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The hidden value of artisanal fisheries in Honduras

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Abstract

Declining fisheries catches are a global trend, with management failing to keep pace with growth in fishing effort and technological advances. The economic value of Honduras' catches was estimated within the industrial and artisanal sectors. Catches were found to be 2.9 times greater than the official statistics between 1950 and 2015. The merging of industrial and artisanal catch data masked the decline in industrial catches and hid the strong growth of artisanal fisheries. In 1996, annual artisanal fisheries landed catches surpassed the industrial fishery sector, and in 2000, the annual net value of artisanal fisheries eclipsed the value of the industrial fisheries. These data highlight the importance of artisanal fisheries in Honduras and challenge the long-held belief that the industrial sector contributes more to the national economy. The global paucity of fisheries data highlights the need for comprehensive strategies to collect more detailed and accurate fisheries data.

KEYWORDS

artisanal fisheries, catch reconstruction, fisheries data, industrial fisheries, IUU fishing, marine fisheries, small-scale fisheries, subsistence fisheries

1 | INTRODUCTION

The Republic of Honduras is located on the Central America Isthmus, with coastlines on both the Atlantic and Pacific Oceans (Figure 1). In accordance with the United Nations Convention on the Law of the Sea, Honduras claimed its exclusive economic zones (EEZs) in both the Atlantic (within FAO statistical Area 31) and the Pacific (within FAO statistical Area 77). The north shore of Honduras, located within the Caribbean basin of the Atlantic Ocean, is the longer of the two coastlines and is bordered by the EEZs of Guatemala, Belize, Mexico, Cuba, the Cayman Islands, Jamaica and Nicaragua. The Pacific coastline is much smaller and is exclusively within the Gulf of Fonseca, fully enclosed by the EEZs of El Salvador and Nicaragua (Figure 1). The sharing of EEZ borders with numerous countries, particularly within the Honduran Caribbean, has implications for transboundary fish stock management and the potential for cross-border fishing activities (Perez, 2009).

Fishing has been an important economic sector in Honduras for more than 100 years (MacKenzie & Stehlik, 1996), contributing 5% of the country's gross domestic product with an average value of US $385 million per year (Beltrán Turriago, 2011). Fishers employ a diverse range of gears to exploit lagoon and riverine systems, coral reefs, other near-shore habitats (e.g. seagrass beds), extensive offshore banks and pelagic waters (Box & Canty, 2011; Soto, 2012). The main fisheries on the Caribbean coast are for Caribbean spiny lobster, *Panulirus argus* (Latreille), and queen conch, *Lobatus gigas* (L.), while the main fishery on the Pacific coast targets western white shrimp, *Litopenaeus occidentalis* (Streets) (FAO 2002).

Artisanal and subsistence fisheries have been present in Honduras at least since the Mayan era, however, the large expansion of artisanal fisheries across the Caribbean and Pacific coasts

is a relatively recent phenomenon, commencing in the 1970s (MacKenzie & Stehlik, 1996). Artisanal fisheries provide an essential source of nutrition and employment to coastal communities, especially in remote coastal areas where there are few other economic alternatives. Due to a lack of processing infrastructure, catches from the Honduran Pacific coast supply only national markets (Box & Bonilla, 2009), while artisanal fisheries on the Caribbean coast supply both national and international markets. In addition, the shallow hydrology precludes the deployment of larger boats within the Gulf of Fonseca, which restricts the Honduran industrial fishery to the Atlantic coast (Soto, 2012).

The Honduran national industrial fishery began in the late 1950s (FAO, 2002). Previously, only foreign industrial fleets, mainly from the United States, were fishing and landing in Honduras. As international fleets began to leave Honduran waters, the national industrial fishing fleet started to develop. An additional trigger was the collapse of the United States industrial conch fishery in 1975, which enabled the Honduran industrial fishery to start supplying the United States market. Currently, 90%–95% of industrial marine catches are exported, primarily to the United States (Espinoza, 2007). Recreational fisheries are practised across the Honduran shore in the Caribbean, but sport fishing operations are primarily located in the Bay Islands, where the majority of international tourism is concentrated, receiving over 700,000 tourists per year (INE, 2018).

Signs of overexploitation have been documented in Honduran fisheries. The conch fishery closed in 2003 due to a trade embargo placed on conch exports by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 2003). The Nassau grouper, *Epinephelus striatus* (Bloch), population collapsed in 2004 (Box & Bonilla, 2009). According to Honduran fishers, the decline and collapse of these fisheries was a consequence of irresponsible fishing practices and habitat degradation via destructive fishing gears (Korda, Hills & Gray, 2008), which mirrors trends in Jamaica (Hughes, 1994) and the Caribbean as a whole (Gobert et al., 2005).

Overfishing is a great challenge facing governments and the scientific community (FAO, 2016). As a minimum requirement, effective management requires reliable data, with catch data representing the most fundamental of all fisheries data. Comprehensive and accurate records of fisheries' catches are important to allow monitoring of fisheries' trends over time, with the effect of fisheries' regulations to be observed, and subsequently adjusted if required (Belhabib, Koutob, Sall, Lam & Pauly, 2014). However, while technological advances in fishing vessels and gears are evident, systems to record catch data and monitor fisheries have not kept pace. There is a chronic need for improvements in data collection and the incorporation of these data into fisheries management (Pauly et al., 2002). The status of the world's fisheries may be worse than currently perceived, given that a large fraction of catches has been missing from national fisheries catch estimates in virtually every country of the world (Pauly & Zeller, 2016a,2016b). Crucially, the pattern of missing data changed over time as an inadvertent by-product of well-intentioned efforts to improve data collection systems, resulting in a time series bias now known as "presentist bias" (Zeller & Pauly, 2018). Thus, there is a concerted global effort led by the *Sea Around Us* initiative to reconstruct national, and by extension, regional and global fishing statistics that add comprehensive estimates for all unreported catches to officially reported landing data to derive a better and more comprehensive understanding of fisheries catches over time (Funes et al., 2015; Pauly & Zeller, 2016a,2016b; Zeller, Booth, Davis & Pauly, 2007; Zeller, Harper, Zylich & Pauly, 2015; Zylich et al., 2014).

