Fisheries Centre

The University of British Columbia

Working Paper Series

Working Paper #2015 - 27

Rise and fall of Venezuelan industrial and artisanal marine fisheries: 1950-2010

Jeremy J. Mendoza

Year: 2015

Email: mendoza.jeremy@gmail.com

Rise and fall of Venezuelan industrial and artisanal marine fisheries: 1950-2010

Jeremy J. Mendoza

Instituto Oceanográfico de Venezuela, Universidad de Oriente, Cumaná, Venezuela
mendoza.jeremy@gmail.com

Abstract

Venezuelan fisheries account for a substantial proportion of fisheries catches in the Caribbean Sea and adjacent waters, as well as tuna in the eastern Pacific Ocean. High productivity within the Exclusive Economic Zone (EEZ) is associated with an extensive continental shelf, a coastal upwelling and the runoff of large rivers. Statistical data from national and international sources, publications, grey literature and expert opinions were used to reconstruct Venezuelan fisheries catches during the period 1950-2010 by estimating reported and unreported landings, unreported catches and discards at the lowest taxonomic resolution possible. Total reported landings by all fisheries increased from 50,000 $t{\cdot}year^{-1}$ in 1950 to a maximum of 513,600 $t{\cdot}year^{-1}$ in 2004 and later declined to 167,600 $t{\cdot}year^{-1}$ by 2010. On the other hand, total estimated catch (reported, unreported, and discards) increased from around 82,000 $t{\cdot}year^{-1}$ in 1950 to a maximum of 688,000 $t{\cdot}year^{-1}$ in 2004 and then declined steadily to about 221,000 $t{\cdot}year^{-1}$ by 2010. Total discards reached a maximum of 74,000 $t{\cdot}year^{-1}$ in 1989 at the height of the trawl fishery, but later declined to just under 1,000 t in 2010 after the closure of the trawl fishery in early 2009. Small-scale fisheries (artisanal, subsistence, and recreational) represented 74% of total catches for the period 1950-2010. Data showed a sequential rise and decline of the industrial (trawl and tuna) and artisanal fisheries during the study period, a result of sequential overfishing. At present, the most pressing problem for the Venezuelan fisheries administration is regulating the complex and diverse artisanal sector in order to recover overfished populations and prevent further overfishing.

Introduction

The Venezuelan coastline occupies most of the southern margin of the Caribbean Sea, and shares with Trinidad and Tobago the northwestern limit of the Guianas Coastal Province (Longhurst 1998). The continental shelf area is approximately 100,000 km^2 and the Exclusive Economic Zone (EEZ) is around 475,000 km^2 (www.maritimeregions.org). This EEZ is an approximation as there are still ongoing discussions with several neighboring countries over entitlement to the area. In contrast to many other Caribbean countries, Venezuela's shelf width is significantly large along the Orinoco delta and in northeastern Venezuela, where maximum shelf width extends to 150 km. Shelf width is significantly reduced along the central Venezuelan coast and gains in extension towards the west in the Gulf of Venezuela. Four distinct ecological regions can be identified along the Venezuelan coasts (Novoa *et al.* 1998; Cervigón 2005) that have characteristic environmental conditions and faunal assemblages (Figure 1):

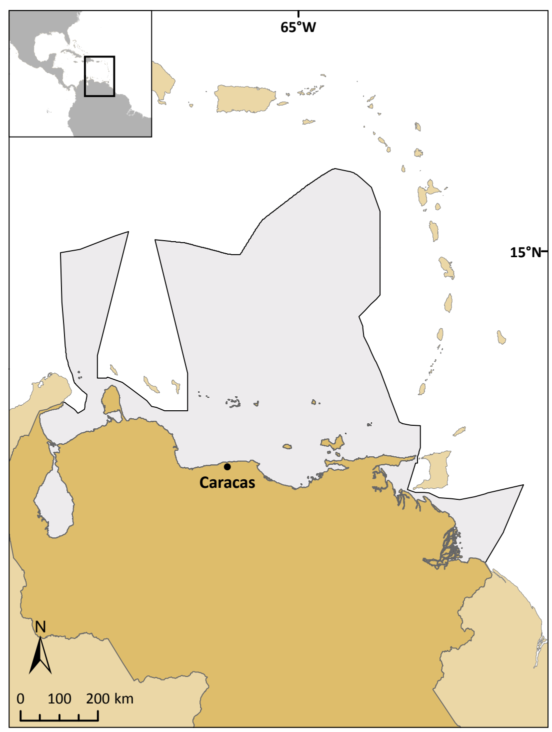

Figure 1. Map of Venezuela, showing the country's EEZ claims

Eastern area: the Orinoco delta and Gulf of Paria along the Atlantic margin dominated by runoff from the Orinoco River and under the influence of the Brazil Current. The faunal assemblage is characteristic of the Guianas-Brazil shelf with a predominance of demersal commercial species, such as shrimp (Penaeidae), weakfishes and whitemouth croaker (Sciaenidae), catfish (Ariidae), largehead hairtail (Trichiuridae), and mullets (Mugilidae). Further offshore, snappers (Lutjanidae) and groupers (Serranidae) are abundant. In the pelagic domain, sierra, Spanish and king mackerels (Scombridae) and jacks (Carangidae) are common.

1) Northeastern area: the northeastern Venezuelan shelf is characterized by a main coastal upwelling event from November to May and the influence of the Orinoco River plume (in its western section) in the rainy season (June-October). Pelagic fish species are dominant in this area, especially Clupeidae (*Sardinella aurita* and *Opisthonema oglinum*), Scombridae (*Auxis thazard, Sarda sarda, Euthynnus alletteratus, Scomberomorus brasiliensis*

and *S. cavalla*) and Carangidae (*Caranx hippos* and *Trachurus lathami*). In the demersal domain, grunts (Haemulidae), snappers, groupers, catfish, and small sharks (e.g., *Rhizoprionodon* spp. and *Mustelus* spp.), among others, are abundant and diverse. Mollusks are also common and abundant, especially bivalves (*Arca ventricosa*, *Pinctada imbricata*, *Perna perna* and *P. viridis*) and cephalopods (*Octopus* spp. and *Loligo* spp.).

2) Central area: central Venezuela has a very narrow shelf with limited upwelling and river runoff. Seamounts and island groups (archipelagos of Los Roques and Las Aves) are present offshore. The faunal assemblage has the strongest affinity with the rest of the Caribbean. The invertebrate commercial faunal includes spiny lobster (*Panulirus argus*) and queen conch (*Strombus gigas*). Haemulids, scarids and lutjanids are common demersal species, while billfishes and tunas are common in the pelagic domain.

3) Western area: western Venezuela has a wide shelf area under the influence of estuarine waters from Lake Maracaibo in the south and coastal upwelling along the eastern margin of the Gulf of Venezuela. Penaeid shrimp and blue crab (*Callinectes* spp.) are important invertebrate commercial species. The demersal fish faunal assemblage is dominant and presents a strong affinity with the Guianas-Brazil shelf (Sciaenidae, Ariidae and Mugilidae).

Small-scale fishing activities have been conducted in Venezuela since Pre-Columbian times by Amerindian peoples (Suárez and Bethencourt 1994) and fishing was an important economic activity during the colonial period. The exploitation of the pearl oyster (Pinctada imbricata) around Cubagua Island in northeastern Venezuela, during the early 16th century, led to the first recorded depletion of a fisheries resource in the Americas (Romero *et al.* 1999; Romero 2003).

In modern times, artisanal fishing has also dominated fish and invertebrate catches with common fishing gears such as handlines, longlines (bottom and pelagic), gillnets, dredges, beach seines, boat seines and purse seines (Novoa *et al.* 1998). The artisanal sector has been traditionally divided into coastal, medium-range and long-range components. The coastal fishery is the largest component with more than 14,000 registered vessels that operate within the "territorial sea" (waters within 12 nautical miles from the baseline of the coast). These vessels are usually wooden boats between 6 m and 9 m length and powered by one or two outboard engines with a typical crew of three fishers. These boats may operate individually or cooperatively, depending on the target species. For example, when fishing for small pelagics with seines or purse seines, four to six boats may be used simultaneously.

The medium-range fleet operates within the Venezuelan EEZ and that of neighboring Caribbean island countries, and is here considered 'industrial'. Boats are typically wooden decked vessels, 10 m to 14 m length powered by inboard diesel engines with crews of five to seven fishers. The long-range fleet operates mainly along the Guianas-Brazil shelf from Venezuela to northern Brazil, but especially in EEZ waters of Suriname and French Guiana. Vessels are similar to the medium-range fleet, except for their larger size (14-24 m) and crews (10-15 fishers). This long-range fleet, operating in French Guiana and Suriname, is also considered an industrial fleet. The medium range and long-range fleets usually operate with handlines and longlines (bottom and pelagic) and target demersal and pelagic species such as snappers, groupers, king mackerel, dolphinfish and billfishes.

Industrial trawling was introduced in the late 1940s by Italian immigrants who started their operations in the Gulf of Venezuela using Mediterranean type stern trawlers. Florida type double-rigged trawlers were introduced in the early 1960s and became the main type of vessel used in this fishery. By the late 1960s, the industrial trawl fleet had expanded its activities to the northeastern and eastern continental shelf. This fleet rapidly increased in numbers and by the late 1980s reached 450 vessels nationwide. Penaeid shrimp, mollusks (octopus and squid) and demersal fish species (Sciaenidae, Haemulidae, Carangidae, Trichiuridae, among others) were the main target species. Due to the increase in number of vessels, conflicts with the coastal artisanal sector and overexploitation of fishery resources, management measures were taken to control fishing effort during the 1980s, mainly spatial and temporal restrictions and prohibition of new vessel construction. These measures led to a significant reduction in landings and number of vessels, and by 2006 there were around 260 trawlers operating in Venezuelan waters. Additionally, in 2008 a new fisheries and aquaculture law was enacted by presidential decree that prohibited industrial trawling in Venezuelan waters and became effective in April 2009.

Industrial fishing for tunas started in the mid 1950s by the introduction of a Japanese longliner targeting mainly yellowfin tuna (Thunnus albacares) in the western Atlantic. Results were encouraging and led to the development of an industrial longline fleet that was producing an average of around 3,000 $t \cdot year^{-1}$ by the mid 1970s. In the late 1970s and early 1980s, a surface tuna fleet, composed of pole and line vessels and purse seiners, was developed through government incentives. The surface tuna fleet operates in the western Atlantic (pole and line vessels and medium size seiners) and in the eastern tropical Pacific (large purse seiners) targeting mainly yellowfin tuna and to a lesser extent skipjack tuna (Katsuwonus pelamis). By the mid 1990s the surface tuna fleet numbered 30 purse seiners and 17 pole and line vessels and had catches of about 80,000 $t \cdot year^{-1}$.

