

Estimation of fisheries removals and primary economic impact of the small-scale and industrial marine fisheries in Colombia

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ABSTRACT

Colombia has coasts on both the Atlantic and Pacific Oceans, but its marine fisheries are limited by the relatively small size of commercially important stocks. However, diverse fishery resources have traditionally been exploited by coastal communities, and industrial fisheries have grown in recent years with the intensification of tuna fishing in both oceans. The management of Colombia's fisheries has been hampered by frequent administrative changes, which has notably led to the disappearance of a part of the official landings data. We estimated total fisheries removals (reported plus discards and unreported catches) in the Colombian Atlantic and Pacific Oceans for the period 1950–2006. We used secondary sources of information to estimate missing data, and we estimated subsistence fishing and the unreported by-catches of the shrimp and tuna fisheries. We used available information on seafood prices to estimate the relative economic impact (gross revenues) of the small-scale and industrial sectors for the period 2000–2006. Our results suggest that for the period 1950–2006, the Colombian marine fisheries catches may have been almost twice the landings reported by FAO on behalf of the country (2.8 times higher in the Atlantic; 1.3 times higher in the Pacific). Although the total gross revenues of industrial fisheries were higher than those of the small-scale sector, the latter commanded higher gross revenues in the Atlantic in 2006.

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1. Introduction

Colombia has coasts on the Atlantic (Caribbean Sea) and Pacific Oceans (Fig. 1), but its marine fisheries are restricted by the relatively small size of commercially important stocks [1]. However, Colombian marine fisheries are diverse, and they have contributed historically to the livelihood of the country's coastal communities [1–3].

Fisheries management in Colombia has been impaired by frequent transfers of management responsibilities between government agencies. In recent times, these tasks fell on the National Institute of Fisheries and Aquaculture (INPA). With the closure of INPA in 2003, the Colombian Institute of Rural Development (INCODER), a subsidiary agency of the Ministry of Agriculture and Rural Development, became responsible for data collection and policy making for fisheries. In light of the dispersion of fishery information in Colombia and the knowledge gaps on the economic contribution of marine fisheries to the country's economy, the goal of this study was to gather fisheries data from scattered sources on marine fisheries to estimate total

fisheries removals (vs. reported catch) and to evaluate the socioeconomic contribution of the small-scale and industrial fisheries. The present study builds on preliminary work done on Colombia's historical catches [4].

1.1. Small-scale fisheries

Small-scale fisheries (nets cast from the shore and boats less than 15 m) target coastal resources in both oceans. The entire product is consumed in Colombia, and small-scale fisheries supply the majority of the seafood that is sold in the country [5–7]. There are approximately 14,000 small-scale fishers in the Caribbean, and approximately 15,000 in the Pacific coast [8]. The most common fishing gears used by small-scale fisheries are cast nets, gill nets, surrounding nets, traps, and long lines [9]. Surrounding nets are widely used by small-scale fishers to capture shrimp, and their mesh size is frequently below the legal limit [9–11]. These nets capture large numbers of immature shrimp and fish [6]. In the port of Buenaventura, shrimp is captured using surrounding nets, while in the Tumaco area shrimp fishing is done with artisanal trawl nets that are operated from motorized canoes [6]. The small mesh size of these nets (1.0–2.5 cm) results in the incidental catch of large numbers of juvenile fish [10]. In 2005 and 2006, 20% and 61% of reported

