

A nationwide assessment of threats to bonefish, tarpon, and permit stocks and habitat in Belize

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Abstract Although Belize has developed an international reputation as being a leader in environmental conservation given that approximately 26 % of its terrestrial and marine territories are designated as protected areas, there remains persistent threats to the country's bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*), permit (*Trachinotus falcatus*), and associated habitats. While some of these threats resemble those found in other regions and countries such as pollution or overfishing, Belize's fisheries also face unique threats because of its proximity to Guatemala and the rapid pace of development along the Belize coast. However, fishing guides and lodge owners have been instrumental in pursuing policies that protect and sustainably manage bonefish, tarpon, and permit stocks. This paper provides a nationwide assessment of some of the major threats facing bonefish, tarpon, permit and associated habitat in Belize, as well as some of the responses to counter these threats.

Keywords Gill nets · Coastal development · Marine reserves · Mangroves

Introduction

With more than 26 % of its territory found in protected areas, Belize has become an international leader in

environmental conservation, especially within the developing world (Meerman 2005). These protected areas consist of both terrestrial and marine parks, including the world's first jaguar preserve and extensive marine reserves focused on its barrier reef and offshore atolls (Porter-Bolland et al. 2012; Primack et al. 2013; Villamizar et al. 2014). Support for protected areas is partly driven by Belize's increasing reliance on international tourism, especially the rapidly expanding nature tourism segment, including sport fishing, within the larger international tourism economy. Belize has become a leading destination for sport fishing for bonefish, tarpon, and permit within the larger Caribbean and Central American region (Cisneros-Montemayor et al. 2011). However, the larger Belize environment, like other landscapes in tropical countries, has also undergone extensive degradation due to a variety of activities ranging from slash-and-burn agriculture in lowland forest ecosystems to coastal pollution and mangrove destruction due to the development of its tourism infrastructure during the past 30 years (Crabbe 2014; Seidl et al. 2014). The natural environment and protected areas, in other words, do not exist in a vacuum. Instead, they are impacted and influenced by local and regional economic, political, and social conditions.

This paper roughly divides Belize into three zones to better understand and organize how threats to bonefish (*Albula vulpes*), tarpon (*Megalops atlanticus*), and permit (*Trachinotus falcatus*), herein described as BTP, and associated habitat vary within the country. Divisions include Zone 1 in northern Belize, ranging from Ambergris Caye to Belize City; Zone 2 in central

