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A RECONSTRUCTION OF COLOMBIA'S MARINE FISHERIES CATCHES

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ABSTRACT

Colombia has distinct EEZs of relatively comparative size on its Atlantic and Pacific coasts, both with diverse fisheries. Historically, regulation of the fisheries has frequently moved between different government agencies, to the detriment of effective management and enforcement. Shrimp was the largest fishery until the mind-1980s, when overfishing resulted in a decline and its importance replaced by tuna and anchovy fisheries. Small-scale coastal fisheries are also important contributors and utilize a variety of gear. This report is an update of the Colombia catch reconstruction completed by Wielgus *et al.* (2007; see also Wielgus *et al*. 2010), and attempts to reconstruct fish catches for the period 1950-2010, on both coasts, and includes removals not normally reported, such as discards and subsistence fisheries. The total reconstructed catch for 1950-2010 was found to be 2.3 times that reported to the FAO over the same time period, with industrial landings contributing 42% of the overall catch. Subsistence and artisanal fisheries made up 23% and 15%, respectively. Discards (industrial) accounted for 20% of the catch. Anchovies (Engraulidae) were the most important taxa, making up 18%, followed by drums and croakers (Sciaenidae), with 10%. The reconstruction demonstrates the need for effective management and reporting structures to reduce the discrepancies between reported and actual catches. It also highlights the high degree of by-catch and discards in industrial shrimp fisheries and the need for effective solutions to reduce fish wastage.

INTRODUCTION

Colombia has coasts on both the Atlantic (Caribbean Sea) and Pacific Oceans, with a slightly larger EEZ in the Atlantic ocean (399,380 km^2) than in the Pacific (326,655 km^2) (Figure 1). Its fisheries are very diverse and contain a multitude of species (Prado and Drew 1999). Although human communities on both coasts have historically fished as an important part of their livelihood, the relatively small size of commercially important stocks has constrained Colombian fisheries (Squires and Riveros 1978; Pérez-Ramírez 1986; Prado and Drew 1999). Government agencies are responsible for collecting and analyzing fisheries statistics, as well as regulating fishing activities, but this function has been frequently moved between agencies, to the detriment of fisheries management. Most recently, management responsibilities transferred from the National Institute of Fisheries and Aquaculture (INPA), which managed the fisheries from 1990-2003, to a subsidiary agency of the Ministry of Agriculture and Rural Development – the Colombian Institute of Rural Development (INCODER).

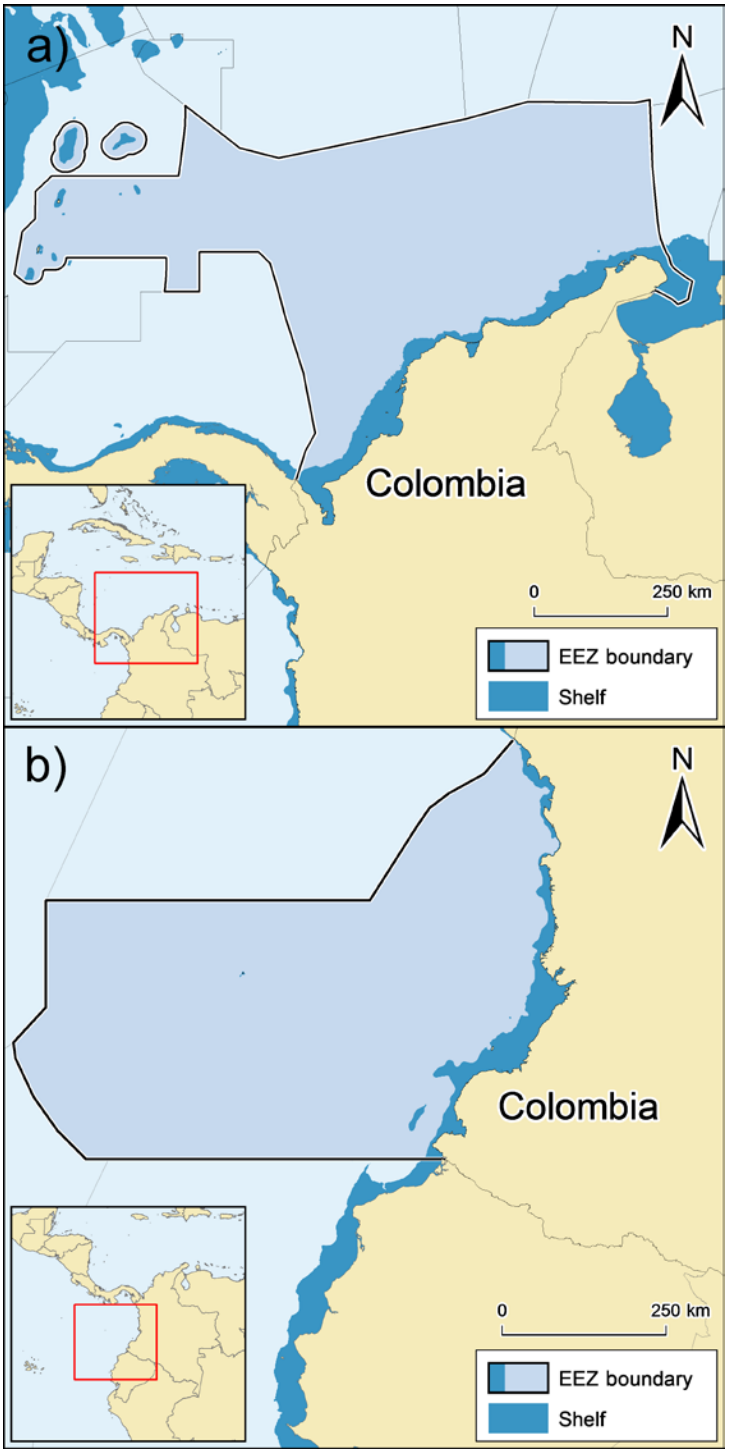

Figure 1. Columbia's EEZ in a) the Atlantic Ocean (Caribbean Sea) and b) the Pacific Ocean.

