We estimate a range of $2.8 to $6.3 million in indirect economic impacts from reef and mangrove associated fisheries in 2007.

The total economic impact (direct and indirect) of reef- and mangrove-associated fisheries is estimated at US$17.0 to $22.2 million for 2007.

Appendix 1C: Technical Notes and Data Sources - Shoreline Protection

1) Vulnerable Lands.

a. Storm Surge and Wave Heights: Modeled storm data for the 25 year storm event came from: Organization of American States (OAS). 2002. *Atlas of Probable Storm Effects in the Caribbean Sea.* (Online at: http://www.oas.org/CDMP/document/reglstrm/index.htm.)

Location	Modeled Wave Height (m)	Modeled Strom Surge (m)	Combined total (m)
San Pedro	4.2	0.6	4.8
Belize City	4.1	1.0	5.1
Dangriga	4.0	1.1	5.1
Punta Gorda	3.1	1.3	4.4

Based on these storm surge and wave height estimates, we elected to use a 5 m elevation as the threshold for defining vulnerable land (within 1 km of the coast).

b. Coastline. The coastline was derived from a data set provided by SERVIR reflecting the Exclusive Economic Zone (EEZ) for Belize.

c. Elevation. Elevation is based on NASA's Shuttle Radar Topography Mission (SRTM) 90m DEM, which includes errors from roofs and tree tops. To address these errors, the DEM was corrected to be less than 5 m in areas where mangroves are identified as present or where the error appears to be caused by tops of buildings in urbanized areas.

2) Protection by Reefs and Mangroves

a. Coral Reefs. The Coral Reef map is from the Belize Coastal Data CD (WRI, 2005) and is based on data from the Belize Tropical Forest Studies (BTFS) Ecosystem Map (2004), and data from the Wildlife Conservation Society (WCS) and the Belize Coastal Zone Management Authority and Institute (CZMAI).

b. Mangroves. Data on mangroves from three sources were used in this analysis:

- **a)** Unpublished data from the Belize Forestry Department (FD) (2008), which updates their 1992 map of mangroves; (this data set did not include Turneffe Atoll).
- **b)** Emil Cherrington (SERVIR) developed a map of change in mangrove extent using LANDSAT imagery and the 1990 mangrove map by Zeisman as a base;
- **c)** Lola Fatoyinbo (WRI) mapping of mangroves from 2000 / 2002 LANDSAT imagery.

The data from the Forestry Department was used as the base, with areas of disagreement between the FD and Cherrington data resolved using the WRI data set. Data from WRI were also used to fill in mangrove data for Turneffe.

There were slight registration issues between the mangrove and shoreline data sets (so mangroves do not reach the coast in many areas). To compensate for this issue, a 50 m distance threshold was used to identify shoreline (the line) protected by mangroves. (In Turneffe, this distance was reduced to 20 m, as the WRI data were well registered to the coast).

3) Relative Shoreline Stability (7 of 9 factors were implemented). The relative stability (resistance to erosion) of each shoreline segment is evaluated based on the integration of up to nine physical factors. For Belize, data were available for seven of the nine factors which influence the relative stability of the shoreline: coastal geomorphology, geology, coastal protection by structures (atolls or sea walls), the coral reef index (reef proximity, type and continuity), hurricane frequency, coastal elevation, and coastal vegetation. Data were not available for wave energy or presence of damaging activities, such as sand mining Each individual factor can range in value from 0 to 4 (with 4 being the highest stability). The nine factors and their associated values are provided in Table 13.

Factor 1 – Coastal Geology classes are based on the Geology of Belize from Selva Maya –

- **a)** 1 - Alluvial geology was assigned as Class 1 - Unconsolidated sediments;
- **b)** 2 - Limestone and sedimentary geology was assigned Class 2 - Sedimentary.

Factor 2 – Coastal Geomorphology – This factor is a combination of geomorphology classes from Selva Maya, combined with the Mangrove dataset described above. Areas mapped as mangrove take precedence.

- **a)** 1 - If alluvial and not mangrove, it is classed as a beach
- **b)** 2 – Current mangroves
- **c)** 3 - if limestone or sedimentary and not mangrove, it is classed as limestone bluff
- **d)** 4 – Areas where there is **sea wall (Belize City only).**

Factor 3 – Coastal Protection by Atolls – We developed a proxy indicator of fetch as input to classify the coast as to level of protection by land, islands, atolls, and other emergent reef.

- **a)** Fetch was derived at 300 m. resolution for 3 directions – due West, NW and SW. This was done both for land alone and land and emergent reef;
- **b)** These two layers were combined with a weighting of 2X for land and 1 X for land and emergent reef (as land offers more protection).
- **c)** The results were split into five rough quintiles, of up to 350, 700, 1050, 1500, and over 1500 cells), which were assigned to the 5 factor categories). (See Figure 1 below – the reef blocks some energy, but land is a greater barrier). Results for atolls in Belize are similar to the map of wave exposure from Burke, 1982 (Figure 2).

