RECONSTRUCTION OF TOTAL MARINE FISHERIES CATCHES FOR BELIZE, 1950-2008[1]

Dirk Zeller
Sea Around Us Project, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada; d.zeller@fisheries.ubc.ca

Rachel Graham
Ocean Giants Program, Wildlife Conservation Society, P.O. Box 7, Punta Gorda, Belize; rgraham@wcs.org

Sarah Harper
Sea Around Us Project, Fisheries Centre, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

ABSTRACT

Before the economic impacts of potential oil spills on the fisheries sectors of Belize can be assessed, we need to know more reliably what is at stake. Thus, we need to know how much is actually caught, both at present as well as in the past. Such a baseline cannot be readily provided through officially reported landings data, which are known to be incomplete for most countries. We applied a globally established catch reconstruction approach to the fisheries sectors of Belize to provide a more accurate accounting of total fisheries catches by all sectors back to 1950. This estimate accounts for all fisheries sectors including commercial and non-commercial catches for domestic, tourist and export use. National data and those which are supplied to the Food and Agriculture Organization of the United Nations (FAO) represent mainly catches sold through the fishing cooperatives and those deemed for export. When compared to landings data as presented by the FAO on behalf of Belize, our estimate of total catches were over 3.5 times larger. The FAO and national data report average annual landings of around 2,700 t·year^{-1} since 2000, while our reconstructed total catch estimate averages 6,000 t·year^{-1}. This discrepancy was mainly due to unreported catches of sharks, unreported subsistence catches and under-reported catches for the domestic markets and tourism sector. Yet, these sectors contribute substantially to the economic well being of the country. Illegal catch by fishers from neighbouring countries is also a major concern for Belize; however, limited information prevented us from estimating the scope and magnitude of these catches. This study not only highlights the need for improved and holistic accounting of fisheries catches, but clearly illustrated that renewable marine resources are substantially more important for the general economy of Belize than official data would suggest.

INTRODUCTION

Belize, formerly British Honduras, is located on the east coast of Central America between 18˚and 15˚N and 88˚and 89˚W, with a land area of around 22,600 km^2 and an Exclusive Economic Zone (EEZ) of 35,000 km^2 (www.seaaroundus.org; Figure 1). Adjacent to Belize are Mexico to the north, Guatemala to the west and south and the Caribbean Sea to the east. The coastline is flanked by the second longest barrier reef in the world (Heyman and Kjerfve, 2001), beyond which offshore areas drop off to between 300 and 600 fathoms depth. There are several reef areas located offshore, outside of the barrier reef.

[1] Cite as: Zeller, D., Graham, R., Harper, S., 2011. Reconstruction of total marine fisheries catches for Belize, 1950-2008. *In*: Palomares, M.L.D., Pauly, D. (eds.), *Too Precious to Drill: the Marine Biodiversity of Belize*, pp. 142-151. Fisheries Centre Research Reports 19(6). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Belize was a British colony from 1862 until gaining partial independence in 1964 and full independence in 1981, and is now part of the British Commonwealth of Nations and a member of the United Nations (Shusterich, 1984). The ethnic composition of the Belizean population consists mainly of Mestizo and Creole, representing approximately 75% of the population, with the remaining 25% consisting of Maya, Garifuna and other ethnicities. A recent census indicated that just under half of the population live in urban centers, which is a decrease from earlier decades (Tietze *et al.*, 2006). Belize has the lowest population density of the Central American countries and one of the lowest population densities in the world, with approximately 9 inhabitants·km$^{-2,}$ Honduras has 49 inhabitants·km$^{-2,}$ and Guatemala has 95 inhabitants·km^{-2} (Heyman and Kjerfve, 2001).

Figure 1. Map of Belize, showing the coastal districts and main coastal cities.

The commercial fishing industry of Belize has traditionally focused on lobster (*Panulurus argus*) and conch (*Strombus gigas*), with the commercial lobster fishery starting in the 1920s (Sheppard, 2000). The establishment of fishing cooperatives in the 1960s greatly improved the sale and marketing of these products for export. Prior to the establishment of the cooperatives, fishing was mainly conducted for subsistence purposes (Craig, 1966; Shusterich, 1984). The cooperatives, however, quickly gained favor and became the major channel for moving fisheries products, mostly to foreign markets. Finfish fisheries have predominantly supplied the local market, although in recent years, export of snapper (Lutjanidae) and grouper (Serranidae) have become more prevalent. A small shrimp fishery also existed, starting in the mid-1960s, with only a few artisanal trawlers and minimal expansion in the subsequent decades (Shusterich, 1984). All trawl fishing was banned in Belize in late 2010, brining this fishery to an end. Sharks, although not consumed locally, are caught for export using mainly gillnets, and supply meat and fins to Guatemala, Honduras, Mexico and Asia (Graham, 2007). It is likely that Belize will enact legislation banning the use of gillnets in the near future, thus substantially limiting shark catches.

The establishment of fishing cooperatives in the 1960s brought about some significant changes to the fishing industry. Most importantly, it allowed fishers to establish a lucrative export market and command a high price for items such as lobster, conch and finfish (Price, 1987). The cooperatives started in the north and expanded throughout the country. Today, there are five main cooperatives (National, Northern, Placencia, San Pedro and Rio Grande), the National and Northern cooperatives being the largest both in numbers of fishers and catches. However, only 50% of licensed fishers belong to one of the five main cooperatives and there are many unlicensed fishers operating in Southern Belize (Anon., 2008a).