Industrial fisheries

Until the mid-1980s, shrimp was the most important contribution to the reported landings of the industrial fishery in both the Atlantic and the Pacific (Mora-Lara 1987). However, since overfishing began to take place in the mid-1980s(Mora-Lara 1987; Anon. 1988), tuna has replaced shrimp as the largest component of the industrial catch. Since industrial fishing first started in Colombia (late 1950s for the Pacific, and mid-1960s for the Atlantic (Gómez-Canchong *et al.* 2004)) little has changed in regard to the trawlers used (Rueda *et al.* 2004; Zúñiga-Clavijo *et al.* 2004). Most of these trawlers are based in shallow water, have a capacity of around 20-40 t (Squires and Riveros 1978; Barreto-Reyes *et al.* 2001), and are fuel inefficient. Due to the unselective nature of the gear utilized, there are large proportions of unreported by-catch that are either discarded or retained and marketed (Duarte *et al*. 2006).

Colombia also has an industrial fishery for anchoveta (*Cetengraulis mysticetus*) and thread herring (*Opisthonema* spp.) in the Pacific. These fish are used in fish-meal and fish-oil production, and most of these products are exported (Beltrán-Turriago and Villaneda-Jiménez 2000). As well as small industrial fisheries for spiny lobster (*Panulirus argus)* and queen conch (*Lobatus gigas*[1]*)* in the Caribbean, high value fish such as snappers, groupers and sharks, are also targeted in both oceans for the export market.

Small-scale fisheries

Small-scale fisheries are a large contributor to the overall quantity of fish landed in Colombia and coastal resources in both oceans using small boats (less than 15m) and nets cast from shore (Magnusson *et al.* 1983; Mora-Lara 1987; Pereira-Velásquez 1993), most commonly utilizing cast nets, gill nets, surrounding nets, traps and longlines (Beltrán-Turriago 2001). The small-scale shrimp fishery favours surrounding nets, but suffers a high capture rate of immature shrimp and fish, due to the nets often have mesh sizes below the legal limit (Friedemann and Arocha 1984; Mora-Lara 1986, 1987; Beltrán-Turriago 2001). Large numbers of under-sized fish are also caught in the Tumaco area, where artisanal shrimp trawl nets with small mesh sizes (1.0-2.5cm) are operated from motorized canoes in the mangroves, resulting in large incidental catches of juveniles (Friedemann and Arocha 1984). Some of the catch of small scale fisheries is purchased by the industrial sector and exported, although most of it supplies the Colombian domestic market for consumption (Beltrán-Turriago 2001).

Here we present an update (extending the catch to 2010) of the reconstruction of the Colombian Atlantic and Pacific fisheries catches by Wielgus *et al.* (2007, 2010), which was conducted using the methodology in Zeller *et al.* (2006, 2007). First we estimate the contribution of small-scale fisheries as a proportion of the reconstructed officially-reported landings. We then estimate unreported catches, including fish consumed by fishers and their families (subsistence), fish caught incidentally during tuna fishing, and the discarded and unreported by-catches of the shrimp industry. Lastly, the reconstructed total catch and landings statistics reported by FAO (FAO Fishstat) are compared.

[1] Previously *Strombus gigas*

METHODS

The methods used in this reconstruction closely follow the methods outlined in the previous reconstruction of Colombia's marine fisheries (Wielgus *et al.* 2007; Wielgus *et al.* 2010). The purpose of this reconstruction was to update the catch time series to the year 2010. Therefore, the 2010 FAO dataset was used as the baseline data for this reconstruction.

Commercial fisheries

The FAO 2011 dataset, for 1950-2010, was taken as the baseline for the commercial landings. It was deemed to be mostly representative of the commercial sector and was only missing a few specific components. For the purposes of this reconstruction large pelagic taxa were not considered: Bigeye tuna, Black skipjack, skipjack tuna, yellowfin tuna, and tuna-like fishes. Additional studies will address these catches.

Contribution of small-scale sector

Wielgus *et al.* (2007) provided estimates of the small-scale sector contributions to total reported landings for the years 1995 and 1999-2005 for the Atlantic and the years 1986 and 1999-2005 for the Pacific. We assumed a percent contribution of 80% for the year 1950 in both the Atlantic and the Pacific, and interpolated the percent contributions between the known years. The resulting percent contributions were applied to the reported FAO landings by species to find total artisanal and industrial catch amounts. Since miscellaneous fish values ("marine fishes nei") were relatively high in both the Atlantic and Pacific catches, 90% of the total "marine fishes nei" category for each sector was taken and disaggregated using the proportional breakdown of the remaining taxa (excluding the invertebrates).

Shrimp fishery

Catches of the shrimp fishery were estimated using reported data for 1950-2010 from the 2011 FAO database. Wielgus *et al.* (2007) separated catches into artisanal and industrial classifications; however, *Sea Around Us* classifies any fishing using towed gear as industrial, regardless of scale, in accordance with Martín (2012). Therefore, all shrimp catches in this reconstruction were considered industrial.

By-catch and discards

FAO total reported shrimp landings were used in combination with ratios calculated by Wielgus *et al.* (2007) to account for the removal of non-shrimp species from the Atlantic and Pacific Oceans. A by-catch/shrimp ratio of 2.57 and a discard/shrimp ratio of 9.58 was apportioned to the Atlantic, while a by-catch/shrimp ratio of 2.43 and a discard/shrimp ratio of 0.89 was used for the Pacific, based on a mean of the ratios determined by the studies of Anon. (1983) and Duarte *et al.* (2006). García (1985) found that by-catch was reported to fishing authorities in Cartagena between 1974 and 1983. A reported by-catch/shrimp ratio of 0.15 was therefore subtracted from the by-catch/shrimp ratios mentioned above to give an unreported by-catch/shrimp ratio of 2.42 for the Atlantic and 2.28 for the Pacific. The obtained by-catch and discard numbers were then disaggregated taxonomically using proportions calculated from (Anon. 1983) and (Trujillo 1986) for the Atlantic and Pacific, respectively.