In this report, statistical data from various sources, publications, grey literature and expert opinions were used to reconstruct Venezuelan marine fisheries catches, in space and time, for the period 1950-2010 by estimating reported landings, unreported catches and discards at the lowest taxonomic resolution possible.

Methods

Main data sources

The FAO landings database includes reports of landings for 62 species or taxonomic groups from Venezuela for the period 1950-2010. The number of species and taxonomic groups registered in the FAO database has increased through time: 29 species or groups were reported between 1950 and 1960, 51 between 1961 and 1970 and 61 between 1971 and 1980. This probably reflects increased taxonomic resolution at the national source, as well as changes in target species through time. An analysis for the period 1984-1999 (Mendoza *et al.* 2003) showed minimal quantitative differences between the FAO data and national data, indicating good transfer of data from the national source to the global FAO database (Garibaldi 2012). However, in recent years (2004-2010), transfer of data from the national source to the FAO database has not been as effective, as only 48 species or taxonomic groups appear as estimates.

The institution responsible for collecting fisheries data in Venezuela is the *Instituto Socialista de la Pesca y Acuicultura* (INSOPESCA), while fisheries research is conducted by the *Instituto Nacional de Investigaciones Agricolas* (INIA), as well as universities and NGOs. Data for artisanal and industrial marine and estuarine fisheries are collected by 29 offices of INSOPESCA present in 11 coastal states (from east to west: Delta Amacuro, Monagas, Sucre, Nueva Esparta, Anzoátegui, Miranda, Vargas, Aragua, Carabobo, Falcón and Zulia) and 2 inland states (Mérida and Trujillo) bordering Lake Maracaibo (Anon. 1996). Most artisanal fisheries data rely on reports by fishers of their monthly landings. However, for certain specialized artisanal fisheries, such as that for Spanish sardine (*Sardinella aurita*) and turkey wing (*Arca ventricosa*), landing controls and cannery reports are also used. On the other hand, industrial fisheries data rely on log books, landing controls and, to a lesser extent, onboard observers. Data collected by INSOPESCA for marine fisheries, aggregated by species or taxonomic group, year and state, were available in digital form for the period 1984-2010. Additionally, data on paper aggregated by species or taxonomic group and year, but not by state, were available for the years 1967-1969, 1971-1973, 1975, 1979-1981 and 1983, and data on paper aggregated by year and state, but not by species or taxonomic group, were available for the years 1965-1972 and 1976-1983 from yearly statistical reports of the Ministry of Agriculture and Animal Husbandry (*Anuarios Estadísticos del Ministerio de Agricultura y Cría*).

The International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Inter-American Tropical Tuna Commission (IATTC) are the Regional Fishery Management Organizations (RFMOs) responsible for tuna fisheries in the Atlantic Ocean and eastern tropical Pacific Ocean, respectively. These organizations record information on major tuna species, small scombrids, billfishes and swordfish, and incidental catch of other species (dolphinfish, elasmobranchs, etc.). Catch data by species and gear were downloaded from the respective websites and data corresponding to Venezuela were extracted and compared to the FAO database. There is a close correspondence between ICCAT and FAO landings data for Venezuelan tuna fisheries in the western Atlantic, especially after 1973. Considering that ICCAT data reports landings by species and gear, the information from this source was retained to represent Venezuelan landings from the western Atlantic Ocean. In the Pacific Ocean, differences in reported landings between FAO and IATTC data are larger than those in the Atlantic between ICCAT data and FAO data. Main differences are: 1) FAO records go back to the mid 1970s and IATTC data records start in 1980; 2) FAO reports data by FAO statistical areas 77 (Eastern Central Pacific) and 87 (South Eastern Pacific), while IATTC data are aggregated; 3) FAO data reflect landings of main tuna species (*T. albacares*, *T. obesus* and *K. pelamis*) and black skipjack (*Euthynnus lineatus*), while IATTC include these species and 12 additional species or taxonomic groups; and 4) there are differences in the amounts reported by both institutions depending on species. These are usually small (i.e., 10%) for *T. albacares* and *K. pelamis*, which represent the bulk of Venezuelan catches, but may be large in some years (i.e., 50%) for *T. obesus* or even larger for *E. lineatus*. The approach used in this study for the main tuna species was to: 1) use FAO data for years prior to 1980 and IATTC data thereafter; and 2) Use FAO percent catches per statistical areas in order to spatially disaggregate IATTC catches of main tuna species. For the rest of the species, catches reported by IATTC were spatially disaggregated by FAO statistical areas proportionally to the total catch of the main tuna species caught by the Venezuelan fleet.

Trawl fishery data were jointly collected by INSOPESCA and INIA in the main fishing ports: Güiria in eastern Venezuela (1973-2008), Cumaná (1970-2008) and Guanta (1970-2004) in northeastern Venezuela, Puerto Cabello (1973-2008) in central Venezuela and Punto Fijo (1956-2006) in western Venezuela. INIA data also include fishing effort estimates for assessment purposes. These data were recently reviewed for eastern and northeastern Venezuela by Mendoza *et al.* (2010) and for western Venezuela by Pomares-Ferraz *et al.* (2010).

IUU estimates

Few studies have estimated unreported catches for Venezuelan fisheries. For industrial fisheries, data are considered accurate as there are few landing ports and there are statistical systems in place. However, for the trawl fishery in eastern Venezuela, for the period 1973-1986, data only include shrimp landings and aggregated data for all fish species; after 1986 the most important commercial fish species were identified in the landings. In order to estimate landings of commercial fish species prior to 1987, percent composition for these species for the period 1987-1990 was applied to the aggregated fish landings for the period 1973-1986.

For the artisanal fisheries, the situation is much more complex and varies according to fishery and target species. Artisanal fisheries directed to single species, such as sardine and turkey wing in northeastern Venezuela, and shrimp and blue crab fisheries in Lake Maracaibo, have few landing sites and a significant amount of their landings occur at processing plants where data are collected. The medium range fisheries and long range fisheries target relatively few species (snappers, groupers, king mackerel, dolphinfish and billfish) depending on season and fishing areas, and landing sites are relatively few. However, a significant amount of landings (especially southern red snapper *Lutjanus purpureus*) of the medium and long range fleet are landed in other countries (mainly, French Guiana and Suriname). Data from INSOPESCA include the category *Foreign Ports* (without country specification) for non-identified snappers, groupers, and *Rhomboplites aurorubens*, but only for the period 1988-2000. For the rest of the small-scale fisheries that mainly target demersal and pelagic fish species, there are hundreds of landing sites along the coast and landing data rely essentially on reports by fishers. In order to account for under-reporting in small-scale fisheries, INSOPESCA uses a correction factor of 40%.

Few independent studies have estimated unreported landings in Venezuelan small-scale fisheries. For coastal multi-species fisheries in northeastern Venezuela, Mendoza and Freon (1991) estimated that, after applying the correction factor used by INSOPESCA, unreported landings represented between 90% and 120% of reported landings. The same approach applied to data from Salaya *et al.* (1987) in central Venezuela, with results of unreported landings ranging from 0.4 to 1.5 times reported landings. However, in Los Roques archipelago in central Venezuela, unreported fish landings were greater than 4 times the reported landings (Posada 1993), while in the lobster fishery estimates of under-reporting ranged from 0.6 to 2 (Posada *et al.* 1996). In the fishery for trigonal tivela clam (*Tivela mactroides*) in Margarita Island, reports from Marcano (1993) and Crescini (2012) indicate that unreported catches are approximately 10 times greater than reported landings.

Landings of recreational fisheries for billfishes (Family Istiophoridae) during the period 1961-1996 have been reported to ICCAT, but since the mid-1990s, the fishery has become exclusively catch and release and there are no records of landings. However, this fishery began in the early 1940s (Alió 2012) and therefore, linear interpolation was used (assuming a catch of zero in 1945) in order to estimate unreported catches for the period 1950-1960.

Little is known about subsistence fisheries in Venezuela, as they are not common along the coastal marine environments in the country. However, traditionally, small-scale (artisanal) fishers keep a part of their catch for household consumption and to give away among members of their community (Mendoza 1999). Novoa (1986) estimated that this proportion amounted to approximately 5% in artisanal fisheries of the Orinoco River, and Gómez-Gaspar and González (2008) reported that around 1% of an unusually large catch of *Sardinella aurita* was used for these purposes in Margarita Island. Additionally, the Warao indigenous people inhabit the Orinoco delta, where freshwater and estuarine fish, from subsistence and commercial fishing, represent their main source of animal protein. Studies of Warao fisheries are scarce and have been conducted in the upper and mid-delta where freshwater species are predominant most of the year (Ponte and Mochcco 1997; Lasso *et al.* 2004). Nevertheless, a significant portion of the Warao population lives in the lower delta where estuarine species are common (Cervigón 1985) and many of these species have common Warao names (Novoa 2000b). It is considered that two factors have led to reduced subsistence fishing activities in the Orinoco delta. First is the closure of the Manamo channel in 1965, which was supposed to contribute to agriculture development, but failed and substantially modified the natural hydrological cycle in the western delta, causing displacements of the Warao population to regional urban centers and other areas of the delta (García-Castro and Heinen 1999; Heinen and Gassón 2006). The second factor is the increased assimilation of the Warao people since the 1950s (Gruson 2009).

In view of the above, the following assumptions were made to estimate unreported landings from small-scale fisheries:

1) For the sardine and turkey wing fisheries, reported landings were considered accurate and no unreported landings were estimated;

2) For the proportion of penaeid shrimp corresponding to small-scale fisheries, it was estimated that unreported landings represented 20% of reported landings. For the blue crab fishery in western Venezuela (i.e., Lake Maracaibo) unreported landings were estimated at 15% of total landings in this area, while for the rest of the country the estimate was 100%;

3) For non-identified snappers, *Lutjanus purpureus*, groupers, *Rhomboplites aurorubens*, dolphinfish and king mackerel, which are mainly fished by the medium- and long-range fleets, unreported landings were estimated at 50% of total landings. For landings in foreign ports by the long-range fleet, data from Caro *et al.* (2011) were used for *L. purpureus* and *R. aurorubens* in French Guiana, and data on imports of snappers (fresh and frozen) to the U.S. (obtained from www.st.nmfs.noaa) from Suriname were used as an estimate of Venezuelan landings of *L. purpureus* in Suriname;

4) For queen conch (*Strombus gigas*), unreported landings were estimated at 3 times reported landings, while for *Tivela mactroides*, *Donax* spp. and non-identified venus clams, unreported landings were estimated at 10 times reported landings;

5) For all other species corresponding to the small-scale coastal fisheries, unreported landings were estimated as equal to reported landings;

6) For small-scale subsistence catches from the coastal multi-species artisanal fisheries, it was estimated that 5% of the sum of reported and estimated unreported landings was used for self consumption in fisher communities. However, high valued species such as snappers, groupers, gags, shrimps, lobster and king mackerel were excluded from this estimate. For the mono-specific fisheries of sardine and turkey wing, it was estimated that 1% of reported landings were used for this purpose; and

7) For Warao subsistence fisheries, it was estimated that they corresponded to 10% of the sum of reported landings and IUU estimates of estuarine species for the states of Monagas and Delta Amacuro during the period 1950-1965, 7.5% for the period 1966-1984 and 5% for the period 1985-2010.