In recent decades, Belize has become a popular tourist destination with over 250,000 tourists visiting the country annually (Anon., 2010). The development of the tourism industry was, in part, linked with overfishing, which caused fishers to seek alternate economic activities. Another reason for this shift is the struggle of fishers to make a living due to high fuel costs and lack of capital to maintain equipment and vessels (Anon., 2008a). In the popular tourist areas some of the hotels are actually owned by lobster fishers who used their capital from fishing to start tourism businesses (Price, 1987). Tourism began in the 1980s, and by the 1990s, the industry was well-established. Tourists come to partake in a variety of marine related activities such as diving and sport fishing. During their stay in Belize, tourists commonly enjoy the local cuisine, with a particular taste for Caribbean lobster. This has put further pressure on the marine ecosystem in recent decades (Gillett, 2003).

A survey conducted in the early 1940s by British scientist Ernest Thompson, estimated artisanal and subsistence catches to be approximately three million pounds (1360 t) and one million pounds (454 t), respectively (Thompson, 1944). Thompson (1944) further stated that marine fisheries exports were minimal at that time. Prior to improvements in transportation and processing infrastructure that allowed

for the expansion of commercial production (i.e., lobster and conch fisheries expansion in 1960s), fishing was mainly for subsistence and domestic purposes (Craig, 1966).

Due to a combination of low population density and high reef productivity, it is not surprising that neighboring countries enter Belizean waters to fish. Some of these fishers have special permits to fish in Belize (A. Matura-Shepherd, pers. comm.), while others fish illegally (Heyman, 1996). Depleted fish resources in Honduras and Guatemala have driven fishers to illegally exploit the waters of Belize, which, historically, had less pressure on its marine resources (Heyman and Kjerfve, 2001). The demand for fish products in Guatemala and Honduras increases every year during the Lenten Season, during which Catholics abstain from eating meat (Heyman, 1996). During this time, salted fish (e.g., shark, mackerel, jack and snook) are illegally transported from Belize to Guatemala and Honduras. Other forms of illegal catch from both foreign and local fishers are the harvest of undersized and out of season lobster and conch (Price, 1987; Arce *et al.*, 1997; Perez, 2009).

The goal of this study was to provide a comprehensive estimate of Belizean fisheries catches that includes all fisheries sectors, both commercial and non-commercial, and which accounts for the domestic, foreign and tourist markets. We estimated total marine fisheries catches by Belize over the period 1950-2008 and compared this reconstructed catch estimate to the total landings presented nationally and by the FAO FishStat database. This re-assessment of total marine fisheries catches will help establish a more appropriate baseline of marine extractions in order to monitor future changes and to make more informed management decisions regarding the marine environment and its resources.

METHODS

Population

Human population data were obtained from Populstat (http://www.populstat.org) and from the Statistical Institute of Belize (http://www.statisticsbelize.org.bz/dms20uc/Main.asp) in order to calculate *per capita* subsistence catch rates and domestic market supply. We estimated the coastal urban population for the four main coastal towns and cities (Belize City, Corozal, Dangriga and Punta Gorda; Figure 1), which was then used to derive the *per capita* domestic market supply of fish. To estimate the coastal rural population, we subtracted the urban population of the four main coastal towns from the total coastal population (of the four coastal districts—Corozal, Belize, Stann Creek and Toledo; Figure 1). In the 1950s, a greater proportion of the population lived in the four main urban centers than in the countryside. In the recent time period (2000s), an almost equal proportion of the coastal population resides in these four urban centers as compared to rurally (Figure 2). However, this does not necessarily reflect a migration from urban to rural areas as we only considered these four main urban centers; other communities likely expanded during the time period and sprawl from the main centers likely occurred.

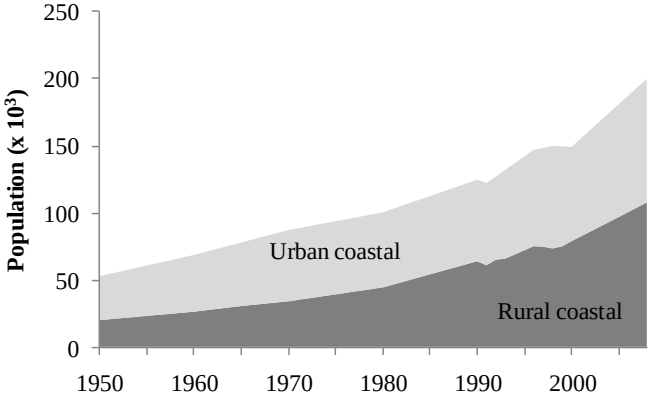

Figure 2. Coastal population in the four coastal districts (Corozal, Belize, Stann Creek and Toledo) of Belize. The urban coastal population in the four main urban centers (i.e., Belize City, Corozal town, Dangriga and Punta Gorda).

Artisanal fishery

The artisanal fishery includes catches for export and for the domestic market. An in-depth look at the data indicated that the reported landings accounted only for catches sold through the fishing cooperatives, which were mainly for export, while the catch by independent fishers for the domestic market was largely un-represented.

