Updating catch reconstructions of Central American countries to 2018*

Melanie Ang[a], Tim Cashion[a], Elaine Chu[a], Angie Coulter[a], Brittany Derrick[a], Maria Frias-Donaghey[a], Simon-Luc Noël[a], Emmalai Page[a], Veronica Relano[a], and Rachel White[b]

a) *Sea Around Us*, Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada

b) *Sea Around Us*- Indian Ocean, School of Biological Sciences, University of Western Australia, 35 Stirling Hwy, Crawley 6009, WA, Australia

Abstract

Updates to 2018 are presented for earlier marine fisheries catch reconstructions for Central American countries and one island which covered the years 1950 to 2010. This is presented in the form of 6 brief accounts dealing with Belize, Clipperton Island (France), El Salvador, Guatemala, Honduras and Nicaragua (Panama is covered elsewhere). The major challenges in updating these catch reconstructions were estimating small-scale catch and the effectiveness of bans applying to selected target species. We addressed these challenges through an approach that used population and per capita consumption rates and a targeted literature search to evaluate whether illegal fishing was likely to continue after implementation of fishing bans for select species. Other issues, notably how we have dealt with the changes between successive releases of FAO landing data, are address separately for each country.

Introduction

Fisheries catch reconstructions were updated for 2011-2016 for Central American countries including Belize, Clipperton Island (France), El Salvador, Guatemala, Honduras and Nicaragua but omitting Panama, which has a chapter of its own in this volume. Country specific methods to reconstruct fisheries are presented individually in the sections below and are forward-carried to 2018.

Methods

Belize

The original reconstruction of Belize's marine fisheries catches from 1950 to 2008 was completed by Zeller *et al.* (2011), then updated to 2010 (Zeller *et al.* 2016). This account updates this reconstruction to 2016, which was then carried forward to 2018 using FAO data.

The FAO data up to 2016 was accepted as the reported baseline. Retroactive changes were made to reported landings of conch (*Lobatus gigas*) and sea cucumber (Holothuroidea) to account for changes to tonnage in recent releases of the FAO data (Figure 1).

Since the original reconstruction (Zeller *et al.* 2011) was completed, several major developments in Belize have occurred regarding its fisheries. Firstly, since the end of 2010, all bottom trawling has been banned within its EEZ (Oceana 2010). This ban resulted in the decline of reported shrimp landings from 2011-2016 and in the decrease in the associated discards. Reconstructed industrial discards from the shrimp fishery were updated to 2016 based on the methods described by the original reconstruction (Zeller *et al.* 2011). Reported shrimp landings came to a halt in 2016.

* Cite as: M. Ang, T. Cashion, E. Chu, A. Coulter, B. Derrick, M. Frias-Donaghey, S.-L. Noël, E. Page, V. Relano and R. White. 2020. Updating catch reconstructions of Central America to 2018, p. 79-93. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific.* Fisheries Centre Research Report 28(6).

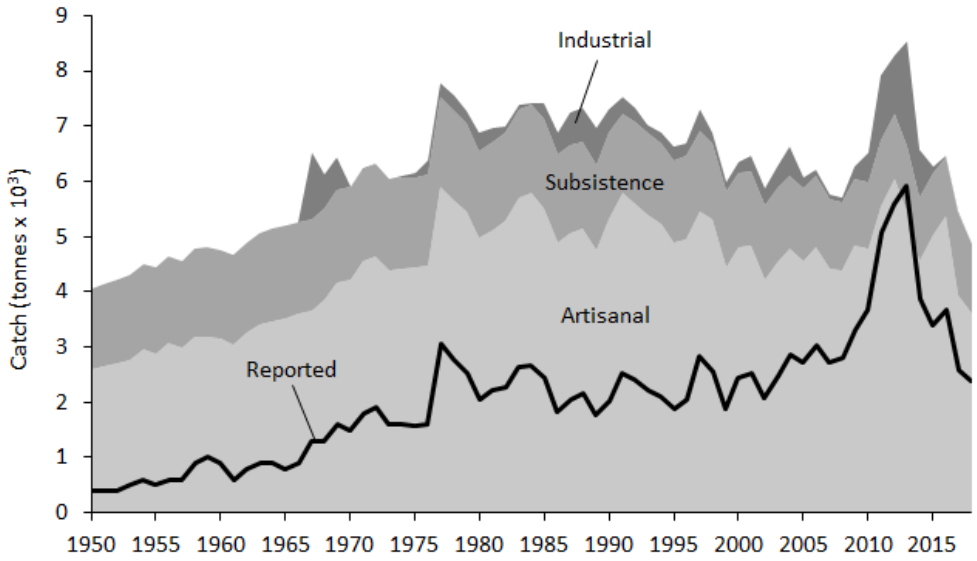

Figure 1. Reconstructed domestic fisheries catches from within Belize's EEZ by fishing sector for 1950-2018.

Secondly, in 2015, Belize ended open-access to its fisheries resources (Ramos 2015) and developed a "Managed Access" program. This may have a strong impact on catches from Belize's EEZ in the future.

Artisanal catch

Reconstructed artisanal catch was estimated separately for the finfish, shark, conch and lobster fisheries. The catch rates for 2008 were carried forward and multiplied by updated coastal population data[22] to calculate total artisanal finfish demand for 2011-2016. The unreported finfish caught by artisanal fisheries was determined by subtracting reported marine fish landings from the reconstructed total demand for finfish. In the absence of updated information, unreported shark catch was held constant at the 2010 amount of 800 tonnes for 2011-2016. Lobster landings were reconstructed based on the ratio of unreported landings to reported landings from 2000-2010 and then applied from 2011-2016.

Subsistence catch

Subsistence catches were updated for 2011-2016 based on the original methods (Zeller *et al.* 2011). The coastal population consumption rates for urban and rural coastal populations in 2008 were multiplied by updated population data from the Statistical Institute of Belize[23]. While the urban coastal population consumption was assumed to remain stable at 1.39 kg per person, the rural coastal population was assumed to continue to decline from 2009-2016 at the same rate as described in the original reconstruction (Zeller *et al.* 2011). Taxonomic breakdowns were held constant for 2011-2016 for unreported catch by subsistence, artisanal, and industrial fisheries at the ratio from 2008 described by the original reconstruction (Zeller *et al.* 2011). Percentage breakdowns for gear used by commercial fisheries were maintained for each species using the breakdown from 2014.