Temporal and spatial data allocation

As stated earlier, the FAO database has good correspondence with national data (Mendoza *et al.* 2003), but has a higher level of taxonomic aggregation. As the available disaggregated national data do not cover the complete time period in the FAO data, especially prior to 1967, average percent species composition for the period 1967-1973 from the national source was used to disaggregate FAO data for the period 1950-1966. On the other hand, spatially allocated data only exist in the national data for the period 1984-2010. In order to spatially allocate data for years prior to 1984, average percent landings per area for the period 1984-1990 was used to spatially allocate data for the period 1950-1983. However, in some cases when strong changes or trends existed in the data for 1984-1990, the period was shortened to include only the first few years (i.e., 1984-1986 or 1984-1987).

Discards

Industrial fisheries

In the eastern tropical Pacific tuna fisheries, IATTC onboard observer programs allow the estimation of discards since 1993. The most recent report (IATTC 2012) presents retained and discarded catch by gear for the main tuna species and 14 additional species or taxonomic groups for the period 1993-2011. In order to estimate discards by Venezuelan purse seiners, I estimated the ratio of discards per species or taxonomic group to retained catch for the entire purse seine fleet and applied this ratio to the Venezuelan catch. In order to estimate discards for years prior to 1993, the average discard rate for the years 1993-1996 was used. Additionally, discards were allocated to FAO areas 77 and 87 as a function of percent total tuna catch per area and per year.

There are no estimates of discard rates and species composition for tuna fisheries in the western Atlantic Ocean. In the eastern Atlantic, discard rates of skipjack tuna and yellowfin tuna caught in association with fish aggregating devices (FADs) were estimated at 4.2% and 0.13% per tonne landed, respectively (ICCAT 2009). In the western Atlantic, most tuna sets by Venezuelan seiners are on free schools (i.e., not associated with flotsam or other marine animals), but around 34% of sets are associated with whale sharks (Gaertner and Medina-Gaertner 1999). Considering that slow moving whale sharks may have similar aggregating effects as FADs (Fréon and Dagorn 2000), discard rates for FADs in the eastern Atlantic were applied to 34% of the landings of Venezuelan purse seiners and bait boats fishing in the western Atlantic. The discard rate for yellowfin tuna was also applied to albacore and bigeye tunas, while that for skipjack was also applied to blackfin tuna.

Discard rates for the trawl fishery have been estimated through various studies using onboard observers to estimate total catch and species composition of discards. Marcano *et al.* (2001) present results obtained in eastern and northeastern Venezuela during the 1990s, Penchaszadeh *et al.* (1984) estimated discards for the small trawl fishery in central Venezuela. Valdez (1984) and García-Galicia (2004) presented results for western Venezuela. Depending on regions and years, discard rates vary between 50% and 75% of the total catch, with an overall average of 65%. Also, data for eastern Venezuela show changes in discarding practices for commercial fish species during the development of the fishery, due to high abundance of shrimp in the early years and the lack of markets and processing facilities in this area of the country until the mid 1980s. In order to estimate discards of commercial fishes in this area, regressions of catch-per-unit-of-effort (CPUE) against time for the period 1987-2008 were used to estimate CPUE for the years 1973-1986 and then catches were estimated by multiplying by effort. These catches exceeded estimated landings for these species during the period 1973-1986 (see section on IUU estimates), and the difference between them was considered as discards. Also, for certain lower valued species, shorter time series in CPUE were used to estimate discards as CPUE values showed increasing trends in the initial years analyzed, likely reflecting discarding practices instead of changes in apparent abundance; for example, Ariidae and *Selene setapinnis* (1990-2008), *Trichiurus lepturus* (1993-2008) and *Macrodon ancylodon* (1997-2008).

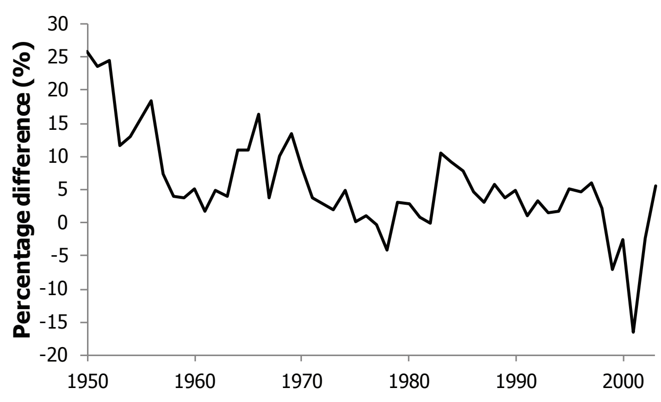

Figure 2. Percent differences between FAO data and national data for the period 1950-2003.

Artisanal fisheries

There are no estimates of discard rates in the Venezuelan artisanal fisheries. However, for most fishing gears used (handlines, longlines and gillnets) discards rates in small-scale fisheries are usually negligible. For small pelagic species (*Sardinella aurita*, *Centengraulis edentulus*, *Opisthonema oglinum* and *Scomber colias*) caught mainly with beach and boat seines and artisanal purse seines, a discard rate of 1.2% was used (Kelleher 2005).

Results

General

Total fisheries catch in domestic waters

The FAO database and the reported landings data reconstructed in this study show a relatively good correspondence (i.e., differences of ± 0-5%) during most of the period analyzed (Figure 2), except for 1950-1956, 1964-1966, 1969 and 2001. In the earlier years, these differences are mainly attributed to the non-identified marine fish category, and in 2001 the difference is mainly related to FAO data reflecting an underestimate of *Sardinella aurita* landings of 40,000 t. As stated earlier, there has been a poor transfer of data from the national source to FAO since 2004 and, therefore, it is not possible to easily compare both sources.

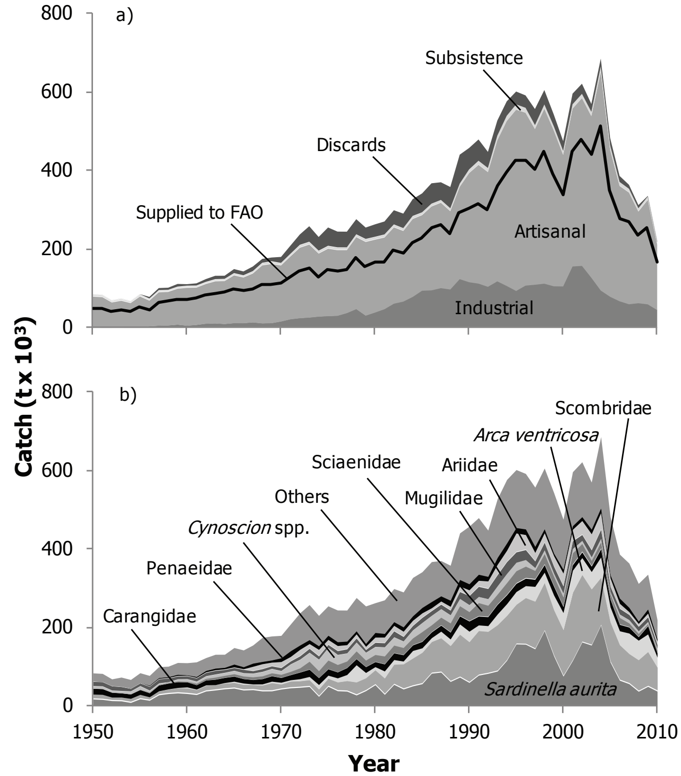

Figure 3. Reconstructed total catch for Venezuela (excluding catches in foreign waters), 1950-2010, a) by sector, with comparison to the reported national data, and b) by major taxonomic groups. Note that recreational catches are not visible and that 'others' consists of 31 additional taxonomic categories.

The total reported landings of Venezuelan fisheries show an almost continuous increase from around 46,000 t in 1956 to approximately 513,000 t in 2004 (Figure 3a); that is more than an order of magnitude increase in less than 50 years. However, after the peak in 2004, there has been a steep and steady decline in reported landings until the end of the series when about 167,000 t were reported in 2010, which corresponds to levels of reported landings reached in the late 1970s. Estimated reconstructed landings (i.e., reported and unreported landings from all sectors) follow a similar trend and also reached a maximum in 2004 at about 666,000 t while by the end of the series in 2010 estimated reconstructed landings reached a value of approximately 217,000 t. Total estimated catch (landings and discards) also reached a maximum in 2004 at about 686,000 t but the difference between this estimate and estimated landings (i.e., the value of the discards) reached a maximum slightly greater than 74,000 t in 1989, and later decreased as discards from the trawl fishery declined during the 1990s and 2000s until its closure in early 2009. By the end of the series in 2010, total estimated catch had decreased to approximately 218,000 t and discards only represented around 1,000 t. Total reconstructed catches for Venezuela within domestic waters over the 1950-2010 time period were estimated to be 18,358,000 t, which is 45% higher than the national reported landings. Unreported landings represented 23% of the total catch and discards represented 8%.

The majority of Venezuelan catches come from the western central Atlantic, which contributes 90% to the total catch. The eastern central Pacific constitutes 6% of the total catch and the remaining 4% comes from the southeast Pacific. Within the western central Atlantic 80% of the catch is artisanal, followed by 18% industrial, 2% subsistence, and 0.01% recreational. Catches in the two Pacific FAO areas are 100% industrial.

The reconstructed total catch of Venezuela is dominated to *Sardinella aurita* with 3,831,300 t (20.9%) of catch (landings and discards; Figure 3b). The family Scombridae is the next largest contributor with 18.6% of the catch (3,423,400 t). *Thunnus albacares* contributes 50% (1,713,800 t) of the Scombridae catch with *Katsuwonus pelamis* being the second largest contributor at 16% (549,000 t). *Arca ventricosa* (6.1%), Carangidae (5.3%), Sciaenidae (5.1%), *Cynoscion* spp. (4.3%), Mugilidae (4.3%), Ariidae (3.9%), and Penaeidae (3.3%) are also major contributors to the reconstructed total catch.

