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MARINE FISHERIES CATCH RECONSTRUCTIONS FOR CONTINENTAL ECUADOR: 1950-2010

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ABSTRACT

Ecuador is considered the fishing capital in the Southeastern Tropical Pacific where it harbors the largest tuna and artisanal fisheries in the region. Despite being one of the smallest countries in the world, Ecuador embraces about 234 fishing ports and villages with 63,972–87,278 fishers along the Ecuadorian mainland coast. This paper presents reconstructions of Ecuador's mainland fisheries catches in the Exclusive Economic Zone (EEZ) over the 1950-2010 time period. Total landings associated with the industrial and artisanal fisheries were compiled and analyzed in an effort to accurately depict the amount of seafood that has been extracted from this country over the last six decades. Total reconstructed catch averaged 91,400 t·year^{-1} for the first two decades, increased to a peak of 2.2 million t in 1985, and then decreased again, leveling out at an average of 360,500 t·year^{-1} from 2002-2010. The total catch for all sectors from 1950 to 2010 was almost 30.2 million t, of which the small pelagic fishery, artisanal fisheries, shrimp fishery and industrially tuna fishery contributed 74%%, 19% and 4%%, and 2% respectively. Subsistence fisheries represented mainly by mangrove cockles and red crab play an important role for the local economy of ancestral communities of fishers relying on estuarine mangrove forests, but overfishing may jeopardize the sustainable harvest of these species. Commerce of shark fins extracted from bycaught sharks are officially permitted by the Ecuadorian government, but questions linger whether some shark species are targeted or incidentally captured even with recent efforts to control shark fisheries in this nation. While a good agreement was found between the industrial tuna fisheries reported by local agencies and FAO tuna catches, indicating reliable transferring of data, discards and landed by-catch in the shrimp industry are under-reported, as are small pelagic fisheries and data from the artisanal fisheries sector (e.g. shark landings). As a result, this reconstruction shows that, overall, Ecuador's fisheries catches (for the mainland EEZ) are 1.9 times those reported to FAO. Tradeoffs need to be made to lessen unsustainable fishing activities while conserving threatened fish species and managing sustainable fisheries in the long term.

INTRODUCTION

Five thousand years ago, maritime cultures on Ecuador's southern coastline made rafts of balsa wood. They floated upon the eastern Pacific searching for fish and diving for Spondylus (*Spondylus calcifer* and *Spondylus princeps),* thorny oysters with red, orange, or purple-hued lips that they carved into jewelry and used in a system of bartering over vast distances. Fishers eventually traded balsa wood rafts for canoes, which they used to travel the coast and catch demersal fish (Revelo and Guzmán 1997)

For thousands of years the low-tech fisheries off the Ecuadorian coast looked more or less the same. But over the last half-century, big changes have taken place for Ecuador's fisheries, due to the introduction of industrial fisheries that help feed a global market for seafood and many new technologies. It is this era—from the 1950s onward—that is the focus of this study.

Today, five provinces form the coastal region of continental Ecuador: Esmeraldas, Manabi, Guayas, Santa Elena and El Oro. The Galapagos Islands are also an Ecuadorian territory but are not considered in this study, which deals exclusively with the Ecuadorian mainland. Ecuador is considered a low-income country with negative economic growth. Sachs (2005) attributes Ecuador's perilous economic conditions to: 1) geographical difficulties; 2) political rifts and the rich/poor divide between Ecuadorians of European descent and indigenous or Mestizo populations; and 3) the country's vulnerability to extreme external shocks (e.g. instability in international prices for leading exported commodities).

Despite being a poor nation overall and a relatively small country (i.e., 256 370 km^2 or 0.19% of the terrestrial surface of the Earth), Ecuador is home to 14 million people, as well as high levels of natural resources, including marine biodiversity (Figure 1). Ecuador is also among the top 25 nations in the world for landed value of fish and fisheries products, which contribute a reported 6% to the national gross domestic product (GDP) (Boyd 2010).

Figure 1: Map of Ecuador with its Exclusive Economic Zone (EEZ).

Industrial fishing began in the 1950s. Fisheries targeted small amounts of tuna for export, and a tuna canning industry began in the late 1950s. For instance, boats caught 1,129 t of tuna in 1957, more than half of which was canned and one-fifth was frozen for export (Chiriboga 1966). By 1965, less than ten years later, Ecuador was catching 13 times more tuna. Today, the tuna fisheries, important to both the industrial and small-scale sector, are located mainly in Manabí, Santa Elena and Guayas provinces in Ecuador's continental coast. The species of Scombridae that are the most commonly targeted are the yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*) and wahoo (*Acanthocybium solandri*). In addition, several other species regularly captured are the black skipjack (*Euthynnus lineatus*), striped bonito (*Sarda orientalis*), and Pacific sierra (*Scomberomorus sierra*) (Cabanilla 2007; Herrera *et al.* 2007)

The shrimp industry also came to Ecuador in the 1950s (Chiriboga 1966) and by 1963 the industry had grown to 156 boats with 3,000 crew catching 200 pounds of shrimp tails daily (INP 1964). In the 1980s, shrimpers were fishing illegally inside the 8-mile limit and causing conflict with artisanal fishers and their gear (Anon 1998). In 1996, the shrimp fleet registered 266 boats with an annual catch of 4,800-6,600 t between 1985-1995 (Revelo and Guzmán 1997). Marine shrimps were very important to the Ecuadorian economy through the 1970s and 80s, but they were overfished (Chalén 2010) and a series of pathogens were introduced (Cruz *et al.* 2003). The wild shrimp species harvested include mainly Pacific white shrimp (*Litopenaeus vannamei*), Western white shrimp (*L. occidentalis*), Pacific blue shrimp (*L. stylirostris*), as well as yellowleg or brown shrimp (*Farfantepenaeus californiensis*) and crystal or pink shrimp (*F. brevirostris*). Other species of shrimps captured are deep sea shrimp (*Solenocera agassizi*) and titi shrimp (*Protrachypene precipua*). Today there are between 130-143 shrimp trawlers, which continue to land their shrimp catches in the major ports of Guayaquil, Puerto Bolivar, Manta, Esmeralda, Posorja, and Puerto el Morro. Most shrimp exported from Ecuador today is farmed (Cruz *et al.* 2003).

In the mid-1960s, an industrial purse seining fleet developed to fish small pelagic species (e.g., anchovy, sardines, mackerel, herring) for fishmeal (Revelo and Guzmán 1997). However, the cold Humboldt Current does not travel throughout Ecuador's continental waters and so Ecuador's anchovy population is smaller than Ecuador's southern neighbors Peru or Chile. In 1964, there was one fishmeal factory in Manta producing roughly 1,000 t of fishmeal each year while the artisanal sector was producing around 400 t (Quiroga and Armas 1964).

Today, there are fishmeal factories in several other fishing communities and harbors, including Salango, Posorja and Anconcito (González *et al.* 2006). At present, fisheries have shifted from small pelagic species usually targeted for fishmeal to demersal fish to sell as fishmeal (González *et al.* 2006; Prado 2009). In 2007, approximately 5,000 t of white fish were landed for this purpose (Jurado and Prado 1998). There has been estimated that for each ton of fishmeal produced, about 4 tonnes of fish are required. Ecuadorian fishery researchers have considered this as a waste of biomass because of the high commercial and protein value that otherwise can be used for human consumption (Jurado and Prado 1998; González *et al.* 2006; Prado 2009), which echo global concerns about the wastefulness of the fishmeal industry (Diana 2009; Duarte *et al.* 2009; Pikitch *et al.* 2012).

In the meantime, small-scale fisheries, which used cotton nets and canoes until the mid-1960s, began competing for the same fish resources as the industrial sector, and also began to mechanize their fleet with motors (Revelo and Guzmán 1997), as well as nylon nets and fiberglass boats (Gaibor *et al.* 2002). In the early 1970s, small-scale fishers began fishing for large pelagics (Revelo and Guzmán 1997). In the 1980s, demand for whitefish for export grew but the industrial fishery was not equipped to fish for them so again the small-scale sector outfitted itself with new gear and began traveling further offshore (Revelo and Guzmán 1997). Through the 1980s, fresh fish exports (by air) increased while internal consumption declined in spite of legal requirements for frozen fish firms to supply 5 percent of their product to the internal market (Wood *et al.* 1998).

As the industrial sector has grown, so, too has the artisanal fishing sector, which Ecuadorian law defines as fishers using manual gears and small boats to fish for domestic consumption as well as earnings. The growth in the artisanal sector is evident in the increasing numbers of ports, boats, and fishers. In the late 1980s, artisanal fisheries landed their catch at an estimated 57 ports (CFN 1988), 70 ports in the early 1990s (Campbell *et al.* 1991), and 158 different ports in the late 1990s.

During the 1980-1990 period the Ecuadorian artisanal fleet was estimated to have 1,900 boats (Salas *et al.* 2007), while some 7,000 vessels were operating in the early 1990s. By the late 1990s, this number had raised to an estimated 15,500 artisanal vessels (Ormaza and Ochoa 1999). More recently, up to 15,900 boats are thought to be active in 2008 (Coayla Berroa and Rivera Miranda 2008). These numbers show a doubling of vessels in less than one decade.

The most common vessels in the artisanal sector are small rafts (2-3 crewmembers) with 20-50 HP outboard motors; long wooden canoes for 3-4 crewmembers; and 10 m wooden or fiberglass-open boats, with 75-100 hp outboard motors (Massay 1987). Fishing techniques include surface and deep longlines (4-11.5 km in length with about 100-1,500 hooks); surface (3 km in length and 15 m in depth) and deep (300-400 m in length) gillnets; and other tools (e.g. hand line, scissor-net, hummer-bottom-gillnet, chinchorro) (Cedeño 1987; Martínez *et al.* 1991; Gaibor *et al.* 2002). Fifty percent of the artisanal fishing vessels use gillnets (Martínez *et al.* 1991).

Artisanal fishing effort has increased greatly since 1994, with the ensemble of a “mother” or supply wooden ship coupled with up to 4 or ten fiber glass boats with the aim to increase the intensity of the fishing effort around fishing zones, which included harvesting using gillnets, longlines and hand-lines in these areas and even close to the Galapagos (Herrera *et al.* 2007; M. Peralta, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 4 June 2010).); Although at the beginning the role of the “mother” ship was only to bring boats to the fishing zones, actually it also conducts fishing activities in addition to the fiberglass boats (M. Peralta, pers. comm. Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 4 June 2010).