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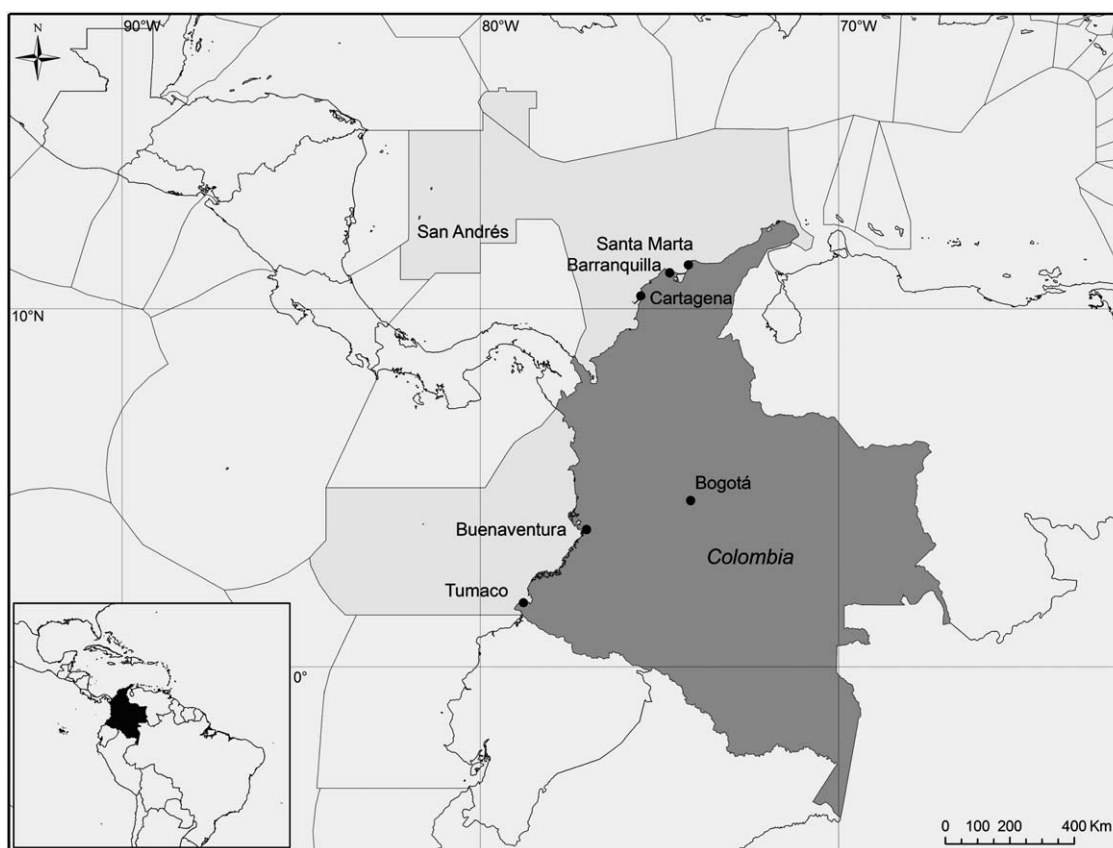


Fig. 1. Colombia's EEZ and major ports in Atlantic and Pacific waters.

shrimp landings were done by the small-scale sector in the Atlantic (mean=41%). In the Pacific, 48% and 31% (mean=40%) of reported shrimp landings were done by the small-scale fisheries, respectively.

1.2. Industrial fisheries

Industrial fishing (defined as fishing with boats larger than 15 m) in Colombia began with shallow-water shrimp trawling in the Pacific Ocean (for *Penaeus occidentalis*, *Xiphopenaeus riveti*, and *Trachypenaeus* spp.) in the late 1950s, and in the Caribbean Sea (for *Farfantopenaeus brasiliensis*, *Farfantopenaeus notialis*, and *Farfantopenaeus schmitti*) in the mid-1960s [12]. Shrimp was the most important contribution of the industrial fishery to total reported landings in both oceans until the mid-1980s, when overfishing began [6,13]. The industrial shrimp trawlers have remained virtually unchanged since they began operating in Colombia [14,15]. Most trawlers have a capacity of 20–40 t [16]. They are fuel-inefficient, and, as their gear is unselective, a large proportion of the by-catch is discarded or retained and marketed without being reported to the fisheries authorities [17]. Shrimp trawlers in the Caribbean are based in Barranquilla, Cartagena, and Santa Marta (Fig. 1), but they fish along the entire coast [18]. In the Pacific Ocean (Fig. 1), there are shrimp trawlers in Buenaventura and Tumaco [15,19]. The Buenaventura trawlers operate along the entire Pacific coast, while the trawlers based in Tumaco operate only in the local waters [11,19].

Since the 1990s, tuna has been the most important component of industrial landings [8,20]. Tuna fishing takes place in EEZ waters of the Atlantic and Pacific with boats of less than 400 t capacity, and in international waters (for *Thunnus albacares* and

Katsuwonus pelamis) with larger boats [8]. There are industrial fisheries for anchoveta (*Cetengraulis mysticetus*) in the Pacific and thread herring (*Opisthonema* spp.) in the Atlantic [8]. Fish of high value (e.g., snappers, groupers) are caught in the Caribbean and Pacific, and sold in Colombia. A small fishery for spiny lobster (*Panulirus argus*) exists in the Atlantic continental platform and off the San Andrés Archipelago (Fig. 1). Approximately 300 t of lobster are caught annually [21]. Industrial fisheries in Colombia employ approximately 37,000 people in fishing operations and processing plants [22]. Most of the shrimp and tuna catches are exported, and these fishery products account for 89% of all fishery exports [23].

