State of Belize Fisheries Report 2020

OCEANA Protecting the World's Oceans

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This report provides an overview of fisheries in Belize within the overall context of the economic, political and environmental state of the country. We provide a thorough review of the commercial and subsistence fisheries in Belize and attempt to assess the status of the resource ecologically and economically. Finally, after review of the state of governance and current management structures, we provide recommendations for improving the fisheries of Belize.

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Executive Summary

Around the world Belize is recognized as a unique and beautiful country for its colorful coral reefs, sandy beaches, lush rainforests, historic Maya temples and vibrant cultures. Home to the Western Hemisphere's longest barrier reef which includes the Belize Barrier Reef Reserve System - a UNESCO World Heritage site, and world-class fishing spots, Belize draws over a million tourists to its shores each year. The importance of maintaining healthy reefs and mangroves to support these multimillion-dollar industries is not lost on any of us. But less well recognized is the importance of marine fisheries to the Belizean economy, cultures, food security, livelihoods and human health, not to mention to the health of the coastal ecosystems themselves. Healthy fish populations, from the smallest baitfish to the largest sharks, are critical to the overall health of the reef ecosystem and the national economy. The fishing industry brings Belize approximately 28 million BZD per year but not all of its benefits have been quantified; fishing also plays an important role in supporting local livelihoods and nutrition. All told, the cultural, economic and environmental contributions of fisheries to Belize cannot be overstated.

Most Belizeans have been savoring seafood all their lives. Whole fried snapper is a restaurant staple, and the favorite fillet is always grouper. The fish market is a prominent feature in every coastal municipality – a bustling scene of species, colorful characters and salty language. Every restaurant in the cayes and along the coast proudly advertises fresh-caught seafood on their menus; tourists and locals alike expect and relish it. The opening of the lobster season is a reason to celebrate.

Conch and lobster are the foundation of the Belizean fisheries economy, generating valuable export earnings and employment for over 90 percent of the country's registered fisherfolk. These two seasonal marine commodities contribute most of the gross domestic product derived from fisheries. However, the value of snapper, grouper and other fisheries in Belize is not well known and is, in most cases, very much undervalued. More than 50 percent of Belizeans live along the coast, and more than 190,000 people (about half of its population) are dependent on tourism and fishing. In many of these communities, a number of residents rely on subsistence fishing for their primary source of protein.

Yet Belize's fisheries are at risk. Iconic species such as the goliath grouper have all but disappeared. Spawning aggregations, once populated by tens of thousands of snappers and groupers, are shadows of their former selves. Increasing fishing pressure, both legal and illegal, is beginning to make its mark on other species. Some of the larger, mobile shark species in Belize, such as the lemon, blacktip and scalloped and great hammerheads are likely at risk from overfishing. The sea cucumber fishery, which boomed and busted within a few short years, tells a cautionary tale. Even the conch and lobster fisheries are showing warning signs. Meanwhile, the Coronavirus disease (COVID-19) pandemic's impact[1] on the country's tourism and fisheries sectors, national economic trends and future projections challenge us to stabilize both food security and livelihoods. As this reality hits home for more and more Belizeans, the need for sound and timely fisheries-related data will only increase.

Luckily, there is still time to tackle our challenges. Moreover, Belize has shown remarkable leadership in

1 At the time of the writing of the report, data for 2020 and the impacts from COVID-19 to Belize's fisheries is preliminary and not fully available for inclusion in the report.

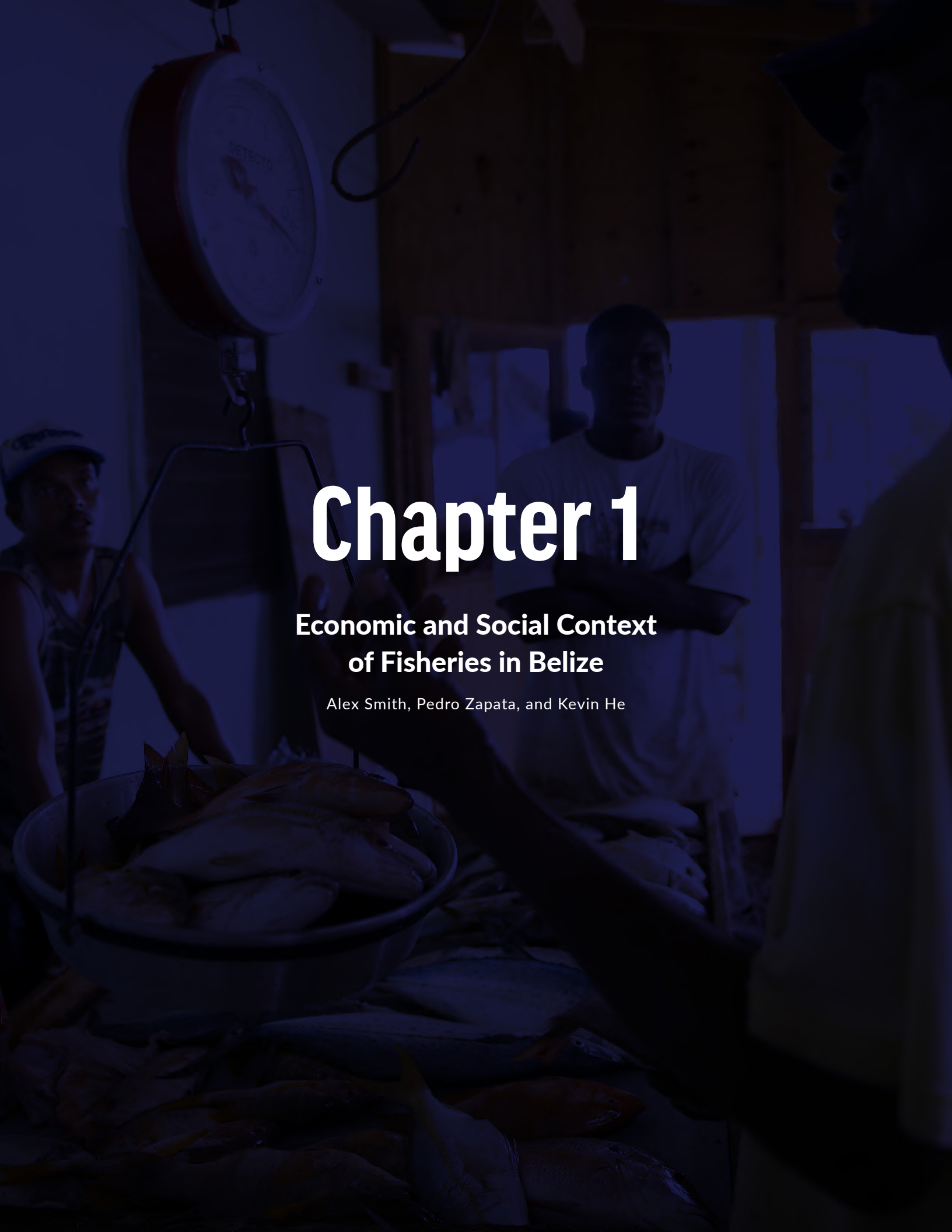
protecting its marine and coastal resources, by creating a marine protected areas network, sport fishing regulations, and crucially, putting a stop to the threat of offshore oil drilling and banning trawling and gillnetting. In 2016, the Government of Belize launched nationally the innovative Managed Access program to begin regulating fishing activity on a more local level; and, in 2020, passed the Fisheries Resources Act which is designed to improve and enhance sustainable fisheries management, as well as banned the use of gillnets in Belize's Exclusive Economic Zone (EEZ) in November 2020. (Some sections of this report have been written prior to the gillnet ban.)

Although a lack of nationwide collection of landings data, regular enforcement and consistent monitoring of species composition and size has made it difficult to ascertain the state of Belize's fisheries with a high level of detail and accuracy, we have sufficient information to prioritize the next steps. Top priorities should include improved monitoring, enforcement, and transparency to strengthen fisheries management. We also know enough to prioritize measures to enhance protection of endangered species such as Nassau and goliath grouper.

Through a few key actions – collection, analysis, and sharing of catch data; transparent public consultation on management initiatives; stronger enforcement of existing regulations; and prioritization of management for at-risk finfish species – we can ensure that Belize's fisheries, and the people who depend on them, have sustainable futures.

List of Acronyms

BBRRS	Belize Barrier Reef Reserve System
BRUV	Baited Remote Underwater Video
BTB	Belize Tourism Board
BZD	Belizean Dollar
CARICOM	Caribbean Community of Nations
CITES	Convention on International Trade of Endangered Species
CRFM	Caribbean Regional Fisheries Mechanism
CSME	CARICOM Single Market and Economy
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GNI	Gross National Income
GOB	Government of Belize
HDI	Human Development Index
HRI	Healthy Reefs Initiative
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund
IUCN	International Union for the Conservation of Nature
MAR	Mesoamerican Reef
MPA	Marine Protected Area
MPI	Multidimensional Poverty Index
MSME	Micro, Small and Medium-sized Enterprises
PHMR	Port Honduras Marine Reserve
PSA	Productivity-Susceptibility Assessment
SAU	Sea Around Us
SICA	Central American System of Integration
SIB	Statistical Institute of Belize
TL	Total Length
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
WHC	World Heritage Committee
WFP	World Food Programme



Chapter 1

Economic and Social Context of Fisheries in Belize

Alex Smith, Pedro Zapata, and Kevin He

Introduction

Belize is a small country of little more than 419,000 people (SIB 2020a). It is an atypical place in many ways. Although it is a Central American country, it shares most of its attributes, history, culture and economic ties with the greater Caribbean region, much more so than its Spanish-speaking neighbors. This dual nature is not only present in Belize's culture, but also in its regional geopolitical ties. Belize is the only nation that is part of both the Caribbean Community of Nations (CARICOM) as well as the Central American System of Integration (SICA). Belize's fisheries sector is more similar to that of a typical Caribbean nation than to its Central American neighbors. A significant contributing factor to this dynamic is that Belize was a British colony, and remains part of the Commonwealth, whereas other Central American countries are former Spanish colonies. As a result, Belize's economy, system of government and social structure have their roots in the British system. It is also the only Central American country whose national language is English (although many Belizeans also speak Creole as well as some Spanish). The resulting language barriers, as well as an unresolved territorial dispute with neighboring Guatemala, have likely also contributed to this dynamic.

Recent immigration has transformed Belize's economy and culture. There have been heavy influxes of migrants from El Salvador and Guatemala fleeing civil war and poverty over the last two decades, leading to a gradual transformation of culture, language, ethnicity and economic activity. It is easy to see why residents of neighboring countries would be tempted to go to Belize. It has a higher living standard than four other Central American countries and is ranked 110 out of 189 countries and territories in the world on the United Nations Development Programme (UNDP) Human Development Index (HDI), with a 2019 HDI value of 0.716. As such, it is categorized as a High Human Development country[2]. Its score places it below the Dominican Republic (ranked 88) and Jamaica (101) and above El Salvador (124), Guatemala (127), Nicaragua (128) and Honduras (132) (UNDP 2020a).

However, Belize's high overall living standard masks some declines in economic and social conditions. After a period of rapid economic growth in the 1980s when real gross domestic product (GDP) growth exceeded 10 percent per year, Belize's economy began to slow down in the 1990s (Carneiro 2016). Growth continued into the 1990s as Belize's HDI score generally trended upwards with an overall increase of 9 percent but has plateaued since 2011. In 2015, Belize's gross national income (GNI) per capita reached a peak of 6,846[3] (UNDP 2020b). Since 2015 there has been a gradual decline and, in 2019, the GNI per capita was 6,382. A high level of vulnerability to natural disasters, plus a high dependence on foreign trade has made volatility one of the hallmarks of Belize's economy. For example, from 1994 to 2013, weather-related disasters contributed to an average annual loss of approximately four percent of Belize's GDP (Carneiro 2016).

Furthermore, assessments by multilateral institutions like the World Bank conclude there is clear evidence of an increase in poverty levels, despite limitations in quality and quantity of data (Carneiro 2016). GDP growth was at 3.2 percent for 2018 and growth for 2019 projected at 1.5 percent (IMF 2019). There is persistent

2 The UNDP defines this as a Human Development Index score between 7.00 and 7.99

3 The standard of living is measured by Gross National Income (GNI) per capita expressed in constant 2017 international dollars (USD) converted using purchasing power parity (PPP) conversion rates (UNDP 2020b).

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geographic variability in poverty rates across Belize. This includes a dramatic rural poverty level of 55 percent of the population in 2009, compared with only 28 percent in urban areas in the same year (Carneiro 2016). The 2010 census found the Toledo District to have the highest incidence rate of poverty, 60 percent of the population, followed by Corozal (56%), Stann Creek (44%), Orange Walk (43%), Cayo (41%) and Belize District (29%) (MEDCICP 2010). In 2019, the Inter-American Development Bank's (IDB) Belize poverty mapping study using satellite imagery and existing survey data found that Toledo and Corozal districts were the poorest in the country with Stann Creek and Orange Walk districts showing a reduction in poverty over the last decade (Hersh et al. 2020).

Economy & Trade

Belize's marine and coastal resources contribute to its economy in several important ways, such as supporting thriving fishing and tourism industries and offering protection from natural disasters. In 2009, it was estimated that these resources contribute between 15 and 22 percent of Belize's GDP (Carneiro 2016). In 2019, the tourism and seafood production sectors contribution had increased to 30 percent of Belize's GDP, however, the fishery sector accounted for only 1 percent of GDP (SIB 2019a).

The International Monetary Fund (IMF) classifies Belize as a highly open economy, meaning it has a high volume of trade in goods and services, in total, and as a percentage of GDP (IMF 2011). Belize's open economy is primarily import-driven and it maintains a high trade deficit in comparison with its regional peers. In 2019, Belize imported 1.9 billion BZD (1 USD = 2 BZD) worth of goods, while exporting only 414 million BZD (SIB 2019a). This allows Belize to provide a wide variety of products and services to its citizens at a reasonable cost, but it has also made the Belizean economy more vulnerable to variations in exchange rates and tariffs.

For the period 2014 to 2019, Belize's primary trade partners were the United States (U.S.), for its imports, and the United Kingdom (U.K) for its exports (SIB 2016; SIB 2019a). In 2019, the U.S. sold 44 percent of Belize's imports, and the U.K. bought 39 percent of its exports (SIB 2019a). Belizean products have duty-free access to the market through the Caribbean Basin Initiative, so they can enter the U.S. and be sold free of import tariffs (Villanueva 2014). Belize is also a member of the CARICOM Single Market and Economy (CSME), an agreement that provides for the free exchange of goods and services and eased labor movement between the 15-member Caribbean states. In 2019, CARICOM accounted for 20.6 percent of Belize's exports, second to the U.K., but only 2.4 percent of Belize's imports (SIB 2019a). In terms of trade openness, Belize is more closely integrated with Caribbean states than its Central American neighbors.

Export diversification remains a challenge for Belize. Primary products, like crude oil, sugar and fruit juices make up the majority of export products, over 50 percent, followed by resource-based products, like chocolate and food condiments, which make up roughly 30 percent (Carneiro 2016). However, export earnings from primary products and agricultural goods (which include marine products) are insufficient to create an economic platform for sustained growth. They are subject to high variability, both in terms of productivity, which depends on

stable climatic conditions, and in terms of global market prices, which can undermine stability in the economy (Villanueva 2014). Tourism is one area that shows a high level of growth potential and may help mitigate these risks.

SEAFOOD PRODUCTION'S CONTRIBUTION TO BELIZE'S GDP

In 2019, seafood production (capture fisheries and aquaculture) contributed approximately one percent of annual GDP, or an estimated 27.7 million BZD in revenue, the second lowest revenue contribution over the last ten years (SIB 2021a) (Table 1). This reflects a 78 percent decline in revenue compared to 2014, when seafood production revenue peaked at 128 million BZD (SIB 2021a) (Table 1; Figure 1). Seafood production's contribution to GDP started to decline in 2015 when there was a 36% reduction in revenue contribution compared to 2014; and shrimp farming lies at the center of this volatility. In 2015, a disease outbreak infected most of the shrimp farms in Belize resulting in significant reductions in the quantity of shrimp produced that year and in subsequent years. Currently, shrimp production remains at 10% below its 2014 production level.

In 2019, seafood production reflects a 78 percent decline in revenue compared to 2014

It is important to note that production data is reported by the national fishing cooperatives and does not include fish sold directly to consumers, to restaurants, to private companies licensed for export, or caught by independent fishers who are not members of a cooperative. Due to incomplete data collection, official statistics of seafood production and value are significantly underestimated. In fact, catch reconstruction estimates by the Sea Around Us[4] suggest that total actual catch could be approximately double what is reported (Zeller et al. 2011), potentially masking significant trends in catch.

	2010^{r}	2011^{r}	2012^{r}	2013^{r}	2014^{r}	2015^{r}	2016^{r}	2017^{r}	2018^{r}	2019^{p}
GDP (TOTAL)	2,399	2,445	2,504	2,536	2,639	2,708	2,707	2,756	2,837	2,886
SEAFOOD PRODUCTION	103.7	100.2	97.6	121.9	128.0	82.6	29.4	28.6	27.5	27.7
PERCENT OF GDP	4.3	4.1	3.9	4.8	4.9	3.0	1.1	1.0	1.0	1.0

Table 1: Belize total gross domestic product (GDP) and proportion generated by seafood production (2010 – 2019) in millions of Belize dollars (BZD); r-revised; p-provisional.

Sources: SIB 2021a Statistical Institute of Belize: GDP by Activity 1992 to 2019; SIB 2021b – SIB: Percent of Total GDP by activity 1992 to 2019. (http://www.sib.org.bz/statistics/gross-domestic-product);

4 The Sea Around Us uses the "catch reconstruction" (Pauly and Zeller 2016) approach, compiling a wide variety of data and information sources to estimate fish catches missing from officially reported statistics. Data for Belize and other countries can be accessed at: http://www.seaaroundus.org/data/#/eez

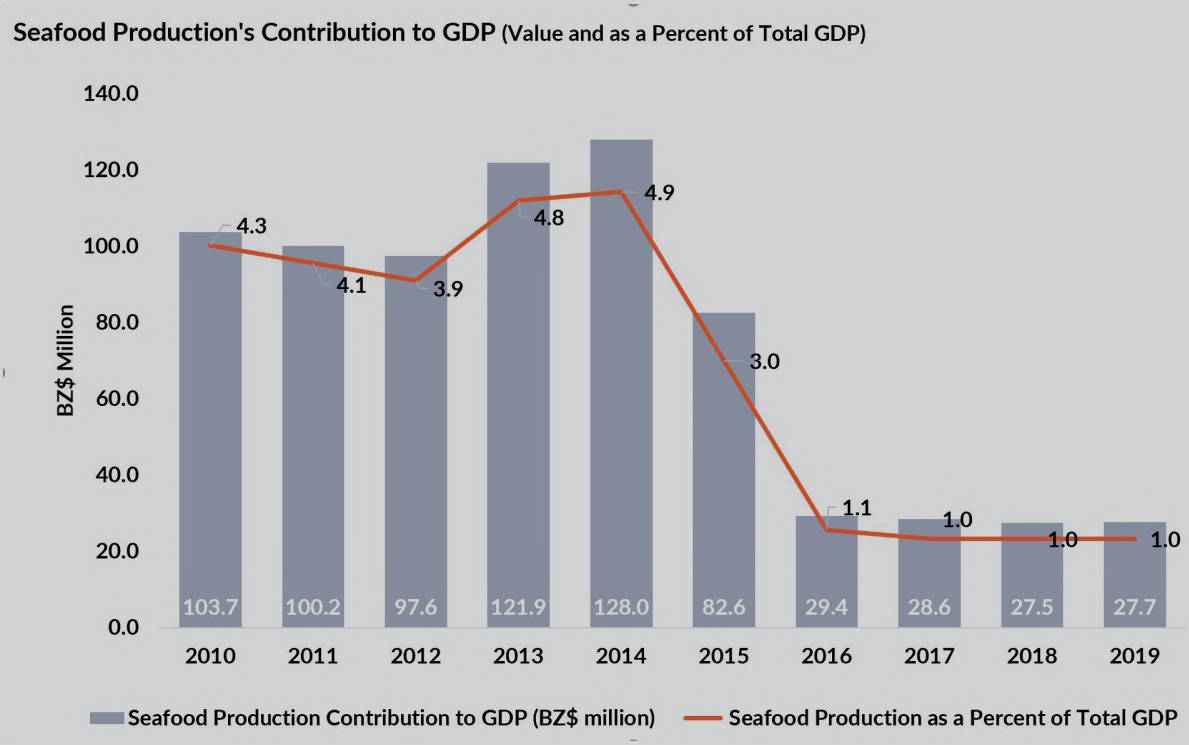


Figure 1: Seafood production's contribution to Belize's gross domestic product (GDP) for the period 2010 to 2019 expressed as value (BZD million) and as a percent of total GDP. (Source: SIB 2021a; SIB 2021b)

Relative contribution of seafood production to GDP is related, at least in part, to the status of fishery resources in the country. Jamaica has a long history of overfishing, and its depleted stocks have yet to recover, meaning they are not contributing their full potential as an economic resource. In Belize, despite the reduction in shrimp production, the two main fisheries for conch and lobster are still relatively healthy, so the fisheries sector still contributes to the economy; although with better management their future contribution will be sustained.

TOURISM DRIVES BELIZE'S ECONOMY

Tourism is one of the largest sectors contributing to Belize's GDP (Metzgen 2014; Chow 2019). In 2019, tourism comprised approximately 17 percent of employment and contributed 29 percent to GDP (SIB 2019a). That same year, approximately 503,000 overnight tourist arrivals were recorded of which 65% were from the U.S.. Cruise tourism also continues to rise steadily, and in addition to overnight tourists, 1.2 million cruise ship tourist arrivals were also reported in 2019 (SIB 2017; SIB 2019a) (Figure 2).

Tourism also accounted for about 40 percent of the total exports (the amount of Belizean goods and services purchased by citizens of other countries) between 2008 and 2012 (Nuenninghoff et al. 2015). Tourism activity is concentrated in the areas of San Pedro, Caye Caulker, San Ignacio and Placencia. Interestingly, for some years, Belize was the only country in the Caribbean where both fisheries and tourism represent a high percentage of GDP, pointing to the unique value and productivity of the coastal ecosystem that Belize possesses.

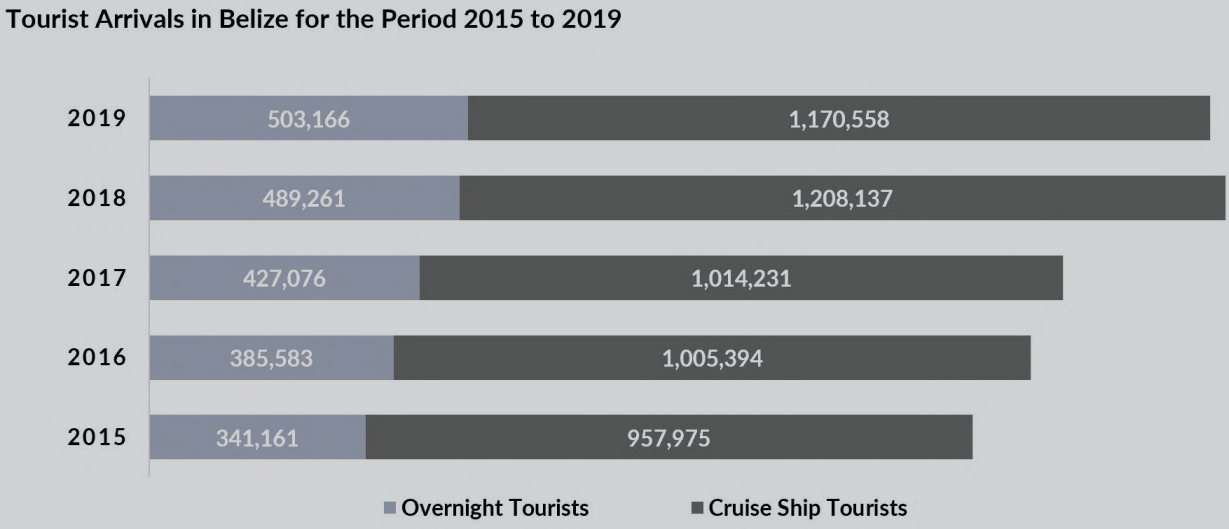


Figure 2: Overnight and cruise ship tourist arrivals in Belize for the period 2015 to 2019. Source: SIB 2017; SIB 2019a.

The Government of Belize (GOB) has targeted tourism as a lever for future economic growth in the country, leading to significant attention in the form of foreign direct investment. This development in the tourism sector is being guided by the 2012 to 2030 National Sustainable Tourism Master Plan (BTB and MTCAC 2011). Cruise ship tourism is expected to increase with the construction of additional facilities in southern Belize, for example. Some civil society organizations, however, have expressed concern that the drive to develop tourism infrastructure poses a threat to the health of natural resources (many of the popular tourism destinations are in ecologically vulnerable areas) and increases local costs of living. These concerns are rooted in past experience, as some recent developments have resulted in increased sedimentation and the clearing of mangrove forest (Brune and Sanders 2008).

CONCH AND LOBSTER: TRADITIONAL TRADE

Marine products were the country's largest export sector in 2014, in terms of value, overtaking crude petroleum (SIB 2016). This is in stark contrast to the recent past; in 2010, the value of marine product exports lagged behind crude petroleum, sugar, bananas and orange concentrate. In 2014, combined export from capture fisheries and aquaculture production generated an estimated 113 million BZD in revenue (SIB 2016). Due to the reduction in shrimp production (Figure 3), however, marine export revenue decreased to 88 million BZD in 2015 (SIB 2016); with a further reduction to 42 million BZD in 2016 (SIB 2018).

The farmed shrimp industry has not recovered and since 2016, wild-capture[5] species have dominated exports. Since 2019, marine product export revenue from wild-capture has increased to 43 million BZD (Figure 4), primarily due to increases in the export values of lobster (tails, whole and head meat) and conch (Figure 5) (SIB

5 Wild-capture products include: lobster tail, whole lobster, lobster meat, conch, whole fish, fish fillet and crab.

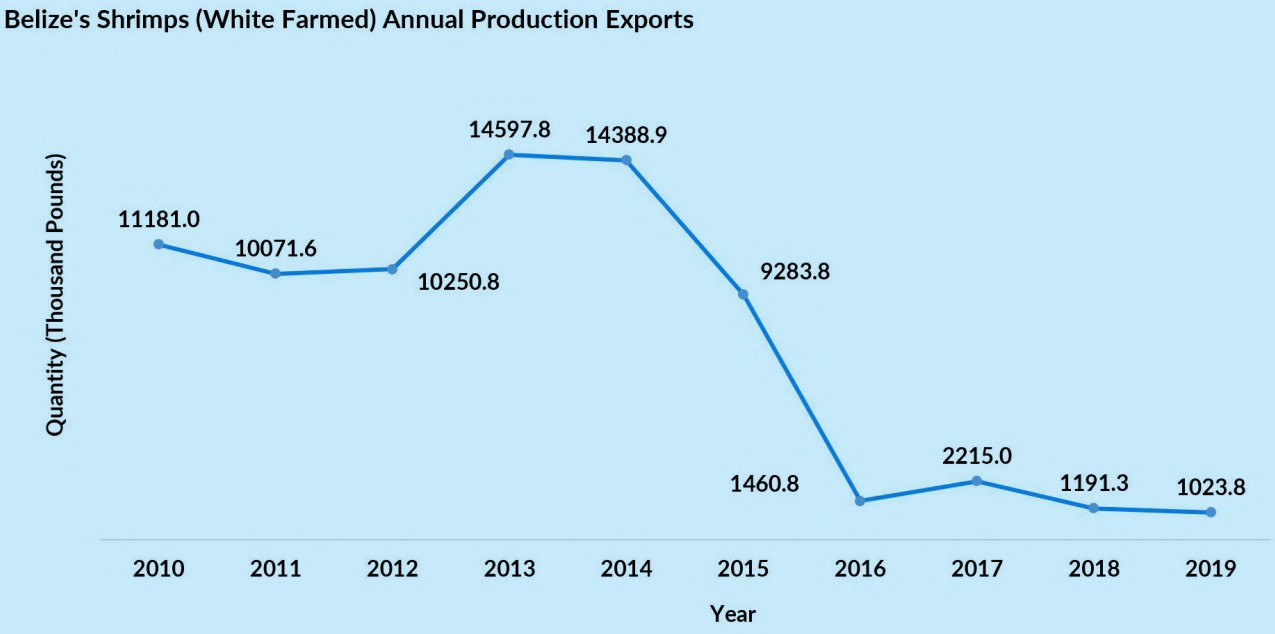


Figure 3: Belize's Shrimps (White Farmed) Annual Production Exports for the period 2010 to 2019. Source: SIB 2019b.

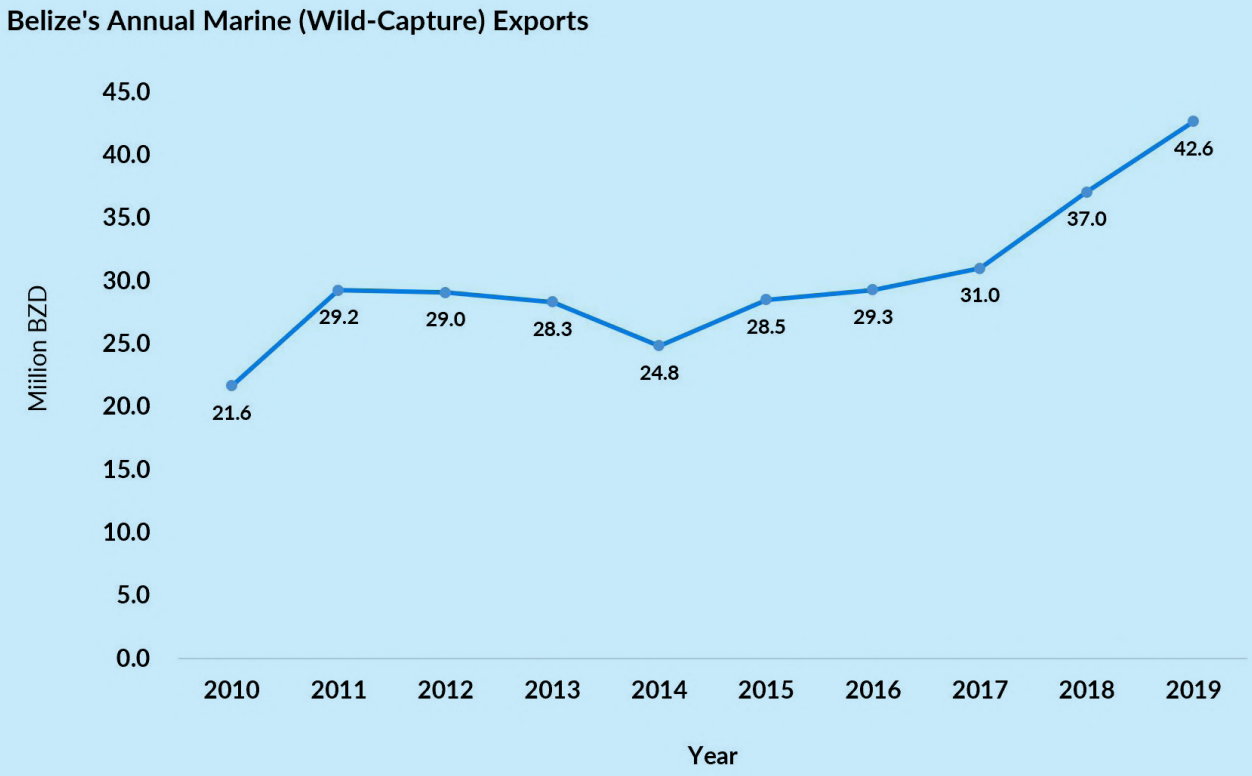


Figure 4: Belize's Marine Products (Wild-Capture) Annual Exports Value (BZD) for the Period 2010 to 2019. Source: 2019b.

2019a). Indeed, spiny lobster and queen conch are the two most lucrative seafood exports. In 2019, lobster and conch combined accounted for 99 percent of marine wild-capture export revenues, with lobster accounting for 64 of the 99 percent (SIB 2019a). Over a seventeen-year period (2003 to 2019), the highest export revenue values for lobster and conch were reported in 2019 with revenues of 27 million BZD and 15.4 million BZD, respectively (SIB 2019b).

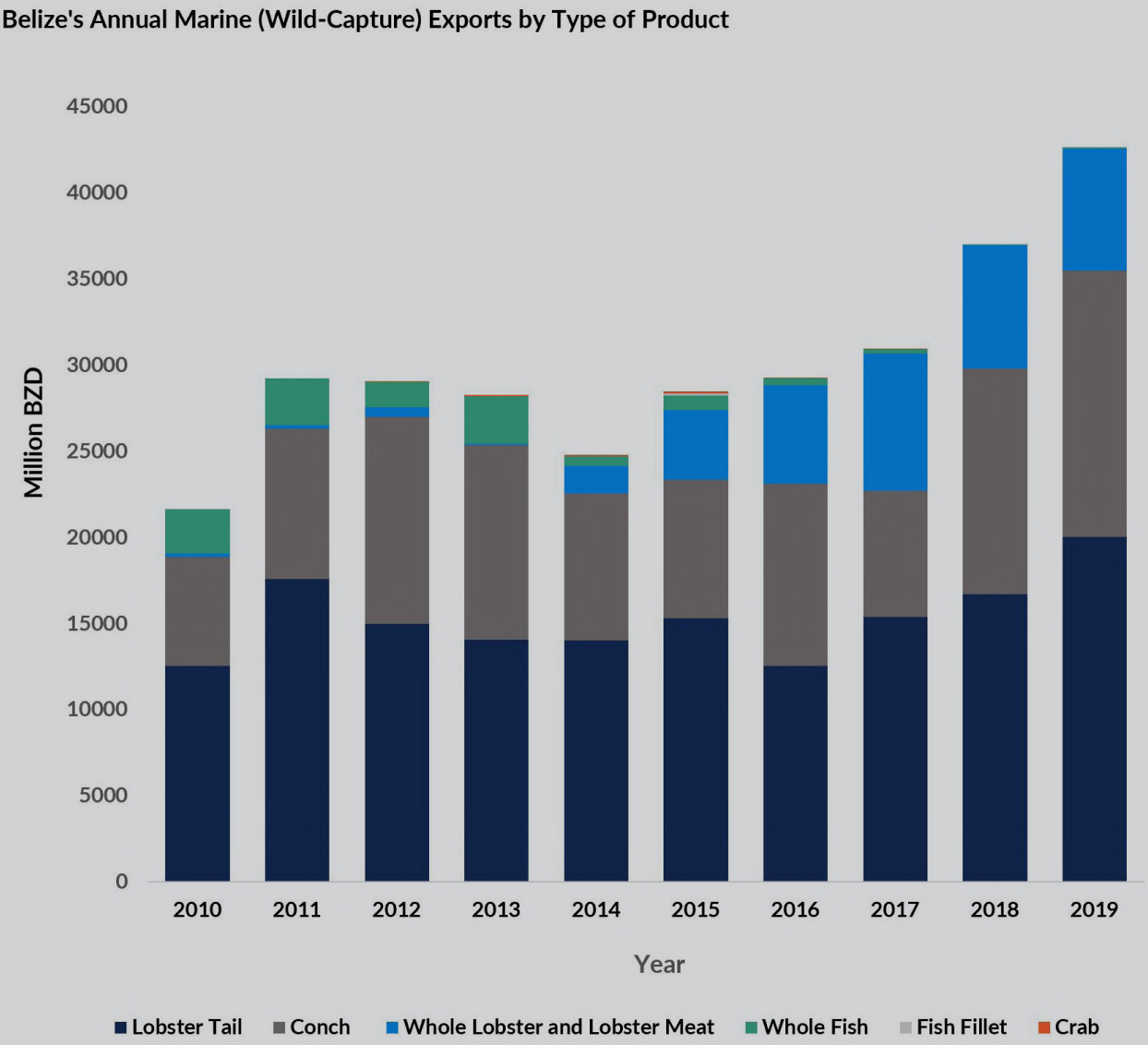


Figure 5: Belize's Annual Marine (Wild-Capture) Exports by type of product for the period 2010 to 2019. Source: SIB 2019b.

Currently, only fishing cooperatives and two private companies are eligible for lobster export licenses. The Northern and National Fishermen Cooperatives, the two largest in the country, have certified processing plants that process lobster products for export. The smaller southern cooperatives deliver their products to one of these plants for export (Villanueva 2014). Lobster is processed and sold as whole lobster, tails or head meat.

Finfish are also exported to foreign markets, but this has exhibited a downward trend in recent years, reflective of both declining catch and a declining export market (Wildtracks 2011; SIB 2019b) (Figure 6). The largest exporter of wild-caught finfish is Rainforest Seafood Ltd, a private, Jamaican-owned corporation. The peak production, based on these two cooperatives, occurred in 1983 with over 1 million pounds (whole fish). It has fluctuated widely in the years since, but shown a general trend of decline, reaching just 342,000 pounds in 2014 (Villanueva 2014). Export records similarly show a declining trend. The same cooperatives report exporting 392,000 pounds of whole fish in 1990 and only 275,000 pounds in 2014 (Villanueva 2014). In 2019, an estimated 61,000 pounds of whole fish were exported (SIB 2019b) (Figure 6). Additional wild-caught export products include sea cucumber, stone crab and tropical fish for the aquarium trade, while farmed shrimp and tilapia are the two major exports from the aquaculture sector. The main international markets are the United States, Mexico, Canada, Hong Kong and Caribbean countries like Jamaica and Trinidad and Tobago (Masters 2014).

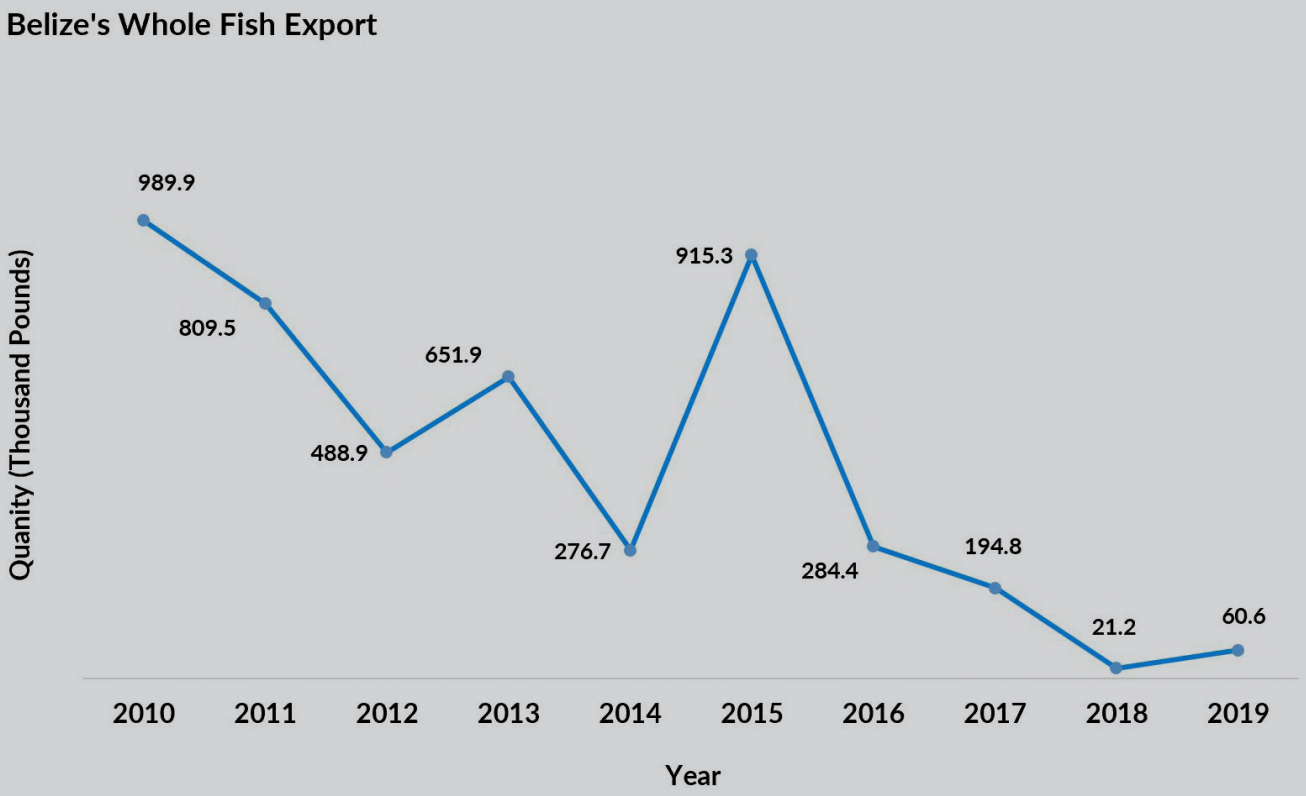


Figure 6: Belize's Whole Fish Export (Quantity – Thousand Pounds) for the period 2010 to 2019. Source: SIB 2019b

The Domestic Seafood Economy: Invisible, but Tangible

FINFISH ARE AN IMPORTANT PART OF LOCAL MARKETS AND DIETS

The bulk of marine products harvested in Belize are sold on the export market. This is especially true for lucrative species like conch and lobster, although there is still some amount of local consumption. Approximately 80 percent of conch and lobster are exported through cooperatives with the remaining 20 percent sold for local consumption (Wildtracks 2011). In the lobster fishery, there is a statute in place that requires Belizean cooperatives to sell a minimum of five percent of catch domestically (Wildtracks 2011; Villanueva 2014). However, to date, no consistently reliable data exists on the proportion of other seafood products retained for local consumption, although estimates do exist. According to the Seas Around Us (SAU), 21.3 percent of fish catch in 2014 was classified as subsistence catch, which includes catch taken home for consumption and locally traded or bartered (SAU 2016).

Based on the level of artisanal fishing, it is likely that a significant proportion of finfish landed are sold directly to consumers. The largest domestic market is in Belize City which, in 2008, accounted for 65 percent of sales by volume from major fish markets (Corozal, Dangriga, Punta Gorda and Belize City) (MAF 2009). Official statistics put marine finfish production at more than 360,000 pounds (primarily whole fish); however, this does not account for a significant portion of production that is sold directly or kept for personal use (Villanueva 2014). The Belize Fisheries Department (BFD) relies heavily on fishing cooperatives to collect production data, therefore, finfish data have the highest risk for underreporting of total production.

Due to the amount of seafood available domestically, fish is likely an important source of food security in Belize and has high potential for growth. In coastal communities throughout Belize, fish (especially from small-scale subsistence fishing) can serve as an important source of key micronutrients for the Belizean population, of which about 6 percent is undernourished (FAO, IFAD, WFP 2015). A 2012 report from the Caribbean Regional Fisheries Mechanism (CRFM) found that Belizeans consume about 7 kg/capita/year[6] (Masters 2014). While this is low compared to the global average of 20 kg/capita/year (FAO 2018), the relative contribution of seafood is

6 Because calculations for seafood consumption likely rely on official fishery production and export statistics, which do not account for the unrecorded local consumption, it is potentially severely underestimated. It is unclear to what extent similar data gaps exist for other countries in the region.

high, amounting to about 12 percent of animal-based protein consumed by Belizeans (Golden et al. 2016). Just as other aspects of Belizean culture strike a middle ground between Caribbean and Central American traditions, seafood consumption in Belize, too, is low compared to its Caribbean neighbors (for example, fish compose 20 percent of animal protein eaten in Barbados and Grenada, and 10 percent in Haiti) yet high by Central American standards (fish compose just one percent of animal protein in both Guatemala and Honduras) (Golden et al. 2016).

However, country-level statistics likely mask regional dynamics within Belize, wherein small-scale fishing communities are heavily reliant on seafood for food security. Coastal Belizean households are disproportionately poor. A study conducted in 2012 by CRFM found that, of the 10 CARICOM countries studied, Belize had the second highest percentage of poor and vulnerable fishing households. At the local level, the Toledo district showed the highest incidence rate of poverty with 17 percent of fishing households classified as poor or vulnerable (CRFM 2012). Healthy, well-managed fisheries could provide low-cost and high-quality animal protein while also offering one potential opportunity out of the poverty trap for generations of Belizeans.