More recently, the Minister of Agriculture, Cattle, Aquaculture and Fisheries of Ecuador through the Sub-Secretariat of Fisheries Resources (SRP) has undertaken the Fisheries Census Project in order to collect new fishery data and assess the fishing communities along Ecuador’s mainland/continental coast. The first phase took place in late 2009/early 2010, when about 118 fishing communities out of 173 were assessed, reflecting a total of 43,634 artisanal fishers. In 2011, the second phase began, during which 234 fishing communities were registered and the population of artisanal fishers was estimated to be between 63,972 and 87,278.[1]

Amidst all of this activity and general growth of the fishing sector, the monitoring of Ecuadorian fisheries, large or relatively small, has not been comprehensive. Although the National Fisheries Institute began monitoring commercial fisheries in 1960 (Cruz *et al.* 2003), the statistics are questionable and often under-reported. For instance, Patterson *et al.* (1990) found the reported landings of small pelagic fishes dubious when compared to fishmeal production. Monitoring fishmeal plants and human consumption, Patterson *et al.* (1990) re-estimated small pelagic catches for fishmeal using a conversion factor of 4.45 tonnes of fish required to make one tonne of meal, which is conservative when compared to other estimates of fishmeal production ratios

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[1] http://www.subpesca.gob.ec/subpesca401-censo-pesquero-registra-243-comunidades-pesqueras.html (Accessed 02/04/2014)

(e.g.,Castillo and Mendo 1987). He found the reported catches of small pelagic fishes were far too low. Similarly, Jacquet et al. (2008) found the shark catches in Ecuador were also seriously under-reported.

For the small-scale sector, national catch reports for the 1990s are representative of only eight of the 138 artisanal ports. Discarded fish at sea are also not reported, which is common in fisheries around the world (Zeller and Pauly 1995). The goal of this study, like many others (e.g.,Jacquet *et al.* 2008), is to construct a more accurate profile of fisheries catches from the ground up, in this case for the mainland of Ecuador.

MATERIALS AND METHODS

Industrial tuna, billfishes, mahi mahi, and shrimp

FAO tuna landings were compared to those reported in reports from official governmental agencies, including the Instituto Nacional de Pesca, INP (National Institute of Fisheries of Ecuador) and Sub-Secretariat of Fishery Resources (SRP), between 1991 and 2010 (Arriaga and Martinez 2002; Herrera *et al.* 2007; Pacheco-Bedoya 2010, 2011). This comparison revealed relatively good transfer of commercial tuna data between the agencies (INP/SRP) of the Ecuadorian government and the FAO, except for minor differences between the period 2000 and 2008 when catches for yellowfin, bigeye and skipjack tuna reported by INP (Pacheco-Bedoya 2011) was about 10% higher than the FAO tuna data for this specific species. Tuna landings at Ecuador's mainland coast were adjusted to exclude tuna catches (i.e. yellowfin, bigeye and skipjack tuna) from the high seas (i.e. tuna catches out of the EEZ) and Galapagos waters using calculations from (Schiller *et al.* 2013). After the adjustment, FAO tuna data were accepted as Ecuadorian tuna fishery catches. Similarly, we also took the FAO landings for billfishes, mahi mahi, and shrimps as accurate industrial reports.

FAO data for the shrimp fishery is somewhat limited, in particular for titi shrimp, which is only reported from 2007 onwards. Little and Hererra (1992) describe catches of titi shrimp in 1991, indicating the existence of a fishery for at least 20 years, but since first referencing the report it has become unavailable so we have been unable to verify the catch data. Although whiteleg shrimp are reported as far back as 1950, reporting for western white shrimp and yellow leg shrimp begins only in 1995, whilst reporting starts for blue shrimp and crystal shrimp in 2000 and it is unlikely that the shrimp fishery was targeting a single species for so long. Therefore, the FAO shrimp data should be considered with caution and further work is necessary.

Discards and landed by-catch from shrimp trawlers

Discarding is a common practice within the fishing industry, and unwanted fish that have been caught are simply thrown back to sea. Discards can include damaged fish, non-target species, and undamaged target species that are discarded to make room for more valuable ones. Shrimp trawl fisheries are typically associated with considerable by-catch, which can either be landed or discarded at sea. There are two major fishing fleets dedicated to harvest shrimp, including the shrimp ("Langostino") trawl vessels and the titi shrimp ("Pomada") trawl vessels. The former mainly capture Pacific white shrimp (*L. vannamei*), Western white shrimp (*L. occidentalis*), Pacific blue shrimp (*L. stylirostris*), followed by yellowleg/brown shrimp (*F. californiensis*) and crystal/pink shrimp (*F. brevirostris*), while the latter harvest exclusively titi shrimp (*P. precipua*). Yet, due to the indiscriminate nature of fishing gear (i.e., shrimp trawl nets) used to harvest shrimp, by-catch is common in shrimp fisheries and often a large portion of incidental catches is thrown overboard. However, this portion of the catch, known as discards, is rarely, if ever reported (Zeller and Pauly 1995).

Shrimp by-catch: reconstruction methods

An estimate of by-catch was available for 1982 from Wood *et al.* (1998), who reported 18,000 t of landed by-catch and 23,500 t of overall by-catch (i.e., 5,500 t discards) for the 8,000 t of shrimp caught that year (which means shrimp was 25% of total catch – a relatively conservative ratio compared to other shrimp fisheries). We then used this by-catch ratio (2.94 t by-catch: 1 t shrimp) against official shrimp catches reported by the FAO to estimate the total by-catch for 1950-2009 (minus 1982). Based on Wood *et al.* (1998), we estimated a ratio of 18,000 t of landed by-catch for the 8,000 t of shrimp caught in 1982 to estimate landed by-catch as a ratio to official FAO shrimp catches for 1950-1981 and 1983-2010. Given that Wood *et al.* (1998) found discards represented 23% of total by-catch, we used this percentage to distinguish the discards from our overall by-catch estimation. As a result, we obtained a 1950-2010 times series estimate of discards. With regard to the remainder of by-catch, i.e., landed by-catch, we assume they were represented in the reported estimates of small pelagic fish and whitefish. A report by Little and Hererra (1992) also provided data which allowed us to calculate by-catch to shrimp ratios (separate data were given for the two types of vessels: *Langostino* and titi shrimp targeting vessels which are known as *Pomada*) as well as retained by-catch to discarded by-catch ratios. They estimated a by-catch/shrimp ratio of 11.6 for *Langostino* vessels (with 46% of by-catch being discarded) and 1.4 for *Pomada* vessels (with 70% of by-catch being discarded). All of these values produce higher amounts of total by-catch and a greater amount of that catch discarded, except for the by-catch/shrimp ratio for the titi shrimp fishery. However, the *Langostino* vessels make up the majority of the catch, and therefore the more conservative estimates of Wood *et al.* (1998) were used in the reconstruction.

The report by Little and Hererra (1992) was still utilized as it contained the only reliable estimation in the existing literature for the species composition encompassing the by-catch in Ecuadorian shrimp trawlers (shrimp and titi shrimp vessels). This report contains data reported for vessels that operated along the Ecuadorian coast from March to November 1991, as shown in Table 1 (Little and Hererra 1992). The shrimp trawl by-catch is basically encompassed by 261 species of marine fauna (56 families), in which 83% are whitefish (217 species), accounting for 75-90% of the shrimp trawler catches (Little and Hererra 1992).[2] Based on the data reported by Little and Herrera (1992), there was an important number of fish families caught in the by-catch and the ichthyofauna generally consisted of species associated with soft substrates of the trawling grounds, as shown in Table 1. Rays accounted for a large proportion (>30-50%) of the total catches and these were nearly always discarded. Demersal species, which are important to artisanal fishers, appeared frequently in by-catch and retained fish was presumably consumed by local communities or processed for exportation (Little and Hererra 1992). Currently, several species of fish caught as by-catch include flounders (*Paralichthys woolmani*), croakers/drums or “corvinas” (weakfish species, *Cynoscion* spp.), mullets (*Mugil cephalus*), white snook (*Centropomus viridis*), tilefish or ocean whitefish (*Caulolatilus affinis*), Pacific harvestfish/pompanos or “chazo/gallinaza” (*Peprilus medius*), moonfish (*Selene peruviana*), hakes (*Merluccius gayi*), snappers (*Lutjanus*), and several species of groupers (*Epinephelus* spp.; *Mycteroperca xenarcha*; *Diplectrum maximum; Paralabrax callaensis*), which are also traditionally targeted by artisanal fisheries2, as reported in Table 1. To the best of our knowledge, data on the actual composition for these white fish species have not been reported after 1991 and anecdotic information available from local experts was unavailable.

[2] http://www.subpesca.gob.ec/subpesca274-srp-explica-eliminacion-de-pesca-de-arrastre.html (Accessed 02/04/2014)

For this reconstruction, species breakdown was determined using the by-catch data from Little and Hererra (1992) in Table 1. For taxa such as Pomadasidae where a range of percentages was given, the mid-point was taken, and then the percentages were normalized to get back to a total of 100%. These percentages were then applied to the by-catch and discard totals for each year.

Industrial small pelagic fish catches

The monitoring and analysis of fisheries and landings involving the harvesting of small pelagic fishes conducted by the purse seiner fleet was started in 1981 by the National Institute of Fisheries (Instituto Nacional de Pesca, INP) through the Small Pelagic Fishes Program (González *et al.* 2006; Prado 2009). The Program aims to monitor the fleet to collect fisheries biological data to assess the population status and recommend management actions for sustainable harvesting. It is known that the small pelagic fisheries began in the 1960s when the first wooden vessels were built to fish thread herrings (aka, pinchagua), *Opisthonema* spp. (González *et al.* 2006). Subsequently, after the collapse of the Peruvian anchovy (*Engraulis ringens*) in Peru during the 1970s, a substantial number of high scale, stainless steel vessels were purchased and transported from Peru by Ecuadorian companies. The number of the fleet increased from 48 small, wooden vessels in 1971 to 277 vessels, including both wooden and stainless steel vessels, in 1991 (Aguilar 1993; González *et al.* 2006) This new fleet caused a significant increase in small pelagic fisheries in Ecuador and promoted the development and improvement of existing fish meal factories and canning industries.

Due to the increased number of vessels and broad magnitude of the new fleet, new fishing zones were explored and several other small pelagic fish species were exploited, including sardines (*Sardinops sagax; Etrumeus teres*), mackerel (*Scomber japonicus*), and Pacific anchoveta (*Cetengraulis mysticetus*), which were present in Ecuadorian waters, but not previously harvestable due to limitations of the former fleet. In time, the overcapacity in the fleet took a considerable biomass of small pelagic fish, which has showed an evident decline since the beginning of the 1990s (González *et al.* 2006; Prado 2009). The decline was attributed to not only the fishing pressure, but the ENSO events (i.e. El Niño) that occurred during 1982-1983, 1987-1988, 1991-1992, and 1997-1998, when ocean-atmospheric conditions and lack of primary productivity impaired food availability for pelagic fish (Aguilar 1993, 1999).