Figure 1: Modeled Fetch (WRI 2008)

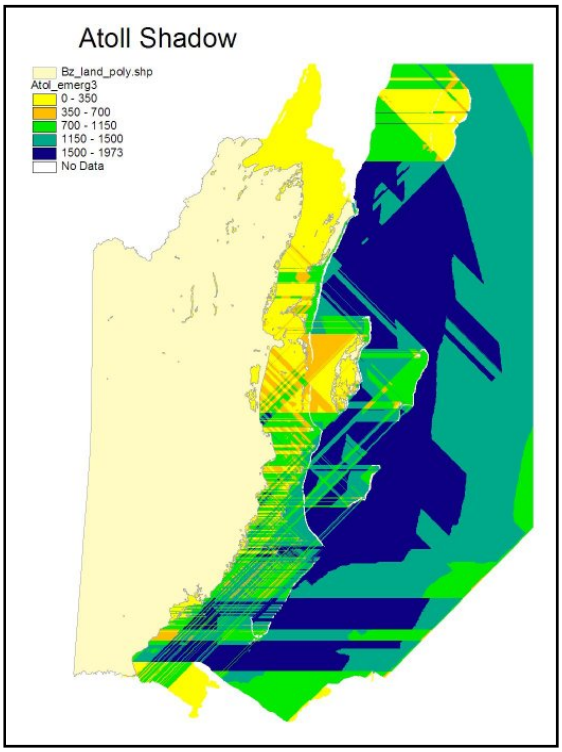
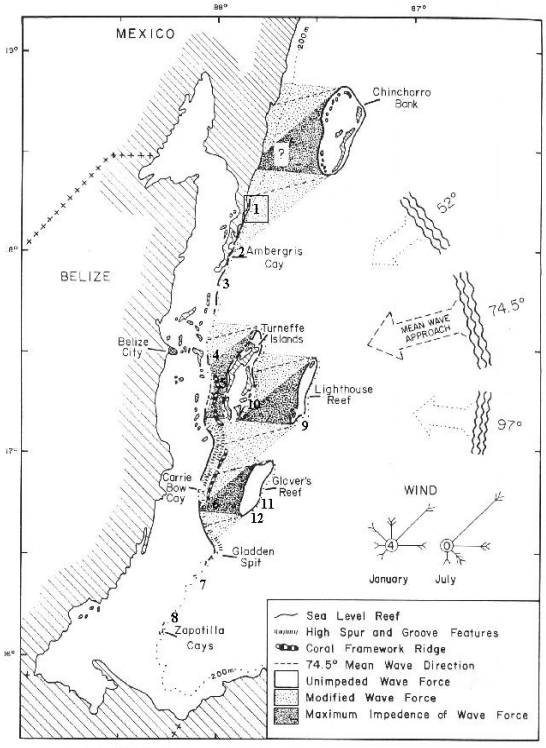


Figure 2: **Map of Belize showing wave e**xposure regimes (modified from Burke 1982)



Factor 4- Coral Reef Index. The reef index was modified for Belize at a workshop held at CZMAI in March 2008. Using that revised methodology, shoreline segments which are "protected by coral reef" were classified as to the closest reef's distance offshore, reef type and the continuity of reef protecting that segment of coast:

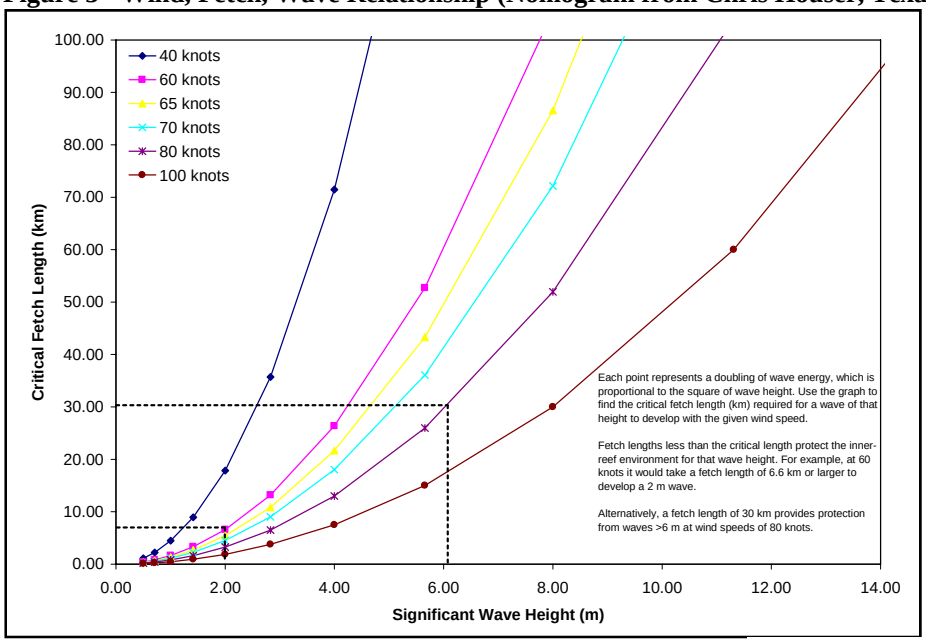
1. **Reefs were classified by type –**
   - Emergent Barrier Reef (4)

- Emergent Reef on Windward side of Atoll (4)
- Fringing Reef or reef on Leeward side of Atoll (3)
- Patch Reef (2)

2. **Reefs were classified by Continuity –**
   - Continuous (2)
   - Discontinuous (1)
3. **Distance offshore** (thresholds selected based on Nomogram below).
   - within 250m (4.0)
   - 250 – 500m (3.5)
   - 500 – 1000m (3.0)
   - 1 – 2 km (2.5)
   - 2-4 km (2.0) 4-8 km (1.5)
   - 8-16 km (1.0) and
   - Over 16 km offshore (0.5)

The Reef Index was calculated by taking the Sum of three individual factors / maximum-possible (10) * 4 (for scaling). The reef index ranges from 1.4 to 4.0.