These proportions were adjusted to reduce the amount of miscellaneous uncategorized fish by removing the 'whitefish' and 'trash' components and re-normalizing (Table 1).

Table 1. Proportions of taxa present in retained by-catch and discards of the shrimp fishery in the Atlantic and Pacific Oceans (Anon. 1983; Trujillo 1986).

Atlantic		**Pacific**	
Taxon	**%**	**Taxon**	**%**
Lutjanidae	18.0	Portunidae	24.4
Sciaenidae	14.1	Sciaenidae	14.5
Mullidae	10.6	Engraulidae	12.8
Cilus gilberti	9.9	Squalidae	8.2
Ophidiidae	7.7	Carangidae	3.4
Haemulidae	6.4	Gerreidae	3.4
Ariidae	6.0	Clupeidae	3.0
Trichiurus lepturus	5.3	Loliginidae	2.1
Gerreidae	4.9	Marine fishes not identified	28.3
Caranx	3.1		
Priacanthidae	2.3		
Clupeidae	1.8		
Sphyraena	1.1		
Selene setapinnis	1.0		
Chloroscombrus chrysurus	0.9		
Marine fishes not identified	6.8		

Subsistence

Combining information from a number of sources (Rodas-López *et al.* 1994; Manjarrés *et al.* 2005a, 2005b, 2005c), Wielgus *et al.* (2007) calculated that 50.6% of total annual catch was retained, rather than sold, by small-scale fishers in the Caribbean. In 1986, 98% of Caribbean fish catches, excluding tunas, were from the small-scale sector, suggesting that 49.6% of the total catches (excluding tunas) were retained for personal consumption. This was converted into a raising factor of 1.98 (1/0.504), therefore we multiplied the Caribbean reported catch by 0.98 to calculate the subsistence catch.

In the Pacific, Tobón-López *et al.* (2008) reported that twenty fish families made up 64% of the catch. From this, Wielgus *et al.* (2007) combined the contribution of families of low commercial but high subsistence value, as well as the families containing species not reported in official data and found that these 10 families made up 29.1% of the total catch. In 1978, 76.2% of the Pacific landings, excluding tunas and clupeids, were caught by the small-scale sector (Pereira-Velásquez 1993), therefore suggesting that 22.2% of total catches were unreported. This was converted to a raising factor of 1.22 (1/0.778), therefore we applied a factor of 0.22 to the reported catch to calculate the contribution of the subsistence sector.

No species information was available for the Atlantic subsistence catch. However, as it was take home commercial catch we simply excluded the high value species from the commercial catch and grouped the remaining species by family in order to derive an assumed breakdown. The Pacific subsistence catches were broken down by species according to the percentages in Table 2 which were derived from the information provided in Wielgus *et al.* (2007).

Table 2. Family breakdown for subsistence catches in the Pacific (derived from Wielgus *et al.* 2007).

Family	Percentage (%)
Haemulidae	20
Sciaenidae	20
Muraenidae	10
Labridae	10
Synodontidae	10
Cirrhitidae	10
Scaridae	10
Balistidae	10

RESULTS

Total reconstructed catch

The total reconstructed catch for the 1950-2010 time period was 2.3 times that supplied to the FAO on behalf of Colombia. Overall, landings of the industrial fisheries dominated the catch, with 42.4%. Subsistence fisheries were the next most important, with 22.8%, followed by the artisanal sector, which contributed 14.5%. Discards of the industrial fisheries were responsible for 20.3% of the catch (Figure 2a). Both oceans contributed almost equally to the overall catch total (50.8% in the Pacific, 49.2% in the Atlantic).

Catches grew throughout the time period, with significant peaks in the mid-1960s and early 1990s. Beginning at 4,000 t in 1950, catches grew steadily from the late 1950s to 76,300 t in 1966. Catches then almost doubled to 142,000 t the following year, but returned to 62,300 in 1969. Catches remained relatively stable in the 1970s and 1980s, averaging 68,900 $t \cdot year^{-1}$ between 1970 and 1989. A rapid growth at the start of the 1990s resulted in a peak of 158,800 t in 1991, and an equally dramatic decline to 86,300 t in 1993. Catches thereafter declined slowly, to 36,900 t in 2010.

Across both oceans, Colombian fisheries were dominated by anchovies (Engraulidae, 18.4%). The other important taxa contributed a smaller percentage, but in similar proportions, with drums and croakers (Sciaenidae) making up 9.6%, followed by snappers (Lutjanidae, 7%) and shrimp (Penaeidae, 5.9%) (Figure 2b).

Industrial

Removals of the industrial sector contributed 62.7% of the total catches for Colombia, with discards making up 32.4% of the total industrial removals. Reconstructed industrial catches increased steadily from 1,600 t in 1950 to 70,000 t in 1968, and then declined immediately to 24,400 t in 1969. After this drop, industrial landings increased fairly steadily to a maximum of almost 119,000 t in 1991 before falling to 26,900 t by 2010.

Anchovies (Engraulidae) were the largest single family group of the industrial catch at 22.8%, with Sciaenids and Penaeids the next largest with 11.8% and 9.4%, respectively. Of the anchovy catch, 88.2%

is *Cetengraulis mysticetus,* which alone constitutes 20.1% of the total industrial catch and is by far the most important single species caught. The rest of the classified catch consists of family groups of much smaller percentages with Lutjanidae (7.5%), swimming crabs (Portunidae, 5.1%) and surmullets (Mullidae, 3.5%) the other largest taxa.