Mackerel (*S. japonicus*) and Southern sardine or South American pilchard (*S. sagax*) sustained the rapid growth of the industry since 1974. During the 1981-1990 period, the total landings reached a maximum volume of 1,998,587 tonnes in 1985 and a minimum of 238,891 tonnes in 1990 (González *et al.* 2006). The highest biomass harvested between 1984 and 1986, and following decline from 1990 to 1994 coincides with the diminishing landings of the South America pilchard. In 1995, a gradual increment of landings was reported, reaching approximately 623,500 tonnes by 1996 and dropping again in 1998 with about 189,000 tonnes (González *et al.* 2006). A slow increment in landings is also observed by 1999, reaching up to 434,356 tonnes in 2001, when Chilean jack mackerel (*Trachurus murphyi*) and chub mackerel (*Scomber japonicus*) made up most of the landings, in a similar fashion to that reported in 1995. During 1999-2000 and after 2001, the composition of the landings appeared to be represented mainly by taxa other than the common species traditionally harvested to sustain the small pelagic fisheries (e.g., thread herrings, mackerel, South American pilchard/sardine and red eye round herring)..This grouping of fish species are used mainly for the elaboration of fishmeal meal (González *et al.* 2006; Prado 2009) and includes the following fish species: Shortfin scad or "picudillo" (*Decapterus macrosoma*); Mexican moonfish or "carita" (*Selene oerstedii*); Pacific bumper or "hojita" (*Chloroscombrus orqueta*); Pacific harvestfish/pompano (*Peprilus medius*); Longnose anchovy or "rollizo" (*Anchoa nasus*), catfish or "bagre" (*Arius* spp); sea robins or "gallineta" (*Prionotus* spp); and Pacific drum or "barriga juma" (*Larimus gulosus*).

While the Peruvian anchoveta/anchovy (*E. ringens*) emerged in Ecuadorian waters in 2001 due to its recovery from exploitation during the 1970s, of particular concern is the drastic decrease and total absence of the South American pilchard or Southern sardine (*S. sagax*) from 2005 to 2010 in the Ecuadorian landings. This has also caused fishers to target other species (demersal/bottom dweller fish). Overfishing and capture of small size fish, in some cases below the sexual maturity average size (e.g. thread herrings, mackerel), and violations of fishing permits/seasons (a.k.a., "vedas"), coupled with density independent events (i.e. ENSOs), have negatively impacted small pelagic fish populations off Ecuador.

Small pelagic fishery: Reconstruction methods

Based on gray literature, we obtained estimates of industrial small pelagic landings for 1981-2010 (Patterson *et al.* 1990; Patterson and Scott 1991; Arriaga and Martinez 2002; González *et al.* 2006; Prado 2009; INP 2010). These estimates were compared to totals of the FAO small pelagic landings, including the taxa mentioned in the 'Others' section that were reported by the FAO data (Table 2) – shortfin scad (*Decapterus macrosoma*), sea catfish (Ariidae) and the pacific bumper (*Chloroscombrus orqueta*). For these 29 years, annual small pelagic catches were on average 1.55 times the small pelagic catches reported by FAO on behalf of Ecuador. We multiplied small pelagic catches reported by FAO from 1963-1980 by the average factor between 1981-1984 (2.35) to obtain better estimates of industrial small pelagic catches. There were no catches of small pelagic fish reported before 1963.

The species composition of total catches for the small pelagic fishery was disaggregated by species per year for the period 1981-2010, based on the existing literature mentioned above. For the years 1963-1980, the average contribution of each taxon for 1981-1983 was calculated and carried back for each year. The taxa collectively caught for fishmeal were categorized as 'miscellaneous marine fishes'.

Artisanal marine fish catches

Artisanal fishing communities of Ecuador use mainly longlines and surface gillnets (mesh eye: 7.5-13 cm) to capture pelagic fishes such as dolphinfish or mahi mahi, locally known as "dorado" (*Coryphaena hippurus*); skipjack tuna (*K. pelamis*); wahoo (*A. solandri*), yellowfin tuna (*T. albacares*); bigeye tuna (*T. obesus*); sword fish (*Xiphias gladius*); sailfish (*Istiophorous platypterus*); and different species of marlins: striped (*Tetraptorus audax*); black marlin (*Makaira indica*); and blue marilin (*Makaira nigricans*) (Herrera *et al.* 2007; Alava *et al.* 2012). These fisheries also include some shark species that are either targeted or incidentally captured, including the blue shark (*Prionace glauca*); thresher-sharks (*Alopias* spp.); hammerhead-sharks (*Sphyrna zygaena; S. lewini*); the bull shark (*Carcharhinus leucas*); the Oceanic whitetip shark (*C. longimanus*); mako-sharks (*Isurus oxyrinchus*); the Pacific angel shark (*Squatina californica*), as well as several species of rays (*Dasyatis longus; D. brevis; Mobula spp.; Aetobatus narinari; Gymnura marmorata; Rhinoptera steindachneri; Rhinobatus leucorhynus; Torpedo tremens;* and, *Raja velezi*), as reported elsewhere (Aguilar *et al.* 2007; Jacquet *et al.* 2008; Peralta 2009).

Artisanal fishery: reconstruction methods

Official small-scale catch estimates were available for 1963, 1974-1987, 1989-1995 and 2009 (Quiroga and Armas 1964; Martinez 1991; INP 1999; Peralta 2009). To derive data for the gap years, we used interpolation and extrapolation, based on separately available estimates of the number of fishers (Census 1954; Revelo and Guzmán 1997; Solís and Mendívez 1999) which we used to derive catches/fisher.

However, data obtained and reported nationally for small-scale Ecuadorian fisheries are representative of 8 artisanal ports at most: Esmeraldas, Manta, San Mateo, Santa Rosa, Anconcito, Engabao, Playas, Puerto Bolivar (Villón *et al.* 1992; Arriaga and Martinez 2002; Herrera *et al.* 2007). According to a 1999 survey, these 8 ports represents only 21,005 of the nation's 56,068 artisanal fishers, who spanned the remaining 130 ports at that time (Solís and Mendívez 1999) Assuming fishers nationwide have comparable average per capita catch rates, this implies that reported catch reflects only 37.5% of Ecuador's total catch. Using methods similar to estimating shark captures for mainland Ecuador (Jacquet *et al.* 2008), our estimates of small-scale landings, derived mainly from official data, were thus presumed to represent 37.5% of total artisanal catch and were increased by 2.7 times from 1950 to 2010 to give countrywide estimates of artisanal catches and account for the number of ports and 62.5% of fishers that went unmonitored. Data for shark landings were obtained largely from (Jacquet *et al.* 2008), which covered years between 1979 and 2004. Data for years 2005-2010 was sourced from the Ecuadorian Government (INP 2010).

A species breakdown was achieved by calculating the proportion of each taxa in the reported FAO data. The most complete breakdown was reported in the most recent years, so the average contribution of each taxa in the years 2006-2008 was taken and multiplied against the reconstructed total for each year. For species that had no reported landings in those years, the average proportion for the nearest 3 years to 2006 with reported data was taken. Species breakdown for sharks was calculated based on the proportions each taxa were reported by the FAO each year. For the period 1979-1991, where there was no reported data, proportions were calculated using the average percentage of the catch each species contributed in 1991 and 1992.

Several years of the reported data in the artisanal fishery contained anomalous spikes in the 'Marine Fishes nei' category, where catches were much larger than the reconstructed catch and almost double the reported catch for the preceding and succeeding years. These were assumed to be errors and were negatively adjusted to match the reconstructed total for that year. It should also be noted that it was determined through the Galapagos reconstruction (Schiller *et al.* 2013) that all reported 'Sea cucumbers nei' and 'Green spiny lobster' were catches from the EEZ surrounding Galapagos and therefore these catches were excluded from the FAO baseline comparison for the catches in the Ecuador mainland EEZ.

Local Consumption

In Ecuador, the annual fish and shellfish consumption as a source of protein (i.e. < 2 g of fish protein) currently ranges from 5.0 to 10 kg per person, according to FAO (2012). While the fish consumption had a maximum of 14.2 kg/person/year in 1989 (Noriega-Curtis and Vera-Rivas 1989), it decreased by a minimum average of 5.0 kg/person/year during the 2007–2009 period (FAO 2012), showing a decline of 65%. While independent consumption rates from fish market surveys or consumer studies for Ecuador were unavailable, we assume that the annual consumption rate of subsistence catches may be < 5 kg/person or fall within the range 5–10 kg/person. The local consumption of fish for subsistence has not been assessed in coastal Ecuador, but it may well represent <1% of total marine catches or landings as all fish products are basically sold out by artisanal fishers (Manuel Peralta, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador,12 August 2013).

Subsistence Fisheries

Some human communities target benthic species for subsistence that may be also considered as part of small scale artisanal fisheries. These species can include crabs (e.g., mangrove red crab, *Ucides occidentalis*; blue crab, *Cardisoma crassum*; “pangora,” *Menipes frontalis*; and the dog crab *Xantipes* sp.) and about 23 species of mollusks, mainly arks or cockles such as the black arks or mangrove cockles, *Anadara tuberculosa*, *A. similis* and *A. grandis* (Cruz *et al.* 2003), locally known as "concha prieta," “concha mica” and “pata de mula” (mule foot), respectively. It is important to notice that several other molluscs such as octopuses (*Octopus mimus*; Luis Flores, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 14 March 2014), oysters (*Crassostrea rizophorae*), clams (*Donax* sp.) and mussels (*Mytela strigata*) are also targeted for local consumption and sold out in fish markets. Because of the lack of data reported for most species, this section on subsistence fisheries is focused on mangrove red crab and *Anadara* cockles.

The mangrove red crab is the major traditional crustacean species harvested in large numbers by crab collectors in mangrove-estuarine areas along the Ecuadorian coast (Cruz *et al.* 2003; Solano *et al.* 2010). The exploitation of crab is exclusively conducted in mangrove forest reserves, mangrove concessions temporarily owned by fisher communities and open access areas of Guayas and El Oro provinces, providing the major source of incomes and subsistence for 1,800–2,200 artisanal crab fishers and families (Chalén and Correa 2003; Solano *et al.* 2010), but it is subject to seasonal closings regulated by fisheries authorities (i.e. SRP). To the best of our knowledge, catches for the mangrove red crab have not been yet reported to FAO as the harvesting and landings of this species only started to be officially monitored and assessed in 2002 (Chalén and Correa 2003). Therefore, this hampers our ability to perform a comparison of mangrove red crab landings with FAO data.

Mangrove red crab: Reconstruction methods

Briefly, data from the INP indicate that the captures of mangrove crabs (i.e. reported as number of crabs) ranged from 5.2 x 10^6 crabs in 2004 (Solano and Mendivez 2005) to 7.7 x 10^6 crabs in 2010 (Solano 2011). Using an estimated average wet weight of 80g/crab, this trend is roughly translated in 413 and 615 t for 2004 and 2010 respectively, and shows an increase of 33% in landings. This may indicate an increased effort in crab catches, although Cruz *et al.* (2003) previously suggested a general decrease in crab captures associated to the construction of shrimp farm ponds in mangrove areas.