Transition from 2016 to 2018

The catch reconstructed to 2016 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

[22] http://www.sib.org.bz/statistics/population
[23] http://www.sib.org.bz/statistics/population

Marine biodiversity protection

Belize has agreed to protect its considerable marine biodiversity (see contributions in Palomares and Pauly 2011) through the international Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention. It is also a signatory to regional treaties and agreements such as the Regional Seas Convention (Marine Conservation Institute 2020).

Belize has 30 MPAs and 13 marine managed areas. Together these areas cover 3,641 km² (Marine Conservation Institute 2020), i.e., 10.1% of its EEZ of 36,200 km² (Zeller *et al.* 2016). "According to the Wildlife Conservation Society, the government of Belize has approved a plan to expand its marine areas designated as no-take zones from 4.5% to 11.6% of its total waters. Much of the expansion will cover deep-sea areas at depths ranging from 200 to 3,000 meters, currently underrepresented in Belize's system of marine protected areas" (Dasgupta 2019). One of the previous efforts to conserve biodiversity in Belize was a moratorium on oil exploration and offshore drilling. This resulted in the Belize Reef being removed from the United Nation's list of endangered world heritage sites (Scocca 2020).

The first MPA in Belize, the Half Moon Caye Natural Monument, was designated as early as 1982 (Marine Conservation Institute 2020). Later on, Belize's government realized that MPAs do not only protect ecosystems, but that the resulting ecological effects can also boost tourism. Belize eventually saw the need to use a more integrated approach to manage its marine resources. In 1989, the country started a process to create an Integrated Coastal Management Plan (Cho *et al.* 2005). However, "the major challenges to MPA management in Belize are the lack of adequate administration and the failure of the MPA program to evolve with the changing trend towards devolution of authority from government to greater community involvement in MPA management" (Cho *et al.* 2005).

The existent regulations in the protected areas are enforced by the reserves' staff, i.e., fishery officers. "To further strengthen the enforcement capabilities the reserves' staff are established as Police Special Constables. To maximize results, patrols are prioritized especially on illegal activity hotspots and are designed to intercept marine products onboard fishing vessels and campsites. The Conservation Compliance Unit (CCU) personnel assist the marine reserves by providing various officers to cover for personnel on vacation, sick leave and training thus continuing the enforcement presence" (Belize Fisheries Department 2013).

Clipperton Island (France)

The fisheries resources and potential catches in the waters around the uninhabited Clipperton Island were described by Pauly (2009), who also tentatively reconstructed the catches of distant-water fleets fishing in the waters around this island from 1950 to 2010 (Pauly 2016). This account updates this reconstruction to 2014, which was then carried forward to 2018.

Based on several reports of fishery resources from the area (Pauly 2009, 2016), unreported catches of Elasmobranchii and *Panulirus penicilliatus* have been allocated to the EEZ of the Clipperton Islands from 1980 to 2014. Catches of other taxa from other sources have been indirectly estimated from catches of distant-water fleets operating in the Eastern Central Pacific.

A fisheries access agreement between Mexico and France has allowed the former to fish in the waters of Clipperton Island since 2007, with regular amendments and changes to prevent over-exploitation and illegal fishing in the area (Fabius 2014). As a neglected French overseas territory, Clipperton Island has very little reported information on fish removals from its waters. However, since 2010, the high commissioner in French

Polynesia, in consultation with the Minister of International Affairs of France, can issue permits for fleets from foreign countries to fish in Clipperton Island's waters (Fillon *et al.* 2010). The island has little French presence, though plans exist for a permanent climate research station which may provide a deterrent for illegal fishing (Folliot 2016).

In 2017, Clipperton Island was established as a marine protected area; this designation implemented a no-take zone within 12 nautical miles of this small island (Petit 2018). Other than permitted Mexican tuna fishing in the island's EEZ, there should no longer be any fishing of sharks or lobster (*Panulirus penicillatus*), both of which tend to be coastal. We assumed there was no other fishing occurring in the Clipperton Island EEZ after 2016.

Transition from 2016 to 2018

The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France has agreed to protect biological diversity of Clipperton Island through the international Convention on Biological Diversity (Aichi), United Nations Convention on the Law of the Sea, the World Heritage Convention and its commitments extend to NGOs and/or public

Clipperton Island, with 9 km^2, is home to an MPA (Marine Conservation Institute 2020),i.e., 0.002% of the EEZ of 431,270 km^2 (Pauly 2016). "The waters of Clipperton are also home to a precious biodiversity potential, which we have to protect. [...] It has one of the highest proportions of threatened species in the tropical eastern Pacific, and is the only one of the five oceanic islands and archipelagos in the region that lacks complete governmental protection. In addition to the high concentration of threatened species on and around the island, large amounts of marine debris (plastics and other refuse) are known to wash ashore" (Marine Conservation Institute 2020).

A study that described the biodiversity at this remote atoll from shallow water to depths of over one thousand meters using a mixture of technologies was conducted by Friedlander *et al.* (2019). These authors found relatively low diversit,y but a high endemism and unique biogeography. They concluded that it would be beneficial to expand the existing 12 nautical mile protected area as well as improve the vessel monitoring system and surveillance to restore population of sharks, tuna and other pelagic species.

El Salvador

El Salvador's marine fisheries catches were reconstructed for 1950-2010 by Donadi *et al.* (2015, 2016). The present account documents how this reconstruction was updated to 2017, then carried forward to 2018. FAO reported landings data from 2010 to 2017 continued to be used as the reported data baseline. Landings and associated bycatch from tuna and other large pelagic fisheries are addressed separately (Coulter et al. 2020) and are therefore not described here. Retroactive changes were detected between various releases of the FAO data. Reported landings of 'Marine fishes nei' were updated in 2008-2009 and in 2012-2013 to align with the most recent FAO data (Figure 2).