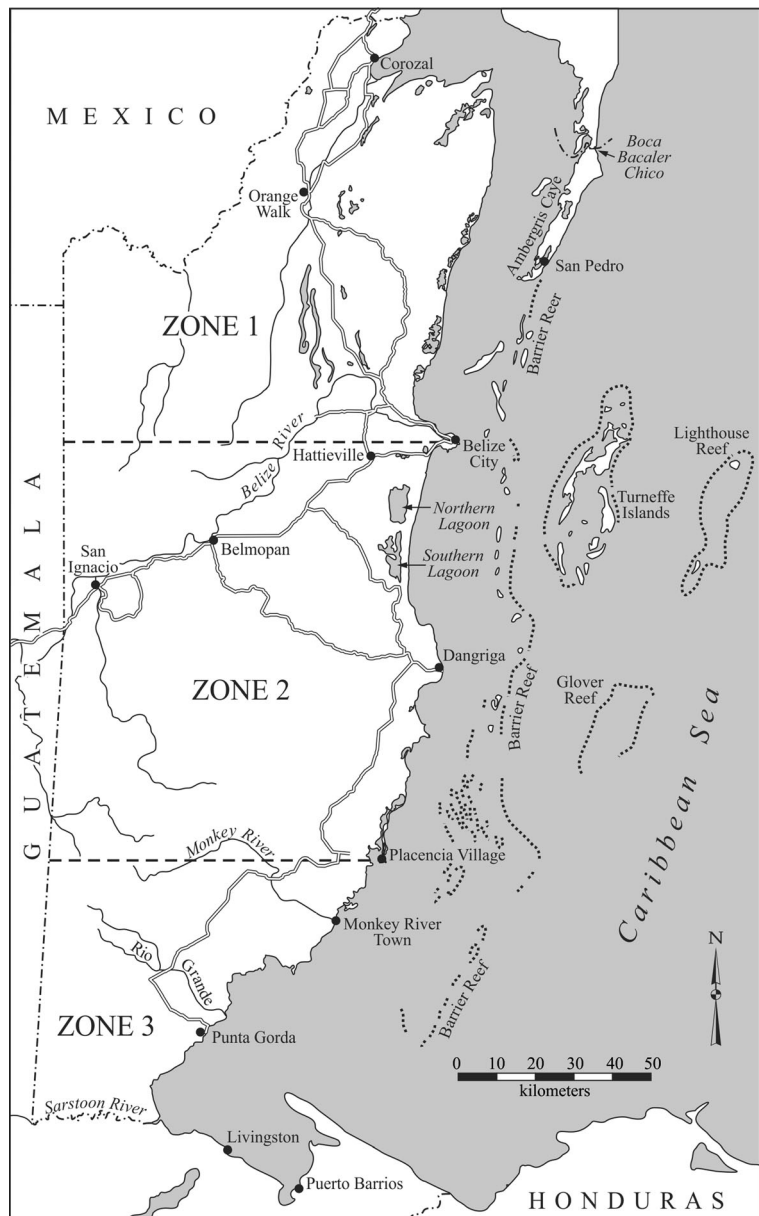
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Belize, found approximately from Dangriga to Placencia; and Zone 3 in southern Belize, from Placencia to the Guatemalan border (Fig. 1). Certainly in many instances threats overlap (i.e., tourism related infrastructure development and gill nets), but each region also faces unique challenges regarding the sustainable management of BTP stocks and habitat. Also, it would be impossible in a single paper to closely examine or even list every human impact that threatens fishery resources. Instead, this paper discusses specific, prominent threats in each zone, thereby creating a

nationwide profile of important human-driven impacts on BTP stocks and habitat. Although not data driven, information in this paper is based on more than 20 years of research focused on environmental change and conservation in Belize, including two recent projects that document mangrove deforestation on Ambergris Caye using satellite imagery, and a participatory mapping project with flats fishing guides that identifies threats to BTP stocks and habitat in specific areas.

Sport fishing for bonefish, tarpon and permit generated more than \$56 million dollars in 2007 and

Fig. 1 Map of Belize



supported 1864 full time jobs (Fedler and Hayes 2008; Fedler 2011). Therefore, understanding regional threats to BTP stocks and habitat is critical if this growing economy is to continue to provide employment opportunities for the next generation of Belizeans. However, as economically important as these species are, much remains to be understood about BTP ecology, behavior and the long-term human impacts on their populations and habitat (Adams et al. 2014).

Zone 1 – Northern Belize

Within Zone 1, Ambergris Caye and San Pedro town specifically, represent the core location for Belize's coastal tourism economy. International tourism in Belize largely started on Ambergris Caye, and continues to expand north along the beachfront towards the Mexican border (Fig. 1). During the past several decades, San Pedro has been transformed from a quiet commercial fishing village with no cars and small numbers of tourists, to a sprawling and polluted small city.

Ambergris Caye's close proximity to both Belize's barrier reef and the international airport via a short flight has made it a natural location for explosive development (Nolan 2014). Besides snorkeling and scuba diving, sport fishing focused on local flats and the barrier reef are popular and important activities within the Ambergris Caye economy. While jobs created by the exploding tourism industry have been welcomed in Belize, there are significant environmental costs as well. Most of these environmental impacts indirectly effect BTP stocks such as clearing mangroves for hotel and home construction, dredging local sandy flats for construction materials, and sewage and waste disposal or lack thereof (Fig. 2) (Taylor et al. 2007). Direct impacts such as commercial harvesting of BTP are now prohibited, although according to older fishing guides, tens of thousands of bonefish were harvested in the past using seine nets.