The starting point for reconstructions is the official reported landing data provided by national agencies to the Food and Agriculture Organization of the United Nations (FAO); these data are subsequently compared with the formal and grey literature, and inferences on additional, previously unreported catches are validated with local experts (Zeller et al., 2016), Funes et al. (2015) and from reconstructed marine fisheries catch data for the Republic of Honduras, by deriving the best time series estimates of unreported catches for 1950–2010, from both the Atlantic and Pacific coastlines to complement reported data. The present study revised, improved and extended the analysis performed in Funes et al. (2015), by updating the time series to 2015, rectifying all estimates of fishing categories, completing the lacking fishing categories and enhancing the sources of data. Once the corrected reconstructed catch was available, the aim was to describe and compare statistically the catch trends over the years, and to evaluate the economies of the fisheries

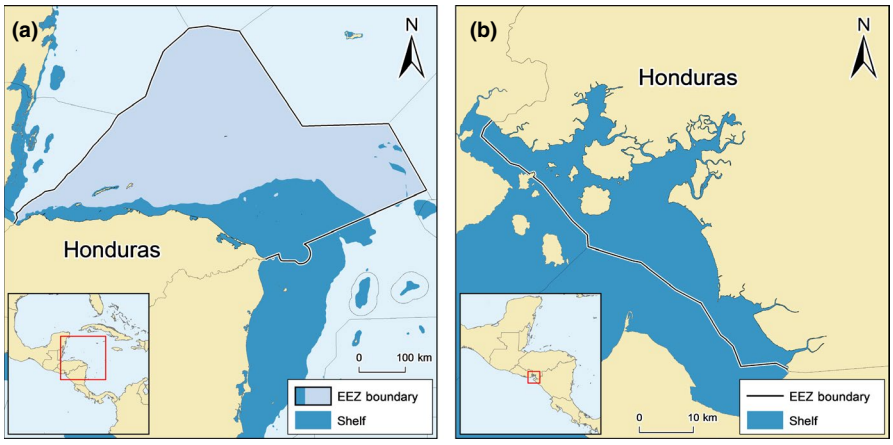

FIGURE 1 Maps of the two parts of the Honduran exclusive economic zone (EEZ). (a): Honduras' EEZ in the Caribbean covers 218,000 km^2, of which 60,300 km2 is shelf, that is, less than 200 m deep. (b): Honduras' EEZ in the Pacific is small (747 km2) and shallow, and consist only of the inner Gulf of Fonseca, shared between El Salvador in the North, Honduras, and Nicaragua in the South [Colour figure can be viewed at wileyonlinelibrary.com]

sectors in Honduras and in the context of the Mesoamerican reef countries (Mexico, Guatemala and Belize).

2 | METHODOLOGY

2.1 | Catch reconstructions

Honduran catch reconstructions were conducted using the method of Zeller et al. (2007, 2016), following the principles described in Pauly (1998). Only marine wild capture fisheries were addressed; therefore, aquaculture production and freshwater catches are not included in the estimates, nor are catch records of marine mammal, turtles, worms, seaweed or algae. For a full list of the categories used in this reconstruction, see Supporting Information (Table S1).

Industrial, artisanal, subsistence and recreational fisheries for fishing areas 31 and 77 (Figure 1) were estimated separately. Artisanal fishing was defined by the Honduran Fisheries Law of 1959, as "fishing within three nautical miles from the shore using boats with a capacity of three tonnes or less and employing basic fishing equipment." All commercial fishing activities encompassed by this definition were considered artisanal. Commercial fisheries with vessels of greater capacity and fishing at greater distances were considered industrial. Subsistence fisheries were defined when landed catch was for personal consumption and no commercial transaction is associated with it. Recreational fisheries were defined as sport fishing; whereby, individuals may pay for a fishing excursion, but retained landed catch was not sold.

2.2 | The Caribbean Sea (FAO Area 31)

2.2.1 | Reported industrial catch

Industrial fishing in Honduras is limited to Area 31 (Caribbean) with four fleets licensed to exploit four resource types: Caribbean spiny lobster, queen conch, shrimp and finfish (primarily grouper and snapper). The industrial sector is diverse, fishing vessel lengths vary from 4 to 78 m (13–258 feet), crews range from 6 to 85 people, and the duration of fishing excursions vary from 10 to 90 days, depending on the fishery (CITES, 2003). National industrial fisheries first appeared in Honduras during the late 1950s (FAO, 2002), at which time only limited catch data were reported. Given that industrial catches were always landed at major ports, all catches from 1950 to 1989 reported to FAO were considered industrial. In 1990, the governmental body DIGEPESCA was created and began to collate fisheries data; therefore, for the period of 1990–2015 industrial landed catch data were obtained directly from DIGEPESCA records.

2.2.2 | Illegal industrial catch

Illegal catch is any catch that is acquired or removed from the EEZ of a country without the consent of that country. In instances where these landed catches are processed through Honduran packaging plants, they become included in official data and contribute to the national economy. Here, illegal catches taken by the Honduran fishing fleet from neighbouring EEZs of Nicaragua and Jamaica were estimated. The Honduran Grand Banks are situated in the far eastern part of the EEZ, close to the Nicaraguan border, extending north-east to the Jamaican border, and the Honduran fleet enters into Nicaraguan and Jamaican EEZ waters illegally. To consider this and remain conservative, illegal catch was estimated as 15% of the total estimated industrial lobster catch, as a constant percentage over time. Estimations on foreign fishing vessels illegally entering to Honduran EEZ were not included in the analysis; however, illegal fishing within the Honduran EEZ was assumed to be equivalent to that of the Honduran fleet in other EEZs, and therefore, the illegal capture of the Honduran industrial fleet was included in the estimations.