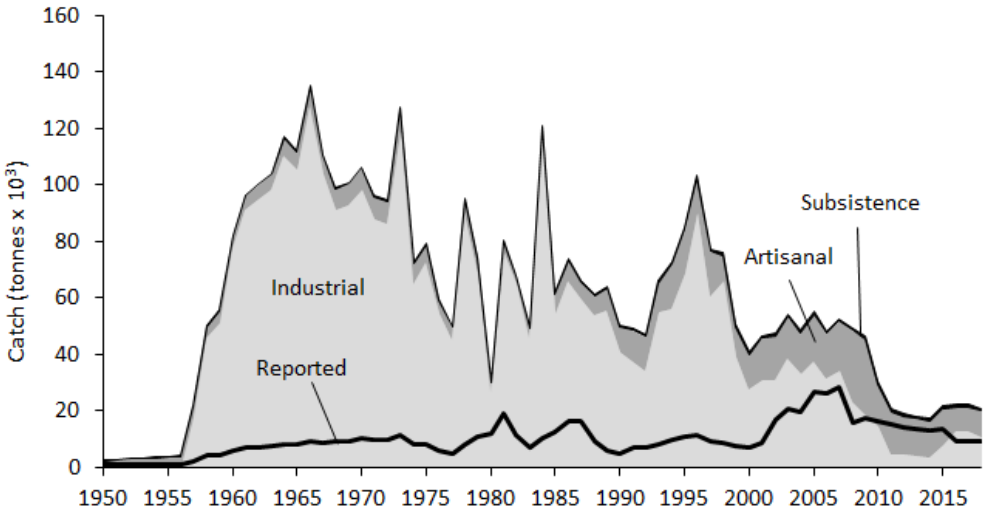

Figure 2. Reconstructed domestic catch within El Salvador's EEZ by fishing sector for 1950-2018.

Shark catches

Reported landings of 'sharks, rays, skates, etc. nei' were updated for 2012-2013. According to a report by El Salvador's Ministry of Agriculture and Livestock (Ministerio de Agricultura y Ganadería; MAG 2016), 210 tonnes of sharks were caught by artisanal fisheries in El Salvador in 2016. This was used as a new anchor point to allocate reported shark catch to artisanal and industrial sectors for 2016-2017. Reported catches from the shark fishery in 2012-2015 were allocated to artisanal and industrial sectors by interpolating between the ratio used in 2010 from the original reconstruction (Donadi *et al.* 2015) and the ratio found from the new report (MAG 2016). Since there were no reported shark catches in 2011, total reconstructed shark catch for this year was interpolated for each sector assuming catch continued at the same level. While there are no unreported industrial catches for the shark fishery, the ratio of reported to unreported shark landings was carried forward to 2017 for the artisanal sector.

Shrimp and pelagic red crab catches

The shrimp fishery underwent a temporary closure during April 20th – May 31st in 2017 due to declining catches in prior years (MAG and CENDEPESCA 2018). Ratios of unreported to reported shrimp catch from 2010 were used to carry forward the landed bycatch, '*morralla*' (landed low-value fish) and discard components of the industrial shrimp fishery to 2017.

El Salvador's fishery for pelagic red crab (*Pleuroncodes planipes*) permanently closed in 2009 (Wehrtmann and Acuña 2011), and thus there were no reported or reconstructed catches after 2009.

Subsistence catches

Subsistence catches were retroactively updated from 1960-2010 to reflect updated population data from the World Bank. Subsistence catches were updated to 2017 as per the original catch reconstruction, carrying forward the same ratio of fishers to total population as well as catch rates as for 2010. The taxonomic compositions and commercial gear per taxon compositions in 2010 for each sector were used to disaggregate catches for 2011-2017.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

El Salvador has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance, and it is also part of the international network of UNESCO Man and the Biosphere (Marine Conservation Institute 2020).

El Salvador has 15 MPAs and three marine managed areas. Together, these areas cover 378 km^2 (Marine Conservation Institute 2020), i.e., 0.4% of anEEZ covering 93,710 km^2 (Donadi *et al.* 2016). Moreover, there are several conservation programs carried out by the IUCN or NGOS to protect coastal ecosystems such as mangroves, or restore species populations, e.g., sea turtles.

Bahia de Jiquilisco is home to a natural area, a Ramsar site and an UNESCO-MAB Biosphere Reserve where efforts were undertaken to protect marine turtles. El Salvador has a tradition of sea turtle egg consumption, and the demand for eggs persists (Liles *et al.* 2015). In 2009, the Ministry of Agriculture and Ranching (governing the Fisheries Law) and the Ministry of the Environment and Natural Resources (governing the Wildlife Conservation Law) banned the marketing and consumption of sea turtle eggs (Parker 2018). "This ban represents one of the most significant advances for sea turtle protection, particularly for the hawksbill turtle, in the entire eastern Pacific region (Gaos and Yañez 2012)" (Parker 2018). However, this conservation program faces great challenges, notably in the Bahia de Jiquilisco, a low-income area.

Another example of a turtle conservation program is found in a small artisanal fishing community, Barra de Santiago, located in the Municipality of Jujutla. "Barra de Santiago is exceptional in that there is an all-women community organization called the Association of Community Development of Women in Barra de Santiago (AMBAS, in Spanish) leading sea turtle and other conservation initiatives" (Massey and McCord 2017). A study that involved AMBA members showed that marine conservation, and especially turtle conservation, is still far from established, but that some communities are aware of the issues and are trying to protect marine species even without external support. "[…] Industrial trawlers can kill up to 15-20 sea turtles per night during the nesting season. If the sea turtle is a female, they cut out the eggs. Then they chop up the body into multiple pieces so the body parts sink instead of washing up on shore. Juan said that all industrial boats by law are supposed to fish further than three nautical miles from the shore, farther than five nautical miles from the Ramsar site, and use TEDs [(Turtle Excluder Device)], but violate these laws constantly. […A] participant's] vision for the future includes more capacity building workshops for men, women, and young people so the community can learn skills and create more jobs that do not rely so heavily on exploiting natural resources. She would like more jobs in place such as more bakery classes, motor repair classes, and workshops to learn how to make handicrafts and souvenirs. She envisions a future where people would not have to sell sea turtle eggs, but could instead depend on other stable sources of work for their livelihoods" (Massey and McCord 2017).

Guatemala (Caribbean and Pacific)

The reconstruction of Guatemala's marine fisheries catches was completed for 1950-2010 by Lindop *et al.* (2015) for Guatemala's Caribbean (Lindop *et al.* 2016a) and Pacific coasts (Lindop *et al.* 2016b). This brief account documents how these reconstructions were updated to 2014, then carried forward to 2018.

Newly released FAO data were accepted as the reported component. Some retroactive changes were made to reported landings in the Eastern Central Atlantic to correspond with the updated FAO data. The original reconstruction (Lindop *et al.* 2015) used national data as the reported baseline. However, national data could not be found for the year 2011-2014; thus, the total landings reported by the FAO were used for 2011-2016, while the taxonomic composition of the nationally reported catch from 2010 was applied to reported catch for 2011-2016 to disaggregate reported catch by taxon.

