

THE IMPLICATIONS OF MISREPORTING ON CATCH TRENDS: A CATCH RECONSTRUCTION FOR THE PEOPLE'S REPUBLIC OF THE CONGO, 1950-2010¹

Dyhia Belhabib and Daniel Pauly

*Sea Around Us, Fisheries Centre, University of British Columbia,
2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada*

d.belhabib@fisheries.ubc.ca; d.pauly@fisheries.ubc.ca

ABSTRACT

The official fisheries statistics for the People's Republic of the Congo, also known as 'Congo (Brazzaville)' feature increasing landings, despite current, if anecdotal evidence of over-exploitation. This reconstruction brings to light that strong under-reporting in the past masked a massive exploitation and thus biased the trends of reported data. Reconstructed domestic catches within Congo (Brazzaville)'s EEZ increased from 7,110 t in 1950 to a peak of 99,300 t in 1977, declined to 30,500 t on average during the 1990s and then increased slowly to 45,000 t in 2010. Reconstructed total catches from the Congo within its EEZ were on average 2.8 times the data supplied to the FAO. As opposed to official statistics, which may have justified the licensing of an over-capitalized foreign industrial fleet, the reconstructed catch confirms fishers' accounts of declining catches and resources availability. This situation threatens the livelihoods of the coastal population of the Congo, which faces increasing resource scarcity and poverty.

INTRODUCTION

The People's Republic of the Congo, or 'Congo (Brazzaville)', thus named after its capital to avoid confusion with the 'Congo (ex-Zaire)', is located in central West Africa (Figure 1). The relatively narrow coast opens to the Atlantic Ocean on the west, and ranges from Angola (Cabinda) in the South to Gabon in the North.

The first steps toward independence from France began with a strong nationalist movement as early as 1926, due mainly to mistreatment of the Congolese by the French administration (Bernault 1996). The Congo became an autonomous republic in 1958, followed by a series of upheavals in 1959 and finally independence in 1960. Although the Congo may be considered peaceful when compared to its neighbours in the South, it remains a good example of how the democratization process can trigger a series of conflicts (Bazenguissa-Ganga 1999). Due to deteriorating economic conditions and a high unemployment rate (Bernault 1996), this led to a revolution in 1963 and a *coup d'état* in 1968. This period of instability eventually ended when an army colonel assumed the Presidency, and led the country into re-establishing its relations with France, and notably the French state oil company, Elf. This also involved a political conflict in 1993-2000 which ended in a civil war (www.ucdp.uu.se) that killed over 18,000 people between 1993 (3,000) and 1997 (15,000). The conflict further exacerbated with greater casualties in 1999, in addition to over 20,000 women raped (Yengo 2006) and between 100,000 to 300,000 people displaced (Bazenguissa-Ganga 1999). However, the security in the country has improved significantly since 2002, when groups of armed fighters were disbanded. Economically, the Congo relies mainly on minerals, agriculture and the oil sector which represents around 65% of the GDP. Despite a prevailing oil sector and an average GDP per capita of \$3,800, which is relatively high compared to the rest of Africa, poverty and child malnutrition still prevail, particularly in rural areas (The World Bank 1997). With over a third of monthly expenses dedicated for bushmeat

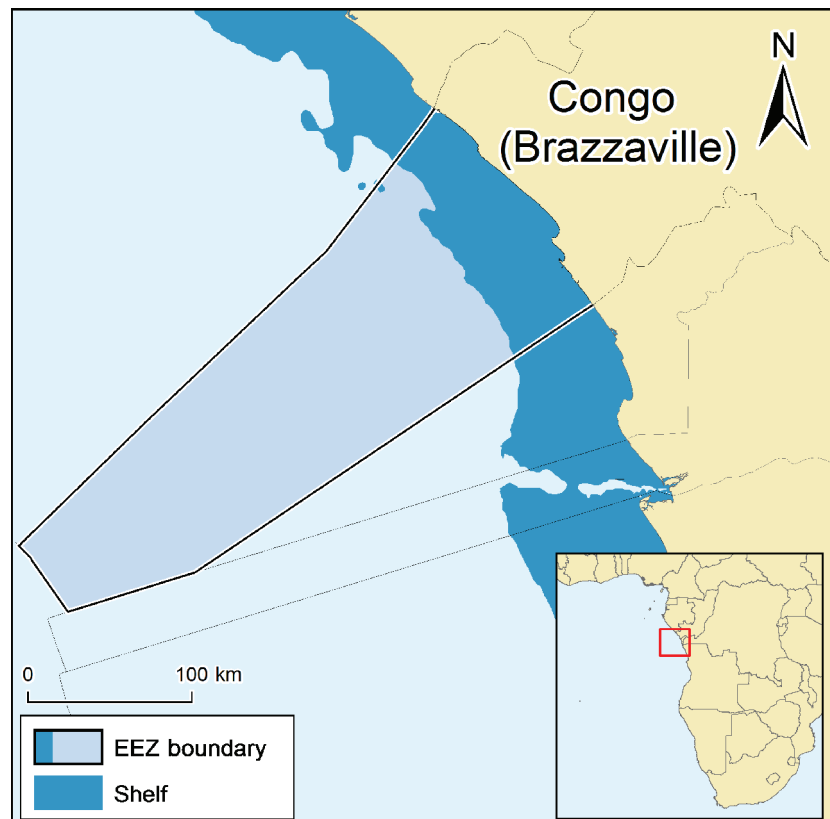


Figure 1. Map of Congo (Brazzaville) with Exclusive Economic Zone (EEZ).