Figure 3 - Wind, Fetch, Wave Relationship (Nomogram from Chris Houser, Texas A&M)



Factor 5 - Storm Factor – Historic storm tracks come from StormCARIB (http://stormcarib.com/) were used to look at frequency of different categories of hurricane event. A storm intensity surface was developed. Belize was split into two categories –

a. The north of Belize (Belize City Latitude and North) was assigned a 2 – affected by at least a category 3 every 25 years;
b. The middle and south of Belize were assigned a 3 – affected by at least a category 2 every 25 years.

Factor 6 – Coastal Elevation - This factor is derived from the 90m SRTM DEM from NASA. As described previously, there are errors in this DEM associated with treetops and buildings. I used the same corrections (for mangroves and for cities) as was used in developing the Vulnerability layer. If an area showed as > 5 m in the DEM in a mangrove or urban area, it was reclassed to 2 – (2 to 5 m).

The shoreline was classified as follows.

Class	Description	Sq Km	
1	0 - 1 m	699	39%
2	2 - 5 m	1,041	58%
3	6 - 12 m	46	3%
4	over 12 m	17	1%

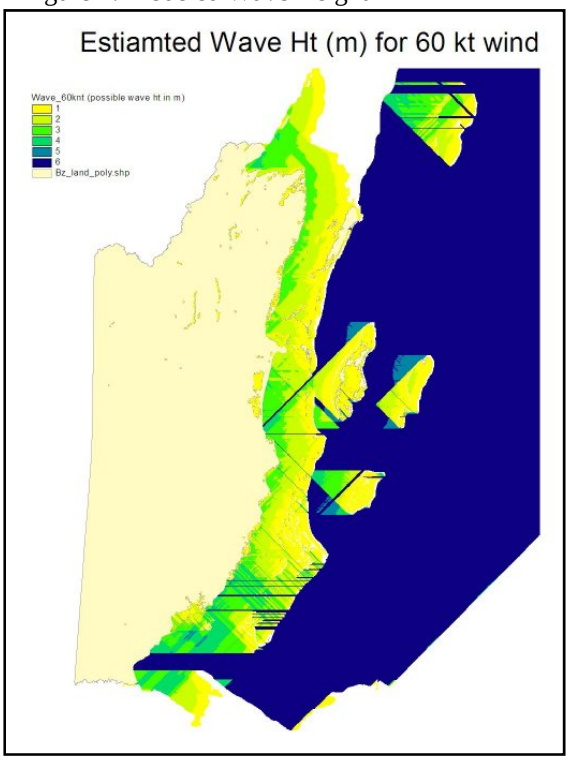
Factor 7 – Coastal Vegetation – was based on Belize Ecosystems 2004 (BTFS), updated with more recent mangrove maps (described above). Areas which are no longer mangrove were reclassed as 1.9 (the average value for non-mangrove areas in the shoreline).

Two factors were not included in the Shoreline Stability Analysis –

- A mapping of anthropogenic activities (such as sand mining) was not available;
- Wave energy –was not available.
  - We had hoped to use modeled wave heights from Belize Hydromet, but these are not available.
  - Will Heyman of Texas A&M University has measurements inside and outside the reef for one location, which shows significant reduction in wave energy inside the reef.

We conducted an exploratory analysis to produce an estimate of maximum possible wave height for a 60 knot wind, based on the nanogram provided by Chris Houser. Figure 4 demonstrates this analysis for Belize . We incorporate land and emergent reefs as barriers, then calculate fetch behind these features. Using the nanogram, fetch can be translated into maximum wave height for a given wind speed an duration (see Figure 3). Using this technique, we estimate that a 60 knot wind can generate waves reaching about 3 m inside the reef. This wave height estimate was not included in the analysis.

Figure 4: Modeled Wave Height



5) Property Values

The values below reflect average values for land and built structures (when present) from 2007-08 gathered through internet searches.

Table C1 – Average Property Values by Locale

PLACE_NAME	Coastal properties (US$ per sq ft)	Inland properties (US$ per sq ft)
Ambergris Caye	$14	$7
Belize City	$15	$7
Caye Caulker	$16	$8
Corozal	$2	$1
Dangriga / Hopkins	$9	$4
Other Developed Coast	$4	$2
Other Cayes	$3	$2
P.G.	$4	$2
Placencia	$15	$7
San Pedro	$22	$12

Table C2 - Coastal Protection Factors
Source: Institute of Marine Affairs (IMA) and WRI, adapted for Belize