Unreported catch along the Caribbean and Pacific coasts
Updated population data from the World Bank and the 2010 per capita subsistence catch rate were used to calculate subsistence for 2011-2014. Unreported catch by artisanal and industrial fishing sectors were carried forward using the 2010 ratios to the subsistence catch and reported catch respectively. The taxonomic breakdown for 2011-2014 followed the 2010 ratio.

Transition from 2014 to 2018
The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection
Guatemala has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Guatemala has three MPAs and one marine managed area. Together, these areas cover 1,013 km^2 (Marine Conservation Institute 2020), i.e., 0.86% of the 117,680 km^2 EEZ in the Pacific and Caribbean (Lindop *et al.* 2016a, 2016b). These MPAs are: Hawaii Multiple Use area (designated in 2016), Punta de Manabique Wildlife Refuge (designated in 2005) and Monterrico Multiple Use area (designated in 1977). Punta de Manabique is the largest of these, with an overall reported area of 1,527 km^2 and a marine area of 294 km^2 (Marine Conservation Institute 2020). Large amounts of waste, mainly of terrestrial origin and not from fishing activities, have been found on the beach of Punta de Manabique. Among the visible waste were 12.8 plastic pieces·m^{-2} and 2.75 pieces of clothes·m^{-2} (Wolford 2018).

The marine manage area is the Ramsar Site of Punta de Manabique, designated in 2000 (Marine Conservation Institute 2020). This Ramsar Site is 1,329 km^2 of marine, marshes, swamps, coastal and terrestrial ecosystems. “The marine area is shallow with a sandy bottom and a few patches of corals. [It is home to] several threatened and vulnerable mammal species, such as *Allouatta palliatta*; *Tapirus baiirdii, Tayassu tajacu, Tayassu pecari* and *Panthera onca* are also found in the area, as are *Crocodylus acutus* and *Iguana iguana*” (Ramsar sites information service 2020).

Honduras (Caribbean and Pacific)

The reconstruction of Honduras’ marine fisheries catches was completed for 1950-2010 by Funes *et al.* (2015) for both coasts; see also Funes *et al.* (2016a) for the Caribbean and Funes *et al.* (2016b) for the Pacific coast of Honduras. These reconstructions were later improved and extended to 2015 by Canty *et al.* (2019), and this brief account documents how these reconstructions were updated to 2017, then carried forward to 2018.

The methods by Canty *et al.* (2019) were used to update the subsistence catch for 2016-2017 from both the Caribbean and the Pacific coast of Honduras.

Fisheries within the Eastern Central Pacific

Retroactive changes were detected in reported landings of "Marine fishes nei" in 2015 for the Pacific coast (i.e., the inner Gulf of Fonseca), and these data were updated using the 2017 release of the FAO data. Unreported catch for the artisanal sector were updated for 2016-2017 using the ratios to reported catch per taxonomic category for 2015 described in Canty *et al.* (2019). Unreported catches of clams (*Anadara* spp. and *Donax* spp.) were held constant at the 2014 amount for 2015-2017.

Fisheries within the Western Central Atlantic

Canty *et al.* (2019) used DIGIPESCA reported data to reconstruct the industrial component of various target species. DIGIPESCA data were not available during the 2017 update. Thus, industrial catch of shrimp and finfish reported by DIGIPESCA were averaged for 2011-2015 in order to get a value for 2016 and held constant at the value for 2017. Lobster catch was calculated as 0.001 tonnes in 2016 based on reports that catches were 15% higher in 2016 compared to 2015[24], and this value was held constant for 2017. Industrial catch for conch was 316 tonnes in 2016 (DIGIPESCA 2017) and was held constant for 2017. An anchor point for industrial catch of sea cucumber was determined as 142.5 tonnes in 2017 and was derived from multiplying the five boats reportedly involved in the fishery with a catch rate of 28.5 tonnes per boat per year[25], and catch for 2016 was interpolated between the 2015 and 2017 anchor points.

The artisanal catch was reconstructed following the methods of Canty *et al.* (2019). The unreported rate and rate at which finfish are illegally caught were held constant for 2015-2017 (Canty *et al.* 2019). Although there was a temporary ban on conch fishing as of 2003, national data still reports conch catches and monitoring are likely to not cover all small-scale vessels. Thus, we assumed that illegal domestic fishing of conch was still occurring and estimated conch catches for years without reported data (2008 and 2014) by interpolating between the reported amounts in the year before and after. Currently, there is a scientific quota for conch of 201 tonnes of cleaned meat, and illegal fishing is well known to occur (Prada *et al.* 2017).

Recreational fisheries along the Caribbean coast

Recreational catch was updated to 2017 using the method used by Canty *et al.* (2019) and updated information on the number of international tourist arrivals from the World Bank for 2016-2017. The recreational catch was disaggregated by taxa as indicated in Table 1.

Table 1. Taxonomic breakdown for recreational catch. Source: Canty *et al.* (2019)

Species	Catch (%)
Acanthocybium solandri	40
Coryphaena hippurus	30
Thunnus atlanticus	10
Sphyraena barracuda	20

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Honduras has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance. It is also part of the international network of UNESCO Man and the Biosphere (Marine Conservation Institute 2020).

[24] https://www.laprensa.hn/honduras/935051-410/honduras-con-dificultades-para-cubrir-cuota-de-caracol-en-las-exportaciones

[25] https://www.elheraldo.hn/pais/1182161-466/sobornos-y-regal%C3%ADas-en-tr%C3%A1fico-de-licencias-en-la-direcci%C3%B3n-general-de

Honduras has 30 MPAs and three marine managed areas. Together, these areas cover 9,213 km² (Marine Conservation Institute 2020), which corresponds to about 4.21% of its EEZ of 218,800 km², of which only 747 km² are in the Pacific (in the Gulf of Fonseca, not further mentioned below), while most is in the Caribbean (Funes *et al.* 2016a, 2016b).