Mangrove clearance is especially problematic because mangroves provide both habitat for BTP stocks and stabilize coastal environments (Valiela et al. 2001; Taylor et al. 2007). Cooper et al. (2009) documented that mangroves contribute US\$174–249 million per year to Belize's economy, based in part on coastal stabilization and the habitat they provide for so many sport and commercial fish species. So the destruction of mangroves leads to both short term (immediate habitat destruction) and potentially long term (coastal erosion

and siltation) problems for BTP populations, which will ultimately have significant impacts on the Belize economy (Cherrington et al. 2010).

The growth of tourism on Ambergris Caye has led directly to the widespread destruction and degradation of mangroves (McMinn 1997; Timothy and White 1999). A study conducted by the author and former graduate student found that between 1986 and 2012, Ambergris Caye lost almost ten percent of its mangrove forests. According to Rhine (2013), mangrove cover on Ambergris Caye declined from 8535 ha in 1986 to 7321 ha in 2012. Not only have mangroves been completely cleared leading to dramatic habitat changes, this ecosystem has also been degraded due to the same development-related pressures. Our study found that by 2012 only 1663 ha of "quality" mangrove habitat remained, or roughly 21 %. We defined quality mangrove habitat as closed canopy, contiguous forest (Rhine 2013). On satellite images, degraded mangroves appear to be "moth eaten" on its edges, or in contrast, show sharp edges indicating human impacts, often due to dredging. Mangroves were also considered degraded if they became dumping grounds for both trash and sewage, an increasingly common impact around San Pedro as the town expands without adequate public services.

Mangrove degradation on this scale is simply not sustainable if Belize officials and local populations want the economy to continue to be based on marine recreation, including sport fishing. And given the dependence on tourism on Ambergris Caye and other nearby cayes, it would seem logical that mangrove protection would be a higher priority for local authorities. However, given that existing laws protecting mangroves are often ignored by developers, or developers pay relatively miniscule fines for mangrove destruction, it appears that stemming the current tide of destruction won't subside as long as demand for new developments continue.

The sport fishing industry isn't without impacts on BTP stocks and habitat either. As more tourists visit Ambergris Caye, more locals have become fishing guides to benefit from the lucrative sport fishing industry. While this can mean more individuals participating in a sustainable industry, it also results in more guides and boats and more pressure and impacts on the resource. For example, as competition has grown, guides rarely pole their boats onto shallow flats. Instead, guides speed from one flat to the next, which scares fish, alters behavior, and leaves propellor scars in the turtle grass. In conversations with various guides, older, more

Fig. 2 Development in Ambergris Caye Mangroves, nearest village is San Pedro, photo taken in September 2014 by the author



experienced individuals complain about younger guides who they claim have less patience and feel more pressure to “deliver” fish to clients. According to these same guides, many flats close to San Pedro contain far fewer permit today than in the past because of the constant and intense boat traffic. This situation can be thought of as a sport fishing “tragedy of the commons” where individuals feel pressure to extract as many resources as possible before someone else in the community extracts the same resources. Although beyond the scope of this study, it seems reasonable to wonder if new guides also mishandle fish, leading to higher mortality rates. Mishandling in this case refers to keeping fish out of water to long or hauling large tarpon into a boat for photo opportunities.

However, given the lucrative nature of guiding, there is growing concern about not only managing the environment, but also the participants in this industry, especially new guides. Conversations among guides and lodge owners have begun to take place that might lead to better regulation of internal behavior that would lessen the impact on BTP stocks and habitat. For example, for the first time, the idea of managed access is being discussed to help reduce the impacts of sport fishing on certain flats. Also, guides feel that if they are better organized, they can also present a united front in terms of monitoring illegal development or illegal commercial fishing (i.e., fishing in a reserve). While

these actions are in the early stages, enough changes have occurred in the area so that guides and associated lodges feel pressure to act.