A reconstruction for the time period was achieved by calculating a per-capita consumption rate for crab, using data for the coastal rural population within 10km of the coast. Coastal population data was available for the years 1990,2000 and 2010 (CIESIN 2012) so the years without data were interpolated between the anchor points, and the years prior to 1990 being reduced annually by an average of the 1990-2000 and 2000-2010 interpolations. The per-capita was estimated by applying the tonnages for 2004 and 2010 to the coastal population, and interpolating between them. The average per-capita crab consumption for those 7 years was applied for 1950-2003 and applied to the estimated coastal population to estimate subsistence tonnage for the whole time period.

Cockles

Cockles are part of the ancestral harvesting playing an important role as traditional seafood for local consumption, nutrition and source of incomes for the human communities inhabiting coastal mangrove areas (Mora and Moreno 2009b; Mora *et al.* 2009), mainly in northwest Ecuador within the Cayapas-Mataje Ecological Mangrove Reserve (Esmeraldas province), harbouring the last remnants of pristine mangrove forests and the highest number of cockle harvesters (Ocampo-Thomason 2006; Flores and Licandeo 2010). However, since the late 1990s, a massive exploitation by cockle gathering, in particular for *A. tuberculosa* and *A. similis*, coupled with an increased harvesting effort of small size individuals, i.e. < 4.5–5 cm, has caused a marked reduction of the local populations (Santos and Moreno 1998; Mora and Moreno 2009a; Mora *et al.* 2009; Mora *et al.* 2010). Furthermore, the loss of mangrove areas and expansion of shrimp aquaculture ponds have likely affected the depletion of cockles in Ecuador (Ocampo-Thomason 2006; Carvajal and Alava 2007). Yet, despite low volume landings, these shellfish species are still highly commercialized and consumed locally. It is estimated that about 70% of the harvested cockles are locally consumed as part of the internal market in coastal Ecuador (E. Mora, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 8 August 2013). The market of cockles exhibits a dynamic complexity as these species seem to be part of an ongoing and regional trade between Colombia-Ecuador and Peru. Anecdotally, it is known that both Ecuador and Colombia export cockles to Peru for local consumption, but Colombia exports about 95% of the cockles harvested in this country (Peru) to Ecuador (Elba Mora and Luis Flores, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 8 August 2013). The figures of the real volumes exported or imported among these three countries are unreported. However, based on the local consumption in Ecuador, it can be estimated that approximately 30% of the cockles are exported to Peru (E. Mora. pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 8 August 2013), but it is unknown how much of the Colombian cockles arriving to Ecuador are re-exported to Peru. Thus, it can be problematic to designate reliable export estimates from Ecuador and determine whether the mangrove cockle is a species harvested just for subsistence.

Anadara Cockles: Reconstruction methods

The artisanal landings of cockles are mainly distributed in six sites, including Esmeraldas province (San Lorenzo, Muisne), El Morro (Guayas province) and the El Oro province (Puerto Bolivar, Puerto Jeli, Hualtaco) (Mora and Moreno 2009a; Mora *et al.* 2009; Mora *et al.* 2010; Flores and Morales 2011). From a general report of fisheries catch in Ecuador for the 1985–1997 period (INP 1999), official cockles landings (tonnes) were available for 1985, 1987 and 1988, with data gaps for 1986 and 1989-1997. According to unpublished information (Fundación Natura, Diario (Newspaper) “Hoy,” 2 November 2000) cited by Rendón-Yllescas and Suárez-Gómez (2007), about 63 million cockles were harvested in 1997 at the national level. More recently, landings (i.e. number of cockles) were also officially available for 2004, 2005 and 2008-2010 from technical reports of the INP (Mora and Moreno 2009a; Mora *et al.* 2009; Mora *et al.* 2010). Thus, unreported landings for the previous missing years and for 1998–2003, 2006 and 2007 were interpolated to reconstruct the cockles harvest from 1985 to 2010. The annual landings of cockles harvested in 1997 and 2004-2010 were converted to tonnes assuming an estimated wet weight of 20g per cockle.

To estimate *Anadara* cockle tonnage for the rest of the time period, consumption per-capita was calculated using the coastal population estimates (rural population within 10km) and the reconstructed cockle tonnages described above. The average cockle consumption per-capita for 1985 and 1986 was calculated and then applied against the population for each year 1950-1984.

Although FAO data for *Anadara* clams only began in 1985, there were catches categorized as ‘Clams,etc nei’ from 1950. Therefore, the annual FAO ‘clam’ catches were reassigned as ‘Anadara clams’ according to the reconstructed totals. Where the reconstructed catch was less than the reported ‘clam’ total, the deficit remained categorized as ‘Clams, etc nei’. To conservatively estimate the contribution from the artisanal and subsistence sectors, an 80:20 split was applied to the total reconstructed catch for each year.

Recreational Fisheries

Although it is fairly well known that recreational (sport) fisheries occur off the Ecuadorian coast, there is no information collected in term of systematic records of catches or landings by the regional fisheries agencies (Luis Flores, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 6 April 2013; Manuel Peralta, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador,12 August 2013). Yet, sport fishing mainly takes place as a human activity representing a very small fraction when compared to the overall artisanal fisheries in Salinas (Santa Elena Peninsula province), Manta and in some fishing villages around the Machalilla National Park (Manabí Province). Ecuador has few sport-fishing operators, but their catch logbooks represent an important source of data to characterize and monitor this fishery in the future. Based on information available in personal and operators web sites, the major sport fish species caught include large pelagic fish such as blue, black and striped marlins (*M. nigricans*, *I. indica*, and *K. audax*), sailfish (*I. platypterus*), wahoo (*A. solandri*), tuna (i.e. yellowfin and bigeye tuna, *T. albacares*, *T. obesus*), and dolphin fish (*C. hippurus*). Unfortunately, there are no documented reports of catches coming from recreational fisheries for continental Ecuador and the landings should be considered negligible relative to the overall marine catches, i.e. «0.5–1% (Manuel Peralta, pers. comm., Instituto Nacional de Pesca-INP, Guayaquil, Ecuador, 12 August 2013).

RESULTS

Industrial fishery: Large pelagic and shrimp fisheries

As mentioned in the methods section, the FAO data for both tuna and shrimp over the 1950-2010 time period were taken as reported. We suspect the accuracy in these sectors is in part because these fisheries are industrial and these species groups are exported and therefore closely monitored. While shrimp landings accounted for 1.1% of the total marine catch, tuna landings made up 2.2% of the total reconstructed catches, being well below relative to that reported for tuna harvested (i.e. 80% of total catch) around the Galapagos Islands (Schiller *et al.* 2013). The notable decline in year 2000 (Figure 2) for tuna catches is thought to be the result of the civil tensions and resulting fisheries closures, although the fishery exhibits a fluctuating recovery throughout the 2000s. Other large pelagics (marlins, sailfish, swordfish, etc.) contributed another 0.7% to the total reconstructed catch. Common dolphinfish was the largest contributor with 82% of the other large pelagic catch.

By-catch and Discards

By-catch and discards from shrimp trawlers can be relatively high, accounting for 75% of the total catch from the shrimp fishery. Figure 3 shows the shrimp catch as reported to FAO along with our reconstructed tonnage for landed by-catch and discards. Landed by-catch and discards made up 2.6% and 0.8% of total marine catches for the period 1950-2010. Our reconstruction showed that shrimp trawlers harvest an average of 5,500 t (shrimps) per year, representing only 25.4% of the fishery's total catch. Discards amounted to 17.2%, whilst landed by-catch was 57.4%,i which is either sold to fishmeal factories or at the local market for human consumption (whitefish). The species composition of the shrimp trawlers by-catch and discards is reported in Table 1.

Small pelagic fishery

Small pelagic fisheries accounted for approximately 74% of the total reconstructed catches. A mismatch between small pelagic fisheries data reported by government reports (i.e. INP/SRP) and the data reported by FAO was found for the period 1981-2010, as shown in Figure 4. As aforementioned, missing data for the period 1963-1980 and 2010 were re-constructed by using a factor of 1.7 to trackback the historical trends and predict better estimates of small pelagic fisheries in Ecuador. Since the mid-1980s the harvest of small pelagic fish has decreased drastically without signs of recovering. Following 2005, a low steady state trend is noticed, showing again a decline by 2010 (Figure 4).

Shark fisheries

Sharks are caught by both the industrial and artisanal sector. Total reconstructed shark catches averaged 5,000 t·year-1 from 1979-1986. Catches then increased experiencing two peak periods, one from 1987-1989 averaging 10,100 t·year^{-1}, and the second from 1993-1997 averaging 11,200 t·year^{-1}. Catches then dropped to a low of just under 2,300 t in 1999, increased to 8,000 t in 2001, dropped again to 2,300 t in 2005, and then experienced the highest peak, averaging 13,300 t·year^{-1} from 2007-2010. The majority of catches came from the artisanal sector which contributed almost 93% of the catch (discussed further below). Industrial shark catches averaged just 530 t·year^{-1} over the time period, with a peak of 1,550 t in 1995.

Artisanal fisheries

The reconstructed Ecuadorian artisanal fishery represented 18.6% of total marine catches, with annual catches ranging from just under 55,000 t in 1950 to a peak of 1610,500 t in 1994. Catches declined after that, averaging 105,000 t·year^{-1} in the 2000s. According to our re-constructions, annual artisanal shark catches contributed 4% of the artisanal catch and averaged 6,900 t·year^{-1} (range: 1,670-17,500 t·year^{-1}) over the 1979-2010 time period. Of particular concern is the significant under-reporting of shark catches in Ecuador (i.e. the total reconstructed catch is more than 4 times greater than FAO sharks' reports), as reported previously by Jacquet *et al.* (2008). The artisanal cockle fishery contributed almost 2% to the total artisanal catches, averaging 1,700 t·year^{-1} over the 1950-2010 time period.

Anadara cockle fishery

The cockle fishery is for both artisanal and subsistence purposes. Total landings of *Anadara* cockles were 1.2 times the data reported by FAO and decreased by almost 93% from 1985 (the peak of catches, 4,550 t) to 2010 (lowest point, 340 t), which is likely due to the increased harvest effort for local consumption and external market. It was assumed that 80% of the catch was for artisanal harvest and 20% was kept for subsistence purposes.

Subsistence fisheries

For the subsistence fisheries, *Anadara* cockle catches averaged 410 t·year^{-1} over the time period, whilst mangrove red crab catches averaged 360 t·year^{-1}. Subsistence fisheries contributed 0.2% to total reconstructed catches.

Total reconstructed catch

The annual marine fisheries catch reconstruction for continental Ecuador in comparison to the data reported by FAO is shown in Table A1 and an overview of the primary species composition is provided in Table A2.