Factor	***Level Of Coastal Protection***				
	Very High 4	**High 3**	**Medium 2**	**Low 1**	**None 0**
Coastal Geomorphology	Rocky, Cliffed Coastline Or Sea Wall	Soft (Limestone) Cliffs or Low Bluffs	Mangroves	Beaches	N/A
Coastal Geology	Igneous and/or Volcanic	Metamorphic	Sedimentary	Unconsolidated Sediments	N/A
Coastal Protection Structures	Significantly protected by a large atoll or 2 prominent headlands	Protected by atoll, or by headlands	Slightly protected by atoll	Protected by one or two small headlands	No protection by atoll or headlands
Coral Reef Index *(sum of 3 factors / 10 *4)*					
Reef Type	Emergent Reef (barrier or windward side of atoll)	Fringing and Leeward side of atoll	Patch	--	No reef present
Reef Distribution	---	---	Continuous	Discontinuous	No reef present
Reef Distance Offshore (m)	< 250 m / 250 – 500m	.5 – 1 km / 1 - 2 km	2 – 4 km / 4 – 8 km	8 – 16 km / > 16 km	No reef present
Wave Energy (~ Max. Wave Height)	< 25 cm	25 – 50 cm	50 – 100 cm	1 – 2 m	> 2 m
Storm/Hurricane Events	Affected by at least a category 1 every 25 years	Affected by at least a category 2 every 25 years	Affected by at least a category 3 every 25 years	2 or more category 3 or higher expected every 25 years	N/A
Coastal Elevation (m)	> 12	6 – 12	2 - 5	0 - 1	< 0 (N/A) **
Coastal Vegetation *)* **Type**	Mangroves	Forest / Coastal Woodlands	Shrub and Thicket	Savannah and Wetlands	None
Coastal Anthropogenic Activities	No sand mining, coastal development, etc.	Misc. Other Activities	Either sand mining or coastal development	Sand mining and coastal development	N/A

Appendix 2: Technical Notes and Data Sources for Economic Valuation of Glover's Reef

A. Tourism and Recreation

The value of reef-related tourism in GRMR is assessed using a similar method to the one applied at the national level. This approach involves calculating gross revenues and taxes from tourism associated with the reserve, including reef recreation, coralline beach use, and spending on accommodation, food, and other things on days that a tourist has visited the reserve. For most Marine Protected Areas (MPAs) in Belize, we can assume that all tourists visiting a reserve are utilizing coral reefs or mangroves during their visit, either snorkeling, diving, or fishing, or by sitting on a coralline beach. In the case of Glover's Reef, visitors stay on a coral atoll, and all tourism can safely be counted as "reef-associated.". In addition, Glovers attracts a high percentage of tourists who are avid divers and likely to be interested in and respond to the condition of the reef.

Accommodation

To calculate accommodation revenues associated with the MPA, we need both an estimate of the number of visitors to the reserve each year, and a rough breakdown of where they spend the night on the days that they visit. In Hol Chan, for example, rangers estimate that 77 percent of visitors to the reserve come with tour operators from San Pedro, and 22 percent from Caye Caulker. Glover's Reef has five active resorts within the reserve, and gets day trip visitors from Hopkins and Dangriga on the mainland.[14] In addition, at least 40 chartered yachts visit the reserve each year, bringing divers who come specifically to dive its protected coral reefs (Reserve Manager's estimate).

It should be possible to get a breakdown of day-trip and week-long visitors to the reserve, since the fee level is different for these two groups. However, this information was not available for 2006 or 2007 at the time of this report. We use the rough occupancy rate estimates from the Glover's Reef Marine Reserve Management Plan (Wildtracks / Wildlife Conservation Society 2007:57) to estimate that approximately 3,200 visitors stay at resorts inside the reserve each year, spending an average of 6.5 night.[15] Many of the hotels inside the reserve sell their rooms as part of all-inclusive packages that include diving, snorkeling, and other reef-related activities. No separate estimate of reef recreation levels inside the reserve is available, so we use average per-person package rates to estimate revenues for the all-inclusive hotels, and attempt to estimate all remaining reef recreation activities separately (see below). Including these all-inclusive packages, we estimate that the accommodation sector inside Glover's Reef Marine Reserve earns approximately US$2.9 to $4.3 million per year.[16] Using estimates from the WCS Socioeconomic Monitoring Surveys in 2005 and 2006 (discussed in Reef Recreation, below), we estimate that an additional 3,500 – 5,300 day-trip visitors come to the reserve each year from Hopkins and Dangriga. We count one night of accommodation revenue for each day-trip visitor to the reserve; using 2007 room rates for these areas, we estimate that day-trip visitors spend an estimated US$233,000 - $349,000 on accommodation for days associated with the reserve.[17]

No formal tally is kept of the number of yachts that visit the reserve each year. To account for some of this uncertainty, we vary the reserve manager's estimate of 40 yachts by + / - 20 percent. We estimate that each boat spends an average of 1.5 days in the reserve. Using the average price per day of chartering a yacht in the area ($853), we estimate total MPA-associated revenues from yachts at between US$41,000 and US$61,000 per year.

[14] Placencia can probably be added to this list for 2008- onward, but this analysis looks only at tourism activities in 2007.

[15] According to the management plan, there are 120 beds in the five hotels inside the reserve (Wildtracks / WCS 2007:65). The average occupancy rate is estimated to be 50% for four of the properties; we estimate a more conservative 35% for Glover's Reef Atoll Resort. The occupancy rate for all rooms in the reserve comes to approximately 44% overall, which is consistent with the Belize Tourism Board's published occupancy rate statistics for small offshore islands in Belize (44.6 percent in 2007).