FISHERIES ARE INTEGRAL TO THE ECONOMY

Across the Caribbean, fisheries are well-documented as a source of employment. In 2016, approximately 500,000 people in the region were employed in the fisheries sector, either directly or indirectly (CRFM 2018[7]). This number represents close to six percent of the region's workforce. In Belize, nearly 13,000 people benefit economically from the fishing industry (Gongora 2012b). In 2019, this included approximately 3,400+, predominantly small-scale, fishers operating across the country (Press Release -Ministry of Blue Economy's Position on S.I. No. 57 of 2021). Fishing closures for commercially targeted species are staggered in Belize, allowing fishermen to operate year-round. Over 90 percent of these registered fishers participate in the conch and lobster fisheries, meaning that only 10 percent of registered fishers fish exclusively for finfish, sharks or sea cucumbers (McDonald et al. 2017).

Most of the fishers in Belize belong to one of the four main fishing cooperatives distributed across four regions: Northern Fishermen Society Cooperative Ltd., National Fishermen Producers Cooperative Society Ltd., Placencia

7 Calculated using "Some estimates indicate that, for each person employed in capture fisheries and aquaculture production, about three jobs are produced in the secondary activities" (FAO 2010 in CRFM 2018).

Producers Cooperative Society Ltd. and Rio Grande Fishermen Cooperative (Table 2).

COOPERATIVE	HEADQUARTERS	MEMBERSHIP[8][9]	EXPORT LICENSE
Northern Fishermen Society Cooperative Ltd.	Belize City	1,231 (611 active)[8]	Lobster, Conch
National Fishermen Producers Cooperative Society Ltd.	Belize City	531 (all active)[8]	Lobster, Conch
Placencia Producers Cooperative Society Ltd.	Placencia, Stann Creek	41[9]	Lobster
Rio Grande Fishermen Cooperative	Punta Gorda, Toledo	40[9]	Whole Lobster, Finfish, Sea Cucumber

Table 2: Belizean fishing cooperatives and membership.

Processing facilities are a growing sector of the fisheries economy. These plants freeze, fillet and pack finfish, lobster and conch for export. From 2009 to 2017 (the years the sea cucumber fishery was open), additional facilities existed for salting and boiling sea cucumber. The Belize Fisheries Department reports the four fishing cooperatives employ at least 137 people for processing, packaging and administration (Villanueva 2014). This figure does not include employment by private corporations. Given the relative scale of fishing in Belize, upstream activities are likely a small component of fisheries employment. A 2012 study found about 51 percent of each boat's costs are spent on fuel, 19 percent on crew wages and 9 percent on ice, with the remainder used to pay cooperatives' fees, oil, bait, licenses and on the maintenance of boat and gears (Masters 2014). While most fishers repair their own gear, there is a cottage industry of boat and engine repair along with some large boat yards in the country.

The total economic contribution of the fishing industry is not captured fully through direct impact measures like total revenues and employment. Its impact begins before fishing even takes place, when fishing gear is bought or made and boats are made and repaired, or after fishing takes place when fish is cleaned and processed. These effects are captured through an instrument known as multipliers. Economic multipliers provide quantitative estimates of how changes in the fishing sector affect overall economic activity, while income multipliers refer to changes in income and employment. According to a global economic impact study of ocean fisheries conducted in 2010, fisheries in Belize exhibit multipliers valued at 3.46 for economic impact (Dyck and Sumaila 2010; Masters 2014). This means that, to account for the real impact of fishing, every dollar made by the sale of fish dockside should be multiplied by 3.46 to know its total economic impact. For context, Belize's multiplier of 3.46 was the 12th highest multiplier of the countries studied (Dyck and Sumaila 2010).

The valuable tourism industry also depends on healthy marine resources. In recent years, Belize has capitalized on the global growth of the eco-tourism market, especially marine eco-tourism. One study estimates that, in 2010, marine eco-tourism provided 4,000 jobs and generated 128 million BZD in direct revenues - roughly 20 percent greater than the reported revenue from commercial fishing (Cisneros-Montemayor et al. 2013). A case study conducted in Turneffe Atoll found that the total expenditures from tourism dwarfed commercial fishing

8 Source: pers. comm. Belize Dept of Cooperatives staff, 10 Feb., 20

9 Source: Villanueva 2014

In 2015, more than half of all tourists to Belize visited the Belize Barrier Reef and 42 percent of tourists visited a marine protected area

revenue, contributing nearly 26 times more to the local economy[10]. Both the fishing and tourism industries rely heavily on healthy marine resources. In 2015, more than half of all tourists to Belize visited the Belize Barrier Reef and 42 percent of tourists visited a marine protected area (MPA) (BTB 2016). The Belize Tourism Board (BTB) found snorkeling, diving and fishing to be popular activities among tourists from all regions with an average of 70, 30 and 20 percent of all tourists participating, respectively. In the survey section gauging tourist satisfaction, marine attractions rated higher than any other category with 90 percent of tourists assigning a "good" score—the highest score in the survey (BTB 2016).

The sport fishing industry is also a key driver of tourism and local revenue for several coastal communities. Famous for bonefish, permit and tarpon, Belize has become a premier destination for recreational saltwater fly fishing, a catch-and-release industry. A 2013 study found that sport fishing for bonefish, permit and tarpon accounted for 41 million BZD in direct expenditures with an additional 70 million BZD in associated indirect spending (Fedler 2014). The industry generates significant employment as well as offering a culturally compatible alternative income source to many commercial fishers. Often these small coastal communities with access to rich natural resources have few opportunities for income diversification. Further development of eco-tourism that employs and benefits people from local communities, particularly sport fishing tourism, provides opportunity for alternative and supplemental livelihoods for communities traditionally dependent on fishing. Whenever possible, the benefits from increased eco-tourism development should be linked to poverty alleviation and gender equity. Local participatory governance helps to ensure more equitable development and distribution of these benefits (Neuninghoff et al. 2015).

DEBT AND HURRICANES LOOM, BUT IT COULD BE WORSE

By almost any account, the main challenge facing the Belizean economy is its mounting debt crisis. Public debt was above 90% of GDP in 2019 (IMF 2019). While there are a variety of root causes, poor fiscal policy, reduced commodity exports (especially of oil and marine products) and natural disasters are major contributors to Belize's national debt. Unfortunately, Belize is not alone in this crisis, which affects the wider Caribbean region and has been growing for the past few years, in some cases as far back as 1980. The ratings firm Moody's has described this as the "Caribbean's Silent Debt Crisis", in that "...the build-up of debt in the Caribbean region has been neither sudden, nor caused by the global financial crisis. Instead, it happened gradually over many years" (Moody's 2016).

The Coronavirus disease (COVID-19), an infectious disease caused by the coronavirus, was declared a pandemic by the World Health Organization (WHO) on 11th March, 2020. The stringent measures such as lockdowns that were put in place to prevent the spread of COVID-19 negatively impacted industries such as tourism. In Belize, the closure of cruise ship ports in March 2020 resulted in a 71 percent decrease in cruise tourist arrivals in 2020 compared to 2019 (BTB 2021). Overnight tourist arrivals also experienced a 71 percent decline from 2019 to 2020 (BTB 2021). The Belizean economy was significantly impacted as the tourism sector contributes to 40% of GDP and 60% of foreign exchange earnings (IMF 2021).

10 Calculated from Fedler 2011.

The preliminary estimates for revenue derived from seafood production show that in 2020, Belize earned 20.2 million BZD, a decrease of 27% compared to 2019 (SIB 2020b; SIB 2021a). Lobster tail exports, the highest seafood revenue generator, increased by 5 percent to 21.1 million BZD in 2020 (SIB 2020b; SIB 2021a). Conch export revenue, however, decreased by 37 percent from 15.4 million BZD in 2019 to 9.7 million BZD in 2020 (SIB 2020b; SIB 2021a). On the domestic front, the decline in tourism activity triggered the closure of many restaurants and hotels in popular tourist destinations such as San Pedro Town and Caye Caulker Village, negatively impacting the fisherfolks who supply seafood to these establishments (Burns Perez 2021). Overall, the decrease in government revenue and an increase in expenditure to implement measures to address the pandemic exacerbated the debt crises with public debt projected to increase from 98 percent of GDP in 2019 to 126 percent in 2020 (IMF 2021). The economic downturn may be felt for many years, with projections of real GDP 2019 levels not being seen until 2025 (IMF 2021).

A higher than normal vulnerability to weather phenomena make Belize's debt a worsening concern, especially given the importance of Belize's tourism and fishing industries and overall dependence on export of primary goods. The country's GDP output declined by 0.8 percent in 2016, partially due to the destruction of crops by Hurricane Earl that year (IMF 2017). This has further deteriorated the debt-to-GDP ratio, which was 92.3 percent in 2017 (IMF 2019). Unfortunately, this is not new. Like many countries in the region, Belize has a long history of crippling natural disasters. The most recent example before Earl was in 2007, when Hurricane Dean made landfall in northern Belize and caused between 160-200 million BZD in damages, or between six to eight percent of GDP.

As bad as these disasters are, they would be much worse if not for Belize's rich marine and coastal ecosystems

As bad as these disasters are, they would be much worse if not for Belize's rich marine and coastal ecosystems. These natural resources are the country's first line of defense against climate-related impacts, which are only projected to worsen in the coming years. Belize's coral reefs and mangroves not only support its fishing industry and attract thousands of visitors every year, but they also provide protection from the impact of major storms by greatly reducing the size and force of the waves that reach the shore. The World Resources Institute (WRI)

estimated that, in 2009 the overall value of these services was between 1.58 billion -to 2.24 billion BZD a year (Cooper et al. 2009). This value most likely increased in the years since then due to higher risk of damage (more severe and frequent extreme weather events) and greater exposure (increased development and investment along the coasts). As the third most vulnerable country to natural disasters among Small Island Developing States (IMF 2016), these ecosystem services are important considerations as well (Carneiro 2016).

Discussion

The recent downturn in Belize's economy and the added challenges associated with climate change emphasize that the road to economic prosperity for Belize will not be easy. However, protecting and managing its natural resources effectively will increase resilience to climate change, natural disasters and economic variability, putting Belize on the right path to a sustainable future.

Fishing is part of the Belizean DNA. It is a valued cultural tradition and an important source of food and income for many coastal communities. And yet, as is the case with small-scale fisheries around the world, the lack of accurate statistical data, particularly for local domestic consumption, has contributed to a persistent undervaluation of its impact on Belize's national economy. Therefore, Belize's capture fisheries' contribution to its GDP, is likely an underestimate of its overall importance to the country. There is overwhelming evidence of the indirect value of sustainable fisheries and a healthy marine environment to the overall quality of living for many Belizeans.

There are large economic sectors, such as commercial fishing, sport fishing and non-extractive marine tourism (i.e. diving), that depend on healthy oceans to exist, and that often stand in competition with each other. For example, thriving oceans drive the sustained growth of tourism in Belize, which is welcome and desirable. However, increases in tourism also drive greater demand for seafood in restaurants and hotels as well as increasing recreational fishing, which, if unchecked, can cause harm to marine ecosystems. This underlying economic tension is not unique to Belize, but it does create a complex policy landscape, where needs of specific people and sectors must be balanced with the collective national interest.

On the surface, this appears to be yet another variation of the ongoing "development versus. environment" dilemma. Upon closer inspection, however, there are opportunities to mitigate this dilemma and, more importantly, identify win-win solutions. Healthy oceans and healthy fish populations are the foundation of Belize's economic activity. Without healthy oceans, Belize would lose its constant stream of international visitors, a source of income and a hallmark of its cultural identity. Perhaps most critically, without healthy oceans, Belize would lose its most important line of defense against storms and hurricanes, which are widely projected to become stronger and more frequent in the future. Belize's ocean is its bloodline, and its protection must be a top priority.

Wilfredo Alamilla, Fisherman

“For the love of fishing”

– words from the wise

“When I was a child a teacher used to ask me what I want to be when I got older. And it was always my dream to be a fisherman. That was my desire, my first love.”

These are the words of Wilfredo Alamilla, who has been fishing the waters off South Ambergris Caye for over 60 years. During his lifetime, he has seen the fishing business evolve from what he describes as a “simple life” to an industry facing many challenges.

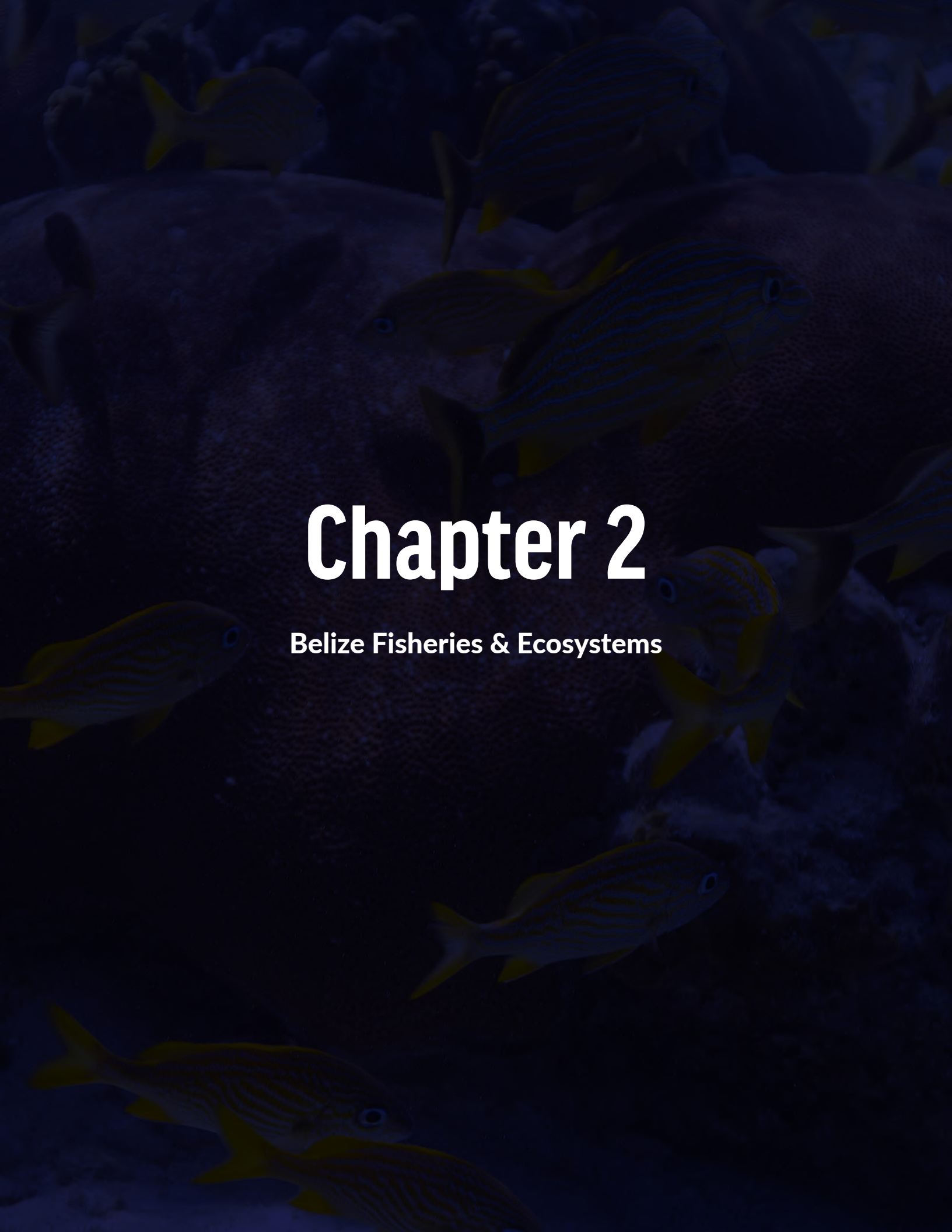
As a young fisher, Alamilla worked with his uncles, using a dugout canoe and paddle. The fishing grounds were too far away to paddle to each day, so he would spend days or weeks camping on Cangrejo Caye, selling to a passing buyer once a week. He recalls that “It was very different to how it is today”. Fishermen were very respectful to one another, and most fishers abided by the laws - protecting fish stocks for the future. Catches too, were superior at that time, and lobster fishers had the privilege of selecting the largest to sell and releasing smaller ones for another day. He describes a time when finfish were more plentiful, and had two seasons each year; one from the bay at the back of the island, and one from the front on the Mexican side. During the first cold fronts, the fish would run in great quantities through the fishing grounds, however, he believes that the setting of oil rigs in the Gulf of Mexico made this season all but disappear.

Whilst Alamilla speaks of his early fishing days with fondness, he admits that the work is easier now; he has a motorized boat and fishing trips are completed by the afternoon. Along with his eldest son, he utilizes Cuban traps and shades for lobster fishing, stone crab traps, and beach traps for finfish, but is saddened that thieves often take the beach traps, which are expensive to replace. He shares that during stormy weather, fishers reap their best catches, however, he recalls bad storms and hurricanes where he lost all his traps, and the challenges of starting all over. But this is balanced by those good seasons where he happily reaps the good catches that nature provides, adding “It is very enjoyable, when you know you can pay your bills and get a little money for savings, for future days to come”.

During his early fishing days, Alamilla would sell produce through a fishing cooperative, who had a market in Jamaica, but more recently sells to local restaurants that supply the tourism industry. Over the past year, the COVID-19 global pandemic has hit the fishers hard, and they have lost their market. Alamilla acknowledges the need for fishers to be less dependent on tourism, and suggests that the cooperative system in place when he was younger, may hold the answer. He hopes that the new government will find new ways of handling the industry to secure its future.

“I am very saddened lately because things are not going properly”. He is referring to thieves and illegal fishermen, and licensed fishers who are repeatedly breaking the laws, yet still getting their license renewal approved. He also speaks of climate change, of mangroves falling into the sea, and of the toxins released by sargassum. “I see all those beautiful times coming to an end very quickly”. He believes more interaction is needed between government and traditional fishers, with more programs, attention, and control in the waters. He adds, “I have seen it from when it was really good, and I see the opportunities it provides for people like me to make a living. If it is well taken care of, it can keep providing for us for a long time”.

For Alamilla, his childhood dream came true, and he concludes that for him, “It is about being free and having that interaction with nature. I love nature, being out there, enjoying it. For me it is fantastic doing what you love to do. I’ve been lucky, very lucky.”



Chapter 2

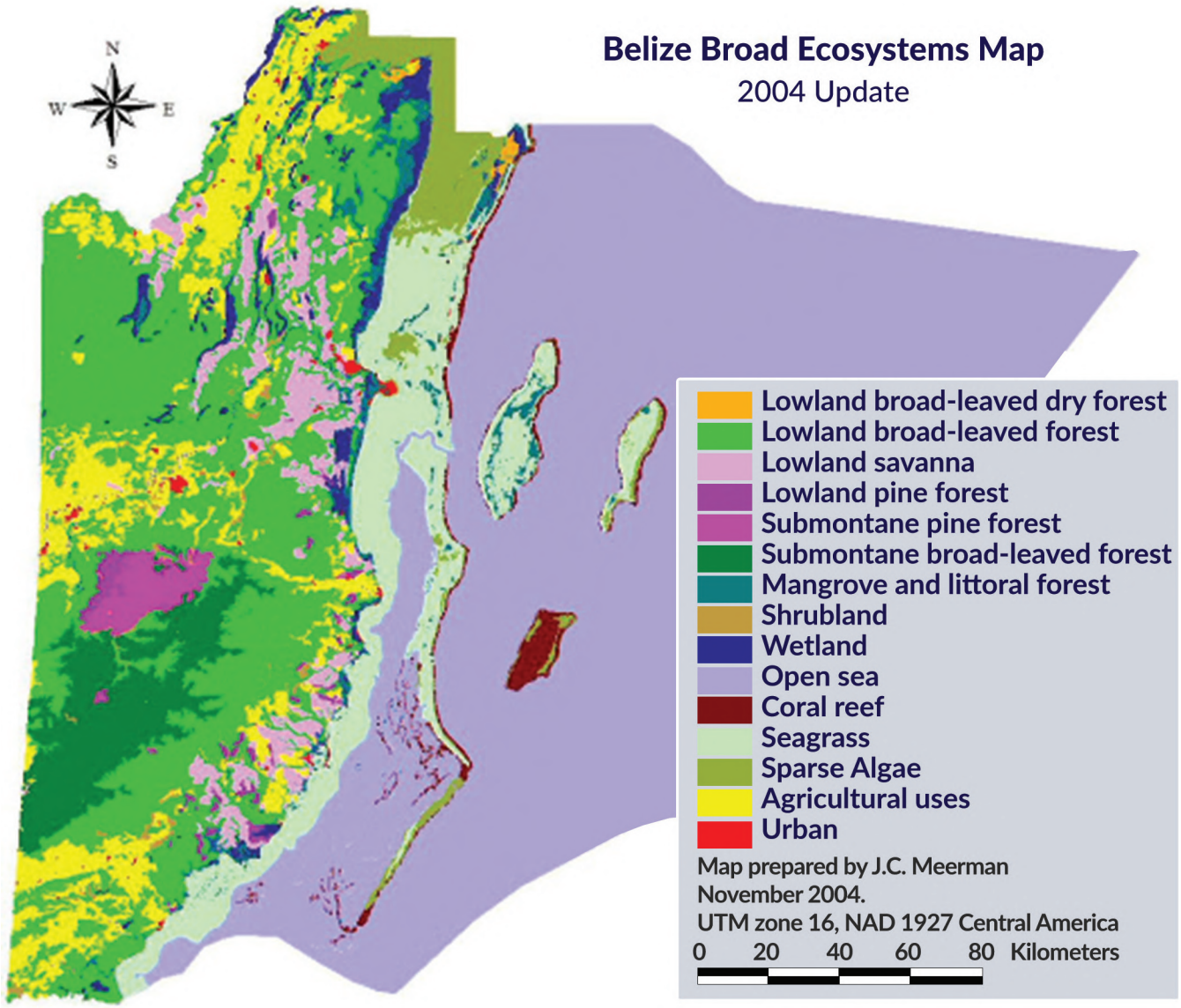
Belize Fisheries & Ecosystems

Status of Ecosystems in Belize

Heather Ylitalo-Ward

Once described as the "most remarkable reef in the West Indies" by Charles Darwin in 1842, the diverse marine habitats of Belize are crucial in maintaining the health of the entire ecosystem. Belize depends on these habitats for tourism, fisheries and shoreline protection. The categories of marine habitats found in Belize are most broadly defined as coral reefs, mangrove forests and seagrass beds (Meerman 2004)(Figure 7).

Figure 7. Map of ecosystems in Belize (Meerman 2004).



MARINE HABITATS OF BELIZE ARE DIVERSE AND PRODUCTIVE

Belize's Reefs are Many and Varied

There are three classifications of coral reefs – fringing reefs, barrier reefs and atolls – and all three are present in Belize (Wildtracks 2010a). A fringing reef is directly offshore from the mainland, with little or no lagoon between shore and reef. A barrier reef, on the other hand, is characterized by a large lagoon separating it from shore; barrier reefs run parallel to shore, forming extensive reef complexes. Atolls are roughly circular reef systems that surround large, often deep, central lagoons.

Belize is home to the longest barrier reef in the Western Hemisphere. The reef runs almost 185 miles from the northwest to the southeast and consists of fore reef, reef crest and back reef. The fore reef begins on the outer edge of the reef crest, facing the open ocean. It is here that spur and groove formations are found, which are home to innumerable invertebrates and commercially fished species such as grouper and snapper. As the reef extends towards the open ocean, the depth increases and the coral abundance decreases. The reef crest is associated with the highest intensity surf; it is home to hardy coral that can withstand breaking waves and exposure during low tide. The reef crest is also the area that is most commonly damaged in hurricanes. The back reef is protected by the reef crest and is often characterized by impressive coral formations and sponges. The back reef can also contain patch reefs of varying size. Again, these areas are home to many commercially important species such as snapper, hogfish and grunts (Wildtracks 2010a).

Three of the four atolls in the Western Hemisphere are located in Belize: Lighthouse Reef, Turneffe and Glover's Reef. Lighthouse Reef, home to the Great Blue Hole, is one of the most spectacular in the world. Lighthouse is 25 miles long and approximately 4.5 miles wide. Turneffe is the largest of the atolls, reaching a length of 30 miles and a width of 10 miles. Glover's is slightly larger than Lighthouse in area with a length of 20 miles and a width of 7 miles (Wildtracks 2010a). Around the atolls, all of the commercially important species are found: lobster, conch, sea cucumbers, snapper, grouper and other finfish (Blanco and Cho-Ricketts 2015).

In Belize, the only definitive fringing reef is at Rocky Point in Ambergris Caye. There is no lagoon between shore and reef; without a lagoon to protect fringing reefs from runoff and pollution, they are often particularly threatened by land-based pollution and development (Grimshaw and Paz 2004).

Mangrove Forests Have Many Roles

There are three species of mangrove trees and one closely associated species in Belize. These include the red, black and white mangroves, and the buttonwood tree, respectively. Mangroves are salt-tolerant trees that are found in brackish water, pure seawater or even water twice the salinity of ocean seawater. In Belize, they are found along the shores of the mainland and the cayes. There are also many mangrove islands scattered between the shore and the barrier reef (Murray et al. 2003).

Mangroves in Belize serve many functions, from filtering pollutants, dissipating the impact of waves and preventing erosion, to serving as nursery and mating habitats for countless bird, fish, and invertebrate species. They have been estimated to contribute 348-498 million BZD per year to the economy through tourism, fisheries and shoreline protection (Cherrington et al. 2010). Mangroves also contribute to carbon sequestration and their

disturbance can release large amounts of greenhouse gases (Alongi 2012).

Seagrass Beds are Important Nursery Areas

Seagrass beds are found in shallow areas with soft, sandy bottoms sheltered from strong waves and currents. They are generally found growing shoreward from the reef. In Belize two species of seagrass dominate: turtle grass (Thalassia testudinum) and manatee grass (Syringodium filiforme). Seagrass meadows are important in nutrient cycling, filtration, sediment stabilization (Wildtracks 2010a). Like mangroves, seagrass beds also warrant protection for their role as a carbon sink (Fourqurean et al. 2012). In addition, mangroves serve as habitat for many other species: a single acre of seagrass can support up to 40,000 fish and 50 million small invertebrates. The commercially important conch, lobster, tarpon, hogfish, yellowtail snapper and great barracuda use seagrass beds as important nursery areas (Wildtracks 2010a). In addition, endangered manatees and green turtles depend on seagrass beds for food. Threats to seagrass beds include dredging for land reclamation, as well as scarring from high boat activity, pollution and runoff (Vaslet et al. 2012; CZMAI 2014). Increased tourism activity may exacerbate these threats, as well as cause additional disturbance from diving or wading in seagrass meadows. Macroalgae blooms, which have plagued Belize in a number of recent years, can slow the growth of seagrass beds and inhibit their recovery (Thomsen et al. 2012; Han and Liu 2014).

DESPITE PROTECTIONS, BELIZE'S MARINE HABITATS REMAIN AT RISK

Belize's MPA network includes nine marine reserves, 11 spawning aggregation sites (6 of which are within existing marine reserves), two marine natural monuments, two marine wildlife sanctuaries, two marine national parks and two Nassau grouper and species protection sites (Figure 8; Appendix 1). Seven of the MPAs form the Belize Barrier Reef Reserve System (BBRRS) which was inscribed as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site in 1996. In 2009, the BBRRS was placed on UNESCO's List of World Heritage in Danger due to a number of threats including unsustainable development. In 2018, the BBRRS was removed from the in Danger after the GoB's implemented safeguarding measures such as a moratorium on oil exploration in Belize's maritime space. In 2019, Belize signed the '30by30 pledge', which is a call to action for world leaders to achieve a target of at least 30% of global oceans under MPA protection by 2030 (GOV.UK 2020). Currently, 21 percent of Belize's territorial sea is within a MPA (HRI 2016). The expansion of the Sapodilla Cayes Marine Reserve increased the percent of the territorial sea that is fully protected in replenishment or no-take areas[11] from 4.5 percent to 11.6 percent (GOB 2019). However, effective governance remains difficult for many reasons including limited human and financial resources to enforce fisheries regulations and lack of a monitoring and reporting system to access fishers' catch data within a reasonable timeframe that will allow for effective decision making (UNCTAD 2020). The system also suffers from a lack of trust between fishers, scientists and policy makers (Gray 2016). In addition, there are many threats to the marine habitats of Belize that are not addressed by protected areas (Young 2008).

> Seven of the MPAs form the Belize Barrier Reef Reserve System (BBRRS) which was inscribed as a United Nations Educational, Scientific and Cultural Organization (UNESCO) World Heritage Site in 1996

Once considered to have the most pristine reefs in the Caribbean, Belize experienced an ecological shift beginning in the late 1990s with a decline in coral cover and an increase in algae (McClanahan and Muthiga 1998; McField et al. 2010). Much of this shift was due to coral disease outbreaks, overfishing, sedimentation, pollution and extreme hurricanes, which devastated areas with already reduced resilience. Adding to these are the stressors of climate change, including increasing sea temperature and ultraviolet levels (WHC 2013). These stressors often lead to coral bleaching, which has been reported in Belize since 1995 (McField 2000). In 2015-2016, across the entire Mesoamerican Barrier Reef (MAR) which, in addition to Belize, includes Mexico, Guatemala and Honduras, 21 percent of corals bleached although there was no observed mortality (HRI 2018).

The Healthy Reefs Initiative (HRI)[12], which has been monitoring reef health and reef fish biomass in Belize and throughout the MAR since 2006, lists the Belize Barrier Reef overall as being in "fair" condition (Reef Health Index (RHI) of 3.0) (McField et al. 2020). Herbivorous fish biomass, particularly for parrotfish, received the only

11 In Belize, "replenishment" zone refers to the no-take areas within reserves and parks and includes both conservation and preservation zones.

12 The Healthy Reefs Initiative is one of the first efforts to develop measurable indicators of coral reef health. The Reef Health Index evaluates the ecological condition of the Mesoamerican Barrier Reef according to four key indicators – coral cover, fleshy macroalgal cover, herbivorous fish density, and commercial fish density – vital to the functioning of healthy reefs. Annual Report Cards and country Eco-Audits are available on the Healthy Reefs for Healthy People website: http://www.healthyreefs.org

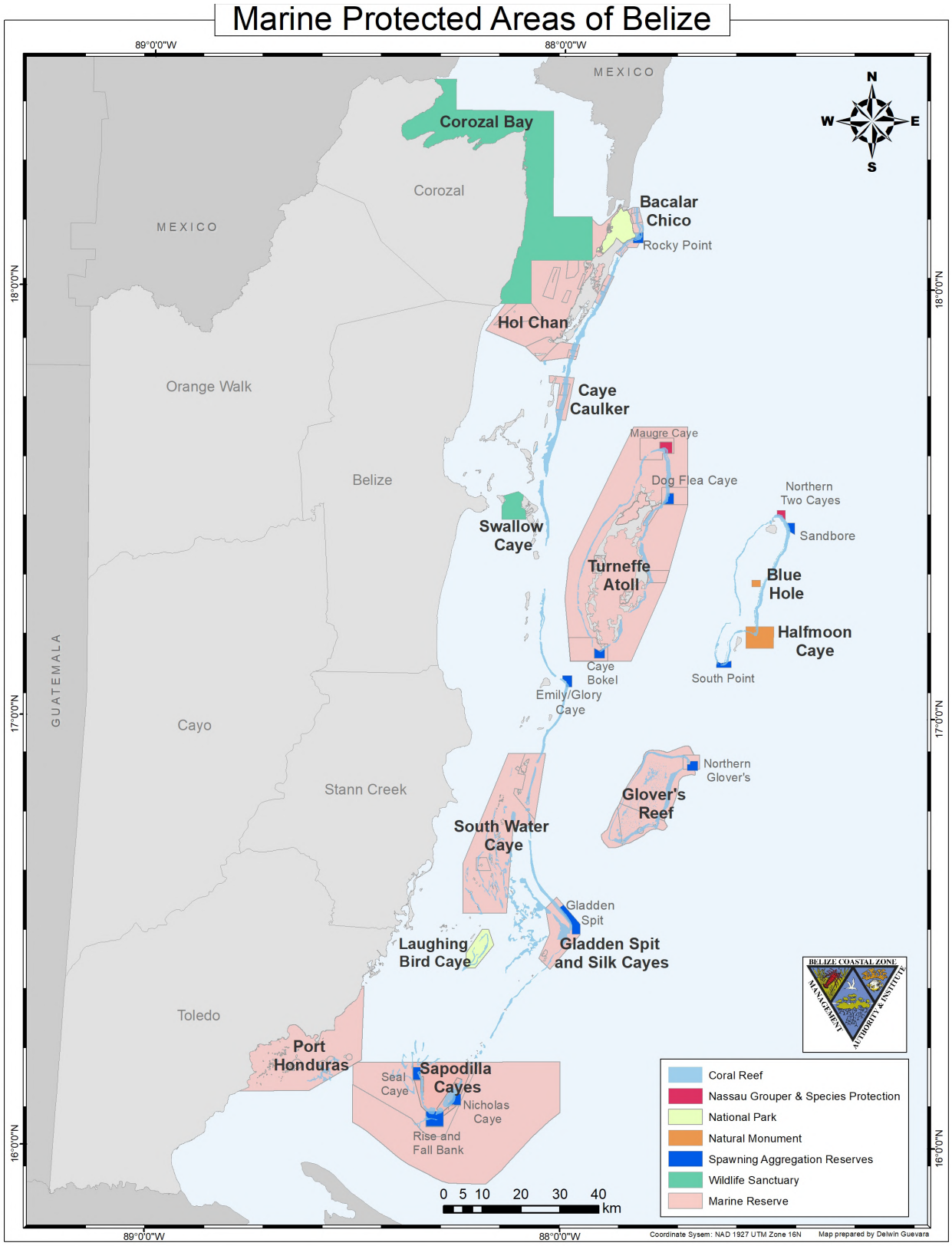


Figure 8. Marine protected areas network in Belize.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"good" indicator rating while coral cover and commercial fish biomass rated as "fair". Fleshy macroalgae cover, although decreasing, remains high and is therefore rated as "poor" (McField et al. 2020). There are subregional disparities: four of the six subregions ranked as "fair", the Southern Barrier Reef had the best reef health (RHI 3.3); Lighthouse Reef and Central Belize Barrier Reef between Belize City and Placencia (RHI 3.0); and Glover's Reef (RHI 2.8). Turneffe Reef and the Northern Barrier Reef were ranked as "poor" with RHIs of 2.5 and 2.3, respectively. Although Belize's reef health showed a slight improvement compared to the previous HRI report (HRI 2018), the reef continues to face numerous threats such as agricultural runoff, incomplete sewage treatment and illegal fishing (McField et al. 2020). Improperly regulated tourism development in environmentally sensitive areas, such as the Turneffe Atoll, also degrades the health and decreases the benefits of these ecosystems because of extensive dredging of back-reef flats for landfill, clear cutting of mangroves and destruction of seagrass beds (Salas and Shal 2018).

It has been reported that the annual rate of destruction of mangroves in Belize is 3.6 percent per year, mostly as a result of coastal development

Coastal development is also a threat to Belize as it often involves clearing of both mangrove forests and nearby seagrass beds (Vaslet et al. 2012; McField et al. 2020). It has been reported that the annual rate of destruction of mangroves in Belize is 3.6 percent per year, mostly as a result of coastal development (Young 2008). A more recent study shows that over a 36-year period (1980 to early 2017), Belize lost approximately 5.4% (4100 ha) of its 1980 mangrove cover (Cherrington et al. 2020). Within the BBRRS, approx. 89 ha of mangroves were lost during the 1996 to 1997 period, with most of the loss occurring in South Water Caye Marine Reserve during 2000 to 2010. Mangrove loss outside the BBRRS (1996 to 2017) occurred primarily in the areas around Belize City and its nearby cayes (37.3 % of the total area of mangrove loss); Ambergris Caye (18.8%) and the Placencia Peninsula and nearby cayes (17.3%). It should be noted however, that the highest rate of loss occurred primarily during the period 2004 to 2010 and has decreased thereafter (Cherrington et al. 2020). Invasive species such as the lionfish have also dealt a major blow to marine ecosystems in Belize. Lionfish have no natural predators in Belize and are thought to decrease native fish populations by eating juveniles (Green et al. 2012).

Clearly, Belize is facing many threats to its marine ecosystems, underscoring the importance of conservation and management. Together the reefs, seagrass beds and mangroves provide a continuum of habitat for multiple life stages of marine species. And together they provide a more resilient front against both natural and human-induced threats. It is important that the health of these ecosystems is maintained as they provide more protection together than they do individually (Guannel et al. 2016).

The Fisheries of Belize

Tess M. Geers

INTRODUCTION

Though small, Belize is uniquely positioned geographically to support an abundant and diverse marine community. Belize's reefs sustain over 550 species of fish (including at least 18 sharks and rays) and over 2,000 marine invertebrates; its mangroves and flats provide habitat for abundant recreational fish resources and its deeper waters are home to migrating whales, sharks, tunas and swordfish (Palomares and Pauly 2011). Historical accounts boast of beaches full of nesting sea turtles and reefs teeming with life. Many of Belize's Caribbean neighbors have suffered catastrophic declines of some of the most important commercial species, followed by serial depletion of estuarine and reef fish and invertebrates.

the national cooperatives saw a **90%** decline in deliveries of finfish between 1983 and 2009

Belize's small population and early recognition of its natural wonders – the BBRRS, designated as a World Heritage Site – have somewhat spared Belize's fisheries. However, continually increasing demand, both domestically and abroad, and pressure from increased tourism is taking its toll on Belizean fisheries and therefore on the health of its reefs. In the markets today, rarely seen are the massive groupers and snappers of previous years. Instead, we settle for miniature versions; we see favored species replaced by smaller snappers, grunts and even farmed tilapia. Even when they are in season, Belizeans and local restaurants often don't have access to lobster and conch.

Despite the gaps in available data for most fisheries, the warning signs are everywhere. For example, the national cooperatives saw a 90 percent decline in deliveries of finfish between 1983 and 2009 as a result of declining catch and a declining export market (Wildtracks 2011). More recent HRI reports list the status of commercial fish (snappers and groupers) biomass in Belize in "fair" condition overall, with low or declining fish biomass in the Southern, Lighthouse, Turneffe and Northern zones, as opposed to an improvement in the Central Barrier and Glover's Reef zones (McField et al. 2020).

Here we present a summary of the best available science on the major fish and invertebrate stocks of Belize to provide an indication of the status of Belizean fisheries and the major threats they face. In most cases national statistics are not broken down to the species level and have not been updated in several years. Additionally, national statistics typically only cover fish caught and sold through the cooperatives, which leaves out the considerable catch destined for domestic consumption as well as commercial catch by private companies. Furthermore, one cannot rely on data supplied to the FAO (Food and Agriculture Organization of the United Nations) by Belize on national fisheries statistics as these data include any vessel carrying a Belizean flag, regardless of where they are fishing. In many cases we present estimates compiled by the Sea Around Us, as these are often the only statistics at the national level broken down by species. However, given the considerable difficulty in gathering fisheries catch data in Belize, these estimates are also highly uncertain. The Belize Science

Team[13], which is a collaboration of managers and scientists from the Belize Fisheries Department and a number of partner organizations, has begun to collect and analyze data for many of the fisheries in Belize (McDonald et al. 2017). These include productivity susceptibility analyses (PSA)[14] and data-poor assessments, some of which are presented here; however, most of this information has not yet been published.

SNAPPER DOMINATE FINFISH LANDINGS, BUT OVERFISHING LOOMS

Ecology of Snapper

Snapper of the Lutjanidae family are a diverse group of bony fish found in tropical and subtropical marine waters around the world. They typically reside near the seafloor around coral or rocky reefs or in mangrove habitats and can be found from shallow waters to depths over 1650 feet (Anderson Jr. 2002). Most snappers are active nocturnal predators feeding on a wide variety of smaller fish, crustaceans and molluscs (Anderson Jr. 2002). Some species can grow to nearly three feet in length and live to more than 50 years old (Froese and Pauly 2016). Snapper are caught all along the coast of Belize in mangrove and reef habitats, including both deep and shallow reefs. Where they are found (and caught) depends on the species. In the Bacalar Chico Marine Reserve, cubera and yellowtail snapper were primarily found in the outer fore reef areas, whereas mutton, dog and grey snapper were mostly found in the back (inner) reef zone (Paz & Grimshaw 2003 in (Grimshaw and Paz 2004). In the Caye Caulker Marine Reserve, yellowtail, lane and mutton snapper are targeted in the seagrass areas of the reef flats (McRae 2004).

Spawning occurs at night, with peak spawning seasons that vary by species and area. All snapper have separate sexes and the largest females produce exponentially more eggs than smaller females, often spawning multiple times throughout a season. Many snapper species form spawning aggregations coinciding with the lunar cycles (Anderson Jr. 2002).

Snapper Fisheries of Belize

The most-targeted species of snapper vary by region. In the Corozal Bay Wildlife Sanctuary grey snapper were the most abundant and preferred snapper among fishers (SACD 2009). Slightly further south in the Caye Caulker Marine Reserve, yellowtail, lane and mutton snapper were the most targeted (McRae 2004). At Glover's Reef, schoolmaster snapper, yellowtail snapper and California red snapper were the most commercially important snappers (Tewfik 2016a), while at the Port Honduras Marine Reserve (PHMR), lane snapper were the most frequently caught (Foster et al. 2011). In the deep slope area, both southern red snapper and silk snapper have

13 The Belize Science Team gathers and evaluates data, conducts data analyses, and provides advice on the AMF to BFD. BFD has the final say over the recommendations given by the Science Team, allowing for decisions to be made that are in accordance with policies and management plans of the government.

14 "Productivity susceptibility analysis scores life history parameters important for stock productivity and attributes of the fishery that are important for determining the susceptibility of the stock to the fishery to compute a vulnerability or risk score. Vulnerability scores above 2.0 are generally associated with overfishing but do not prove that overfishing is occuring. PSA results can also be used to prioritize stocks for further analysis, data collection, and precautionary management based on the risk of overfishing" - Belize Science Team

been noted to be abundant and a potentially valuable target for commercial fisheries (Gongora 2014). Some of the most commonly caught species are listed in Table 3.

The amount of snapper caught and landed in Belize has not been systematically documented over time or throughout the country. Estimates at PHMR put landings of snapper at about 95,000 pounds annually (Foster et al. 2011). Additionally, an estimated 100,000 pounds of deep-water snapper are harvested from areas near the Turneffe Atoll annually (Fedler 2011). Catch comes from spear and handline fishing concentrated at the fore reef area along the coast of Belize. Because most of this catch is sold at local markets (such as the Vernon Street market in Belize City) or directly to hotels, rather than through the cooperatives, there are no official statistics (Fishers workshop 2011; Wildtracks 2011). Reconstructed catch estimates from Sea Around Us put average annual snapper landings in Belize at 2.5 million pounds between 2009-2013 (Figure 9. Reconstructed catch of snapper in Belize (SAU 2017)). This is roughly half the volume landed in the 1980s (a high of 4.9 million pounds was landed in 1987). Yellowtail, mutton and lane snapper were the top landed species.