Artisanal

Total artisanal landings accounted for 14.4% of total catches. Reconstructed artisanal catches for Colombia increased steadily from 1,120 t in 1950 and peaked at almost 32,900 t in 1967. Landings dropped to 18,200 t in 1969 and peaked several times before reaching 27,400 t in 1992. Thereafter, there was a steady decrease to a low of approximately 2,500 t in 2010.

Catch composition in the artisanal sector is the similar to that of the industrial sector, with the same families dominant in the catch. The anchovy *Cetengraulis mysticetus* is again the fish caught most, making up 28.0% of the total catch. Mullets (Mugilidae, 10.4%), Centropomidae (9.0%), catfish (Ariidae, 7.3%) and Lutjanidae (6.8%), make up the next largest proportions.

Subsistence

Reconstructed subsistence catches increased from 1,300 t in 1950 to around 44,200 t in 1967, before decreasing fairly steadily to a low of 5,200 t in 1983. Landings peaked again at 28,800 t in 1992 and decreased relatively steadily to 7,500 t in 2010. Total reconstructed subsistence catches accounted for 22.8% of the total catch.

The largest contributors to the composition of subsistence catches consisted were Centropomidae (12.0%), grunts (Haemulidae, 10.1%), mojarras (Gerreidae, 9.5%), Ariidae (9.5%) and Sciaenidae (7.1%).

Atlantic

In the Atlantic, the subsistence sector was most important, contributing 29.0% of the total catch, followed by the industrial landings and artisanal sector, with 23.8% and 14.6%, respectively. Discards accounted for 32.7%. Primary taxa caught were Lutjanidae (11.5%), Sciaenidae (9.8%) and Ariidae (9.5%).

Pacific

In the Pacific, the industrial sector landings accounted for almost two thirds of the catch, with 61.7%. The subsistence sector contributed 16.5%, with artisanal fishing making up 14.3%. Discards made up the remaining 7.5%. Primary taxa were Engraulidae (37.3%), Sciaenidae (9.3%) and Penaeidae (8.4%).

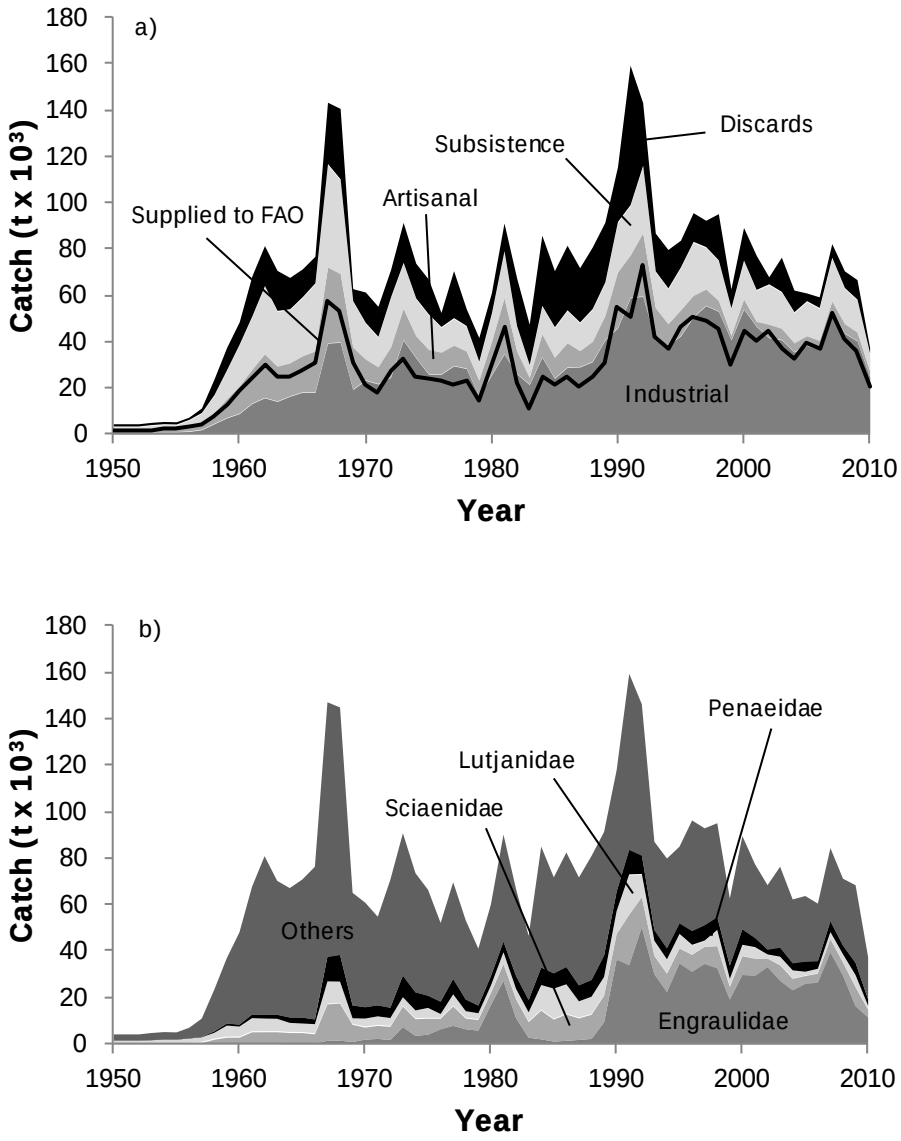

Figure 2. Reconstructed catch estimates for Colombia, 1950-2010, a) by sector, including data reported to FAO, b) by primary taxa. 'Others' includes 52 taxa not identified individually.

DISCUSSION

The reconstruction demonstrates fish catches that are 2.3 times the data officially reported and thus suggests that a significant portion of fish removals are not recorded by authorities. In particular, this includes elements of the small-scale subsistence fishery and by-catch and discards of the shrimp fisheries. Discards form over 20% of the total reconstructed catch, however the rate is significantly lower in than the Pacific, which has one of the highest discard rates in the world (Alverson *et al.* 1994). This may be due to the higher number of commercially important species in the Pacific (Table 3.)