[16] We calculate revenues for Glovers Reef Atoll Resort separately from the other resorts, rather than doing a straight average, since the resort's room and occupancy rates were outliers for hotels inside the reserve (and were not all-inclusive).

[17] We used nightly rates (*not all-inclusive package rates)* for all mainland hotels, including the bigger resorts, and calculated day-trip reef recreation separately, because some information on these activities was available.

Reef Recreation

Very little information is available on the amount of reef recreation that occurs on Glover's Reef. We were able to produce a very rough estimate of participation in reef-related activities, including diving, snorkeling, sport fishing, and kayaking by day trip visitors using the results of interviews with tour operators in Gibson et al. 2005 and 2006. The surveys asked tour guides in these areas the number of trips they make to the reserve in a year, and the average number of tourists per boat. The responses provide a rough picture of reef recreation in the MPA, but the answers are subjective, and the studies were not designed to be comprehensive. It is unclear to what extent visitors from resorts such as Jaguar Reef and Hamanasi are covered in the study, for example. To take some of this uncertainty into account, we vary the reef recreation volume estimates by +/- 20 percent to arrive at a range of 3,546 to 5,319 day-trip visitors to Glover's Reef in 2007. According to the surveys, 56 percent of day-trip visitors are divers, 38 percent are snorkelers, and the remaining five to six percent are sport fishermen.

Estimating the number of dive and snorkel trips sold **inside** the reserve is complicated by the fact that many of the hotels on the atoll offer dive packages. The average room rates used in the accommodation estimates, above, take these package rates into account. As a result, revenues from most reef recreation activities inside the reserve are counted as accommodation revenue.[18] Information on the actual number of dive and snorkel trips taken at these resorts was not available. We worked with local experts to estimate the remainder of reef recreation inside the reserve (i.e. dives, snorkel trips, and kayak trips taken by guests at the non-all-inclusive hotels, such as Glover's Reef Atoll Resort). We conservatively estimate that between 1,400 and 2,148 dive trips, 600 – 900 snorkel trips, and 550 – 820 kayak rentals are sold outside of packages to guests inside the reserve each year[19]. After subtracting out taxes, total revenues from day-trip and MPA overnight guest reef recreation are estimated at approximately US$390,000 - $587,000 per year. As mentioned above, this *excludes* all reef recreation sold through all-inclusive packages. For further detail, see Table 1, below. These estimates are extremely rough, and should be considered 'placeholders' until better reef-use data are available in future.

Table 1: Reef Recreation in Glover's Reef Atoll

Reef Recreation Activity	Revenues (USD)
Diving	
Day Trips	$233,998 - $350,997
MPA overnight guests (**excluding** all-inclusive packages)	$68,736 - $103,104
Equipment rental	$16,921 – $25,382
Snorkeling	
Day Trips	$63,451 - $95,162
MPA overnight guests (**excluding** all-inclusive packages)	$12,336 - $18,504
Sport Fishing	
Day Trips	$32,054 - $48,082
MPA overnight guests (**excluding** all-inclusive packages)	unknown
Kayaking (MPA overnight guests only)	$2,739 - $4,109
TOTAL Reef Recreation Revenue associated with the MPA	$430,235 - $645,339
TOTAL Reef Recreation Revenue minus taxes	$391,123 - $586,671

Other Spending

[18]Note: This is a departure from our approach at the national level, where BTB reports *accommodation only* room rates for all hotels (all reef recreation activities are counted separately). If this valuation is repeated in future, especially with improved data, it may be worth separating out the "activity" portion of the package rates and moving these revenue estimates into the recreation section, providing a more accurate picture of the accommodation / recreation breakdown for the reserve.

[19] This estimate of "dives sold" takes into account the fact that most guests dive or snorkel more than once during their one week stay.

In addition to accommodation expenses from days that tourists visit the MPA, we also estimate other tourist expenditures (on food, transportation, etc.) for days associated with the reserve. Because most of the resorts inside GRMR are all-inclusives, we only estimate "other spending" for the day-trip visitors. We did not have specific information on tourist spending in Dangriga and Hopkins, so we use the assumption from the national valuation that 40 percent of tourist spending, on average, goes toward accommodation. After subtracting reef recreation from the remaining 60 percent of total spending, we estimate that MPA-associated tourists spend approximately US$37,000 - $56,000 per year on other expenses.

Taxes and Fees

For this study, we estimate tax revenues generated through the hotel tax and the general sales tax (GST) only. We also include MPA fees in this section. Future assessments may wish to expand this to include other taxes and fees. Accommodation associated with Glovers Reef brought in US$280,000 - $420,000 in tax revenues in 2007. We assume that most hotels add the nine percent hotel tax on top of their advertised room rate. Reef recreation associated with the reserve brought an additional US$39,000 - $59,000 in GST. Other spending by day-trip tourists contributed $3,700 - $5,600 more in tax revenue. We assume that most business and tour operators do include sales tax in their advertised rates, and subtract GST from gross revenues before counting it here. GRMR collected US$21,630 in MPA fees in 2006. We would prefer to include 2007 numbers, but they remain unreleased as of the writing of this report.

Total taxes and fees associated with the MPA are estimated at roughly US$345,000 - $507,000 per year.