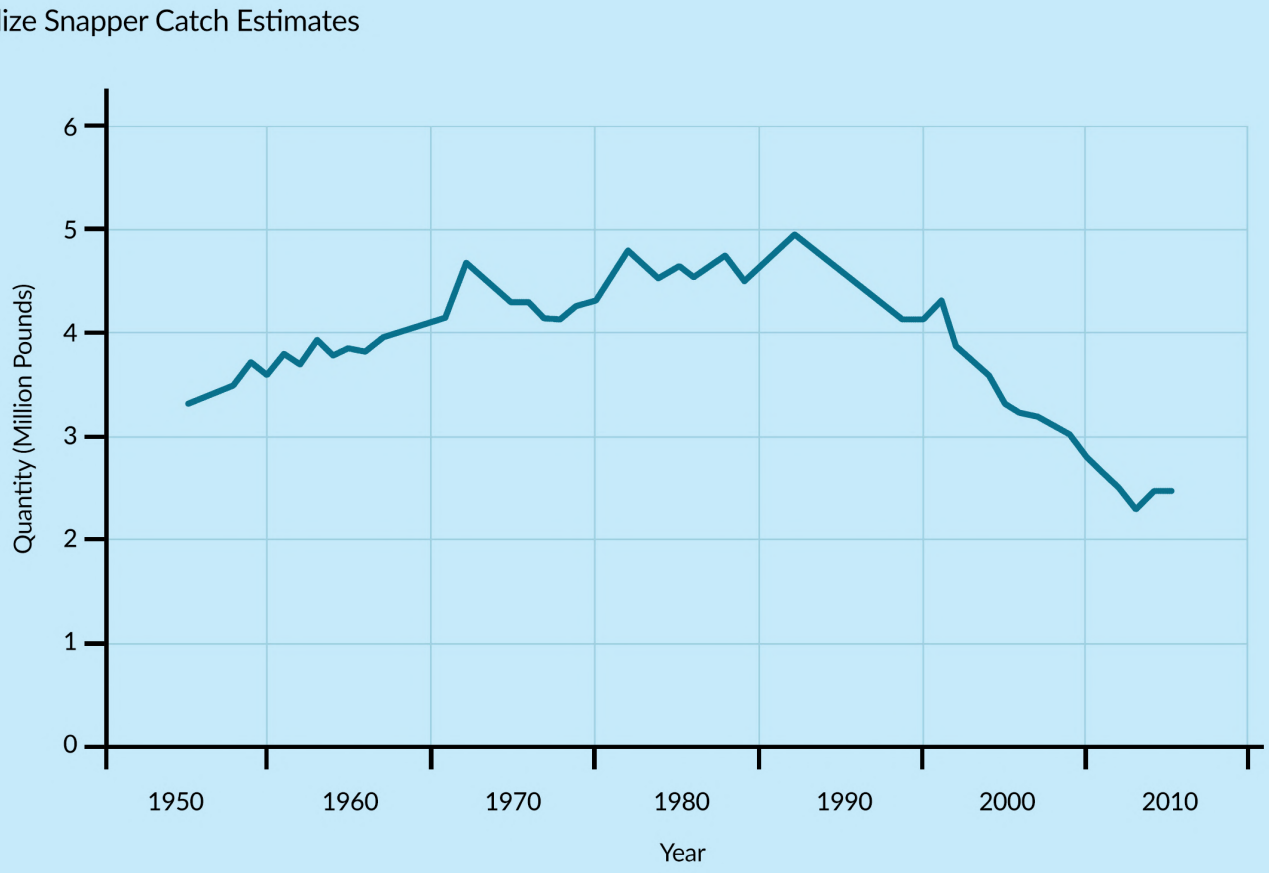

Figure 9. Reconstructed catch estimates of snapper in Belize (SAU 2017).

As with many other reef fish species in Belize, snappers are primarily targeted with handlines and in deeper water with rod and reel (Foster et al. 2011). In mangrove habitats set lines may be used. In northern Belize, around the communities of Sarteneja and San Pedro, beach traps are also used to catch inshore (back reef) snapper species (Appendix 2). In the south, fish traps are used as an alternative gear. Lastly, spear guns and slings are used while diving. Gillnets also frequently catch inshore snapper species, though not as a primary target.

Health of Major Snapper Stocks is at Risk in Belize

There is no systematic assessment of the snapper fishery in Belize, or even for individual species across Belize. One of the difficulties in determining the stock status of snapper species in Belize is that snapper are often reported together as one group, while there are probably at least 10 species that are harvested commercially. Any trends for the group as a whole may be reflective of serial depletion or of only one or two more abundant species, obscuring the true status of individual species. The decreasing trend in landings since the 1980s (Figure 10. Reconstructed catch estimates of snapper in Belize (SAU 2017).) is also cause for concern, given that it is unlikely that fishing pressure has decreased over the same period. Possible drivers of this decline include reduced availability of snapper due to population decline, decline in the size and weight of snapper species caught, or a shift to more domestic sales, subsistence catches and illegal fishing, which are more difficult to track.

average annual snapper landings in Belize at 2.5 million pounds between 2009-2013. This is roughly **half** the volume landed in the 1980s

The best scientific evidence from some of the reserves does point to concerning trends in various snapper populations. Although snapper were frequently observed in sampling at PHMR between 2011 and 2014, at sites outside of the reserve snapper were seen much less frequently and virtually not at all in 2014 (Foley et al. 2016a). This may be an indication of unsustainable harvest outside of the reserve. Similarly, in the Gladden Spit and Silk Cayes Marine Reserve observations of snapper increased steadily in the replenishment zone, but dropped sharply in 2010 and encounters generally appear to have declined in the general use zone since 2006 (Wildtracks 2010a). A variety of snappers are also known to have declined over the past 12 years in the Caye Caulker Marine Reserve (McRae 2004). At the Glover's Reef Marine Reserve (GRMR), biomass of mutton snapper has shown a statistically significant decrease in both the replenishment and general use zones between 2004 and 2012 (WCS 2013). Mutton snapper are also being caught as juveniles before they are able to reproduce[15] (Tewfik 2016b, Appendix 3). In addition, mutton snapper status has been evaluated based on length-based indicators; these showed that mutton snapper is experiencing overfishing in Glover's and is likely overfished (Babcock et al. 2013). HRI surveys further show a downward trend in mutton snapper observations throughout Belize and they are considered Near Threatened according to the International Union for Conservation of Nature (IUCN) Red List[16].

By compiling several data sources, we can categorize the major commercially-fished snapper species in Belize into the following categories (Table 3).

15 Catching fish as juveniles before they are able to reproduce is known as "recruitment overfishing." Recruitment overfishing is extremely harmful to fish populations as it prevents them from being able to rebound as abundance declines. Minimum size limits are a tool used in fisheries management to try to prevent recruitment overfishing (Froese, 2004). Minimum size limits prohibit the catch of undersized fish by requiring that a fish reach a minimum length (generally the average length at maturity, L_m) to be landed legally. See Appendix 4 for more details on size limits in Belize.

16 The IUCN Red List compiled by the International Union for Conservation of Nature is internationally-recognized as the most comprehensive, global approach to evaluating the conservation status of plant and animal species. Individual species listings can be found on the website at: http://www.iucnredlist.org/

Table 3. Commonly caught species of snapper in Belize and assessment of fishery risk: High, Medium, or Low risk based on a compilation of data sources.

HIGH RISK EVALUATED AS MEDIUM-HIGH RISK WITHOUT CONFLICTING TRENDS		
Red Snapper (Northern) Lutjanus Campechanus	A PSA by the Belize Science Team reveals a high level of risk and the species is listed as Vulnerable by IUCN. It may also be targeted by the deep slope fishery and is not tracked by the inshore HRI survey. Southern red snapper and vermilion snapper may also be at risk due to their similar characteristics.	
Red Snapper (Southern) Lutjanus Purpureus	No observations or assessments of this species have been made in Belize, but its slow growth and late age at maturity make it vulnerable to fishing pressure. It is a target of the deep-slope fishery and may be confused with the northern red snapper L. campechanus.	
Vermilion Snapper Rhomboplites Aurorubens	No observations or assessments of this species have been made in Belize, although it is a target of the deep-slope fishery and may be confused with the northern red snapper L. campechanus. It is considered Vulnerable by the IUCN.	
Dog Snapper Lutjanus Jocu	A PSA by the Belize Science Team reveals a medium level of concern and the trend observed through HRI surveys is decreasing.	
Mahogany Snapper Lutjanus Mahogoni	HRI surveys show a decreasing trend.	
Mutton Snapper Lutjanus Analis	A decreasing trend has been observed in HRI surveys and at the Glover's Reef Marine Reserve; length-based indicators show that mutton snapper is experiencing overfishing in Glover's and is likely overfished (Babcock et al. 2013). The species is also considered vulnerable according to the IUCN Red List.	

MEDIUM RISK EVALUATED AS MEDIUM RISK OR WITH CONFLICTING TRENDS		
Schoolmaster Snapper Lutjanus Apodus	A PSA by the Belize Science Team reveals a medium level of concern, while observations from the HRI surveys show an increasing trend. However, according to length-based indicators schoolmaster snapper is likely to be overfished and experiencing overfishing at Glover's Reef Marine Reserve (Babcock et al. 2013)	
Cubera Snapper Lutjanus Cyanopterus	Although the species is listed as Vulnerable by the IUCN, observations in Belize through the HRI surveys show an increasing trend.	
Silk Snapper Lutjanus Vivanus	A PSA by the Belize Science Team reveals a medium level of concern; this species is not tracked by the HRI surveys. It is considered a species of Least Concern by the IUCN.	
Yellowtail Snapper Ocyurus Chrysurus	Although a PSA by the Belize Science Team reveals a low level of concern, a decreasing trend has been observed in the HRI surveys.	
Lane Snapper Lutjanus Synagris	Although a PSA by the Belize Science Team reveals a low level of concern, a decreasing trend has been observed in the HRI surveys. The IUCN lists it as Near Threatened.	

LOW RISK EVALUATED AS LOW RISK WITH NON-CONFLICTING TRENDS		
Black Snapper Apsilus Dentatus	A PSA by the Belize Science Team has categorized this species as low risk and it is listed as Least Concern by the IUCN.	
Blackfin Snapper Lutjanus Buccanella	A PSA by the Belize Science Team has categorized this species as low risk; however, the species was not observed in HRI surveys.	
Grey Snapper Lutjanus Griseus	A PSA by the Belize Science Team has categorized this species as low risk and the trend in HRI surveys is increasing. The IUCN lists it as Least Concern.	

GROUPER ARE SHADOWS OF THEIR FORMER SELVES

Ecology of Groupers in Belize

There are about 160 species of grouper worldwide, occurring in both shallow- and deep-water reefs and structured rocky habitat in temperate and tropical locations. Many species are top-level predators, playing an important ecological role in their ecosystems. In some cases they have even been described as keystone species or ecosystem engineers, shaping the habitat complexity and species diversity in the areas in which they live (FSU 2016).

Grouper tend to spawn at the reef edge or shelf break, forming dense spawning aggregations. Larvae float in the ocean for 1.5-2 months, depending on the species, and then settle into inshore nursery habitats. Juveniles of some species may spend from several months to as many as six years in the nursery habitat (FSU 2016). Many species of grouper are long-lived and late to mature, making them more vulnerable to fishing pressure. Grouper also exhibit a sex change during their life cycle, switching from female to male after a certain period of time, which varies from species to species. Therefore, the largest fish in the population will be males. This trait makes them more vulnerable to fishing pressure because as the largest individuals are removed there are fewer males available to reproduce.

Grouper Fisheries of Belize

Historically, black (Mycteroperca bonaci), Nassau (Epinephelus striatus) and goliath grouper (E. itajara) were the primary target of fisheries for grouper throughout Belize, from Corozal Bay and Bacalar Chico in the north to Glover's Reef and south to PHMR. However, in recent years as these species have become depleted, jimmy or red hind (E. guttatus) has also become a popular target. Tiger (M. tigris), yellowfin (M. venenosa) and red grouper (E. morio) are also common in Belize, though the extent to which they are targeted by fisheries is unknown. Handlines are the primary gear used to fish grouper in Belize (Appendix 2). However, as with snappers, several other gear types may be used depending on the species and region.

Goliath grouper historically accounted for the highest proportion of the grouper landings, followed by jimmy hind, Nassau grouper and black grouper, according to estimates by the Sea Around Us. However, as with snapper, landings of grouper are not documented independently from other commercially-caught fish, nor are landings recorded for individual species, so official documentation of recent catches is unavailable. The Sea Around Us (2017) has estimated that average grouper landings in Belize were approximately 77,000 pounds during 2009-2013, which represents a nearly 50 percent decline from peak landings in 1983 (Figure 10).

average grouper landings in Belize were approximately 77,000 pounds during 2009-2013, which represents a nearly **50% decline** from peak landings in 1983

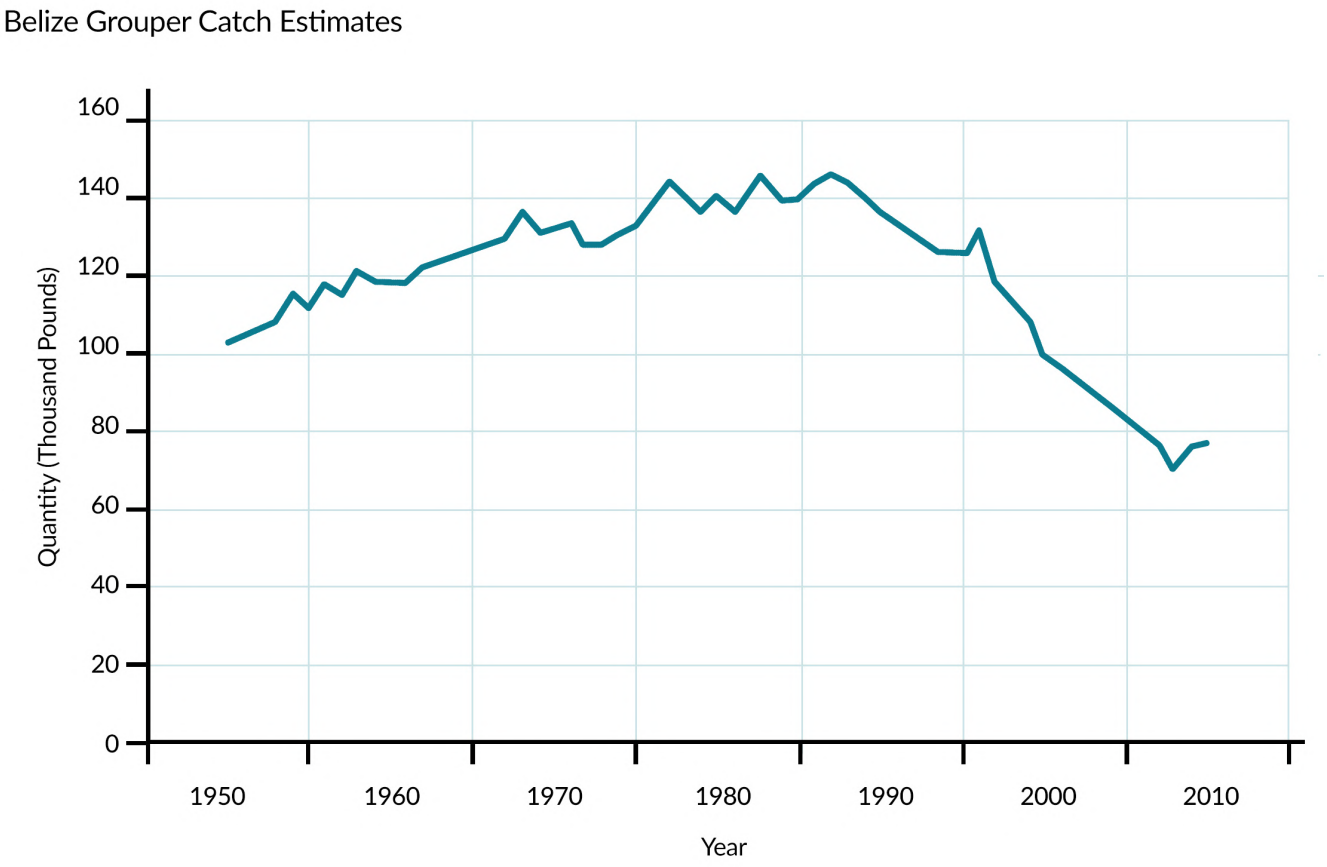

Figure 10. Reconstructed catch of grouper in Belize (SAU 2017).

Nation-Wide Crash in Grouper Populations Evident

Overall, it appears that there has been a precipitous decline in grouper species throughout Belize; nearly everywhere they have been recorded their populations have decreased. Grouper and other sea bass have shown a declining trend in the PHMR area since 2011, even within the replenishment zones, and densities in 2014 appear to be critically low (Foley et al. 2016a). At the Gladden Spit and Silk Cayes Marine Reserve observations of grouper have generally been low and have declined since 2008 (Wildtracks 2010a). At Glover's Reef, Dangriga fishers traditionally fished on the spawning bank aggregations of 20,000 to 30,000 individuals, but a significant decline in numbers was seen after the mid-1980s (Burns and Tewfik 2016; Wildtracks and WCS 2007). Furthermore, spawning aggregations, which are the backbone of grouper reproduction, have collapsed throughout the country (Paz & Grimshaw 2001 in (Wildtracks 2010b), Sala et al. 2001).

NASSAU GROUPER

Fishing pressure, particularly on spawning aggregations, has caused Nassau grouper to decline by over 80 percent in Belize since the late 1970s (Paz & Grimshaw 2001 in (Wildtracks 2010b)). In the early 2000s, some even predicted that Nassau grouper would disappear completely from Belize by 2013 if existing management conditions persisted (Paz & Grimshaw 2001 in (Wildtracks 2010b)). In 2001, the Belize Spawning Aggregation Working Group (BSAWG) was formed in response to the decline in reef fish spawning aggregations. In 2003, as a result of the BSAWG's efforts, the GOB, declared 11 Spawning Aggregation Site Reserves (Statutory Instrument (S.I.) 161 of 2003) to protect important fish spawning grounds (GOB 2003). The Working Group

which is a network of organizations including the GOB entities, Fishermen Associations and Co-operatives, Co-management NGOs and other NGOs has been involved in monitoring and managing the Nassau grouper SPAG sites.

Although Nassau grouper has not disappeared completely, the species may be considered functionally extinct in Belize. The Belize Science Team has evaluated it as being at high risk according to a PSA and it is now considered Critically Endangered by the IUCN Red List criteria.

Length-based assessment of Nassau grouper at Glover's Reef Marine Reserve shows that it is overfished and that overfishing is occurring (Babcock et al. 2013). Biomass of Nassau grouper at Glover's Reef has shown a significant decline in the general use zone since 2004 but remained stable within the replenishment zones (WCS 2013). However, spawning aggregations are massively depleted in the area. Monitoring at the Northeast Point spawning aggregation at Glover's Reef showed a large decline between 2006 and 2007, with 3,000 individuals down to just 800 (Wildtracks and WCS 2007). For the period 2015 to 2018, the Spawning Aggregation Working Group (SPAGWG) reported a maximum average count of 925 individuals in 2018 (Table 4) (SPAGWG 2018). In 2019, however, only 336 individuals were observed during SPAG monitoring (McField et al. 2020).

This story is repeated throughout Belize. Nassau grouper are known to have declined over the past 12 years in the Caye Caulker Marine Reserve (BFD, pers. com; McRae, unpub. data in (McRae 2004)). At the Sapodilla Cayes Marine Reserve, the Nicholas spawning site no longer supports enough Nassau groupers to fulfill their ecological role and spawning itself has never been observed between 2000 and 2009

(Wildtracks 2010b). In 2015 and 2017, the maximum average count was 96 individuals in 2017 (SPAGWG 2017). Data from Rocky Point Spawning Aggregation Site in Bacalar Chico Marine Reserve where, between 2009 to 2014, on the majority of observed days, no Nassau grouper were seen at all (Brown 2015). In 2003, the Dog Flea Caye spawning aggregation at Turneffe Atoll still had the highest number of Nassau grouper observed in Belize (about 5,000) but was down from historical averages of about 30,000; however, in 2006 and again in 2011, no Nassau grouper were observed at the site (Wildtracks 2011).

SPAWNING AGGREGATION (SPAG) SITE	SPAWNING AGGREGATION (SPAG) SEASON				
	2015	2016	2017	2018	2019
Sandbore, Lighthouse Reef	3000	4000	3500	4033	-
Northeast Point, Glover's Reef	450	350	413	925	336
Maugre Caye, Turneffe Atoll	497	352	373	13	-
Nicholas Caye, Sapodilla Cayes	137	-	96	107	-

Table 4. Nassau grouper maximum counts at 4 SPAG sites during the 2015 – 2018 SPAG season.

Source: SPAG Working Group Biennial Report 2017; SPAG Working Group Annual Report 2018); McField et al. 2020.

An assessment of Nassau grouper Spawning Aggregation Sites management over the years from 2004 to 2018 shows large fluctuations in numbers across all sites, yet even at the sites with high abundance numbers are well

below historical levels. At Gladden Spit, over 1,000 Nassau grouper were observed in 2008, but in the years since, numbers have never exceeded 400; just 29 were counted in 2014. Also, in 2014, no grouper whatsoever were observed at either Emily or Dog Flea Caye, where illegal fishing is suspected (Cho-Ricketts 2015). In 2018, the highest observed number of Nassau gouper (4033 individuals) was observed at Sandbore Spawning Aggregation site at Lighthouse Reef.

GOLIATH GROUPER

Goliath grouper have been evaluated as at a high risk from fisheries according to a PSA by the Belize Science Team; the species is listed as Critically Endangered by the IUCN Red List and data suggest the species is overfished. Goliath grouper were once known to be common in the Corozal Bay Wildlife Sanctuary, but now only occur infrequently as small individuals (SACD 2009), and in the nearby Caye Caulker Marine Reserve they are known to have declined over the past 12 years (BFD, pers. com; McRae, unpub. data in (McRae 2004). In PHMR mean size at harvest of goliath grouper has decreased dramatically despite relatively stable catches (Foster et al. 2011). Data from southern Belize show that most goliath groupers are taken before they reach reproductive age. Low levels of adults were found from the coastal to outer reef zones, and at the Punta Gorda fish market 98 percent of goliaths were juveniles (Graham et al. 2009).

BLACK GROUPER

Length-based analysis of black grouper at Glover's Reef Marine Reserve indicates that they are overfished with continued overfishing occurring (Babcock et al. 2013). Catch data at Glover's Reef also show that black grouper catch includes juveniles below reproductive age (Tewfik 2016a). Surveys of abundance at Glover's Reef and through the HRI surveys show no indication of recovery or increased biomass (WCS 2013). Meanwhile, black grouper was the only grouper species observed in large numbers during monitoring at the Rocky Point Spawning Aggregation (Bacalar Chico Marine Reserve), but the data nonetheless suggest a stark decline between 2009 and 2014 (Brown 2015). Because they form many small spawning aggregations (rather than a few large ones), black grouper may be less susceptible to fishing than other grouper species (Paz and Sedberry 2007). The species is listed as Near Threatened by the IUCN, although it was evaluated by the Belize Science Team as low risk according to a PSA.

JIMMY HIND

Unfortunately, there is virtually no information available on the status of the jimmy hind, which is now one of the most commonly caught grouper species in Belize. A PSA conducted by Oceana staff puts it at a medium risk from fisheries and HRI surveys show a declining trend.

GRUNTS AND PORGIES SHOW RESILIENCE

Ecology and Fisheries

Grunts of the Haemulon genus are common to reef environments of the western Atlantic Ocean from around the Chesapeake Bay in the U.S. to central Brazil. Common grunt species in Belize include the white grunt (Haemulon plumierii), black grunt (H. bonariense), French grunt (H. flavolineatum), bluestriped grunt (H. sciurus) and the white margate (H. album). Grunts are often found in large, multi-species schools over the reef during the day. They are generally nocturnal predators and forage over seagrass flats for crustaceans and molluscs living on the

seafloor. Grunts provide an important food source for many other larger reef predators, such as snapper, grouper, sharks, and others. Although grunts mature at a small size, they typically do not mature until about three to five years of age (Darcy 1983). Spawning is thought to occur year-round, but peaks may occur, varying by location and species (Darcy 1983).

Porgies, namely Diplodus sp. and Calamus sp., have a similar distribution and characteristics of grunts. Common porgies in Belize include the pluma porgy (Calamus pennatula) and the jolt-head porgy (C. bajonado). They inhabit shallow tropical and temperate waters, including seagrass beds, estuaries and reefs. Adults tend to be more solitary and grow larger than grunts.

Grunts and porgies are targeted throughout Belize, primarily as a subsistence food source and for sale to local markets and restaurants. They are primarily targeted with handlines but may also be caught frequently in fish pots and traps. Porgies are estimated to make up about four percent of the catch at Glover's Reef, while grunts make up about two percent; proportions are similar at the South Water Caye Marine Reserve (Tewfik 2016a, Tewfik 2016b). Because they are primarily targeted for subsistence use, there is virtually no reporting of information on grunts and porgies in Belize. According to estimates by the Sea Around Us, an average of 188,000 pounds of grunts and porgies were landed between 2009-2013.

Status of Grunts & Porgies in Belize

Grunts appear to remain relatively abundant in Belize and as a whole, Haemulon species appear to have a stable or increasing abundance in Belize according to HRI surveys. In local surveys, grunts also appear to be relatively abundant; however, this may in part be due to decreases in abundance of other species. The blue-striped grunt has been observed in very high numbers at Turneffe Atoll due to abundant mangrove habitat (Wildtracks 2011); it was also the most frequently observed species in the backreef habitat at the Bacalar Chico Marine Reserve in the early 2000s (Grimshaw and Paz 2004).

Grunts were the second or third most frequently observed group in sampling at PHMR between 2011 and 2014; however, outside of the Reserve grunts were seen much less frequently, particularly in 2014 (Foley et al. 2016a). This may be an indication of unsustainable harvest outside of the Reserve. White grunt population density has been measured at PHMR at least since 2009. Although densities are quite variable, it appears that grunt populations benefit from replenishment zones and deep-water areas that might have limited access by fishers. Porgies also appear to remain relatively abundant and are increasingly observed in HRI surveys, though no local studies on their abundance have been conducted.

The apparent relative health of grunts and porgies in Belize may be due to them being less vulnerable and more resilient to fishing pressure than some of the other reef fish species in Belize given their life history characteristics. However, it may also simply be a result of low fishing pressure.

COASTAL PELAGICS ARE AN UNQUANTIFIED, BUT PRODUCTIVE RESOURCE

Ecology & Fisheries

Jacks, mackerels and barracuda all occupy the upper levels of the food chain in the Belize marine ecosystem. Barracudas are more frequently found near the reef areas, while jacks and mackerels are more common in open water. Mackerels are found in the outer reef area. Jacks often form schools, though larger individuals may inhabit reef areas. Some jacks and pompanos are also common in the flats and seagrass beds.

Although in other countries, jacks, mackerels and barracudas are common sport or recreational species, in Belize they are often caught for domestic markets. These species are frequently targeted by gillnets. Commonly caught mackerel species in Belize include king (Scomberomorus cavalla), cero (S. regalis) and Spanish mackerel (S. maculatus). They are all very similar in appearance and may be called by the same common name – kingfish. Commonly caught jacks include the blue runner (Caranx crysos), crevalle jack (C. hippos) and the horse-eye jack (C. latus). The great barracuda (Sphyraena barracuda) is the most commonly caught barracuda species in Belize. At PHMR it is estimated that about 150,000 pounds of mackerel and jacks, caught primarily with gillnets, are landed annually (Foster et al. 2011). Barracuda are ranked as the fourth most preferred species by fishers in the Corozal region (SACD 2009) and are reported to be the most frequently caught species at Glover's Reef (Wildtracks and WCS 2007). Barracuda contribute about 18 percent of the catch at Glover's Reef, while jacks and mackerel each contribute less than one percent (Tewfik 2016a). The contributions are lower at South Water Caye where snappers take up a greater proportion of the total catch. Overall, the Sea Around Us estimated that on average 377,000 pounds of jacks, 203,000 pounds of barracuda and 4,900 pounds of mackerels were caught annually in Belize from 2009-2013.

Stock Status Indicators for Coastal Pelagics are Elusive

A PSA by the Belize Fisheries Team shows that jacks are at a low risk of overfishing in Belize; however, at some sites where they are heavily targeted, there may be cause for concern. The same goes for mackerel and barracuda, with king mackerel having a slightly higher risk. PHMR is the only area where the abundance of coastal pelagic species in Belize has been measured. There, mean densities of jacks were low and variable in the

PHMR area over the four-year period from 2011-2014; different patterns were observed inside and outside of the reserve areas (Foley et al. 2016a). Although coastal pelagics tend to be fast-growing, making them less vulnerable to fishing pressure, they are subject to indiscriminate fishing by gillnets, which may be taking juveniles of these and other species.

SPORT FISH (BONEFISH/TARPON/PERMIT/SNOOK) ARE ECONOMIC HEAVYWEIGHTS

Ecology

BONEFISH (ALBULA VULPES)

Bonefish are found throughout the temperate and tropical waters of the western Atlantic Ocean and eastern Pacific Ocean. In the Atlantic they are most common around southern Florida and the Caribbean. They tend to inhabit coastal flats, warm shallow areas that may be sandy or covered with seagrass. Bonefish can grow to nearly two feet, though smaller individuals are more common in the Atlantic. Bonefish reach maturity around three to four years and can live to nearly 20 years (Morey 2016a). Bonefish spawn throughout the year; they move to deeper water to spawn so that the larvae are distributed by the currents. They may form large pre-spawning aggregations in the flats areas (Morey 2016a). The preferred habitat of early juvenile bonefish is


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unknown, as they have not been found in large numbers in typical nearshore nursery habitats in Florida (Ault et al. 2007). Bonefish are generally thought to have a restricted home range, though larger adults may undertake longer migrations.

In Belize, Turneffe Atoll is thought to support the greatest abundance of bonefishing sites, and they are considered resident there - (Wildtracks 2011). They travel in loose schools along the shallow back-reef flats. Spawning and subsequent recruitment sites have yet to be identified in Turneffe, but the species is known to spawn from November through May (Bonefish and Tarpon Trust 2011 in Wildtracks 2011). In addition, bonefish was identified as one of the most abundant species in a survey of Deer Caye in the Corozal Bay Wildlife Sanctuary. They were encountered in large numbers as juveniles indicating that this may be an important nursery area (SACD 2009)

ATLANTIC TARPON (MEGALOPS ATLANTICUS)

As with bonefish, Turneffe is considered as one of the primary tarpon fishing areas in Belize and both resident and migratory individuals are known to use the Atoll. Adults inhabit shallow coastal areas but are also capable of long migrations in deeper water. Tarpon tagged in North Carolina have later been caught in Cuba (Ault et al. 2007). Some information is known about migration patterns of tarpon in the Gulf of Mexico and southern U.S., but the extent of migration to or from Belize is unknown. Females are significantly larger than males. Tarpon can live to be at least 50 years old and some research suggests that they may even reach 70 or 80 years. They mature after about 10 years (Ault et al. 2007).

Tarpon are thought to spawn year-round, but with peaks in the summer. Adults form pre-spawning aggregations slightly offshore (one to three miles) before moving to deeper water to spawn (Ault et al. 2007). In Belize spawning occurs in the late spring and summer near the new and full moons, at which point the mature migratory tarpon move offshore forming spawning aggregations (Wildtracks 2011). Tarpon larvae spend two to three months in the currents of the open ocean. Juvenile tarpon inhabit warm, estuarine and mangrove environments. Adult tarpon are very tolerant of a wide range of salinities and oxygen levels, but cannot tolerate cold water (Ault et al. 2007).

Despite their massive importance to recreational fisheries in a number of countries, many gaps still exist regarding the ecology of bonefish and tarpon. Migrations, spawning areas, essential juvenile habitats, stock dynamics, and their ability to survive catch and release remain unknown (Ault et al. 2007).

PERMIT (TRACHINOTUS FASCIATUS)

Permit are members of the jack family, typically growing to about three feet and living up to 20 years. They are found throughout the western Atlantic in shallow waters. Permit are solitary or may form small schools. They become mature after two to three years. Permit feed over the flats, using their hard mouth to dig out and eat crustaceans and molluscs on the seafloor (Morey 2016b). A resident population of permit is known to inhabit the very shallow inshore flats of Turneffe Atoll. Spawning behavior has also been observed for the species at Turneffe between February and October; groups of 300 or more reproductive adults form spawning aggregations at the Turneffe Elbow, gathering at sunset during the full moon spawning period (Graham et al. 2005 in (Wildtracks 2011).

SNOOK (CENTROPOMUS UNDECIMALIS)

Though not part of the “typical” sport fish group of bonefish, tarpon and permit, snook display similar characteristics to these species. Snook switch from males to females after a certain period of time. Sex reversal appears to occur shortly after spawning and is closely related to the size of the fish, occurring when they are between 2.3-7.5 feet over a range of ages (Andrade et al. 2013). As a result, the majority of small snook are

male and the majority of large snook are female. Snook are widely distributed, ranging from New York, U.S.A. to Rio de Janeiro, Brazil. Juveniles inhabit rivers and estuaries and adults can be found in brackish waters along the coast, particularly near mangroves. Adults feed on smaller fish, shrimp and crabs. Snook can live to about 20 years and grow to over three feet (Press 2016). The habits of snook in Belize have not been studied, so there is little information on critical habitat areas, timing of reproduction or movement. However, the species has been studied in the nearby Amatique Bay in Guatemala (Andrade et al. 2013). In this area, spawning occurred in the summer with the onset of the rainy season and warmer waters; this timing also coincided with the heaviest fishing pressure (Andrade et al. 2013).

Sport Fishing in Belize

Bonefish, tarpon and permit are the primary targets of sports fishers – together they comprise the "grand slam" of flats fishing – catching all three in one day. Snook are also commonly targeted as sport fish, along with barracuda, jacks and snapper. In addition, snook support an important small-scale commercial and subsistence fishery in Belize. Bonefish and permit are mostly targeted in the shallows or back reef flats, while tarpon are typically caught in creeks, channels and rivers (Fedler and Hayes 2008). Snook are commonly caught near the mangroves and around river mouths. Sport fishing is conducted with rod and reel, either fly rods or spinning reels (Appendix 2). Bonefish, tarpon and permit cannot be retained by Belize law, so this is a catch and release fishery only. Snook is also targeted by local fishermen with gillnets and can be retained and sold.

Sport fishing occurs along the entire length of Belize from Ambergris Caye to Punta Gorda. Turneffe Atoll is recognized as one of the top global destinations for bonefish, tarpon and permit sportfishing (Wildtracks 2011), generating over 8 million USD annually as a result of sport fishers visiting the Atoll (Fedler 2011). Snook are also considered important, though to a lesser degree (Wildtracks 2011). In addition, bonefish are the most important sport fish caught at Glover's Reef (Wildtracks and WCS 2007). Snook were one of the top ten most commonly caught fish at PHMR.

Because bonefish, tarpon and permit are catch and release only, there are no statistics on catch. One could estimate catches based on licenses sold and trips taken, but to our knowledge these data have never been compiled. The Sea Around Us has estimated that approximately 48,000 pounds of snook are landed annually in Belize. Observations by sportfishing associations suggest that snook are heavily targeted by illegal gillnet fishers, and anecdotal reports of permit fillets being sold in the Dangriga fish market suggest that permit may also be harvested illegally.

Stock Status Indicators for Sport Fish

Overfishing is likely not a major threat for bonefish, tarpon and permit stocks in Belize due to the catch and release nature of the fishery. However, there is concern that unregulated fishing, particularly from gillnets has reduced their populations from historic levels (SACD 2009). This is of particular concern for snook, which are often retained in gillnets and other fisheries and therefore may be subject to overfishing. At PHMR, fishers believe that snook has declined drastically due to gillnet use near river mouths and along the coast (Foster et al. 2011). Potential negative impacts on sport fish habitats include mangrove deforestation, seagrass habitat loss due to an increase in sport fishing guides and corresponding boating activity, and effluents from development along the coast and on cayes (Steinberg 2015). Without knowing more about spawning areas, nursery habitats, and migration patterns for sport fish species in Belize, it is difficult to identify additional threats that may put the stocks at risk.

QUEEN CONCH IS THE LARGEST VOLUME EXPORT FISHERY IN BELIZE

Ecology & Fisheries

Queen conch Lobatus (Strombus) gigas range from southern Florida to northern Brazil, across the Caribbean and including parts of the Gulf of Mexico. Adults inhabit seagrass and algae habitats up to 330 feet deep, progressively moving to deeper water as they grow older (Theile 2001). Juveniles prefer shallow seagrass habitats and sand flats. Their diet consists of algae and bits of decaying plant matter and it is largely the same for juveniles and adults. Adult queen conch have few predators given their large, thick shell and strong muscle, but juveniles are susceptible to crustaceans, other molluscs, finfish, sharks and rays. Queen conch mature at three to four years and can live up to 20 years (CFMC 1999). Spawning season and length vary considerably throughout the species range, but peaks typically occur in mid-summer. Conch move inshore to shallower habitat at the beginning of the spawning period and aggregate throughout the spawning season. Females deposit multiple egg masses in clean, sandy areas throughout the spawning season. Conch larvae spend two to four weeks swimming in open water before settling into seagrass and algae habitat similar to that of young lobsters (Mitton et al. 1989). In Belize, both South Water Caye and Sapodilla Cayes are known for high densities of juvenile conch, though the number of adults is relatively low compared to other areas (Wildtracks 2010b). After initial growth in length, conch devote energy to developing a flared lip and thickening their shell. Maturity and age therefore are not

easy to determine, and are related to a combination of length, lip thickness and development of the flared lip[17] (CFMC 1999; Foley 2016; Foley & Takahashi 2017). Nonetheless, shell length remains the sole standard for legal minimum size measurements.

The conch fishery is open from October through the end of June or until the total allowable catch (currently set at 800,000 pounds) is reached. Conch are harvested throughout Belize from seagrass beds and sandy/rubble habitats surrounding the patch and barrier reefs. They are captured exclusively by hand via free diving; SCUBA gear is prohibited. During the conch season some fishers travel to the fishing grounds in sailboats measuring up to 30 feet equipped with several smaller dories, which they then use to cover a larger area (Appendix 2). More experienced divers may venture into deeper seagrass habitat past the reef break. However, because SCUBA gear is prohibited, there is a limit to how deep divers can go; most divers do not exceed 60 feet.

Stock Status Indicators

Conch landings in Belize have increased by more than 400 percent during the last 23 years from a low of 245,000 pounds in 1989 to over 1 million pounds in 2012 (Figure 11; Villanueva 2014). Prior to 2012, the last

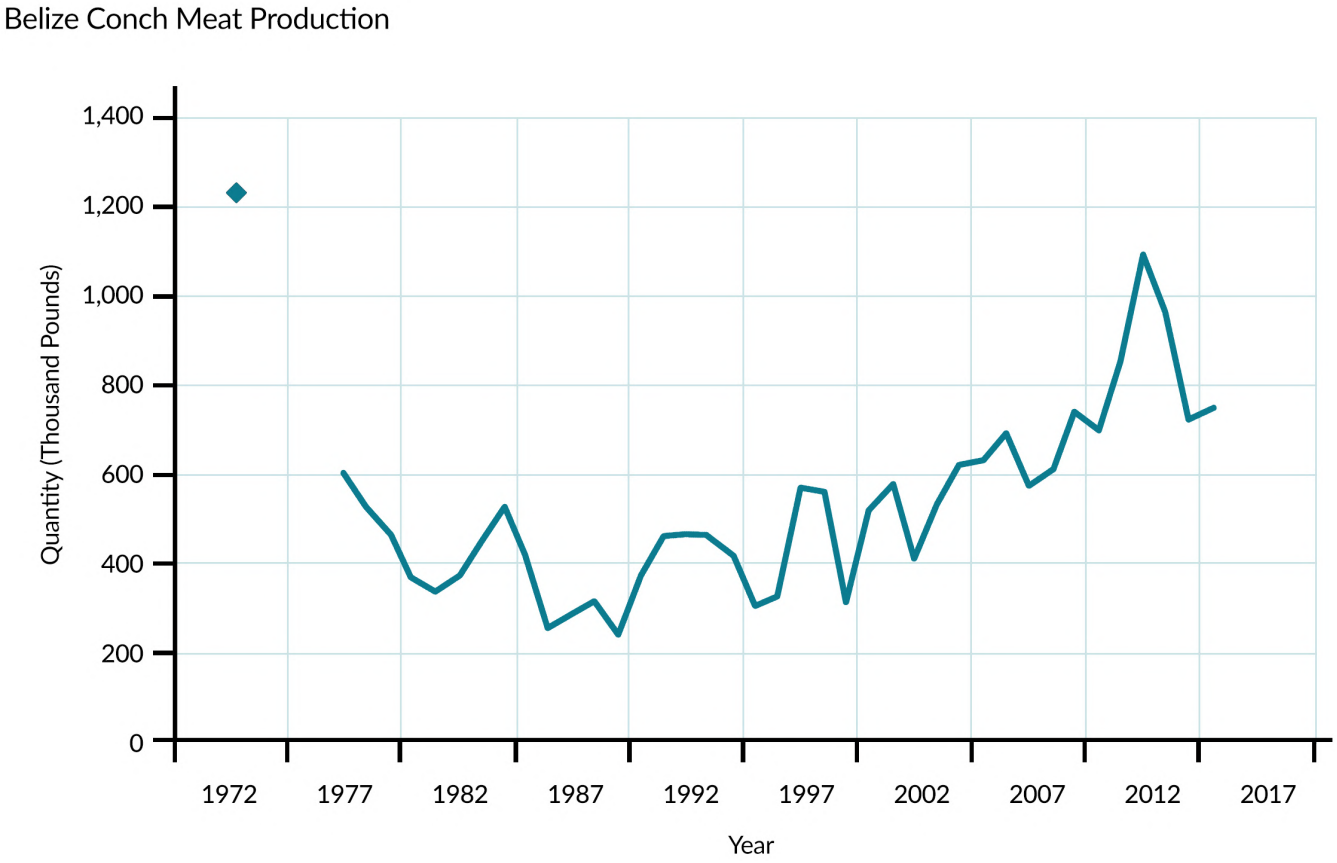

Figure 11. Conch meat production in Belize (Belize Fisheries Department).

17 Recent work at the Port Honduras Marine Reserve by Dr. James Foley of the Toledo Institute for Development and the Environment has examined the relationship between shell lip thickness and maturity. Initial results indicate that lip thickness is a more reliable indicator of maturity than either shell length (currently regulated) or operculum (foot) size, particularly for males (Foley 2016). This study may allow managers and inspectors to determine maturity based on market clean weight as well (TIDE 2016).

time queen conch production in Belize reached over 1 million pounds was in 1972, after which it experienced an 80 percent decline over the next 15 years (Ministry of Agriculture and Fisheries 2008 in (Wildtracks 2010a). Production from Turneffe Atoll, in particular, appears to have dropped from around 34,000 pounds in 2004 to around 15,000 pounds in 2009 (Fedler 2011; Wildtracks 2011). In 2012, Belize implemented a Total Allowable Catch (TAC) for conch (S.I. No 54 of 2012) which allows for an export quota to be set on an annual basis. Since 2012, conch production has ranged between 590 thousand pounds to just over 1 million pounds (Figure 12; SIB 2019b).