Table 3. Number of taxa (common names) included in the marine landings statistics currently available from the Colombian fisheries management agency (INCODER).

	1975-1990		1991-2005	
Categories	Atlantic	Pacific	Atlantic	Pacific
Fishes	29	29	135	173
Crustaceans	4	4	13	21
Mollusks	4	4	1	10

That subsistence fishing is important in both oceans (particularly the Atlantic, where it makes up 30% of the catch) is unsurprising given that Colombia has one of the highest numbers of internally-displaced people worldwide (between 2 to 3 million people according to UNHCR 2007). Food security is a critical issue in many parts of the country and fish is therefore an important component of the diet in coastal communities. As more of the displaced population seeks an alternative means of sustenance and income, subsistence fishing becomes an increasingly important component of unreported fishing in the Colombian Atlantic and Pacific EEZs (Beltrán-Turriago and Villaneda-Jiménez 2000).

The data exhibits large fluctuations in landings over the years, which may in part be associated with unreliable landings data. Data collection in Colombia has been hampered by the frequent shifts of management responsibilities between various government agencies and the changes in collection procedures that result. The logistical problems of collecting data from remote communities and the reduced number of staff at fisheries management agencies may also contribute to the variance (Sáenz 1962; Ciardelli-Fadul 1968; Anon. 2000).

Fluctuations are also likely to be due to overfishing and/or environmental factors. In 1973 and 1983, for example, El Nino events coincided with decreases in Pacific shrimp landings. Overfishing in the mid-1980s resulted in the replacement of shrimp by tuna as the primary fish in the catch (Mora-Lara 1987; Anon. 1988). Since the last assessment, which included data up to 2006 (Wielgus *et al.* 2010), there has been a significant decrease in total landings and discards. This is mostly due to falls in anchovy (Engraulidae), Sciaenid and Lutjanid catches– the other main contributing taxa remained comparatively stable through the 2006-2010 period. As with other fluctuations, this may well be associated with overfishing as a result of increased pressure on the anchovy fishery by the industrial sector as demand increases for fishmeal and fish oil in areas such as the fast-growing aquaculture sector (Tacon and Metian 2008).

The reconstruction may also underestimate total catches in Colombia because there are other unreported extractive activities not included. Illegal fishing methods, such as dynamite and fish poisons, which also have an impact on non-target species, have been observed on both coasts (Giudicelli 1979; Friedemann and Arocha 1984; Pérez-Ramírez 1986); however, Colombia has a limited ability to enforce regulations (UNEP 2006). This deficiency in enforcement has also resulted in illegal fishing taking place in the San Andres Archipelago, a Colombian island chain 775 km northwest of the Atlantic coast. Colombia has granted fishing rights to the United States, which requires vessels to provide records of catches to Colombian fisheries management authorities, but there is no available information indicating that such records have been provided.

Improved governance of fisheries in Colombia would certainly begin to improve management and reduce the discrepancy between reported and actual catches. The fisheries would also be improved by technical management measures improvements to reduce by-catch and discards, such as the Turtle Excluder Devices that shrimp boats are required to deploy (Prado and Drew 1999), as well as a more rigorous enforcement of minimum mesh sizes.

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REFERENCES

Alverson DL, Freeberg MH, Pope JG and Murawski SA (1994) A global assessment of fisheries by-catch and discard. FAO Fisheries Technical Paper No. 339, Food and Agriculture Organization of the United Nations (FAO), Rome. 233 p.

Anon. (1983) Análisis evaluativo de la pesquería artesanal e industrial en el Golfo de Urabá [Evaluation of the artisanal and industrial fisheries in the Gulf of Urabá]. INDERENA, Cartagena, Spain. 11 p.

Anon. (1988) Informe sobre el estado y administración de la pesquería de camarones de agua someras en la costa del Caribe [Report on the status and administration of shallow-water shrimp fisheries in the Caribbean]. INDERENA, Bogotá, Colombia. 21 p.

Anon. (2000) Report of the workshop on management of the Caribbean spiny lobster (*Panulirus argus*) fisheries in the area of the Western Central Atlantic Fishery Commission. Mérida, Mexico, 4–8 September 2000. FAO Fisheries Report No. 643, Food and Agriculture Organization of the United Nations (FAO), Rome. 66 p. Available at: www.fao.org/fi/projects/fishcode/publications/other/FR643.pdf [Accessed: June 6, 2007].

Barreto-Reyes CG, Polo-Romero GA and Mancilla-Páramo B (2001) Nálisis biólogico-pesquero y económico de la fauna acompañante en la pesquería de arrastre industrial colombiana [Fisheries-biology and economic analysis of the incidental bycatch of industrial trawling in Colombia]. FAO Fisheries Circular No. 974, Food and Agriculture Organization of the United Nations (FAO), Rome. Available at: ftp://ftp.fao.org/docrep/fao/007/y2859e/y2859e00.pdf [Accessed: June 1, 2007].

Beltrán-Turriago CS (2001) La pesca artesanal en Colombia [Artisanal fisheries in Colombia]. FAO Fisheries Circular No. 957/2, Food and Agriculture Organization of the United Nations (FAO), Rome. 71 p. Available at: ftp://ftp.fao.org/docrep/fao/005/ad056s/ad056s00.pdf [Accessed: June 5, 2007].

Beltrán-Turriago CS and Villaneda-Jiménez AA (2000) Perfil de la pesca y la acuicultura en Colombia [Profile of fishing and aquaculture in Colombia]. Instituto Nacional de Pesquisas da Amazônia (INPA), Bogotá, Colombia. 26 p.

Ciardelli-Fadul Q (1968) The marine fisheries of Colombia and their statistics. pp. 133-144 *In*. Proceedings of the Gulf and Caribbean Fisheries Institute 20.