Export market

Catches by the artisanal fishers belonging to the fishing cooperatives were, on the whole, accounted for in the national statistics and FAO FishStat data. We compared national catch data to catches presented in the FAO FishStat database and found a close match. Therefore, we concluded good transfer of data between the Belize government (Ministry of Aquaculture and Fisheries) and the FAO. However, these data were only catches from export records and from the fishing cooperatives. From 1950-1976, national landings data accounted only for exported fish and invertebrates, whereas the 1977-2008 time period, they were estimates of total production from fishing cooperatives. In the early time period, the main fisheries products were lobster and conch. While approximately 90% of lobster, conch and shrimp are exported (Anon., 2008a), finfish are mainly caught for domestic consumption (Shusterich, 1984), particularly in the early period, but were poorly reported (Weber, 1968). A small amount of finfish was exported, and in more recent times exports of snapper and grouper increased substantially. From 1977 onward, the national fisheries statistics estimated both exports and total landings of finfish (but only if sold through the fishing cooperatives). Therefore, to estimate under-reported finfish catch between 1950 and 1976, we compared the first few years when national data report both exports and total production (1977-1981), calculated the average difference, and then applied that percentage as an add-on to the 1950-1976 finfish data. This resulted in a cooperative-equivalent 'reported' finfish catch of 136 t for 1950.

For lobster, conch, crab and squid, we used the FAO data as they matched closely the national data. However, in the early period, we assumed that lobster and conch were under-reported, as the national and FAO estimates were low and increased dramatically after the establishment of fishing cooperatives, which was the advent of improved reporting. Therefore, we took a five-year average (lobster: 1959-1963 and conch: 1966-1970) and carried this back to 1950 to account for poor data collection prior to the establishment of the fishing cooperatives.

Domestic market

As the national (hence FAO) data only covered landings sold through the cooperatives (which were mainly exported), we estimated unreported artisanal catches by independent fishers for domestic consumption, sold through the major city fish markets. Thompson (1944) reported that between 3 and 4.5 million pounds (1360-2770 t) of fish were sold in Belize, which we assumed to be the amount of fish sold primarily through the urban markets, as exports were minimal. Using this estimate, we assumed an urban market supply of 1360 t for 1950, from which we subtracted the FAO reported (and early time period adjusted) domestic finfish catch (136 t for 1950, see above) and in combination with the urban population for the four main urban centers, derived a 1950 *per capita* rate for unreported artisanal catches of 37 $kg \cdot person^{-1} \cdot year^{-1}$.

For the early 1990s, Adams (1992) estimated average *per capita* fish consumption for Belize to be 20 $kg \cdot person^{-1} \cdot year^{-1}$. Using this estimate and the human population for 1990, we derived a total domestic demand of 3780 t, which was partially met through subsistence catch (see below). The remaining demand (i.e., 33 $kg \cdot person^{-1} \cdot year^{-1}$) was supplied through artisanal (i.e., small-scale, commercial) fisheries.

In the early 2000s, a data collection program initiated by the Ministry of Agriculture and Fisheries aimed at estimating domestic finfish landings at four of the main landing sites in Belize. With minimal resources available to conduct such a study, estimates were only gathered for a few years. These data were not included in the national fisheries statistics or the data given to the FAO (J. Villanueva, pers. comm., Ministry of Agriculture and Fisheries). These data were, however, presented in a Ministry of Agriculture and Fisheries annual report (2008), which estimated that 649 t of finfish were supplied by Belizean fishers to the four domestic markets in Corozal Town, Dangriga Town, Punta Gorda Town and Belize City. Converted to a *per capita* rate using only the populations of the four main coastal towns and cities, this represents approximately 7 $kg \cdot person^{-1} \cdot year^{-1}$ of artisanal unreported finfish for the domestic market, which was applied to 2008. This is likely an underestimate, given the limited resources available for sampling and the lack of expansion of sample estimates to total market estimate. However, given the scarcity of such data and the fact that finfish remained largely a component of the independent, non-cooperative fisheries catches (i.e., un-reported), we used this estimate as the most comprehensive account of unreported artisanal catches for the recent time period. For all years between the three anchor points used (1950, 1990 and 2008), *per capita* catch rates were interpolated linearly before expansion to unreported artisanal catches using urban human population data. The estimates of unreported artisanal

catches were combined with the reported finfish catches to obtain likely total artisanal fish catches. Note that the reported finfish catches include fish, mainly snapper and grouper, destined for export.

Table 1. Species composition of artisanal finfish catches for Belize, 1950-2008 derived from Heyman and Graham (2000) and J. Villanuva (pers., comm., Belize Fisheries Department).