The total reconstructed catch for Ecuador 1950-2010 was overall 1.9 times the data reported by the FAO, with the largest discrepancy occurring at the beginning of the time period (average of 11 times in the early 1950s) and improved reporting in the later time period when catches are estimated to be only 1.5 times that reported by FAO on behalf of Ecuador in the 2000s. Annual catches rose gradually through the 1950s and 60s from 58,000 t in 1950 to 426,000 t in 1975, before rapidly increasing to almost 1.5 million t in 1980. There was a sharp crash in 1983 to 680,000 t followed by another, much larger, peak of over 2.1 million t in 1985. This was followed by another crash, with the catch dropping to 370,000 t in 1990. Catches then remained relatively stable, averaging 456,000 t $year^{-1}$ for the last 20 years of the time period (Figure 5a).

Industrial catches made up 81.2% of the reconstructed total catch, with the artisanal and subsistence sectors contributing 18.6% and 0.2% respectively. Discards made up 0.8% of the fish caught.

Fish caught in the small pelagic fishery were most dominant species, contributing 4 of the 5 most prevalent species and 67% of the total reconstructed catch (Figure 5b). Chub mackerel (*Scomber japonicas*; 23.9%) were most dominant, followed by Pacific sardines (*Sardinops sagax*, 20.4%), Pacific thread herring (*Opisthonema libertate*, 11.1%), red-eye round herrings (*Etrumeus teres*, 5.6%) and Pacific anchoveta (*Cetengraulis mysticetus*; 4.5%).

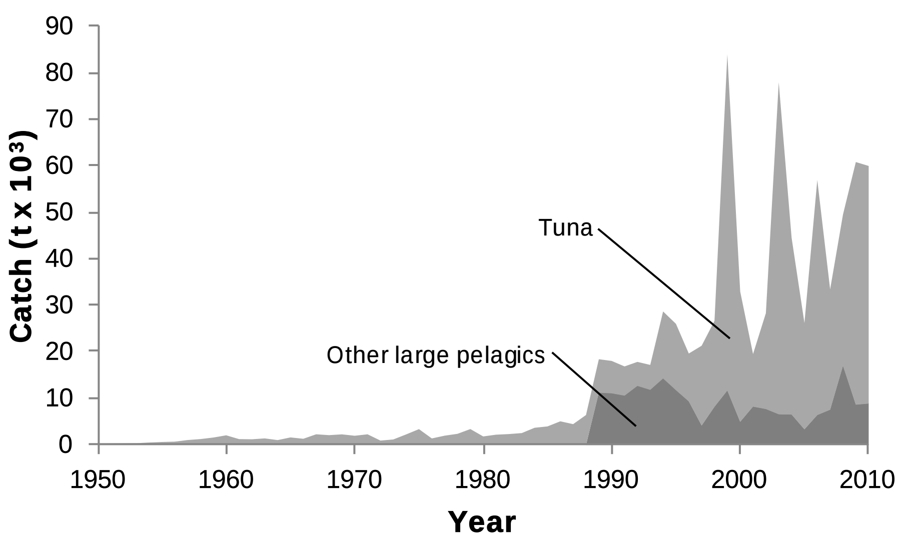

Figure 2. Total reconstructed catch of the tuna fishery and other large pelagics (sailfish, marlin, swordfish, dolphinfish).

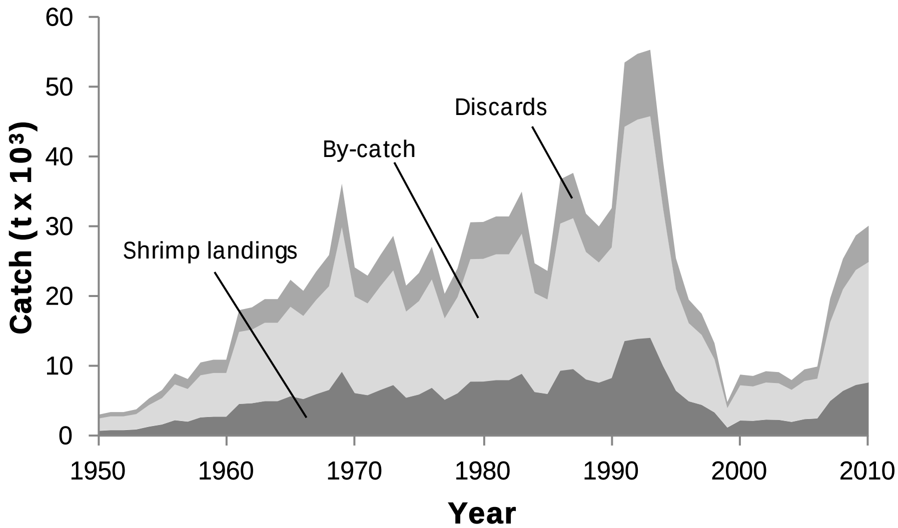

Figure 3. Total reconstructed catch of the shrimp fishery, including landed by-catch and discards, for mainland Ecuador, 1950-2010.

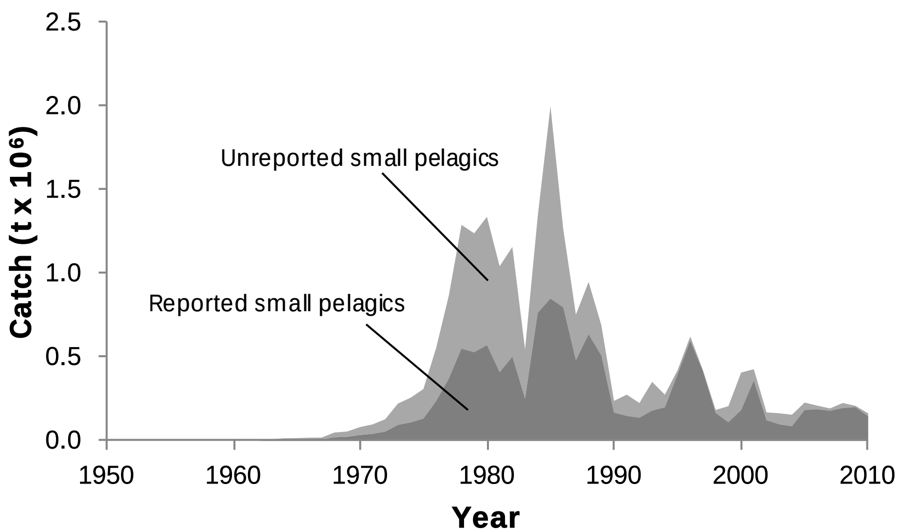

Figure 4. Total reconstructed landings of small pelagic fish from 1950 to 2010 in Ecuador's mainland EEZ compared to the FAO landing data over the same time period. In the last three decades, a significant decline of total harvest is observed over time.

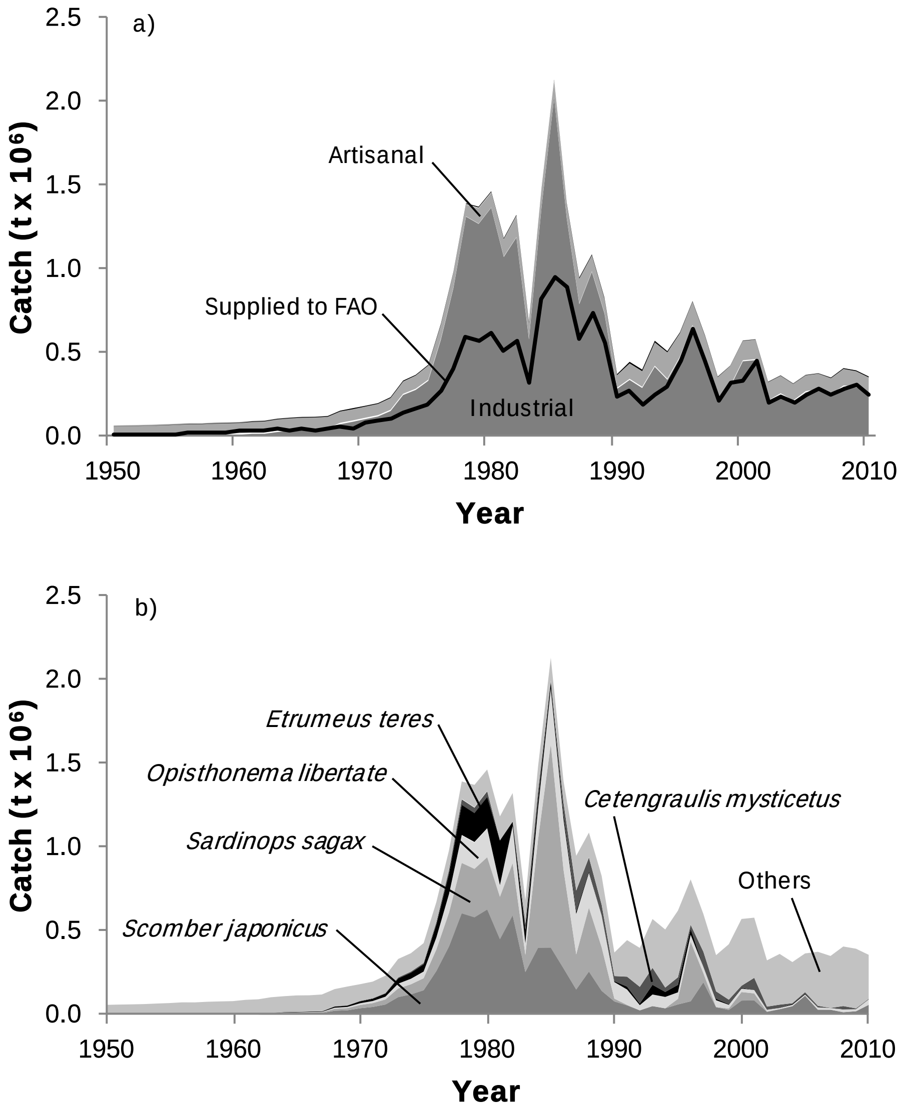

Figure 5. Total reconstructed catch for Ecuador mainland EEZ fisheries 1950-2010, by a) sector, with the FAO landings for the mainland overlaid as a line graph. All sectors and discards are included in the reconstruction, but the contribution of subsistence sector and discards are too small to be visualized; and b) by major species. 'Others' consists of 90 additional taxonomic categories.

Table 1. Species composition of the fish catches by shrimp trawler vessels for Ecuador, March-November 1991. Adapted and updated from Little and Hererra (1992).