Duarte LO, Gómez-Canchong P, Manjarrés LM, García CB, Escobar FD, Altamar J, Viaña JE, Tejada K, J. S and Cuello F (2006) Variabilidad circadiana de la tasa de captura y la estructura de tallas en camarones e ictiofauna acompañante en la pesquería de arrastre del Mar Caribe de Colombia [Circadian variability in the catch rate and size structure of shrimp and by-catches of the Colombian Caribbean trawl fishery]. Investigaciones Marinas 34: 23-42.

Friedemann NS and Arocha J (1984) Pescadores artesanales de la Boquilla y Tumaco [Artisanal fishers of La Boquilla and Tumaco]. IDRC Research Report 3P82-0258, International Development Research Centre (IDRC), Bogotá, Colombia. 241 p.

García MA (1985) Efectos de la pesca de arrastre sobre la fauna acompañante del camarón [Effects of trawl fishing on shrimp bycatches]. FAO Fisheries Report No. 327, Food and Agriculture Organization of the United Nations (FAO), Rome. 65-78 p.

Giudicelli M (1979) La pesca artesanal marítima en la costa caribeña de Colombia: su situación, sus posibilidades y sus necesidades para el desarrollo [Artisanal marine fisheries in the Colombian Caribbean: Status, possibilities, and requirements for development]. WECAF Report No. 8, Western Central Atlantic Fishery Commission (WECAFC), Panama. 62 p.

Gómez-Canchong PG, Manjarrés LM, Duarte LO and Altamar JE (2004) Atlas pesquero del área norte del Mar Caribe de Colombia [Fisheries atlas of the northern Colombian Caribbean]. Grupo de Investigacion Evaluacion y Ecologia Pesquera (GIEEP), Santa Marta, Colombia. 229 p.

Magnusson M, Aubray R, Boerema LK, Giudicelli M and Shepard MP (1983) Colombia: desarrollo y ordenación de las pesquerías marinas [Colombia: Development and planning of marine fisheries]. Food and Agriculture Organization of the United Nations (FAO), Rome. 92 p.

Manjarrés L, Vergara A, Torres J, Rodríguez G, Arteaga E, Viaña JE, Arévalo J and Galvis R (2005a) Evaluación de peces demersales e ictioplancton en el Mar Caribe de Colombia, incluyendo condiciones oceanográficas. Parte 1: Crucero INPAVECEP/ UE/DEMER/9507 (julio de 1995) [Evaluation of demersal fish and icthyioplankton in the Colombian Caribbean, including oceanographic conditions. Part 1: INPA-VECEP/UE/DEMER/9507 cruise, July 1995]. Intrópica 2: 51-86.

Manjarrés L, Vergara A, Torres J, Rodríguez G, Arteaga E, Viaña JE, Arévalo J and Galvis R (2005b) Evaluación de peces demersales e ictioplancton en el Mar Caribe de Colombia, incluyendo condiciones oceanográficas. Parte 2: Crucero INPAVECEP/ UE/DEMER/9510 (octubre/noviembre de 1995) [Evaluation of demersal fish and icthyioplankton in the Colombian Caribbean, including oceanographic conditions. Part 2: INPA-VECEP/UE/DEMER/9510 cruise, October/November 1995]. Intrópica 2: 87-115.

Manjarrés L, Vergara A, Torres J, Rodríguez G, Arteaga E, Viaña JE, Arévalo J and Galvis R (2005c) Evaluación de peces demersales e ictioplancton en el Mar Caribe de Colombia, incluyendo condiciones oceanográficas. Parte 3: Crucero INPAVECEP/ UE/DEMER/9604 (abril de 1996) [Evaluation of demersal fish and icthyioplankton in the Colombian Caribbean, including oceanographic conditions. Part 3: INPA-VECEP/UE/DEMER/9604 cruise, April 1996]. Intrópica 2: 117-149.

Martín JI (2012) The small scale fleet in the reform of the Common Fisheries Policy. Policy Department B: Structural and Cohesion Polices, European Parliament: Directorate-General for Internal Policies of the Union - Fisheries, Brussels (Belgium). 44 p.

Mora-Lara O (1986) El estado de la pesca industrial y artesanal en Colombia y sus posibilidades de desarrollo [The status of industrial and artisanal fishing in Colombia and the possibilities for their development]. pp. 1019-1032 *In* Anon. (ed.), Proceedings of the international conference of the Groupe d'Ètude des Resources Maritimes (GERMA) on small-scale fisheries and economic development and of the third biennial conference of the International Institute of Fisheries Economics and Trade (IIFET) on fisheries trade. Development and Policies V (2). University of Quebec, Rimouski, Canada.

Mora-Lara O (1987) Análisis de la pesca de langostino efectuada por la flota camaronera de Buenaventura y el "trasmallo electrónico" [Analysis of shrimp fishing by the industrial fleet in Buenaventura and by surrounding nets]. INDERENA, Bogotá, Colombia. 15 p.

Pereira-Velásquez F (1993) La pesca en el Pacífico [Fishing in the Pacific]. pp. 58-64 *In* Leyva P (ed.), Colombia Pacífico: Tomo II. FEN, Bogotá, Colombia.

Pérez-Ramírez G (1986) The case of small fisheries and the economic development of Colombia. pp. 967-971 *In* Anon. (ed.), Proceedings of the international conference of the Groupe d'Ètude des Resources Maritimes (GERMA) on small-scale fisheries and economic development and of the third biennial conference of the International Institute of Fisheries Economics and Trade (IIFET) on fisheries trade. Development and Policies V (2). University of Quebec, Rimouski, Canada.

Prado J and Drew S (1999) Research and development in fishing technology in Latin America. FAO Fisheries Circular No. 944, Food and Agriculture Organization of the United Nations (FAO), Rome. 31 p.