Tourism & Recreation Total

The total direct economic contribution of reef and mangrove-associated tourism in the Glover's Reef Marine Reserve is estimated at US$3.9 - $5.9 million per year. As was the case in the national level valuation (p. 12), we can also produce a rough estimate of the *indirect* economic impact of tourism and recreation in GRMR (i.e. the benefits to domestic industries that support the coastal tourism in Belize). We use a multiplier range of 1.2 – 1.4 to estimate that Glover's Reef contributes an additional US$0.7 to $2.2 million in indirect economic impacts to Belize.

Table 2: Tourism and Recreation Revenues Associated with Glover's Reef Marine Reserve

MPA-associated accommodation	US$3.2 - $4.7 million
MPA-associated recreation	US$0.4 - $0.6 million
Other spending on MPA-associated days	US$.04 - $.06 million
Taxes and Fees	US$0.3 - $0.5 million
Total Direct Impact	**US$3.9 - $5.9 million**
Total Indirect Impact	**US$0.7 - $2.2 million**

Data Limitations

Reef recreation numbers could be improved through a number of different record-keeping measures. Ideally, rangers should be in place to monitor use of the reserve, including the number of divers and snorkelers brought into the MPA each day. In such a large reserve, this does not appear to be realistic at current staffing levels. Requiring better reporting from tour operators and hotels outside the reserve, and improving coordination between MPA managers and resorts inside the reserve could lead to better record-keeping; having rangers visit the resorts once a week to collect tickets and estimates of diver and snorkeler numbers, for example, could improve both reef recreation estimates and collection of visitor fees.

If the day-trip and overnight visitation estimates are even roughly accurate, reported visitation (and thus collection of fees) vastly undercounts actual use of the GRMR. Park visitation for 2007 had still not been reported by end of

2008, but 2006 numbers show only 4,281 visitors to the reserve. This study estimates total overnight and day-trip visitation to be between 6,300 and 8,000 people – or between 50% and 100% over recorded visitation (likely somewhere in between these two extremes).

B. Fisheries

Glovers Reef Atoll is an important site for commercial fishing in Belize, with fishermen from Sarteneja, Dangriga, and Hopkins regularly utilizing the general use zone of the reserve to catch lobster, conch, and finfish. Although comprehensive landing data for Glover's Reef Atoll is not collected by the government, the Wildlife Conservation Society (WCS) conducts a fisheries monitoring program (the Fisheries Catch Data Collection Program) to determine trends in catch and fishing pressure inside the MPA. The WCS program collected data from 230 fishermen between 2004 and 2007. With the help of Dr. Robin Coleman of WCS, we used catch per unit effort data from these surveys to estimate average annual catch of lobster, conch, and finfish inside the reserve.

A total of 41 boats with approximately 200 crew members visited the reserve in 2007. The number of visits per boat ranged from one to fifteen, with fishermen from Dangriga and Hopkins typically staying for 1-2 days, and sailboats from Sarteneja fishing for a week at a time. In total, fishermen logged an estimated 47,000 hours fishing inside the reserve in 2007 (WCS 2008).

WCS estimates that landings from Glover's Reef (by weight) break down into roughly 20 percent lobster, 75 percent conch, and 5 percent finfish (Coleman 2008). We use the estimate of total fishing hours (above) and catch per unit effort by fish type (Table 3) to calculate lobster, conch, and finfish catch associated with the reserve in 2007 (see Table 3).

Table 3: Catch per Unit Effort and Estimated Total Catch for Glover's Reef by Fish Type [a]

Fish / Shellfish	CPUE 2007 (lbs per hr)	Percent of Total Effort	Glover's Catch (lbs / yr)	% of total catch
lobster	1.60	43%	32,178	20%
conch	4.90	52%	119,307	75%
finfish	3.38	5%	7,920	5%
Total		100%	159,406	100%

[a] Source: Modified by WRI from data provided by WCS 2008

To calculate total revenues, we need to know the proportion of total catch that is sold outside of the Cooperatives at local prices, and the proportion that is sold to the Cooperatives to be processed and exported overseas. We consulted local experts to estimate that 85% of lobster, 95% of conch, and 5% of finfish caught in the reserve are sold to the Cooperatives, with the remainder sold to restaurants, hotels, and markets in the local area. Using national average fish prices for 2007, we estimate that commercial fisheries in Glover's Reef Atoll earned approximately US$1.2 million in 2007 (see Table 4). We vary the catch estimates by + / - 20 percent to estimate a range of US$1.0 to $1.5 million in fisheries revenues per year.

Table 4: Total Revenues from Commercial Fisheries on Glovers Reef, 2007

Fish / Shellfish	% sold to co-ops	avg. co-op sale price/lb US$	% sold locally	avg. local sale price/lb US$	total revenue US$
lobster	85%	$ 19.39	15%	$ 8.75	**$ 572,441**
conch	95%	$ 5.26	5%	$ 5.00	**$ 626,005**
finfish	5%	$ 2.50	95%	$ 3.00	**$ 23,563**
Total					**$ 1,222,009**

C. Summary

The total economic contribution of tourism and fisheries associated with Glover's Reef Atoll is estimated at US$4.9 to $7.3 million per year.