2. Materials and methods

We estimated real catches in the Colombian Atlantic and Pacific for the years 1950–2006 using the methodology in Zeller et al. [24,25]. First, we reconstructed the officially-reported landings. We then estimated unreported catches, consisting of discarded and unreported by-catches of the shrimp industry, fish caught and consumed by fishers and their families (subsistence), and fish caught incidentally during tuna fishing. Finally, we evaluated the economic impact of the small-scale and industrial sectors.

2.1. Officially-reported landings

Parts of Colombia's official landings data have been lost during the multiple changes in the fisheries management system; INCODER currently holds official landings data only for the years 1975–2006. This information consists of landings data for

different number of taxa (by common names of species) for different years (Table 1).

Official data for the years 1959–1965 and 1970–1974 were obtained from secondary sources [26,11], respectively. These statistics consist of total landings for the Atlantic and Pacific Oceans, and are not disaggregated by taxa. For completing the reported landings time series, we assumed that the country's officially-reported landings for missing years (1950–1958 and 1966–1969) could be represented by the data reported for those years by FAO on behalf of Colombia. This assumption was made because the officially-reported landings for the intervening years are similar to those reported by FAO (Fig. 2). Data provided by INCODER for 2005 and 2006 included specific landing data for the small-scale and industrial sectors.

2.2. Unreported by-catch and discards of the shrimp fisheries

Two studies in the Atlantic Ocean and two in the Pacific Ocean investigated the by-catch of the industrial shrimp fishery. In the Atlantic, INDERENA [27] reported a mean retained by-catch/shrimp ratio of 2.59 for 3 trawlers during a typical 21-day fishing trip in the southern Caribbean, while the mean discards/shrimp ratio was 11.46. In a study of the shrimp-trawling fleet operating

during 3 months in the central and northern Caribbean, Duarte et al. [17] found a mean retained by-catch/shrimp ratio of 2.54 and a mean discards/shrimp ratio of 7.70. Because the Atlantic fleet fishes along the entire Caribbean coast, we averaged these estimates and obtained a mean retained by-catch/shrimp ratio of 2.57 and a mean discards/shrimp ratio of 9.58.

In the Pacific, Trujillo [28] reported on the catches of shrimp trawlers in Tumaco over a 10-month period. He estimated a retained by-catch/shrimp ratio of 3.9 and a discards/shrimp ratio of 1.32. For a 21-day fishing trip of a boat based in Buenaventura, Barreto-Reyes et al. [16] documented a retained by-catch/shrimp ratio of 2.13 and a discards/shrimp ratio of 0.80. The fishing fleet in Buenaventura is approximately 5 times larger than the Tumaco fleet [11], and we used this weight to estimate mean rates of 2.43 for retained by-catch/shrimp and 0.89 for discards/shrimp.

In a study of the shrimp by-catches that were reported to the fishing authorities in Cartagena between 1974 and 1983, García [29] found a by-catch/shrimp ratio of 0.15. This value was subtracted from the mean retained by-catch/shrimp ratios above, and the resulting rates and the mean discard/shrimp ratios were applied to shrimp landings to estimate the unreported retained by-catch and discards for each area. We are not aware of studies that have measured the by-catch of small-scale shrimp fisheries in Colombia. Because of the lack of selectivity of the fishing methods employed by these fisheries, we assumed that their by-catch rates (discards and unreported retained by-catch) were the same as those of the industrial shrimp fisheries.

2.3. Subsistence fishing

Rodas-López et al. [30] found that small-scale fisheries in the Cartagena region sold only 60% of their catch. The remaining 40%

Table 1

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

Categories	1975–1990		1991–2006	
	Atlantic	Pacific	Atlantic	Pacific
Fishes	29	29	135	173
Crustaceans	4	4	13	21
Mollusks	4	4	1	10