2.2.3 | Unreported industrial catch

Undeclared discards are part of the industrial unreported catch in Honduras. Discards are absent or minimal in the conch and lobster fisheries, as conch are hand-collected and lobster are either hand-collected or caught in traps. The capture of finfish is mainly from vertical long lines, where low-valued bycatch is usually consumed and accounted for in the subsistence fishery category (see below). The major non-selective industrial fishery component is the bottom-trawl shrimp fishery. Unregulated shrimp discards were estimated following Davies, Cripps, Nickson, and Porter (2009), who suggested a bycatch rate of 78%, where no bycatch was landed. This percentage was applied to FAO reported shrimp landings for 1950–2015 to estimate what was taken from the sea to be discarded later. Any bycatch in the industrial finfish fishery was assumed to be either recorded in the official records or used for personal consumption and therefore estimated under subsistence.

2.2.4 | Reported artisanal catch

The large extent of the Caribbean coastline provides suitable fishing grounds across the Honduran mainland and island archipelagos, with more than 135 different fishing communities (Stephen Box, personal observation) with over 7,000 registered artisanal fishers included in the DIGEPESCA fisher registration system. The geographical dispersion and remoteness of many of these communities have made it difficult to collect catch data from these fisheries, resulting in limited available data.

From 2001, FAO records included some artisanal fishing activity (Diana Vasquez, Centro de Estudios Marinos, personal communication). It was assumed that the remainder of FAO catch unaccounted in DIGEPESCA data was artisanal catch for the period of 2001–2015, where FAO landings exceeded DIGEPESCA reports. Since artisanal fishing in this region was not reported until recently, the FAO landing data for the early time periods were assumed to be industrial fisheries. As a conservative estimate, the reporting of artisanal fisheries to the FAO was considered to improve linearly from 0% of catch reported to the FAO in 1989 to

the calculated percentage of FAO catch estimated to be artisanal in 2001 (i.e. 74% of reported data).

2.2.5 | Illegal artisanal catch

Transboundary fishing by artisanal fishers is a problem with Honduran boats making excursions into Belizean territorial waters and Guatemalans fishers making excursions into Honduran (and Belizean) waters (Perez, 2009). To incorporate this and remain conservative, illegal artisanal catch was estimated as 15% of the total estimated artisanal catch, as a constant percentage over time. These illegal catches were identified and labelled as Honduras fishing in Belizean waters. The catches of foreign artisanal fleets fishing illegally in Honduran waters were not estimated. As per the industrial fishery, illegal fishing of others in Honduran waters was assumed to be equivalent to the illegal transboundary fishing activity of the Honduran artisanal fleet and therefore to include illegal landed catch.

2.2.6 | Unreported artisanal catch

Despite artisanal fisheries existing in Honduras since the pre-Columbian period, no data were available for the artisanal fishery for the period 1950–2000. Reporting of artisanal fisheries has occurred since 2001 primarily from the cities of La Ceiba, Puerto Cortex and Tela along the Caribbean coastline. However, no catch data have been collected from many of the smaller fishing communities in more remote location along the Honduran north shore, despite their considerable fishing effort (Stephen Box, unpublished data). In addition, large inconsistencies were found between the FAO data set of 2011 and other sources of information. For example, differences in reported catch vary in magnitudes of 4.8–10 times, principally for lobster and finfish catch (e.g. FAO, 2002; Heyman & Granados-Dieseldorff, 2012). To remain conservative, estimates of unreported artisanal catch assumed that reported artisanal catch reflected 50% of total catch from artisanal fisheries from 2001 to 2015. Total reconstructed artisanal catch from 2001 to 2015 was used to calculate an average catch rate per artisanal fisher: annual tonnage of the reported artisanal data (2001–2015) divided by the number of fishers for that time period, which led to an overall catch rate (i.e. tonnes of fish per fisher per year). In the period of 1950–2000, reconstructed artisanal annual catch was estimated by multiplying the catch rate by the number of artisanal fishers estimated for each year (FAO, 2002); see methodology2 of artisanal fisher's estimation in subsistence section.

2.2.7 | Subsistence fisheries

Fishers from the artisanal sector may set aside a portion of their catch for personal consumption (MacKenzie & Stehlik, 1996); the artisanal fishery-derived subsistence catch was estimated by multiplying the number of artisanal fishers by an amount of fish per capita for home consumption. FAO (2002) documented a total of 9,132 fishers on the Atlantic coast, which also matched well with grey literature estimates (Box & Canty, 2011). The artisanal fisher population was assumed to change over time as a fixed proportion (0.00177%) of the national population of Honduras from 1950 to 2015 (World Bank, 2017). The per-fisher level of subsistence catch was taken from a study conducted in the neighbouring country of Guatemala (Trujillo, Cisneros-Montemayor, Harper, Zylich & Zeller, 2012), which estimated a take-home subsistence portion of 70 kg/fisher/year. This estimate is conservative considering that fishers share the catch with their family.

In addition, the common Caribbean donax, *Donax denticulatus* L., is gathered by hand, usually by local women and children (MacKenzie & Stehlik, 1996). The donax catch is intended only for subsistence and not sold at markets (MacKenzie & Stehlik, 1996). As a minimum, an estimated average of 5 kg of donax per year per artisanal fisher's household was used in our calculations. Therefore, a total subsistence catch of 75 kg/fisher/year was estimated for the Honduran Caribbean region. This is likely a very conservative estimate.