The Cayos Cochinos archipelago forms part of the Mesoamerican Barrier Reef System (MBRS), where it has an above average coral reef fish species richness. It was one of the first marine protected areas (MPAs) created in Honduras in 1993 and is now a Natural Marine Monument with a size of 1,220 km². Before the area was protected, artisanal and industrial fishing occurred in Cayos Cochinos (Cáceres *et al.* 2020). Nowadays, there is still a lack of effective restrictions design and enforcement. "In addition, strong criticism has been leveled toward the management of the Monumento Natural Marino Archipiélago de Cayos Cochinos, because the ecological studies have not incorporated social aspects that involve the native Garífunas communities of the archipelago (Brondo and Bown 2011), and they have even been considered to be enemies by the agents of conservation, tourism, and the Honduran state (Loperena 2016)" (Cáceres *et al.* 2020). In another study focused on the overfished spiny lobster, local management actions are also present as a powerful tool for new policies in Honduras (Chollett *et al.* 2017).

Río Plátano is a National Park, Biosphere Reserve and UNESCO-MAB (Mand and the Biosphere Reserve) "[with] the largest surviving area of undisturbed tropical rainforest in Honduras. [It] is one of the few remaining in Central America. […]. But the future of this exceptional richness, in a country torn by conflict, poverty, and adverse socioeconomic conditions, strongly depends on the readiness of its authorities to consolidate efforts to manage and conserve it (IUCN 2011). The reserve was placed on the World Heritage List in Danger in 1996 and in 2011, because of encroachment by cattle ranchers, loggers, illegal hunters, wildlife traders, and burn colonists and also because of the inadequate management of its natural and cultural resources by the government […]" (Claudino-Sales 2019).

Nicaragua (Caribbean and Pacific)

The marine fisheries catches of Nicaragua were reconstructed for the period 1950 to 2010 by Haas et al. (2015), who dealt with both its Caribbean and Pacific coasts (see also Haas *et al.* 2016a, 2016b). Here, we briefly document how these reconstructions were updated to 2017, and carried forward to 2018.

Conch and sea cucumbers

Retroactive changes were made to the landing records for stromboid conch between different releases of the FAO data to account for shell weight using adjustment factors. As a result, landings of conch by artisanal fisheries were updated for the entire series (Figure 3 and 4) in order to match the data in FAO (2019).

Conch landings were also excluded from the subsistence calculations, as this valuable commodity tends to be sold rather than consumed by fishers and their families. Similarly, sea cucumber, whose catches have also increased greatly since they were first reported in 2005, have no local consumers; all catches are exported (Toral-Granda 2008).

These retroactive changes caused artisanal catches to be overestimated and the subsistence catches to be underestimated. Thus, reconstructed subsistence catches were re-estimated for 1997-2010 by excluding conch and sea cucumbers.

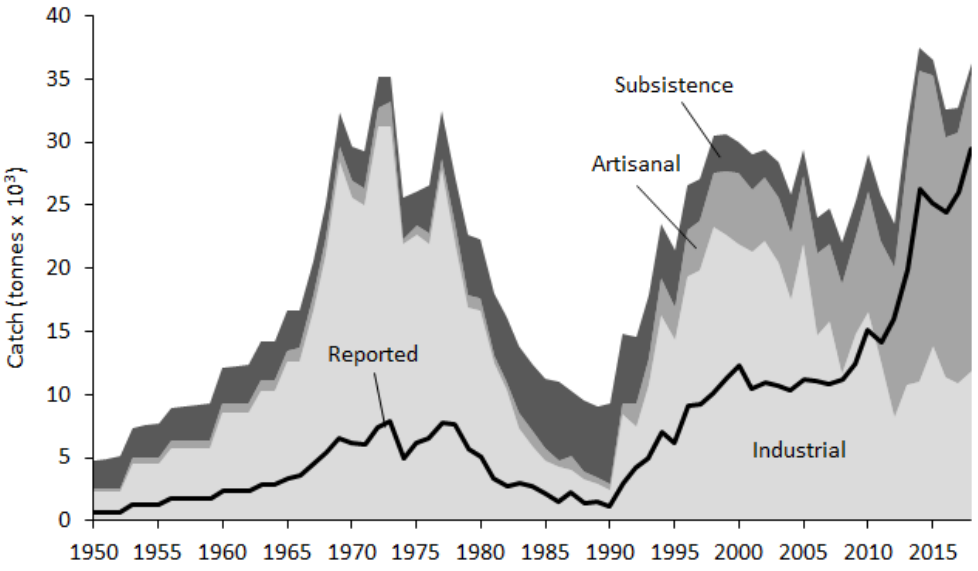

Figure 3. Reconstructed domestic catch within Nicaragua's Caribbean EEZ by fishing sector for 1950-2018.

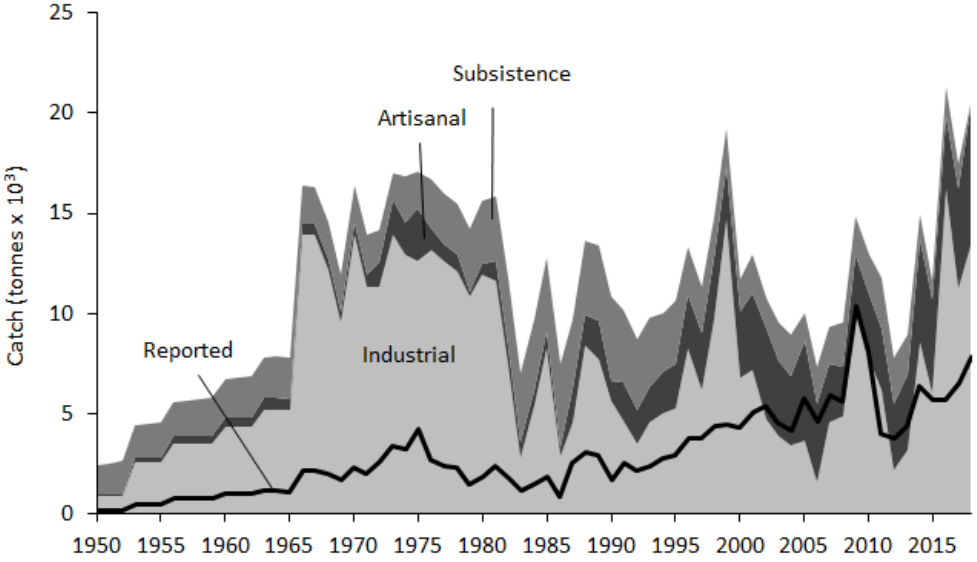

Figure 4. Reconstructed domestic catch within Nicaragua's Pacific EEZ by fishing sector for 1950-2018.