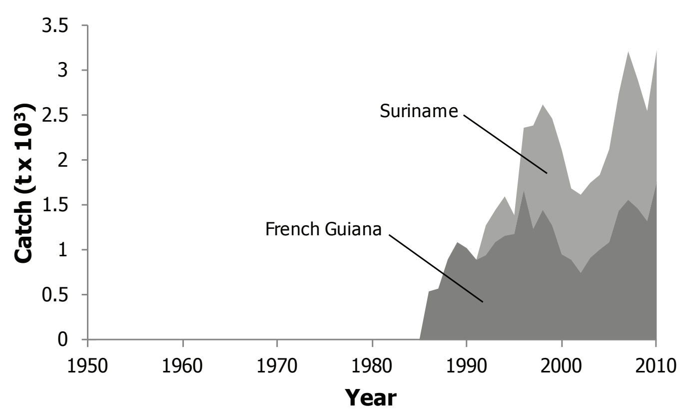

Figure 4. Reconstructed total catch for semi-industrial (long-range artisanal) catches by Venezuela in other countries' EEZ waters, 1950-2010.

Venezuelan catch in foreign waters

Venezuelan semi-industrial (here: 'industrial') catches in foreign waters totaled over 46,000 t (Figure 4). Catches from French Guiana's waters were estimated to be 28,000 t over the 1986-2010 time period. Catches started at about 500 t in 1986 and quickly increase to over 1,000 t in 1989. Catches then remained relatively stable and averaged just under 1,200 t·year^{-1} from 1989-2010, Catches peaked at 1,670 t in 1996 and have peaked again in 2010 with 1,750 t. Catches from Suriname's waters were estimated to be 18,000 t over the 1992-2010 time period. In 1992 just over 300 t was caught. A peak of 1,190 t in 1999 was followed by a decrease which lasted until 2004. Catches peaked again in 2007 at 1,650 t, followed by another decrease and then a small increase in 2010 (1,470 t).

Southern red snapper (*Lutjanus purpureus*) is taken from both French Guiana's and Suriname's waters and contributes 95% of the total catch taken in foreign waters. Relatively equal amounts are taken from both countries' waters (58% of the catch is from French Guiana with the other 42% taken from Suriname). Vermillion snapper (*Rhomboplites aurorubens*) is also caught in French Guiana's waters but only constitutes 9% of the catch from French Guiana.

There are also records of Venezuelan vessels in the waters of Aruba, 25 km north of the coast of Falcón Province in eastern Venezuela; their estimated catch is small and presented in Ramdeen and Pauly (*in press*).

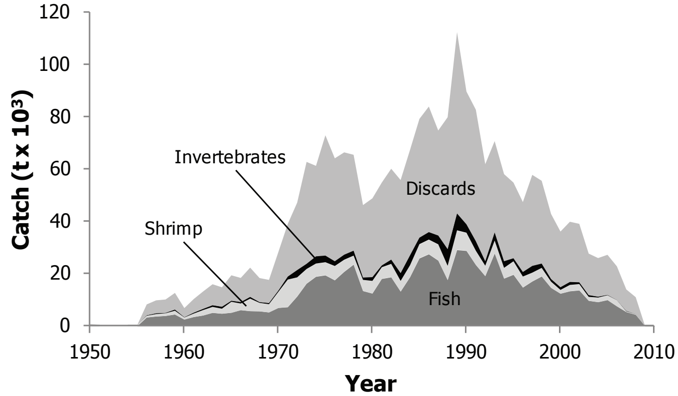

Figure 5. Landings by taxonomic groups and estimated discards from the industrial trawl fleet in Venezuela, 1950-2010.

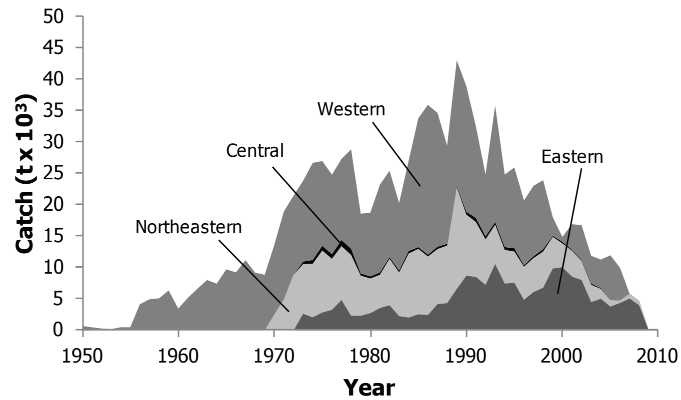

Figure 6. Landings from the Venezuelan industrial trawl fishery, by area, 1950-2010.

Large-scale fisheries

Trawl fishery

The industrial shrimp trawl fishery in the western central Atlantic shows a significant increase during the 1970s, with reported landings reaching a first peak of about 29,000 t in 1978. Reported landings started to increase again during the 1980s, and reached a reported maximum of approximately 43,000 t in 1989, afterwards landings decreased continuously until the fishery was closed in March 2009. Total reported landings from this fishery over the 1950-2010 time period were estimated to be 999,000 t (Figure 5). In addition to the landings reported, there were a large amount of discards. Over the 1950-2010 time period, discards totalled 1,342,000 t. Discards followed the same trend as landings.

Shrimp landings reached a reported maximum of over 10,000 t in 1971, and then declined sharply and fluctuated around 5,000 t·year^{-1} until the early 1980s, and later increased during the rest of the decade and reached a new peak in 1989 around 7,300 t·year^{-1} (Figure 5). Thereafter, reported landings decreased and averaged around 2,000 t·year^{-1} in the early and mid 2000s. During the early years, shrimp species represented an important percentage of the landings, with an average of 36% from 1962 to 1972; however, their contribution decreased in following years and only averaged 12% of total landings from the year 2000 until the fishery was closed. The contribution from finfish showed a significant increase from under 4,000 t·year^{-1} in the beginning of the series until a maximum value of over 27,000 t·year^{-1} was reached in 1986, afterwards landings showed a steady decline and just before the fishery closure, less than 5,000 t·year^{-1} were being landed. Landings of other invertebrate species (97% molluscs) were the least important and never exceeded 4,000 t·year^{-1}, except during 1988-1989 when peak landings of over 6,000 t·year^{-1} were observed. By the end of the series their contribution was under 200 t·year^{-1}. Discard estimates increased from under 5,000 t·year^{-1} in 1956 to a maximum of approximately 69,000 t·year^{-1} in 1989, then declined steadily and by the end of the series in 2008 estimates were around 6,000 t·year^{-1} (Figure 5).

The trawl fishery in the western area was the most important contributor to total reported landings during most of the period analyzed and contributed between 40% and 100% on average (Figure 6). In this area, landings peaked in 1986 when almost 24,000 t·year^{-1} were landed. Until 1992, the trawl fishery in the northeastern area was the second most important, reaching a maximum of about 16,000 t·year^{-1} in 1989, but was displaced by the eastern area during the rest of the period. The trawl fishery in central Venezuela reached its maximum in 1977-1978 with reported landings of around 1,000 t·year^{-1}, but for most of the period contributed less than 2% of total landings.

Tuna fisheries

Venezuelan tuna fisheries in the western Atlantic were dominated by longline landings from the mid 1950s until 1979, and during this period landings averaged over 2,200 t·year^{-1} (Figure 7a). Afterwards, landings from bait boats and, especially, purse seiners show a significant increase in the early 1980s and have since dominated the fishery. In 1994, landings from purse seiners reached a maximum of approximately 26,000 t·year^{-1} and that of bait boats reached a maximum of 6,800 t·year^{-1} in 1988. During the last decade of the study period, landings from bait boats and purse seiners have decreased more or less constantly, while that of longliners showed an increase in the last two years. Yellowfin tuna (*T. albacares*) has been the main target species of Venezuelan tuna vessels during the study period (384,800 t total), reaching a maximum of just under 25,000 t·year^{-1} in 1994 and by the end of the series had decreased to less than 5,000 t·year^{-1} (Figure 7b). Skipjack tuna (*K. pelamis*) is the second most important species and landings reached a maximum of over 12,000 t·year^{-1} in 1982 and peaked again at about 11,000 t·year^{-1} in 1993. After 2001, landings decreased more or less steadily, and by 2010 were just above 2,000 t·year^{-1}. Contributions from other tuna species have been much less significant, averaging about 14% of total landings per annum from 1957-2010. Landings of bigeye tuna (*T. obesus*) peaked at just over 4,200 t·year^{-1} in 1983 and showed a significant decline by the end of the time period. Marlin, sailfish, and swordfish catch only constitutes 2.3% of the overall Atlantic tuna fishery. Total catches of these species were 280 t·year^{-1} over the time period (1957-2010). Discard estimates of the main tuna species in the western Atlantic were relatively small and only exceeded 175 t·year^{-1} in 1982-1984 and 1993. Discards represent 0.4% of the total catch from the Atlantic tuna fishery.

Fishing for tunas in the eastern tropical Pacific increased significantly during the 1980s and reached around 60,000 t·year^{-1} by 1990 (Figure 8a). After a period of relative stability, landings increased significantly in the late 1990s and reached a maximum of approximately 125,000 t·year^{-1} in 2002. Thereafter, landings decreased substantially and by 2010 had reached around 37,500 t·year^{-1}. During most of the study period, Venezuelan purse seiners fished predominantly in the eastern central Pacific (FAO area 77) and, from 1985 to 2003, an average of 69% of the landings per annum came from this area. However, in the more recent period, fishing in the south eastern Pacific (FAO area 87) increased and averaged 58% of total landings during the years 2004-2010. In the eastern tropical Pacific, yellowfin tuna (*T. albacares*) has been the main target species of Venezuelan purse seiners and landings of this species reached a maximum of around 123,000 t·year^{-1} in 2002, and later declined to about 21,000 t·year^{-1} in 2010 (Figure 8b). Also, the relative importance of yellowfin decreased after the 2002 peak and averaged 44% of total landings between 2004-2010, as opposed to 77% of total landings between 1980 and 2003. This shift in target species led to maximum landings of skipkjack tuna (*K. pelamis*) of approximately 28,000 t·year^{-1} in 2008 and more than 9,000 t·year^{-1} of bigeye tuna (*T. obesus*) in 2004-2005. Incidental catch of all other species was only 0.22% of the total Pacific tuna fishery catch. By-catch was on average approximately

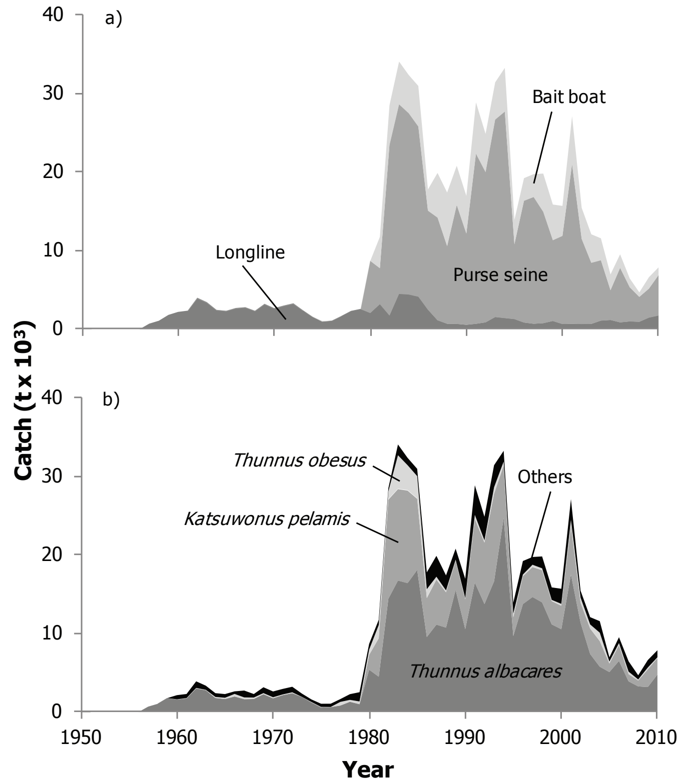

Figure 7. Industrial landings of tuna by Venezuelan vessels in the western Atlantic, 1950-2010, by a) vessel type, and b) taxonomic group. 'Others' contains 7 additional taxonomic categories.