2.2.8 | Recreational fisheries catch

Recreational fisheries were categorised as the capture and non-release of sport fish species (e.g. mahi mahi, *Coryphaena hippurus* (L.)). To estimate catch from this sector, Honduran sport fishing companies using online searches were made via Google and TripAdvisor with combinations of the following search terms, "sport," "fish*," "recreation*," "trip*," "excursion*," "tourism," "activities," "Honduras," "Bay Islands," "Roatan," "Utila," "Guanaja," "Cayos Cochinos" (*represents derivatives of a search term, e.g. fish, fishing). Secondly, following Belhabib et al. (2016), YouTube videos were identified using names of sport fishing companies collated in the previous search. From each video, the number of fish caught and their species were identified and recorded. The weight of landed catch was sometimes reported by the fisher; where this did not occur, fish length and subsequently their weight were estimated using species-specific parameters to transform length to weight from www.fishbase.org (Froese & Pauly, 2018). The number of annual trips of each company was estimated through tallying the number of reviews and Instagram posts each company received per year; these were cross-referenced to prevent duplication of fishing excursions. The number of reviews ranged from 16 to 18 for the most popular companies over the last 3 years, and the number of Instagram posts was around 150. Recreational tourism fishing was assumed to have started officially in 1985, based on information gained from the sport fishing company websites. The number of companies that offered fishing excursions was estimated to have grown linearly from 1 to 32 between 1985 and 2012, by which time all companies had been established. The number of fishing excursions per company was set to vary between 20 and 33 following trends in the number of annual visitors to Honduras (INE, 2018), as validated by local consultants (Mayra Nuñez, Centro de Estudios Marinos, personal communication).

In addition, since 1999 an international annual fishing tournament is held on Roatán, targeting mainly billfishes (Istiophoridae).

The amount of fish taken during fishing tournaments was estimated. Lists of the capture, discriminated by participant, in each category, were available for past editions on the tournament's official Facebook page. Total catch was estimated by approximating each species' weight (available on www.fishbase.org) and considering all the participants and days of tournament. Retained catches decreased after 2009 when the main target species started to be released (i.e. catch and release), but fishers still kept some bycatch species for example mahi mahi or wahoo, *Acanthocybium solandri* (Cuvier),. In 2011, captures from tournaments increased as the island of Guanaja started to host an annual sports fishing event.

2.3 | Gulf of Fonseca (FAO Area 77)

2.3.1 | Reported artisanal catch

An industrial fishery sector as defined by the Honduran Fisheries Law of 1959 is not present in the Gulf of Fonseca; all data reported by FAO are considered to be from the artisanal fisheries. Any Honduran-flagged offshore vessels were not considered in this study, as they fish outside Honduran waters (Le Manach et al., 2016; Schiller, 2014).

2.3.2 | Illegal artisanal catch

Transboundary fishing activities are known to occur in Pacific waters; fishers from Honduras make fishing excursions into the waters of El Salvador and Nicaragua. A conservative estimate of illegal catches was thought to be 5% of the total estimated artisanal finfish catch, a constant percentage over time. Illegal transboundary fishing activity of El Salvadorian and Nicaraguan fishers within Honduran territorial waters was assumed to be equal to the illegal fishing activity of the Honduran artisanal fishers, and all landed catch by the Honduran artisanal fleet was included within current estimates.

2.3.3 | Unreported artisanal catch

Several reports on fishing activities within the Gulf of Fonseca (Box & Bonilla, 2009; Soto, 2012) presented significantly larger catches than reported in the FAO 2011 data set. These reports consist of annual assessments in 2004 and 2008. For each major target group (crabs, clams, finfish and shrimp), there were differences between the catches in the assessments and the FAO data set for the same years. An unreported catch ratio of the difference between the assessments and the FAO data set for each of the major target groups was estimated and applied as a fixed ratio of the reported catches through 2015. Although reporting within the artisanal fishery has improved, it remains low and fluctuates year to year. To minimise any bias, a constant percentage differential between reported and unreported catch was applied throughout the period of 1950–2003.

Soto (2012) suggested that there are no significant discards in the shrimp fishery, because the majority of the fish caught as bycatch is retained and consumed. Therefore, any bycatch was assumed to be part of the catch of subsistence fisheries. Furthermore, as artisanal fisheries within this area employ trammel and cast nets rather than trawls (Box & Bonilla, 2009; Heyman & Granados-Dieseldorff, 2012; MacKenzie & Stehlik, 1996), discarded bycatch is minimal.

2.3.4 | Subsistence fisheries

Subsistence fisheries catches were calculated following the procedures described for the Caribbean, except that the majority of subsistence catch was based on the incidental fish bycatch from the shrimp fishery (see above). In this case, the anchor point for the number of artisanal fishers was 1,600 in 2004 (Soto, 2012).

2.3.5 | Recreational fisheries

No records of recreational fishing in the Gulf of Fonseca could be found, and local experts had no knowledge of any commercial enterprises engaged in recreational fisheries. It was assumed that all landed catch would be consumed and therefore considered any domestic recreational fishing that may occur to count as subsistence fishing, whose catch was estimated above.

2.4 | Fisheries economics

Economic data (i.e. landed value) for the fisheries of Honduras, Mexico, Belize and Guatemala were provided by the *Sea Around Us*. The landed value of the catch is based on the ex-vessel price data which represent the prices in real 2010 US$ paid to fishers at the first point of sale, combined with catch volumes, represent the landed value of the catch (Sumaila, Marsden, Watson & Pauly, 2007; Swartz, Sumaila & Watson, 2013; Tai, Cashion, Lam, Swartz & Sumaila, 2017). The landed value data for the four countries that make up the Mesoamerican reef ecoregion (Honduras, Mexico, Guatemala, and Belize) were examined, and reconstructed landed catch data—discards not included—were downloaded from the *Sea Around Us* data portal (http://www.seaaroundus.org/data/#/search).