Zone 2 – Central Belize

Central Belize has also witnessed a rapid transformation of some of its coastal zone and BTP habitat due to development associated with the tourism economy (Key 2002; Wells et al. 2014). This expansion has been especially intense in and around Placencia, with developers drawn to the area’s white sandy beaches (Fig. 1). However, unlike Ambergris Caye, large-scale shrimp farms are also a driving factor that has transformed the landscape, especially the Placencia Lagoon (Fig. 3).

The Placencia Lagoon, a 24 km long shallow estuary rimmed by mangroves and containing extensive turtle grass flats, provides habitat for numerous rare and endangered species such as the West Indian manatee (*Trichechus manatus*), as well as BTP populations. As such, the lagoon is an important destination for local fly fishing guides, especially those who target small tarpon. Although the number of shrimp farms has ebbed and flowed during the past 15 years due to global shrimp price fluctuations, the Placencia area has been responsible for close to 40 % of Belize’s overall shrimp production during this time frame. Shrimp farms have largely been created outside the mangrove zone, so instead of deforestation, effluent impacts BTP stocks and habitat (Wells et al. 2014).

Fig. 3 Shrimp Farm near Placencia Lagoon, nearest village is Placencia, photo taken in September 2014 by the author



Effluent from shrimp farms has created eutrophic conditions with high nutrient loads and low levels of dissolved oxygen. Although the high nutrient loads haven't impacted the area's mangroves, and in fact some shrimp farms have actually planted more mangroves to help filter runoff, the lagoon's sea grass beds have declined dramatically. According to Ledwin (2010), the extent of sea grass shrank in Placencia Lagoon from 83 % coverage in 2003 to just 7 % coverage in 2007. Related, high nitrogen and low dissolved oxygen levels were recorded in the lagoon during the same period, implicating shrimp farms as a driving force in this change. As sea grass beds have declined, so too has the quality of angling according to local fishing guides. Although based on anecdotal reporting, fishing guides and long time anglers alike have reported declining fishing success and fewer BTP sightings, while at the same time spending more time on the water. Again, these are anecdotal reports, however, when coupled with reports of declining sea grass and increased eutrophic conditions, the reports are certainly plausible.

However, a word of caution regarding the role of shrimp farms in the decline of sea grass beds. As previously mentioned, Placencia has also undergone a rapid expansion of tourism-related infrastructure. The building boom gained momentum after Hurricane Iris in 2001 caused widespread destruction, leading to depressed real estate prices, which in turn created opportunities for speculators. As development spreads,

mangroves decline, leading to more erosion along the coast and greater turbidity in the Lagoon. And increased turbidity has been shown to negatively effect sea grass extent and density. So while eutrophication from effluent has certainly played a role in the decline of sea grass in the Lagoon, the decline has been exasperated by the destruction of surrounding mangroves as well (Harborne et al. 2006).

Besides shrimp farms, cruise ship tourism also threatens Placencia's coastal ecosystems and BTP stocks. Just south of Placencia lies Harvest Caye, which encapsulates some of the challenges faced by coastal and marine conservationists in Belize in an age of international tourism. Norwegian Cruise Lines purchased Harvest Caye in 2013 to construct a docking station to facilitate quick access to mainland day trips. As cruise ship tourism has exploded in Belize during the past decade, cruise lines have sought new docking locations which is a challenge along Belize's shallow, mangrove fringed coastline.

Transforming a low lying mangrove caye into a facility capable of hosting thousands of annual visitors will not only directly destroy the Harvest Caye, but also potentially harm the nearby reef and grass flats through dredging, sedimentation, and the generation of tons of garbage. The area is simply not equipped to handle the potential waste generated by both visitors and new residents drawn to the area by employment opportunities. As of the writing of this paper, dredging has begun

and the local authorities in Placencia have approved the project, much to the dismay of local and national environmental and sport fishing groups.

As one flies over the Placencia area today, large sections of the coast are completely devoid of mangroves, awaiting construction crews. Some of the cleared areas have been molded into unnatural geometric shapes surrounded by canals awaiting luxury homes that are almost always owned by foreigners (Fig. 4). Like on Ambergris Caye, regulations protecting mangroves are sometimes ignored, or developers simply pay nominal fines given the much greater profits generated by developments.