Common name	Scientific name	Percent of total catch (%)
Yellow tail snapper	*Ocyurus chrysurus*	20.01
Mutton snapper	*Lutjanus analis*	18.02
Lane (or silk) snapper	*Lutjanus synagris*	9.80
Cero mackerel	*Scomberomorous regalis*	8.48
Crevalle jack	*Caranx hippos*	7.28
Great barracuda	*Sphyraena barracuda*	4.34
Grunt	*Haemulon sciurus*	3.24
Cubera snapper	*Lutjanus cyanopterus*	1.07
Dogteeth snapper	*Lutjanus jocu*	1.07
Grey snapper	*Lutjanus griseus*	1.07
Red snapper	*Lutjanus cartagnensis*	1.07
School master	*Lutjanus apodus*	1.07
Common snook	*Centropomus undecimalis*	1.02
Cobia (cabillo)	*Rachycentron canadum*	0.77
Black drummer fish	*Pogonias cromis*	0.77
Lookdown	*Selene vomer*	0.77
Atlantic spade fish	*Chaetodipterus faber*	0.77
Yellow goatfish	*Mulloidichthys martinicus*	0.77
Hogfish	*Lachnolaimus maximus*	0.77
Horse eye jack	*Caranx latus*	0.77
White mullet	*Mugil cephalus*	0.77
Pompano jack	*Alectis ciliaris*	0.77
Saucereye porgy	*Calamus calamus*	0.77
Yellow fin mojarra	*Gerres cinereus*	0.77
Longjaw squirrel fish	*Holocentrus marianus*	0.77
Sea bream	*Archosargus rhomboidalis*	0.77
Goliath grouper	*Epinephelus itajara*	0.67
Spanish mackerel	*Scomberomorus maculatus*	0.57
Jimmy hind	*Epinephelus guttatus*	0.47
Nassau grouper	*Epinephelus striatus*	0.30
Black grouper	*Mycteroperca bonaci*	0.20
King mackerel	*Scomberomorus cavalla*	0.11
Palometa	*Trachinotus goodei*	0.06
Little tunny	*Euthynnus alletteratus*	0.05
Tarpon	*Megalops atlanticus*	0.03
Misc. marine fishes	MMF	10.00

Tourist market

The development of a thriving and highly valuable tourism industry (see Cisneros-Montemayor and Sumaila, this volume), which began in the 1980s, brings thousands of visitors to Belize each year to partake in marine related activities (e.g., diving, sport fishing), including consuming large quantities of seafood, particularly lobster. King (1997) reports that the majority of the lobster served in restaurants of the popular tourist area of Caye Caulker are undersized and illegally harvested. From King (1997), we were able to derive an estimate of the amount of illegally caught, undersized lobster consumed by tourists. King (1997) estimated that 125,000 undersized (<4 ounces or 112 g) lobster were consumed by tourists on Caye Caulker alone in 1990. Assuming a tail weight of 100 g and using a tail weight to whole weight conversion factor of 2, we derived an estimate of 25 $t \cdot year^{-1}$ of undersized lobster consumed by the tourists of Caye Caulker in 1990. We assumed that by 2008, this annual consumption had been halved (12.5 t) due to declining lobster stocks. Using tourism industry data (Anon., 2010), we derived the number of tourist nights per year based on number of hotel rooms and occupancy rates on Caye Caulker, and estimated a per tourist lobster consumption rate of 0.9 $kg \cdot tourist^{-1} \cdot night^{-1}$ for 1990 and 0.14 $kg \cdot tourist^{-1} \cdot night^{-1}$ for 2008. We then expanded our estimate to cover all of Belize using similar information on the number of tourist nights. Tourism in Belize is concentrated along the coast, with the majority of tourists partaking in marine related activities, particularly those associated with the reef (Shusterich, 1984).

Taxonomic breakdown

The main invertebrate species caught by the artisanal sector are lobster (*Panulirus argus*) and conch (*Strombus gigas*), mainly for export. The taxonomic breakdown for the finfish component of the artisanal catch was derived using artisanal fisheries landings data from Heyman and Graham (2000) and a list of targeted finfish provided by the Belize Ministry of Agriculture and Fisheries (J. Villanueva, pers., comm., Ministry of Agriculture and Fisheries). The species composition was applied to both the finfish component of the FAO data and the amount estimated as unreported artisanal catches (Table 1).

Industrial (large-scale, commercial) fishery

While the majority of the fisheries of Belize are small-scale, we considered shrimp catches and tuna catches to be large-scale. Some reports describe the shrimp fishery as being artisanal; however, this fishery deployed trawlers and although catches are relatively low compared to shrimp fisheries in other parts of the world, we consider it to be industrial in scale.

Shrimp trawling started in Belize in 1966 with three trawlers operating in the waters south of Stann Creek (Weber, 1968). By 1988, there were 11 trawlers operating in Victoria Channel and the lagoon between

Placencia and Belize City (McField *et al.*, 1996; Harborne *et al.*, 2000). In the recent decade, the fleet has decreased to only two trawlers (Matura-Shepherd and Stockbridge, 2010), and as of 2010, this trawl fishery has been closed. We compared national shrimp catches to the FAO Fishstat shrimp landings and found an almost perfect match. Therefore, we accepted the FAO Fishstat data as being representative of catches by the shrimp fishery. We applied the species breakdown given by Weber (1968) for the shrimp catch, which was equal proportions of pink shrimp (*Penaeus duorarum*), brown shrimp (*Farfantepenaeus aztecus*) and white shrimp (*P. schmitti*). To estimate discards, we used a shrimp to discarded bycatch ratio of 1:5, given by Allsopp (1980) for the early time period (1966-1978); for the recent time period (2000s), we used a 1:2.5 shrimp to discard ratio from Kelleher (2005). For the period 1978 to 2000, we interpolated linearly between the two rates. We assumed that discarding was greater in the early time period and that any bycatch that was landed was already accounted for in our estimate of subsistence catch (if taken home) or market fish (if sold locally). For the species composition of discards, we used the 1968 FAO study of incidental catch by the shrimp trawl fishery (Weber, 1968). The species composition for incidental catch was mainly silk snapper (*Lutjanus vivanus*), cuskeel (*Lepophridium kallion*) and mojarra (Gerridae), with some assorted flatfish.