Common name	Taxon name Family: species	Shrimp/prawn ("Langostino") vessels	Titi shrimp ("Pomada") vessels
		Percent of total catch (%)	
Rays*	Rajidae; Dasyatidae	31.00–50.00	33.00
Small Serranids	Serranidae: *Diplectrum* sp. *Paralabrax* sp.; *Hemianthias* sp.	3.00–13.00	2.00
Pacific harvestfish/ Pompano	Stromateidae: *Peprilus medius*	2.00–11.00	2.00
Grunts	Pomadasidae	4.00–10.00	NR
Flounders	Bothidae	5.00–9.00	2.00
Jacks	Carangidae: *Seriola* sp.	2.00–8.00	2.00
Catfish	Ariidae: *Bagre* sp.	2.00–7.00	15.00
Croakers	Sciaenidae: *Cynoscion* sp. *Micropogonias* sp.	1.00–7.00	6.00–30.00
Snapper	Lutajinade: *Lutjanus* sp.	4.00	NR
Red mullet/goatfish	Mullidae	3.00	NR
Groupers	Serranidae: *Epinephelus* spp.; *Mycteroperca xenarcha*	2.00	NR
Tilefish	Malacanthidae: *Caulolatilus affinis*	1.00	NR
Small sharks**	Triakidae: *Mustelus* spp. Heterodontidae: *Heterodontus* sp.	1.00	NR
Other species***		NR	4.00
Selected species***		< 0.05%	<0.05%

*Presumably rays belonging to the genus *Raja* and *Dasyatis*.
**Presumably *Mustelus henlei* and *M. lunatus; Heterodontus mexicanus*
*** Other and selected species refer to the following fish families reported by Little and Hererra (1992): Anthiidae, Batrachoidae (i.e. toadfishes), Branchiostegidae, Centropomidae (*Centropomus*), Ephippidae, Lobotidae, Merlucidae (*Merluccius gayi*), Muraenidae, Ophidiidae, Sparidae, Sphyraenidaa (i.e. *Sphyraena ensis*)
NR = unreported

Discussion

The catch reconstructions for the fisheries of mainland Ecuador presented here are conservative given the catch/fisher rates presented in some regional instances (see Revelo and Guzmán 1997). We recognize the amount of uncertainty and bias in these reconstructions, but believe they better represent reality following the precautionary approach. In addition to reconstructing catches, anecdotes and personal communications can be important sources of understanding for resource management (Pauly 1995). Under this premise, this research shows that marine fisheries catches by Ecuadorian mainland fishers are an average of 1.9 times those reported by FAO (1950–2010). Our findings further support the notion that the use of FAO data to characterize historical trends for some fisheries, including small pelagic, artisanal and sharks, may lead to false conclusions (Clarke 2004) and need to be used with caution.

The exploitation of marine fisheries in Ecuador is a driving socio-economic force at the national level, but scant fishery management has conspired against the conservation of important marine species, including non target species (by-catch and discards), small pelagic fishes, sharks and rays. In addition, the intense collection of shrimp larvae (Martinez 1991) and the burgeoning shrimp farming, associated with the reduction of a substantial coverage of mangrove forests, became a very big industry in the mid-1980s and 1990s (Cruz *et al.* 2003; Carvajal and Alava 2007). Around 1990, there were 32,400 larvae collectors in Ecuador and 1,200 capturing adult shrimp (Martinez 1991). The practice of larvae collection caused extreme detriment to other species. Collectors used mosquito nets to capture any larvae available, including the larval stage of many other species, and then put the larvae in freshwater, which only the shrimp could tolerate (Luis Morales, pers. comm.).

By-catch is high and unaccounted for. We suspect that our estimated shrimp trawlers by-catch was discarded at sea and only occasionally landed to make fishmeal at artisanal plants (Herdson *et al.* 1985) although Little and Hererra (1992) suggested that retained fish was consumed by local communities. Wood *et al.* (1998) estimated that shrimp accounts for 25% of total catch, which is conservative relative to other studies on shrimp by-catch. Indeed, a study by Little and Hererra (1992) indicated different rates, with the shrimp harvested by shrimp trawlers (*Langostino* vessels)in 1991 accounting for only 8% of the total catch. Titi shrimp (*Pomada*) vessels, on the other hand, had a higher shrimp proportion with 38% of catches. Wood *et al.* (1998) also estimated % of discards, which came to 17% of total catch, compared to Little and Hererra (1992) whose data suggested 42% and 36% for the shrimp and titi shrimp vessels, respectively. We also recognize it could have changed temporally (and likely to become smaller portion) but without an additional anchor point, thought it best to stick with the conservative estimate. Because of the negative impacts on benthic communities inhabiting the continental shelf and ocean bottom, as well as conflicts with traditional artisanal fisheries, the shrimp trawl fishery was recently banned in Ecuador by the Ecuadorian government (MAGAP 2012).

Fishing gears used in artisanal fisheries have proved to have direct implications in several marine species and epipelagic macronekton in coastal Ecuador. For instance, sea turtle by-catch events were estimated to be 4.8 turtles/1,000 hooks in some Machalilla National Park fishing harbors (Barragán *et al.* 2009) and about 200 sea turtles/day in the dolphin-fish high fishing season in Cabo, San Francisco (Alava *et al.* 2012). Likewise, seabird by-catch associated with artisanal longline fishing gears targeting hake (*M. gayi*) is estimated to be about 9-13 waved albatrosses (i.e. 155 longline sets; 350 hooks per set) (J. Hardesty, pers. comm., American Bird Conservancy) or 0.11 albatrosses/1,000 hooks (Darquea-Arteaga *et al.* 2010). Not even humpback whales breeding off Ecuador escape from the deleterious impact of by-catch, being often victims of entanglement and stranding along Ecuador's mainland coast (Alava *et al.* 2012).

As a result of growing concerns over the sustainability and health of shark populations, large-scale shark fishing and shark fin export were banned in Ecuador in 1989 and 2004 respectively (Jacquet *et al.* 2008). While these efforts initially made Ecuador a world-leader in protective shark legislation, in July 2007, the Ecuadorian Government officially enacted an amendment to the previous laws. Although this amendment still prohibits shark finning and the dumping of sharks at sea, fishers are now allowed to trade fins extracted from sharks incidentally caught during fishery activities under a special permit (Jacquet *et al.* 2008). Prior to the ongoing shark legislation, Manta, the major harbor city for tuna and shark fisheries in Ecuador, was described as the epicenter of Ecuador's 'shark mafia', where blue sharks (*P. glauca*) and pelagic thresher sharks (*A. pelagicus*) accounted for nearly 90% of all shark landings (Jacquet *et al.* 2008). Unfortunately, in Ecuador, 'incidental catch' can be as high as 70% (Aguilar *et al.* 2007), and it is unclear how local fisheries authorities are able to fairly monitor and discriminate between shark by-catch and potentially targeted species during fishing activities at sea.

In this context, the ultimate goal of the recent fishery census (2010-2011) conducted by the SRP was to provide a baseline and database to determine projects with the aim to improve the life quality of fishers, to promote the sustainable use of bio-aquatic resources, and to seek projects, in which artisanal fishers can be included in activities other than fishing to generate added value and conserve the fish biomass. If this is the really case, the Ecuadorian government might be able meet the international conduct criteria for sustainable management of fisheries and the primary objectives of the Convention on Biological Diversity in the foreseeable future. Funding for some mollusc aquaculture or mariculture production, including mangrove cockles (Cruz *et al.* 2003) coupled with ongoing mangrove concessions as common property arrangements (i.e. cockles in custody) can be sustainable approaches to enhance higher catch shares, reduce pressure in wild populations, promote mangrove conservation and community empowerment (Beitl 2011). For instance, recent data show that cockles landings increased by 44% in 2011 relative to 2010, with a total harvest close to 30 million cockles or ≈750 t (Flores and Morales 2011; Mora *et al.* 2011; Mora *et al.* 2012). As for cockles, the long-term monitoring of mangrove red crab harvesting and seasonal closures must continue to ensure the its sustainable management for local communities. Furthermore, the recovery and conservation of some mangrove areas in coastal Ecuador due to the law enforcement, monitoring and surveillance projects, environmental stewardship and education to local communities (Carvajal and Alava 2007) will likely enhance the habitat suitability (e.g. nursing areas) for the survival of benthic invertebrates and fish species.

In Ecuador, fishery science and management need to evolve and improve substantially to provide robust data and reliable risk assessments to support the decision making process and management actions in Ecuador. This implies that tradeoffs need to be made to lessen unsustainable fishing activities benefiting international markets while conserving threatened fish species and managing sustainable fisheries in the long term.

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References

Aguilar F (1993) La pesquería de especies pelágicas en el Ecuador. Boletin Cientifico y Tecnico 12(2): 1-6.

Aguilar F (1999) La pesquería de peces pelágicos pequeños en el Ecuador entre 1981 y 1998 Boletin Cientifico y Tecnico 17(14): 20.

Aguilar F, Revelo W, Coello S, Cajas J, Ruiz W, Diaz M and Moreno J (2007) Artisanal landings of sharks and rays in themain Ecuadorian ports during 2006. Instituto Nacional de Pesca, Guayaquil, Ecuador. 19 p.

Alava JJ, Barragan MJ and Denkinger J (2012) Assessing the impact of bycatch on Ecuadorian humpback whale breeding stock: a Review with Management Recommendations. Ocean and Coastal Management 57: 34-43.

Anon (1998) La pesca artesanal de peces demersales en el Puerto de Anconcito durante el primer trimestre de 1998. Unión Europea y Republica del Ecuador.

Arriaga L and Martinez J (2002) Plan de ordenamiento de la pesca y acuicultura del Ecuador. Subsecretariat de Recursos Pesqueros, Guayaquil, Ecuador. 116 p.

Barragán MJ, Baquero A and Yumiseva C (2009) Captura incidental de tortugas marinas en pesquería artesanal. Zona de influencia del Parque Nacional Machalilla, evaluación preliminar 2002-2003. *In* Resumenes del III Simposio Regional Sobre Tortugas Marinas en el Pacífico Suroriental, 6-7 de noviembre de 2009, Santa Elena, Ecuador.

Beitl CM (2011) Cockles in custody: the role of common property arrangements in the ecological sustainability of mangrove fisheries on the Ecuadorian coast. International Journal of the Commons 5: 485-512.

Boyd C (2010) Fishery Sector. The Importance of Biodiversity and Ecosystems in Economic Growth and Equity in Latin America and the Caribbean: An economic valuation of ecosystems, United Nations Development Programme (UNDP). 307 p.

Cabanilla C (2007) Seguimiento de los desembarques de peces pelágicos grandes durante 2007. Instituto Nacional de Pesca, Guayaquil, Ecuador. 13 p.

Campbell RJ, Fallows I, Scott J, Ortiz T, Rodríguez T and Mora T (1991) Una revisión del sector pesquero artesanal en el Ecuador y los factores de consideración para su desarrollo. Boletin Cientifico y Tecnico 11(8): 89.

Carvajal R and Alava JJ (2007) Mangrove Wetlands Conservation Project and the shrimp farming industry in Ecuador: Lessons learned. World Aquaculture 38(3): 14-17.

Castillo S and Mendo J (1987) Estimation of unregistered Peruvian Anchoveta (*Engraulis ringens*) in official catch statistics, 1951-1982. The Peruvian Anchoveta and Its Upwelling Ecosystem: The Decades of Change, Instituto del Mar del Peru, Callao, Peru. 351 p.