2.5 | Statistical analysis

Reported and unreported data from both the Atlantic and Pacific coasts were combined to generate a total Honduran reconstructed catch time series for 1950–2015. Trends of catches tonnages and trends of reconstructed economic values (landed value of catches) over time, from reported and unreported catches of the industrial and artisanal sector, were analysed using segmented linear regressions, in the R package SEGMENTED (Muggeo, 2008), and changes in the slope were evaluated applying Davies tests in the same package. Segmented regression models determine regression breakpoint years that indicate a significant change in trend over time and segmented line slopes. Prior to analysis, all data were evaluated for normality, and all data were identified to be within the boundaries of normal distributions.

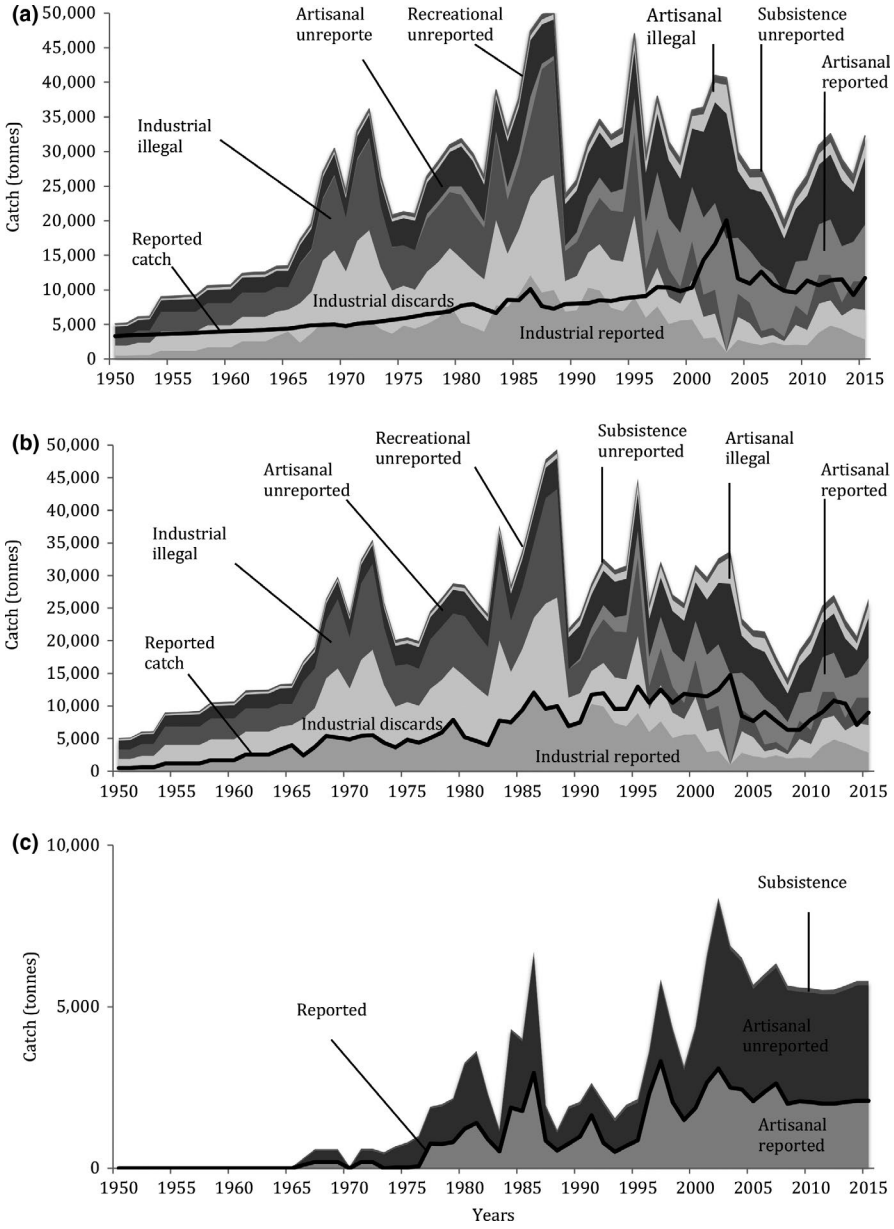

FIGURE 2 Honduran catch reconstructions for the period of 1950-2015. (a) Total combined catch from Areas 31 and 77 (Note: official reported catch black line); (b) catch reconstructions for Area 31; and (c) catch reconstructions for Area 77 (note different *y*-axis scale)

3 | RESULTS

The total reconstructed catches as estimated here for 1950–2015 were 2.9 times greater than the data reported to FAO by Honduras (Figure 2a). Official records reported total landed catches of approximately 500 t in 1950 increasing to 11,079 t by 2015. This compares to the present reconstructions that estimated total catches of around 5,000 t in 1950 and 32,000 t in 2015 (Figure 2a). Catches from the Caribbean Sea in the Atlantic Ocean (FAO Area 31) comprised the greatest contribution to total Honduran catches, with approximately 80% in 2015. For the Caribbean side (FAO Area 31), official catch records reported approximately 500 t in 1950, which increased to just under 9,000 t in 2015, while the catch reconstruction estimated 5,000 t in 1950, which increased to over 26,000 t in 2015 (Figure 2b). Catches from the Pacific Ocean (FAO Area 77) have increased in importance: in 1950, they accounted for less than 0.01% of the total catch, while by 2015 they comprised over 20% of the total reconstructed catch. No official records were identified for this area in 1950, while the reconstruction suggested catches of 23 t in 1950 (Figure 2c). By 2015, official records reported catches of 2,000 t, while this reconstruction estimated catches of nearly 6,000 t (Figure 2c).