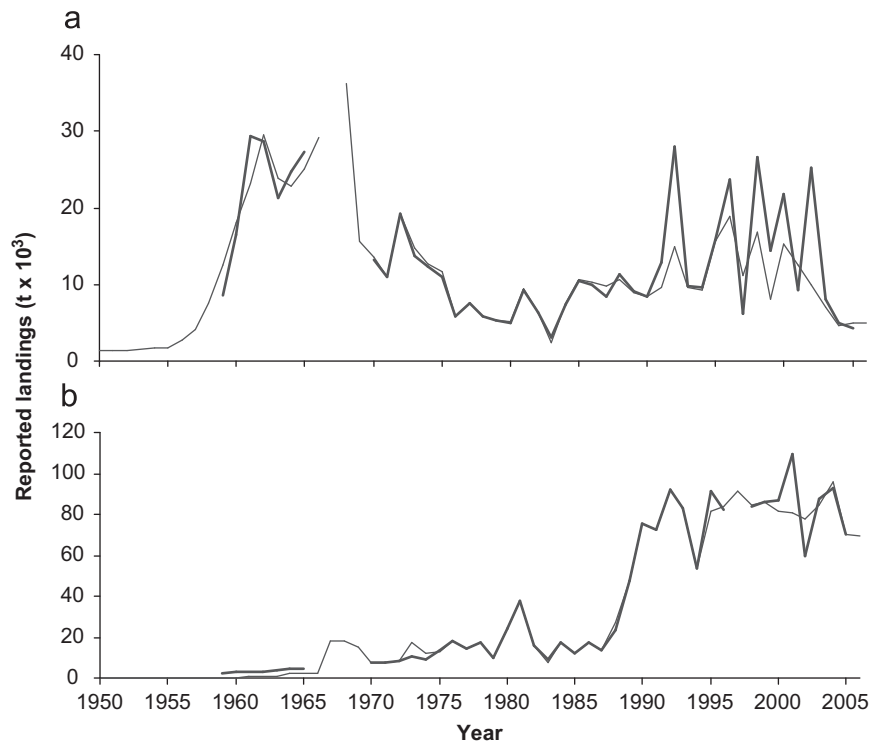


Fig. 2. Fishery landing statistics for Colombia in the (a) Atlantic and (b) Pacific Oceans for 1950–2006. Note differences in scale. Data obtained from the fisheries management agency (INCODER) or secondary sources are indicated by the dark line, and landings data from FAO are represented by the light line. Note differences in scales.

was of low commercial value and was retained for consumption by the fishers and their families (i.e., subsistence). In an inventory of fishery resources throughout the Colombian Caribbean, Manjarrés-Martínez et al. [31–33] reported that the percent contribution of commercially important fish to total removals was 51%, 54%, and 66% in April, July, and October/November, respectively. The estimates of subsistence catch in Rodas-López et al. [30] were based on data for November, so we used the ratio of the mean percent contribution of the catch of low commercial value ($1 - [0.51 + 0.54 + 0.66]/3 = 0.43$) to the percent contribution in October/November ($1 - 0.66 = 0.35$) to estimate that the annual percentage of the total removals that is used for subsistence by small-scale fishers is 49% (1.23×0.40). Reports for 1986 [11], 2005 (official catch data), and 2006 (official catch data) indicated that for those years, respectively, 98%, 81%, and 93% (mean=91%) of the fish landed in the Caribbean (excluding tunas and thread herring) was caught by the small-scale sector. This suggested that, on average, 45% (0.49×0.91) of total removals (excluding tunas and thread herring) was used for subsistence and not reported in the Caribbean area. Thus, we adjusted the reported fish landings in the Caribbean (excluding tunas and thread herring) by a factor of 1.81 ($1/1 - 0.45$) to account for subsistence fishing.

Tobón-López et al. [34] studied the catch composition of small-scale fisheries in the central Pacific for an entire year. They found that 20 fish families contributed 64% of the catch.

From these 20 families, we added the contribution to total removals of the families that were classified by Tobón-López et al. [34] as having low commercial but high subsistence value (Haemulidae and Scaenidae), and those families containing species whose catch was not reported in the official statistics (Ophichthidae, Muraenidae, Labridae, Tetraodontidae, Synodontidae, Cirrhitidae, Scaridae, and Balistidae). We used the database FishBase [35] to identify the family of fish species that were reported by their (Spanish-language) common names. The contribution of the 10 families to total removals was 29%. Reports for 1989 [7], 2005 (official catch data), and 2006 (official catch data) indicated that, respectively, for those years 76%, 58%, and 74% (mean=69%) of the fish landed in the Pacific (excluding tunas and anchoveta) was caught by the small-scale sector. This suggested that, on average, 20% (0.29×0.69) of total removals (excluding tunas and anchoveta) was used for subsistence and not reported in the Pacific area. Thus, we adjusted the reported fish landings in the Pacific (excluding tunas and anchoveta) by a factor of 1.25 ($1/1 - 0.20$) to account for subsistence fishing. We consider that this estimate may be conservative because Tobón-López et al. [34] reported on only 20 fish families (the other families were grouped in a single category), and it is likely that other families include species that are not marketed, but are important for subsistence.