Cedeño A (1987) Características generales de las artes de pesca artesanal en el Ecuador. La Pesca Artesanal en el Ecuador, ESPOL, CEPALES, ILDIS, Quito, Ecuador. 288 p.

CFN (1988) Analisis del sector pesquero. Sectoriales, Corporación Financiera Nacional, Ecuador.

Chalén X (2010) La flota de arrastre pescando basura. Revista Terra Incognita 67: 1-6.

Chalén X and Correa J (2003) Seguimiento de la actividad de extracción del cangrejo rojo durante la veda (Febrero 2002). Documento Interno INP, Instituto Nacional de Pesca, Guayaquil, Ecuador. 21 p.

Chiriboga H (1966) La pesca en el Ecuador. Instituto Nacional de Pesca, Guayaquil, Ecuador.

CIESIN (2012) National Aggregates of Geospatial Data Collection: Population, Landscape, And Climate Estimates, Version 3 (PLACE III). Center for International Earth Science Information Network (CIESIN), Columbia University, Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). Available at: http://sedac.ciesin.columbia.edu/data/set/nagdc-population-landscape-climate-estimates-v3 [Accessed: 28 03 2014].

Clarke S (2004) Understanding pressures on fishery resources through trade statistics: a pilot study of four products in the Chinese dried seafood market. Fish and Fisheries 5: 53-74.
Coayla Berroa R and Rivera Miranda P (2008) Estudio sobre la seguridad en el mar para la pesca artesanal y en pequeña escala. 2. América Latina y el Caribe. FAO Circular de Pesca 1024/2, FAO, Rome. 58 p.
Cruz M, Gabor N, Mora E, Jiménez R and Mair J (2003) The known and unknown about marine biodiversity in Ecuador (Continental and Insular). Gayana (67): 232-260.
Darquea-Arteaga J, Baquero A, Hardesty J and Vallejo F (2010) Primera evaluación de captura incidental de aves marinas en la costa de Ecuador. Primer Simposio de Biodiversidad Marina y Costera de Latinoamérica y El Caribe, Segundo Simposio Ecuatoriano de Biodiversidad Marina y Costera, Grupo de Trabajo sobre Biodiversidad Marina y Costera del Ecuador, Ministerio del Ambiente del Ecuador, 9-12 December 2010, Manta, Ecuador. 21 p.
Diana JS (2009) Aquaculture production and biodiversity conservation. BioScience 59: 27-38.
Duarte CM, Holmer M, Olsen Y, Soto D, Marbà N, Guiu J, Black K and Karakassis I (2009) Will the oceans help feed humanity? . BioScience 59: 967-976.
FAO (2012) The state of the world fisheries and aquaculture 2012. FAO Fisheries and Aquaculture Department, Rome, Italy. 209 p.
Flores L and Licandeo R (2010) Size composition and sex ratio of *Anadara tuberculosa* and *Anadara similis* in a mangrove reserve from the northwest of Ecuador. Revista de Biología Marina y Oceanografía 43(3): 541-543.
Flores L and Morales M (2011) La explotación de *Anadara tuberculosa* y *Anadara similis* en Puerto El Morro: un análisis después de una década sin monitoreo. Boletin Cientifico y Tecnico 1(2): 25-36.
Gaibor N, Rosero J and Altamirano M (2002) El impacto de la migración humana en las artes de pesca artesanales y semi-industriales utilizadas en los Parques Nacionales Galápagos (Isla Isabela) y Machalilla Informe de consultoria: (estudio realizado en 1999). The Nature Conservancy y Fundacion Natura 63 p.
González N, Prado M, Guzman J, Castro R, Solano F, Jurado V, Peña M and Galindo P (2006) Análisis de la pesquería de peces pelágicos pequeños en el Ecuador (1981-2006). Instituto Nacional de Pesca, Guayaquil, Ecuador.
Herdson D, Rodríguez WT and Martínez J (1985) The coastal artisanal fisheries of Ecuador and their catches in 1982. Boletin Cientifico y Tecnico 8(4): 1-50.
Herrera M, Elias E, Castro R and Cabanilla C (2007) Evolución de la pesquería artesanal del atún en aguas ecuatorianas. Instituto Nacional de Pesca, Guayaquil, Ecuador. 27 p.
INP (1999) De los desembarques pesqueros en el Ecuador 1985 -1997. Instituto Nacional de Pesca, Guayaquil, Ecuador.
INP (2010) Desembarques de peces pelágicos pequeños. Instituto Nacional de Pesca, Guayaquil, Ecuador. 6 p. Available at: http://www.inp.gob.ec/inp/irba/estadisticas/Desembarques%20de%20PPP%202000%20-%202009.pdf [Accessed: 02/04/2014].
Jacquet J, Alava JJ, Pramod G, Henderson S and Zeller D (2008) In hot soup: sharks captured in Ecuador's waters. Environmental Sciences 5(4): 269-283.
Jurado V and Prado M (1998) La pesquería de peces pelágicos pequeños en el Ecuador durante 2007. Documento interno. Instituto Nacional de Pesca, Guayaquil, Ecuador. 17 p.
Little M and Hererra M (1992) The by-catch of the Ecuadorian shrimp fleet. Instituto Nacional de Pesca, Guayaquil, Ecuador. 90 p.
MAGAP (2012) Reunión busca alternativas ante la prohibición de la pesca de arrastre. Boletín-UCS-012-2012, Ministerio de Agricultura, Ganadería, Acuacultura y Pesca, Guayaquil, Ecuador, 02 Marzo de 2012. Available

at: http://www.magap.gob.ec/mag01/index.php/prensa-boletinesprensa/2736-reunion-busca-alternativas-ante-la-prohibicion-de-la-pesca-de-arrastre [Accessed: 04/04/2012].
Martinez J (1991) Las pesquerias artesanales en la costa continental del Ecuador durante el primer semestre 1991. Boletin Cientifico y Tecnico 11(4): 1-42.
Martínez J, Coello S and Contreras S (1991) Evaluación de las pesquerías artesanales en la costa de Ecuador durante 1990. Boletin Cientifico y Tecnico 11(4): 1-42.
Massay S (1987) Notas sobre la pesca artesanal de peces en algunos puertos pesqueros de las Provincias del Guayas y Manabí. pp. 9-15 *In* Martínez J, Ansaldo A, Hurtado M and Montano R (eds.), La Pesca Artesanal en el Ecuador. Instituto Nacional de Pesca, Guayaquil, Ecuador.
Mora E, Flores L, Moreno J and Gilbert G (2012) La pesquería de la concha (*Anadara tuberculosa* y *A. similis*) en los principales puertos de desembarque de Ecuador en el 2011. Boletin Cientifico y Tecnico 22(3): 1-16.
Mora E and Moreno J (2009a) La pesquería artesanal del recurso concha en las zonas de Esmeraldas y El Oro durante el 2008. Boletin Cientifico y Tecnico 20(1): 17-36.
Mora E and Moreno J (2009b) La pesquería artesanal del recurso concha en las zonas de Esmeraldas y El Oro durante el 2008. Boletin Cientifico y Tecnico 20(1): 17-36.
Mora E, Moreno J and Jurado V (2009) La pesquería artesanal del recurso concha en las zonas de Esmeraldas y El Oro durante el 2008. Boletin Cientifico y Tecnico 20(1): 17-36.
Mora E, Moreno J and Jurado V (2011) Un análisis de la pesquería del recurso concha en el Ecuador durante el 2010. Boletin Cientifico y Tecnico 21(2): 1-13.
Mora E, Moreno J, Jurado V and Flores L (2010) La pesquería de la concha (*Anadara tuberculosa* y *A. similis*) en el 2009: indicadores pesqueros y condición reproductiva en la zona sur y norte de Ecuador. Boletin Cientifico y Tecnico 20(8): 35-48.
Noriega-Curtis P and Vera-Rivas J (1989) A regional survey of the aquaculture sector in Latin America. FAO, Rome, Italy.
Ocampo-Thomason P (2006) Mangroves, people and cockles: Impacts of the shrimp-farming industry on mangrove communities in Esmeraldas Province, Ecuador. *In* Hoanh C, T., Tuong T, P., Gowing JW and Hardy B (eds.), Environment and livelihoods in Tropical Coastal Zones: managing agriculture-fishery-aquaculture conflicts, Bac Lieu, Vietnam. 140-153 p.
Ormaza F and Ochoa LA (1999) Puertos pesqueros artesanales de la costa continental ecuatoriana. Instituto Nacional de Pesca, Guayaquil, Ecuador
Pacheco-Bedoya L (2010) Volúmenes de captura de atún industrial 2000-2008. Instituto Nacional de Pesca, Guayaquil, Ecuador. 3 p.
Pacheco-Bedoya L (2011) Desembarque total de las principales especie de atún capturada por la flota atunera cerquera, durante 2009/2010. Reporte Pesquero, Instituto Nacional de Pesca, Guayaquil, Ecuador.
Patterson K, Castello M, Santos M and Barcia M (1990) Validation and recalculation of catch and effort data for the Ecuadorean coastal purse seine fleet for the period 1981-1989. Boletin Cientifico y Tecnico 10(2).
Patterson KR and Scott IR (1991) Plan de ordenamiento pesquero para las species pelágicas pequeñas del Ecuador. Boletin Cientifico y Tecnico 11(9): 1-80.
Pauly D (1995) Anecdotes and the shifting baseline syndrome of fisheries. Trends in Ecology & Evolution 10: 430.
Peralta M (2009) Desembarques de la pesca artisanal de peces pelagicos grandes y tiburones en la costa ecuatoriana durante 2008. Boletin Cientifico y Tecnico 20: 1-23.
Pikitch E, Boersma PD, Boyd IL, Conover DO, Cury P, Essington T, Heppell SS, Houde ED, Mangel M, Pauly D, Plagányi É, Sainsbury K and Steneck RS (2012) Little fish, big Impact: Managing a crucial link in ocean food webs. Lenfest Ocean Program, Washington, DC. 110 p.

Prado M (2009) The fishery for small pelagic fish during 2008 in Ecuador. Boletin Cientifico y Tecnico 20(4): 1-25.

Quiroga D and Armas AO (1964) Apuntes e informaciones sobre la situación de la producción pesquera ecuatoriana y sus mercados. Instituto Nacional de Pesca, Guayaquil, Ecuador. 24 p. Available at: http://books.google.ca/books?id=B4zeJQAACAAJ [Accessed: 01/04/2014].

Rendón-Yllescas MK and Suárez-Gómez EV (2007) Manejo sustentable y comercialización de concha prieta en cautiverio, en Puerto el Morro-Provincia del Guayas, para su exportación hacia España. Bachelor Tesis. BSc thesis, Escuela Superior Politécnica del Litoral, Facultad de Ciencias Humanísticas y Económicas, Guayaquil, Ecuador.