Differences in trends between reported and reconstructed catch time series were observed (Figure 3). Reported total catches suggested a continuous period of growth from 1950 to 2000, after which catches began to decline (Figure 3a, Table 1). These reconstruction estimates followed a similar trend, but the period of growth is shorter, 1950–1986, after which time catches declined (Figure 3a, Table 1). In the industrial fishery, reported and reconstructed estimates followed the same trend; a period of growth from 1950 to 1986 was observed, followed by a significant decline (Figure 3b, Table 1). However, reconstruction estimates suggested a

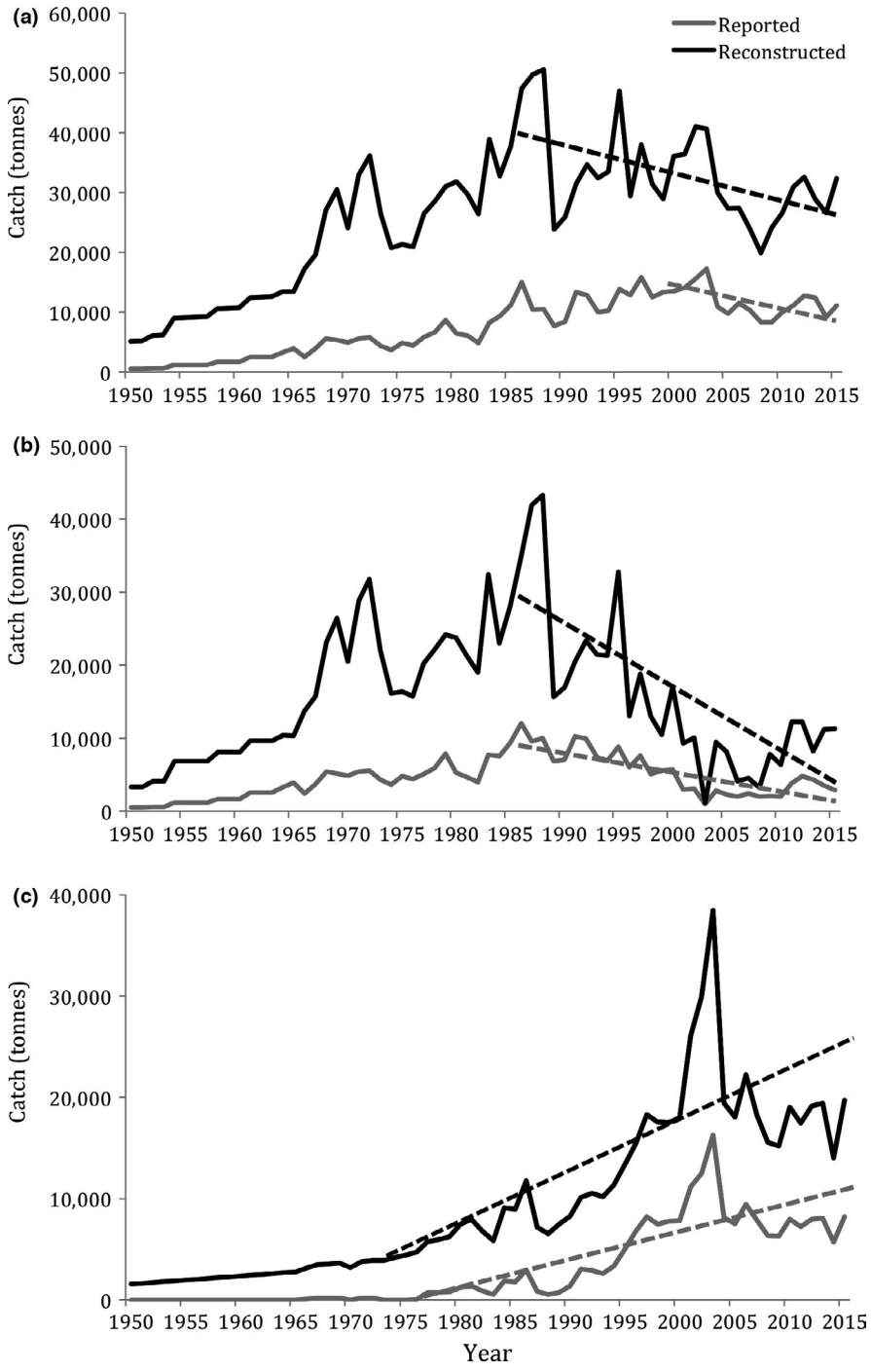

FIGURE 3 Reported catches (grey) and total reconstructed catch estimates (black) for total catches of (a) all Honduran fisheries, (b) industrial fisheries and (c) artisanal fisheries (note different *y*-axis scale). The regression trend lines (dashed lines) represent periods of catch decline or increase (identified as a breakpoint by segmented regression analyses)

much stronger decline in industrial catches (which include discards) after 1986 (Figure 3b, Table 1). While unreported industrial landings drove much of this difference, unreported discards from this sector also contributed (Figure 2a). Reconstructed and reported estimates for the artisanal fisheries followed matching trends, with a period of relatively gradual growth followed by a period of more rapid growth, starting in the early and late 1970s, respectively (Figure 3c, Table 1). The growth of artisanal fisheries is associated with an increased contribution of this sector to total landed catches of the country, and by 2015, artisanal catches accounted for approximately 61% (nearly 20,000 t) of the total catch (Figure 2a).