Zone 3 – Southern Belize

A common joke among locals in southern Belize is that they are geographically “blessed” because the area doesn’t contain any white sand beaches. As a result, the development pressures that exist in other parts of Belize don’t impact the southern coast to the same degree. Instead of sandy beaches, the southern coastline is dominated by large river systems such as the Rio Grande, Moho, and Temash, and Monkey Rivers. The coastline is muddy and mangrove fringed, one that attracts tourists more interested in sport fishing, birding, and the area’s archaeological attractions rather than beaches.

While tourism-related development doesn’t represent the primary threat to BTP habitat and stocks in southern Belize, other human-driven threats exist. The most

significant threat in southern Belize is gill nets used by illegal foreign commercial fishermen. Gill nets and foreign fishing are especially problematic in southern Belize because both coastal Guatemala and Honduras are within an easy boat ride. This proximity presents challenges for fisheries management and conservation officials because coastal Honduras and Guatemala are home to hundreds of thousands of people. And these hundreds of thousands of people that live on Belize’s southern doorstep place great pressure on regional marine resources.

The presence of these nearby large populations can be seen during the rainy season when literally tons of garbage from Guatemala and Honduras is carried out to sea, some of which eventually makes its way to the mangroves and shores of southern Belize. Most of the offshore mangrove cayes are today choked with plastic, Styrofoam, and other trash that originates south of Belize’s border. These polluted cayes are a disconcerting sight given that while fishing far offshore, one assumes he/she is far from the impacts of civilization.

A visit to the fish markets in Guatemala’s Puerto Barrios or Livingston provides more insight into the pressure these countries have on regional marine resources. According to conversations with vendors in 2012, fish size has consistently decreased during the past decade, and fishermen have to travel farther away to find enough fish to sell. And as fish stocks have declined, Guatemala and Honduran fishermen

Fig. 4 Housing Development north of Placencia, nearest village is Placencia, photo taken in September 2014 by the author



appear willing to take chances and fish illegally in neighboring Belize. For example, during my visit to Puerto Barrios, the author saw at least six large tarpon in the market. When asked about their origin, the vendor smiled, and then waved me away, refusing to answer my question. Another vendor told the author that manatee meat was occasionally sold, which he claimed was harvested in Belizean waters.

Marine resources, including BTP stocks, are susceptible to poaching because there are few marine patrol boats in southern Belize, coupled with a large and easily accessible area. According to local fishermen and fishing guides, poachers enter Belizean waters at nightfall, set nets, collect them before dawn, and slip out before being detected. This is common in the rainy season when gill nets are often placed across the mouths of rivers and creeks, devastating local fish stocks such as snook (*Centropomus undecimalis*) and juvenile tarpon. River gill netting is especially common south of Punta Gorda where Guatemalan fishermen have easy access to Belizean waters (Fig. 1). Located on the Belize-Guatemalan border, the Sarstoon River tarpon and snook fishery has been ruined by Guatemalan gill-netters according to guides in Punta Gorda.

On a positive note though, the creation of Paynes Creek National Park in 1999 has helped stem the tide of cross border poaching, at least in the northern third of the Toledo District where the park is located. Payne's Creek contains some of the best permit fishing flats and lagoons in Belize, so their protection represents an

opportunity for a sustainable fishery based on sport fishing (Fig. 5). A cooperative relationship has developed between fishing guides and park rangers, where fishing guides act as informal rangers to report any suspicious boats in the park. According to both guides and rangers poaching with nets by foreign boats in the park has significantly decreased as sport fishing has increased.

A new Belizean Coastguard station is also being constructed (2015) on the southern end of the barrier reef in the Sapodilla Cayes Marine Reserve on Hunting Caye. This station will likely increase patrols in the region, although they are to be largely focused on drug trafficking. However, any increased marine patrol presence will likely discourage poachers, at least from the outer cayes.