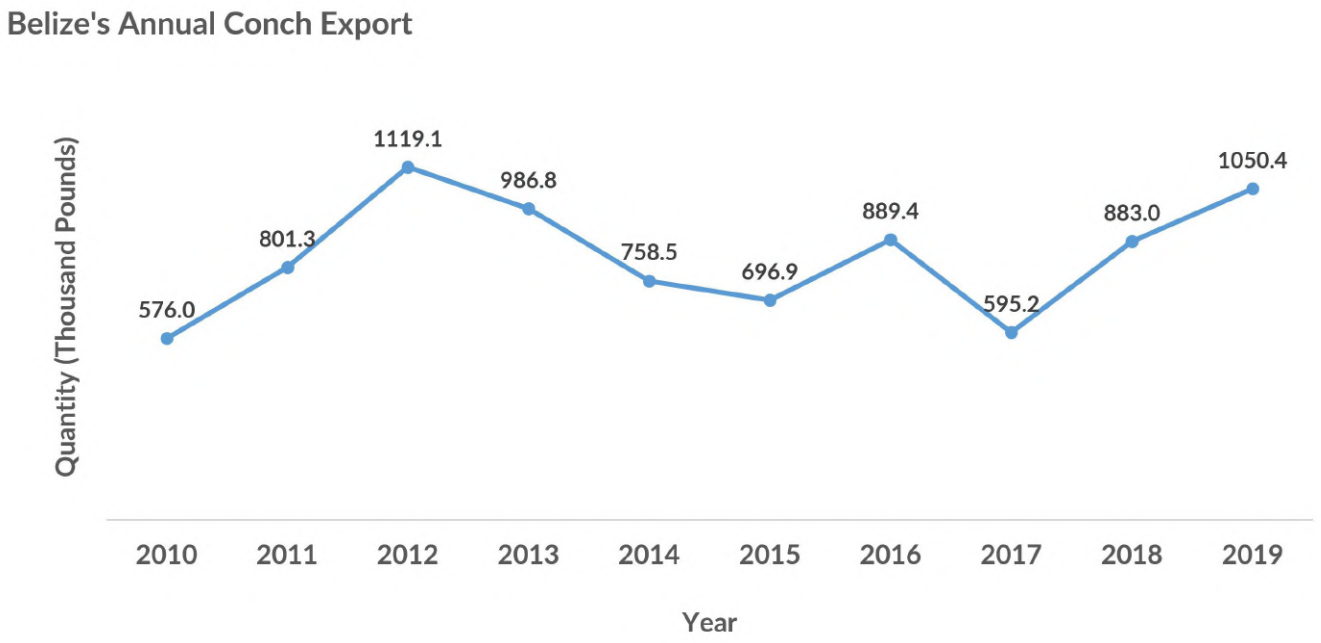

Figure 12. Belize's Annual Conch Export (SIB 2019b)

Queen conch are overexploited throughout most of their range, with very few populations considered healthy (Gascoigne 2002). The Belize Fisheries Department carries out an annual nationwide survey to assess the conch population in its waters and is in the process of developing an adaptive management framework to inform a fisheries management plan (McDonald et al. 2017). The 2012 assessment summary is optimistic, though without further information from previous assessments as well as more recent assessments, it is difficult to determine the current status of the conch fishery in Belize. The 2012 assessment estimated the density of conch in Belize at 337.4 conch/ha, the highest observed in the last six years (Gongora 2012a), and much higher than at other heavily exploited locations throughout the Caribbean, which often have less than 20 conch/ha (NMFS 2014). Reference values are provided by the HRI target of 300 – 400 adults per hectare (MAP 2011 in (Wildtracks 2011) and indications that spawning and mating only occur at densities of at least 48 adult conch/ha and 56 adult conch/ha, respectively (Stoner and Ray-Culp 2000). The assessment concludes that "this data shows that conch density is high and there is no risk of recruitment failure in the local fisheries" (Gongora 2012a). In addition, recruitment of young conch appears to remain strong given the high percentage of two to three year old conch in the population (33 percent and 38 percent, respectively (Gongora 2012a). However, local surveys and assessments of conch age at harvest paint a different picture.

Local surveys of conch populations at various marine reserves show mixed results. Southern Environmental Association (SEA) surveys at Gladden Spit and Silk Cayes found significantly more conch in the replenishment zones than in the general use zones, indicating that the replenishment zones were likely effective in protecting conch in the area (SEA data 2008 in Wildtracks 2010a). At Turneffe Atoll, the population abundance may be considered "fair" with between 64-331 conch/ha; however, none of the marine reserve's management zones had

a conch density equal to or higher than 50 sexually mature conch per hectare (UB ERI and TASA, 2019). Trends in conch density at Glover's Reef vary by habitat and management type, with some areas showing increases and others showing decreases. Overall, adults showed no trend, while large juveniles increased from 2004-2012 (WCS 2013).

PHMR has perhaps one of the most well-studied conch populations in Belize. Monitoring has been conducted since 2003. Conch were depleted in PHMR prior to the beginning of the monitoring program and showed little to no recovery through 2009; no clear trend was observed in abundance during that time period, nor was there any difference between the general use and replenishment zones (Foster et al. 2011). Fishermen did report decreases in catch from 2004-2009 (Foster et al. 2011). Later analysis in 2013 indicated that there was evidence that conch overfishing was occurring prior to 2011 in PHMR; there also appears to be depletion evident in the replenishment zones, which may indicate illegal fishing activity and poor enforcement. Furthermore, the percentage of larger adults in the fished population continues to drop year after year, which may indicate growth overfishing (Foley 2013). Unfortunately, by 2016, the situation had not improved. According to a survey in 2016, conch densities had declined in all zones at PHMR and are now well below the threshold needed for healthy reproduction; closed seasons in 2013, 2014 and 2015 did not succeed in increasing abundance during the reproductive period (Foley et al. 2016b).

The continued reliance on shell length as a measure of legal size has contributed to the problem. As of 2012, average shell length had increased (Gongora 2012a). However, shell length is now known to be a poor indicator of conch age or maturity (Foley & Takahashi 2017). The current legal minimum size does not appear to fully protect juveniles, with up to 90 percent of fished conch being immature in 2012 (Foley 2013). Instead, shell lip thickness provides a more accurate indication of age and maturity (Foley 2016, Foley & Takahashi 2017).

SPINY LOBSTER IS A 20 MILLION DOLLAR EXPORT INDUSTRY IN BELIZE

Ecology of Spiny Lobster

The Caribbean spiny lobster Panulirus argus is widespread and historically abundant throughout the western Atlantic Ocean, its range stretching from North Carolina, U.S.A. to Brazil. Mating times and spawning seasons vary throughout the species range, with peaks generally occurring in the warmer spring and summer months (Lipcius et al. 1983; Cascorbi 2005). Females carry the fertilized eggs for up to a month – during this time they are called "berried" and it is illegal to harvest them. While they are carrying the eggs, females migrate to the outer edges of the reef where the eggs are then hatched and released into the open water. From there, they travel on currents for several months, being transported to other areas; larvae have the potential to disperse across much of the species' range. Thus, spiny lobster throughout the western Atlantic are considered a single stock. Larval lobster settle into shallow algal habitat, particularly the red algae Laurencia sp. (Butler and Hernkind 1991). After about a week, the larvae metamorphose into juveniles and move into shallow seagrass habitats, sponges and small crevices where they remain for the next 1-1.5 years (Ehrhardt 2005). Young adults and adults inhabit more complex rocky and reef habitats and typically enter the fishery at two to three years of age (Ehrhardt 2005).

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Lobster Fishery of Belize

Lobster is the most valuable wild capture fishery in Belize. In 2019, export earnings from the lobster fishery totaled an estimated 20 million BZD (SIB 2019b). Production (tail weight) has stayed around 400,000-600,000 pounds since the 1990s; production amounted to about 535,000 pounds in 2019, making it the second largest fishery in Belize by volume (BFD 2016; SIB 2019b) (Figure 13). The lobster fishery is seasonal with a four-month closure from mid-February through mid-June. Spiny lobster are caught throughout Belize on barrier and patch reefs along the coast. Most of the fishing is conducted on the inland side of the reef where the water is shallower and calmer (Gongora 2010). Only the best (or most reckless) fishers venture to the fore reef or deep reef for lobster.

Several different types of gear are used to catch lobster in Belize. During the fishing season, most fishers go out in sailboats loaded with several dories, which are then used for free diving or deploying and collecting traps

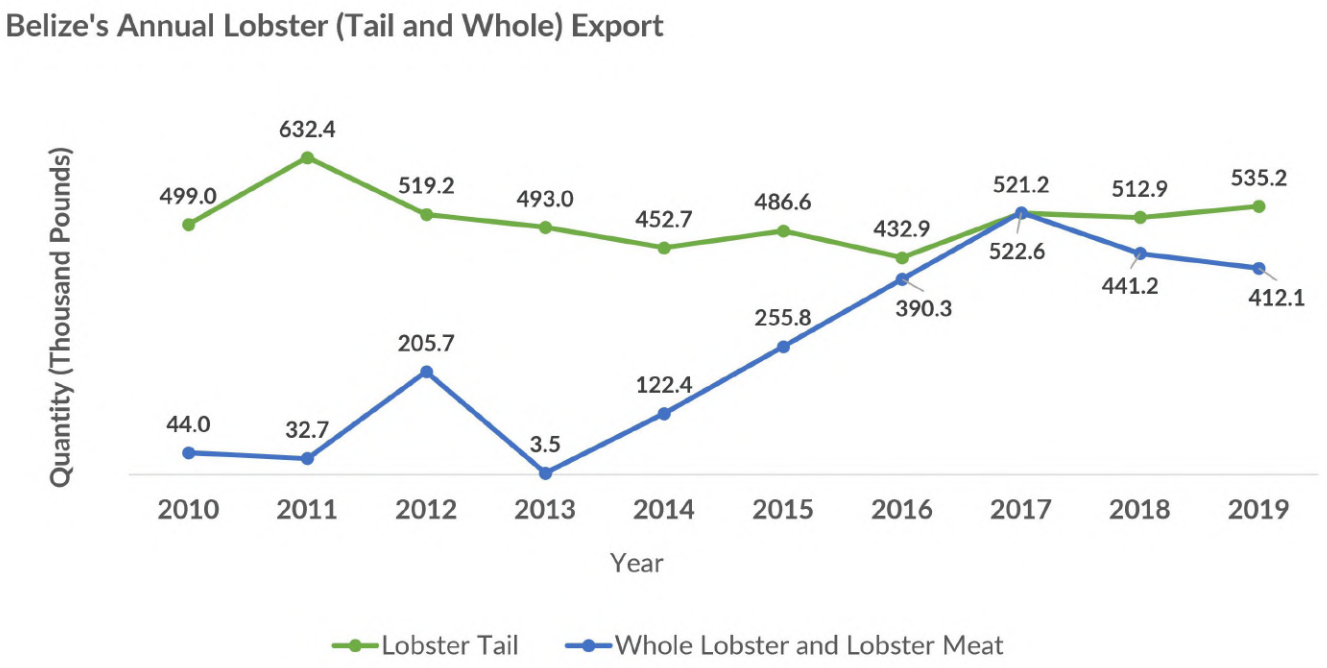

Figure 13: Belize's Annual Lobster (Tail and Whole) Export. Source: SIB 2019b

(Appendix 2); as with conch, SCUBA gear is prohibited for lobster fishing. Lobster traps and hook sticks are the primary gear used to catch lobster throughout Belize. Hook sticks are reportedly more common in the northern part of the country and on Half Moon Caye, Turneffe Atoll and Lighthouse Reef. Jamos (hand nets) and snares (pole with a loop on the end) are also used to collect lobsters from under shades (casitas); these gear types have the benefit of allowing fishers to release the lobster alive if it is undersized (Appendix 2). Historically, gillnets were used in the area around Monkey River to target migrating lobsters. The use of gillnets initially produced large yields, but after two to three years the catch stabilized, despite increases in gillnet use, and eventually they were abandoned (Huitric 2005). Today the Fisheries Act includes a clause which states that "no person shall employ or attempt to employ a gillnet to take fish from the shorelines [within five miles] of Monkey River or Placencia," although anecdotal evidence of gillnet fishing raises concerns about lack of adequate enforcement.

Health of Lobster Stocks in Belize

The last country-wide assessment that is publicly available for spiny lobster in Belize is from 2010. The assessment shows declines in catch per unit effort, biomass and recruitment between 1999 and 2009 and also shows an increase in fishing mortality during the same time period (Gongora 2010). This is consistent with previous assessments that showed high fishing mortality and declining catches (Gongora 2010). Lobster catches in Belize peaked in the early 1980s at just over two million pounds live weight (Gongora 2010). Landings decreased during the late 80s, were variable in the 90s and then stabilized in the early 2000s at about 1.5 million pounds live weight, on average (Gongora 2010). In the past there was continued optimism that lobsters were being harvested sustainably in Belize due to the stable production numbers since the early 2000s, but average sizes appear to be declining and for some fishers individual catches are no longer enough to support their families and their livelihoods (Wildtracks 2010b). Individual reserves also conduct monitoring of benthic species and, in general, results of these surveys show medium to low and declining abundance of spiny lobster in Belize. These reports raise concerns of unsustainable practices in the fishery such as overfishing and harvest of immature lobsters.

For example, Turneffe Atoll, which in the early 2000s contributed 20 percent of national lobster sales, has seen a 70 percent decline in lobster sales to cooperatives between 2004 and 2009, from 109,533 pounds to 33,381 pounds (Fisheries Dept. data 2004 – 2009 in (Fedler 2011). The decline of Turneffe sales as a percentage of national sales may indicate that the Turneffe fishery is declining faster than others in Belize (Wildtracks 2011). Although Turneffe is now a marine reserve with replenishment zones, it was not designated until 2012, which may account for the depletion relative to other areas.

average sizes appear to be declining and for some fishers individual catches are no longer enough to support their families

At Gladden Spit and Silk Cayes Marine Reserve studies have shown relatively moderate numbers of lobster within the reserve, approximately 12.4 lobsters observed per hour in the replenishment zone, and approximately 8.8 per hour in the general use zone (SEA data 2008 in (Wildtracks 2010a)). Lobster encounter rates were higher within the Gladden Spit and Silk Cayes Marine Reserve than in the nearby reserves of Laughing Bird Caye National Park and Sapodilla Cayes Marine Reserve (Wildtracks 2010a); low numbers of lobster have been observed at the Sapodilla Cayes Marine Reserve since monitoring started in 2008 (Wildtracks 2010b).

There appears to have been overfishing of lobster in PHMR prior to the implementation of Managed Access, with some recovery and good spillover effect[18] from the replenishment zones since then (Foley 2013). However, the high ratio of males to females is of concern because there are fewer females available to reproduce (Foley 2013). An assessment of logbook data from the pilot Managed Access program estimated that there were approximately 12,000 lobsters available to the fishery at PHMR in 2011-2012 and that about 70 percent of the fishable stock was harvested each year (Babcock et al. 2015). Lobster abundance has increased slightly in PHMR in 2015 after poor years in 2013 and 2014; mean shell length has also improved (Foley et al. 2016b).

At Glover's Reef, the most recent available data is an analysis of logbook data from the pilot phase of the Managed Access program. The results suggest lobster at Glover's Reef are not experiencing overfishing (Babcock et al. 2015). The model estimated approximately 66,000-79,000 lobsters at Glover's Reef with about 70 percent of the fishable stock being harvested each year. New lobsters appear to arrive during the fishing season, likely due to the large replenishment zone within the reserve and the surrounding deep-sea area (Babcock et al. 2015). This is consistent with earlier surveys that found a greater number of lobsters within the replenishment zone, particularly those of larger sizes (Wildtracks and WCS 2007). Furthermore, spiny lobsters show a slightly increasing trend at Glover's Reef from 2004-2012 with approximately even numbers of males and females in the population, both signs of a healthy population (WCS 2013). However, the most recent study indicates lobsters are being caught at suboptimal sizes; because larger lobsters produce more eggs, raising the minimum size limit may increase the yield (Babcock et al. 2015).

Because of the extended larval stage and long distance traveled by larval lobster, the replenishment of individual lobster fisheries is not straightforward, making management difficult. Populations are likely to be heavily impacted by exploitation in other regions, both within and outside of Belize, as well as by the suitability and availability of baby and juvenile habitat. At the same time, evidence suggests that lobsters respond well to no-take reserves, making this a promising tool for effective management of lobster fisheries. Additionally, Belize's size limit of 76 mm (2.99 inches) shell length does not appear to adequately protect immature females. It is important to base size limits on local studies of size at maturity as length at maturity varies throughout the species range from 70-95 mm (2.75-3.74 inches) shell length (Geers 2007).

18 The "spillover effect" occurs when a species becomes so abundant in a no-take area that the population moves or "spills over" into other fished areas.


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SUPERSTARS OF THE REEF – HOGFISH, PARROTFISH, TRIGGERFISH AND ANGELFISH – SHOW WARNING SIGNS IN BELIZE

Ecology & Fisheries

Like groupers, hogfish, angelfish and parrotfish switch from females to males after a certain period of time. For hogfish, this is typically after about three years and reaching over one foot in length (Bester 2016). In all these species, an older and larger male schools with a group of smaller females, his harem, which the male will guard and spawn with exclusively. If the dominant male dies, a large female will switch sexes and become the dominant male. Hogfish, angelfish and parrotfish have eggs that float in the water and larvae that spend several weeks swimming in open water before settling into juvenile habitat (Bester 2016). Triggerfish are highly territorial and both males and females tend to the eggs once they are spawned and fertilized. Unlike the others, triggerfish lay their eggs in a small depression on the seafloor and guard them until they are hatched.

All the species in this group are strongly reef associated. Hogfish and triggerfish use their long snouts and strong teeth to eat shellfish like crabs, sea urchins and snails living on the seafloor. Angelfishes are important to reef health because they help coral grow by eating the faster growing sponges. Parrotfish play a similarly important role by consuming sponges and algae that grow on reefs, though some do eat the corals themselves as well. Parrotfish are protected via a 2009 fishing ban in Belize due to their important role in maintaining reef health. These species, with the exception of parrotfish, are caught throughout Belize, primarily in the patch reef and reef crest areas. Fishers targeting hogfish depend primarily on spears or fish traps; the others are caught with a combination of handlines, traps and spears. Among reef species, hogfish are by far the primary target (Tewfik 2016a, 2016b). In particular, hogfish and queen triggerfish are two of the important commercially caught finfish at Glover's Reef (Wildtracks and WCS 2007). Hogfish make up about ten percent of the catch at Glover's Reef and South Water Caye (Tewfik 2016a, 2016b). Data collected at these locations also indicate that the majority of hogfish are caught after the sex change has occurred and are therefore large males (Tewfik 2016a, 2016b; Appendix 3). Data from Sea Around Us indicate that about 39,500 pounds of hogfish and related species are landed each year in Belize. According to data collected at Glover's Reef, triggerfish make up about one percent of the total number of fish landed and angelfish make up less than one percent; at South Water Caye triggerfish made up over three percent of the catch (Tewfik 2016a, 2016b). Of the angelfish, gray, French and queen angelfish are the primary targets.

Stock Status Indicators

HOGFISH (LACHNOLAIMUS MAXIMUS)

Hogfish appear to be declining throughout Belize based on surveys and studies at individual locations throughout the country; a downward trend has also been observed in HRI surveys. Babcock et al. (2013) found that hogfish were near the overfished threshold at Glover's Reef and that overfishing was occurring. Furthermore, hogfish exhibited a significant decline at Glover's Reef in all zones from 2004-2012 (WCS 2013). Density of wrasses, which include hogfish, in the PHMR area both inside and outside of the reserve have been low since 2011, with the exception of 2012 when densities peaked in all areas (Foley et al. 2016a).

PARROTFISH (SCARUS SPP. & SPARISOMA SPP.)

Initially parrotfish appeared to be suffering in Belize; however, since a ban on harvesting in 2009 it is likely that many populations have recovered. The difficulty is that few areas have recent data on biomass or abundance to confirm these trends. As assessed by HRI, herbivorous fish biomass (which encompasses both parrotfish and surgeonfish) is considered to be in "fair" condition (2018). In general, herbivorous fish biomass has been increasing since the ban on parrotfish harvesting in 2009, but in some areas recovery is slow (Kramer et al. 2015).

In the PHMR sampling area, parrotfish were the most abundant family from 2011-2014, both inside and outside of the replenishment zones. In 2014 they made up about 60 percent of the individuals observed outside of the reserve area (Foley et al. 2016a). Striped parrotfish were the most abundant finfish species observed at PHMR in 2012 (Foley 2013). Additionally, HRI surveys throughout the country show an increasing trend in stoplight parrotfish.

At Glover's Reef, Babcock et al. (2013) found that stoplight parrotfish were near the overfished threshold and that overfishing was occurring. This is particularly interesting given that there is a ban on fishing for all parrotfish in Belize. However, Babcock et al. only examined data through 2011, prior to implementation of the Managed Access pilot program and only two years after the parrotfish ban, so this may still be reflective of historic overfishing. Nevertheless, parrotfish recovery appears to be slow in the Glover's Reef area. Based on assessments of the coral patch reefs in the lagoon, biomass of the four parrotfish species (princess, redband, redtail and striped) is low overall in spite of fluctuations from 2008 to 2009; however biomass of parrotfish and other finfish may be underestimated due to the lack of data on the fore reef (WCS 2013). McClanahan and Muthiga (2020) in their 22-year study of patch reefs in the Glover's Reef lagoon, found that 9 years after the ban, large parrotfish (species > 6 inches) abundance had declined in both the General Use Zone and replenishment zones. Over the last couple decades, however, the patch reefs in the lagoon have become dominated by algae, which suggests that the habitat for the parrotfish may be more crucial in determining population recovery than fishing mortality, and that parrotfish recovery approaches may need to take this into consideration (McClanahan and Muthiga 2020).

Sapodilla Cayes is considered to have a moderate population of medium-sized parrotfishes (Wildtracks 2010b). In 2010, Turneffe Atoll was considered to have healthy abundances of herbivorous finfish; however, a significant drop was observed between 2006 and 2010 and some larger parrotfish species are now scarce (Wildtracks 2011). In 2017, independent ecosystem surveys conducted by the University of Belize Environmental Research Institute within the Turneffe Atoll Marine Reserve showed that the biomass of herbivorous fish were in poor condition with parrotfish absent in the larger size classes (> one foot) and having the highest frequency in the smaller 2 to 8 inch class (Martinez et al. 2018). Similar to the patch reefs at Glover's Reef, the continuing phase shift from coral reefs to fleshy macroalgae is now considered critical (Martinez et al. 2018).

TRIGGERFISH (BALISTES SPP. & CANTHIDERMIS SPP.)

Triggerfish have shown an increasing trend in HRI surveys over the past four years. This is the only national or local data available on triggerfish populations in Belize. However, given their high catch rates at areas such as Glover's Reef and the ban on parrotfish, it is possible that more effort may be exerted on these species than in the past.

ANGELFISH (POMACANTHUS SPP.)

Angelfish population declines may be of concern throughout Belize; given the ban on parrotfish, it's possible that effort may have been deflected to angelfish. Angelfish have exhibited a continuous declining trend in the PHMR area in all areas since 2011 (Foley et al. 2016a). Gray angelfish have also exhibited a downward trend in HRI

surveys. Babcock et al. (2013) found that gray angelfish were near the overfished threshold at Glover's Reef and that overfishing was occurring. However, French angelfish was the only species in Babcock's study that appeared to have a healthy population size and was not subject to overfishing.

SUMMARY

Belize's fisheries potential is far from being fully realized due to the depletion of numerous stocks. Even conch and lobster, which currently dominate the export market and are the focus of fisheries management measures, are potentially less productive due to the low minimum size permitted. Finfish stocks for some of Belize's most iconic and important fisheries, including Nassau and goliath grouper, mutton snapper and hogfish are clearly overexploited. Fishers are instead turning to less well known or smaller species, but without management, it is only a matter of time before these too become depleted. Many species are being harvested as juveniles, before they can mature and reproduce, driving down the stocks' ability to replenish itself. A handful of species have benefited from protections, including parrotfish, tarpon, bonefish and permit, but these are the exception, not the rule. Without better regulation of all species, overfishing will continue, risking depletion to the point where fishers can no longer sustain their livelihoods. Moreover, the protections that are in place are undermined by indiscriminate fishing gear such as gillnets, as well as illegal fishing activity. With proper management and enforcement, Belize's fisheries can support an even stronger and more vibrant fishing economy.

BAIT FISH: TINY BUT VITAL

Bait fishing is carried out using cast nets in shallow, nearshore seagrass flats, often near mangroves. Targeted species are mainly the redear herring (Harengula humeralis) and, in smaller quantities, the scaled sardine (H. jaguana). These species are principally used as bait for catching larger finfish species with hook and line or baited traps (McRae 2004). These species are an important component of the nearshore food web and thus management is necessary to prevent overharvesting and to ensure that there are sufficient fish in the water to sustain their predators, which are themselves important and valuable fished species. Furthermore, anecdotal reports suggest a recent scarcity in bait fish and indicate that the Fisheries Department may see this as a priority for management.

SUSTAINABLE, WILD-CAUGHT BELIZEAN SHRIMP (FARFANTEPENAEUS SP., LITOPENAEUS SP.)

Wild-caught shrimp fisheries are not documented in official Fisheries Department or marine reserve reports. Since a ban on trawl fishing was implemented in 2010, there has been no large-scale commercial fishery for shrimp in Belize. However, fishing for shrimp in shallow water using a cast net may be observed around Belize City and elsewhere. With low effort and little bycatch, this may be one of the most sustainable shrimp fisheries in the world! As such, it is likely that shrimp populations are healthy in Belize; however, it is unknown whether other factors such as pollution or disease may be impacting their populations.

SEA CUCUMBER: A CAUTIONARY TALE

Opened in 2009, sea cucumber is one of the more recent fisheries to develop in Belize and it tells a cautionary tale. In Belize, 18 species of sea cucumbers have been reported (Pawson 2000 in Rogers 2013). Since the 1990s, fishing for sea cucumbers has been occurring in Belize with the harvest either sold to Asians living in Belize or transported by boat to Guatemalan buyers via the Gulf of Honduras (Rogers 2013; Rogers et al. 2018). Of the known commercial species found in Belize, only Holothuria mexicana and Isostichopus badionotus are commercially harvested in Belize; Actinopyga agassizii, Astichopus multifidus are not fished (McNab and Rogers 2017).

In 2009, the sea cucumber fishery was formalized which led to harvesting for export to international markets (Rogers et al. 2018). The Belize Fisheries Department allowed for the harvest of H. mexicana only, however, I. badionotus was also harvested due to its higher economic value than H. mexicana (Rogers 2013). There was a 6-month fishing season from 1 January to 31 June but once the TAC had been met, the season was closed. Seventy fishers were granted fishing licenses annually while 5 to 7 exporters were granted sea cucumber exporting licenses (James Azueta, BFD, personal communication in Rogers 2013). The BFD also required reporting of catch as part of license conditions (Rogers et al. 2018).

Between 2011 to 2012, approximately three years after the sea cucumber fishery had opened, Rogers (2013) conducted a study to assess the density, abundance and distribution of sea cucumbers in Belize. The survey areas included sites along the entire coast, namely: Turneffe Atoll, Lighthouse Reef, Glover's Reef, Bacala Chico, Gladden Spit and Sapodilla Cayes. H. mexicana had a higher density (161.8 individuals per hectare) than I badionotus (117.4 individuals) (Rogers 2013). The total estimated TAC for H. mexicana was estimated at 7,318,971 lbs, and with a TAC of 182,750 lbs per annum, Rogers (2013) estimated that the fishery could only last for a few more years.

The sea cucumber fishery had become very lucrative, increasing fishers income to 154 times the minimum wage in 2010; however, by 2016, income had decreased to only 5 times the minimum wage (Rogers et al. 2018). The decrease in income was due to a decline in the stock in shallower water which required fishers to dive to greater depths and competition with illegal fishers from Honduras and Guatemala (Rogers et al. 2018). At PHMR, by 2015, the density of donkey dung sea cucumber declined to its lowest level since sea cucumber monitoring began in 2011 with declines evident in both the replenishment and general use zones (Foley et al. 2016b). By 2016, H. mexicana was considered overfished and in 2017 the entire fishery was closed (Rogers et al. 2018). One of the main challenges in the management of sea cucumbers was that the TAC was set based on wet weight, however, the estimated exported catch was based on dry weights (partially to fully dehydrated) sea cucumbers (Rogers et al. 2018). Sea cucumbers can lose about 54% of their total length and 84% of their body weight (Rogers et al. 2019), which means that, possibly, sea cucumbers were harvested at as much as 95% over the quota, resulting in the drastic decline in abundance (Rogers et al. 2018). Additionally, at times export data for sea cucumber and other species such as mussels are lumped into a "other fish" category making it difficult to determine total catch (Rogers et al. 2018).

It would be wise to take a lesson from the story of the sea cucumber fishery and ensure that prior to establishing a fishery, more is understood about the biology and the ecology of the species, the market and that effective management measures are in place prior to opening a new fishery or increasing effort in existing fisheries. Finally, as in the case of sea cucumbers, the viability of the species as an alternative aquaculture species should also be explored as a means to alleviating harvesting pressure on wild populations (Rogers 2018).

Lionfish in Belize

Heather Ylitalo-Ward

BACKGROUND AND BIOLOGY

Invasive Indo-Pacific lionfish were introduced into the waters off Florida in the late 1980s, likely due to escape or release from aquaria (Albins and Hixon 2011). Since then, their numbers have been increasing at an alarming rate with their range now spanning from as far north as Boston, U.S., south through Central America, and east across the coast of Venezuela (USGS 2018).

There are two species of lionfish in the Caribbean, the red lionfish (Pterois volitans), and the devil firefish (Pterois miles). The red lionfish is the most abundant, representing more than 90 percent of the individuals found. It can be challenging for an untrained eye to tell the difference between the two as the only structural difference is one less dorsal and one less anal spine (Searle et al. 2012).

fast growth, high reproductive output, out-competition of predators, efficient hunting techniques and venomous spines. They reproduce faster and more prolifically than many of the reef fish in the Caribbean

The reason for the rapid spread of lionfish across the western Atlantic is a combination of fast growth, high reproductive output, out-competition of predators, efficient hunting techniques and venomous spines. They reproduce faster and more prolifically than many of the reef fish in the Caribbean (Morris and Whitfield 2009; Gardner et al. 2015), utilizing resources that were once available to native fish. In addition, they have no natural predators in the Caribbean, allowing them to swim and reproduce freely with little population control from predation. They also appear to be very resilient to parasites, again removing a threat to their population growth (Albins and Hixon 2011). Lionfish can live in a wide variety of marine habitats, enabling them to spread widely throughout the Caribbean. They can be found in mangroves, seagrass beds, coral reefs, along the continental slope and in man-made structures like abandoned lobster and fish traps (Searle et al. 2012). Lionfish tolerate a wide range of salinities, allowing them to travel into brackish water near river mouths (Jud et al. 2014). They are also able to survive temperatures down to 10°C (50°F), although they have been found in waters off of Massachusetts in the U.S., indicating they might be more resilient to cold temperatures than previously thought (Morris and Whitfield 2009).

Lionfish reach maturity in approximately one year at around seven inches for females and five inches for males. Males will often do elaborate displays for the females, extending their fins and spines, enticing her to mate. If the female is responsive, the lionfish will swim around each other and the female will release two mucous egg masses containing 15,000 to 30,000 eggs that float to the surface (Morris and Whitfield 2009). The male will then fertilize the egg masses and larvae hatch out 36 hours later. Females can produce egg masses every four days once they reach maturity (Morris 2009).

LIONFISH AS A THREAT TO FISHERIES AND REEF HEALTH IN THE CARIBBEAN

Lionfish were initially sighted in Belize in 2008 near Turneffe Atoll and since then they have become ubiquitous in Belizean waters. Lionfish present a major threat to fish populations in Belize. They consume juveniles of a wide variety of ecologically and economically important species such as grouper, snapper and parrotfish (Morris and Whitfield 2009; Côté et al. 2013; Selwyn et al. 2014;). In Belize, there are concerns of lionfish consumption of economically important invertebrates, such as juvenile lobster (Searle et al. 2012). A study in Belize also found that lionfish often target a critically endangered social wrasse (Halichoeres socialis) as prey, threatening their populations even further (Rocha et al. 2015). Their primary prey include small or juvenile fish and small invertebrates such as shrimp and crabs (Searle et al. 2012) and, as a result, lionfish have been found to reduce recruitment of native species by up to 80 percent and the overall native fish biomass by 65 percent on artificial reefs (Albins and Hixon 2011). Likewise, a study off of Turneffe Atoll found that the populations of some fish had lower rates of recruitment after lionfish had been introduced to the area although, it could not be determined conclusively that this change in recruitment was solely caused by the lionfish (Selwyn et al. 2014).

In Belize, there are concerns of lionfish consumption of economically important invertebrates, such as **juvenile lobster**

In addition to predation, lionfish threaten native species by competing for food and space. Snapper, groupers, and spiny lobster have all been observed sharing space with lionfish, and are known to prey on many of the same species as the lionfish (Searle et al. 2012). Lionfish abundance does not appear to be influenced by populations of native predators such as grouper in most areas of the Caribbean (Hackerott et al. 2013; Valdivia et al. 2014). However, a study in Belize found a correlation between high grouper numbers and low numbers of lionfish. Low lionfish abundance was also correlated with high wave action and MPAs, so it could not definitively be due to grouper presence (Gamazo 2013). Worst-case scenario projections suggest that the combined pressures of predation and direct competition could lead to trophic cascade effects on coral reefs, potentially leading to depletion of apex predators (Albins and Hixon 2011).

Studies suggest that lionfish numbers are likely increasing in Belize. Blue Ventures has done extensive monitoring of the Bacalar Chico Marine Reserve and found population abundance of lionfish to be increasing yearly (Chapman et al. 2013). In addition, the Toledo Institute for Development and Environment (TIDE) has monitored lionfish catch at PHMR and found both total catch and catch per unit effort increased from 2012-2014, indicating lionfish population growth (Holah and Foley 2015).

They consume juveniles of a wide variety of ecologically and economically important species such as **grouper, snapper and parrotfish.**

Lionfish mitigation is needed in Belize to help protect the already stressed native fish populations (Albins and Hixon 2011). Also, lobster represent one of the two largest commercial fishery exports in Belize; if lionfish are consuming the juveniles or eggs, they pose an economic threat to this industry (Searle et al. 2012; Chapman et al. 2013). If lionfish populations remain unchecked, the reefs will become more homogenized and less resilient against climate change (Albins and Hixon 2011). However, regardless of the potential impact of lionfish on other reef species, lionfish can provide an alternative to more heavily exploited species. These arguments illustrate the need for and benefit of lionfish mitigation in Belize.

MITIGATION OF LIONFISH

In 2009, the Bahamas, Dominican Republic, Jamaica, St. Lucia, and Trinidad and Tobago began a regional initiative called Mitigating the Threats of Invasive Alien-Species in the Insular Caribbean. In the Bahamas, culling techniques have had varied results. Culling every six months appeared to reduce lionfish populations more effectively than every three months. However, species richness and prey biomass did not increase in culled locations (Smith et al. 2016). In addition, lionfish on culled reefs adopted alert postures and hid deeper in reefs during the day than those found on unculled reefs (Côté et al. 2014). In Jamaica, a decrease in lionfish populations was reported in areas with consistent fishing pressure after the start of their "Eat it to Beat it" campaign (Chin 2014). In Cuba, CubaMar has begun investigating the effect of culling and subsistence fishing in various MPAs around the country.

Fisheries-based extraction is considered the most effective and financially sustainable approach to lionfish control (Bogdanoff et al. 2014). It seems unlikely that lionfish will ever be fully eradicated because of their high reproductive and growth rates. Thankfully, it appears that reducing lionfish population size may be sufficient to restore and maintain ecosystem health. Native fish biomass can increase 50-70 percent when lionfish are fished to levels below a threshold determined by site-specific models (Green et al. 2014).

Blue Ventures is currently developing a strategy to determine appropriate target catch levels; they surveyed 50 sites in Belize to estimate lionfish and determine target numbers for suppression (Blue Ventures, unpublished). While they and TIDE have reported increased lionfish numbers in the Bacalar Chico Marine Reserve and PHMR, they report that numbers appear to be declining in many areas, both through observations and in informal interviews with local fishers (J. Chapman, personal communication 9 June, 2016). However, this observation is common in invasive species, with boom and bust cycles often repeating until the population can reach a stable carrying capacity (Côté et al. 2013). It may also be a sign that the fishery approach to lionfish population control is already working in those areas accessible to fishers. Anecdotal reports suggest that less accessible areas may not benefit in the same way, for example with lionfish withdrawing to deeper waters.

Developing a fishery for lionfish may offer **socioeconomic benefits** to fishers

Developing a fishery for lionfish may offer socioeconomic benefits to fishers by providing an alternative fisheries target. This would only be possible in areas accessible to fishers, not in no-take areas or replenishment zones, due to the challenges it would pose for enforcement. Informal interviews with fishers have indicated that there is a lack of financial incentive to fish lionfish. Many complain that the price is not worth the effort and perceived danger in collecting lionfish. Another problem they encounter is a wavering demand in the market. Tourists most commonly consume lionfish and, during the slow season, restaurants may not be purchasing as much lionfish. To raise demand and market price, new policies such as tax incentives could be used to stimulate the fishery, along with consumer-oriented campaigns. In addition, there continues to be a misconception among both fishers and restaurateurs that lionfish can be poisonous if not prepared correctly; in response, efforts are being directed to overcoming this misconception.

In addition to fisheries-based extraction, replenishment zones and marine reserves can provide refuge for important species and support source populations for many fisheries. It is imperative that lionfish are culled in these areas to ensure healthy replenishment zones. While allowing lionfish fishing in no-take areas would pose a challenge for enforcement, possible strategies for control in replenishment zones include culls by specific protected area managers or rangers, recreational SCUBA diver culls, or lionfish culling competitions. Ultimately, it will be critical to maintain ecosystem resilience through MPAs and sustainable fisheries management.

A Detailed Look at the Sharks and Shark Fisheries of Belize

Demian D. Chapman

INTRODUCTION

There is increasing public interest in the status of sharks in Belize. This stems in part from some species becoming living attractions for the ecotourism industry, which features in-water experiences with nurse sharks at Shark Ray Alley, Hol Chan Marine Reserve; Caribbean reef sharks at the Blue Hole at Lighthouse Reef; and whale sharks at Gladden Spit. Sharks are also targeted by the fishing sector in Belize, providing a variety of products for human consumption and contributing to national food security (Zeller et al. 2011). Besides these economic uses, sharks are top predators in coastal, barrier reef and offshore habitats in Belize and may provide important, if poorly understood, ecosystem services (Roff et al. 2016).

The first step to successfully managing shark fisheries is to understand the basic biology of the species involved

and the characteristics of the catch. The objective of this chapter is to provide background on the sharks, their fisheries and the current state of shark fisheries management in Belize in order to outline future research and management interventions that could improve upon what is currently in place. I first summarize the life history and ecology of the shark species that are frequently landed in the Belizean fishery and provide preliminary results from a standard survey of the relative abundance and diversity of sharks at seven reefs distributed across Belize. I then outline the current state of the shark fishery, including information about its size, characteristics, products, markets, species composition and regulation. Lastly, I discuss a range of options that could build a more effective fisheries management system, together with the underlying research requirements needed to support these initiatives.

THE SHARKS OF BELIZE

Belize exhibits a shark fauna typical of the Central American Caribbean, primarily composed of subtropical and tropical species from the Order Carcharhiniformes. Its coastal and epipelagic shark fauna has been characterized in Pikitch et al. (2005), Chapman et al. (2011) and Zeller et al. (2011). The mid-water and deep, bottom-associated shark fauna is in the process of being surveyed (http://saveourseas.com/update/deep-drops/). Here, I describe key life history information from the species interacting most with the Belizean coastal shark fishery. Most information in these summaries is derived from the IUCN Red List species accounts.

Caribbean Sharpnose (Rhizoprionodon Porosus)

IUCN status: Least Concern.

The Caribbean sharpnose shark is a small coastal species that occurs from the Gulf of Mexico south to Venezuela and throughout the Caribbean islands. Both sexes reach sexual maturity at 2-2.3 feet total length (TL), which corresponds to an age of approximately two years. Females produce a litter of one-eight offspring every year, with larger females producing larger litters. Longevity is approximately 10 years. This is one of the most productive species of sharks, with an intrinsic rate of population increase of 0.146 (Smith et al. 1998). This means the population can grow at a rate of 14.6 percent per year and is therefore highly resilient to fishing (Figure 14). This species is composed of at least two genetically differentiated stocks in the region separated by the Equatorial Current (Mendonça et al. 2011), each of which is likely to be replenished by internal population dynamics rather than immigration from other regions. In Belize, Caribbean sharpnose are found in shallow coastal areas along the mainland, often over soft bottom habitats. They also occur over the barrier reef and at the offshore atolls. This species feeds on small fish and invertebrates.

Caribbean Bonnethead (Sphyrna cf. Tiburo)

IUCN status: Least Concern.

The Caribbean bonnethead is a cryptic hammerhead species recently separated from the bonnethead shark (S. tiburo), which was previously described as a widely distributed species from North Carolina to Brazil (Fields et al. 2016). The precise distribution of the Caribbean bonnethead awaits further study. It is likely that the basic life history and ecology of this species is similar to that of the Atlantic bonnethead S. tiburo. Atlantic bonnetheads are small coastal sharks, maturing at lengths of between 2.6-3.1 ft TL for females and between 2.2-2.8 ft TL for males. Age at first maturity is from two-three years, depending on location. Genetic studies indicate a high degree of structure in populations of this species, indicative of either residency or return migration ("site-fidelity") by individuals within certain regions (Escatel-Luna et al. 2015; Fields et al. 2016). Atlantic bonnetheads

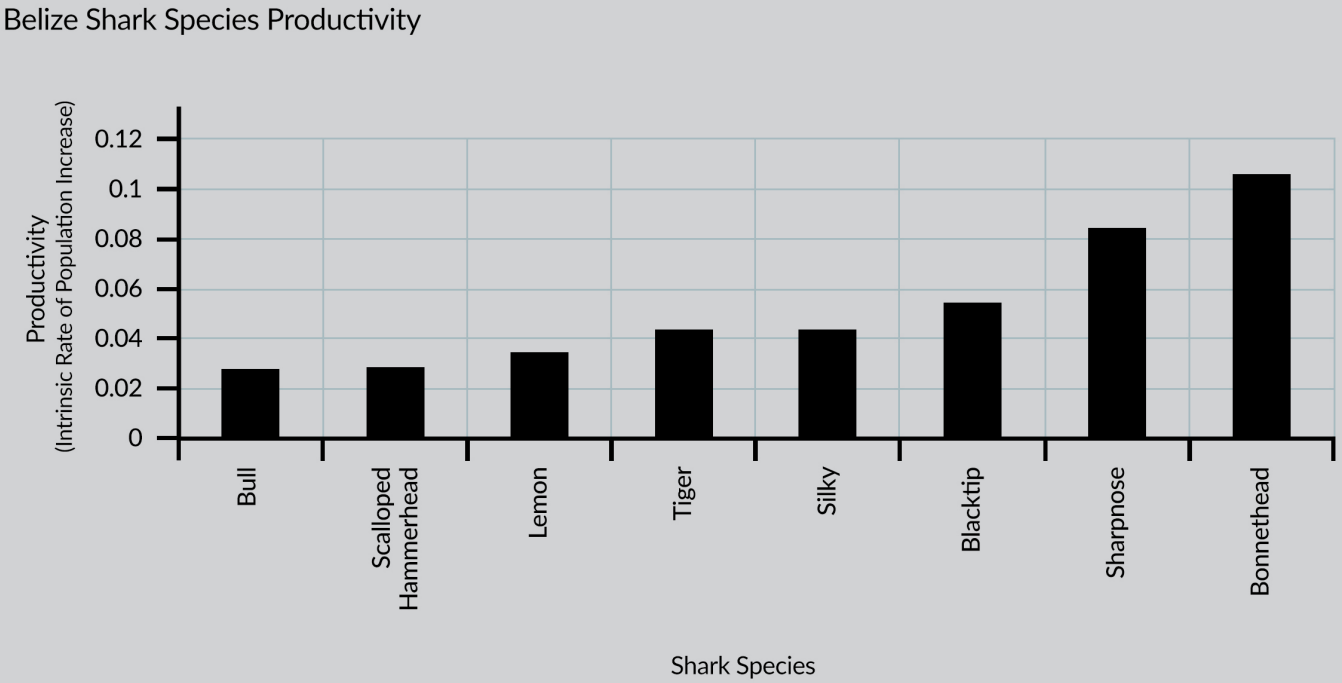


Figure 14. Relative productivity of the main shark species in Belize – greater productivity corresponds to greater resilience to fishing pressure.

give birth to live young with a gestation period of five months. Litter size ranges from four to twenty and the reproductive cycle is annual. The Atlantic bonnethead is a highly productive species (Figure 14) and is not considered overfished. However, fisheries in Brazil have nearly extirpated bonnetheads, which is cause for concern given uncertainty about the number of species and their status in the region. The geographic limits of the stock(s) occurring in Belize are not known, except that the northern boundary is at least as far as the Yucatan Peninsula. In Belize bonnetheads mainly inhabit nearshore habitats along the mainland over soft bottom and seagrasses, where they prey on invertebrates (especially crabs) and small fish. All life stages can usually be found in similar habitats.