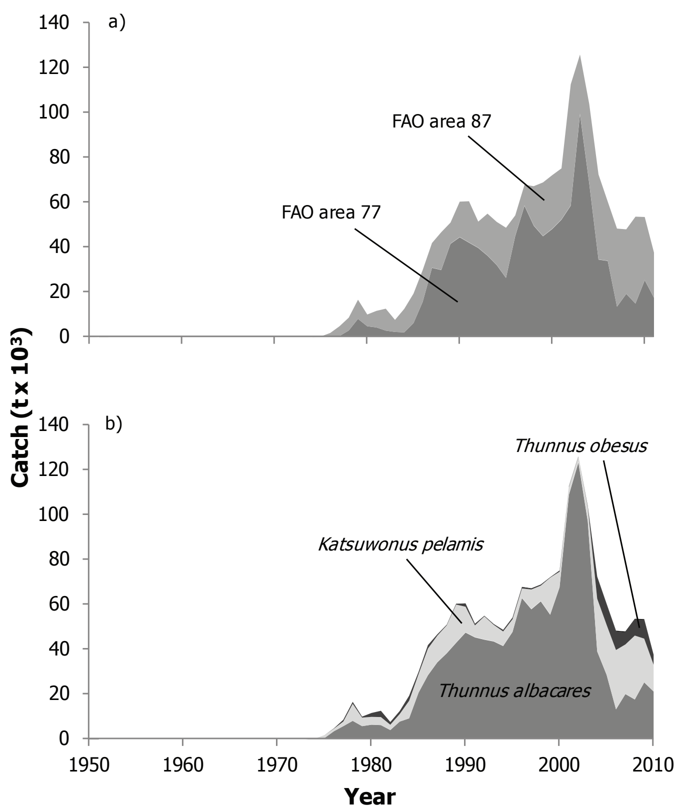

Figure 8. Industrial landings of Venezuelan purse seiners in the Pacific by a) area, and b) taxonomic group. Eight additional taxonomic categories are captured. 'Other' catches only represent 0.2% of the catch and are not visible on the graph.

100 t·year^{-1} over the time period (1974-2010). Discard estimates of tunas and other species in the eastern tropical Pacific exceeded 4,000 t·year^{-1} in 1989 and 1997, and by the end of the study period in 2010 had declined to less than 500 t·year^{-1}. Discards represent 4% of the total catch from the Pacific tuna fishery.

Small-scale fisheries

Small-scale fisheries clearly dominate Venezuelan fisheries yields (Figure 3a); if only reported landings are considered, small-scale fisheries average 79% of total fisheries landings per annum during the period 1950-2010, but if unreported catches are taken into account, the average contribution of small-scale fisheries during this period increases to 84%. Yields from the small-scale fisheries reached values of about 475,000 t·year^{-1} in the mid 1990s and peaked at approximately 571,000 t·year^{-1} in 2004. Total small-scale fisheries catches over the 1950-2010 period (including discards) were estimated to be 13,596,000 t, which is 74% of the total reconstructed catch. Artisanal fisheries catches constitute 97.2% of the small-scale catch with subsistence equating to only 2.8% and recreational fisheries less than 0.1%.

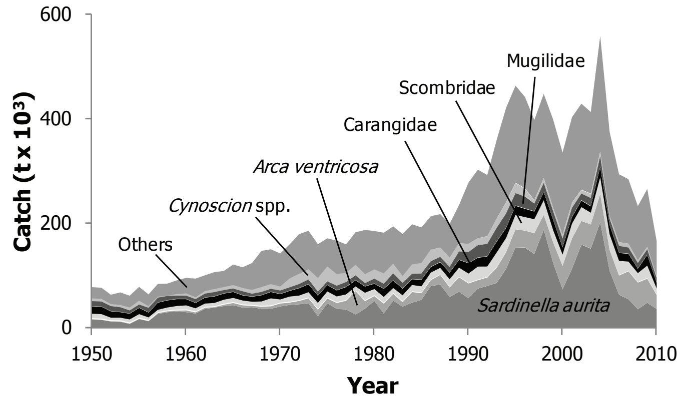

Figure 9. Reconstructed total catch of the artisanal fishery in Venezuela, 1950-2010. This includes reported and unreported landings, as well as discards. 'Others' consists of 54 additional taxonomic categories.

<u>Artisanal catches</u>

Total artisanal catches for Venezuela were estimated to be 13,212,000 t over the 1950-2010 time period. Reported landings contributed 70.3% to the total. It was estimated that 29.3% of catches are unreported landings and that 0.4% of catches were discarded. Catches peaked in 2004 at 558,000 t and have since declined to 167,000 t in 2010.

Artisanal landings (reported and unreported) are dominated by *Sardinella aurita* with 3,721,000 t over the 1950-2010 time period (28% of the total artisanal landings; Figure 9). This is traditionally the main artisanal fishery in Venezuela. More than 99% of *S. aurita* catches come from the northeastern area. Catches increase fairly steadily from 17,000 t in 1950 to 186,000 t in 1998. Catches then drop suddenly down to 73,500 in 2000. Catches rebound and increase to a second peak of over 200,000 t in 2004, after which they decline rapidly to under 37,000 t in 2010. Interestingly, although *S. aurita* contributes 28% to total artisanal landings, if only the reported landings are considered, *S. aurita* makes up 40%. There were also 44,600 t of *S. aurita* discarded over the 1950-2010 period, which is 90% of total discards from the artisanal fishery. This is only 1% of total *S. aurita* catches.

The second most important contributor to the catch is the turkey wing (*Arca ventricosa*), which is caught by an artisanal dredge fishery in the northeastern area and contributes 8% to total artisanal landings. Landings of *A. ventricosa* (Figure 9) increased steadily from the mid-1950s and reached an isolated first peak of 44,300 t·year^{-1} in 1978, but later decreased to previous levels and started increasing again with fluctuations from the mid-1980s and reached a maximum of around 57,700 t·year^{-1} in 2001. Landings remained high in subsequent years with an average of 46,000 t·year^{-1} between 2002 and 2009, but declined substantially in 2010 when landings reached a value of about 26,500 t·year^{-1}.

Cynoscion spp., i.e., croakers, were also an important contributor to the catch with 710,300 t over the 1950-2010 period (5.4% of total artisanal landings; Figure 9). *Cynoscion* spp. catches were highest starting in the early 1970s up until the mid-1990s with an average of almost 18,900 t·year^{-1}. Catches declined suddenly in 1997 down to 6,000 t and remained relatively constant until 2010 when landings equalled 4,400 t. In terms of higher level taxa, the families which are also important to the catch include Scombridae (7.3%; 954,200 t), Carangidae (6.2%; 814,600 t), and Mugilidae (5.6%; 742,700 t). Scombridae catches remained relatively constant over the first half of the time period, undergoing an increase from the early 1980s to the early 1990s. Catches also decreased significantly in 2010 from 25,000 t in 2009 to 12,500 t. Carangidae catches remained stable over the entire time period with only a slight increase occurring during the late 1980s. Catches averaged 12,000 t·year^{-1} from 1950-1987, and just under 16,000 t·year^{-1} from 1988-2010. Mugilidae catches averaged 8,700 t·year^{-1} from 1950-1988. Catches increased from just over 11,000 t in 1988 to over 28,600 t in 1994, after which catches declined to 9,400 t in 2010.

The other 10% of discards consisted of *Opisthonema oglinum*, *Trachurus lathami*, *Cetengraulis edentulus*, and *Scomber colias* with 1,700 t, 1,500 t, 1,200 t, and 330 t discarded, respectively.

Subsistence catches

Subsistence catches come from both take home artisanal catch and traditional Warao catch. Total subsistence catches from the 1950-2010 time period were estimated to be 383,600 t. Catches increased steadily from 2,600 t in 1950 to 6,900 t in 1989. Catches then rapidly increased to an initial peak in 1995 of 13,800 t. Catches then decreased to 9,700 t in 2000 before rising again to a second peak of 15,100 t in 2004. Following that there was a steady decline to 5,000 t in 2010. Take home catches were estimated to contribute 97% of the subsistence catch with traditional subsistence representing the remaining 3%. Subsistence catches consisted mainly of Mugilidae (10.8%), *Sardinella aurita* (9.7%), *Cynoscion* spp. (9.5%), Scombridae (9.2%), Ariidae (7.8%), and Carangidae (8.6%).

Recreational catches

Recreational catches were estimated to be only 770 t over the 1950-1996 time period. Catches have fluctuated over the time period, peaking in 1969 with 50 t. A second peak was reached in the early 1990s with an average of 31 t·year^{-1} from 1992-1994. Catches fell to 15 t·year^{-1} in 1995-1996, after which the fishery became catch and release. Catches consisted of 38% Atlantic white marlin, 35% Atlantic sailfish, and 27% Atlantic blue marlin.

Discussion

Overall, there is a good correspondence of national landings data and the FAO database. The larger differences (i.e., 20%) occur at the beginning of the series from 1950 to 1956 and are related to the 'marine fishes nei' (not elsewhere included) category. It is not clear why these differences exist between the two datasets. Also, the Venezuelan fishery administration needs to update data reports to FAO in recent years (from 2004 onwards) to adequately reflect Venezuelan reported landings at the global and regional level (Garibaldi 2012). Several assumptions were necessary in order to disaggregate Venezuelan reported landings spatially and taxonomically. Spatially disaggregated data by species were only available for the period 1984-2010, and the period 1984-1990 was taken as the reference base for spatial disaggregation in most cases (63%). As the northeastern and western areas represented more than 95% of landings during most of the available time series, it is possible that landings from the eastern and central areas may have been underestimated prior to 1984. However, if present, this underestimation is unlikely to be large, considering the relatively low productivity of the central area and the geographical isolation of the eastern area, especially in the earlier years of the series. Additionally, taxonomically (but not spatially) disaggregated data were available for most years between 1967 and 1983, and average percent species composition from the 1960s and early 1970s was used to disaggregate FAO data from 1950 to 1966. This assumption of taxonomic composition is unlikely to hold for such a long period, but may be considered adequate to represent trends in the early years of fisheries development.