However, even with the creation of protected areas and a new Coastguard station, pressure from impoverished and growing populations across borders will continue to pose challenges for fisheries managers, fishing guides, and Belizean fishermen. The Belizean government must be more aggressive regarding marine patrols and enforcement in its waters, not just with drug trafficking, but marine resources as well. The prosecution of Guatemala fishermen is a sensitive issue given the larger, contentious political relationship between the two countries (i.e., Guatemala claims Belize). Belize authorities are sometimes reluctant to pushback against Guatemalans for fear of igniting a larger dispute. However, if there are to be healthy BTP stocks as well

Fig. 5 Lagoon in Paynes Creek National Park, nearest village is Monkey River Town, photo taken in September 2014 by the author



as commercial species for the next generation, then foreign incursions will have to be dealt with in the very near future.

Conclusions

Belize should be commended for its conservation commitment by designating so much of its land and marine territory as protected. Within these protected areas are some of the most biodiverse and complex ecosystems on the planet including the longest barrier reef in the Western Hemisphere and various terrestrial tropical forest ecosystems. Belize has also become a world-class sport fishing destination for BTP partly because of progressive fisheries management that includes a catch and release policy for these species. However, outside protected areas, the marine and terrestrial landscape is changing due to the rapid and often unregulated expansion of tourism-related infrastructure, among many factors.

These two, seemingly opposite trajectories are actually quite closely related. Tourists want to visit Belize to sport fish, scuba dive, and bird watch. But as their numbers increase, so does the impact of the tourism infrastructure. The construction of the cruise ship terminal near Placencia provides an unfortunate example of this dilemma. The terminal represents immediate jobs and local revenue, but will have long-term destructive impacts on local mangrove forests, sea grass flats, BTP stocks, and the nearby coral reef.

There are no easy answers moving forward. The Belizean environment cannot simply be locked up, protected from all development. However, that doesn't mean development can't be better managed and current regulations enforced, which will indirectly lead to greater value being placed on ecosystem services (see Foley et al. 2013; McKenzie et al. 2014). One recent development that will contribute to better enforcement is the formation of a national fishing guides association. By acting with a more unified voice, guides can play a greater role in how and where development takes place and make sure environmental regulations are followed. Given the economic value of BTP fishing, guides have earned the right to have a seat at the national development table. And with that seat guides and their allies can begin to demand more marine patrols, enforcement of existing regulations, and initiate new policies such as managed access in marine protected areas. Vigilance

and oversight by local actors such as guides, commercial fishermen, and lodge owners will help assure that future generations can participate and benefit from some of the best BTP fishing on the planet.

References

- Adams AJ, Horodysky AZ, McBride RS, Guindon K, Shenker J, MacDonald TC, Carpenter K (2014) Global conservation status and research needs for tarpons (Megalopidae), ladyfishes (Elopidae) and bonefishes (Albulidae). *Fish Fish* 15(2):280–311
- Cherrington EA, Hernandez BE, Trejos NE, Smith OA, Anderson EA, Flores AI, Garcia BC (2010) Technical report: identification of threatened and resilient Mangroves in the Belize barrier reef system. Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC)
- Cisneros-Montemayor AM, Sumaila UR, British Columbia Univ., Vancouver(Canada) (2011) Fisheries centre. In: Palomares MLD (ed.) The economic value and potential threats to marine ecotourism in Belize (Vol. 19, No. 6). UBC, Vancouver, BC (Canada)
- Cooper E, Burke L, Bood N (2009) Coastal capital Belize. The economic contribution of Belize's coral reefs and Mangroves. WRI Working Paper. World Resources Institute, Washington DC. 53 pp. Available online at <http://www.wri.org/publications>
- Crabbe MJC (2014) Capacity building and policy development in Belize marine protected areas, an example for Caribbean integrated coastal management. *Rev Biol Trop* 62(3):287–291
- Fedler AJ (2011) The economic value of Turneffe Atoll. Unpubl. Turneffe Atoll Trust, Belize
- Fedler AJ, Hayes C (2008) Economic impact of recreational fishing for bonefish, permit and tarpon in Belize for 2007. Gainesville: Friends of Turneffe Atoll
- Foley MM, Armsby MH, Prahler EE, Caldwell MR, Erickson AL, Kittinger JN, Levin PS (2013) Improving ocean management through the use of ecological principles and integrated ecosystem assessments. *Bioscience* 63(8):619–631
- Harborne AR, Mumby PJ, Micheli F, Perry CT, Dahlgren CP, Holmes KE, Brumbaugh DR (2006) The functional value of Caribbean coral reef, seagrass and mangrove habitats to ecosystem processes. *Adv Mar Biol* 50:57–189
- Key CJ (2002) The political economy of the transition from fishing to tourism, in Placencia, Belize. *International Review of Modern Sociology*, 1–18
- Ledwin S (2010) Assessment of the ecological impacts of two shrimp farms in Southern Belize (Doctoral dissertation, University of Michigan)
- McKenzie E, Posner S, Tillmann P, Bernhardt JR, Howard K, Rosenthal A (2014) Understanding the use of ecosystem service knowledge in decision making: lessons from international experiences of spatial planning. *Environ Plan C Gov Policy* 32(2):320–340
- McMinn S (1997) The challenge of sustainable tourism. *Environmentalist* 17(2):135–141