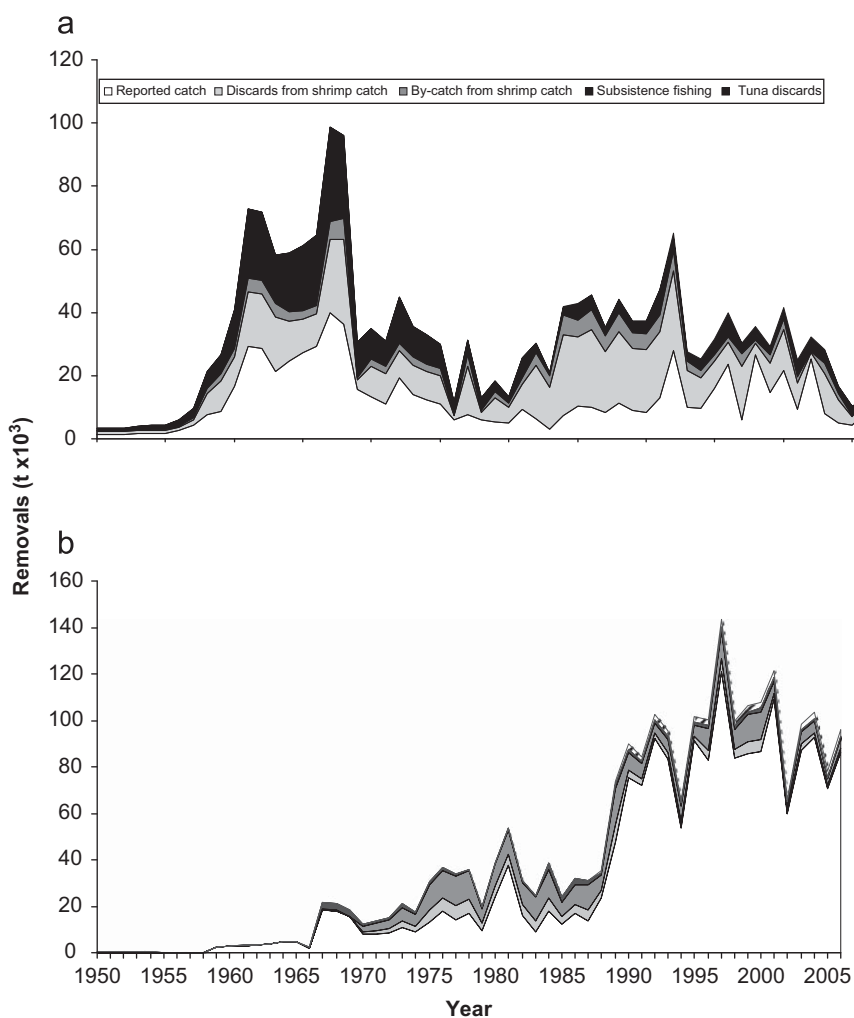


Fig. 3. Reconstructed total fisheries removals for the Colombian (a) Atlantic and (b) Pacific Oceans for 1950–2006. The reconstruction includes retained but unreported by-catch, discard, and subsistence components. Note differences in scales.

2.4. Discards from tuna fishing

During four trips aboard tuna fishing vessels with capacity < 400 t in the Colombian Pacific, Lara [36] reported that the discard/tuna ratio was 0.027 for casts directly on tuna schools and 0.056 for casts on floating objects. The mortality rate for the discarded fish was higher than 99%. Casts on tuna schools caught 1.59 as much tuna per hour as casts on floating objects, so we applied the weighted mean of discards/tuna (0.045) to tuna landings to estimate annual discards. We did not find studies reporting discard rates for any region in the Caribbean. The mean discard rate for tunas, bonito, and swordfish fisheries are 2.1 higher in the Atlantic than in the East-Central Pacific [37], so we applied a discards/tuna ratio of 0.095 to the tuna landings in the Colombian Caribbean.