The tuna and billfish fishery is a recent development in Belize, with the FAO only reporting catches since 2007. Information on this fishery was limited. Although large pelagic species are plentiful, they are not often caught, as most fishing takes place in inshore waters, in the shallow reef areas (Craig, 1966). Furthermore, the Ministry of Agriculture and Fisheries reports that pelagic species make up less than 1% of finfish caught for the domestic market (Anon., 2008b). Much of the development in the pelagic fisheries associated with Belize is related to foreign owned and foreign operated flag of convenience vessels (Gillett, 2003), and thus are not really Belizean national fisheries. The issue and problematic nature of flag of convenience registries will have to be addressed by the Belize governement.

Subsistence fishery

Catches that did not enter the formal market, i.e., catches either taken home by fishers, or locally traded or bartered, are defined here as subsistence catches. Thompson (1944) estimated subsistence catches to be approximately one million pounds (454 t) in the late 1940s. We assumed that this estimate represented mainly subsistence catches taken by people predominantly living in the major settlements and towns (i.e., what we now call the four main coastal cities and towns: Belize City, Corozal, Dangriga and Punta Gorda). Using the urban coastal population for 1950, we derived an urban subsistence catch rate for 1950. By 1990, we assumed that subsistence fishing in urban areas was much reduced from 1950, and decreased the urban subsistence catch rate to 10% of the 1950 rate (i.e., 1.38 $kg \cdot person^{-1} \cdot year^{-1}$). We held this rate constant from 1990 to 2008.

People living in rural areas likely had limited access to markets, especially in earlier decades. Therefore, their seafood demand was almost entirely met through subsistence fishing. For 1950, we assumed the rural *per capita* consumption rate to be the same as for people living in urban areas. Thus, for the rural areas, the 1950 subsistence catch rate was derived by combining the urban subsistence and domestic unreported artisanal rates (13.8 $kg \cdot person^{-1} \cdot year^{-1}$ and 37 $kg \cdot person^{-1} \cdot year^{-1}$, respectivly) for a rural subsistence catch rate of 50.8 $kg \cdot person^{-1} \cdot year^{-1}$. For recent times, i.e., 2008, we assumed that rural subsistence catch rates had declined to 20% (i.e. 10 $kg \cdot person^{-1} \cdot year^{-1}$) of the 1950 *per capita* rate due to increased availability of other protein sources.

Shark fishery

Although sharks are generally not consumed locally, a shark fishery has existed in Belize since the late 1930s. Thompson (1944) described shark fishing as starting a few years before WWII, targeting predominantly tiger (*Galeocerdo cuvier*) and nurse sharks (*Gyglinostoma cirratum*) for the leather trade, and taking place mainly in the southern part of Belize. National data and FAO FishStat data present shark landings for some years, but catches were low when compared to trade data obtained through the *Sea Around Us* Project trade database (W. Swartz, unpublished data, 2010), which report export amounts of over 1,000 t in some years. Furthermore, Graham (2007) estimated from interviews with shark fishers in Southern Belize that catches were over 800 t in 2006. We took Graham's (2007) estimate as the most comprehensive account of shark catches for Belize in recent times. A recent fisher survey (R. Graham, unpubl. data., Wildlife Conservation Society) suggests that shark abundance has declined since the mid to late 1980s, that sharks captured are smaller and gillnets are the primary culprit. Therefore, we assumed that catches in 1985 were 50% higher than the 800 t reported for 2006 (Graham, 2007) and that the

fishery started in 1937 at zero catches. We interpolated linearly between these anchor points to derive a time series estimate of shark catches from 1950-2006. For 2007 and 2008, we held the 2006 estimate fixed at 800 t. The taxonomic breakdown of shark catches was derived from the detailed account of shark fishing in Southern Belize by Graham (2007), which presents the frequency of elasmobranch landings. The Ministry of Aquaculture and Fisheries provided us with a list of shark species caught in Belize, which was similar to Graham (2007), but also included bull shark (*Carcharhinus leucas*; J. Villanueva, pers. comm., Ministry of Aquaculture and Fisheries). We assumed a catch frequency for bull shark of 5% (by number of sharks) and re-scaled Graham's (2007) frequency distribution to account for the addition of bull shark. To convert catch frequency to catch composition (i.e., percentage of catch tonnage), we obtained weights for each species using length-weight relationship from FishBase (www.fishbase.org). We estimated, for most species, common length as 60% of asymptotic length as presented in FishBase and used the default 'a' and 'b' for all species except *Rhizoprionodon porosus* (Caribbean sharpnose shark), where we used the 'common length' directly. Based on these calculations and Graham's (2007) shark catch frequency, we derived a species breakdown, which we applied to total shark catches throughout the time period (1950-2008; Table 2).

Table 2. Species composition of shark catches in Belize derived from Graham (2007) and J. Villanueva (pers., comm., Belize Fisheries Department).