Commercial fisheries along the Caribbean and Pacific coasts

National (INPESCA 2017) data were compared with FAO data (FAO 2019) and determined to be similar; therefore, landing reports from FAO were used to update reported landing from artisanal and industrial fisheries. Reported landings of marine fish from 2011 to 2017 were assigned to artisanal and industrial sectors based on the percentage contribution of each sector in 2010.

Lobster fisheries in the Caribbean

Reported landings of lobsters caught along Nicaragua's Caribbean coast from 2007-2016 were attributed to artisanal and industrial fisheries based on percentage composition in INPESCA (2017). Based on this report, we set the new anchor point of 44% industrial and 56% artisanal in 2007 and interpolated linearly between

the last anchor point in 1989. As a result, retroactive changes were made to the sector breakdown of reported landings of lobsters from 1990-2010.

Lobster fisheries in the Pacific
Reported landings of lobsters along the Pacific coast were attributed to artisanal and industrial fisheries based on 2010 ratios.

Shrimp fisheries in the Caribbean and Pacific
The ratio of bycatch to shrimp landings from 2010 was held constant for 2011-2017 to calculate the amount of bycatch. The declining percentage of discarded bycatch was extrapolated forward to 2017 to estimate unreported landings and discards. As bycatch is increasingly being retained and utilized (Kelleher 2005), discard rates are assumed to continue on a declining trend.

Subsistence fisheries in Caribbean and Pacific
Subsistence catches were estimated for 2011-2017 by subtracting all artisanal landings deemed for local consumption and the ratio of industrial shrimp landings from the calculated demand. The total population for Nicaragua was updated for 2011-2017 with data available from the World Bank, and the original trend in per capita consumption rate was extrapolated to 2017 to calculate the total demand for fish. The calculated total demand for fish in 2011-2017 was used to estimate subsistence catches based on the 2010 relationship between subsistence catches and total demand for fish. The taxonomic breakdown of subsistence catches from 2010 was assumed to remain constant for 2011-2017. The gear breakdown for each species was maintained based on 2014 ratios for 2015-2017.

Transition from 2017 to 2018
The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection
Nicaragua has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Nicaragua has six MPAs and four marine managed areas. Jointly, these areas cover 35,973 km^2 (Marine Conservation Institute 2020), i.e., 16.15% of the EEZ of 222,754 km^2 (Haas *et al.* 2016a, 2016b). One of these MPAs in the Caribbean coast is the 'Cayos Miskitos and Franja inmediata Reserve' (designated in 1991 with 4,335 km^2; Marine Conservation Institute 2020), where "indigenous territorial authorities have made an important effort to develop rules of control, regulation, and management of the reserve. However, frequently, these norms are not considered legitimate by state authorities and therefore are not enforced by the regional or national jurisdictions. The result is a social and legal environment of uncertainty and contradicting norms regarding the observation of fishing regulations and access to natural resources. In consequence, conflicts and misunderstandings between different types of users take place repeatedly" (González 2018).

"On the Pacific Coast, there are several mangrove reserves. They include: Reserva Natural Delta del Estero Real; Reserva Natural Estero Padre Ramos; Refugio de Vida Silvestre Isla Juan Venado; Refugio de Vida Silvestre Río Escalante Chacocente; and Refugio de Vida Silvestre La Flor. There are four marine management

zones that are extensions of terrestrial reserves. They are Estero Padre Ramos, Juan Venado Island, Escalante Chacocente River, and La Flor (MARENA 2016)" (Jameson *et al.* 2019b).

Even though the government of Nicaragua has made efforts to support its indigenous people and their food security with, for example, a 'Strategy for the Sustainable Development of Artisanal Fisheries', the exclusion of non-right holders in certain areas by indigenous authorities is not easy. "For instance, the illegal fishing operations of industrial and foreign fleets continue to be a major problem, for which the indigenous authorities do not have the capacity to stop. To the contrary, communities continuously report episodes of illegal fishing in their maritime territories. Paradoxically, these industrial fishing companies have often obtained permission from the Ministry of Fisheries, INPESCA" (González 2018).

"Nicaragua's Caribbean Coast is an important feeding, nesting, and/or breeding ground for four of the world's seven sea turtle species: hawksbill (*Embrochelys imbricate*), loggerhead (*Caretta caretta*), green (*Chelonia mydas*) and leatherback (*Dermochelys coriacea*) (Lagueux & Campbell, 2005). The West Indian manatee (*Trichechus manatus*) is distributed almost continuously along the Caribbean Coast, given the numerous brackish lagoons and freshwater rivers preferred by the species" (Jameson *et al.* 2019a).

"The beach at the Padre Ramos mangrove estuary nature reserve located on the northwest Pacific Coast of Nicaragua is one of the last two major nesting beaches for the eastern Pacific population of hawksbill turtles. Nicaragua has recently banned freshwater fishing of the Nicaragua (bull) shark as well as the sawfish (*Pristis perotteti*). The bull shark can survive for an extended period of time in fresh water and the sawfish also moves freely between the Lake Nicaragua and the sea (Thorson 1982)" (Jameson *et al.* 2019b).

Discussion

The countries listed above share several features, including the difficulty in comprehensively covering small-scale fisheries with reporting systems and in enforcing bans on select target species. We have used alternative secondary sources and methods to reconstruct catches from small-scale fisheries and illegal fishing that may continue despite bans. We welcome feedback and information that can be used to improve our current reconstructions of the marine fisheries catch of Central American countries.

Acknowledgements

Funding for the work presented here was provided by the Minderoo Foundation, by the Marisla, Oak, and David and Lucille Packard Foundations, and by the Bloomberg Philanthropies through Rare.

References (by country)

Belize

Belize Fisheries Department. 2013. Ecosystem Management Unit. Available at: www.fisheries.gov.bz/ecosystem-management-unit/

Cho, L. 2005. Marine protected areas: A tool for integrated coastal management in Belize. *Ocean & Coastal Management,* 48(11-12): 932-947. doi.org/10.1016/j.ocecoaman.2005.03.007

Dasgupta, S. 2019, Belize to nearly triple area under strict marine protected areas. *Mongabay*, 8 April, 2019. Available at: news.mongabay.com/2019/04/belize-to-nearly-triple-area-under-strict-marine-protected-areas/#:~:text=The%20government%20of%20Belize%20has,percent%20of%20its%20total%20waters.

Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org

Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28(5).

Oceana. 2010. Belize Bans Bottom Trawling in Exclusive Economic Zone. Available at: oceana.org/press-center/press-releases/belize-bans-bottom-trawling-exclusive-economic-zone
Palomares, M.L.D. and D. Pauly (eds). 2011. Too Precious to Drill: The Marine Biodiversity of Belize. Fisheries Centre Research Report 19(6), 175 p.
Ramos, A. 2015. Belize ends open access to marine fisheries. *Amandala*, 12 December, 2015. Available at: amandala.com.bz/news/belize-ends-open-access-marine-fisheries/
Scocca, G. 2020. The Preservation of Coral Reefs as a Key Step for Healthy and Sustainable Oceans: The Belize Case. *Journal of International Wildlife Law & Policy*, 23(1): 1-17.
Zeller, D., R. Graham and S. Harper. 2016. Belize, p. 203 *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A critical appraisal of catches and ecosystem impacts*. Island Press, Washington, D.C.
Zeller, D., R. Graham and S. Harper. 2011. Reconstruction of total marine fisheries catches for Belize, 1950-2008, p. 142-151. *In:* M.L.D. Palomares and D. Pauly (eds). *Too Precious to Drill: The Marine Biodiversity of Belize*. Fisheries Centre Research Report 19(6).

Clipperton Island (France)

Fabius, L. 2014. Accords entre la France et le Mexique sur la pêche à Clipperton - Réponse du Ministère des affaires étrangères et du développement international, p. 2534. *In:* France Sdl (ed). *Journal Officiel des questions du Sénat*. Sénat de la France, Paris, France.
Fillon, F., M.-L. Penchard, J.-L. Borloo, B. Kouchner, B. Hortefeux, H. Morin, F. Baroin and B. Le Maire. 2010. Décret du 29 juin 2010 fixant les conditions dans lesquelles des navires battant pavillon d'un État étranger peuvent être autorisés à pêcher dans la zone économique située au large de l'île de Clipperton. Journal Officiel de la Polynésie Française, République Française, Paris, France. 2 p.
Folliot, P. 2016. Valoriser l'île de la Passion (Clipperton) par l'implantation d'une station scientifique à caractère international. République Française, Paris, France. 83 p.
Friedlander, A.M., J. Giddens, E. Ballesteros, S. Blum, E.K. Brown, J.E. Caselle, B. Henning, C. Jost, P. Salinas-de-León E. Sala. 2019. Marine biodiversity from zero to a thousand meters at Clipperton Atoll (Île de La Passion), Tropical Eastern Pacific. *PeerJ*, 7: e7279.
Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org
Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic*. Fisheries Centre Research Report 28(5).
Pauly, D. 2009. The fisheries resources of the Clipperton Island EEZ (France), p. 35-37. *In*: D. Zeller and S. Harper (eds). *Fisheries Catch Reconstructions: Islands, Part I*. Fisheries Centre Research Report 17(5).
Pauly, D. 2016. France (Clipperton Island), p. 253. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.
Petit, J. 2018. How France Could Become a World Leader in Ocean Protection. Pew Bertarelli Ocean Legacy. *Huffington Post*, 7 June, 2018.

El Salvador

Coulter, A., T. Cashion, A. Cisneros-Montemayor, S. Popov, G. Tsui, F. Le Manach, L. Schiller, M. Palomares, D. Zeller and D. Pauly. 2020. Using harmonized historical catch data to infer the expansion of global tuna fisheries. *Fisheries Research,* 221:105379. doi.org/10.1016/j.fishres.2019.105379
Donadi, R., A. Au, K. Zylich, S. Harper and D. Zeller. 2015. Reconstruction of marine fisheries in El Salvador 1950-2010. Fisheries Centre Working Paper #2015 - 35, 23 p.
Donadi, R., A. Au, K. Zylich, S. Harper and D. Zeller. 2016. El Salvador, p. 245. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.
Gaos, A.R. and I.L. Yañez. 2012. Saving the Eastern Pacific Hawksbill from Extinction, p. 245–262. *In:* J.A. Seminoff and B.P. Wallace (eds). *Turtles of the Eastern Pacific: Advances in Research and Conservation. Arizona-Sonora Desert Museum Studies in Natural History*. University of Arizona Press, Tucson.
Liles, M.J., M.J. Peterson, Y.S. Lincoln, J.A. Seminoff, A.R. Gaos, and T.R. Peterson. 2015 Connecting International Priorities with Human Wellbeing in Low-Income Regions: Lessons from Hawksbill Turtle Conservation in El Salvador. *Local Environment*, 20(11): 1383–1404.

MAG. 2016. Estadisticas de Producción de la Pesca Industrial, Artesanal Marina y Artesanal Continental, 2016. MAG (Ministerio de Agricultura y Ganadería), El Salvador.
MAG and CENDEPESCA. 2018. Evaluación del estado del recurso camarón marino, para conocer el impacto de la aplicación de las vedas del 2017 en la pesca industrial. MAG (Ministerio de Agricultura y Ganadería) and CENDEPESCA (Dirección General de Desarrollo de la Pesca y la Acuicultura), Santa Tecla-La Libertad, El Salvador.
Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org
Massey, L. and P. McCord. 2017. AMBAS in Action: How an all-women's group is leading sea turtle conservation efforts in El Salvador. Center for Marine Biodiversity and Conservation. UC San Diego. Available at: escholarship.org/uc/item/7w75h1cg
Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28(5).
Parker, E.E. 2018. Evaluating Direct Incentive Initiatives for Sea Turtle Conservation: Insights from Egg Collectors in Bahía de Jiquilisco, El Salvador. Center for Marine Biodiversity and Conservation. UC San Diego. Available at: escholarship.org/uc/item/18d0v442
Wehrtmann, I.S. and E. Acuña. 2011. Ch 10: Squat lobster fisheries, p. 297-322. *In:* G.C.B. Poore, S.T. Ahyong and J. Taylor (eds). *The biology of squat lobsters*. CSIRO Publishing, Collingwood, Australia.