2.5. Primary economic impact

We assessed the primary economic impact (gross revenues) of the small-scale and industrial fishery operations for the period 2000–2006. Gross revenues function as economic “engines” in the economy, as they initiate a cycle of spending into other sectors of the economy. For example, revenues are spent in paying for materials to repair boats and fishing equipment, purchasing food for fishing trips, and hiring transportation services for fishery products. We searched the literature for the most recently published prices for the products

of each fishery, including export prices (FOB) for products of the industrial fisheries. Although the years for published prices of several fishery products differed, we were not concerned with the effects of inflation nor did we apply a discount rate, since our goal was to evaluate the relative contribution of each fishery sector during each year. For small-scale fisheries, the mean price of 21 fish species that were reported for 2008 in Colombian pesos (COP) in the markets where fishermen sell their products was 5178 COP/kg (SD=2111) and 14,152 COP/kg (SD=\$5993), respectively (US\$2.25/kg (SD=\$0.92); the reported price of shrimp for 2008 was US\$2.71/kg [23]. We assumed that the proportions of shrimp by-catch that is sold and consumed for subsistence by the small-scale sector is the same as given above.

Industrial fisheries sell their fish catch directly to supermarkets in Colombia, so we used the mean price for 17 fish species reported in supermarkets in 2008: US\$7.81/kg (SD=\$2.85) [23]. We assumed that shrimp by-catch is also sold by the industrial fishers at this price. Prices of export products of the industrial fisheries (F.O.B.) in 2006 were US\$4.54/kg for shrimp and \$US1.12 for tunas [38]; F.O.B. prices of spiny lobster in 1999 were US\$5.92/kg [21]. Thread herring (caught in the Atlantic) and anchoveta (caught in the Pacific) are converted to fishmeal and fish oil directly by plants owned by some of the industrial fishing companies. For approximately 4.5 kg of wet fish, 1 kg of fishmeal and fish oil are obtained [39] in the proportion of two parts fishmeal per one part fish oil [40]. All of the fishmeal and fish oil produced in Colombia are sold nationally at the internationally traded prices, so we used the international price