A conservative approach was used in order to estimate unreported landings, thus these may underestimate true unreported catches. For example, reported landings by the industrial trawl and industrial tuna fleets were considered to be accurate, but there is likely to be a certain amount of under-reporting for both fisheries, albeit relatively small when compared with artisanal fisheries. Additionally, reported landings from the monospecific sardine and turkey wing artisanal fisheries were also considered accurate; in these cases the correction factor of 40% applied to small-scale fisheries by the fisheries administration was considered to account for under-reporting. For the multi-species coastal small-scale fisheries, a factor of 100% (Salaya *et al.* 1987; Mendoza and Freon 1991) was used; in more isolated locations, such as the Los Roques archipelago (Posada *et al.* 1996), estimates indicate much larger values of unreported landings (i.e., 400%). The much larger factor (1000%) used for beach clams is derived from estimates (Marcano 1993; Crescini 2012) based on commercial fishing and does not account for the unknown amounts produced by subsistence or recreational fishing, which are common for these species. Estimates of under-reporting by the coastal, medium range and long range artisanal fisheries exceeded 100,000 t·year^{-1} during the 1990s and early 2000s and peaked at about 137,000 t·year^{-1} in 2004. These catches in the 2000s were equivalent to between 22% and 30% of total (industrial and artisanal) reported landings. When estimates of subsistence fisheries are included, unreported landings exceeded 110,000 t·year^{-1} during the 1990s and early 2000s and reached a maximum of about 152,000 t·year^{-1} in 2004.

Discard rates for the trawl fishery were based on observer programs in the different fishing areas of the country. Overall, discard rates were similar for the different areas at about 65%. However, most studies were done in the 1980s and 1990s when the different fisheries were well developed. Therefore, it was not possible to estimate long term temporal changes in discard rates at the species or taxonomic group level from the trawl fisheries. Total discards from the trawl fishery reached a maximum around 69,000 t·year^{-1} in 1989. For tuna fisheries in the western Atlantic, there are no studies on discard rates and it was assumed that discarding practices, for main tuna species, were similar to those in the eastern Atlantic. These rates were only applied to 34% of the catch based on the proportion of sets on whale sharks, assuming that these large and slow moving animals have an effect similar to that of fish aggregating devices (Fréon and Dagorn 2000) used in the eastern Atlantic. In this case also, it was not possible to estimate temporal changes in discard rates. Total estimated discards for main tuna species from the western Atlantic were relatively small and only exceeded 175 t·year^{-1} in 1982-1984 and 1993. Total discards of tuna and associated species from the eastern Pacific Ocean are available since 1993 (IATTC 2012), and discard rates have decreased substantially for most species through the years. However, in order to estimate discard rates during the 1970s, 1980s and early 1990s, average discard rates for the years 1993-1996 were used. Considering that most sets by the Venezuelan fleet were made on free schools and dolphin associated schools, and that most discards are associated with flotsam and FADs, it is likely that discards are overestimated for the Venezuelan fleet in the eastern Pacific Ocean, especially for skipjack tuna and black skipjack in the early years of the fishery. Total discard estimates from Venezuelan industrial and small-scale fisheries reached a maximum of approximately 74,000 t·year^{-1} in 1989, of which 93% corresponded to the trawl fishery.

Venezuelan fisheries have undergone important and significant changes during the period 1950-2010. These changes can be viewed, in a simplified way, as the sequential rise and fall of the industrial trawl fishery, the industrial tuna fisheries and, more recently, the small-scale fisheries. The development of these fisheries from the 1960s to the early 1980s was stimulated by government spending in infrastructure, cheap credit and low fuel prices (Novoa 2000a). Since the 1980s, currency devaluations, preferential exchange rates for the agricultural sector (including fisheries) and increasingly subsidized fuel prices further stimulated investment in the export-oriented industrial trawl and tuna fisheries, as well as in the medium-range and long-range fleets targeting snappers and groupers. Also, increased inflation and impoverishment led to a greater demand for relatively low valued Spanish sardine and turkey wing. In the last decade, government policy has also favored cheap credit for the small-scale coastal fisheries.

By the late 1980s, it was clear that the trawl fishery had reached unsustainable levels and several measures (essentially, time closures and prohibition of new entries) were taken to reduce fishing effort. However, these measures were insufficient and overfishing continued in most areas. At the time of the ban on trawling, in early 2009, despite a reduction in the number of trawlers by about 40%, many species were still overexploited (Mendoza *et al.* 2010; Pomares-Ferraz *et al.* 2010).

Venezuelan tuna surface fisheries started in the western Atlantic in the late 1970s, and soon after expanded to the eastern Pacific, Venezuelan tuna landings have been declining in the western Atlantic since the early 1990s, and in the eastern Pacific since the early 2000s. Yellowfin tuna, which is the main target species of Venezuelan vessels in both oceans, is considered overfished in the Atlantic and eastern Pacific, but with present levels of fishing mortality below MSY levels (Anon. 2012). Recently, total landings of yellowfin tuna have been increasing in both oceanic regions, but Venezuelan landings do not follow these recent trends. In the western Atlantic, decreased catchability due to environmental conditions may explain low catch rates in recent years (ICCAT 2011), while reduced landings by Venezuela from the eastern Pacific is likely related to a reduction in the number of purse seiners from 25 in 2000 (IATTC 2003) to 17 in 2010 (IATTC 2012).

The Spanish sardine artisanal fishery reached its peak in 2004 with about 200,000 t·year^{-1} and later declined significantly. It has been proposed that high effort levels and increased catchability due to reduced upwelling explain record landings in 1998 and 2004 (Rueda-Roa 2012). Also, since 2004 there has been a regime shift in the southeastern Caribbean with reduced upwelling, associated water column nutrient enrichment and changes in the planktonic community on which Spanish sardine feeds (Taylor *et al.* 2012). Hydroacoustic biomass estimates in 2009 show a significant decrease in abundance of Spanish sardine when compared to estimates obtained during the 1980s and 1990s (Gassman *et al.* 2012). These unfavorable environmental conditions have likely affected recruitment levels and carrying capacity of Spanish sardine in the northeastern Venezuelan shelf. Interestingly, landings of several species of medium sized pelagics (*Sarda sarda*, *Euthynnus alleteratus* and *Auxis thazard*), which feed on small pelagics, in the northeastern area also presented maximum landings in 2004-2005 and later declined significantly, which may also be related to the aforementioned environmental changes and a decrease in prey abundance.

The turkey wing fishery showed maximum landings of around 58,000 t·year^{-1} in 2001, and stayed at relatively high values until 2009, but drastically declined afterwards. Fishing effort in this fishery has increased in recent years through public loans for new boats and the area fished has expanded to compensate for reduced catch rates. A stock assessment based on a catch dynamics model (Vasconcellos and Cochrane 2005) indicated that the turkey wing stock was heavily overfished in 2011 (J. Mendoza, unpublished data). Southern red snapper and yellowedge grouper caught by the Venezuelan medium range artisanal fleet in the southeastern Caribbean are considered to be overfished (Mendoza and Larez 2004), while assessments of southern red snapper targeted by the long range artisanal fleet in French Guiana also indicate that this stock is overfished, but recruitment levels have remained high (Caro *et al.* 2011). Several species of demersal fishes (weakfish, catfish and grunts, for example) landed by the coastal small-scale fishery have shown significant declines since the mid to late 1990s, despite the reduction in landings and effort by the trawl fleet since 1990 and the ban on trawling in early 2009, which may indicate excessive effort from the small-scale fishery. Landings from the small-scale fisheries for shrimp and blue crab in Lake Maracaibo have remained at historic highs during the last decade; however, decreased landings in 2010 for both resources may indicate that these levels are not sustainable.

Hopefully, from the above it is clear that overfishing has been the driving force behind the sequential rise and fall of Venezuelan industrial and small-scale fisheries. The development of excess capacity is a pervasive characteristic of fisheries and the most difficult problem to solve in fisheries management. As of today, the most pressing problem for the Venezuelan fisheries administration is how to regulate the complex and diverse artisanal sector. Despite the bleak outlook outlined above, no effective measures have been taken to limit fishing effort or catch levels in artisanal fisheries. Moreover, the northeastern Venezuelan shelf has traditionally been the most biologically productive fishing area in the Caribbean. The relatively recent regime shift in this area has been linked to global climate change (Taylor *et al.* 2012) and, hence, not reversible anytime in the foreseeable future. As the diverse and productive small-scale fisheries in this area developed under a more productive environment, the implication is that even greater reductions in fishing effort would be required in order to account for the new regime.

Acknowledgements

I thank Daniel Pauly and *Sea Around Us*, a scientific collaboration between the University of British Columbia and The Pew Charitable Trusts, for inviting me to make this contribution, and Dirk Zeller for providing guidelines and reviewing data and the manuscript. I wish to thank my colleagues José Alió, Freddy Arocha and Jesús Marcano for sharing their knowledge on Venezuelan fisheries, and Angel Díaz, Alvelis García-Galicia, Annie Silva and Alexander Barrios for their assistance in locating data sources. I extend my appreciation also to INSOPESCA for providing national fisheries data.

References

Alió J (2012) Recreational fishery component of the Caribbean large marine ecosystem, large pelagic fisheries case study: Southern Caribbean area (Venezuela). Caribbean Regional Fisheries Mechanism. 28 p.

Anon. (1996) La actividad pesquera-acuícola en Venezuela. Servicio Autónomo de los Recursos Pesqueros y Acuícolas (SARPA), Ministerio de Agricultura y Cría, Caracas, Venezuela. 105 p.

Anon. (2012) ISSF stock status ratings-2012. Status of the world fisheries for tuna. ISSF Technical Report 2012-04, International Seafood Sustainability Foundation (ISSF). 88 p.

Caro A, Lampert L and Thomas M (2011) Description de la pêcherie vénézuélienne de vivaneaux dans la ZEE de Guyane et évaluation du stock du vivaneau rouge (*L. purpureus*) en 2010. Rapport Interne, IFREMER. 79 p.

Cervigón F (1985) La ictiofauna de las aguas costeras estuarinas del delta del Rio Orinoco en la costa Atlántica occidental, Caribe. pp. 57-78 *In* Yañez Arancibia A (ed.), Fish community ecology in estuaries and coastal lagoons: Towards and ecosystem integration. UNAM Press, Mexico.