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and fish, animal protein intake is a household priority (The World Bank 1997; Fa *et al.* 2003). Indeed, with some 4.2% of the Congo households fishing (Anon. 2006), fish contributes over 50% of the animal protein intake (Anon. 2011b) and around 2 to 3% of the national GDP (Horemans and Kebe 2006; COREP 2012). However, with declining fisheries resources (Nguinguiri and Katz 1996) due in part to overexploitation by foreign fleets, notably those from China, a complete lack of transparency and a high level of corruption (Transparency International 2010), which led to licenses being awarded to some 70 foreign vessels despite the sustainable level being much lower (Maloueki 1999, 2005), coastal populations find themselves trapped between increasing poverty and limited choices of livelihood (Brugère *et al.* 2008).

Official catch statistics reported by the Food and Agriculture Organization (FAO) on behalf of the Congo exhibit a continuous increasing trend, which in the light of the above issues, appears to be highly dubious. Although, there have been a great effort by the *Office de la recherche scientifique et technique d'outre-mer* (ORSTOM, now IRD) as early as 1981 to collect artisanal and industrial (small-pelagic) fishing data, “catch statistics for the 1970s are virtually non-existent” (Jul-Larsen 1994a). In addition to industrial trawl and artisanal fisheries being under-estimated given their scattered nature (as industrial fleets operate in other countries’ Exclusive Economic Zones (EEZ) and artisanal are dispersed across the entire coast of the Congo), discards and foreign catches are also largely unknown. Herein, we reconstruct fisheries catch data between 1950 and 2010, by making coherent and compatible what little is known of the marine fisheries of the Congo, and thus generating what we hope are realistic fisheries catch trends.

METHODS

Coastal population

The total population was obtained from the database of the World Bank (www.worldbank.org) for the period between 1960 and 2010 and from Populstat (www.populstat.org) from 1950 to 1959. Coastal rural and urban population estimates for 1990, 2000 and 2010 were extracted from CIESIN (2012), then expressed in percent of total population. We extrapolated backwards the rural and urban population percentage and completed the time series by a series of linear interpolations. We then multiplied the resulting percentages by the total population to obtain the coastal rural and urban population of Congo (Figure 2)

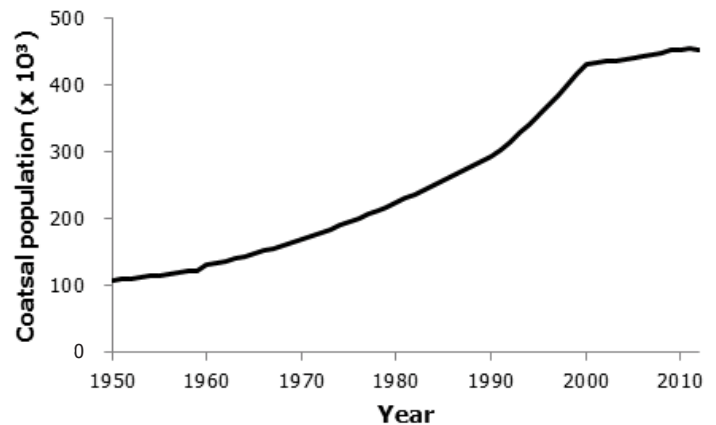


Figure 2. Coastal population of the Congo, 1950-2010, adapted from www.worldbank.org and www.populstat.org (see text).

Subsistence fisheries

In the past small-scale fisheries were directed mainly for personal consumption and canoe (*villi*)-type fisheries were described to be for subsistence (Le Gall 1975). Herein, we consider subsistence fishing, anything that is taken by non-artisanal fishers for household consumption, including children (Vennetier 1968)²; thus the part that is taken home by artisanal fishers is considered as a fraction of the artisanal fishery. Households in the Congo can consume fish as much as 5.8 times a week on average as revealed by a survey sampling 70 households in Pointe-Noire (Le Gall 1975). In the Pointe-Noire area, fish consumption ranged between at least 65 kg·capita⁻¹·year⁻¹ (Lagoin and Salmon 1970) and 85 kg·capita⁻¹·year⁻¹ (Cayre and Fontana 1977). These numbers are likely too high for the rest of the Congolese coast; however, they give a clear indication of the importance of fish consumption to Congolese households.