Revelo W and Guzmán MZ (1997) La pesca artesanal en Santa Rosa de Salinas Provincia del Guayas. La Organización de las Naciones Unidas para la Agricultura y la Alimentación, Guayaquil, Ecuador. 56 p.

Sachs J (2005) The end of poverty. Penguin Books, London.

Salas S, Chuenpagdee R, Seijo JC and Charles A (2007) Challenges in the assessment and management of small-scale fisheries in Latin American and the Caribbean. Fisheries Research 87: 5-16.

Santos M and Moreno J (1998) Evaluación de la pesquería de concha prieta en el Archipiélago de Jambelí y Estuario del Rio Muisne. pp. 3-15 *In* Instituto Nacional de Pesca (INP) and Program de Manejo de Recursos Pesqueros (PMRC). Documento 1, Orientaciones Técnicas para la Ordenación de la Pesquería de Concha Prieta. Convenio INP – PMRC, Ecuador.

Schiller L, Alava JJ, Grove JS, Reck G and Pauly D (2013) A Reconstruction of fisheries catches for the Galápagos Islands, 1950-2010. UBC Fisheries Centre Working Paper, University of British Columbia, Vancouver, Canada. 35 p.

Solano F (2011) Análisis de las capturas del cangrejo rojo (*Ucides occidentalis*) en puertos de las provincias de Guayas y El Oro en Ecuador, durante el 2010. Boletin Cientifico y Tecnico 21(2): 15-24.

Solano F, Flores L and Ruiz W (2010) Capturas de cangrejo rojo (*Ucides occidentalis*) en los puertos de la provincia del Guayas y El Oro, Ecuador, durante 2009. Boletin Cientifico y Tecnico 20(8): 1-14.

Solano F and Mendivez W (2005) Seguimiento al proceso de comercialización del cangrejo rojo (*Ucides occidentalis*): Documento Interno. Instituto Nacional de Pesca, Guayaquil, Ecuador. 19 p.

Solís P and Mendívez W (1999) Puertos pesqueros artesanales de la costa continental Ecuatoriana. Programa de Cooperación Técnica para la Pesca. Unión Europea-VECEP ALA92/43, Instituto Nacional de Pesca, Guayaquil, Ecuador. 346 p.

Villón C, Chalén X, Balladares M and Castro F (1992) Las pesquerias artesanales en la costa del Ecuador durante el primer semestre de 1992. Boletin Cientifico y Tecnico 12(6): 1-30.

Wood C, Boustead P, Mora Y and Grijalva M (1998) Ecuador: A review of the handling, distribution and marketing of fresh and frozen fish from the artisanal sector. Boletin Cientifico y Tecnico 9(5): 1-81.

Zeller D and Pauly D (1995) Good news, bad news: global fisheries discards are declining, but so are total catches. Fish and Fisheries 6: 159-159.

Appendix Table A1: Breakdown of total reconstructed catch (t) by sector for Ecuador's mainland, 1950-2010.

Year	FAO landings[a]	Total reconstructed catch	Industrial	Artisanal	Subsistence	Discards
1950	4,420	58,500	2,930	54,600	351	541
1951	5,064	60,200	3,300	55,900	362	608
1952	5,486	61,500	3,320	57,200	372	608
1953	5,809	63,200	3,670	58,400	388	676
1954	7,963	66,400	5,130	59,800	434	946
1955	9,573	69,200	6,220	61,300	499	1,149
1956	15,751	73,500	8,250	63,000	625	1,554
1957	17,593	73,200	7,940	63,500	423	1,419
1958	20,603	77,100	10,110	64,700	433	1,824
1959	22,734	79,100	10,770	66,000	443	1,892
1960	27,309	80,800	11,240	67,200	453	1,892
1961	28,092	88,500	16,300	68,600	492	3,108
1962	32,159	91,700	16,590	71,100	818	3,175
1963	37,646	103,900	26,900	72,700	904	3,378
1964	37,282	110,000	32,870	72,900	909	3,378
1965	40,055	114,700	36,900	73,100	935	3,851
1966	37,366	115,500	37,650	73,300	980	3,581
1967	39,430	120,200	41,840	73,400	986	4,054
1968	52,644	152,500	73,630	73,400	991	4,459
1969	46,906	167,700	88,110	72,500	797	6,209
1970	76,775	181,600	104,170	72,500	802	4,155
1971	85,377	197,000	119,680	72,500	848	3,952
1972	99,177	232,700	151,970	75,500	853	4,459
1973	141,521	331,900	247,820	78,300	879	4,929
1974	157,820	366,200	278,200	83,300	925	3,709
1975	188,951	426,200	332,440	88,700	1,030	4,020
1976	269,547	670,300	577,460	86,900	1,200	4,662
1977	406,608	980,300	886,770	88,800	1,221	3,509
1978	590,380	1,388,900	1,312,360	71,300	1,147	4,134
1979	572,146	1,368,800	1,269,070	93,300	1,152	5,261
1980	612,782	1,460,300	1,365,710	88,200	1,165	5,270
1981	508,528	1,181,000	1,071,630	102,900	1,107	5,405
1982	566,938	1,319,800	1,187,440	125,700	1,220	5,405
1983	315,500	681,300	579,100	95,000	1,189	6,013
1984	820,268	1,478,600	1,368,270	104,800	1,253	4,256
1985	952,112	2,125,400	2,022,740	97,300	1,295	4,069
1986	887,378	1,391,300	1,303,530	80,500	1,010	6,314
1987	576,718	946,300	789,780	149,400	683	6,472
1988	736,591	1,084,400	982,510	95,700	733	5,473
1989	558,559	826,600	734,980	85,700	738	5,162
1990	236,934	370,400	284,230	79,900	615	5,610
1991	269,594	444,000	337,560	96,300	909	9,180
1992	187,897	397,800	289,670	98,000	662	9,391
1993	247,531	569,600	416,070	143,400	686	9,491
1994	291,576	507,400	338,370	161,600	710	6,756
1995	454,032	619,800	470,720	144,000	733	4,381
1996	635,339	805,400	660,070	141,200	757	3,365
1997	445,632	599,800	458,080	137,900	781	3,020
1998	207,174	354,700	223,310	128,300	758	2,297
1999	315,901	419,700	296,140	121,900	735	855
2000	334,633	570,100	448,860	119,000	713	1,528
2001	445,735	577,800	455,620	120,000	686	1,494
2002	192,636	323,600	206,920	114,400	660	1,610
2003	238,564	361,900	251,060	108,600	633	1,587
2004	197,931	313,500	208,190	103,400	517	1,393
2005	247,069	364,900	263,830	98,900	527	1,655
2006	276,610	374,700	276,110	96,300	559	1,724
2007	240,430	349,800	244,510	101,400	590	3,390
2008	278,211	406,200	297,690	103,500	622	4,369
2009	309,680	393,000	294,740	92,700	656	4,941
2010	240,451	356,600	249,850	100,900	683	5,178

[a] These are the adjusted FAO landings which account for a few years of over-reporting of the artisanal sector.

Appendix Table A2: Species breakdown of total reconstructed catch (t) for Ecuador mainland, 1950-2010.

Year	*Scomber japonicus*	*Sardinops sagax*	*Opisthonema libertate*	*Etrumeus teres*	*Cetengraulis mysticetus*	Others
1950	-	-	-	-	-	58,500
1951	-	-	-	-	-	60,200
1952	-	-	-	-	-	61,500
1953	-	-	-	-	-	63,200
1954	-	-	-	-	-	66,400
1955	-	-	-	-	-	69,200
1956	-	-	-	-	-	73,500
1957	-	-	-	-	-	73,200
1958	-	-	-	-	-	77,100
1959	-	-	-	-	-	79,100
1960	-	-	-	-	-	80,800
1961	-	-	-	-	-	88,500
1962	-	-	-	-	-	91,700
1963	4,270	2,150	1,160	1,290	241	94,800
1964	7,230	3,640	1,970	2,180	408	94,600
1965	7,770	3,920	2,120	2,340	439	98,200
1966	8,870	4,470	2,420	2,670	500	96,600
1967	9,310	4,690	2,540	2,810	525	100,400
1968	23,320	11,760	6,360	7,030	1,316	102,700
1969	26,060	13,140	7,100	7,860	1,470	112,000
1970	38,320	19,320	10,450	11,560	2,162	99,800
1971	45,870	23,130	12,510	13,830	2,588	99,100
1972	60,440	30,480	16,480	18,230	3,410	103,700
1973	104,010	52,450	28,360	31,370	5,868	109,900
1974	120,430	60,730	32,840	36,320	6,794	109,100
1975	144,520	72,880	39,400	43,580	8,153	117,600
1976	258,390	130,300	70,450	77,920	14,577	118,600
1977	405,100	204,280	110,450	122,160	22,854	115,500
1978	602,170	303,660	164,180	181,590	33,972	103,400
1979	578,770	291,860	157,800	174,530	32,652	133,200
1980	624,750	315,050	170,340	188,400	35,246	126,600
1981	448,090	255,100	68,390	266,180	2,832	140,400
1982	589,380	314,100	219,850	25,550	2,832	168,100
1983	252,670	104,160	69,160	79,340	40,384	135,600
1984	396,910	648,780	182,070	52,030	54,029	144,700
1985	397,860	1,215,590	328,070	40,740	5,788	137,300
1986	274,850	590,260	297,720	29,210	74,246	125,000
1987	149,300	210,100	240,580	14,370	126,420	205,500
1988	255,550	382,340	206,770	9,220	84,346	146,200
1989	141,330	260,870	189,790	840	63,433	170,300
1990	78,640	16,900	98,630	5,470	30,996	139,700
1991	55,020	3,380	91,620	17,180	59,637	217,100
1992	25,650	210	31,020	9,690	99,672	231,500
1993	50,980	0	69,250	57,660	101,683	290,100
1994	37,810	210	67,780	29,820	26,343	345,400
1995	60,860	33,130	39,160	44,280	45,627	396,700
1996	79,270	355,500	40,930	34,260	26,282	269,200
1997	191,750	55,970	37,640	1,090	89,520	223,800
1998	44,580	1,010	40,410	8,850	44,338	215,500
1999	28,110	8,760	22,100	3,610	27,036	330,000
2000	83,680	51,290	19,980	4,400	13,294	397,500
2001	84,930	41,940	20,000	30	73,017	357,900
2002	16,850	1,900	10,810	600	18,043	275,400
2003	32,510	620	6,740	1,040	19,046	301,900
2004	50,190	530	8,320	4,750	4,903	244,800
2005	112,370	0	8,060	4,510	9,418	230,500
2006	29,770	10	13,320	340	9,749	321,500
2007	29,550	0	9,690	360	739	309,500
2008	14,620	0	16,970	1,770	18,091	354,700
2009	20,430	0	12,540	640	4,224	355,200
2010	58,590	0	32,620	2,110	823	262,500