Cervigón F (2005) La ictiofauna marina de Venezuela: una aproximación ecológica. Inst. Oceanogr. Venezuela, Univ. Oriente 44(1): 3-28.

Crescini R (2012) Dinámica poblacional del guacuco *Tivela mactroides* (Born, 1778) (Bivalvia:Veneridae) de la ensenada de La Guardia, isla de Margarita, Venezuela. Master's thesis, Universidad de Oriente, Cumana, Venezuela. 93 p.

Fréon P and Dagorn L (2000) Review of fish associative behaviour: Toward a generalisation of the meeting point hypothesis. Rev. Fish Biol. & Fish 10: 183-207.

Gaertner D and Medina-Gaertner M (1999) An overview of the tuna fishery in the southern Caribbean Sea. pp. 66-86 *In* Scott MD, Bayliff WH, Lennert-Cody CE and Schaefer KM (eds.), Proceedings of the international workshop on the ecology and fisheries for tunas associated with floating objects, February 11–13, 1992. Special Report 11. Inter-American Tropical Tuna Commission (IATTC), La Jolla, California.

García-Castro A and Heinen D (1999) Planificando el desastre ecológico: Impacto del cierre del Caño Manamo para las comunidades indígenas y criollas del Delta Occidental (Delta del Orinoco, Venezuela). Antropológica 91: 31-56.

García-Galicia A (2004) Evaluación ecológica y económica de los descartes en la pesquería de arrastre de fondo del golfo de Venezuela [Ecological and economic assessment of discards in the trawl fishery in the Gulf of Venezuela]. Graduate thesis, Universidad Nacional Experimental Francisco de Miranda, Punto Fijo, Venezuela. 136 p.

Garibaldi L (2012) The FAO global capture production database: A six-decade effort to catch the trend. Marine Policy 36: 760-768.

Gassman JPD, López A, Achury A, Barrios J, Cárdenas A, Díaz H, Hernández L, González L and Mendoza J (2012) Seguimiento de la pesca de la sardina (*Sardinella aurita*) como recurso de interés estratégico: cuantificación de la biomasa mediante prospección acústica (Proyecto INPA 045). *In* III Congreso Venezolano de Diversidad Biológica, May 22, 2012, San Carlos, Venezuela.

Gómez-Gaspar A and González W (2008) Captura record de sardina *Sardinella aurita* en la isla de Margarita, Venezuela. Memoria Fund. La Salle Cienc. Nat 169: 135-142.

Gruson A (2009) Las formas de productividad de la población Warao. Estudio etnográfico para un desarrollo sostenible desde la cultura Warao. Social Research Center, Caracas, Venezuela. 58 p.

Heinen D and Gassón R (2006) El verdadero delta indígena: Elementos para una ecología histórica del delta del Orinoco. Revista Copérnico. Año III 5: 61-66.

IATTC (2003) Tunas and billfishes in the eastern Pacific Ocean in 2002. Fishery Status Report 1, Inter-American Tropical Tuna Commission (IATTC), La Jolla, California. 100 p.

IATTC (2012) Tunas and billfishes in the eastern Pacific Ocean in 2011. Fishery Status Report 10, Inter-American Tropical Tuna Commission (IATTC), La Jolla, California. 166 p.

ICCAT (2009) Report of the 2008 ICCAT yellowfin and skipjack stock assessments meeting. Collect. Vol. Sci. Pap. 64(3): 669-927.

ICCAT (2011) Report of the standing committee on research and statistics. Report for biennial period 2010-2011 Part I (2010)-Vol. 2, International Commission for the Conservation of Atlantic Tunas (ICCAT), Madrid, Spain. 269 p.

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

Lasso CA, Meri JA and Lasso-Alcala OM (2004) Composición, aspectos ecológicos y uso del recurso íctico en el Bloque Delta Centro, delta del Orinoco, Venezuela. Memoria Fund. La Salle Cienc. Nat. 269: 87-116.

Longhurst A (1998) Ecological geography of the sea. Academic Press. 398 p.

Marcano J (1993) Explotación y Dinámica Poblacional del Guacuco Tivela mactroides en la Ensenada de La Guardia Edo. Nueva Esparta. Master□s thesis, Universidad de Oriente, Cumana, Venezuela.

Marcano L, Alio J, Novoa D, Altuve D, Andrade G and Alvarez R (2001) Revision de la Pesca de Arrastre in Venezuela. pp. 330-378 *In* Tropical shrimp fisheries and their impact on living resources. FAO Fisheries Circular 974. Food and Agriculture Organization of the United Nations (FAO), Rome.

Mendoza J (1999) Análisis de la Pesca Artesanal Marítima en Venezuela: Situación Actual y Perspectivas. Informe Técnico preparado para Ministerio de la Producción y Comercio e Instituto Interamericano de Cooperación para la Agricultura, Caracas, Venezuela. 119 p.

Mendoza J, Booth S and Zeller D (2003) Venezuelan marine fisheries catches in space and time: 1950-1999. pp. 171-180 *In* Zeller D, Booth S, Mohammed E and Pauly D (eds.), From Mexico to Brazil: Central Atlantic fisheries catch trends and ecosystem models. Fisheries Centre Research Reports 11 (6). University of British Columbia, Vancouver.

Mendoza J and Freon P (1991) Produccion y esfuerzo de pesca de la flota artesanal costanera en Juan Griego, isla de Margarita, durante los años 1983, 1985 y 1986. Memoria Fund. La Salle Cienc. Nat 135-136: 129-144.

Mendoza J and Larez A (2004) A biomass dynamics assessment of the southeastern Caribbean snapper-grouper fishery. Fisheries Research 66: 129-144.

Mendoza J, Marcano L, Alió J and Arocha F (2010) Autopsia de la Pesquería de Arrastre del Oriente de Venezuela: Análisis de los Datos de Desembarques y Esfuerzo de Pesca. pp. 69-76 *In* Proceedings of the 62nd Gulf and Caribbean Fisheries Institute. Gulf and Caribbean Fisheries Institute (GCFI).

Novoa D (1986) Una Revisión de la Situación Actual de las Pesquerías Multiespecíficas del Río Orinoco y una Propuesta del Ordenamiento Pesquero. Memoria Soc. Cienc. Nat. La Salle 126: 167-192.

Novoa D (2000a) Análisis histórico de la pesca comercial en Venezuela. Pasado, presente y futuro. Master□s thesis, Universidad Central de Venezuela, Caracas, Venezuela. 149 p.

Novoa D (2000b) La pesca en el golfo de Paria y delta del Orinoco costero. Editoral Arte. 140 p.

Novoa D, Mendoza J, Marcano L and Cárdenas J (1998) El Atlas Pesquero Marítimo de Venezuela. MAC-SARPA, Caracas, Venezuela. 197 p.

Penchaszadeh PE, Salaya JJ, Guzmán R and Molinet R (1984) Estructura de la Pesquería de Arrastre de Golfo Triste, Región Centro Occidental de Venezuela, con Especial Referencia al Material de Descarte o Broza. Universidad Simón Bolívar, Instituto de Tecnología y Ciencias Marinas (INTECMAR), Caracas, Venezuela. 48 p.

Pomares-Ferraz O, González L, Álvarez R, Barreto T, Smith J and García A (2010) ¿Porqué la Pesquería de Arrastre se Hizo Insostenible en Venezuela? Estudio de Caso: Pesquería de Arrastre del Golfo de Venezuela (1956-2008). pp. 105-113 *In* Proceedings of the 62nd Gulf and Caribbean Fisheries Institute. Gulf and Caribbean Fisheries Institute (GCFI).

Ponte V and Mochcco O (1997) Evaluacion de las actividades pesqueras de la etnia Warao en el delta del rio Orinoco, Venezuela. Acta Biologica Venezuelica 17(1): 41-56.

Posada J (1993) Los Recursos Pesqueros del Parque Nacional Archipiélago de Los Roques, Venezuela. pp. 79-92 *In* Proceedings of the 41st Gulf and Caribbean Fisheries Institute.

Posada J, González FJ and Hauschild M (1996) Status of spiny lobster fisheries in the □Archipiélago de Los Roques□ national park, Venezuela. pp. 121-142 *In* Proceedings of the 44th Gulf and Caribbean Fisheries Institute. Gulf and Caribbean Fisheries Institute (GCFI).

Romero A (2003) Death and taxes: The case of the depletion of pearl oyster beds in sixteenth century Venezuela. Conservation Biology 17(4): 1013-1023.

Romero A, Chilbert S and Eisenhart MG (1999) Cubagua's pearl-oyster beds: The first depletion of a natural resource caused by Europeans in the American continent. Journal of Political Ecology 6: 57-78.

Rueda-Roa DT (2012) On the spatial and temporal variability of upwelling in the southern Caribbean Sea and its influence on the ecology of phytoplankton and of the Spanish sardine (Sardinella aurita). Ph.D thesis, University of South Florida, Florida, U.S. 143 p.

Salaya JJ, Osorio L and Guedez. T (1987) Diagnosis de la pesca artesanal en el área de Golfo Triste, Venezuela: Puerto Cabello, Tucacas, Chichiriviche y San Juan de Los Cayos. pp. 779-794 *In*. Proceedings of the International Conference on Fisheries Vol. 2. University of Quebec, Rimouski, Canada.

Suárez MM and Bethencourt C (1994) La pesca artesanal en la costa caribe de Venezuela. Fundacion Bigott, Caracas, Venezuela. 269 p.

Taylor GT, Muller-Karger FE, Thunell RC, Scranton MI, Astor Y, Varela R, Troccoli-Ghinaglia L, Lorenzoni L, Fanning KA, Hameed S and Doherty O (2012) Ecosystem responses in the southern Caribbean Sea to global climate change. PNAS 109(47): 19315-19320.

Valdez J (1984) Contribución al conocimiento de la fauna de la broza de los arrastres en el Golfo de Venezuela. Memoria Soc. Cienc. Nat. La Salle 122: 55-77.

Vasconcellos M and Cochrane K (2005) Overview of world status of data-limited fisheries: Inferences from landing statistics. pp. 1-20 *In* Kruse GH, Gallucci VF, Hay DE, Perry RI, Peterman RM, Shirley TC, Spencer PD, Wilson B and Woodby D (eds.), Fisheries assessment in data-limited situations. Alaska Sea Grant College Program, University of Alaska Fairbanks.

Appendix Table A1. FAO landings vs. reconstructed total catches (in tonnes), and catch by sector with discards shown separately for Venezuela, 1950-2010.