Table 5: Tourism and Fishing Revenues Associated with Glover's Reef Marine Reserve

	Total Revenues (USD)
MPA-associated accommodation	$3,158,243 – 4,737,344
MPA-associated recreation (outside of all-inclusives)	$291,123 - $586,671
Other spending on MPA-associated days	$37,287 - $55,914
Taxes and Fees (including MPA fees)	$345,028 - $506,722
Total Tourism Value	**$3,931,680 - $5,886,652**
Lobster revenue	$457,951 - $686,926
Conch revenue	$500,803 - $751,205
Finfish revenue	$18,850 - $28,276
Total Fisheries Value	**$977,604 - $1,466,407**
Total Tourism and Fisheries Value, Glover's Reef	**$4,909,285 - $7,353,058**

WORLD RESOURCES INSTITUTE

WWF

World Resources Institute and World Wildlife Fund. 2008. Financial Overview of MPAs in Belize*

MPA	Management			Total Area (ha)		Visitation (#/yr)					Fee Level ($BZ/day)		
	Paper Park	Manage-ment Type	NGO managers or co-managers	Land	Water	Domestic (2006)	Foreign (2006)	Domestic (2007)	Foreign (2007)	Is there undercounting of visitors?	Domestic	Foreign	Other
Fisheries MPAs													
Caye Bokel		Co	UB	0	558								
Dog Flea		Co	UB	0	576								
Gladden Split & Silk Cayes		Co	Friends of Nature	??	10,453	292	4,340	2,836	4,455	No	$0	$20	25 (special permit); 30 for whaleshark
Glover's Reef		Gov.	(WCS)	42	35,025		4,281			yes	$20	$20	$500-1,000 for research; 30/wk; 10/day
Hol Chan		Unique	Hol Chan Trust Fund	92	1,453	3,954	42,771	4,147	52,471	Yes between 5-8%	$0	$20	
Port Honduras		Co	TIDE	673	39,796	490	545	324	431	yes - by 10%	$0	$10	
Sapodilla Cayes		Co	TASTE	28	15,591	-	2,226	-	1,654	Yes by 30%	$0	$20	8.00 camping fee
South Water Caye		Gov.	(??)	130	47,573				5,663	Yes	$0	$10	$10.00 for kayaking
Joint Fisheries \ Forestry MPAs													
Bacalar Chico		Gov.	(GreenReef)	5,185	6,303	-	952	-	1,166	Yes 25% - 50%		$10	30.00/wk for camping
Caye Caulker		Co	FAMRACC	63	3,911	988	16,211	1,224	18,387	probably some	$0	$10	

Source: WRI and WWF 2008.

*Table was completed by MPA Managers using the best available information. WRI has left the figures as they were reported to us.

MPA	Management			Total Area (ha)		Visitation (#/yr)					Fee Level ($BZ/day)		
	Paper Park	Manage-ment Type	NGO managers or co-managers	Land	Water	Domestic (2006)	Foreign (2006)	Domestic (2007)	Foreign (2007)	Is there undercounting of visitors?	Domestic	Foreign	Other
Forestry MPAs													
Blue Hole (LH)		Co	Belize Audubon Society	0	414	100	9,300	100	9,156	Yes by 20% for domestic and 3% for foreign	$0	$60	
Corozal Bay	x	Gov.		0	73,050								
Half Moon Caye (LH)		Co	Belize Audubon Society	18	3,936	100	9,500	100	9,405	Yes by 20% for domestic and 3% for foreign	$2.50	$20	10.00 for camping
Laughing Bird		Co	Friends of Nature	18	4,077	474	9,427	787	9,221	no	$0	$20	
Swallow Caye		Co	Friends of Swallow Caye	0	3,631	50	4,800				$2	$10	
Govt Paper Parks													
Caye Glory	x	Gov.		0	547								
Sandbore (LH)	x	Gov.		0	521								
South Point	x	Gov.		0	533								
TOTAL (for parks with avail. data)						6,448	104,353	9,518	112,009				

*Table was completed by MPA Managers using the best available information. WRI has left the figures as they were reported to us.

Source: WRI and WWF 2008.

MPA	Revenue from fees (BZ$)			Distribution of fee		Business		Estimated Current Management Costs ($BZ/yr)	Targeted Management Costs ($BZ/yr)	Government funding	
	2005	2006	2007	MPA	Gov. of Belize	Y / N	Year			Typical level of gov funding ($BZ)	What does this pay for (fuel? Staff?)
Fisheries MPAs											
Caye Bokel						Y	2008				
Dog Flea						Y	2008				
Gladden Split & Silk Cayes	$183,310	$241,868	$146,298	80%	20% (?)	Y	2002	(2006) - 643,000 (2007) - 500,000	$700,000	(2006) - 48,000	ranger, biologist, fuel and administrative costs
Glover's Reef		$85,620						$200,000	$300,000	Fisheries dept. supports management (~ $200,000)	4 staff and fuel
Hol Chan	$886,675	$893,451	$972,725	40% salaries; 25% fuel; 10% maintenance, boats and building; 10% assistance to other MPA's; 10% upgrade and purchase of new equipment; 5% utilities	0%	Y	2001	(2007) - 700,000	$900,000		
Port Honduras	$18,459	$15,259	$9,650	60% to TIDE	40% to Fisheries	Y	2007	(2007) - 258,189	$734,980		contribute fuel for annual conch survey
Sapodilla Cayes	$67,120	$19,500	$23,160	0%	100% to government MPA fund	Y	2005	(2004) - 532,000; (2005) - 620,000 with 10% increase every year after	current costs + $300,000	Fisheries dept. supports management (~ $200,000)	fisheries dept pays for staff salaries and fuel for patrols and some monitoring
South Water Caye		$43,870	$56,633		100% to government MPA fund	N		$151,000	$200,000	Fisheries dept. supports management (~ $200,000)	24,000 for fuel, 87,000 for salaries, 15,000 maintenance, meetings 5,000, research equipment 20,000.
Joint Fisheries \ Forestry MPAs											
Bacalar Chico		$41,160	$11,670	0%	100% to government MPA fund	Y	2003	(2007) - $200,000	$500,000	Fisheries dept. supports management (~ $200,000)	fuel, staff salaries, administrative costs, patrols
Caye Caulker		$162,110	$183,870		100% to government MPA fund	N		$125,900	$212,000	Fisheries dept. supports management ($125,900)	Fuel, salaries for 5 people, maintenance of boat