Common name	Species name	Fraction of total shark catch
Caribbean sharpnose	*Rhizoprionodon porosus*	0.17
Blacktip shark	*Carcharhinus limbatus*	0.06
Great hammerhead	*Sphyrna mokarran*	0.35
Scalloped hammerhead	*Sphyrna lewini*	0.12
Nurse shark	*Ginglymostoma cirratum*	0.15
Bonnethead	*Sphyrna tiburo*	0.01
Lemon shark	*Negaprion brevirostris*	0.03
Bull shark	*Carcharhinus leucas*	0.11

RESULTS

Artisanal fishery

Catches by the artisanal fishery for both foreign and domestic markets, which include conch, lobster, finfish, crab and squid, totaled approximately 200,000 t over the 1950-2008 time period, increasing from 2,260 t·year^{-1} in 1950 to a peak of 4,600 t·year^{-1} in 1984 before declining to 3,200 t·year^{-1} by 2008 (Figure 3). Of this, approximately 100,000 t remained in Belize for domestic consumption by locals and tourists. Lobster catch was over 36,000 t, with at least 12% of this supplying the tourist market. Of the remaining lobster catch, roughly 90% was exported to foreign markets.

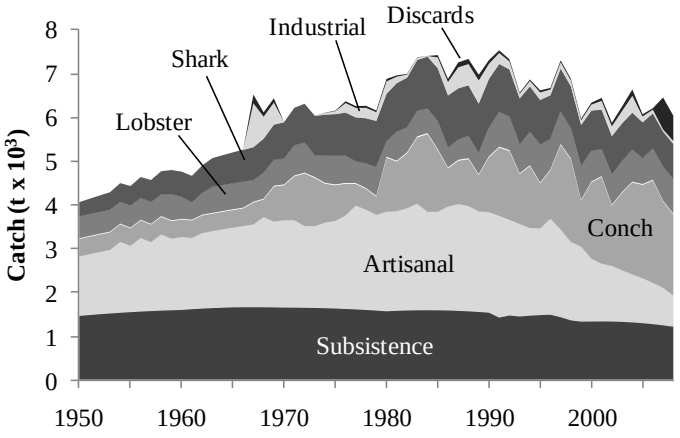

Figure 3. Total reconstructed catch by fisheries sector for Belize, 1950-2008. Artisanal sector represents reported and unreported finfish; Industrial includes shrimp and pelagic fish catches.

Industrial fishery

Shrimp catches for the period 1967-2008 were approximately 2,240 t and discards associated with this fishery were estimated to be 8,700 t (Figure 3). Tuna and billfish catches for 2007 and 2008, the only year of reporting, totalled 1,263 t (Figure 3).

Shark fishery

Estimated total shark catches for the period 1950-2008 were approximately 50,000 t, increasing from 328 t·year^{-1} in 1950 to a peak of 1,200 t·year^{-1} in 1985 before declining to 808 t·year^{-1} by 2008 (Figure 3). We assumed that these were almost entirely exported both for the Asian shark-fin market as well as to neighboring countries for shark meat consumption. Caribbean sharpnose, great hammerhead, scalloped

hammerhead, nurse and bull shark made up nearly 90% of the catch, while blacktip, bonnethead and lemon shark comprised the remaining 10%.

Subsistence fishery

Catches by the informal sector (considered non-commercial) totalled 90,700 t over the 1950-2008 time period, increasing from 1,475 t·year^{-1} in 1950 to a peak of 1,672 t·year^{-1} in the mid 1960s before declining to 1,230 t·year^{-1} by 2008 (Figure 3). The majority of these catches (82%) were from rural coastal areas, while the remainder (18%) was estimated as the subsistence catch taken by the rural coastal population.

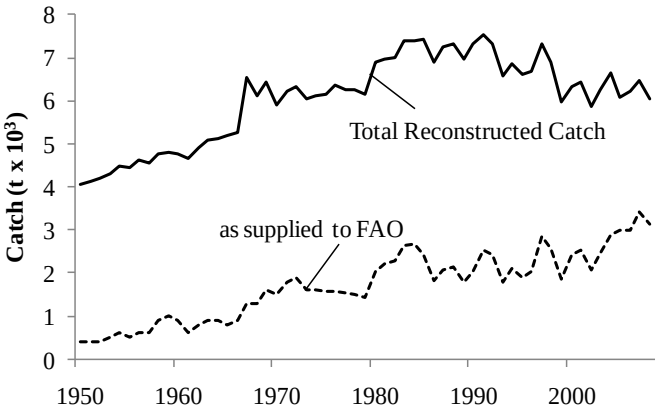

Figure 4. Total reconstructed marine fisheries catch for Belize compared to the total catch as supplied to the FAO by the government of Belize for the period 1950-2008.

Total reconstructed catch

Total marine fisheries catches for Belize, estimated for the period 1950-2008, were approximately 357,000 t, and increased from 4,000 t·year^{-1} in 1950 to a peak of 7,500 t·year^{-1} in 1991 before declining to 6,000 t·year^{-1} by 2008. Our reconstructed catch estimate is 3.5 times larger than the catch total presented by the FAO on behalf of Belize, which was 101,000 t (Figure 4). Conch and lobster comprise almost half of the total catch. In the recent period (2000s), the total reconstructed catch was, on average, 6,200 t·year^{-1}, with approximately 60% being artisanal (including conch, lobster, finfish, etc.), 20% subsistence, 6% industrial and 14% shark (Figure 3). In contrast to the export oriented fisheries for conch and lobster, which show a steady increase or stability in catches (Figure 3), the catches for domestic artisanal and subsistence purposes show a declining trend for recent time periods.