Blacktip (Carcharhinus Limbatus)

IUCN status: Near Threatened.

The blacktip shark is a coastal species distributed throughout the world in warm temperate and tropical regions. It matures at 4.3-4.8 ft TL for males and 5-5.1 ft TL for females, at ages from approximately four-seven years. Females give birth to litters of four to eleven offspring after an 11-12 month gestation period where embryos are nourished via a placental connection (Castro 1996). The reproductive cycle occurs every two years. The species is moderately productive compared to other large sharks, with an intrinsic rate of population increase estimated at 0.054 (Smith et al. 1998; Figure 14). Newborn individuals are typically found in shallow, coastal areas, especially protected lagoons and estuaries. These areas typically meet the definition of a nursery area. A nursery area is a place where there are higher densities of young sharks relative to other areas, that is used consistently over time, and where individuals are resident within the area for months to years (Heupel et al. 2007). Older juveniles and adults occupy deeper coastal areas, and in some places make seasonal migrations in response to changes in water temperature. A population genetic study of this species from the U.S. Atlantic, Gulf of Mexico, Mexico and Belize found that maternally inherited genetic variation was geographically partitioned but bi-parentally inherited genetic variation was not (Keeney et al. 2005). This indicates that females remain within or

return to the region where they were born to give birth ("regional philopatry"), whereas males frequently breed outside of this area (Chapman et al. 2015). This means that Belizean fishers are exploiting a stock in which the females breed within a region that does not extend further north than Yucatan, Mexico and further south than northern Brazil (Pikitch et al. 2005; Sodré et al. 2012). More genetic studies are needed to more precisely define the stock boundaries of blacktips in the region to enable more realistic assessments.

Caribbean Reef (Carcharhinus Perezi)

IUCN status: Near Threatened.

The Caribbean reef shark is a reef-associated predator that is endemic across a patchy distribution from Florida to Brazil. This species matures at around 5-5.6 ft TL for males and > 6.6 ft for females (Pikitch et al. 2005). Age at maturity is currently unknown, but litter sizes are from four to six and the reproductive cycle is thought to occur every two years. All life stages of Caribbean reef sharks are primarily found over hard bottom areas along the barrier reef and all three of the offshore atolls in Belize. It is thought that individuals complete their entire life cycle within the reef habitat (Pikitch et al. 2005). Many individuals are resident for periods of more than one year to Glover's Reef Atoll, which suggests that in offshore habitats in Belize there may be resident populations of Caribbean reef sharks (Bond et al. 2012). Nevertheless, movements of individuals between atolls and into deep water off the reef slope (to 352 m) have been documented in Belize (Chapman et al. 2005). The population of Caribbean reef sharks at Glover's Reef was stable from 2001-2005 (Pikitch et al. 2005) and from 2005-2013 (Bond et al. 2017).

Scalloped Hammerhead (Sphyrna Lewini)

IUCN status: Endangered.

The scalloped hammerhead shark is a coastal pelagic species that is distributed worldwide in tropical and warm temperate regions. It matures at 10 years, 5.9 ft TL for males and 15 years, 8.2 ft TL for females in the Gulf of Mexico, the closest population to Belize that has been subject to life history studies. Scalloped hammerheads give live birth and the gestation period is nine to twelve months. Litter sizes range from 10-40 offspring. In Belize newborn sharks are found in shallow coastal areas along the mainland, separated from large juveniles and adults that range from deeper coastal habitats to the barrier reef and at least some of the offshore atolls and into the open ocean zone. Schooling scalloped hammerheads have been reported at the southern elbow of Turneffe Atoll in Belize. A population genetic study of scalloped hammerheads in the western Atlantic identified at least three distinct populations in maternally inherited DNA: the US Atlantic and Gulf of Mexico, Belize and Brazil (Chapman et al. 2009; Vincent et al. 2014). These findings mean that adult females are breeding in the region where they were born. Additional sampling is required to resolve the boundaries of these stocks and identify any others in the western Atlantic. Scalloped hammerhead populations in many locations are in serious decline, prompting them to be listed on Appendix II of the Convention on International Trade of Endangered Species (CITES) in 2013, which mandates all signatories participating in trade of this species to issue export permits certifying that each export was legally and sustainably obtained (Vincent et al. 2014).

Great Hammerhead (Sphyrna Mokarran)

IUCN status: Endangered.

The great hammerhead is a large coastal and offshore apex predator that is globally distributed in tropical to warm temperate regions. The species lives at least 44 years (Piercy et al. 2010), with males maturing at 7.7-8.8 ft

TL and females at 8.2-9.8 ft TL; maximum size may be as high as 19.7 ft TL. Females give birth to 6-42 offspring after 11 months of gestation and produce a litter every other year. Nursery areas are suspected to exist for this species but have not been located and described in the Atlantic. In Belize great hammerheads are widely distributed in soft bottom and reef habitats from the mainland to all three of the offshore atolls. They primarily feed on rays, smaller sharks and large fish. The population structure and movements of this species are not well known in the region. Great hammerhead populations are suspected to have declined in many locations and they were listed on Appendix II of CITES in 2013.

Lemon (Negaprion Brevirostris)

IUCN status: Near Threatened.

The lemon shark is a large coastal species that is found from New Jersey to Brazil in the western Atlantic. In Belize this species can be found in shallow coastal areas along the mainland, along the barrier reef and on the offshore atolls. Lemon sharks are most common over soft bottoms and are often associated with mangrove-fringed coastlines. Males reach maturity at 7.4 ft and females at 7.7 ft, at ages of 12-13 years. Longevity is at least 37 years (Brooks et al. 2016). Litter sizes are from 4-17 (Clark and Von Schmidt 1965). This species has spring and summer birthing periods, with offspring being released in shallow coastal nursery areas (< 3.3 ft deep) after a 10-12 month gestation period. In Belize nursery areas are known to occur on several cayes on the barrier reef, Glover's Reef Atoll and Turneffe Atoll (Pikitch et al. 2005; Chapman unpublished). Females often home to their exact birthplace to give birth and there are numerous genetically differentiated populations of this species in the region (Feldheim et al. 2014; Ashe et al. 2015). This, combined with their low productivity (Figure 14) and exposure to people because of their preference for shallow, nearshore habitats, makes them highly susceptible to local extirpation. Lemon sharks feed on fish, rays, smaller sharks and invertebrates.

Tiger (Galeocerdo Cuvier)

IUCN status: Near Threatened.

The tiger shark is a large coastal and offshore apex predator that is globally distributed in tropical and warm temperate regions. Tiger sharks are highly mobile and often migrate between coastal and pelagic habitats during the year, although some individuals may reside in a particular area for long periods. Tiger sharks are found throughout Belize in a wide variety of habitats. Longevity is estimated to be 45 years. Size at maturity of males is 7.4-9.5 ft TL and of females is 8.2-11.5 ft TL, with a maximum size of more than 18 ft TL. Litter sizes range from 10-82 offspring, with a gestation period of 13-16 months. Tiger sharks are moderately productive (Figure 14). There are at least two genetically differentiated populations of tiger sharks in the Atlantic, one in the Southern Hemisphere and one in the Northern. Belize, therefore, shares their tiger shark stock with many other countries in the Caribbean and northwest Atlantic (Bernard et al. 2016). Tiger sharks have a very diverse diet, including fish, marine mammals, sharks, sea turtles, sea birds, invertebrates and even marine debris.

Bull (Carcharhinus Leucas)

IUCN status: Near Threatened.

The bull shark is a large, heavy-bodied apex predator that inhabits coastal areas, estuaries and rivers in warm temperate to tropical regions worldwide. Bull sharks can be highly mobile in some areas, but juveniles are often resident in nursery habitats in and around rivers for the first few years of their lives. Bull sharks are primarily found along the coasts and rivers of Belize, although there are several locations along the barrier reef where adults can be found (e.g. Gladden Spit). The maximum size of bull sharks is approximately 11.2 ft TL with males maturing at 5.2-7.4 ft and females at 5.9-7.5 ft. Age at maturity is 14-15 years for males and 18 years

for females. The stock structure of bull sharks is not well known in the Atlantic, except that there is genetic differentiation of the US Atlantic/Gulf of Mexico and Brazilian populations at maternally-inherited markers (Karl et al. 2011). This indicates, at the very least, that females are returning to the region where they were born to give birth.

Nurse (Ginglymostoma Cirratum)

IUCN status: Data Deficient.

Nurse sharks are members of the Order Orectolobiformes and are a large coastal species that is distributed in warm temperate to tropical regions in the western Atlantic. They are strongly associated with the bottom and primarily live in shallow habitats all over Belize. Females produce litters of up to 50 offspring. Age at maturity is estimated to be 10 to 15 years for males and 15 to 20 years for females at sizes > 6.6 ft TL. Populations of nurse sharks in Belize are differentiated from those in the Bahamas and Brazil, perhaps because individuals in some places are long-term residents (Chapman et al. 2005; Karl et al. 2012). Nurse sharks feed on small fish and bottom-dwelling invertebrates.

Silky (Carcharhinus Falciformis)

IUCN: Vulnerable.

Silky sharks are a large epipelagic species that is globally distributed in warm temperate to tropical regions. Maximum size in the Gulf of Mexico is 12 ft TL with males maturing at 7-7.4 ft TL and 6-10 years, and females at 7.6-8.1 ft and 7-12 years. This species makes up a large fraction of the landings of Belizean-flagged vessels operating on the high seas, but these fishing activities are outside of the scope of this chapter. It is encountered offshore of the reef slope of the barrier reef and atolls in Belize and feeds on pelagic fish.

What is the Status of Sharks in Belize?

Two research groups, Global FinPrint (www.globalfinprint.org) and MarAlliance (https://maralliance.org), are conducting surveys of coastal sharks across Belize. Here I outline preliminary results from the former, which is focused on surveying sharks and their relatives, the rays, in coral reef habitats throughout the world. Since 2009 sharks have been surveyed as part of this project in three Belizean marine reserves (Glover's Reef Atoll, Caye Caulker and Halfmoon Caye/Lighthouse Reef Atoll) and four fished sites (Turneffe Atoll, Sandbore Caye/Lighthouse Reef Atoll, Belize City and South Water Caye [prior to this site being zoned as a marine reserve]). The survey employs baited remote underwater video (BRUV), which consists of a video camera mounted on a metal frame with a small, pre-weighed bait source (1 kg of crushed baitfish) mounted on a pole in the camera's field of view. BRUVs were deployed in randomly selected locations during daylight hours at a depth of 2–40 m at each reef. Each BRUV was allowed to film continuously for 85 minutes after settling to the bottom. No BRUVs were simultaneously deployed within 1 km (0.6 miles) of another. All BRUV deployments were scored as "1" or "0", corresponding to each species of shark being "present" or "absent", respectively.

> "larger, more mobile species like great hammerhead, tiger and lemon sharks are relatively rare in Belize compared to the more residential reef species (Caribbean reef and nurse)."
> Demian D. Chapman

Six hundred and nineteen individual BRUV deployments in Belize have been analyzed by Global FinPrint (Glover's Reef Atoll N=182, Caye Caulker N=70, Halfmoon Caye/Lighthouse Reef Atoll N=37, Turneffe Atoll N=90, Sandbore Caye/Lighthouse Reef Atoll N=32, Belize City N=40 and South Water Caye N=168). Nurse sharks were found on 42 percent of deployments on average, ranging from 74.1 percent of BRUVs set at Glover's Reef to 7.5 percent of BRUVs set off Belize City. Nurse sharks were the only species found at all seven reefs surveyed. Caribbean reef sharks were observed on 24 percent of all BRUVS, ranging from 56.7 percent of BRUVs at Halfmoon Caye/Lighthouse Reef to 0 percent at Belize City. The proportion of BRUVs that had nurse and Caribbean reef sharks were generally higher in the reserve sites than the fished sites. Caribbean sharpnose sharks were uncommonly observed (1.2 percent of all BRUVs), as were lemon sharks (0.06 percent of all BRUVs), tiger sharks and great hammerhead sharks (each 0.01 percent of BRUVs). Although more surveys of non-reef habitat are needed, together with broader geographic coverage, these survey data suggest that the larger, more mobile species like great hammerhead, tiger and lemon sharks are relatively rare in Belize compared to the more residential reef species (Caribbean reef and nurse).

THE FISHERY

Size, Gear, Products and Markets of the Belizean Coastal Shark Fishery

Shark fishing has been established in Belize since at least the 1950s, with dedicated fishing operations occurring at that time in San Pedro, Sarteneja, Punta Gorda, Placencia and Dangriga (Zeller et al. 2011). There are currently approximately 60 licensed shark fishers in Belize that are permitted to target sharks, coupled with a larger number of fishers that occasionally catch sharks when targeting other species (e.g. gillnet fisheries for mackerel and handline fisheries for reef fish). Prior to the 2019 ban on gillnetting, most of the target shark fishers primarily use monofilament gillnets and bottom longlines to target sharks, operating out of small camps that are located on cayes near the main fishing grounds. Sharks are frequently processed at these landing sites before being transported to the mainland or being exported out of Belize. The primary products are the fins and meat, but

liver oil and cartilage are both locally traded for alleged medicinal properties and jaws and teeth are sold as curios. The most valuable product on any shark by weight is the fin set (dorsal, pectoral and lower lobe of the tail), which is used to make the Asian delicacy shark fin soup. The global hub for the shark fin trade is Hong Kong, but there has been no direct trade between Belize and Hong Kong since the 1990s (Stan Shea pers comm). Instead, Belizean fishers sell fins to Guatemalan and Mexican fin exporters for prices of approximately 150 BZD/pound (Zeller et al. 2011), who then export them to Asia from their home country. Some shark meat is sold for local consumption in Belize, but the major markets are in Mexico and Guatemala, where shark meat is consumed during the Lenten season (approximately late February to early April, depending on the year). Shark fishers actively target sharks from December to April to meet this demand. Shark meat sells for around 5.00-7.00 BZD/pound (Zeller et al. 2011).

"Belizean fishers sell fins to Guatemalan and Mexican fin exporters for prices of approximately 150 BZD"
Demian D. Chapman

Species Composition of the Catch

Three freely accessible publications provide information on the species composition of the Belizean shark fishery at certain points in time, although none were collected in a nationally representative way. Pikitch et al. (2005) provided a small number of opportunistic observations of sharks observed in fish markets in Dangriga and Belize City made during summer months from 2000-2004. Chapman et al. (2011) extended this by providing additional observations through 2011, including landings at Turneffe Atoll. Zeller et al. (2011) reconstructed total shark catch in Belize from 1950-2008 and assumed a species composition based on landings data collected in southern Belize. The source of this data is not freely available (it is derived from a report to the Fisheries Department by one of the coauthors) and there is no information on how it was collected and over what time period. Given the limitations of all three studies there is currently no precise information on the contemporary species composition of the Belizean shark fishery. However, Caribbean sharpnose, hammerhead (bonnethead, great and scalloped), blacktip, Caribbean reef, bull, tiger and lemon sharks were noted to occur in all three studies, with Zeller et al. (2011) reporting that the two most common species landed in southern Belize were the great hammerhead and Caribbean sharpnose.

The species composition of shark landings is likely dependent on habitat, gear, season and location and thus it is difficult to extrapolate to the entire country from surveying the landings in southern Belize alone. For example, in 2013 and 2014 genetic samples were collected from two fishing camps in northern/central Belize (Turneffe Atoll, N= 117 samples and Robinson's Point, N =755 samples) and DNA barcoding was used to identify the contributing species. The Turneffe Atoll camp landed primarily Caribbean sharpnose and Caribbean reef sharks (> 90 percent of sampled individuals) together with blacktip and lemon. These species are caught with monofilament gillnets set in reef passes in the local area. The Robinson's Point camp landed primarily Caribbean sharpnose and Caribbean bonnethead (42 percent and 26 percent of landed individuals, respectively), but also Caribbean reef (14 percent), blacktip (11 percent), scalloped hammerhead, great hammerhead, tiger, silky and lemon sharks (each < 1 percent). This camp used both monofilament gillnets and longlines to catch sharks and operated along the coast of the mainland and the barrier reef.

The variability in catches between these two camps illustrates why it is imperative to survey the landings of a representative sample of camps to assess the nationwide species composition of the fishery. Nonetheless, the studies of Pikitch et al. (2005), Chapman et al. (2011), Zeller et al. (2011) and the DNA-barcoding surveys described in this work all identify the occurrence of the same species, which should be the primary focus of management.

Shark Fisheries Management

Shark fisheries management in Belize is overseen by the Fisheries Department, which is within the Ministry of the Blue Economy and Civil Aviation of the Government of Belize. Shark regulations are contained within the National Fisheries Act. At present sharks are managed through individual species prohibitions on nurse and whale sharks, seasonal closure of the fishery from August 1-October 31 each year and a ban on gillnets. Fishers are required to hold an annually renewed license to target sharks and must also report data on the volume and species composition of their catch, though this information is not made public. There are also regulations against shark "finning", which is the practice of removing the valuable fins from sharks while discarding the less valuable carcass. In general, finning does not seem to be an issue in Belize because there is high demand for the meat in neighboring countries, but fins are also taken and sold.

Belize is a signatory to CITES, which obligates the nation to regulate international trade in at least five shark species present in its waters (scalloped hammerhead, great hammerhead, silky, oceanic whitetip Carcharhinus longimanus and bigeye thresher Alopias superciliosus). Export of these species requires a permit from the Fisheries Department that certifies the specimen was legally collected in a sustainable fishery. Sharks also potentially benefit from the national marine reserve network in Belize. No fishing is permitted within the replenishment zones of marine reserves and gillnets and longlines are typically prohibited within the larger general use zones. This latter measure dissuades targeted shark fishing in these areas, given the prevalence of these two gear types for targeting sharks. Marine reserves currently cover approximately 25 percent of coastal habitats (including atolls) in Belize. However, lack of monitoring and enforcement has raised concerns about compliance.

Management effectiveness

It is currently difficult to assess the effectiveness of shark fisheries management in Belize, though it is apparent that current regulations benefit some species more than others. Nurse sharks and whale sharks are both prohibited species, which means if they are incidentally caught they must be released alive. Neither species is vulnerable to capture in gillnets and if caught on longlines, nurse sharks are sufficiently hardy to be released alive with a high probability of survival. Both species have little value to the fin or meat trade and were probably never targeted in Belize. Therefore, the prohibition of these species is likely to be an effective management strategy. Indeed, the Global FinPrint BRUV survey discussed previously found nurse sharks to be common at all sites except for Belize City. Nurse sharks are also residential (Chapman et al. 2005) and likely remain within marine reserves for extended periods, reducing potential fishery interactions.

A recently published BRUV study found that sightings of Caribbean reef sharks at four sites in Belize (Glover's Reef Marine Reserve, Caye Caulker Marine Reserve, South Water Caye, and Turneffe Atoll) were significantly higher in the two reserve than the two fished sites (Bond et al. 2012). Again, this species appears to be sufficiently residential to particular reefs that it can potentially complete its life cycle within a marine reserve. Thus, despite being a targeted species of the fishery, the marine reserve network provides some respite for this species.

The remaining targeted shark species in Belize described earlier tend to be more mobile and use a wider variety of habitats to complete their life cycle than Caribbean reef sharks. Thus, these species are the ones that require more intensive management, such as gear restrictions, seasonal closures, species prohibition or nation-wide catch limits. Some of these species (e.g. Caribbean sharpnose and Caribbean bonnethead) are more resilient to fishing than the other, larger species by virtue of their fast rate of intrinsic population increase (Smith et al. 1998). The larger species, such as lemon, blacktip and the two large hammerheads are less productive (Smith

et al. 1998) and are more likely to be overfished in Belize. The low sighting rates of these species on BRUVs in Belize as part of Global FinPrint is cause for concern, given that they all spend some time on the reef habitat that was sampled as part of this survey.

THE FUTURE

Growing local and international interest in shark conservation is fueling increased investment in shark fisheries management in Belize. The Fisheries Department has formed a National Shark Working Group, composed of representatives of the research (including this author), conservation non-governmental organizations and fishing sectors to provide recommendations on shark fisheries management that will be considered for adoption by the government. This group is also contributing to the finalization of a National Plan of Action for Sharks.

One of the most serious limitations for further refinement of shark fishing regulations is the lack of species-specific catch data and an understanding of the nation-wide status of key species other than nurse and Caribbean reef sharks. A top priority is therefore to collect accurate species-specific landings, effort and location data for sharks from a representative sample of fishing camps. This would allow tracking of the volume of catch and changes in species-specific catch rates over time.

Several options are possible to collect these data. The most straightforward approach would be to continue to require fishers to turn in catch logbooks. Although training and/or the provision of field guides can ameliorate species identification issues, data reliability is always going to be an issue with self-reported data. Another

approach would be to conduct fishery-independent sampling of a portion of the catch. This could be achieved by random sampling of sharks at landings sites by the Fisheries Department and/or scientists, or by developing an onboard observer program to sample fishing trips. Both these approaches can enable accurate, species-specific estimates of national landings, but require a significant input of resources and effort. Virtually all the downstream management measures require these data, however, so this investment is likely to be inevitable.

The actual management interventions required to improve the current status of sharks in Belize can be divided into six broad categories: protected areas, protected species, assessment-based catch limits, seasonal closures, size restrictions and gear restrictions. Protected areas can be effective for resident species, but at this stage would need to be designed to benefit mobile sharks. Given the large area that is already contained within protected areas in Belize it seems unlikely that there will be significant public support for expansion of the marine reserve network simply to better protect sharks.

However, it is possible that an expansion of a less restrictive type of protected area, such as zones where shark fishing alone was prohibited, might enjoy some support. If this approach were favored it would require a national survey to identify areas where key species in the fishery that are not benefiting from the current reserve network are located, potentially including key habitats such as nursery areas. These areas could be defined as “Shark Replenishment Zones” similar to ones set up in other parts of the world to support sustainable shark fisheries (Walker 1998). Once these areas were identified and zoned, they would then require financial support for monitoring and patrolling.

One way to obtain the revenue for this could be to levy a “Shark Conservation” tax on tourists using some of the main shark ecotourism sites (e.g. Shark Ray Alley and Blue Hole National Monument) or on all dive tours throughout the country. This income could be used to hire rangers, support patrols and set up shark population monitoring within these zones. Ideally, these associated employment opportunities would be preferentially given to any fisher displaced by the zoning.

Belize could expand the list of prohibited species from nurse and whale sharks to include other vulnerable species (e.g. CITES-listed hammerheads and/or species with the lowest intrinsic rates of population increase; Figure 14). However, at least some of these species are going to experience very high mortality in gillnets and potentially also if they are hooked on longlines, which could negate the benefits of a prohibition. Large hammerheads, for example, are very delicate and a simple moratorium on these species is likely to result in increased dead discards, rather than an overall decrease in mortality rates. Species prohibition is only likely to be effective if fishers can set their fishing gear in such a way that reduces the probability of catching these species or enables live release. It is not known if fishers can avoid certain species by changing where or when they set their nets or longlines. This information could be obtained through fishers’ interviews, catch surveys from observers or fishing camp sampling, or through fishery-independent surveys of candidate species.

Assessment-based catch limits are another approach that could be employed to manage the shark fishery. This would entail gathering enough life history and catch data to set catch limits predicted to be sustainable based on quantitative population assessment models. Once the fishery begins for a season the catch would have to be monitored until it approaches this limit, at which time the season would subsequently be closed. This approach would work best if the catch limit was species-specific or based on aggregated species with similar productivity, so that the end of the season would be triggered by approaching the catch limit of the least productive species. This approach is data intensive, requires quantitative expertise and relies upon excellent communication between the resource manager and the fishing industry. Compliance with and/or enforcement of the closure are obviously of paramount importance when employing this approach, as are frequent quantitative assessments of the stocks and adjustments of catch limits when needed. The stock structure of many species in Belize is not known precisely and is likely to be localized but shared with neighboring countries. Assessments and catch limits are therefore likely to have to be considered within a regional context, which adds another layer of complexity to

In Belize, changes in gillnets could have a large effect on the catch. **A shift away from gillnets** to longlines **might reduce overall catch** because all individuals (across species and sizes) can be entangled in a gillnet, but fewer individuals are attracted to a particular bait at any given time.

The current seasonal closure could be modified to coincide with times when sharks are most vulnerable. One such time could be the pupping season of the least productive species, when pregnant females congregate in predictable locations. Unfortunately, this timing is coincident with peak shark fishing activity that is driven by the high demand for shark meat during Lent. Shifting the season out of this period would decouple supply and demand for shark meat

this process.

Seasonal closure of the shark fishery already occurs, but it is not currently determined by catch limits. As an alternative, the current seasonal closure could be modified to coincide with times when sharks are most vulnerable to capture as a means to reduce catch rates generally or shift the catch away from particularly important life stages. One such time could be the pupping season of the least productive species, when pregnant females congregate in predictable locations close to shore. These times are not well known for the key species in Belize, however, based on data from other parts of their range are likely to be during the spring and summer. Unfortunately, this timing is coincident with peak shark fishing activity that is driven by the high demand for shark meat during Lent. Shifting the season out of this period would decouple supply and demand for shark meat, which could be ameliorated by enhancing long-term storage of meat through freezing.

Another way to regulate shark fisheries is to have size limits, which seek to reduce the overall catch and shift it from vulnerable or key life stages. The most common size limit is to establish a minimum size, which is typically just above the size at maturity. The rationale behind this is that it enables juvenile individuals to reach maturity and produce their first litter. However, it is often the larger, older females that produce the most offspring with the best chances of survival, which argues for a maximum size limit above the size at first maturity.
While there is merit behind size limits, there are several reasons why they may be ineffective in Belize. Size limits require fishers to release certain sizes alive or avoid capturing them, which are both inherently challenging with gillnets and to a lesser extent longlines. Enforcement of size limits would also be impossible after processing, which takes place very early in the supply chain. Overall, it might be more effective to educate fishers about the value of reducing mortality on certain size classes as a voluntary best practice as opposed to setting it high on the regulatory agenda.

Fishing gear restrictions are a potentially useful way to alter the species and size composition of fishery landings due to the variable susceptibilities of species and size classes to certain types and configurations of gear. In Belize, changes in gillnets or longlines could have a large effect on the catch. For example, a shift away from gillnets to longlines might reduce overall catch because all individuals (across species and sizes) can be entangled in a gillnet, but fewer individuals are attracted to a particular bait at any given time. Moreover, longlines allow for live release more often than gillnets, which could facilitate changes in the species composition of landings. Both gear types can be modified (i.e. changes in mesh size for gillnets or hook size and material used to make the leader for longlines) to reduce catch of certain size classes of sharks, although gear modifications can be more difficult to enforce than outright bans. Smaller hooks and light monofilament, rather than steel leader wire, can allow larger sharks to "self-release", thus making the gear more selective for smaller species and size classes.

For gear restrictions or modification to be effective, Belize would first have to determine which species or sizes it wanted to avoid catching and then determine through experimental trials with the fishing sector what gear modifications could have the desired effect without substantially reducing the target catch or increasing catch of other undesirable species (e.g. increased bycatch of other types of wildlife). Enforcement of gear restrictions

requires substantial surveillance effort and often hinges on catching fishers in the act of using the gear in the water as opposed to just possessing it, unless both possession and use of anything other than legal gear is criminalized.

In conclusion, there is growing public pressure within Belize to balance the need for shark conservation with management of the domestic shark fishery. Available evidence indicates that a relatively small number of coastal carcharhiniform sharks dominate the contemporary domestic fishery, ranging from small, productive species like Caribbean sharpnose and Caribbean bonnethead to larger, more vulnerable species (e.g. scalloped and great hammerhead). Belize has established some regulations for the fishery, which primarily supplies an export market for meat and fins. Two protected species appear to be doing well in Belize and one species that resides on reefs remains common within certain marine reserves. The status of many other species is unclear, although large, vulnerable species such as great hammerhead, scalloped hammerhead and lemon sharks are rarely encountered in standard surveys.

The Belize Fisheries Department has established a Shark Working Group to provide advice on how to manage the fishery moving forward. There are several management options that could be employed, each of which has strengths and weaknesses. Each of these approaches requires financial, practical and scientific support, but there are certainly pathways available within Belize to decide on a course of action and move forward with it.

Lionel Sanchez, Legacy

“In the blood"

– a youth’s perspective

It is difficult to imagine an industry that is passed down through the generations in quite the same way as fishing. From small artisanal fishing in dug-out canoes, to large commercial operations, fishing seems to be in the blood.

Raised in Punta Gorda Town, 22-year-old Lionel Sanchez was born into such a fishing family; his father and both of his grandfathers were fishers, and since the age of 12 he has been following in their footsteps. He recalls one of his earliest memories with his grandfather fondly. Sanchez was excited to be taken on his first overnight fishing trip, and they fished throughout the night. By 9 a.m. the following morning, their icebox was full to the brim of fresh product that they would later sell. It is easy to understand the thrill of returning home bearing a bountiful catch to support your family.

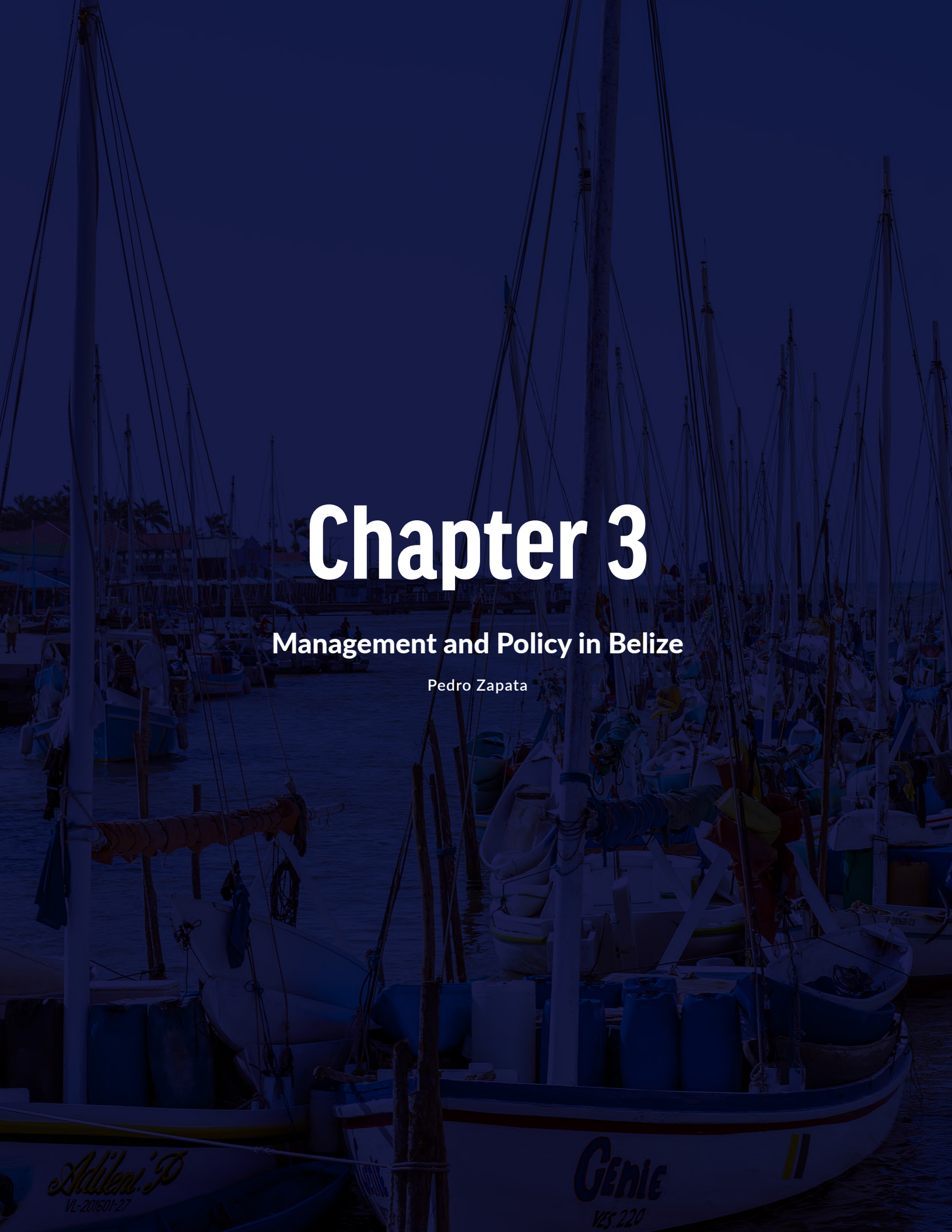
Fishing, fast became a favourite pastime for Sanchez, and it wasn't long before he recognized that he too could turn his passion into a business. His father gifted him a fiberglass dory and he began his fishing career by hand line fishing off the coast of Punta Gorda Town. At that time, a fishing trip would take between four and five hours, during which he would bring home a good day's catch.

Now, he has a motorized fiberglass boat and needs to travel further distances to fish, and it can take up to 12 hours to land the same volume of fish that he could catch in four hours, just ten years ago. Within his short fishing career, Sanchez says he has never again had a plentiful catch to match his first overnight trip with his grandfather.

When we talk about depleting fish stocks, we tend to think that this is something that happens very gradually, in a way that is almost unnoticeable as the years and generations pass, so that it is only in talking to our elders that we learn of "the good ol' days". But Sanchez has seen the changes within his ten-year fishing career, and believes that more should be done to protect the industry that his family and community rely on.

Despite his family ties to the fishing industry, Sanchez has twice been denied a Managed Access license, which means he can only fish outside of the marine reserve. Consequently, he is resourceful and divides his time between different activities such as bike repairs and working part time in a local factory to earn a living. But for him, fishing is more than an income, it is a passion, a hobby, his peace of mind.

In the same way that he learned the skills from his grandfather and father, he plans to share his knowledge and skills with his children in the future. Fishing is something that from a long time ago they would say "go to school son, don't be a fisherman". Sanchez wants youth to understand that being a fisher or a farmer is not a "low life", that for those with the right attitude, it is "something that will have pennies in their pocket, will provide for the community, and meet a market". So, it seems that as long as there is demand for fish, he will be there to supply, and will share with his children in turn. After all, it's in the blood.



Chapter 3

Management and Policy in Belize

Pedro Zapata

Government and Policy in Belize

THE GOVERNOR GENERAL, PRIME MINISTER AND DEPUTY PRIME MINISTER

Belize is a parliamentary democracy and a member of the Commonwealth of Nations. Previously known as British Honduras, the country changed its name to Belize in 1973. It has a short history as an independent state, dating back to 1981, when the country became independent from the United Kingdom. As in other members of the Commonwealth, Belize's head of state remains Queen Elizabeth the Second, who appoints and is represented by the Governor General. This position has been held since November 1993 by Sir Colville Young until his retirement in April 2021. He is succeeded by Froyla Tzalam, who was appointed as Governor General in May 2021. However, as in many former British colonies, the role of the British Crown and its representative are largely symbolic, with little real decision-making power.

One example of this symbolic power can be found in Article 37 of the Belize Constitution, which affords the Governor General the power to appoint the Prime Minister. The same article, however, greatly narrows the discretion with which the Governor General can act, indicating that the Governor General "shall appoint (as Prime Minister) a member of the House of Representatives who is the leader of the political party which commands the support of the majority of the members of that House." In other words, only one person can be Prime Minister, the leader of the party with the majority of seats in the National Assembly. By the same token, the Prime Minister can lose that position either by being removed from a leadership position within their party or by the party losing said majority.

This system, which mimics many former British colonies, translates to periodic elections where the people of Belize vote for their representatives to the House of Representatives, choosing between different parties and knowing that the leader of the party that ends up in the majority will then serve as Prime Minister. One of the main responsibilities of a Primer Minister is to select a Deputy Prime Minister and other Ministers with which to form a Cabinet. This collective body is the principal executor of policy in the country and is accountable to the National Assembly. To fulfill this responsibility of executing policy, each Minister has a staff of civil servants. The role of coordinating this staff typically falls on the Chief Executive Officer (CEO) of each Ministry.
As of November 2020, the position of Prime Minister is held by the Honourable John Briceño, who is member of, and leads, the People's United Party.

THE NATIONAL ASSEMBLY

Legislative power in Belize is vested in the National Assembly, comprised of a House of Representatives and a Senate. Members of the House and the Senate serve from the moment they are elected until the next dissolution of the National Assembly, which happens at least every five years. There are 31 members of the House of Representatives from each of Belize's constituencies. They are elected by electoral vote.

Belize also has a 13-member Senate, where members are appointed (not elected) by the Governor General, on the advice of different institutions. All elected representatives, including the Prime Minister, then become members of the Belizean Parliament's House of Representatives. The Senate of Belize previously consisted of just 12 members, each representing a different sector. In October 2013, however, Prime Minister Dean Barrow signed the commencement order for the appointment of a 13th Senator to represent the NGO sector, which was previously unrepresented in the Senate. The NGOs in good standing met to define the process by which the NGO Senator would be appointed and on January 10, 2017 they elected Osmany Salas, then President of the Belize Tourism Industry Association (BTIA), to be the NGO Senator. On 25 November, 2020, Salas was re-appointed as NGO Senator.

Importantly, it is the National Assembly that has the power to review and amend Belizean law. This happens when bills are introduced and discussed either in the House or the Senate. If one is approved, and assented by the Governor General, it must then be published in Belize's official Gazette. Once this happens, it becomes an Act and is then part of the Belizean legal system. The National Assembly also has the power to propose and amend the national budget. Through the use of Statutory Instruments, updates, amendments, and provisions can also be implemented by the appropriate Minister and carry the same weight as laws debated in the House.

There are many important differences between parliamentary systems like Belize and presidential systems like the United States. While a full account of these distinctions is not necessary here, it is worth noting two of them, especially as they relate to the process by which policies, including fisheries policies, are developed:

- Elections don't have a set date in parliamentary systems, they have deadlines. In the case of Belize, the Prime Minister may, at any point before the month of November in 2020, ask the Governor General to dissolve the National Assembly and call for an election. A new five-year calendar then begins.

- The Prime Minister is a member of the House of Representatives and may draw from it or the Senate to select his cabinet. Since Representatives must stand for elections, but Senators are appointed, this means that some members of the administration have to stand for elections and win in order to retain their positions, while others do not. By comparison, the U.S. Presidential Cabinet is appointed by the President directly and does not have to stand in elections. As Members of Parliament, even if they have additional executive functions (e.g. Minister of Agriculture), cabinet appointees are most directly accountable to their constituencies on whose vote they rely to keep their seat.

Current Fisheries, Protected Species and Habitat Regulations in Belize

THE LEGAL FRAMEWORK OF FISHERIES IN BELIZE

Belize's highest law is the 1981 Constitution, which established the recently independent country as a sovereign democratic state. Within the Belizean body of laws, Title V refers to Forests, Agriculture, Livestock and Fisheries. Title V contains Chapter 210, also known as the Fisheries Act, and along with Chapter 210-s (its subsidiary laws), it contains the rules and regulations that govern fisheries in Belize. Chapter 210:01, the High Seas Fishing Act, is important in that it refers to the large high seas fishing fleet that sails under the Belizean flag; however, because it does not impact fishing within Belize's exclusive economic zone (EEZ), we have left it out of this analysis.

In 2019, a new Fisheries Resources Bill aimed to provide a framework for fisheries management in Belize was approved by the National Assembly. In January 2020, the Fisheries Act, Chapter 210 of the Laws of Belize, Revised Edition 2000 was repealed by the Fisheries Resources Act, Act No. 7 of 2020, also referred to as the Fisheries Resources Act, 2020 (GOB 2020a). The Fisheries Resources Act provides for the management of aquatic and fisheries resources in Belize, the effective regulation of the fishing industry and the management and regulation of mariculture. The newly revised Fisheries Resources Act is based on modern fisheries management principles, such as sustainable use, ecosystem-based management, use of best available information and application of the precautionary principle, effective enforcement, and improved welfare of fishers and the public. The Act's overall objective is to promote long-term conservation, management and sustainable use of fisheries resources in Belize.

Some of its progressive measures include:

- Establishment of a Fisheries Council which will advise and make recommendations to the Minister
- Provision for co-management of fisheries and areas
- Improved data collection
- Measures to facilitate surveillance and enforcement e.g. mobile transceiver unit (MVU) on fishing vessels
- Requirement of fisheries management plans and their mandatory content
- Provision for managed access and total allowable catch
- Marine reserves and requirement for management plans, zoning and advisory committees
- Significantly increased fines and penalties

- Penalties for damage to marine ecosystem

The Fisheries Resources Act establishes the Fisheries Department as an autonomous institution, created under the Ministry, to administer the Act and regulations made under the Act. The Fisheries Department, headed by a Fisheries Administrator, is responsible for administering the Act, its regulations and enforcing its provisions, and fulfilling its overall objective using certain principles and measures including:

- Conducting the conservation and management of fishery resources in a transparent, accountable and inclusive manner;
- Preventing or eliminating overfishing and excess fishing capacity;
- Collecting, verifying, reporting and sharing in a timely and appropriate manner data on fisheries, including information relating to the ecosystems, social and economic systems in which fisheries occur;
- Minimizing or eliminating where possible pollution and waste originating from fisheries operations, discards, by-catch, lost or abandoned gear and impacts on other species and marine ecosystems;
- Improving the welfare and livelihood of fishers and the fishing community;
- Applying the precautionary approach widely to the conservation and management of fishery resources in order to protect the resources and to preserve the aquatic ecosystems in which they exist;
- Applying an ecosystem approach to the conservation and management of aquatic resources.

Source: GOB 2020a

FISHERIES REGULATIONS IN BELIZE

Licensing:

- All persons on board a commercial fishing vessel are required to hold a valid fisher folk license.
- Any vessels employed in commercial fishing should be licensed at the Fisheries Department.
- Both fisher folk and vessel licenses last for one year and expire on the 31st of December.
- Fees associated with licenses vary.

Size limits:

- There are size limits in place for conch and lobster to protect juveniles of these commercially important fisheries.
- Size limits are also in place for Nassau grouper, one of the most vulnerable grouper species in the Caribbean.

Seasons:

- Seasonal closures exist for certain species like lobster, conch, and Nassau grouper.

Fishing equipment:

- There is a complete prohibition on the use of explosives or any type of poison or chemical that stupefies fish.
- Fishing with the support of SCUBA gear is also prohibited; the only exception being for lionfish with a lionfish hunter license.
- Within the marine protected areas of Belize, there are additional types of prohibited gear, including spear guns, nets, long lines and fish traps.

Species bans:

- There is a total prohibition on the taking of grazers, such as parrotfish (Scaridae family) and surgeonfish (Acanthuridae family), as a measure to protect Belize's reefs (Table 5).
- The harvesting or commercializing of marine turtles, whale sharks, nurse sharks, and manatees is prohibited.
- Tarpon, bonefish and permit have been reserved in Belize for recreational fishing and must be released after being caught.

COMMON NAME (ENGLISH)	SCIENTIFIC NAME
All species of soft coral	All species of Gorgonacea, Alcyonacia
All species of hard or stony coral	All species Scleractinia
Whale shark	Rhincodon typus
Nurse shark	Ginglymostoma cirratum
Sawfish	Pristis perotteti and Pristis pectinate
Rays	All species of rays of the superorder Batoidea
Parrot fish	Scaridae, all species
Surgeon fish	Family: Acanthuridae, all species
Angel fish	Family: Pomacanthidae, all species
Triggerfishes	Family: Balistidae, all species
Green turtle	Chelonia mydas
Hawksbill turtle	Eretmochelys imbricata
Loggerhead turtle	Caretta caretta
Leatherback turtle	Dermochelys coriacea
Seahorse	Hippocampus, all species
Sea star	Asteroidea, all species
Dolphins	Atlantic bottlenose dolphin – Tursiops truncates
	Atlantic spotted dolphin – Stenella frontalis
	Rough-toothed dolphin – Steno bredanensis
	Spinner dolphin – Stenella longirostris
Manatee	Trichechus manatus
All other species of marine mammals (including migratory species)	

Table 5: List of prohibited (fish or have in possession) species (Fisheries Resources Act, No. 7 of 2020) Source: Fisheries Resources Act, No. 7 of 2020 – Schedule (Section 88)

In 2020, Belize achieved its goal of at least 10% of all major habitat types within the Fishery Replenishment Zone with the inclusion of underrepresented deep-sea habitats within the MPA system and the expansion of the Sapodilla Cayes Marine Reserve which now includes the Corona Reef (GOB 2019).