Historically, the industrial fishery was of greatest value; however, as catches declined in this fishery and increased in the artisanal fishery, the artisanal fishery increased in value and surpassed the landed value of the industrial fishery in 2000. The industrial fishery peaked in landed value in 1987, at US$ 59 million, and declined to just under US$ 13 million by 2015 (Figure 4a). The Caribbean (Area 31) artisanal fisheries from the same period showed an increasing value in the fishery since 1950; in 1996, a significant increase in the value of the fishery was observed with a peak value of US$ 35 million in 2003 (Figure 4a). The pattern of artisanal fisheries being of greater economic value was found in all four countries of the Mesoamerican

TABLE 1 Results of segmented regressions and Davies tests for total, industrial and artisanal reconstructed and reported catches of Honduras for the time period 1950–2015, and for reconstructed economic landed value (2010 US$) of the industrial and artisanal fisheries

		Segmented regressions			
Catch sector	**Landed catch time series**	**Breakpoint (year)**	**Line**	**Slope (t./year)**	**Davies test**
Total	Reconstructed	–	1	951.8	–
		1986	2	−407.8	0.0001
	Reported	–	1	284.5	–
		2000	2	−276.4	0.0001
Industrial	Reconstructed	–	1	706.3	–
		1986	2	−909.2	0.0001
	Reported	–	1	226.6	–
		1986	2	−261.9	0.0001
Artisanal	Reconstructed	–	1	105.4	–
		1972	2	456.5	0.04
	Reported	–	1	4.9	–
		1979	2	261.8	0.0002
		Segmented regression			
Catch sector	**Landed value time series**	**Breakpoint (year)**	**Line**	**Slope (US$million/year)**	**Davies test**
Industrial	Reconstructed	–	1	1.2	–
		1986	2	−2.4	0.0001
Artisanal	Reconstructed	–	1	0.2	–
		1996	2	0.8	0.0001

reef region (Figure 4). In Mexico and Belize, artisanal fisheries have been of greater value since 1950, but this gap has only increased over time (Figure 4b,c). In Guatemala, as in Honduras, artisanal fisheries became more valuable around 2001 (Figure 4d).

4 | DISCUSSION

The reconstructed catches for the Honduran fisheries in the Atlantic (FAO Area 31) and Pacific (FAO Area 77) EEZs were 2.9 times greater than the catches (landings only) reported by FAO on behalf of Honduras. The reconstruction illustrated that contrary to the official reported data, which implied a period of continuous growth from 1950 to 2000, total reconstructed catches suggested that the Honduran catches have actually been in decline since 1986. This decline, driven by strongly declining industrial catches, was masked by significant increases in artisanal catches starting in the early 1970s. The growth in artisanal catches meant that by 1996, catches of the artisanal sector exceeded the catches of the industrial fishery and by 2015 accounted for approximately 61% of the total reconstructed catches. Associated with the change in the dominance of landed catch from the industrial to the artisanal sector is a distinct shift in economic importance since 2000, with the artisanal fishery worth more annually than the industrial fishery. There is lag of approximately 4 years between landed catch and the economic value of the artisanal fishery surpassing the industrial fishery. This is due to the high-value species associated with the industrial fishery, for example spiny lobster; in contrast to the lower priced finfish, which contribute a greater proportion of artisanal fishery catches. A similar trend has been observed in Guatemala, while artisanal fisheries have been more economically valuable than industrial catches in Mexico and Belize since 1950. These economic data highlight the importance of artisanal fisheries within the Mesoamerican reef ecoregion, which supports over 2 million coastal people (Kramer & Kramer, 2002), and highlight the need for focused management within this important fishing sector.

The shift in sector emphasis from industrial to artisanal fisheries has important implications for fisheries management, as artisanal fisheries have a greater potential for sustainable use of coastal resources (Pauly, 2006), and to ensure the resilience of coastal communities through food security (Golden et al., 2016) and employment (Beltrán Turriago, 2013). These findings highlight the critical importance of disaggregating data to fisheries sectors to identify important trends and patterns within a country's fishery (Pauly & Zeller, 2016a) and for investing in data collection systems for artisanal fisheries (Pauly & Charles, 2015). The majority of artisanal fisheries in Honduras are within the informal sector and therefore no official records of catches or the associated value exist, which proliferates the underestimation of their importance to coastal communities and their economies.

The reported data for Honduras suggested mistakenly that the country's fisheries were growing until 2000, whereas the