DISCUSSION

Reconstructed catches of marine fisheries for Belize from 1950-2008 totaled approximately 357,000 t. This estimate was over 3.5 times larger than the catches presented by the FAO on behalf of Belize. The main source of this discrepancy was the domestic sector, as catches for domestic consumption by locals and tourist, from both commercial and informal (subsistence) sectors were largely un-represented. This is predominantly due to the system of data collection which relies upon logbooks and records from the fishing cooperatives and trade offices. These only cover a portion of the catch, as independent fishers and non-commercial catches are not accounted for in these reporting systems. Seafood consumption in Belize is not overly high compared to other parts of the world, e.g., the South Pacific (Gillett, 2009). However, lobster is very popular amongst tourists in Belize and finfish is an important protein source for Belizeans. These components that supply the domestic and tourist markets were estimated to be over 200,000 t. Other substantially under-represented fishery components, which were estimated as part of our comprehensive assessment of total catch, were shark fishery catches and discarded bycatch associated with the former shrimp trawl fishery, which together totaled almost 60,000 t.

Of particular concern is the difference in overall signal provided by reported data (dominated by increasing catches of export oriented products) versus domestic supply (dominated by declining domestic catches). This supports the observation made by many Belizeans that fisheries catches are declining, a statement that, until now, had not been supported by any analysis. The discrepancy between the trend in the export oriented lobster/conch fisheries and the domestic finfish fisheries needs addressing through implementation of ecosystem-based management options, including the development of spatial management combining areas open to fishing and full no-take zones, and options for alternative, non-fishing livelihoods to address the potential for substantial excess effort (i.e., number of fishers). The best avenue for such developments lies in improved tourism opportunities and infrastructure for engaging more fishers in tourism ventures.

This study highlights the need for improved data reporting in Belize. The cost of annual monitoring and data collection is often prohibitive, particularly for resource-limited developing countries (Zeller *et al.*, 2007). However, a comprehensive estimate of the catch by the non-commercial sector and by non-registered and non-cooperative fishers, conducted every 4-6 years and interpolated between surveys, would greatly improve the overall accounting of total fisheries extraction by Belize (Zeller *et al.*, 2007).

A recent assessment of the small-scale mutton snapper fishery at Gladden Spit by Graham *et al.* (2008) suggests potential declines in catch per unit of effort (CPUE) and catches of this highly sought-after species. Surveys conducted between 2000 and 2006 indicated a decline in CPUE. While effort was shown to increase, catches seem to be declining. Data from this survey were not used in our estimation of total marine fisheries catches for Belize, as our method of estimating total catch was not able to reflect such a localized decline. However, this study provides strong evidence for over-exploitation of an important domestic fishery, highlighting the need for a more detailed assessment of small-scale fisheries throughout Belize.

Illegal fishing is another issue that needs to be addressed. Territorial disputes over the water's of Southern Belize have encouraged Illegal, Unreported and Unregulated (IUU) fishing. Some licenses have been issued to fishers from neighboring countries, allowing them to fish legally in Belizean waters; however, it is unclear whether these catches are at all reported either by Belize or by the neighboring country. Illegal shrimp trawlers are known to operate in Belizean waters; however, with the legislated ban on shrimp trawling in Belize that came into effect at the end of 2010, illegal trawlers will be more easily identified (Stiles *et al.*, 2010). Shark fishing, also in the southern portion of Belize, has not been adequately recognized in fisheries statistics, and desperately needs better monitoring as shark populations continue to decline globally (Baum *et al.*, 2003). The increased market demand, particularly from Asia, and the high price that shark products command make this a lucrative, but unsustainable industry, and the likely upcoming ban on gillnetting in Belize waters may largely address this issue. The harvest of undersized and out of season lobster is also a concern. The majority of these catches go to the tourist trade, being sold directly to hotels and restaurants without ever being reported as catch. Clearly, enforcement needs improvement, particularly in Southern Belize where much of the illegal shark fishing occurs and where illegal fishers from Guatemala and Honduras come to fish (Anon., 2008a), but also in the north where the majority of lobster trapping occurs.

While there has been a shift in Belize in recent decades from fishing toward tourism, seafood remains an important component of the diet, culture and economy of Belize. Many coastal communities continue to rely on fishing as a source of food and income (Perez, 2009). Coastal development, tourism and climate change all have the potential to alter the marine ecosystem and in turn may impact marine fisheries for which many people in Belize depend upon for their livelihoods. This study provides a baseline of total marine fisheries catches and highlights components of the fishing industry that are currently under-represented in the national statistics. It is hoped that this comprehensive estimate of marine fisheries catches will act as a more appropriate baseline for future management of Belizean fisheries.

ACKNOWLEDGMENTS

This is a product of the *Sea Around Us* Project, a collaboration between the University of British Columbia and the Pew Environment Group. We would like to thank the Belize Fisheries Department for providing us with national landings and export data, and Oceana and the Oak Foundation for funding the conference.

REFERENCES

Adams, J.E., 1992. Fish lovers of the Caribbean. *Caribbean Studies* 25(1/2), 1-10.

Allsopp, W.H.L., 1980. Fish by-catch from shrimp trawling-the main protein source for Caribbean Atlantic countries: reality and potential. Inter-American Development Bank. Round table on non-traditional fishery products for mass human consumption. Washington, D.C., 33 p.