Rodas-López E, Zárate-Villarreal M and Caycedo-Lara M (1994) Magnitud, composición y valores económicos de las capturas con trasmallo, boliche y cordel de tres agrupaciones de pescadores en el área de influencia de Cartagena [Magnitude, composition, and economic value of the catches with surrounding nets, cast nets, and lines of 3 fishing groups in the Cartagena region].

pp. 71-82 *In* Valderrama-Barco M, Rodríguez-Gómez H, Acevedo-Rojas G and Gallo-Nieto J (eds.), Boletín Científico INPA, 1994. Instituto Nacional de Pesquisas da Amazônia (INPA), Bogotá, Colombia.

Rueda M, Higuera-Salazar H and Angulo-Sinisterra JA (2004) Caracterización tecnológica de la flota de arrastre de camarón del Pacífico de Colombia [Technological characteristics of the shrimp-trawling fishery in the Colombian Pacific]. Food and Agriculture Organization of the United Nations (FAO), Rome. 28 p. Available at: ftp://ftp.fao.org/FI/DOCUMENT/rebyc/colombia/FishingTechnology_Pacific_Coast_PPR_1.pdf [Accessed: July 29, 2007].

Sáenz W (1962) Fisheries progress in Colombia. pp. 141-144 *In* Higman JB (ed.), Proceedings of the 14th annual session of the Gulf and Caribbean Fisheries Institute. University of Miami, Coral Gables, U.S.

Squires HJ and Riveros G (1978) Fishery biology of spiny lobster (Panulirus argus) of the Guajira Peninsula of Colombia, South America, 1969-1970. Proceedings of the National Shellfisheries Association 68: 63-74.

Tacon AGJ and Metian M (2008) Global overview on the use of fish meal and fish oil in industrially compounded aquafeeds: Trends and future prospects. Aquaculture 285(146-158).

Tobón-López A, Rubio EA and Giraldo A (2008) Composición y análisis taxonómico de la íctiofauna del golfo de Tribugá, Pacífico norte de Colombia [Composition and taxonomic analysis of ichthyofauna Tribugá Gulf, northern Colombia Pacific]. Latin American Journal of Aquatic Research 36(1): 93-104.

Trujillo OA (1986) Estudio sobre las capturas incidentales de la pesca del camarón en la Ensenada de Tumaco, Pacífico colombiano, 1983-1984 [Study on the incidental by-catches of shrimp fishing in the Bay of Tumaco, Colombian Pacific, 1983-1984]. Fundación Universidad Jorge Tadeo Lozano, Bogotá, Colombia. 37 p.

UNEP (2006) Permanent Commission for the South Pacific (CPPS). Eastern equatorial Pacific, GIWA regional assessment 65. University of Kalmar, Kalmar, Sweden. 81 p. Available at: www.giwa.net/areas/reports/r65/giwa_regional_assessment_65.pdf [Accessed: September 18, 2007].

Wielgus J, Caicedo-Herrera D and Zeller D (2007) Reconstruction of Colombia's marine fisheries catches. pp. 69-79 *In* Zeller D and Pauly D (eds.), Reconstruction of marine fisheries catches for key countries and regions (1950-2005). Fisheries Centre Research Reports 15 (2)University of British Columbia.

Wielgus J, Zeller D, Caicedo-Herrera D and Sumaila R (2010) Estimation of fisheries removals and primary economic impact of small-scale and industrial marine fishery in Colombia. Marine Policy 34: 506-513.

Zeller D, Booth S, Craig P and Pauly D (2006) Reconstruction of coral reef fisheries catches in American Samoa, 1950-2002. Coral Reefs 25: 144-152.

Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fisheries catches for U.S. flag island areas in the western Pacific: The last 50 years. Fisheries Bulletin 105(2): 266-277.

Zúñiga-Clavijo H, Altamar J and Manjarrés L (2004) Caracterización tecnológica de la flota de arrastre camaronero del Mar Caribe de Colombia [Technological characteristics of the shrimp trawling fishery in the Colombian Caribbean]. Food and Agriculture Organization of the United Nations (FAO), Rome. 20 p. Available at: ftp://ftp.fao.org/FI/DOCUMENT/rebyc/colombia/Fishing_Technology_Atlantic_Coast_PPR_1.pdf [Accessed: July 29, 2007].

Appendix Table A1. Reconstructed fish catches for Columbia by sector, 1950-2010, including data reported to FAO