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	50,054	82,500	700	78,900	2,600	7	200
1951	48,941	81,200	500	77,800	2,600	8	200
1952	40,363	67,200	300	64,500	2,200	9	200
1953	45,721	71,800	200	69,000	2,400	11	200
1954	39,598	65,700	500	62,800	2,300	12	100
1955	52,456	82,900	500	79,500	2,600	13	200
1956	45,837	76,000	4,200	65,300	2,200	15	4,400
1957	63,769	98,600	5,600	85,000	2,600	16	5,300
1958	66,610	99,500	6,200	85,500	2,300	17	5,500
1959	72,424	109,100	8,200	91,700	2,400	19	6,800
1960	72,941	108,500	5,600	96,400	2,500	20	3,900
1961	74,311	110,700	7,500	95,000	2,500	20	5,600
1962	82,965	121,600	10,600	101,300	2,500	16	7,200
1963	87,021	130,000	11,400	107,200	2,800	7	8,600
1964	88,456	130,100	9,900	109,400	2,800	11	8,000
1965	98,664	147,200	12,000	121,700	3,100	8	10,300
1966	93,848	141,100	11,900	116,500	2,900	29	9,800
1967	98,528	153,700	13,900	124,500	3,500	26	11,800
1968	107,730	173,200	11,500	147,700	4,200	28	9,800
1969	109,804	176,800	12,000	150,700	4,600	50	9,500
1970	112,741	178,300	16,300	142,800	3,900	30	15,400
1971	128,457	207,300	21,900	160,100	4,400	28	20,900
1972	141,607	235,900	24,700	179,400	5,300	22	26,500
1973	150,858	257,000	26,200	185,900	5,200	11	39,700
1974	129,482	229,400	28,600	160,500	5,200	16	35,000
1975	146,942	253,800	29,900	171,700	5,400	9	46,900
1976	142,456	243,200	30,700	167,200	5,100	11	40,200
1977	147,000	243,000	37,600	160,300	4,800	5	40,200
1978	178,649	275,000	47,700	183,300	5,300	5	38,600
1979	156,232	253,600	31,200	187,600	5,700	6	29,100
1980	167,249	261,800	39,100	185,500	5,400	8	31,800
1981	166,611	269,100	47,600	182,400	5,900	8	33,200
1982	196,203	297,900	61,600	194,200	5,800	4	36,300
1983	188,186	289,300	66,900	179,800	5,400	13	37,200
1984	216,445	326,400	78,800	198,400	6,200	24	43,000
1985	228,885	341,000	94,700	192,300	5,700	19	48,300
1986	252,524	367,500	95,600	213,400	5,800	10	52,200
1987	263,010	370,100	101,200	217,300	5,800	17	45,200
1988	238,884	358,400	97,700	199,200	6,000	9	54,500
1989	292,912	441,300	124,100	235,000	6,900	15	74,300
1990	301,641	458,400	116,300	277,600	8,700	15	54,800
1991	313,122	481,200	112,700	302,100	10,000	15	54,500
1992	300,736	448,600	104,600	291,900	9,700	31	41,300
1993	362,211	529,000	118,500	358,900	11,600	30	38,600
1994	395,831	578,400	106,700	419,700	13,500	33	36,900
1995	424,071	603,400	94,000	461,200	13,800	15	32,900
1996	425,239	594,400	107,600	439,900	12,900	15	31,700
1997	403,491	559,600	109,800	396,100	10,200	-	41,000
1998	447,728	608,500	112,500	445,200	11,300	-	36,800
1999	390,250	545,800	105,900	396,700	10,600	-	30,100
2000	338,761	477,100	105,600	334,700	9,700	-	25,100
2001	448,197	598,200	156,300	401,600	11,500	-	27,100
2002	480,238	623,600	157,800	426,800	11,500	-	25,900
2003	442,522	571,800	127,500	411,100	11,300	-	20,100
2004	513,592	688,100	95,100	555,700	15,100	-	20,200
2005	350,299	484,700	79,100	373,800	10,800	-	18,900
2006	277,150	388,600	67,700	293,500	9,100	-	15,500
2007	269,529	366,300	60,200	284,200	8,500	-	10,200
2008	233,576	314,000	62,800	233,200	6,800	-	8,300
2009	255,058	337,100	60,000	265,700	7,300	-	1,600
2010	167,567	221,100	45,400	166,500	5,000	-	1,000

Appendix Table A1. Reconstructed total catch (in tonnes) by major taxa for Venezuela, 1950-2010. 'Others' contain 31 additional taxonomic categories.

Year	Sardinella aurita	Scombridae	Arca ventricosa	Carangidae	Sciaenidae	Cynoscion spp	Mugilidae	Ariidae	Penaeidae	Others
1950	17,400	10,800	-	14,600	1,700	6,100	10,600	-	700	20,600
1951	16,400	10,800	300	14,600	1,700	6,100	10,600	-	500	20,200
1952	13,300	7,100	200	12,500	1,400	4,900	10,600	-	300	17,100
1953	12,700	7,300	600	10,800	1,500	5,300	9,900	-	200	23,500
1954	8,600	8,000	600	11,300	1,900	6,800	6,600	-	500	21,500
1955	17,900	9,200	300	12,300	2,300	8,500	6,800	-	500	25,100
1956	14,100	7,100	-	10,200	3,200	4,600	9,500	200	2,100	25,100
1957	28,000	7,300	1,300	14,900	2,900	3,100	10,200	200	2,600	28,100
1958	31,200	8,600	1,600	14,800	2,800	1,600	9,100	200	2,700	26,900
1959	32,800	10,800	1,500	14,700	3,600	4,500	7,200	300	3,600	30,300
1960	31,300	11,900	3,200	12,900	3,100	5,700	7,200	100	1,900	31,100
1961	28,600	10,200	2,100	11,100	5,100	5,000	7,800	200	3,100	37,500
1962	37,600	11,900	2,100	12,500	5,300	6,200	8,300	300	4,300	32,900
1963	40,200	11,400	700	13,900	6,800	7,200	9,100	300	4,900	35,400
1964	43,200	12,200	2,300	13,100	6,700	7,100	7,200	300	4,700	33,500
1965	44,900	12,100	4,000	12,900	7,600	7,900	7,200	400	7,900	42,300
1966	40,100	11,900	4,300	11,300	8,000	7,800	8,400	400	5,800	43,000
1967	41,100	10,700	2,300	11,300	8,300	8,800	6,200	9,900	8,800	46,400
1968	37,800	12,500	3,900	13,400	8,400	10,800	6,900	11,400	6,600	61,600
1969	38,000	18,500	4,600	13,800	8,900	10,500	6,600	8,200	6,400	61,300
1970	42,600	10,500	5,400	12,100	9,300	9,100	7,400	14,100	10,400	57,400
1971	45,700	14,800	4,200	13,100	9,600	18,500	7,400	10,100	15,400	68,400
1972	47,000	14,200	6,300	16,900	11,900	21,500	8,600	15,200	12,000	82,300
1973	49,100	15,000	9,200	18,400	21,600	22,300	9,900	10,800	11,100	89,600
1974	24,000	16,200	12,300	17,600	19,000	28,900	8,200	15,300	10,200	77,700
1975	49,600	18,100	8,800	16,200	23,600	31,600	7,700	11,300	11,800	75,200
1976	38,300	20,100	11,200	15,200	20,100	25,100	9,600	11,700	10,800	81,100
1977	37,300	24,400	16,400	17,700	17,900	20,000	10,300	9,300	10,100	79,400
1978	27,600	30,800	44,800	15,600	20,700	22,000	10,400	9,100	8,900	85,100
1979	38,500	30,400	14,500	14,800	17,900	19,400	6,900	6,800	8,400	95,900
1980	53,500	35,700	9,100	12,800	19,200	20,100	10,400	11,900	13,000	76,100
1981	29,200	39,400	18,800	18,000	21,300	22,700	10,500	12,900	10,500	86,000
1982	54,400	49,200	12,900	17,100	20,600	20,700	15,100	12,500	10,800	84,700
1983	42,700	61,700	8,300	16,100	19,300	16,100	11,400	12,000	12,300	89,300
1984	50,600	68,700	20,400	14,300	18,500	20,100	11,200	11,700	12,600	98,200
1985	56,200	77,800	12,600	16,400	25,800	22,700	13,000	10,000	15,200	91,300
1986	82,800	78,600	11,100	14,700	18,600	23,700	12,000	5,700	17,400	102,200
1987	85,500	85,400	18,200	15,300	20,700	21,400	11,400	6,400	14,700	90,300
1988	61,800	89,300	18,100	17,500	23,900	20,300	11,800	8,100	17,100	89,400
1989	72,900	107,200	27,600	20,500	26,300	18,200	17,700	12,200	18,500	119,200
1990	59,400	101,600	28,200	26,100	24,100	17,600	23,100	12,900	17,200	147,300
1991	77,900	111,500	15,800	22,500	34,700	15,300	25,800	13,700	17,300	144,800
1992	82,400	105,000	16,000	23,000	29,300	16,500	26,000	17,400	13,500	118,300
1993	88,300	115,900	28,900	24,800	26,100	20,900	28,500	24,400	19,600	150,300
1994	115,500	112,600	31,500	22,800	30,900	23,200	30,200	26,900	20,800	162,400
1995	157,000	99,300	34,300	21,000	31,800	21,400	26,500	46,100	16,300	148,200
1996	156,400	117,100	32,200	19,000	30,300	16,700	25,400	36,300	16,800	141,800
1997	144,600	119,700	39,500	18,100	22,100	7,300	16,900	19,700	17,600	151,600
1998	191,000	121,000	28,300	19,400	27,400	9,700	19,300	21,900	12,600	155,400
1999	126,700	115,900	39,000	22,500	25,100	7,500	17,800	24,900	8,800	155,100
2000	75,400	116,200	45,200	15,200	24,400	9,800	18,200	30,900	11,800	127,900
2001	115,200	171,600	58,300	14,300	29,500	11,100	19,600	27,300	11,700	138,000
2002	162,000	170,400	45,200	14,600	20,500	8,000	15,100	33,400	12,600	140,300
2003	154,100	141,400	46,300	13,800	14,100	8,900	17,800	39,000	14,200	120,400
2004	204,900	120,100	54,100	21,000	16,700	9,100	23,000	40,200	14,800	182,300
2005	111,200	100,500	39,800	19,700	13,900	5,300	13,200	19,500	9,900	149,400
2006	65,000	88,300	36,800	16,500	17,900	8,300	14,600	11,200	15,000	112,400
2007	56,300	74,500	53,600	15,400	10,800	8,000	13,200	5,600	12,500	113,200
2008	37,000	78,000	51,200	8,900	8,700	6,400	11,600	5,700	7,200	96,500
2009	49,300	86,600	46,200	21,100	5,500	5,300	11,900	7,900	11,900	89,000
2010	37,400	58,500	26,800	11,100	6,900	4,600	9,900	6,800	7,300	48,600