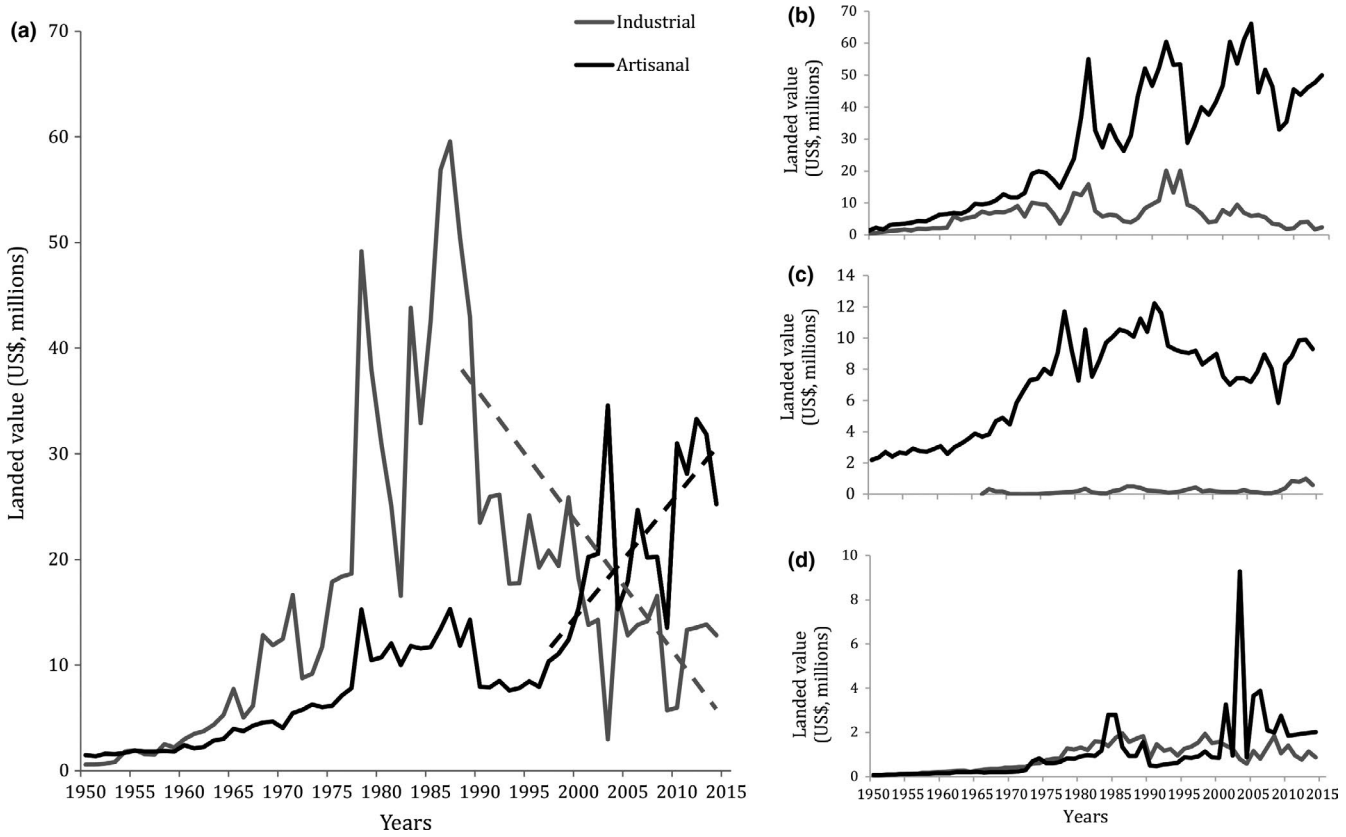

FIGURE 4 Mesoamerican reef ecoregion fishery valuations, based on reconstructed landed data (discards are not included) from the Caribbean Sea fisheries of (a) Honduras, (b) Mexico, (c) Belize and (d) Guatemala (note different *y*-axis scale). Landed catch values are of reconstructed catches, and data for all countries were downloaded from the Sea Around Us online database. The regression trend lines (dashed lines) represent periods of catch decline or increase (identified as a breakpoint by segmented regression analyses) in the Honduran fishery

reconstruction illustrated that the growth period ended much earlier, in 1986, followed by a much stronger decline in catches. The disparity in trends between these two data sets has important implications for fisheries management and data collection from all fisheries sectors. The results highlight that the aggregation of data from different fisheries sectors can mask important changes within a country's fishery (Pauly & Charles, 2015). By disaggregating the industrial and artisanal sectors, it was possible to show how the industrial fisheries have been in decline since 1986, while catches from artisanal fisheries, from both the Atlantic and Pacific Oceans, have increased. The combined catches from the Atlantic and Pacific are greater than the industrial fishery landings. Although a lack of consistent fishing effort data prevented determination of whether the decline in industrial catches was related to a shift in fishing effort from the industrial sector to the artisanal sector, it is likely that the artisanal fishery has undergone independent growth in parallel, rather than in response to a decline in the industrial fleet. This has been mirrored in the economic growth in the artisanal sector and provides further evidence for the need of comprehensive management of artisanal fisheries to maintain food security and livelihoods in coastal communities.

The general results of this catch reconstruction for Honduras are comparable to other reconstructions for Central American countries, with reconstructed data being higher than reported data, 1.4 times for Panama (Harper, Guzman, Zylich & Zeller, 2014), 2.6 times for Costa Rica (Trujillo et al., 2012), 3.4 times for Nicaragua (Haas, Harper, Zylich & Zeller, 2015) and 3.5 times for Belize (Zeller, Graham & Harper, 2011), and about 1.5 globally (Pauly & Zeller, 2016a,2016b). Additionally, artisanal fisheries are of greatest economic importance in the Caribbean fisheries of the four countries of the Mesoamerican reef ecoregion, Mexico, Belize, Guatemala and Honduras. Interannual variability on the reported and reconstructed catches trend is commonly found in all catch reconstruction analysis (e.g. Trujillo et al., 2012; Harper et al., 2014; Haas et al., 2015). This could be a phenomenon based on the natural species fluctuations or a result of changing fishing pressure due to externalities such as fuel prices.

While the estimates of catches improved in terms of tonnages, the taxonomic resolution of these reconstructions is low, and for effective management, the collection of data with greater taxonomic resolution is required. Greater investment needs to be made in collecting such improved data, which should also include fishing effort data across all fisheries sectors. There have been important advances to address the complex task of collecting fisheries data from widely dispersed artisanal fisheries, which are characterised by geographical remoteness, the diversity of supply-chain participants (commercial fish buyers, markets and restaurants) and fishing

gears used. Specifically, in Honduras and Belize a novel freeware application, *OurFish* (https://ourfish.org/), is being implemented that records transactions between fishers and fish buyers, including restaurants, using widely available and extensively used cell phone and Wi-fi technology. This application is connected to national fisher licensing databases, which links each transaction to individual fishers, thus allowing for fisheries data at the individual, community, region and national level to be collated and used for management. This initiative has been a collaborative effort between multiple institutions, including government departments, non-government organisations and local communities. The system supports the aim to provide managers with up-to-date, comprehensive fisheries data on an ongoing basis, which can be used to develop local, regional and national fisheries management plans, and directly include and link principle stakeholders (i.e. local artisanal fishers and fish buyers) within the data collection and data use process. With the advent of these digital platforms that can be used directly by fishing communities, the onus is now on those involved in fisheries management and governance to help scale-up the adoption of these systems to transform fisheries data collection to support data for decision making around the status and use of marine fisheries. Finally, these fisheries management and governance participants also need to ensure that these new data are seamlessly incorporated in all national and international (i.e. FAO) data reporting schemes.

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