Source: WRI and WWF 2008.

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MPA	Revenue from fees (BZ$)			Distribution of fee		Business		Estimated Current Management Costs ($BZ/yr)	Targeted Management Costs ($BZ/yr)	Government funding	
	2005	2006	2007	MPA	Gov. of Belize	Y / N	Year			Typical level of gov funding ($BZ)	What does this pay for (fuel? Staff?)
Forestry MPAs											
Blue Hole (LH)		$374,000	$368,700	100%	0%	Y	in drafting stage	$219,800	unknown at this point		on-site management costs, maintenance, staff salary, equipment, and supplies for research and maintenance, staff insurance, structural upgrades
Corozal Bay	$0	$0			0%						
Half Moon Caye (LH)		$374,000	$368,700	100%	0%	Y	in drafting stage	$219,800	unknown at this point		on-site management costs, maintenance, staff salary, equipment, and supplies for research and maintenance, staff insurance, structural upgrades
Laughing Bird	$63,232	$76,619	$186,432	100%	0%	Y	$2,004	$150,000	$250,000	100%	all fees stay at the park, the fees are used to manage the park by providing fuel, salary
Swallow Caye			$48,100 ?	100%	0%						
Govt Paper Parks											
Caye Glory											
Sandbore (LH)											
South Point											
TOTAL (for parks with avail. data)	1,220,801	2,329,463	2,377,945					$3,344,689			

*Table was completed by MPA Managers using the best available information. WRI has left the figures as they were reported to us.

Source: WRI and WWF 2008.

MPA	What aspects of management could the MPA improve with aspirational funding?
Fisheries MPAs	
Caye Bokel	
Dog Flea	
Gladden Split & Silk Cayes	continue biophysical support, continue surveillance activities, continue 24 hr ranger presence, develop a special enforcement team made up of relevant NGO, and government, enhance all monitoring and enforcement equipment
Glover's Reef	
Hol Chan	
Port Honduras	Prevent further degradation of littoral forests, mangroves and associated nursery (LANDSAT imagery access / aerial surveys equipment with light hawk,involvement of ministerial and political good will to prevent intensive, Reduce fishing pressure in the PHMR by 30% by eliminating illegal fishing and illegal fishing methods (refurbishment of existing stations (Abalone Caye erosion protection measures, electricity, toilet & shower, internet; West Snake Caye implementation), sub-ranger station at Monkey River, one boat and 2 sets of four stroke engines). development – shrimp farms / big scale developments – extend moratorium in mangroves), By 2018, increase commercial species (conch, lobster, snapper, grouper, parrotfish, shark) levels to viable population levels (establish monitoring protocol for snappers, groupers and parrotfish; MAP habitats in PHMR (LANDSAT & ground truthing); stakeholders consultation and advocacy campaigns to increase size of no take zones & re-evaluate sizes of commercial species (minimum reproductive size, etc)). By 2010, have nest monitoring and protection in place for 25% of all marine turtle nests.
Sapodilla Cayes	could improve science program by creating better system to input/extrapulate data (database). More funding to do trainings for biologist and managers to analyze and interpret data. More funding could help boost up the enforcement aspect of the reserve by purchasing better equipment and fuel useage. More funds can be used to buy dive gear, compressor, new boat for better management
South Water Caye	rangers patrol, and legislation for zoning
Joint Fisheries \ Forestry MPAs	
Bacalar Chico	More patrols and enforcement and collection of fees, more systematic monitoring, implement outreach programs
Caye Caulker	increase enforcement, increase monitoring, more mooring buoys in conservation zone,more demarcation buoys in zones, more community outreach programs
Forestry MPAs	
Blue Hole (LH)	funding for new housing, telephone communication, and internet services, monitoring activities such as water quality testing, and other monitoring. Also for mooring infrastructure, patrolling and enforcement
Corozal Bay	
Half Moon Caye	
Laughing Bird	continue biophysical support, continue surveillance activities, continue 24 hr ranger presence, develop a special enforcement team made up of relevant NGO, and government, enhance all monitoring and enforcement equipment
Swallow Caye	
Govt Paper Parks	
Caye Glory	
Sandbore (LH)	
South Point	

All information was provided by MPA managers and co-managing organizations in the fall of 2008