Anon., 2008a. Belize fisheries sector: summary of research. Environmental Defence Fund, 8 p.

Anon., 2008b. Ministry of Agriculture and Fisheries: Annual report 2008. Available from: http://www.agriculture.gov.bz/Document_Center.html [accessed: June 2010].

Anon., 2010. Belize Tourism Board: Tourism Statistics (Hotel Statistics 1998-2008). Available at: http://www.belizetourism.org/ [Accessed July 2010]

Arce, M., Clemetson, A., deLeon, M.E., Gonzalez Cano, J., Marshalleck, S., O'Brian, S., Puga, R., Restrepo, V.R., Richards, G., Rios Lara, V., Sosa Cordero, E., Zetina, C., 1997. Report to the FAO/DANIDA/CFRAMP/WECAFC regional workshops on the assessment of the caribbean spiny lobster (*Panulirus argus*). Region 2: Belize, Southwest Cuba and Mexico. FAO Fisheries Report no. 619, Belize City.

Baum, J., Myers, R., Kehler, D., Worm, B., Harley, S., Doherty, P., 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science* 299, 389-392.

Craig, A.K., 1966. *Geography of Fishing in British Honduras and Adjacent Coastal Waters*. Louisiana State University Press, Baton Rouge, 112 p.

Gillet, R., 2009. *Fisheries in the Economies of the Pacific Island Countries and Territories*. Asian Development Bank, Mandaluyong City, 483 p.

Gillet, V., 2003. The fisheries of Belize. *In From Mexico to Brazil: Central Atlantic Fisheries Catch Trends and Ecosystem Models*. Fisheries Centre Research Reports 11 (6), Fisheries Centre, University of British Columbia [ISSN 1198-6727].

Graham, R., 2007. Vulnerability assessment of sharks and rays. Additional material to the final report to the Belize Fisheries Department (BFD). Wildlife Conservation Society.

Graham, R.T., Carcamo, R., Rhodes, K.L., Roberts, C.M., Requena, N., 2008. Historical and contemporary evidence of a mutton snapper (*Lutjanus analis* Cuvier, 1828) spawning aggregation fishery in decline. *Coral Reefs* 27, 311-319.

Harborne, A.R., McField, M.D., Delany, E.K., 2000. Chapter 13: Belize In: Sheppard, C.R.C., (ed.), *Seas at the Millennium: an Environmental Evaluation*, p. 501-516. Elsevier Science, New York.

Heyman, W.D., 1996. Integrated coastal zone management and sustainable development for tropical estuarine ecosystems: a case study of Port Honduras, Belize. PhD Thesis, Marine Science Program, University of South Carolina, 289 p.

Heyman, W., Graham, R., 2000. *The Voice of the Fishermen of Southern Belize*. Tide and Trigoh, Guatemala City, 44 p.

Heyman, W.D., Kjerfve, B., 2001. The Gulf of Honduras. In: Seeliger, U., Kjerfve, B., (eds.), *Coastal Marine Ecosystems of Latin America*, p. 17-32. Springer-Verlag Berlin Heidelberg, New York.

Kelleher, K., 2005. Discards in the world's marine fisheries. An Update. FAO Fisheries Technical Paper. No. 470. Rome, FAO. 2005. 131 p.

King, T.D., 1997. Folk management among Belizean lobster fisherman: success and resiliance or decline and depletion? *Human Organization* 56, 418-426.

Matura-Shepherd, A., Stockbridge, J., 2010. *Shrimp Trawling in Belize*. Oceana, Belize, 7 p.

McField, M.D., Wells, S.M., Gibson, J.P., 1996. State of the coastal zone report. Belize, 1995. Coastal Zone Management Programme and Government of Belize.

Perez, A., 2009. Fisheries management at the tri-national border between Belize, Guatemala and Honduras. *Marine Policy* 33, 195-200.

Price, M.D., 1987. Cooperatives and development: the lobster fisherman of Belize. Department of Geography, Syracuse University. Available at: sites.maxwell.syr.edu/CLAG/Yearbook1987/price.pdf [accessed July 2010], 6 p.

Shusterich, K.M., 1984. Marine resource development in Belize. *Marine Policy* 8(4), 369-372.

Stiles, M.L., Stockbridge, J., Lande, M., Hirshfield, M.F., 2010. Impacts of Bottom Trawling on Fisheries, Tourism, and the Marine Environment. Available at: http://na.oceana.org/sites/default/files/reports/Trawling_BZ_10may10_toAudrey.pdf [Accessed December, 2010].

Thompson, E.F., 1944. *The Fisheries of British Honduras*. Advocate Co. printers, Bridgetown, 32 p.

Tietze, U., Haughton, M., Siar, S.V., 2006. Socio-economic indicators in integrated coastal zone and community-based fisheries management: case studies from the Caribbean. FAO Fisheries Technical Paper 491, Rome.

Weber, D., 1968. Report to the Government of British Honduras (Belize City) on investigations into the marine fisheries, particularly spiny lobster and shrimp resources. FAO no. TA 2541, Rome.

Zeller, D., Booth, S., Davis, G., Pauly, D., 2007. Re-estimation of small-scale fishery catches for U.S. flag-associated areas in the western Pacific: the last 50 years. *Fishery Bulletin* 10 (5), 266-277.