In November 2020, the Fisheries Resources (Gill Net Prohibition) Regulations, 2020 (Statutory Instrument No. 158 of 2020) (GOB 2020b) was enacted prohibiting gillnets in Belize. The regulations prohibit the use of gillnets for catching fish in fisheries waters (Belize's territorial sea and internal waters and the EEZ); being in possession of a gillnet in fisheries waters; and landing, selling, buying or being in possession of any fish obtained in fisheries waters using a gillnet.

MANAGED ACCESS

In 2011 the Government of Belize, in close collaboration with civil society organizations, implemented a rights-based fisheries management regime in GRMR and PHMR, two marine protected areas that had previously had open access fisheries. Accordingly, this program was called "Managed Access." Through this project the Fisheries Department assigned territorial user-rights fishing (TURFs) to local fishermen in these two areas.

Several benefits of the program were noted such as more than 70% of participating fishers reporting higher catches post program implementation, compliance with fishery regulations and most managed access fishers reporting catch data (BFD 2013 in Fujita et al. 2017).

After five years of successful implementation at Glover's Reef and PHMR, in 2016 the Fisheries Department announced the rollout of the Managed Access program to the entire fishing sector in Belize. In Belizean territorial waters eight areas were designated (Figure 15) and commercial fishers are given access to two, selected by their own choice.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A ninth area, consisting of deep, open water remains accessible to all fishers (although few Belizean fishers are equipped for deep-water fishing).

Challenges to Managed Access implementation include the monitoring of larger areas (the PHMR pilot area was much smaller than most other areas designated). Additionally, during the pilot, displaced fishers could move anywhere outside of PHMR, but now all must be allocated among the eight zones.

In 2017, one year following the national roll out of the Managed Access program, Wade et al.'s (2019) study of fishers' (54 persons) and policy makers' (25 persons) showed varied responses regarding the program, with most respondents being neutral or negative. The respondents' concerns were mainly about inadequate enforcement, poor communication and illegal activities, however, other factors such as a lack of immediate economic benefits could have also accounted for the negative perception, particularly in the case of fishers. While both fishers and policy makers believed that there was minor improvement in enforcement, communication between stakeholders, particularly between the Managed Access Committee representatives and the fishing communities was inadequate. It is apparent that there is a learning curve involved in adopting and implementing the new system effectively, which the program participants are attempting to address collaboratively.

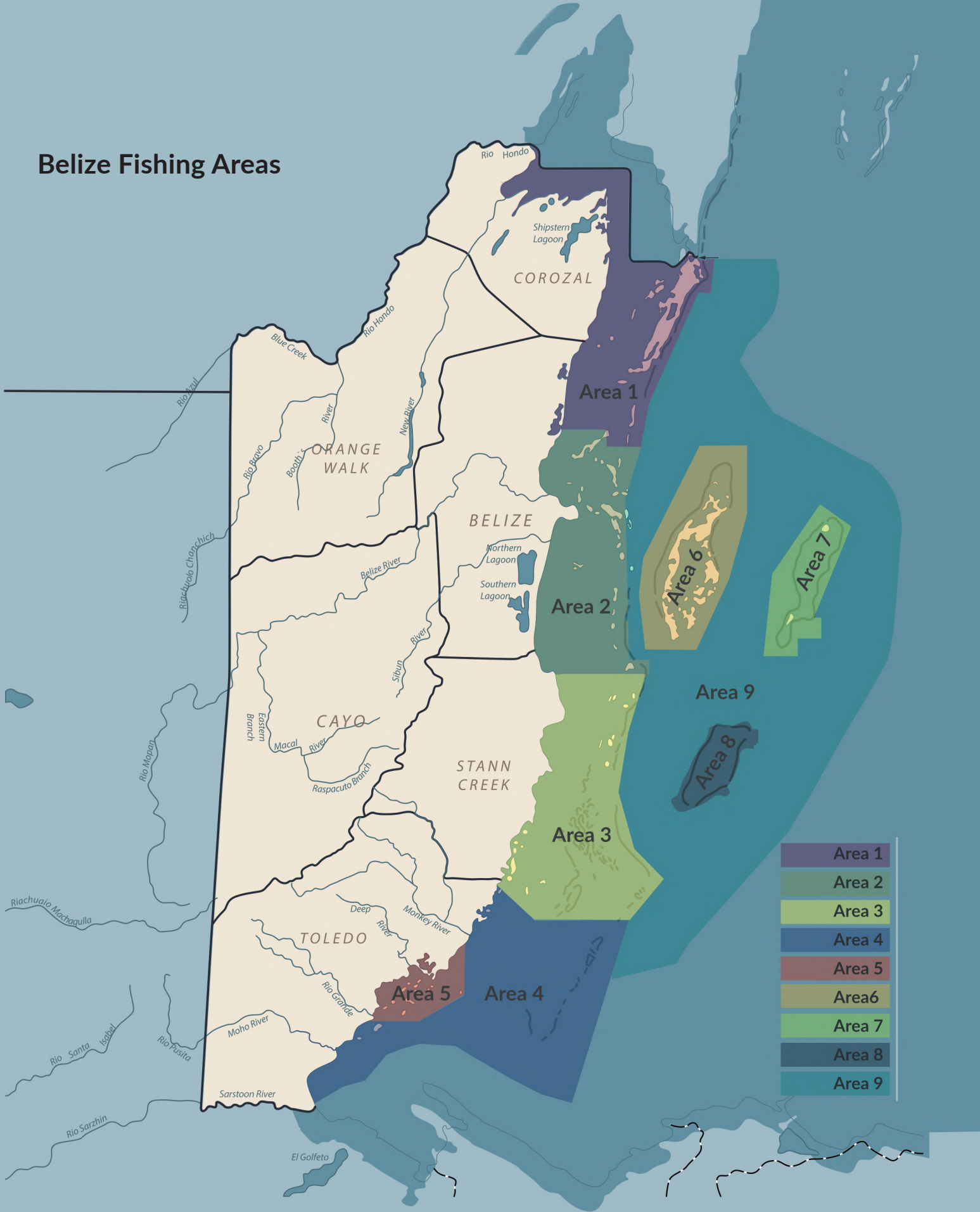

Figure 15. Managed Access areas of Belize (Belize Fisheries Department).

FISHERIES POLICY OUTSIDE OF THE FISHERIES ACT

Agencies and acts overlapping with fisheries

Under the guidance of the Wildlife Conservation Society, and with economic support from the Oak Foundation and USAID (US Agency for International Development), William Edeson and Elisa N. Montalvo (2010) conducted a thorough analysis of the Fisheries Act in Belize, including non-fisheries regulations that affect fishing (Edeson and Montalvo 2010). The following is an abridged version of that analysis.

Chapter 329 of the Belizean legal code is the Coastal Zone Management Act, which establishes two independent bodies: The Coastal Zone Authority and the Coastal Zone Institute, collectively referred to as the Coastal Zone Management Authority and Institute or CZMAI. These bodies have the mandate to conduct the planning, management, and sustainable development of resources within Belize's coastal zone. Although these institutions have no legal faculties related to commercial fishing, there is some overlap between the jurisdiction of the Coastal Zone Authority and the Fisheries Department. Therefore, strong coordination is needed to ensure that both can fulfill their mission.

The clearest example of this overlap is in the case of sport fishing, an important component of the touristic experiences available to visitors in Belize. Sport fishing licenses are issued by the Coastal Zone Authority. Sport fishing in Belize primarily targets species that are restricted to catch-and-release, making it a tourism-driven economic sector, which might explain its odd placement outside of the fisheries regulations and institutions. Other areas of overlapping function occur with the Ministry of Sustainable Development, Climate Change and Disaster Risk Management (MSDCCDRM) of the Government of Belize. This Ministry has within its mandate the enforcement of the Forest Protection Act, which includes the protection and conservation of mangrove forests, a critical ecosystem for many commercially important fish species. The MSDCCDRM is also tasked with enforcing the Wildlife Protection Act. This law does not pertain to commercial fisheries directly, but it does afford some protective measures to endangered species of marine mammals that the Fisheries Act also protects, like whales, dolphins, manatees, seals and a species of otter. The MSDCCDRM is also charged with implementing the rules set forth in the National Parks System Act, which governs the country's protected area system and the management of corals. Finally, the Department of Environment (DOE) within the MSDCCDRM is responsible for enforcing the Environmental Protection Act and the regulations under this Act such as the Environmental Impact Assessment (EIA) (Amendment) Regulations 2020. Development can potentially have significant negative impacts on coastal and marine ecosystems; therefore, the Fisheries Department plays an important role on the 16-member Committee appointed by the Minister to review and approve EIAs and make recommendations to improve the effectiveness and efficiency of the EIA process.

There are several other regulatory overlaps that are explored in depth in the cited article, most of which can be found in many coastal nations and are not unique to Belize. The Belize Port Authority, for instance, shares responsibility with the Fisheries Department for ensuring the seaworthiness of fishing vessels and the Belize Agricultural Health Authority maintains sanitary standards in fish processing facilities. Areas like these and others require, and in fact mandate, coordination between agencies.

Special attention should be given to the Belize Coast Guard, a relatively new body created in 2005, with the mandate to patrol and enforce the law in Belize's maritime space. While the Coast Guard's scope of responsibilities is much wider than just fisheries, it certainly includes it, and Coast Guard officers routinely enforce fisheries regulations through an interagency collaboration approach with the Fisheries Department, Police Department, Belize Defense Force (Maritime Wing) and co-managers of MPAs.

Offshore oil moratorium and mangrove protections

At the end of 2017, the Government of Belize enacted the Petroleum Operations (Maritime Zone Moratorium) Act, 2017 (Act No. 54 of 2017) (GOB 2017), which places an indefinite moratorium on offshore oil exploration and drilling everywhere Belize exercises maritime jurisdiction. This is the world's first nation-wide indefinite moratorium against offshore oil, an historic action that serves to protect the fisheries and habitats of the Belizean EEZ and underscores the daily dependence of tens of thousands of Belizeans on healthy marine resources via fishing and tourism.

More recent habitat protections have been passed as well. In June 2018, the then Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development and Immigration, and now the Ministry of Sustainable Development, Climate Change and Disaster Risk Management, implemented a new regulation to provide stronger protection for mangrove forests. The Environmental protection (Pollution from Plastics) regulations (S.I. No. 8 of 2020) will also have a positive impact on marine habitats by reducing plastic pollution on both terrestrial and marine areas (GOB 2020c).

International agreements

Belize is a part of two regional governance units, both of which have specific fisheries provisions. As a Central American nation, Belize is part of the Central American Integration System (SICA). Two bodies within SICA that are relevant to fisheries are the Central American Commission for Environment and Development and OSPESCA, the Central American Fisheries and Aquaculture Organization. On the Caribbean side, Belize is a standing member of CARICOM. Like SICA, CARICOM has a fisheries management body, called the Caribbean Regional Fisheries Mechanism or CRFM.

Unlike similar regional integration bodies, like the European Union, neither CARICOM nor SICA have any kind of legislative sovereignty or much in the way of legal authority for policy-setting. Both bodies, however, have similar missions of existing as forums where member states can coordinate their fisheries and aquaculture policies, especially as they pertain to shared waters and common resources. Both bodies also engage in very useful regional research.

Belize is also party to a number of conventions, which have been signed by the Prime Minister and ratified by the National Assembly. These include several of importance to fisheries, as well as the ecosystems that support them:

- Ramsar Convention on Wetlands
- UN Plan of Action to Deter Illegal, Unregulated and Unreported Fishing
- UN Fish Stocks Agreement
- Bonn Convention on Migratory Species
- Inter-American Convention for the Protection of Sea Turtles
- UN Convention on Climate Change
- UN Convention on Biological Diversity
- Central American Convention on Environment and Development
- Cartagena Convention on the Protection and Development of the Marine Environment of the Wider Caribbean Region
- UN Convention on the Law of the Sea
- Convention on the International Trade of Endangered Species

BELIZEAN FISHERIES MANAGEMENT IN A REGIONAL CONTEXT

Belize's fisheries management framework is not atypical when compared to other Caribbean nations, and more advanced in certain ways, although it lags some of its Central American neighbors. Like many other Caribbean nations, it has placed a lot of emphasis on creating a management framework for its main export-driven fisheries, conch and lobster. To explore this comparison, two examples of this convergence are presented here – Jamaica and Honduras – reflecting Belize's dual nature as a Caribbean and Central American country.

Jamaica's Ministry of Industry, Commerce, Agriculture and Fisheries has the primary responsibility for fisheries management within Jamaica's EEZ. This Ministry determines, for instance, the dates when the closed seasons

for conch and lobster occur, which are, as in Belize, the main export fisheries products. Like Belize, the Jamaican fishing authority, called the Fisheries Division, issues licenses for fishers and for vessels, both of which last for one year. Unfortunately, also like in Belize, this licensing system doesn't carry with it any significant reporting requirements, so information and data about Jamaican fisheries remains one of its weak spots. One area where Jamaica has pioneered management tools is with the use of Special Fisheries Conservation Areas, the functional equivalent of replenishment (no-take) zones in Belize; such no-take zones are unfortunately still not prevalent elsewhere in the Caribbean region. There are 12 such areas in the country, all of which seek to protect fish nurseries or spawning aggregations by prohibiting fishing of any kind (MICAF 2017).

Central American countries appear, at least on paper, to be ahead of the Caribbean region in terms of fisheries legislation. Honduras, for instance, recently overhauled its fisheries legislation by issuing a new Fisheries Law in 2015. It is a generally progressive law that allows for a participatory fisheries council, as well as the use of instruments like fishery management plans and quotas. As in many other cases, the main challenge for the Honduran government will be effective implementation of this framework. Honduras has also had, in effect, a ban on parrotfish fishing in the Roatan and Bay Islands region. This is a positive measure, but still insufficient, and not as strong as Guatemala and Belize's outright ban on all parrotfish fishing.

More examples exist, both of convergence and of important differences between Belizean fisheries management and its neighbors. These examples demonstrate several ways Belize could absorb positive lessons both from its Caribbean peers and Central American neighbors. At the same time, such comparisons illustrate that Belize has taken a position as leader in the region. Belize's stringent bans against trawling and offshore oil activity, and its development of the Managed Access program have provided a strong marine policy framework that set the country apart from its neighbors. The challenge for Belize, as in many other countries, is effective implementation and enforcement of its forward-thinking laws.

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David Edwards, Family

“The fisher’s feet"

– a family tale

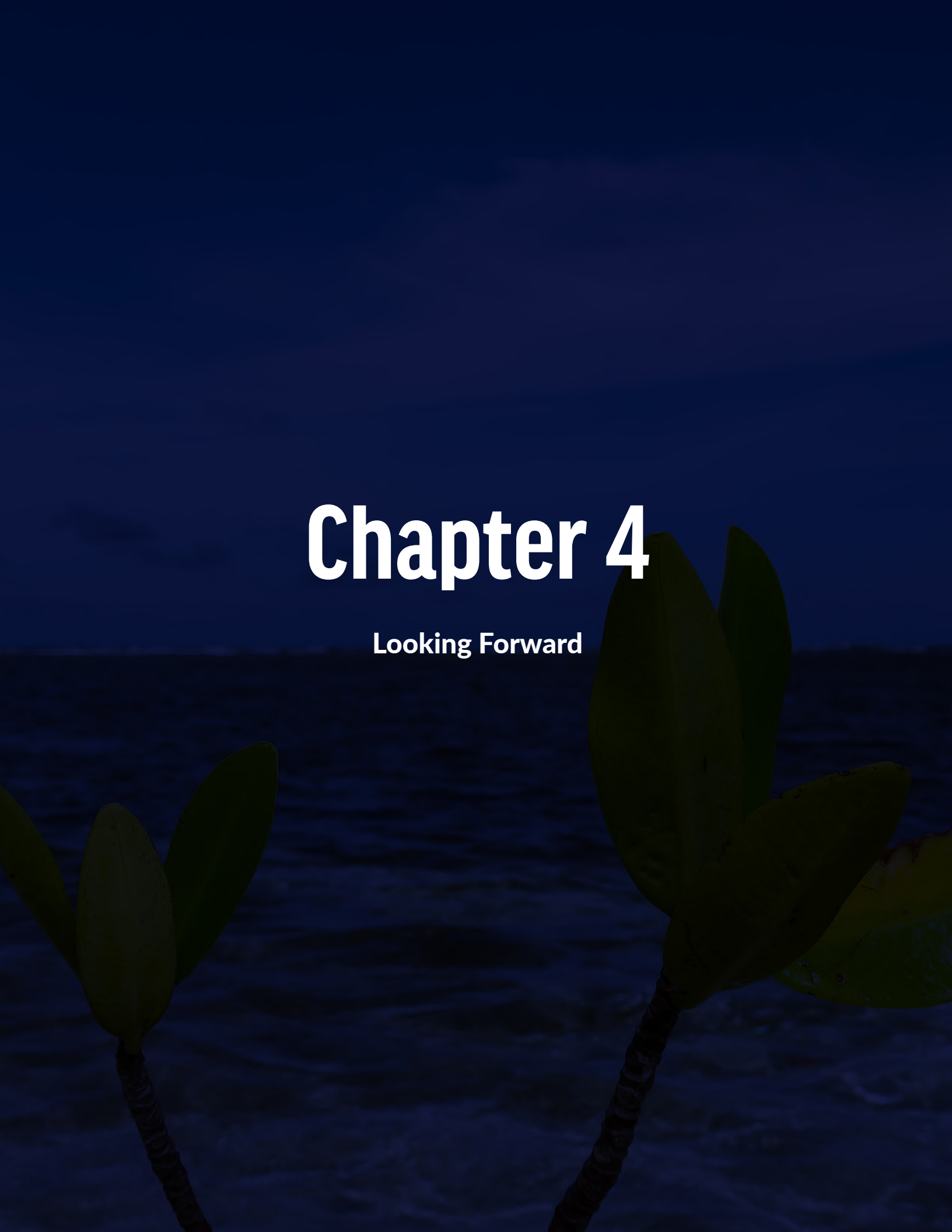
Slimy baits, chest full of ice & the sweet sound of a 15 Yamaha engine is how veteran fisherman David Edwards, 57 years old, starts his fishing days as he sets out for the hour-long journey to his favored fishing ground. With him, one of his three children, who is passionately following his footsteps into the industry. He is confident that his labors will be rewarded, as his catch will sell out within the day. If his regular customers don't snap up what he has on offer, he knows it will only take a short motorcycle ride to the surrounding villages to empty his ice box. This is the life of a devoted family man, whose priority it is to put food on the table at the end of each day.

Edwards began fishing when he was 19 years old, and has a motorized fiberglass boat from which he practices hand line fishing. He enjoys the flexibility that being a fisherman provides, the opportunity to be your own boss, and the fact that "every day I could have pennies in my pocket". He laughs as he recalls the largest fish he caught during all his years as a fisherman. He was fishing with his son and the day was going well; they had caught around 20 pounds of fish and his son was taking a break. Dangling his legs over the side of the boat to wash scales from his feet, his son assured him that there was no danger in the water and he was safe. Suddenly, from right under his feet, a 270-pound Goliath Grouper started tugging the line, and it took the duo two whole hours to battle and bring the giant into the boat. Needless to say, the pair were relieved that the fish favored the bait over his feet, and were extremely satisfied with their takings that day.

With a career that spans almost four decades, Edwards has witnessed a changing underwater environment and declining fish stocks firsthand. He talks of how the sea floor once looked beautiful, like "seeing flowers on the land". Now, areas that were once rich in life, look dead. This changing environment, which he attributes to increased movement in the area, dredging, oil discharge and large boats, has in turn lead to the decline of fish in the area. As a young fisher, he could fill his ice box within three hours in one spot. Now, he has to keep moving, catching only a small amount of fish at a time, spending the whole day at sea.

As a religious man, Edwards is committed to making an honest living for himself, and is a firm believer in following fishing rules and regulations. Well known in the community, he is always happy to share his passion and knowledge fishing, especially in schools to young children but he has a stark warning for current and future generations of fishers: "The rules are for everybody. If we all don't do the right thing, then nothing will be out there for us". He is happy that gill nets have been banned, but says that management authorities need to ensure that all fishers are adhering to the law, so that everyone can continue enjoying the resources. Despite the changes he has witnessed during his lifetime, he remains happy and is able to sleep comfortably at night, knowing that he, at least, is playing his part.

Edwards smiles whilst describing how "fishing takes away all the pressure you have in your head". For him, fishing is a family affair, a skill that he has passed on to his own children. It's difficult to imagine a better way to honor that tradition than to ensure the resources can be enjoyed by the next generation. A devoted family man thinks not only of feeding his family today, but also tomorrow, and that's exactly what he is.



Chapter 4

Looking Forward

Recommendations

Although Belize has been a regional leader in the development of laws and policies to protect habitat, particularly coral reefs, it has fallen short in protecting some of the most valuable and important species that live there – the fish. Catching and eating fish is a Belizean way of life and visitors relish the fresh-caught seafood available on nearly every menu. It is time for the Belizean government and for us as Belizeans to step up and manage our fisheries resources appropriately so that we, and the generations to come, can enjoy the diverse bounty.

Our recommendations encompass improvements to transparency, species protection, harmful fishing gear, and fisheries monitoring. The measures, detailed below, include the following key recommendations:

- Make current fishing licenses public and release collected fisheries data to date;
- Dedicate meaningful and appropriate efforts and budget to fisheries enforcement;
- Strengthen protection for at-risk species and endangered species, including Nassau and goliath groupers, and CITES-listed shark species;
- Establish landing sites nationwide that will assist in enforcement of fisheries regulations;
- Implement a landings monitoring program to facilitate fisheries catch data collection.

TRANSPARENCY AND ENFORCEMENT

First, we call on the Government of Belize to make current fishing licenses public and to release its collected fisheries data to date. New data should be published annually online so that citizens, researchers, and organizations outside of the government can help advance comprehensive fisheries management in Belize more quickly. We particularly urge greater transparency of licensing and trade of shark species fished under CITES protections.

Recognizing the number of current regulations in place, we also urge the government to dedicate meaningful and appropriate efforts and budget to fisheries enforcement. Illegal fishing, whether domestic or from neighboring countries, continues to pose a threat to Belizean fisheries; the threat will only grow worse as resources become more depleted and stricter fishing controls are added. To combat this, the Government should develop, publish and annually report the results of a nationwide protocol for fisheries enforcement, with input from the Fisheries Department, the Belize Defense Force, the Belize Coast Guard and marine reserve co-managers. Following the recent commitment of the Government of Belize to expand the Fish Right, Eat Right program, we also recommend the program to incentivize voluntary compliance and adherence to best practices, both for restaurants through inclusion in the program, and for fishers by increasing the pool of restaurants buying sustainably caught fish.

Priority Measures: Protect Vulnerable Species

Despite the challenges posed by lack of data, we have sufficient information to prioritize certain measures to protect at-risk species and improve management:

- Enhance protection and enforcement of current regulations for endangered fish species, including Nassau, now listed by IUCN as Critically Endangered and goliath groupers. The Fisheries Resources Act 2020 provides for a precautionary approach to be taken in the absence of complete scientific data.
- Establish stronger measures to protect CITES-listed shark species.
- Prevent any new fisheries (species or areas) from occurring without the following: assessment of the status of the resource; implementation of a data collection and vessel monitoring system; and development of a management plan with harvest control rules.
- Limit fishing for deep-water species (red snapper, southern red snapper and vermilion snapper) until an assessment has been conducted.
- Prioritize assessment and management of high-risk snapper and grouper species (dog, mahogany and mutton snapper and black grouper) and hogfish. Management should follow the indicator-based adaptive management framework recently outlined by the Belize Science Team, which allows for the development of harvest control rules, despite a lack of data (McDonald et al. 2017). Management interventions should focus on:
    - Stopping overfishing, particularly of juveniles;
    - Protecting critical habitat, particularly nursery areas and spawning grounds; and,
    - Halting the use of destructive gears that ensnare bycatch and damage habitat.
- Establish increased minimum size measures for lobster to ensure that juveniles are not captured. Transition lobster fisheries from the hook stick to the non-lethal snare to reduce take of undersize lobster.
- Update conch minimum size standards to be based on shell lip thickness, which is now known to provide a better measure of age and maturity than shell length.
- Adopt rigorous and transparent environmental review of new dredging and land reclamation projects. Require best practices to protect nearby habitats and fishing grounds, and prevent dredging in marine protected areas.

Data and Monitoring

It is difficult to comprehensively and sustainably manage all of Belize's fisheries without basic data to inform stock assessments and harvest controls. We urge the Belize Fisheries Department to immediately implement a landings monitoring program, combining both fisher-dependent and fisher-independent data collection through the Managed Access program.

- Assess priority data needs for fisheries management and develop a research and monitoring strategy and action plan with input from relevant stakeholders.
- Collect landings data in volume or numbers for all fish, shark and invertebrate species caught in Belize, broken down by species and catch location, as recorded by fishermen.
- Designate landing sites via the Managed Access program where Belize Fisheries Department officials can

record landings to facilitate collection of accurate data.

- Create and implement a sampling protocol to collect length, weight and age information for all commercially-important species.
- Create a fishery-independent sampling protocol for fishing camps throughout Belize and institute regular monitoring, especially for shark and ray species, in addition to requiring self-reported data.
- Standardize sampling, surveying and reporting protocols for commercially-important fish species and fishing activities in the marine reserves and other categories of marine protected areas, to the extent possible.

In addition, we urge the Government of Belize to commit to making national vessel tracking data publicly available through the Global Fishing Watch platform to improve transparency and enable monitoring and enforcement of Belize-flagged vessels engaged in high-seas fishing activity.

One of the current challenges to investing in fisheries management is a lack of understanding of the importance of fisheries, particularly finfish, to the Belizean economy and society. Therefore, in addition to researching the resource itself, we recommend that research be carried out with specific focus on the three areas:

- Quantify the scale and scope of the domestic seafood economy, including direct sales at markets and to restaurants and hotels.
- Quantify the contribution of subsistence fishing to Belizean communities.
- Estimate direct and indirect value of marine fisheries resources in Belize for commercial, recreational and touristic purposes to help prioritize management objectives.

This report presents preliminary findings on the impact of COVID-19 on the fisheries and tourism sectors; it is recommended that a more thorough analysis be conducted.


BELIZE
has two clear paths ahead...
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The status quo,
which leads to continuing decline of its coastal resource
and leaves its fishermen with slack lines and its reefs bare;

or

tackling fisheries management head-on,
allowing fish stocks to rebound and develop resilient populations
that can sustain all those that rely on them for years to come.

Despite limitations in funds and data, there is sufficient information for Belize to move forward on fisheries management reform now through data sharing, public consultation on management initiatives, greater enforcement of existing regulations and prioritization of management for at-risk finfish species.

Together, we can ensure that

Belizeans can always depend on the sea
for our food, our jobs
and
our way of life.

Paula Williams,
Managed Access Fisher

“Waking up in a woman’s world"

It's 5 a.m. and you're woken by the calls of Northern Terns. You can hear the sound of gentle waves crashing onto the shore in the quaint coastal fishing village of Punta Negra situated in the northern part of the Toledo District. But you're not alone, the entire village of around twelve persons is now awake too. Living here means waking up before the sun and pulling out your cast net to collect a fresh catch of mullet for bait, before heading out to sea for what every fisher hopes will be a bountiful day. After all, they'll be fishing in the Port Honduras Marine Reserve, well known for its extensive mangrove forests and seagrass beds which serves as prime habitats for a variety finfish, lobster and conch. This is how renowned fisherwoman, Paula Williams, typically starts her work day.

Williams, a wife and mother to eight children, devotes her life to fishing, cooking, and her community. She is a Managed Access fisher and says "I really love fishing. I love being at sea, especially when it's calm". She learned fishing from her parents, and says she has been a fisher since she was born. She shares stories of fishing with her own parents when she was just a young girl. One of her fondest memories takes her back to the Lenten season, when they would pack up barrels upon barrels of corned fish to supply to neighboring Guatemala. The village would sell thousands of fish each Easter season, receiving payments in cash and groceries like a bartering system. It was a time of celebration and festivities for the whole community.

Though Paula had left Punta Negra for a short while to pursue formal education, she longed to return to her humble abode by the sea, and so she did just that. One of 13 children, only Williams and her sister now remain in Punta Negra, and both are now hand line fishers. Most days, they use their motorized boat to fish for a few hours for snappers and barracuda to name a few then their catch is sold to another fisher at wholesale prices who will sell in larger towns. Due to declining fish stocks, what used to take an hour to catch, can now take all day. On days when their catch is small, the fish are cooked at home or served at the Negra Grill and Tavern, a restaurant in the village where both sisters work. Williams is famous for making tasty coconut fudge and coconut oil for guests to enjoy and to sell locally. Business at the restaurant was heavily impacted by the COVID-19 pandemic, so the community is taking steps to diversify their livelihoods. For Williams, this has meant planting a vegetable garden to help sustain her family during these challenging times.

Though the dynamics of the fishing industry have changed significantly over the years, Williams is an advocate of sustainable fishing methods, has served on several fishing committees, one of which includes the advisory committee for the Port Honduras Marine Reserve and remains honored and grateful that she can participate in the growth of such vibrant industry. But, she admits there is room for improvement. With an industry as vulnerable as the fishing industry, she strongly believes there must be continuous review of fisheries regulations and increased communication between stakeholders. She hopes that the laws can be reviewed to allow for the preservation of tradition whilst incorporating sustainable practices, and also wishes that fishers, and in particular female fishers, can have a stronger voice on the issues that matter.

But there is one law in particular that she hopes will change. Current laws do not permit children on fishing vessels, so she is unable to share her passion with her own children, the way her parents shared theirs with her. She believes that by the time her children reach the age of 18, the window to fall in love with the fishing life has passed. Only her six-year-old son has shown an interest in fishing; her older children have not been enchanted by her same passions. It is a disconnect that threatens the very core of village life in Punta Negra, breaking generations of traditions, and one that could change the way the village is awoken each day.

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Appendices

APPENDIX 1
MARINE PROTECTED AREAS OF BELIZE

DESIGNATION	NAME OF PROTECTED AREA	MANAGEMENT ENTITY (DEPARTMENT)	CO-MANAGEMENT ENTITY	SIZE (ACRES)	EST.	DESCRIPTION
NATIONAL PARK	Laughing Bird Caye	Forest	Southern Environmental Association (SEA)	10,119	1996	No-take area
	Bacalar Chico	Forest	None	12,640	1996	No-take area
NATURAL MONUMENT	Blue Hole	Forest	Belize Audubon Society (BAS)	1,020	1996	No-take area: fishing, sport fishing and removal of any specimen (dead or alive) from the water is prohibited
	Half Moon Caye	Forest	BAS	9,770	1982	No-take area: fishing, sport fishing and removal of any specimen (dead or alive) from the water is prohibited
WILDLIFE SANCTUARY	Corozal Bay	Forest	Sarteneja Alliance for Conservation and Development	180,510	1998	Regulation of specific gears within the sanctuary
	Swallow Caye	Forest	Friends of Swallow Caye	8,970	2002	Regulations focus on preventing habitat damage
MARINE RESERVE	Bacalar Chico	Fisheries	None	15,766	1996	Divided into four zones: Preservation zone (PZ), Conservation Zone (CZ1 and CZ2) and a General Use Zone (GUZ)

DESIGNATION	NAME OF PROTECTED AREA	MANAGEMENT ENTITY (DEPARTMENT)	CO-MANAGEMENT ENTITY	SIZE (ACRES)	EST.	DESCRIPTION
MARINE RESERVE	Caye Caulker	Fisheries	None	9,670	1998	Divided into three zones: PZ, CZ and GUZ; excludes adjacent forest reserve
	Gladden Spit and Silk Cayes	Fisheries	SEA	25,980	2000	Divided into three zones: GUZ, CZI and CZII (Restoration Area and Spawning Aggregation (SPAG) Site)
	Glovers Reef	Fisheries	None	214,120	1993	Divided into four zones: GUZ, CZ, Seasonal Closure Zone (SCZ) and a Wilderness Zone (WZ). In 2003, a Spawning Aggregation (SPAG) Zone was removed and classified as a SPAG Site Reserve (see below)
	Hol Chan	Fisheries	Hol Chan Marine Reserve Trust Fund Committee	102,400	1987	Divided into eight zones: HCMR No-take Zone, Seagrass Beds, Mangrove Islands, Coral Reef, Bajos General Area, Cayo Frances CZ, Mexico Rocks GUZ and Mexico Rocks No-take Zone
	Port Honduras	Fisheries	Toledo Institute for Development & Environment	100,000	2000	Divided into three zones: GUZ, CZ and PZ
	Sapodilla Cayes	Fisheries	None	321,620	1996	Divided into 4 zones: GUZ, PZ, CZ1 and CZ2; recent expansion in 2020
	South Water Caye	Fisheries	None	117,870	1996	Divided into three zones: CZ, PZ and GUZ

DESIGNATION	NAME OF PROTECTED AREA	MANAGEMENT ENTITY (DEPARTMENT)	CO-MANAGEMENT ENTITY	SIZE (ACRES)	EST.	DESCRIPTION
MARINE RESERVE	Turneffe Atoll	Fisheries	Turneffe Atoll Sustainability Association (TASA)	325,412	2012	Divided into four main zones: CZ, PZ and GUZ and Special Management Zones; also includes three SPAG sites
SPAWNING AGGREGATION SITE RESERVE	Caye Bokel, Turneffe Islands	Fisheries	BAS	1,379	2003	Closed to fishing all year round; classified as Conservation Zone 1 (CZ1) (no extraction)
	Dog Flea Caye, Turneffe Islands	Fisheries	University of Belize	1,424	2003	Closed to fishing all year round; classified as CZ1
	Emily/Caye Glory,	Fisheries	None	1351	2003	Closed to fishing all year round; classified as CZ1
	Rise and Fall Bank,Sapodila Cayes	Fisheries	None	4,252	2003	Closed to fishing all year round; classified as CZ1
	Sandbore, Lighthouse Reef	Fisheries	BAS	1,288	2003	Closed to fishing all year round; classified as CZ1
	Seal Caye, Sapodilla Cayes	Fisheries	None	1,600	2003	Closed to fishing all year round; classified as CZ1
	South Point, Lighthouse Reef	Fisheries	BAS	1,317	2003	Closed to fishing all year round; classified as CZ1
	Gladden Spit, Gladden Spit	Fisheries	SEA	3.997	2003	Closed to fishing all year round; classified as CZ1
	Nicholas Caye, Sapodilla Cayes	Fisheries	None	1,663	2003	Closed to fishing all year round; classified as CZ1
	Northeast Point, Glover's Reef	Fisheries	None	1,536	2003	Closed to fishing all year round; classified as CZ1
	Rocky Point, Ambergris Caye	Fisheries	None	1,409	2003	Closed to fishing all year round; classified as CZ1

DESIGNATION	NAME OF PROTECTED AREA	MANAGEMENT ENTITY (DEPARTMENT)	CO-MANAGEMENT ENTITY	SIZE (ACRES)	EST.	DESCRIPTION
NASSAU GROUPER AND SPECIES PROTECTION SITES	Northern Two Cayes, Lighthouse Reef	Fisheries			2003	A special license may be granted by the Fisheries Administrator to any person engaged in traditional fishing during the Nassau grouper closed season
	Maugre Caye, Turneffe Atoll	Fisheries	University of Belize		2003	Special license (same as above)

Source:

National Protected Areas System Plan (2005) (Appendix 2.1)

Fisheries (Spawning Aggregation Site Reserves) Order, 2003: Statutory Instrument No 161 of 2003

APPENDIX 2
FISHING METHODS IN BELIZE

Introduction to Fishing Methods in Belize

Heather Ylitalo-Ward

August 2016

ACKNOWLEDGEMENTS:

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Contents:

INTRODUCTION

The purpose of this report is to provide a comprehensive and detailed description of the fishing methods used in Belize. It is important to understand the methods used by local fishing communities in order to appreciate the effects of fishing on the marine environment. Informal interviews were conducted in local fishing communities around Belize, with fishers and their family members in 2016. This report aims to provide information on local fishing techniques in Belize that can be used as a reference when discussing management strategies and alternative fishing practices.

BOATS

Sailboat

Traditional wooden sailboats are primarily made in Sarteneja, a northern fishing community in Belize. Around eight fishers will go out to sea on one sailboat for eight to ten days at a time. One person is designated as the chef for the boat. For the most part, the fishers on sailboats are fishing for conch and lobster. Fishers will free dive for conch and lobster (and less frequently sea cucumber) and bring the product back to the sailboat where it is kept on ice during the journey. Fishing on sailboats is a year round practice, as lobster and conch season overlap (conch season is from October to mid-June and lobster season is from the end of June to mid-February). All of the fishers are required to have fisher folk licenses (a specific license for sea cucumber is needed) and sailboats need to be registered with the Belize Port Authority.

Figure 1. Traditional sailboat from Sarteneja

Dory

Dories are small (15-20ft), non-motorized, fishing boats that are usually found stacked on top of sailboats. They are lightweight (either fiberglass or wood) with a shallow-draft. In general, sailboats will carry about 8 dories at a time during lobster or conch season. There is one dory per fisher (excluding the chef) carried on the boat. The sailboat will anchor somewhere while each fisher will venture out in the individual dories and paddle away from the boat. Where the sailboat is moored is usually determined by ocean currents or the direction the vessel is headed. If the vessel is heading south, she will moor south of the drop off points and the dories will then meet at mid to late afternoon to clean their catch. The fishers who use the dories commonly free dive for lobster and conch, checking traps (lobster) or shades that have been set out previously. Dories do not require boat master licenses but the fishers on dories require fisher folk licenses.

Figure 2. Sailboats with dories and supplies stacked on their decks.

Dugout canoe

Dugout canoes are very similar to dories; however they are made out of wood while dories are most commonly made from fiberglass. Also, some dugout canoes will have an outboard motor, while dories are not motorized. Dugout canoes are used throughout Belize, although they are more prevalent in the South, in both ocean and freshwater. They are used to catch tilapia, shad, mojarra, and other fish species with hand lines and nets. They can also be used to catch conch and lobster. Like dories, they do not require registration or boat master licenses, but fishers require a fishing license.

Figure 3. Fisherman with dugout canoe.

Skiff (Panga)

Skiffs are motorized boats of varying sizes (generally 15ft-35ft) that are sometimes referred to as pangas in the north. Some skiffs have live wells in their boats, sections that fill with fresh ocean water to keep the fish alive for long periods of time. Other skiff fishers use coolers that they fill with ice before they leave to fish. Fishing on skiffs is usually limited to day trips; however, trips can last up to four days if the fishers can find somewhere to camp at night. Skiffs are used throughout Belize, from the South to the North. Fishers in skiffs target conch, lobster and finfish. Fishing gear includes hand lines, gillnets, rod and reel, cast nets, lobster traps, set lines, tow lines, fly fishing, and fish pots. When fishers report piracy, they usually say armed men aboard skiffs are raiding fishing camps or robbing produce directly from the sailboat fishers or from the pangas transporting produce to market. Skiffs need to be registered with the Belize Port Authority and the captain needs a boat master's license and a fishing license.

Figure 4. Skiffs lined up on the shore. Coolers can be seen on the boats, ready for fishing.

GEAR

Nets

CAST NET (SPRAT NET)

The cast net is primarily used to catch baitfish off piers, in mangroves, or in flat shallow areas off the coast. Sometimes, the nets will be used to catch tilapia or chiwa (mojarra fish) in freshwater rivers or lagoons. They can also be used to catch shrimp. The nets range in size from 5 to 7 feet across. Mesh size varies depending on the target species. In general, mesh size is very small (less than the 3 inches required for gillnets), but there is no standard mesh size. The smallest mesh sizes are used to target baitfish while slightly larger mesh would be used for something like chiwa or tilapia. Cast nests are used throughout the year and there are no regulations on cast net use. The net is circular with weights around the circumference and a hand line coming from the center of the net. Fishers will often hold part of the net in their mouth and then throw the net open towards the intended target. As the lead line is extended out by the weights, the brail lines are pulled through the center to the bottom. Then, pulling up on the hand line closes the net around the fish, trapping them in the net.

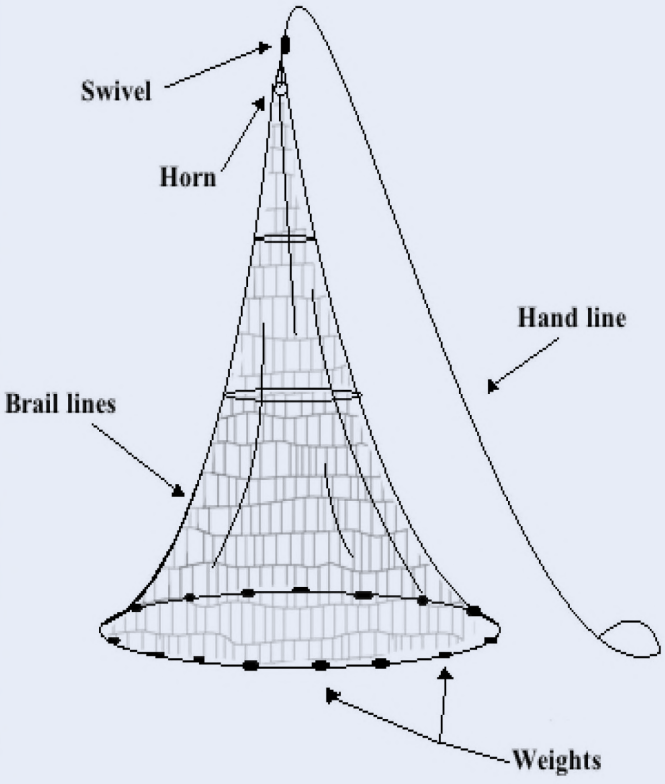

Figure 5. Fisherman holding cast net full of bait fish. Diagram of a cast net showing the basic elements of the structure.

RAATI NET (CRAWL NET)

The raati net is used to catch blue crab (Callinectes sapidus) off bridges or in shallow water. It is constructed around a metal frame, sometimes a bicycle wheel or a metal basket. Chicken skin or feet, cowhide, or other fleshy, tough meat is used as bait for the crabs. Blue crab is considered to be a lower class food and it is mostly fished for subsistence. However, it can sometimes be found for sale at fish markets. Raati nets are most commonly used in the South (Dangriga, Hopkins, etc.) during the months of May to August when the seas are a bit rougher. There are currently no restrictions on raati net use.