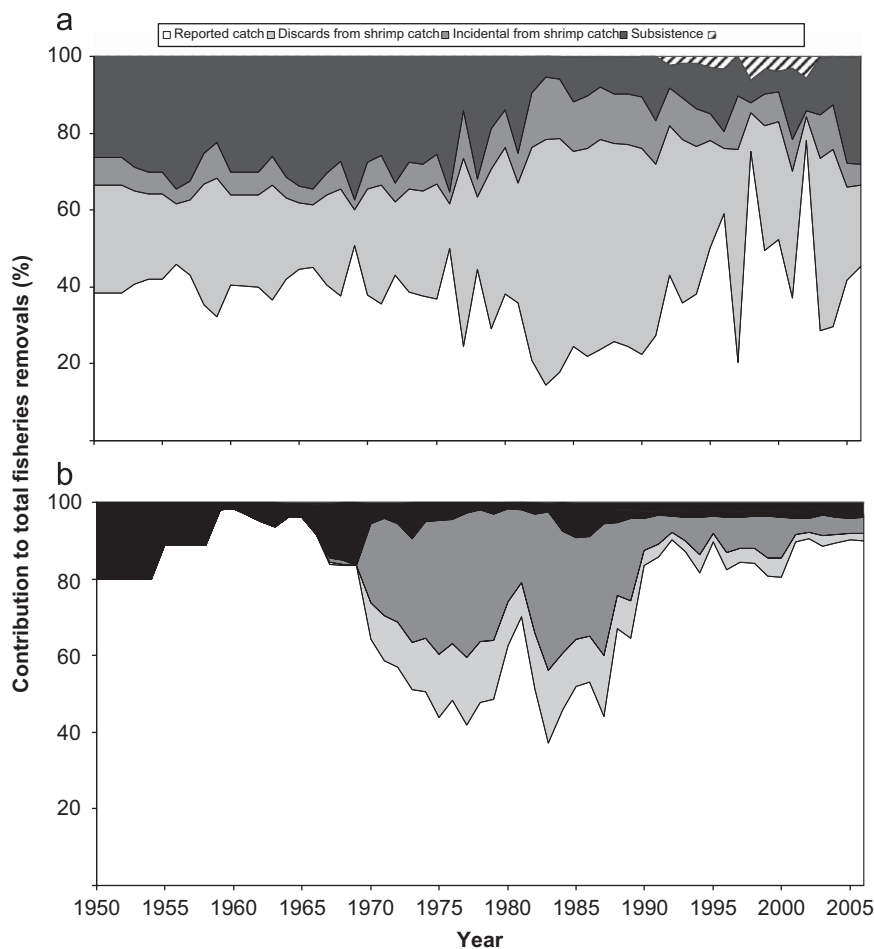


Fig. 4. Percent contribution of the different catch components to the reconstructed total fisheries removals in the Colombian (a) Atlantic and (b) Pacific Oceans for 1950–2006.

published by FAO-Globefish for each year in the period 2000–2006 [41]. The mean price for fishmeal during the period was US\$658 (SD=\$236) per t, and the average price for fish oil was US\$583 (SD=\$184) per t.

3. Results

When accounting for unreported fishing in the Colombian Atlantic and Pacific Oceans, there were considerable differences between the landings that are officially reported by the country and our estimates of total removals (Fig. 3). Our results suggest that for the period 1950–2006, fisheries catches in the Colombian Atlantic may have been 2.8 times higher than the reported landings presented by FAO on behalf of Colombia. In the Colombian Pacific, catches may have been 1.3 higher than the landings presented by FAO. For the country as a whole, total fisheries removals may have been 1.7 times higher than the landings reported by FAO.

Differences in landings between the officially-reported data and those reported by FAO on behalf of the Colombian government have become more pronounced since the beginning of the intensification of industrial fishing in the 1990s (Figs. 2 and 3). Discrepancies between reported landings and total removals were generally larger in the Atlantic than in the Pacific. The unreported by-catch and the discards from shrimp trawling were the largest components of unreported catch in both oceans, and they generally represented a larger proportion in the Atlantic than in the Pacific (Fig. 4).

The contribution of marine fisheries to Colombia's GDP, which is currently in the order of US\$122 billion [42], was modest during the period 2000–2006 (Fig. 5). For most years the gross revenues

of the industrial sector were higher than those of the small-scale fisheries, and they were an order of magnitude higher for several years in the Pacific (Fig. 5). However, gross revenues were similar between the two sectors in the Atlantic in 2005, and they were higher for the small-scale fisheries in the Atlantic in 2006.

4. Discussion

Our estimates of real fishery catches in the Colombian Atlantic and Pacific Oceans suggest that real catches are almost twice as those reported by Colombia to FAO. The retained but unreported by-catch and the discards of the shrimp fisheries are the most important components of unreported catches. The antiquated equipment used by the industrial shrimp fishery and the artisanal methods employed by the small-scale fishery are non-selective, and result in unreported by-catches that are approximately three times larger than the shrimp catches in the Pacific Ocean and twelve times larger than the shrimp catches in the Caribbean. These results are in agreement with FAO reports indicating that the mean discards/shrimp ratio of shrimp trawling in the Caribbean is 12.1, which is one of the highest discard rates of any fishery worldwide [43]. The lower contribution of discards to total fisheries removals in the Pacific may be associated with the higher number of commercially-important species in this area compared to the Caribbean (Table 1). The discard rate in the Colombian Pacific (0.89) is substantially lower than the rates reported for the industrial shrimp trawls in Ecuador and Perú (3.78 and 4.26, respectively [37]).

Industrial fisheries target high-value resources that are exported, and, not surprisingly, their gross revenues are generally much larger than those of the small-scale sector. However, the