- Meerman J (2005) National Protected Areas Policy and Systems Plan. Report to the Protected Areas Systems Plan Office. Belmopan. http://biological-diversity.info/Downloads/Report_result2_finaldraft_s.pdf. Accessed on 1 April 2015
- Nolan KA (2014) Improving socio-economic stability and natural sustainability of coral reef ecosystems through mitigation, ecotourism and education. *Int J Soc Entrep Innov* 3(1):29–38
- Porter-Bolland L, Ellis EA, Guariguata MR, Ruiz-Mallén I, Negrete-Yankelevich S, Reyes-García V (2012) Community managed forests and forest protected areas: an assessment of their conservation effectiveness across the tropics. *For Ecol Manag* 268:6–17
- Primack RB, Bray D, Galletti HA, Ponciano I (Eds.) (2013) Timber, tourists, and temples: conservation and development in the Maya Forest of Belize Guatemala and Mexico. Island Press
- Rhine SB (2013) Historical mapping and monitoring of the Mangrove Forests of Ambergris Caye (Belize) using Multi-date Landsat imagery: a twenty-six year history (master's thesis, The University of Alabama, Tusclaoosa)
- Seidl A, Pratt L, Honey M, Durham WH, Slean G, Bien A (2014) 3. Cruising for a bruising: challenges in sustainable capture of ecosystem service values from cruise ship tourism in Belize. Handbook on the economics of ecosystem services and biodiversity, 40
- Taylor DS, Reyier EA, Davis WP, McIvor CC (2007) Mangrove removal in the Belize cays: effects on mangrove-associated fish assemblages in the intertidal and subtidal. *Bull Mar Sci* 80(3):879–890
- Timothy DJ, White K (1999) Community-based ecotourism development on the periphery of Belize. *Curr Issues Tour* 2(2–3):226–242
- Valiela I, Bowen JL, York JK (2001) Mangrove forests: one of the world's threatened major tropical environments at least 35 % of the area of mangrove forests has been lost in the past two decades, losses that exceed those for tropical rain forests and coral reefs, two other well-known threatened environments. *Bioscience* 51(10):807–815
- Villamizar E, Díaz MC, Rützler K, Nóbrega R (2014) Biodiversity, ecological structure, and change in the sponge community of different geomorphological zones of the barrier fore reef at Carrie Bow Cay, Belize. *Mar Ecol* 35(4):425–435
- Wells EC, Zarger RK, Whiteford LM, Mihelcic JR, Koenig ES, Cairns MR (2014) The impacts of tourism development on perceptions and practices of sustainable wastewater management on the Placencia Peninsula, Belize. *J Clean Prod*