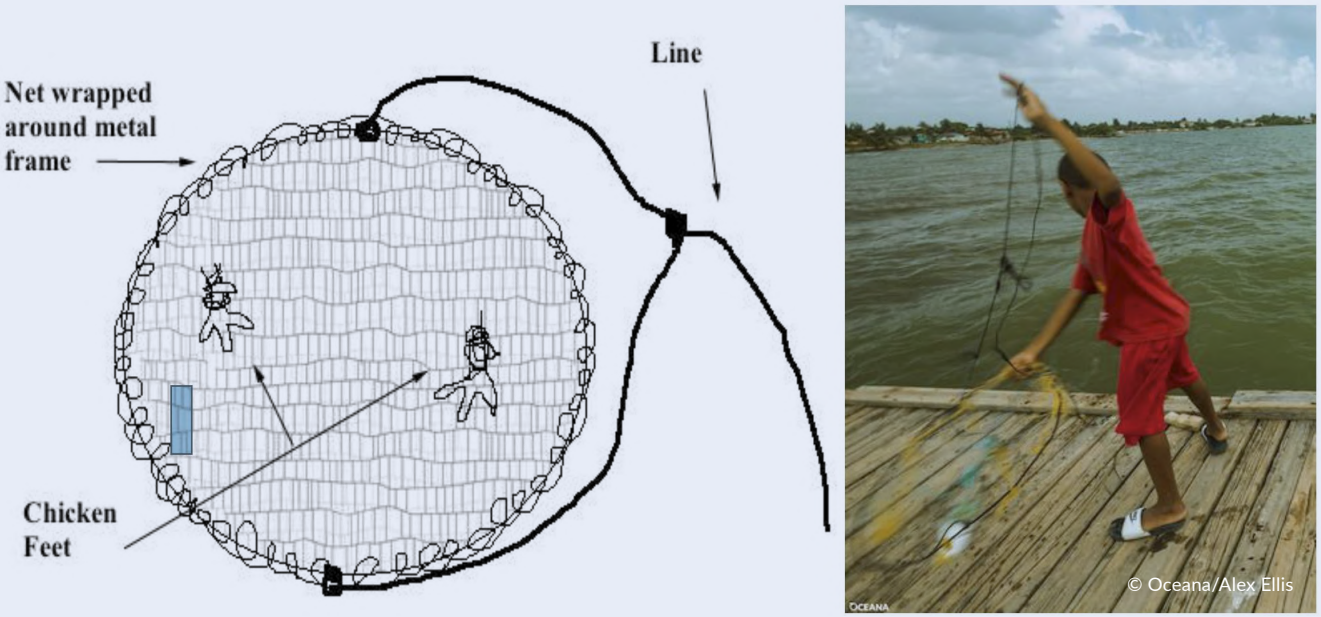

Figure 6. Diagram of raati net and young boy using a raati net off a bridge in Dangriga.

GILLNET

Gillnets are large fishing nets constructed from either natural or synthetic line. They are suspended vertically in the water column with floats on the top edge of the net and lead weights on the bottom. They cost between 1000-1500 BZD. A flag is sometimes attached to either end to locate the nets after they have been set. Fish will swim into the net and get caught by their gills. Fishers will set the nets overnight and then come back in the morning to remove the fish. Gillnets are primarily set by fishers in Sarteneja, Belize City, Hopkins, Dangriga, Punta Gorda, Riversdale, and San Pedro (Biery, 2013). The target fish for gillnets are snook, mackerel, snapper, grouper, barracuda, grunts and sharks. Gillnets are not selective however, and often have high rates of bycatch, including marine mammals, turtles, and protected game fish.

In Belize, gillnets must be registered with the Belize Fisheries Department and the gillnet license must be renewed every year. A license costs 25 BZD. No more than three gillnets 300 feet (100 meters) long (single or joined) are allowed per boat. Gillnets are not permitted to be set around the mouths of rivers. The legal mesh size for gillnets is 3 inches (Poseidon Aquatic Resources Management, 2013). Gillnets are not permitted in marine reserves.

Gillnets are often cited as being used illegally by both domestic and foreign fishers.

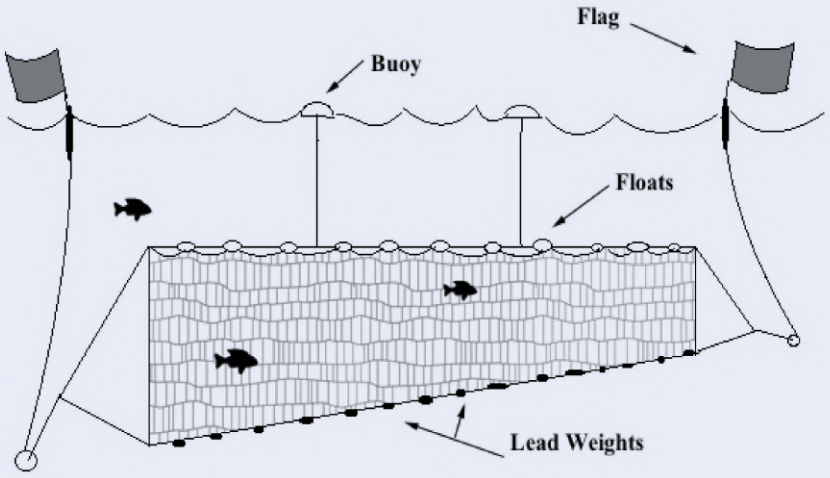

Figure 7. Gillnet in fishing boat and diagram of simple gillnet set up.

BEACH SEINE

Seine nets are used primarily in the North and in Ambergris Caye. Seines can either be used in the shallows or from a boat. In shallow water, two fishers will hold one lead end each and slowly encircle schooling fish (shad, mojarra, or tilapia). Then, they will pull the weighted end up and over, trapping the fish in the pocket, or purse. This action is called “trampa de corona” in the North. From boats, each lead end will be attached to a boat and one or two fishers will swim behind, pulling up the weighted bottom over the fish. The mesh size for inland seines is generally 1 ½ inches while boat seines are generally larger at around 3 inches. Net sizes range from 15 feet for near shore fishing and up to around 40 feet for fishing from boats. Beach seines cannot be used within half a mile of any city, township, village, settlement, or other inhabited locality in Belize, and they not allowed outside the barrier reef within two miles of the Belize River, Haulover Creek or the Sibun River (Belize Fisheries Act, 2003).

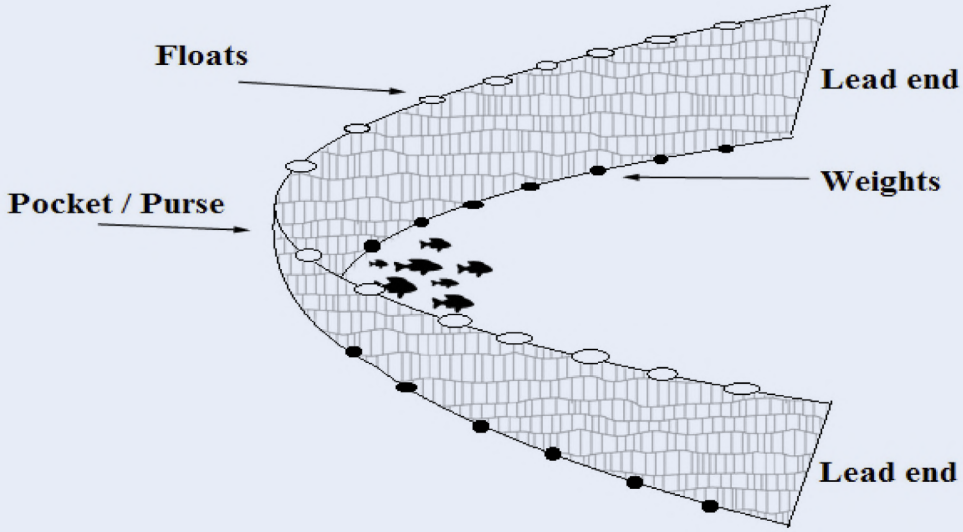

Figure 8. Diagram of beach seine.

JAMO

A jamo is known as a catch net or bully net in English and it is used to catch lobsters, often from shades (casitas), while free diving. Some fishers prefer to use a jamo because they can bring up their lobster catch alive, which helps them discard juvenile lobster more effectively than with a hook stick that might damage the juvenile before they release it. No permit is needed to use a jamo.

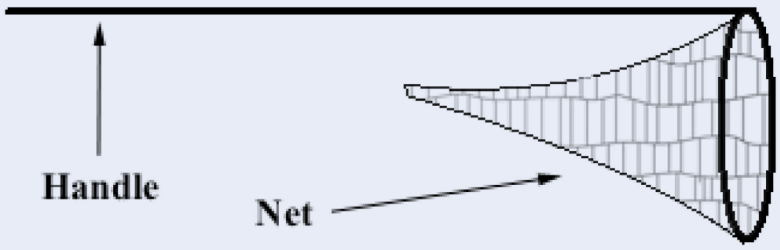

Figure 9. A simple representation of a jamo net used to catch lobster.

SNARE

A snare is used to catch lobster, often from shades (casitas). The free diving fisher will wrap the snare around the tail or head of the lobster and pull to tighten the snare and pull the lobster out of the water. Just like the jamo, the snare will keep the lobster alive allowing for the fisher to discard it responsibly if it is a juvenile. There are no restrictions on snare use.

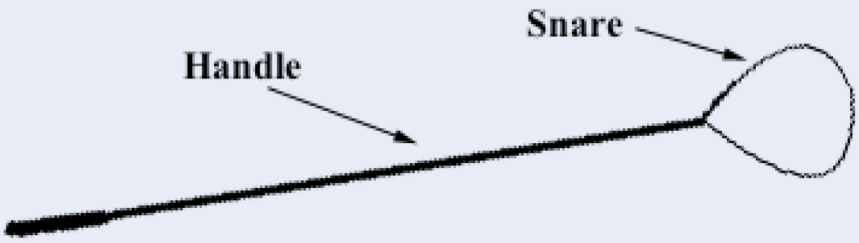

Figure 10. A simple drawing of a snare used to catch lobster.

Traps

BEACH TRAP (FISH TRAP)

In Belize, the traditional fishing traps, also known as beach traps, are mostly found in the north, outside of Sarteneja and Ambergris Caye. The traps are made from galvanized chicken wire strung along mangrove poles. The wire runs approximately 100 feet from the shore out to the circular trap. The traps are in very shallow water around 3 feet deep. As fish encounter the wall of chicken wire, they swim towards the trap where there are corralled until they can be harvested. Beach traps are harvested five days before and five days after the full moon, in the early hours of the morning (4 a.m.). The fishers will place a net on one end of the circular trap and then pull it around to the other side, enclosing the fish within the net. They will then pull the net onto the boat and sort through the fish. The most commonly caught fish are shad, barracuda, and snapper, however there are sometimes tarpon and stingrays found in the traps that are released alive as bycatch. Beach traps require constant maintenance and fishers who own the traps will clean the traps of algae every two weeks and remove leaves every day. Each trap is made from approximately 550 mangrove posts and four rolls of quarter inch galvanized chicken wire. Fishing is seasonal with traps opened in mid-April and removed in mid-November (SACD, 2012).

Beach traps are not permitted in marine reserves except those that were already established in Bacalar Chico from 1996 or those in Corozal Bay Wildlife Sanctuary before 2012. Because of this, beach traps generally remain in families and pass from father to son. Beach traps must be registered with the Sarteneja Alliance for Conservation and Development in the Corozal Bay Wildlife Sanctuary (SACD, 2012). Fisheries regulations list that fish traps must be harvested every three days and juveniles released. If beach traps are not maintained, owners will lose their traps within two years. Fishers with beach traps are required to have fisher folk licenses.

Figure 11. Fisherman in beach trap in Sarteneja

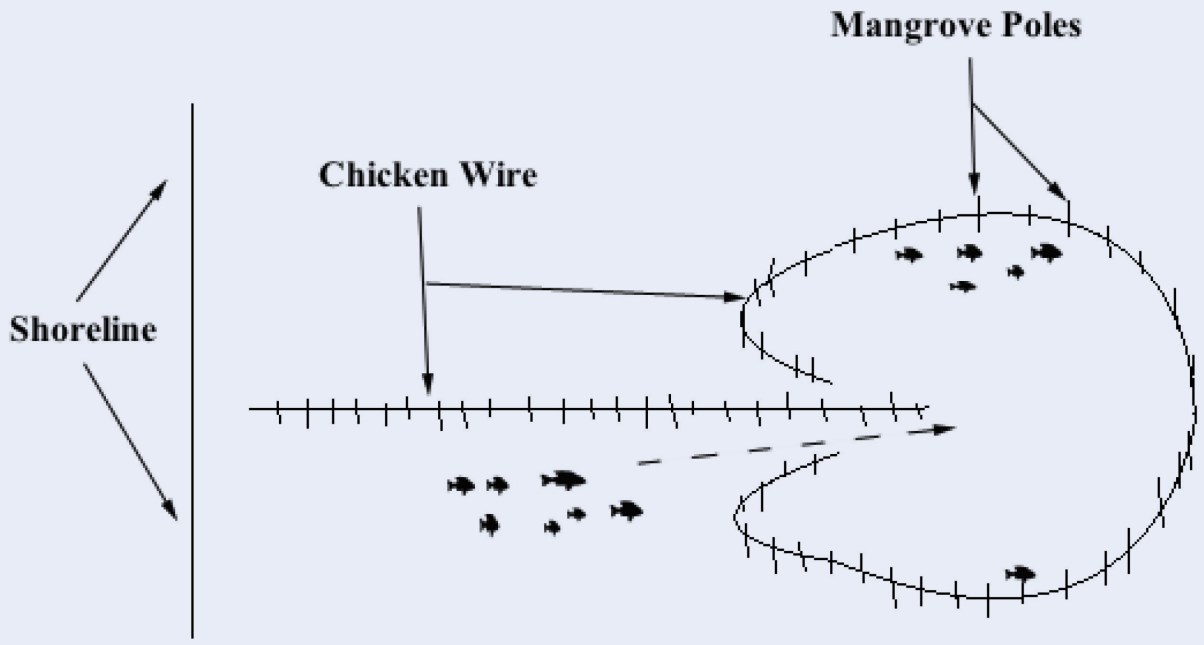

Figure 12. Diagram of fish trap from aerial perspective.

LOBSTER TRAP

Lobster traps are hand built traps that are used to lure lobster. Occasionally, fish will also be found in the traps, but they are not the target species. Fishers will put bait inside the traps (coconut, chicken, beef, or anything "stinky") to attract lobster. The fishers will place the traps in sandy, shallow (approximately 30 feet at the deepest) areas and then return to harvest the lobster a few weeks later. They place a stick or a buoy close by to find the traps and when they are ready to collect them, one person will free dive to the traps and attach a line. Then, someone on the boat will pull the traps up and the lobster out. In some areas, no markings are used due to fears of poaching of traps (Huitric, 2005). Fishers on sailboats, dories and skiffs will use lobster traps. Trapezoidal lobster traps are mainly used in Belize City and in the Northern Cayes (Caye Caulker, San Pedro, etc.) while rectangular wire traps are used in the South in Monkey River and Placencia (Huitric, 2005).

Lobster traps are used during the designated lobster season (mid-June to mid-February of the following year). Lobster traps must be registered with the Belize Fisheries Department and fishers must have a lobster fishing license. No lobster less than three inches (carapace length), with a tail weight less than 4.5 ounces, or found with eggs can be collected (Poseidon Aquatic Resources Management, 2013).

LOBSTER SHADE (CASITAS)

Lobster shades, or casitas, are similar to lobster traps in that they are built to lure lobsters. They are generally made of a sheet of zinc that creates shade under which lobsters will hide. The fishers will then free dive and use a hook stick, snare or net bag (jamo) to collect the lobster. Old tires or oil drums are also sometimes used as lobster shades. There is no standard size to a lobster shade and many objects can be used to attract lobsters to hide under. A lobster fishing license is needed if a fisher will be collecting lobster from a shade.

Figure 13. Lobster traps stacked on top of one another.

FISH POT

Fish pots are used in shallow areas, similar to lobster traps, where fishers can dive down to hook a line to them and retrieve them. However, they are typically much bigger than lobster traps because the larger the traps, the longer the fish will live inside them. They can be four feet by four feet and three feet high, but they vary in size. Fishers will often leave the traps for long periods and if they do not come back soon enough, many of the fish will die. Fish pots can be made of black mangroves, chicken wire, steel, or plastic mesh. The Belize Fisheries Department has to approve the design of the fish trap and a proportion (unknown) of the trap must be biodegradable to prevent ghost fishing (R. Carcamo personal communication 6-30-16). The traps must be registered with the Belize Fisheries Department and they cannot be deployed in areas that will affect the coral reef system or seagrass beds. The traps are baited with lobster, shrimp heads, coconuts or sometimes conch. The target fish are generally red snapper and hogfish, however whatever fish aggregate in the traps are usually harvested. Both juvenile fish and ornamental reef fish end up in the traps and interviewed fishers indicated that these non-target species are rarely thrown back into the water alive. Fish pots are mostly used in the south, especially in the Monkey River fishing communities.

Lines

HAND LINE

Hand line fishing or drop fishing consists of tying a hook to a line with a weight on the end, baiting the hook with sprat, shrimp, or small fish, and throwing the line in the water. The line is not attached to a reel, it is simply held in the hand. Sometimes the line is tied around a plastic or wooden spool. Fishers will use different sized hooks depending on the type of fish that is targeted. Multiple hooks can be tied to each line. Hand line fishers generally target snappers (yellow tail, red, schoolmaster), grouper, grunts, rockfish, jacks, or other finfish. Fishers will drive out to patch coral heads in their skiff (panga) and fish from 1 to 4 days at a time. Hand line fishing is also the method of fishing used at fish spawning aggregation sites. Some fishers will use a hand line attached to a winch to fish in deep slope areas. The fish caught by hand line is mostly for subsistence, however, it can also be sold locally and for export (Zeller et al., 2011). Hand line fishing is common all along the coast of Belize. Hand line fishers are required to have a fishing license with the Belize Fisheries Department.

Figure 14. Fisherman using a hand line.

SET LINE

A set line is similar to a hand line, however, instead of holding the line in the hand, a fisher will tie it to a post in the water and come back for it later. Again, multiple hooks are used on the line. Snappers and groupers are usually the targeted fish for a set line. As with hand lines, the catch is most commonly for subsistence, however it may also be sold locally or to co-ops for export. A fishing license is needed for set line fishing.

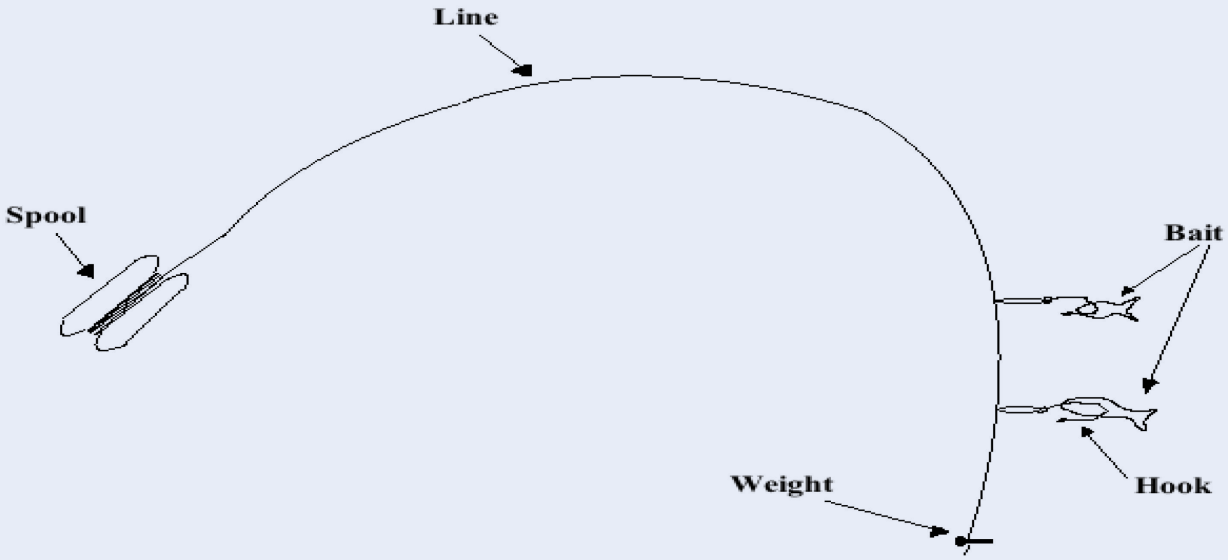

Figure 15. Simple diagram of elements of a hand line.

TOW LINE

A tow line is also similar to a hand line, but tied to the boat and towed behind the boat while moving at around 1 to 2 knots. Tow lines are used to target coastal pelagic species like barracuda and Spanish mackerel. Again, catch is generally for personal consumption but can be sold locally or for export. Tow line fishing requires a fishing license.

FLY FISHING

Fly fishing is a recreational fishing method in Belize. Fly fishers will target sport fish (tarpon, permit, and bonefish). It is not limited to sport fish, however, and fly fishers may also catch snook, billfish, marlin, and mahi mahi, which do not require release after capture. Fly fishing is an angling method that uses a rod, reel and specially weighted line with an artificial "fly" on its end. Fly fishing requires a fishing license.

Figure 16. Fly fisherman on his skiff.

LONG LINE

Long line fishing is a commercial fishing method where hundreds (or thousands) of baited hooks are strung on a line and set out in the water. Each hooked line is called a snood. Long lines can be set out in open water and collected later or they can be attached to boat and dragged from the stern. The latter is more common because fishers report that leaving the lines in the water often results in loss of hooks as they become entangled and this becomes very expensive. In Belize, long line fishing is mostly used to target pelagic sharks. No specific license is needed for long line fishing other than a fishing license, however a permit is needed for shark fishing. There are often high rates of bycatch in the form of turtles, juvenile fish, or sea birds. Long lining is not permitted in marine reserves or replenishment zones (no take zones).

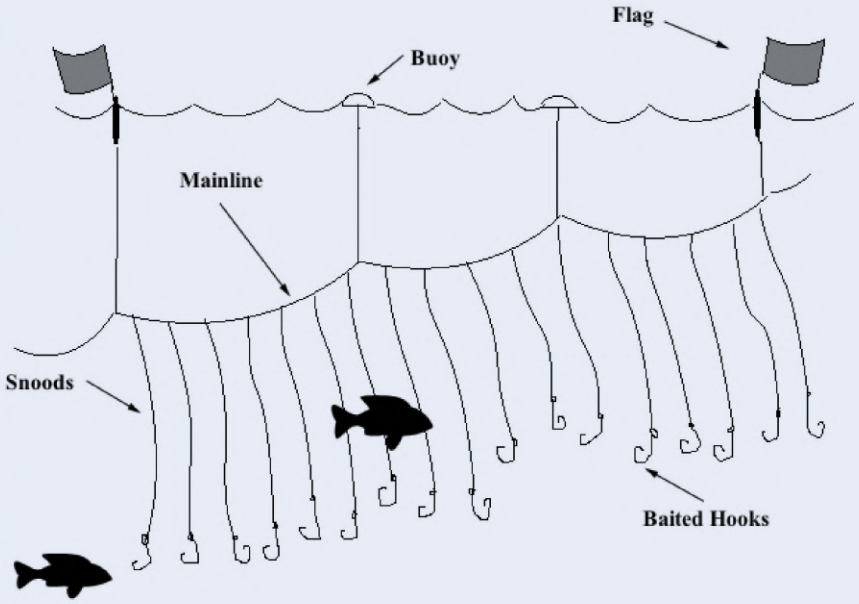

Figure 17. Long line fishing hooks hung up at a fishing camp (left). Simple diagram of pelagic long line fishing set up (right).

ROD AND REEL

Rod and reel fishing is mostly used by sport (recreational) fishers in Belize to catch tarpon, permit, bonefish, marlin, tuna, barracuda, wahoo, and mackerel. It is also called trolling and is mainly used in deep water. Protected game fish (tarpon, permit and bonefish) must be released after capture. A fishing license is required for rod and reel fishing.

ELECTRIC REEL

Electric reels are again mostly limited to recreational or commercial fishers and used in deep waters off of Belize. Target species are large pelagics such as mackerel, marlin, barracuda, wahoo, mahi mahi and protected game fish. A fishing license is required to use electric reels.

Figure 18. Rod and reel on a sport fishing boat.

Spears

SLING (TRIDENT)

A sling (Hawaiian sling or trident) is a type of spear with rubber tubing that wraps around the wrist. It can vary in size but 5.5 feet is a standard length. It is traditionally three-pronged and it is used to catch lionfish and other finfish. The fisher will pull the spear back, stretching the rubber tubing around their wrist, and then release the spear to shoot toward the target fish. Fishers who use a sling or trident to catch lionfish are allowed to use SCUBA gear, however, these are the only conditions under which SCUBA gear can be used in fishing in Belize. The sling is not permitted for use in marine reserves.

Figure 19. SCUBA diver with trident spear, fishing for lionfish.

HOOK STICK

A hook stick is a traditional fishing tool used mainly for commercial and recreational lobster catch. It is a few feet (3-4) long with a barbless hook attached to one end. The fisher will free dive to where a lobster has been spotted (usually under natural coral ledges) and hook it under the belly to bring it back up to the boat. Some fishers prefer to use snares or jamo (net bags) to catch lobster as they do not kill the lobster. A hook stick can kill a lobster, which can be problematic if it is brought up and discovered to be smaller than the legal size limit (3 inches cape length). Hook sticks are used by fishers throughout Belize, but they are reportedly more common in the North and on Half Moon Caye, Turneffe Atoll, and Lighthouse Reef.

Figure 20. Hook stick modified with floats and used to pull fish in off a line. Hook sticks that are used to catch lobster do not have the floats on the end.

SPEAR GUN

Spear guns are used to catch hogfish, barracuda, grouper, snapper and lionfish in Belize. Spear guns are rubber powered or pneumatic powered. In Belize, the most common spear guns are rubber powered. Rubber tubing is stretched on the spear to the trigger to load the gun. Then, as the tubing is released, the spear is propelled forward towards the targeted fish. Spear fishing is not permitted in marine reserves.

Figure 21. Fisher with a spear gun.

Other

SKIN DIVING (FREE DIVING)

Skin diving, or free diving, with a mask and fins is the method used to collect conch and sea cucumber in Belize. Fishers will collect these target species by hand and bring them back to their boats (sailboat, skiff, dory, or dugout canoe). A fishing license is needed to catch conch and a special permit is required to catch sea cucumber. Lobster fishers will also skin dive to catch lobster from underneath lobster shades (casitas) or ledges where lobster congregate. Spear fishers will also skin dive to catch finfish.

Figure 22. Skin diver with three-pronged sling.

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APPENDIX 3
FISH RULER

Heather Ylitalo-Ward
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ABSTRACT

Finfish fisheries in Belize have historically been largely unregulated, which can lead to high juvenile catch rates and overfishing. Size limits can be an effective tool in fisheries management as they offer simple guidelines to fishermen to avoid juvenile catch. An initial study by Oceana in Belize in 2013 found that 83% of fish observed in the markets were juveniles. As a result of this study, a proposed fish ruler was designed with suggested size limits for nineteen species. These size restrictions were based on limited life history parameters. The purpose of this follow-up study was to present size recommendations based on an extensive review of relevant current literature and recorded life history parameters. We originally suggested twenty-one species to be listed on the new fish ruler with size limits based on the highest calculated optimum length (Lopt). However, due to perceived challenges in enforcing these higher size limits, length at maturity was instead recommended for the fish ruler. This fish ruler will then be used in the Fish Right Eat Right campaign (developed by Oceana, Wildlife Conservation Society, Environmental Defense Fund, Belize Fisheries Department, Belize Tourism Board, and the Belize Tourism Industry Association) and distributed to local restaurants as a guideline in sourcing seafood responsibly.

INTRODUCTION

Size Limits

Minimum size limits are a tool used in fisheries management to try to prevent recruitment overfishing, or the overfishing that occurs when fish are caught before they are able to reproduce and replenish the population (Froese, 2004). Minimum size limits prohibit the catch of undersized fish by requiring that a fish reach a minimum length (generally the average length at maturity, Lm) to be landed legally.

Maximum size limits can also be used to protect the largest breeders in a population, since in some species, fecundity increases with size. Therefore, protecting the largest individuals will hopefully encourage high rates of reproduction, replenishing the population. A slot limit sets both a minimum and a maximum size to protect both the small and large fish in a population (Jennings et al., 2001).

For size limits to be effective, they must minimize the mortality rate of the discarded fish. When juveniles are caught, if they are harmed or killed during the process of handling and release, there will be no return on investment within the fishery. One way to minimize mortality is through size-selective gears such as spears or nets designed to exclude juveniles, or by careful handling of undersized fish on hand-lines or other hook-and-line gears (Harley et al. 2000).

Size limits can be quite effective in preventing overharvesting in shallow-water, short-lived species, as they are more likely to survive a catch-and-release process (Van Poorten & Cox, 2013, Harley et al., 2000). Shallow hand-line and dive fisheries where fishers handle each fish individually, a typical practice in Belize, usually have a low discard mortality (Van Poorten & Cox, 2013), which suggests that size limits could be particularly effective here.

Belize Fisheries

With 240 miles of coastline and the second largest barrier reef in the world, Belize is rich in marine biodiversity and represents one of the important fisheries economies in Central America. For many years, the main commercial fishing industry in Belize was lobster and conch, which is where most of the fishing regulations in Belize are focused (Zeller et al., 2011). Finfish species, however, have been increasingly harvested and exported but remain largely unregulated and limited data exists on catch rates (Babcock et al., 2013, Zeller et al., 2011). As a result, it is likely that many species are being overexploited and may also be overfished.

Recently, the government implemented a nationwide Managed Access plan that aims to limit overexploitation of coastal fisheries, but until catch data are recorded, the result of this management policy will be unknown. However, the two pilot sites for Managed Access (Port Honduras and Glovers Reef) showed signs of success with 70% of fishermen reporting higher numbers of fish and an increase in compliance with and enforcement of fishing regulations (Weigel et al., 2014)

As is true in most fishing communities, Belizean fishermen sell fish by weight, driving up demand for larger fish. However, with increasing fishing pressure, large fish are becoming scarce, forcing fishermen to catch smaller individuals. In addition, there are some communities where small fish are in higher demand because they are more affordable, possibly driving up juvenile catch rates (Beiry, 2013). The booming tourism industry in Belize also puts pressure on fishing activity, as tourists expect to eat fresh fish while on vacation (Zeller et al., 2011). All of these factors have contributed to a worrying trend of high rates of juvenile catch with as much as 83% of fish sold in markets below length at maturity (Lm) (Beiry, 2013). This is especially dangerous to fish species with low fecundity, as fewer juveniles will reach adulthood to spawn.

Although little formal research to support size limits currently exists in Belize, the management strategy has proven to be effective across a wide range of ecological and biological parameters (Van Poorten & Cox, 2013, Froese et al., 2008). In Florida, where the ecosystem may be considered similar to that of Belize, they have been implementing size limits on many of their saltwater species, which support their 5.7 billion USD per year recreational saltwater fishing industry and 5.7 billion USD per year commercial fishing industry (www.myfwc.com). If Belize is to join the ranks of other places with sustainable, economically beneficial fishing industries, minimum size limits should be established to allow fish populations to recover from past unregulated overfishing and continue reproducing prolifically well into the future (Oceana, 2012).

The Belize Fisheries Department has been working with local fishing communities and independent scientists to determine minimum fish lengths for 21 fish species in Belize (Ramon Carcamo, personal communication). These limits have been used by the seafood export company Rainforest Seafoods and are being discussed for use in cooperatives nationwide. In addition, the Belize Fisheries Adaptive Management Framework intends to incorporate catch data from the recently implemented Managed Access sites to generate recommended size limits and adjust them according to future fishing pressure scenarios.

Fish Ruler Prototype

In 2013, Oceana produced a report recommending size limits on nineteen species of fish in Belize. These fish were chosen based on fishermen interviews, field observations and catch reconstruction. The prototype of the fish ruler (Figure 1) currently includes the species listed in Table 1.

Table 1. Current species listed on fish ruler prototype from 2013

COMMON NAME	SPECIES NAME	LENGTH ON RULER (INCHES TOTAL LENGTH)
Grunt	Haemulon sciurus	7
Yellowtail Snapper	Ocyurus chrysurus	8
Jimmy Hind	Epinephelus guttatus	9
Lane Snapper	Lutjanus synagris	10
Schoolmaster	Lutjanus apodus	10
Grey Snapper	Lutjanus griseus	10
Dogteeth Snapper	Lutjanus jocu	12
Cubera Snapper	Lutjanus cyanopterus	12
Red Snapper	Lutjanus campechanus	15
Horse-eye Jack	Caranx latus	15
Mutton Snapper	Lutjanus analis	16
Cero Mackerel	Scomberomorus regalis	16
Spanish Mackerel	Scomberomorus maculates	17
Nassau Grouper	Epinephelus striatus	19
King Mackerel	Scomberomorous cavalla	20
Crevalle Jack	Caranx hippos	22
Black Grouper	Mycteroperca bonaci	24
Great Barracuda	Sphyraena barracuda	26
Snook	Centropomus undecimalis	26

The current catch limit sizes are based on a report by Biery (2013) where she calculated Lopt for ten species of concern. Lopt is the length at which the growth rate and the biomass of a cohort are at a maximum (Froese et al., 2008). This can be calculated in a number of ways. Biery originally used a method proposed by Froese in a personal communication, where Lopt = Lm*1.2, and Lm is length at first maturity. She found the species-specific Lm values listed on fishbase.org and used them to calculate appropriate Lopt values. The other nine species recorded were from the list of fish commonly caught in Belize as found by Zeller et al. (2011).

A concurrent study by Babcock et al. (2013) calculated Lopt values using the formula Lopt = 3L∞/(3+M/K), for eight species of fish from the Glover's Reef area of Belize. The values that were found by Babcock et al. were substantially larger than those listed by Biery. Length at maturity can be varied among different populations, sometimes even within the same coastal zone. It is likely that the calculations by Babcock et al. are more accurate for the populations within the economic zone of Belize. Although there is not reliable data for all specific finfish populations throughout Belize for length at maturity, maximum sizes, ages and growth curves, approximate lengths from populations within similar ecosystems can be calculated to offer a foundational guideline for the Belizean fishing industry. Ideally, the life history parameters of specific Belizean populations would be used, but given the limitations in time and resources for that specific research and the need for some current regulations, these calculations can be used until such a time as that data are available. Therefore, this follow-up study recalculates Lopt based on all of the available parameters found in current scientific literature within the Caribbean Sea and the Gulf of Mexico.

Methods

For the above nineteen species, the parameters searched for were length at maturity (Lm), the asymptotic length (L∞), the growth parameter (K), and the approximate maximum age (tmax). Data were collected from current scientific literature and fishbase.org for populations within the Gulf of Mexico and the Caribbean Sea. These parameters were then used to calculate M (rate of natural mortality) as proposed by Babcock et al. (2013). The equations they used are as follows:

ln(M) = 1.44-0.982*ln(tmax) (Hewitt & Hoenig, 2005)

M = -ln(a)/tmax (Hewitt et al., 2007) where a = 0.05 as proposed by Ault et al. (2008)

M = 0.21 + 1.45*K

Once all possible values of M were found, the median value was used to calculate Lopt. For the purposes of this study, the method used by Biery (Lopt = Lm*1.2) was not used as it was suggested as a proxy to a more rigorous scientific method. Instead, the method developed by Beverton (1992) (Lopt = 3L∞/(3+M/K)), was used.

The median value of Lm and L∞ were also used for each species as suggested in Babcock et al. (2013).

Results

Most of the nineteen species that were originally on the fish ruler were found to have a higher Lopt than was listed previously (Table 2). While Biery calculated the Lopt originally, it appears that she used the Lm value for the ruler.

The size limits that were listed by the Belize Fisheries Department agree closely with the Lm values we found in the literature for the suggested species. The main exceptions are the cubera snapper and the crevalle jack, which

they list at substantially smaller sizes (less than half the length at maturity) (Tables 3 & 4). However, the Fisheries Department lists larger sizes for cero and Spanish mackerel than those we found in the literature.

The suggested lengths listed for the new fish ruler are the largest median Lm values for each species. Whether it was the value found by Babcock et al., by the Fisheries Department, or by the current literature review and analysis, the highest estimate was used.

Discussion

In the recent study by Babcock et al. (2013), seven of the eight most heavily fished species in Glover's Reef, Belize were fished below Lopt, indicating rates of overfishing. Four of the eight species they studied are currently on the Oceana fish ruler prototype. Two other overexploited species should be added to the ruler: the hogfish and the grey angelfish. The remaining overexploited species is a parrotfish, which has been banned from fishing in Belize and therefore does not need to be included on the new ruler.

More conservative size limits (higher than length at maturity) have been proven to be effective in a variety of biological systems (Froese et al. 2008, Van Poorten & Cox, 2013). While size limits set at Lopt are significantly more advantageous to fisheries management (Froese et al., 2008), they are often very restrictive and can be more challenging to enforce (Babcock, personal communication). Therefore, length at maturity was decided as the more appropriate measurement to list on the ruler. However, in order to provide some measure of caution, we chose to use the highest median Lm value from the various studies.

The new fish ruler should incorporate the newest data on the appropriate fish lengths in Belize as the Fish Right Eat Right campaign continues. Currently the suggested lengths are in Fork Length measurements; however, it may be beneficial to list them as Total Lengths as it may be easier for restaurant workers to follow. In addition, the Belize Fisheries Department has listed their lengths in Total Length, so to avoid confusion; it might be beneficial to convert the current measurements to Total Length (Table 5).

Although the implementation of size limits is certainly a step in the right direction when it comes to protecting juvenile fish, size limits alone are likely not enough to prevent overfishing or to lead a fishery to recovery if it is already depleted. Another possible strategy to protect juvenile fish would be to introduce the use of circle hooks, which tend to reduce mortality after catch and release (Kerstetter & Graves, 2006) and can be sized appropriately, depending on your target size. Higher rates of juvenile survival post-catch is essential in ensuring a large enough population size for reproduction. However, there are reports that fishers are averse to using circle hooks as they are perceived to catch less fish (James Foley, personal communication). Additionally, seasonal closures during species-specific spawning seasons may help reduce biomass declines as fishers in Belize frequently target spawning aggregations.

Other threats to juvenile fish in Belize include pollution runoff and gillnets. Fertilizer and pollution runoff in Belize can lead to destruction of mangrove and seagrass habitat that provide essential habitat for juvenile fish (Biery, 2013). In addition, gillnet and trap fisheries with small mesh sizes likely damage juvenile fish populations. Gillnets remain legal outside of marine reserves in Belize, although they need to be registered and of a certain mesh size. Despite these regulations, enforcement remains a challenge, and gillnets are indiscriminate in their catch and continue to threaten juvenile fish populations.

Until such time as specific studies on length at maturity can be done on the populations of Belize finfish species, these measurements can serve as a guideline for the restaurants in the Fish Right Eat Right initiative in Belize. Protecting juvenile fish will help ensure future economic and ecological viability of the fishing industry, as well as contribute to maintaining a healthy reef ecosystem that can support lucrative tourism operations.

Table 2. Lopt values calculated for current report listed next to previous Lopt values found in Babcock et al., 2013, and Biery, 2013.

COMMON NAME	SPECIES NAME	LOPT MEDIAN (CM FL)	BABCOCK LOPT (CM FL)	BIERY LOPT (CM)
Grunt	Haemulon sciurus	23.41		22.86
Yellowtail Snapper	Ocyurus chrysurus	34.57		27.94
Jimmy Hind	Epinephelus guttatus	46.71		
Lane Snapper	Lutjanus synagris	31.84		30.48
Schoolmaster	Lutjanus apodus	37.96	33.9	30.48
Grey Snapper	Lutjanus griseus	46.25		
Dogteeth Snapper	Lutjanus jocu	58.35		
Cubera Snapper	Lutjanus cyanopterus	104.54		
Red Snapper	Lutjanus campechanus	63.86		
Horse-eye Jack	Caranx latus	58.42		
Mutton Snapper	Lutjanus analis	50.54	65.7	60.69
Cero Mackerel	Scomberomorus regalis	50.42		48.26
Spanish Mackerel	Scomberomorus maculates	51.22		
Nassau Grouper	Epinephelus striatus	46.72	61.2	
King Mackerel	Scomberomorous cavalla	83.63		60.96
Crevalle Jack	Caranx hippos	75.88		66.04
Black Grouper	Mycteroperca bonaci	78.06	103.3	
Great Barracuda	Sphyraena barracuda	95.18		78.74
Snook	Centropomus undecimalis	68.63		86.36
*Hogfish	Lachnolaimus maximus	36.15	51.2	
*Grey Angelfish	Pomacanthus arcuatus	29.40	37.9	

* = Not originally on fish ruler prototype, FL = Fork length

Table 3. Suggested species to be listed on the new catch limit fish ruler and their measurements in centimeters. Suggested lengths listed are rounded to the nearest half-centimeter. The source of each length is bolded in the table.

COMMON NAME	SPECIES NAME	MEDIAN M	MEDIAN LINF (CM FL)	K	LOPT MEDIAN (CM FL)	MEDIAN LM (CM FL)	BABCOCK LM (CM FL)	FISHERIES LENGTH (CM FL)	CURRENT LENGTH ON RULER (CM)	SUG LENGTH (CM FL)	SUG LENGTH (CM TL)
Grunt	Haemulon sciurus	0.37	35.20	0.22	23.41	**20.00**		18.27	17.78	20.00	22.00
Yellowtail Snapper	Ocyurus chrysurus	0.41	50.05	0.26	34.57	**24.90**		21.58	20.32	25.00	29.50
Jimmy Hind	Epinephelus guttatus	0.31	53.00	0.48	46.71	25.00		**25.40**	22.86	25.50	25.50
Lane Snapper	Lutjanus synagris	0.43	42.87	0.28	23.89	23.05		**26.08**	25.4	26.00	26.00
School-master	Lutjanus apodus	0.32	57.00	0.18	37.96	23.94	**25.00**	17.82	25.4	25.00	27.00
Grey Snapper	Lutjanus griseus	0.32	59.58	0.18	31.88	**30.31**		27.26	25.4	30.50	32.00
Dogteeth Snapper	Lutjanus jocu	0.20	81.55	0.10	34.11	**32.32**		22.09	30.5	32.50	34.00
Cubera Snapper	Lutjanus cyanopterus	0.20	141.20	0.14	67.77	**62.02**		29.21	30.5	62.00	63.50
Red Snapper	Lutjanus campechanus	0.29	90.82	0.18	63.86	**47.23**			38	47.00	49.50
Horse-eye Jack	Caranx latus	0.21	80.23	0.14	58.42	**37.00**		38	37.00	60.30	
Mutton Snapper	Lutjanus analis	0.37	84.74	0.15	50.54	**42.05**	39.00	35.69	40.64	42.00	46.50
Cero Mackerel	Scomberomorus regalis	0.40	75.00	0.22	50.42	40.50		**54.47**	40.64	54.50	54.50
Spanish Mackerel	Scomberomorus maculates	0.63	75.30	0.36	51.22	43.00		**52.24**	43.2	52.00	52.00
Nassau Grouper	Epinephelus striatus	0.34	93.00	0.10	46.72	48.00	52.00		48.26	52.00	52.00

COMMON NAME	SPECIES NAME	MEDIAN M	MEDIAN LINF (CM FL)	K	LOPT MEDIAN (CM FL)	MEDIAN LM (CM FL)	BABCOCK LM (CM FL)	FISHERIES LENGTH (CM FL)	CURRENT LENGTH ON RULER (CM)	SUG LENGTH (CM FL)	SUG LENGTH (CM TL)
King Mackerel	Scomberomorous cavalla	0.40	124.15	0.21	83.63	**63.00**		52.30	50.8	63.00	73.00
Crevalle Jack	Caranx hippos	0.36	91.00	0.38	75.88	**63.60**		18.68	55.88	63.50	73.00
Black Grouper	Mycteroperca bonaci	0.41	128.71	0.17	78.06	72.00	72.00	**73.31-‡125.21**	60.96	‡73.5-125	‡74-127
Great Barracuda	Sphyraena barracuda	0.38	130.80	0.24	95.18	**65.78**		54.01	66.04	66.00	74.5
Snook	Centropomus undecimalis	0.43	95.93	0.27	68.63	**68.75**			66.04	69.00	80.50
*Hogfish	Lachnolaimus maximus	0.30	65.10	0.11	36.15	25.00	**25.00**			25.00	27.00
*Grey Angelfish	Pomacanthus arcuatus	0.38	58.00	0.12	29.40	17.50	**22.00**			22.00	22.00

* = Not originally on fish ruler prototype, TL = Total length, FL = Fork length
‡ = indicates a slot limit

Table 4. Suggested species to be listed on the new catch limit fish ruler and their measurements in inches. Suggested lengths listed are rounded to the nearest half-inch. The source of each length is bolded in the table.