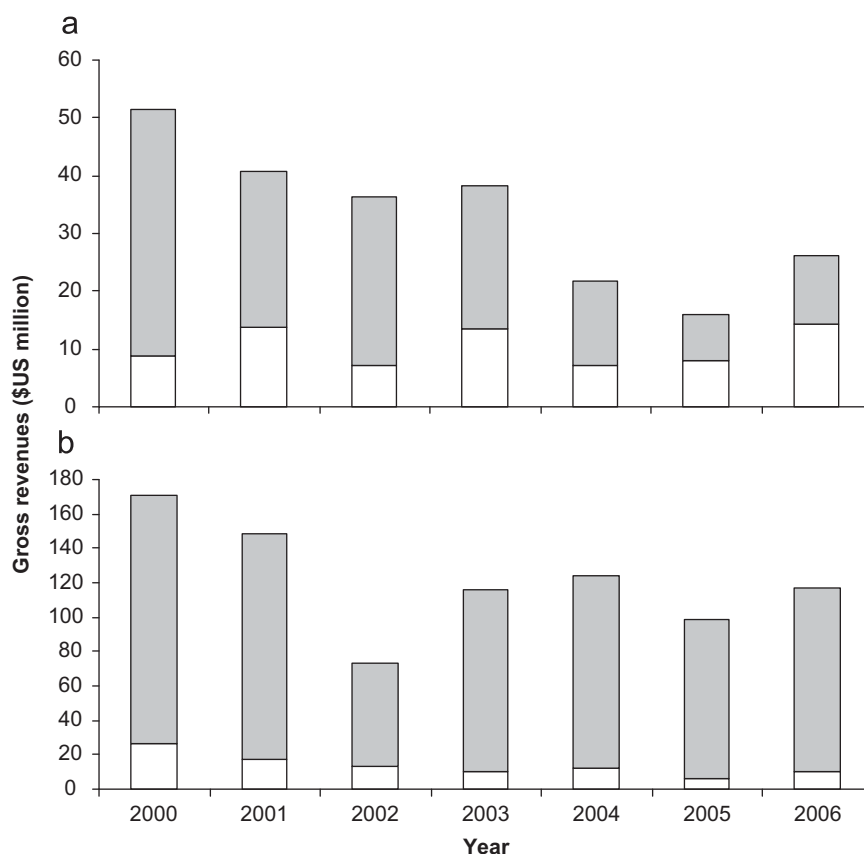


Fig. 5. Gross revenues of the small-scale (white) and industrial (gray) fishery sectors in the Colombian Atlantic (a) and Pacific (b) for the years 2000–2006. Note differences in scales.

small-scale fishery sector catches the majority of seafood that is consumed in Colombia. In addition, small-scale fisheries contribute by providing seafood for the subsistence of fishermen and their families. Subsistence fishing is an important component of unreported fishing in the Colombian Atlantic and Pacific Oceans, which is an indicator of the significance of this fishery to the livelihood of coastal communities in the country. Colombia has one of the highest numbers of internally-displaced people worldwide (between 2 to 3 million people according to UNHCR 2007 [44]), and food security is a critical issue in many areas of the country that have been affected by violence, including parts of the Caribbean and Pacific coasts. Fish is an important component of the diet of coastal communities, and during recent years, the number of people involved in small-scale fishing has increased as part of the displaced population seeks alternative means of sustenance and income [8].

Difficulties with the collection of landings data have been pervasive in Colombia, and it is likely that large fluctuations in landings between certain years are partly associated with unreliable data. Impediments to data collection have been the result of the frequent transfer of management responsibilities between different agencies, and the resulting changes in data collection procedures; the logistical difficulties involved in obtaining information from distant and geographically isolated communities; and the reduced number of staff of the fishery management agencies [24,45,46]. These challenges may help to explain the discrepancies between the official data held by INCODER and the data reported by FAO on behalf of Colombia. However, fluctuations in landings data are also likely associated with overfishing, as discussed above for the shrimp fisheries, but also with environmental factors. In 1973 and 1983, for example, decreases in shrimp landings in the Pacific coincided with strong El Niño events [6]. Similarly, fluctuations in tuna catches in the Pacific during the 1980s and 1990s have been correlated with changes in sea-surface temperatures [47].

In addition to the uncertainty in the reliability of reported landings, our reconstruction may have underestimated total removals in Colombia because it did not include other extractive activities which have been reported, but not quantified. Colombia has a limited ability to enforce fishing regulations [48], and the use of illegal fishing methods such as dynamite and fish poisons (which have a large impact on non-target species) has been observed in both coasts [3,10,18]. Deficient enforcement has also resulted in recurrent illegal fishing by Honduran and Nicaraguan vessels in the San Andrés Archipelago. Colombia has granted fishing rights to the United States in these waters,¹ but United States vessels must provide records of their catches to the Colombian fisheries management authorities. However, we were unable to find any information indicating that these records have been provided.

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¹ The Vásquez-Saccio Treaty between Colombia and the United States was signed in 1972. Under this treaty, the United States gives up any claims over the islands of Quitasueño, Roncador, and Serrana and the surrounding waters, and Colombia grants it fishing rights, under certain conditions. The text of the treaty is available at www.armada.mil.co/tratados/tratcol-usa.doc.

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