Guatemala

Lindop, A., M. Ixquiac-Cabrera, K. Zylich and D. Zeller. 2015. A reconstruction of marine fish catches in the Republic of Guatemala. Fisheries Centre Working Paper #2015-41, 17 p.
Lindop, A., M. Ixquiac-Cabrera, K. Zylich and D. Zeller. 2016a. Guatemala (Caribbean), p. 282 *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.
Lindop, A., M. Ixquiac-Cabrera, K. Zylich and D. Zeller. 2016b. Guatemala (Pacific), p. 283. *In:* D. Pauly and D. Zeller. (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.
Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org
Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28(5).
Ramsar sites information service. 2020. Punta de Manabique. Available at: rsis.ramsar.org/ris/1016
Wolford, J.S.O. 2018. Caracterización de basura marina en tres playas del Refugio de Vida Silvestre Punta de Manabique, Izabal. Semillas del oceano, Guatelmala. 30 p.

Honduras

Brondo, K.V., N. Bown. 2011. Neoliberal conservation, Garifuna territorial rights and resource management in the Cayos Cochinos Marine Protected Area. *Conservation and Society,* 9(2): 91–105
Cáceres, I., E.C. Ibarra-García, M. Ortiz, M. Ayón-Parente and F.A. Rodríguez-Zaragoza. 2020. Effect of fisheries and benthic habitat on the ecological and functional diversity of fish at the Cayos Cochinos coral reefs (Honduras). *Marine biodiversity*, 50(9).
Canty, S., M. Funes, S. Box, K. Zylich, B. Derrick, E. Divovich, A. Lindop, D. Pauly and D. Zeller. 2019. The hidden value of artisanal fisheries in Honduras. *Fisheries Management and Ecology*, 26: 249-259.
Chollett, I., L. Garavelli, S. O'Farrell, L. Cherubin, T.R. Matthews, P.J. Mumby and S.J. Box. 2017. A Genuine Win-Win: Resolving the "Conserve or Catch" Conflict in Marine Reserve Network Design. *Conservation letters*, 10(5): 555-563.
Claudino-Sales, V. 2019. Río Plátano Biosphere Reserve, Honduras, p. 61-66. *In:* V. Claudino-Sales. *Coastal World Heritage Sites*. Springer, Dordrecht.
DIGIPESCA. 2017. Plan de Manejo. Pesquería de caracol gigante *Strombus gigas* del Caribe de Honduras. Secretaría de Agricultura y Ganadería. Dirección General de Pesca y Acuicultura (DIGIPESCA), Gobierno de la República de Honduras. 75 p.
Funes, M., K. Zylich, E. Divovich, D. Zeller, A. Lindop, D. Pauly and S. Box. 2015. Honduras, a fish exporting country: Preliminary reconstructed marine catches in the Caribbean Sea and the Gulf of Fonseca, 1950 – 2010. Fisheries Centre Working Paper #2015-90, 16 p.

Funes, M., K. Zylich, E. Divovich, D. Zeller, A. Lindop, D. Pauly and S. Box. 2016a. Honduras (Caribbean), p. 288. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.

Funes, M., K. Zylich, E. Divovich, D. Zeller, A. Lindop, D. Pauly and S. Box. 2016b. Honduras (Pacific), p. 289. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press. Washington, D.C.

IUCN (International Union for the Conservation of Nature). 2011. A promising future for Rio Platano. Available at: www.iucn.org/?7579

Loperena, C.A. 2016. Conservation by racialized dispossession: The making of an eco-destination on Honduras's North Coast. *Geoforum,* 69: 184–193

Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org

Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28(5).

Prada, M.C., R.S. Appeldoorn, S. Van Eijs and M.M. Pérez. 2017. Regional Queen Conch Fisheries Management and Conservation Plan. FAO Fisheries and Aquaculture Technical paper No. 610. Food and Agriculture Organization of the United Nations (FAO), Rome. 70 p.

Nicaragua

FAO. 2019. FAO Yearbook. Fishery and Aquaculture Statistic 2017. Food and Agriculture Organization of the United Nations (FAO), Rome.

González, M. 2018. Governance and governability: indigenous small-scale fisheries and autonomy in coastal Nicaragua. *Maritime Studies,* 17(3): 263-273.

Haas, A., S. Harper and D. Zeller. 2015. Reconstruction of Nicaragua's fisheries catches: 1950-2010. Fisheries Centre Working Paper #2015-23, 9 p.

Haas, A., S. Harper and D. Zeller. 2016a. Nicaragua (Caribbean), p. 351. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.

Haas, A., S. Harper and D. Zeller. 2016b. Nicaragua (Pacific), p. 352. *In:* D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.

INPESCA. 2017. Anuario pesquero y acuicola 2016. Instituto Nicaraguense de la Pesca y Acuicultura (INPESCA). 140 p.

Jameson, S.C., K. Stevens and R.C. Bennett. 2019a. Nicaragua: Caribbean Coast, p. 725-741. *In*: C. Sheppard (ed). *World Seas: An Environmental Evaluation (Second Edition): Vol. I: Europe, The Americas and West Africa*. Academic Press, London, UK.

Jameson, S.C., K. Stevens, R.C. Bennett and N.J. Cardoza. 2019b. Nicaragua: Pacific Coast, p. 743-757. *In*: C. Sheppard (ed). *World Seas: An Environmental Evaluation (Second Edition): Vol. I: Europe, The Americas and West Africa*. Academic Press, London, UK.

Kelleher, M.K. 2005. Discards in the world's marine fisheries: An update. Fisheries Technical Paper 470. Food and Agriculture Organization of the United Nations (FAO), Rome. xix+131 p.

MARENA. 2016. Mapa Nacional de Áreas Protegidas y Reservas de Biosfera de Nicaragua. Available at : www.tortillaconsal.com/images/ineter_mapa_areas_protegidas_2-11-2016.pdf.

Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org

Noël, S.-L. 2020. Semi-automation procedure for catch reconstruction forward carry, p. 15-20. *In:* B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us: Part I – Africa, Antarctica, Europe and the North Atlantic.* Fisheries Centre Research Report 28(5).

Thorson, T.B. 1982. Life history implications of a tagging study of the largetooth sawfish, *Pristis perotteti*, in the Lake Nicaragua-Rio San Juan system. *Environmental Biology of Fishes*, 7(3): 207–228.

Toral-Grand, V. 2008. Population status, fisheries and trade of sea cucumbers in Latin America and the Caribbean, p. 213-229. *In:* V. Toral-Granda, A. Lovatelli and M. Vasconcellos (eds). Sea cucumbers. A global review of fisheries and trade. FAO Fisheries and Aquaculture Technical Paper. No. 516. Food and Agriculture Organization of the United Nations (FAO), Rome.