COMMON NAME	SPECIES NAME	MEDIAN M	MEDIAN LINF (IN FL)	K	LOPT MEDIAN (IN FL)	MEDIAN LM (IN FL)	BABCOCK LM (IN FL)	FISHERIES LENGTH (IN FL)	CURRENT LENGTH ON RULER (IN)	SUG LENGTH (IN FL)	SUG LENGTH (IN TL)
Grunt	Haemulon sciurus	0.37	13.86	0.22	8.10	7.87		7.19	7.00	8.00	9.00
Yellowtail Snapper	Ocyurus chrysurus	0.41	19.71	0.26	10.21	9.80		8.50	8.00	10.00	11.50
Jimmy Hind	Epinephelus guttatus	0.31	20.87	0.48	10.25	9.84		10.00	9.00	10.00	10.00
Lane Snapper	Lutjanus synagris	0.43	16.87	0.28	9.40	9.07	10.27	10.00	10.00	10.00	
School-master	Lutjanus apodus	0.32	22.44	0.18	9.79	9.43	9.84	7.01	10.00	10.00	10.50
Grey Snapper	Lutjanus griseus	0.32	23.45	0.18	12.55	11.93		10.73	10.00	12.00	12.50
Dogteeth Snapper	Lutjanus jocu	0.20	32.09	0.10	13.43	12.71		8.70	12.01	13.00	13.50
Cubera Snapper	Lutjanus cyanopterus	0.20	55.60	0.14	26.68	24.41		11.50	12.01	24.50	25.00
Red Snapper	Lutjanus campechanus	0.29	35.76	0.18	20.03	18.59			14.96	18.50	19.50
Horse-eye Jack	Caranx latus	0.21	31.59	0.14	15.49	14.57			14.96	14.50	24.00
Mutton Snapper	Lutjanus analis	0.37	33.36	0.15	17.72	16.55	15.35	14.05	16.00	16.50	18.00
Cero Mackerel	Scomberom-orus regalis	0.40	29.53	0.22	17.03	15.94		21.44	16.00	21.50	24.00
Spanish Mackerel	Scomberom-orus maculates	0.63	29.65	0.36	18.14	16.93		20.57	17.01	20.50	24.00
Nassau Grouper	Epinephelus striatus	0.34	36.61	0.10	20.37	18.90	20.47		19.00	20.50	20.50

COMMON NAME	SPECIES NAME	MEDIAN M	MEDIAN LINF (IN FL)	K	LOPT MEDIAN (IN FL)	MEDIAN LM (IN FL)	BABCOCK LM (IN FL)	FISHERIES LENGTH (IN FL)	CURRENT LENGTH ON RULER (IN)	SUG LENGTH (IN FL)	SUG LENGTH (IN TL)
King Mackerel	Scomberom-orous cavalla	0.40	48.88	0.21	27.13	24.80		20.59	20.00	25.00	28.50
Crevalle Jack	Caranx hippos	0.36	35.83	0.38	27.40	25.04		7.35	22.00	25.00	29.00
Black Grouper	Mycteroperca bonaci	0.41	50.68	0.17	31.22	28.35	28.35	ǂ28.8-49.3	24.00	ǂ29-49.5	ǂ29-50
Great Barracuda	Sphyraena barracuda	0.38	51.50	0.24	28.39	25.90		21.26	26.00	26.00	29.50
Snook	Centropomus undecimalis	0.43	37.77	0.27	29.74	27.07			26.00	27.00	32.00
*Hogfish	Lachnolaimus maximus	0.30	35.83	0.11	14.23	9.84	9.84			10.00	10.50
*Grey Angelfish	Pomacanthus arcuatus	0.38	50.68	0.12	11.57	6.89	8.66			8.50	8.50

* = Not originally on fish ruler prototype, TL = Total length, FL = Fork length
ǂ = indicates a slot limit

Table 5. Conversion formulas used for Total Length (TL) to Fork Length (FL) calculations and their corresponding references.

COMMON NAME	SPECIES NAME	FISHERIES LENGTH (CM TL)	FISHERIES LENGTH (IN TL)	CONVERSION FORMULAS	REFERENCE	
Grunt	Haemulon Sciurus	20.32	8	FL=0.899*TL	Fishbase	
Yellowtail Snapper	Ocyurus chrysurus	25.4	10	FL= 1.77 + 0.780*TL	Fishbase	Johnson, A.G., 1983. Age and growth of yellowtail snapper from South Florida. Trans. Am. Fish. Soc. 112(2a):173-177.
Jimmy Hind	Epinephelus guttatus	25.4	10	FL=TL/1.003	Fishbase	
Lane Snapper	Lutjanus synagris	25.4	10	FL=(TL-0.2)/1.08	Fishbase	Thompson, R. and J.L. Munro, 1983. The biology, ecology and bionomics of Caribbean reef fishes: Lutjanidae (snappers). p. 94-109. In J.L. Munro (ed.) Caribbean coral reef fishery resources. ICLARM Stud. Rev 7.
School-master	Lutjanus apodus	20.32	8	FL=(TL-0.9)/1.04	Fishbase	Thompson, R. and J.L. Munro, 1983. The biology, ecology and bionomics of Caribbean reef fishes: Lutjanidae (snappers). p. 94-109. In J.L. Munro (ed.) Caribbean coral reef fishery resources. ICLARM Stud. Rev 7.
Grey Snapper	Lutjanus griseus	25.4	10	FL=TL/1.049	Fishbase	
Dogteeth Snapper	Lutjanus jocu	20.32	8	FL=(TL-0.58)/1.040	Fishbase	Claro, R., A. García-Cagide, J.P. García-Arteaga and L.M. Sierra, 2050. Peculiaridades biológicos de Lutjanus jocu(Pisces: Lutjanidae) en las zonas nororiental y suroccidental de la plataforma cubana. Ecol. Trop. (In press).
Cubera Snapper	Lutjanus cyanopterus	30.48	12	FL=TL/1.023	Fishbase	
Red Snapper	Lutjanus campechanus		FL= 0.956*TL	Fishbase		

COMMON NAME	SPECIES NAME	FISHERIES LENGTH (CM TL)	FISHERIES LENGTH (IN TL)	CONVERSION FORMULAS	REFERENCE	
Horse-eye Jack	Caranx latus			FL=(TL-1.1)/1.6	Fishbase	Thompson, R. and J.L. Munro, 1983. The biology, ecology and bionomics of the jacks, Carangidae. p. 82-93. In J.L. Munro (ed.) Caribbean coral reef fishery resources. ICLARM Stud. Rev. 7.
Mutton Snapper	Lutjanus analis	38.1	15	FL=-0.64+0.92*TL	Fishbase	Claro, R. and J.P. García-Arteaga, 1994. Crecimiento. p.321-402. In R. Claro (ed.) Ecología de los peces marinos de Cuba. Instituto de Oceanologia Academia de Ciencias de Cuba and Centro de Investigaciones de Quintana Roo (CIQRO), México.
Cero Mackerel	Scomberomorus regalis	60.96	24	FL=TL/1.119	Fishbase	
Spanish Mackerel	Scomberomorus maculates	60.96	24	FL=0.857*TL		Florida Fish and Wildlife Commission (12"FL=14"TL)
Nassau Grouper	Epinephelus striatus			FL=TL		Gulf and Carribean Fisheries Institute
King Mackerel	Scomberomorous cavalla	60.96	24	FL=(TL-2.9)/1.11	Fishbase	León, M.E. and M. Guardiola, 1984. Caracterización biológico-pesquera del género Scomberomorus de la zona suroriental de Cuba. Rev. Cub. Invest. Pesq. 9(3-4):1-26.
Crevalle Jack	Caranx hippos	20.32	8	FL=1.404+0.85*TL		Jorgenson, S.C and G.L. Miller, 1968. Length relationships of some marine fishes from coastal Georgia. United States Department of the Interior. US Fish and Wildlife Service, Bureau of Commercial Fisheries. Special Scientific Report. Washington D.C.
Black Grouper	Mycteroperca bonaci	73.66-127	29-50	FL=1.641 + 0.973*TL		Crabtree, R. E., and Bullock, L. H., 1998. Age, growth, and reproduction of black grouper, Mycteroperca bonaci. Florida waters. Fish. Bull, 96(4), 735-753.

COMMON NAME	SPECIES NAME	FISHERIES LENGTH (CM TL)	FISHERIES LENGTH (IN TL)	CONVERSION FORMULAS	REFERENCE	
Great Barracuda	Sphyraena barracuda	60.96	24	FL = 0.886*TL	Fishbase	
Snook	Centropomus undecimalis			FL=0.885*TL	Fishbase	
*Hogfish	Lachnolaimus maximus			FL=TL/1.07	Fishbase	
*Grey Angelfish	Pomacanthus arcuatus			FL=TL	Fishbase	

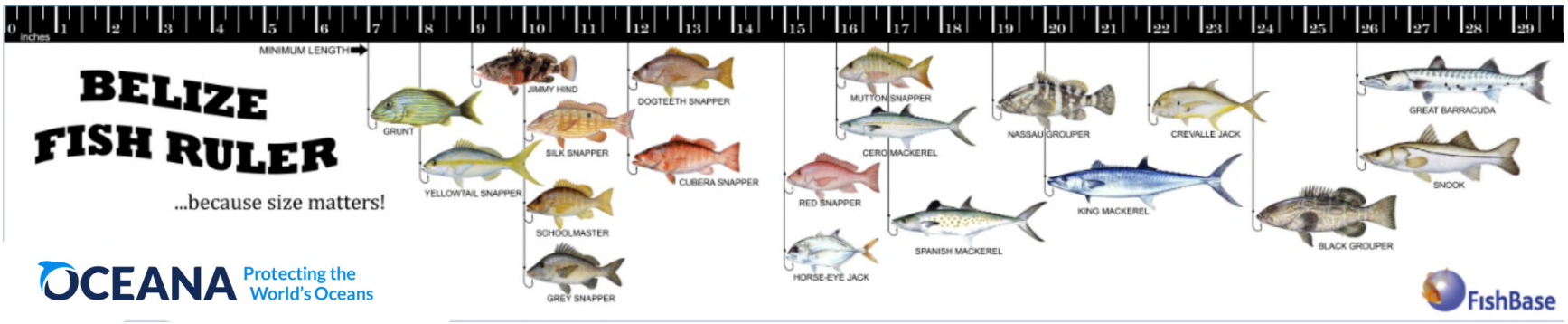

Figure 1. Fish ruler prototype from Biery (2013).

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APPENDIX 4

SOCIOECONOMIC OVERVIEW OF BELIZE

Alexandra Smith
2016

ECONOMICS

Socioeconomics

POPULATION, DEMOGRAPHICS

Belize has a relatively small and highly disbursed population. In 2015, Belize's population was approximately 359,000 with an estimated population density of 16 people per square km[1]. 57.8 percent of the population lives in a rural area. The Belize District, which includes the country's largest city, is home to 28 percent of the population[2]. Population is projected to continue growing in Belize. Approximately 32 percent of the population is under the age of 15. Although the annual birth rate has been in steady decline since 1976, it remains high at 23 births per 1,000 people. The relatively young population structure, high birth rate, and regionally low mortality rate put Belize on a path for fast population growth in the coming years.

Belize has an ethnically diverse population. The four primary ethnic groups consist of Creole, Mestizo, Maya, and Garifuna. Results from the most recent national census, conducted in 2010, show Mestizos to make up the majority of the population (49.7 percent) followed by Creole (20.7), Maya (9.9), and Garifuna (4.6). Other minority groups include the Mennonites, East Indians, and Chinese.

HEALTH

Belize maintains a relatively low mortality rate for region. The most recent estimates for life expectancy in Belize are 72 years for males and 74 years for females. The leading causes of death are categorized as Non-Communicable Diseases including heart disease and diabetes. In 2012, approximately 50% of females died from diabetes related causes. The maternal mortality ratio has decreased significantly to 41.5 per thousand live births. The leading cause of mortality for males are homicide, HIV, and road traffic accidents. Despite progress in health care, Belize has consistently scored lower than the average CARICOM nation over the last 15 years (Figure 1-2).

EDUCATION

Belizean education is modeled on the British system. Although universal compliance has not yet been reached, primary education is free and compulsory through the age of 14. Through agreements with the government, many of Belize's primary schools are run by religious organizations including the Catholic and Methodist churches. Reforms are currently underway to implement more stringent qualification requirements for teachers with an overall aim to improve the quality of education. Secondary education is a non-compulsory competitive four-year high program, requiring passage of a comprehensive exam.

Belize has made significant progress in primary education enrollment. A 2011 Multiple Indicator Cluster Survey (MICS) indicated 95 percent of children primary school age were enrolled in school. Participation rates are higher in urban areas (98 percent) while rural areas report 92 percent enrollment. Participation in secondary school drops dramatically with only 55 percent of at age children enrolled[3] (Figure 1-2).

There are three universities currently operating in the country and the largest by far is the University of Belize headquartered in the capital city of Belmopan. Students may also opt to pursue tertiary education at a junior or

[1] "Belize | Data." The World Bank Data Bank. Accessed October 10, 2016. http://data.worldbank.org/country/belize?view=chart.

[2] Statistical Institute of Belize, Government of Belize, and UNICEF. 2016. Multiple Indicator Cluster Survey 2015: Key Findings. Belmopan, Belize.

[3] Belize Health Sector Strategic Plan 2014 – 2014, Belize Ministry of Health; April 2014

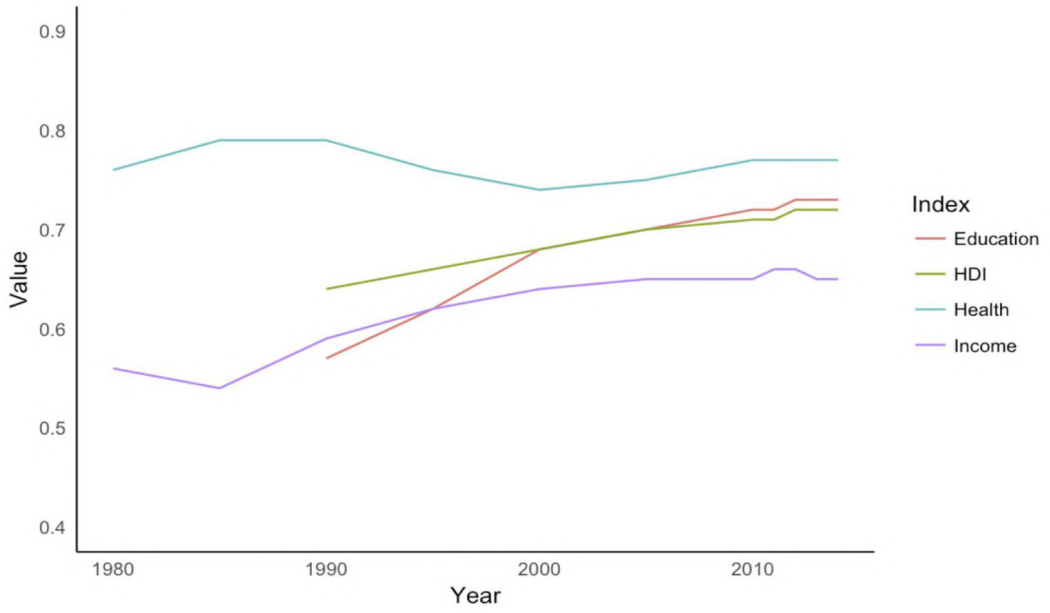
technical college for a two-year degree.

Males and females have equal access to formal education. Men exhibit a higher level of repetition and exclusion from secondary school. More women than men attend the University of Belize although often at a later age.[4]

POVERTY LEVELS AND EQUITY

Belize ranks 101 of 188 countries on the HDI (Human Development Index) and is categorized as a High Human Development county[5]. Since 1990, Belize's score has generally trended upwards with an average annual increase of 0.44 percent per year[6] (Figure 1-2).

Figure 1. Trends for Belize in HDI, Education, Health, and Income from 1980 to 2015 (HDI 2016).



In 2014, gross national income was 7,614 USD[7]. In real terms, gross national income has shown little to no growth over the past five years[8]. There is persistent geographic variability in poverty rates across Belize. The 2010 census found the Toledo District to have the highest incidence rate of poverty, 79 percent of the population, followed by Orange Walk (34.9), Stann Creek (34.8), Cayo (27.4), Corozal (26.1), and Belize District (24.8)[9]. While national measures within Belize show high incidence of poverty, multi-dimensional poverty metrics show lower poverty levels for the country. Belize scored 0.03 on the Multidimensional Poverty Index (MPI)[10] in 2011, a 7 percent increase from 2006[11]. The disparity in poverty measurements can be attributed higher national scores in the additional dimensions accounted for within the MPI. Access to drinking water, education, child

[4] Belize Health Sector Strategic Plan 2014 – 2014

[5] The UNDP considers defines this as a Human Development Index score between 7 and 7.99

[6] United Nations Development Programme. "Human Development Indicators." Belize Human Development Report.

[7] 2011 PPP USD

[8] Belize Human Development Report

[9] Belize Health Sector Strategic Plan 2014 – 2014

[10] The MPI is calculated by the United Nations Development program as the percentage of the population that is multi-dimensionally poor adjusted by the intensity of the deprivations. Before adjusting for intensitity of deprivation, the percentage was calculated to be 7.4 percent living in multidimensional poverty.

[11] Belize Human Development Report

mortality rates and overall health offset low income in the calculation of multidimensional poverty.

Belize faces a high structural unemployment rate[12]. In 2015 the average unemployment was 10.1 percent. Unemployment fell from 11.6 in the previous year, driven primarily by increased participation in the services[13] sector and an 11.5 percent expansion in government services.

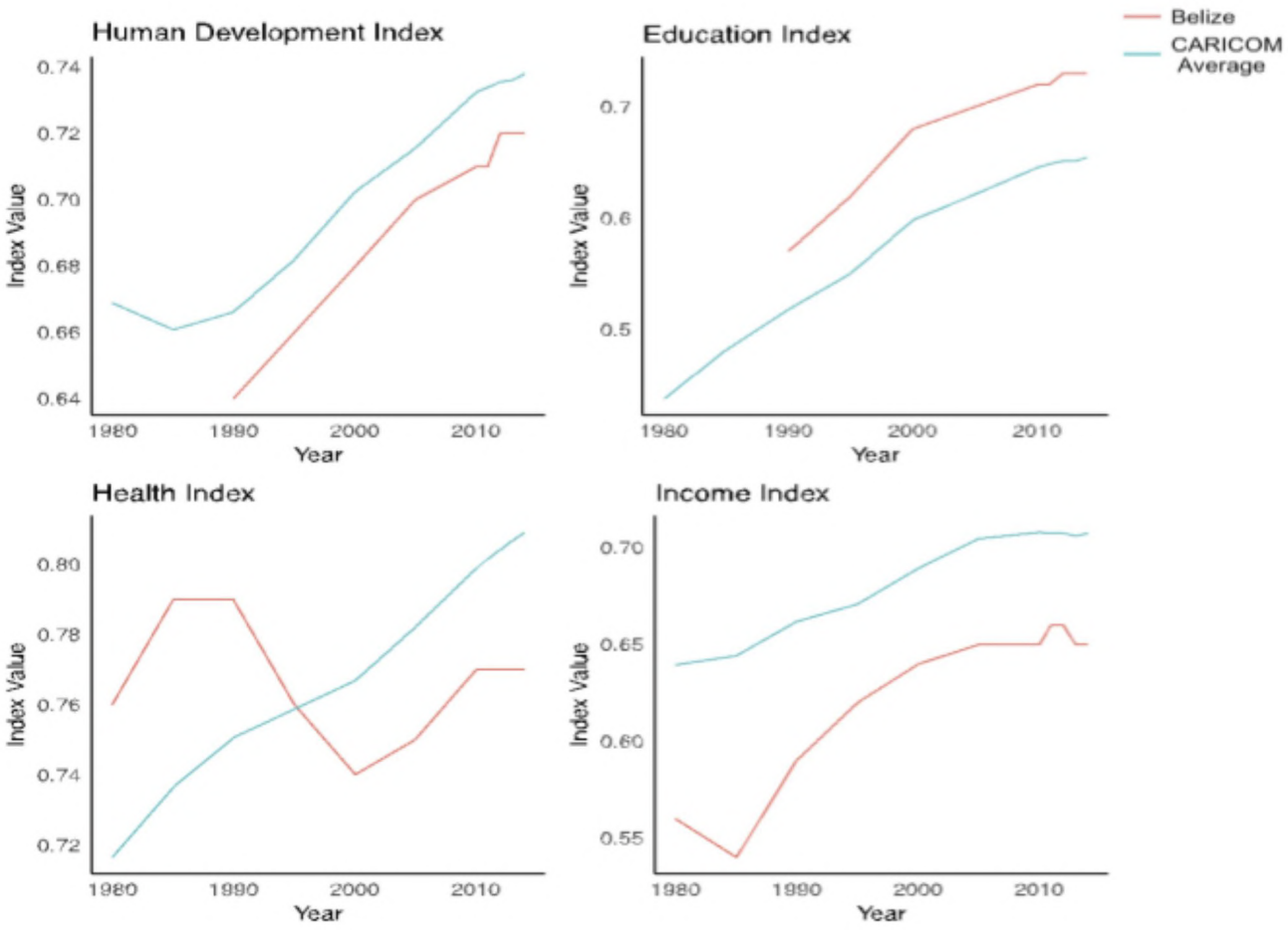


Figure 2. Belize trends in Education, HDI, Health, and Income from 1980 to 2015 as compared to the average of all other CARICOM countries (HDI 2016).

Economics

MAIN ECONOMIC SECTORS

Tourism and agricultural exports are the two largest sectors contributing to Belize's GDP[14]. Tourism makes up approximately 28 percent of employment and contributes roughly 21 percent to GDP[15]. Tourism activity is concentrated in the areas of San Pedro, Caye Caulker, San Ignacio and Placencia. Cruise ship tourism is expected

[12] Metzgen, Ydahlia. "Belize Private Sector Assessment Report." Inter American Development Bank, 2014.

[13] "2015 Annual Report and Statement of Accounts." Central Bank Belize, 2016.

[14] Metzgen, Y., "Belize Private Sector Assessment Report."

[15] Carnerio, Francisco. "Belize - Right Choices Bright Future : Systematic Country Diagnostic." World Bank Group, January 2016.

to increase with the construction of additional facilities in Southern Belize.

Tourism has been targeted as a lever for future economic growth in the country and received significant attention from both the government and international investors in the form of Foreign Direct Investment (FDI). Concerns have been raised that the drive to develop tourism infrastructure threatens the health of natural resources and while influxes of FDI increase local costs of living. Many of the popular tourism destinations are located in ecologically vulnerable areas. In some cases, development has resulted in increased sedimentation and the clearing of mangrove forest[16]. Development of the sector is currently being governed by the National Sustainable Tourism Master Plan which includes strategies and objects through 2030.

Agriculture remains a prominent economic driver in Belize. It is the largest individual employment generator in rural areas. The primary export crops are rice, bananas, sugarcane, citrus, and papaya. In 2015, export revenues from major agricultural products[17] fell due to a reduction in overall output coupled with a decline in global commodity prices. A handful of large private corporation are responsible for the bulk of some primary agricultural exports. There has been some evidence of national vulnerability as a result of individual corporate withdrawals from the country.

Micro, small and medium-sized enterprises (MSMEs) are a fundamental component of Belize's economy. A 2011 study estimated MSME's generate approximately 70 percent of private sector employment[18]. It is estimated that MSMEs produce over 70% of the country's main export crops and an even higher percentage of its domestic food crops[19]. This presents additional barriers to the collection and accuracy of economic indicators for the country as much of the activity at this level is under reported.

Table 1: Belize Total GDP and proportion generated by activity (2010 - 2015) in millions of USD

Source: Statistical institute of Belize: GDP by Activity 1992 to 2015 http://www.sib.org.bz/statistics/gross-domestic-product

	2010r	2011r	2012r	2013r	2014r	2015p
GDP (total)	1,225.45	1,251.21	1,298.02	1,307.51	1,361.12	1,400.21
Agriculture and forestry	118.95	113.29	124.92	123.29	124.69	125.49
% of GDP	9.71	9.05	9.62	9.43	9.16	8.96
Hotels and Restaurants	40.50	41.19	45.73	49.70	54.59	52.80
% of GDP	3.31	3.29	3.52	3.80	4.01	3.77
Fishing	51.87	50.12	49.64	61.08	64.47	42.05

[16] Brune, S., Sanders, A. "Vulnerability and Perce the Coastal Communities of Belize: Case Study of San Pedro, Placencia and Port Loyola." EAP Zamorano, July 2008.

[17] Statistical Institute of Belize, Multiple Indicator Cluster Survey 2015

[18] Metzgen, Y., "Belize Private Sector Assessment Report."

[19] Metzgen, Y., "Belize Private Sector Assessment Report."

	2010r	2011r	2012r	2013r	2014r	2015p
% of GDP	4.23	4.01	3.82	4.67	4.74	3.00
r - Revised p – Provisional						

ROLE OF BELIZE IN GLOBAL TRADE

The IMF (International Monetary Fund) classifies Belize as a highly open economy based on total trade in goods and services as a percentage of GDP. [20]Belize's open economy is primarily import driven. As a result, Belize typically maintains a high trade deficit in comparison with regional peers.

Belize has duty free access to the US market for most export goods through the Caribbean Basin Initiative. [21]The US is Belize's primary export partner, accounting for 25.5 percent of export earnings in 2014, followed by the United Kingdom (19 percent) and Mexico (6 percent). Belize is also a member of the CARICOM Single Market Economy (CSME). This agreement provides for the free exchange of goods and services and eased labor movement between the 15 member Caribbean states. In terms of trade openness, Belize is more closely integrated with Caribbean states than its Latin American neighbors.

Many Belizeans also take advantage of services and supplies in the bordering countries of Mexico and Guatemala. Increases in the cost of living and food prices drive unregistered trade across these borders where many goods can be found at lower prices. After a period of steep inflation in the mid 2000s (13.9 percent in 2008) food prices seem to have stabilized in recent years with an average increase of 0.9 percent increase per year from 2011 through 2015. [22]

Export diversification remains a challenge. Primary products make up the majority of export products, over 50 percent, followed by resource based products which make up roughly 30 percent.[23] Export earnings from primary products and agricultural goods are subject to high variability in global markets and pose a threat to stable economic growth.

Contribution of fisheries to national economy

The Statistical Institute of Belize estimates the fishing industry contributed 3 percent of total GDP in 2015.[24]

EMPLOYMENT FIGURES

Closure of the target commercial species are staggered, allowing fishermen to operate year-round. According

[20] Belize: 2010 Article IV Consultation—Staff Report; Informational Annex; Staff Statement; Public Information Notice on the Executive Board Discussion; and Statement by the Executive Director for Belize, January 2011.

[21] Villanueva, Jaime. "Fisheries Statistical Report 2014: Draft." Belize Fisheries Department, 2014.

[22] "Consumer Price Index." Statistical Insititute of Belize: Statistics. Accessed November 28, 2016. http://www.sib.org.bz/statistics/consumer-price-index.

[23] Bright choices, bright future. Systematic Country Diagnostic. Carneiro 2016

[24] Statistical Institute of Belize, 2015

to a 2012 estimate from the Belize Fishery Department, 12,910 people benefit economically from the fishing industry.[25] This includes approximately 2,500 licensed predominately small-scale fishers operating across the country. Additional employment is generated by fishing cooperatives and processing plants.
Belize has four main fishing cooperatives distributed across 4 regions; Northern Fishermen Cooperative, the National Fishermen Cooperative, Placencia Fishermen Cooperative, and the Rio Grande Cooperative (Table 2).

Table 2: Belizean Fishing Cooperative and Membership (Capture Fisheries Statistical report)

COOPERATIVE	HEADQUARTERS	MEMBERSHIP	EXPORT LICENSE
Northern Fishermen Cooperative	Belize City, Belize	1,155	Lobster, Conch
National fishermen Cooperative	Belize City, Belize	575	Lobster, Conch
Placencia Fishermen Cooperative	Placencia, Stann Creek	41	-
Rio Grande Fishermen Cooperative	Punta Gorda, Toledo	40	Whole Lobster, Finfish, Sea Cucumber

Although there are a few licensed female fishers, fishing in coastal communities is generally dominated by men. Nonetheless, fishing is a responsibility shared by both men and women through separate roles. Women are employed in processing facilities and sell the fish at local markets.

A study conducted in 2012 by the Caribbean Regional Fisheries Mechanism (CRFM) found Belize to have the second highest percentage of poor and vulnerable fishing households of the 10 CARICOM countries studied. At a regional level, the Toledo district showed the highest incidence rate of poverty with 17 percent of fishing household being classified as poor or vulnerable.[26]

FISHING AND TOURISM

Traditional industry metrics do not capture the economic and biological linkages between fisheries and the more substantive tourism industry. In recent years, Belize has capitalized on the growth of the eco-tourism market, specifically, marine eco-tourism. One study estimates that, in 2010, marine eco-tourism provided 4,000 jobs and generated 64 million USD of direct revenues. This is more than 20 percent greater than the reported revenue from commercial fishing.[27]

A 2015 exit survey found more than half of all tourist visited the Meso-American Barrier Reef and 42 percent of tourist visited a marine protected area[28]. The same Belize Tourism Board survey found snorkeling, diving, and fishing to be popular activities among tourist from all regions (with an average of 70, 30, 20 percent of all tourist participating respectively). In the survey section gauging tourist satisfaction, marine attractions rated higher than

[25] Gongora, Mauro. "Status of Fishing Industry." presented at the State of the Coastal Zone Summit 2012, Belize City, Belize, June 8, 2012.

[26] CRFM. (2012). Diagnostic Study to Determine Poverty Levels in CARICOM Fisheries Communities –Technical Document. CRFM Technical & Advisory Document – Number. 2012 / 3. Volume I.

[27] Cisneros-Montemayor et al., "Economic Use Value of the Belize Marine Ecosystem: Potential Risks and Benefits from Offshore Oil Exploration," Natural Resources Forum 37, no. 4 (November 2013):224.

[28] "Belize Travel and Tourism Statistics Digest 2015." Belize Tourism Board, 2016. table 3.21, pg 47

any other category with 90 percent of tourists assigning a "good" score—the highest score in the survey.[29]

In addition to a growing eco-tourism sector, Belize has a robust sports fishing industry. Famous for Bonefish, Permit and Tarpon, Belize has become a premier destination for sports fishers. A 2008 study found that sport fishing for bonefish, permit and tarpon accounted for 21.4 million USD in direct expenditures with an additional 3.8 million USD in associated indirect spending.[30] The sport fishing industry is a key driver of tourism and local revenue for many coastal communities.

The industry generates significant employment as well as offering a culturally compatible alternative income source to many commercial fishers. Often the small coastal communities with access to rich natural resources have few opportunities for income diversification. A case study conducted in Turneffe Atoll found that the total expenditures from tourism dwarfed commercial fishing revenue, contributing nearly 26 times more to the local economy.[31] Further development of eco-tourism and sport fishing tourism provides opportunity for alternative and supplemental livelihoods for communities traditionally dependent on fishing.

INCOME OR EMPLOYMENT MULTIPLIERS

The total economic contribution of the fishing industry is not captured fully through direct impact measures like total revenues and employment. In addition to the linkages between marine resources and tourism, the fishing industry has its own indirect effects on the economy referred to as multipliers. Economic multipliers provide quantitative estimates of how changes in the fishing sector affect overall economic activity, while income multipliers refer to changes in income and employment. According to a global economic impact study of ocean fisheries conducted in 2010, fisheries in Belize exhibit multipliers valued at 3.46 for economic impact and 0.78 for income. [32][33]

The economic multiplier attempts to capture upstream activities, which supply inputs to the fishing industry, and downstream activities, like processing and marketing, that generate additional benefits for the national economy. Given the relative scale of fishing in Belize, upstream activities alone are likely a small multiplier of employment. A 2012 study found about 51% of each boat's costs are spent on fuel, 19% in crew wages; 9% on ice; with the remainder used to pay cooperatives' fees, oil, bait, licenses and on the maintenance of boat and gears.[34] Most fishers repair their own gear. While there are some large boat yards in the country, there is also a cottage industry of boat and engine repair.

Processing facilities freeze finfish, shellfish and conch for export. Additional facilities exist for processing sea cucumber through a series of salting and boiling. The Belize Fisheries Department reports the four fishing cooperatives employ over 137 personnel for processing packaging and administration.[35] This figure does not include employment by private corporations.

Estimations of the income generating value of the fisheries maybe further understated as they do not capture

[29] "Belize Travel and Tourism Statistics Digest 2015." table 3.31, pg 51

[30] Fedler, Anthony J., and Craig Hayes. "Economic Impact of Recreational Fishing for Bonefish, Permit and Tarpon in Belize for 2007." Gainesville: Friends of Turneffe Atoll, 2008

[31] Calculated from: Fedler, Anthony J. "The Economic Value of Turneffe Atoll." Unpubl. Turneffe Atoll Trust, Belize, 2011

[32] The multiplier can be understood as the marginal change in economic activity or income that will occur when output in a given sector changes by one unit. In this case, output is measured in total landed value from the fishery

[33] Andrew J. Dyck and U. Rashid Sumaila, "Economic Impact of Ocean Fish Populations in the Global Fishery," Journal of Bioeconomics 12, no. 3 (October 2010): 227–43.

[34] CRFM. (2012). pg 230

[35] Capture Fisheries 2014, pg 4

subsistence consumption and bartering. Much of the catch sold domestically is sold direct to consumers in local markets or directly to restaurants and hotels. These figures often go unreported, lowering the overall estimated revenue generated by fishing. In addition to the direct generation of income, small-scale subsistence fishing provides essential nutrients to many families across the country. Fishermen's households are composed on average of 4.37 persons and in poor Belizean households, this average is even higher (6.7).[36] Many of these households are likely dependent on the protein provided by subsistence fishing.

Seafood industry highlights

Unprocessed products are purchased from local fishermen and sold either domestically or for export through cooperatives and a handful of private companies. Domestic sales are either direct to consumers in local markets or frozen and sold to restaurants and hotels. The bulk of extracted marine products are sold on the export market. Marine products make up a small percentage of total national imports. In 2014 marine product imports totaled an estimates 561 thousand USD.[37] This estimate includes live fish, crustaceans, mollusk, and frozen fish the majority coming from the United States.

In 2015, the fishing sector generated an estimated 42 million USD in revenue. This is the lowest revenue contribution over the last 5 years and a 34 percent decline on the previous year. While individual fisheries have exhibited variability in total production, combined production of the key wild capture fisheries has remained fairly stable with a five-year peak in 2013. Decline in total production from 2013 to 2015 was driven primarily by a 68 percent decline in whole fish production and a 40 percent decline in sea cucumber production. It is important to note that production data is reported by the fishing cooperatives and does not include direct to consumer transactions or sales from independent, unassociated fishers.

DOMESTIC SEAFOOD ECONOMY

Fish is an important source of food security in the country. Although Belize is a net exporter of food, producing more than 50 percent of their domestic consumption, food prices can be subject to steep inflation. A 2012 study found per capita consumption of fish to be 12.51 kg/capita/year.[38] The most popular finfish for domestic consumption include: lane snapper (Lutjanus synagris), barracuda (Syhyraena barracuda), mackerels (Scomberomorus), grunts (Haemulidae), and goliath grouper (Epinephelus itajara).

While conch and lobster are more commonly sold and exported through cooperatives, most of the finfish landed is sold directly to consumers. Independent fishers sell finfish at established fish markets or directly to hotels, and restaurants. The largest domestic market is located in Belize city which, in 2008, accounted for 65 percent of all national fish consumption.[39] To date, no consistently reliable data exists on the proportion of products retained for local consumption, although some estimate only 10 percent of wild caught fish are consumed domestically. Because the Belize Fishery Department relies heavily on fishing cooperative to collect production data, finfish data have the highest risk for underreporting total production.

EXPORTED SEAFOOD

In 2015, combined export from capture fisheries and aquaculture production generated 40 million USD in

[36] CRFM. (2012).

[37] Simoes, Alexander. "OEC - Belize (BLZ) Exports, Imports, and Trade Partners." The Observatory of Economic Complexity. http://atlas.media.mit.edu/en/profile/country/blz/.

[38] Faostat. 2007

[39] "Annual Report 2008." Belize Ministry of Agriculture and Fisheries, 2009. pg 43

revenue.[40] As of 2014, the government of Belize had issued 1,841 seafood export permits.[41] The main regional and international markets are the United States, Mexico, Canada, Hong Kong, and other CARICOM countries.[42] Export earnings vary and are highly susceptible to changes in global market prices.[43]

Queen conch (Strombus gigas) and spiny lobster (Panulirus argus) are the two single species capture fishery that generate the most export revenue. In 2015, lobster tails accounted for 20 percent of commercial fishing export revenues while conch accounted for 10. Additional wild caught export products include a variety of finfish, sea cucumber, stone crab, and tropical fish for the aquarium trade. Farmed shrimp and tilapia are the two major exports from the aquaculture sector. On-shore farms are managed private companies funded at least in part by foreign investors. Most of the marine products are exported as frozen products after primary processing done by the fishing cooperatives or private corporations.

Lobster

The lobster fishery is seasonal with a four-month closure from mid-February through mid-June. Under current national law, only fishing cooperatives are eligible for lobster export licenses. Lobster is processed and sold as whole lobster, tails, or head meat. The Northern and National Fishermen Cooperatives, the two largest in the country, have certified processing plants that process lobster products for export.[44] The smaller southern cooperatives deliver their products to one of these plants for export. In the lobster fishery, there is a statue in place which requires Belizean cooperative to sell a minimum of 5 percent of catch domestically.[45]

Lobster tail production has experienced significant variability year to year. In 2015, export earnings from the lobster fishery totaled an estimated 8 million USD.[46] This value is above the 5-year average of 7.1 million USD per year and is the first increase in total revenue after 3 consecutive years of declining production (Figure 3).

Conch

Conch is the second most valuable wild caught fishery in the country. It is harvested by skin diving at depths up to 30 meters along the Meso-American Barrier Reef system. The fishery is entirely artisanal, accessed in skiffs and wooden sail boats measuring up to 30 feet. The conch fishery is open from October through the end of June or until the Total Allowable Catch (currently set at 800,000 pounds) is reached. Conch is produced both for export and local consumption.

Conch production has remained relatively stable over the past 5 years, although it has been in decline after peaking in 2012. In 2015, production totaled an estimated 850,000 pounds generating export earnings estimated at 4.1 million USD[47] Although 2015 saw a 17 percent increase in production, revenues declined 5 percent from the previous year (Figure 3).

Finfish

The primary finfish species targeted for the export market include groupers (Epinephelus and Mycteroperca), snappers (Lutjanus and Ocyurus), hogfish (Lachnolaimus maximu), king mackerel (Scomberomorus cavalla) great barracuda (Syhyraena barracuda), and jacks (Alectis, Caranx and Trachinotus).[48]

[40] Central Bank Belize, 2015 Annual report

[41] Villanueva, Jaime. “Fisheries Statistical Report 2014: Draft

[42] CRFM. (2012).

[43] Villanueva, Jaime. “Fisheries Statistical Report 2014: Draft

[44] Villanueva, Jaime. “Fisheries Statistical Report 2014: Draft

[45] Villanueva, Jaime. “Fisheries Statistical Report 2014: Draft, pg 5

[46] Unpublished data from Belize Fisheries Department

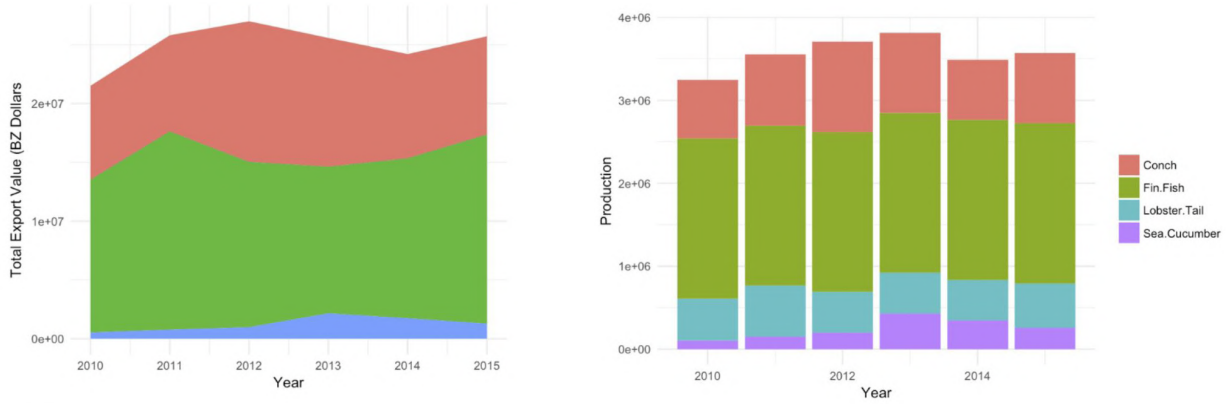
[47] Unpublished data from Belize Fisheries Department

[48] CRFM. (2012).

The two largest exporters of wild caught finfish are the Rio Grande Fishermen Cooperative, located in the Southern district of Toledo, and Rainforest Seafood Ltd, a private, Jamaican owned corporation. In 2014, Rainforest Seafood and Rio Grande Co. exported 270,950 and 4,273 pounds of whole fish valued at approximately 406,000 and 6,500 USD respectively [49] (Figure 3).

Sea Cucumber

Sea cucumber is one of the more recent fisheries to develop in Belize. The two primary species are Donkey Dung sea cucumbers (Holothuria mexicana) and Three-rowed sea cucumbers (Isostichopus badionotus). Opened in 2009, it is caught almost exclusively for export, primarily to Asian markets through US owned companies.



Export earnings for sea cucumber peaked in 2013. The decline in export revenues was due to a decrease in total production in 2014 and 2015. As reported by the Belize Fisheries Department, average export price for sea cucumber has remained stable from 2010 through 2015 at approximately 2.50 USD per wet pound (Figure 3).

The fishery is open from May through the end of June or until the TAC (currently set at 300,000 pounds) is reached. As of 2014, the Belize Fisheries Department had issued 82 individual licenses to extract sea cucumbers. Annual export earnings between 2010 and 2015 averaged 600 thousand USD per year. The Rio Grande Fishermen Cooperative in collaboration with the private company Ocean Giant, is the only cooperative currently engaged in the export of sea cucumber. They have purchasing centers in Punta Gorda and Sipro, an island near Mango Creek.

Figure 3. Value and productivity of key fisheries in Belize. Left: Total export value (BZD) of conch, lobster (by tail), and sea cucumber caught in Belize. Right: Total reported production by volume of the the Belizean fisheries for conch, finfish, lobster (based on lobster tail), and sea cucumber.

Discussion

A valued cultural tradition, fishing is an important source of food and income for many coastal communities. While the value of capture fisheries may not directly contribute a large portion of GDP, the indirect value of sustainable fisheries and a healthy marine environment is inextricably linked to other national industries and overall quality of living for many Belizeans.

Relying solely on sales and income data underestimates of the role fisheries play in the Belizean economy. The omission of informal sales from official revenue statistics further undervalues the importance of this industry.

[49] Villanueva, Jaime. "Fisheries Statistical Report 2014: Draft, pg 12

There are many confounding economic and biological interactions between commercial fishing, sports fishing, and non-extractive marine tourism (i.e. diving). Consequently, the interests of stakeholders in each of these industries are often in opposition. Certainly, the maintenance of health marine ecosystems is critical for the sustained growth of tourism in Belize. However, increases in tourism also drive greater demand for seafood in restaurants and hotels as well as increasing recreational fishing. The value of fisheries represents both a boon and a source of potential loss to this valuable sector that is highly dependent on the overall health of marine resources. Seeking an optimal balance of these activities would require further study into stock health of key species, tourism preferences, and the other indirect local values generated by the fishing industry. A more thorough exploration of the value linkages between sustainable fisheries management and the tourism sector is recommended.

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