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Discards
1950	1,501	4,030	620	1,120	1,330	960
1951	1,501	4,030	640	1,110	1,330	960
1952	1,501	4,030	650	1,090	1,330	960
1953	1,801	4,630	740	1,310	1,630	960
1954	2,001	5,020	800	1,440	1,820	960
1955	1,901	4,890	800	1,340	1,790	960
1956	2,901	6,870	1,090	2,050	2,770	960
1957	4,301	10,850	1,820	2,960	4,150	1,920
1958	7,600	23,380	4,390	4,900	7,380	6,710
1959	12,700	37,010	6,940	8,180	12,310	9,580
1960	18,300	48,100	8,830	11,890	17,800	9,580
1961	23,500	67,850	13,170	14,690	22,750	17,240
1962	30,200	80,910	15,630	18,920	29,110	17,240
1963	24,900	70,210	14,080	15,180	23,710	17,240
1964	24,802	67,200	16,300	14,380	22,990	13,520
1965	27,402	70,870	18,050	15,660	25,200	11,960
1966	30,902	76,310	17,920	17,920	29,040	11,430
1967	57,401	142,810	39,250	32,850	44,250	26,460
1968	53,401	140,150	39,640	29,660	40,460	30,380
1969	30,801	62,340	19,250	18,200	19,700	5,190
1970	20,804	60,900	23,210	9,130	15,420	13,140
1971	17,904	54,730	21,620	7,370	12,780	12,960
1972	27,403	70,560	24,520	13,040	21,260	11,740
1973	32,202	90,950	40,560	13,670	19,480	17,230
1974	24,748	73,330	32,910	9,450	15,960	15,000
1975	23,999	66,450	25,870	10,680	14,930	14,970
1976	23,015	52,070	25,810	9,490	10,730	6,040
1977	21,614	70,110	29,450	8,880	11,520	20,260
1978	22,836	53,750	28,300	7,530	10,630	7,290
1979	14,770	41,230	16,370	6,770	7,950	10,140
1980	29,185	60,580	25,510	14,360	12,010	8,710
1981	46,585	90,690	34,620	24,170	19,940	11,960
1982	21,865	66,990	26,030	9,820	10,520	20,620
1983	10,865	46,970	21,380	3,010	5,250	17,330
1984	24,371	85,410	33,200	9,930	12,010	30,280
1985	21,307	70,110	24,070	9,020	12,840	24,180
1986	24,803	81,070	28,820	10,530	13,870	27,850
1987	20,499	71,390	28,970	7,010	12,030	23,380
1988	24,402	80,320	31,250	8,740	13,810	26,530
1989	30,415	90,990	40,680	10,450	14,170	25,690
1990	54,810	114,930	45,860	24,090	21,430	23,550
1991	50,834	158,790	58,900	18,360	21,360	60,170
1992	73,060	142,630	59,480	27,380	28,800	26,970
1993	42,047	86,320	40,560	13,980	15,470	16,310
1994	37,058	79,260	38,400	9,200	15,090	16,570
1995	46,350	83,260	42,400	11,200	18,190	11,470
1996	50,441	95,130	50,540	9,330	22,900	12,360
1997	48,662	91,870	55,470	7,120	17,920	11,360
1998	45,188	94,710	52,990	4,680	17,100	19,940
1999	29,947	62,200	40,680	1,910	11,550	8,060
2000	44,132	88,750	53,950	4,310	16,450	14,040
2001	40,206	76,810	46,480	2,140	13,400	14,790
2002	44,225	67,450	41,590	5,800	17,050	3,000
2003	36,680	75,930	40,700	4,950	15,540	14,740
2004	32,302	61,730	35,420	3,940	13,040	9,330
2005	39,363	60,480	38,310	4,110	14,740	3,310
2006	36,389	58,810	36,540	3,830	13,880	4,560
2007	52,374	81,790	53,340	4,040	18,530	5,880
2008	40,915	70,030	43,480	4,160	15,220	7,170
2009	36,274	66,250	40,180	3,820	13,850	8,400
2010	20,780	36,920	24,690	2,480	7,540	2,220

Appendix Table A2. Reconstructed fish catches for Colombia by primary taxa, 1950-2010. 'Others' includes 46 taxa not mentioned individually.

Year	Engraulidae	Sciaenidae	Lutjanidae	Penaeidae	Others
1950	0	300	990	100	2,640
1951	0	300	990	100	2,640
1952	0	300	990	100	2,640
1953	0	300	1,140	100	3,090
1954	0	300	1,390	100	3,230
1955	0	290	1,390	100	3,110
1956	0	290	1,880	100	4,600
1957	0	580	2,130	200	7,940
1958	0	2,020	2,590	700	18,070
1959	0	2,890	4,800	1,000	28,320
1960	0	2,890	4,400	1,000	39,800
1961	0	5,200	5,700	1,800	55,160
1962	0	5,220	5,500	1,800	68,400
1963	0	5,240	5,380	1,800	57,790
1964	490	4,400	3,970	2,500	55,840
1965	650	4,230	3,720	2,700	59,570
1966	410	3,920	3,990	2,100	65,900
1967	1,590	15,550	9,520	6,300	109,850
1968	1,630	15,890	9,060	6,800	106,770
1969	1,060	7,350	2,410	2,900	48,620
1970	2,070	5,130	3,530	5,000	45,170
1971	2,370	5,570	3,730	4,800	38,260
1972	1,940	5,580	3,430	4,400	55,210
1973	7,410	8,820	3,650	9,600	61,470
1974	3,690	7,120	3,390	7,670	51,450
1975	4,180	6,830	4,290	5,430	45,720
1976	6,500	4,470	1,700	5,380	34,010
1977	7,940	8,330	4,850	7,240	41,760
1978	6,470	4,610	2,820	5,680	34,170
1979	5,930	4,520	2,560	3,620	24,600
1980	16,810	5,170	2,910	4,650	31,040
1981	27,080	7,260	4,830	5,300	46,230
1982	11,210	8,150	4,110	6,030	37,500
1983	2,880	6,670	3,870	5,850	27,710
1984	2,200	12,230	10,660	8,070	52,250
1985	1,250	9,400	12,950	5,030	41,490
1986	1,560	11,250	12,610	6,220	49,430
1987	1,940	9,210	6,980	6,670	46,600
1988	2,370	10,320	7,400	6,690	53,540
1989	9,470	11,360	7,780	8,960	53,420
1990	36,190	11,030	9,680	5,440	52,590
1991	33,810	21,760	17,050	10,140	76,030
1992	49,930	13,170	9,680	4,540	65,310
1993	29,880	8,020	6,210	4,060	38,160
1994	22,360	7,900	5,880	4,340	38,770
1995	34,560	6,500	5,980	3,030	33,180
1996	30,980	7,390	4,000	5,020	47,750
1997	34,340	7,410	2,430	5,830	41,850
1998	32,500	9,550	6,710	5,370	40,590
1999	19,180	5,450	3,170	5,370	29,040
2000	29,680	8,050	4,650	6,040	40,330
2001	29,210	7,510	4,670	3,560	31,870
2002	32,990	3,770	1,470	1,340	27,870
2003	27,160	6,720	3,400	3,700	34,960
2004	23,080	5,010	3,300	2,770	27,560
2005	25,830	3,450	1,530	1,330	28,340
2006	26,430	3,860	1,790	1,810	24,920
2007	39,270	5,850	2,720	2,310	31,640
2008	29,360	5,720	3,210	2,780	28,950
2009	16,310	8,200	4,850	3,290	33,590
2010	11,560	3,260	1,390	2,490	18,220