Dhont (1963) estimated a per capita consumption rate for the country as a whole of 500 g·capita⁻¹·week⁻¹ for 1957 and 1 kg·capita⁻¹·week⁻¹ for 1962, equivalent to 24 kg·capita⁻¹·year⁻¹ and 48 kg·capita⁻¹·year⁻¹ respectively. Lagoin and Salmon (1970) reported a higher consumption rate for 1967 of 55 kg·capita⁻¹·year⁻¹. For 2005, we converted the per capita calories intake from different kinds of fish and processed seafood products (Anon. 2006; Backiny-Yetna and Zodon 2009) to weight of the processed product, then to live weight using conversion factors from FAO (FAO 2000). We reached a consumption rate of 93.2 g·capita⁻¹·day⁻¹, i.e. 34 kg·capita⁻¹·year⁻¹ for 2005. We assumed the consumption rate was constant between 1950 and 1957, between 2005 and 2010, and then interpolated linearly to fill in the gaps.

In inland fisheries, 35% of the fish caught by households is kept for personal consumption (Béné 2008). Assuming the same rate applies to coastal fisheries, 35% of the fish consumed by the coastal rural populations of the Congo would be caught by the household itself. Therefore, we multiplied the previous consumption rates by 35% and then by the rural coastal population, thus obtaining subsistence catches from the coastal waters of the Congo.

² The author suggests in his description of subsistence fisheries that “all children” in coastal Congo are fishing.

Artisanal fisheries

Artisanal catch data collection was conducted by ORSTOM scientists since the early 1980s at 4 landing sites of the Congo (Kebe and Njock 1995), mainly monitoring sardinella (*Sardinella* spp.) catches. We assume that previously, catches were not monitored. The two types of canoes operating along the coast of the Congo have different capacity and therefore are treated separately in the present reconstruction. The first type includes the motorized and un-motorized Congolese (*villi*) pirogues, also called '*bouatou*' (Dhont 1963), whose length is less than 6 m for the un-motorized ones and between 7 and 8 m for those with motors of 6.5 to 25 hp (Kebe and Njock 1995; Maloueki 1999). Villi fishers use gill-nets and hand lines (Tvedten 1990) and take onboard 1 to 2 fishers. The second type includes the Ghanaian pirogue-type used by the Popo ethnic group from Benin (Maloueki 1999). Their length reaches 14 to 18m and their engine power 25-40 hp (Tvedten 1990; Kebe and Njock 1995; Maloueki 1999) taking onboard 5 to 7 fishers (Mandilou 2010). These boats can carry from 4 t of fish every trip (Kebe and Njock 1995) to "tons of fish... every week" (Tvedten 1990).

Although the *villi* were not considered active fishers in the 1940s and the 1950s when the Popo seemed to have a monopoly (Vennetier 1968), a relatively large number of villi-type canoes was reported as early as 1962, which suggest that a strong villi fishery already in place the 1950s and the 1960s (Dhont 1963; Lagoin and Salmon 1970). This is supported by further evidence suggesting that this fishery was mainly for personal consumption prior to the 1970s (Le Gall 1975), which might be a reason why it is not considered in economic surveys of Congolese fisheries.

Table 1. Reconstructed artisanal fishing effort by ethnic group in the Congo

Year	Total canoes	Reference	Villi canoes	Reference	Popo canoes	Reference
1950	-	-	178	Assumed the effort in 1950 was half of that of 1962	3	Assumed constant
1955	-	-	252	Interpolation	3	Gobert (1985)
1958	-	-	297	Interpolation	16	Gobert (1985)
1960	-	-	326	Interpolation	24	Jul-Larsen (1994a, 1994b)
1962	356	Dhont (1963); Lagoin and Salmon (1970)	356	Dhont (1963); Lagoin and Salmon (1970)	38	Interpolation
1963	-	-	373	Interpolation	45	Jul-Larsen (1994a, 1994b)
1966	-	-	423	Interpolation	120	Jul-Larsen (1994a, 1994b)
1967	460	Lagoin and Salmon (1970)	440	Subtraction	20	Lagoin and Salmon (1970)
1970	-	-	414	Interpolation	24	Jul-Larsen (1994a, 1994b)
1975	500	Le Gall (1975)	370	Interpolation	102	Interpolation
1976	-	-	361	Interpolation	117	Jul-Larsen (1994a, 1994b)
1977	469	Fontana (1980)	352	Subtraction	117	Jul-Larsen (1994a, 1994b)
1978	-	-	362	Interpolation	59	Reduced by half ^a
1980	600	Chaboud and Charles-Dominique (1991)	382	Interpolation	84	Interpolation
1982	-	-	402	Interpolation	110	Jul-Larsen (1994a, 1994b)
1983	542	Nguingui (1991)	412	Subtraction	130	Jul-Larsen (1994a, 1994b)
1986	-	-	381	Interpolation	109	Jul-Larsen (1994a, 1994b)
1987	513	Barro <i>et al.</i> (1989)	371	Barro <i>et al.</i> (1989)	142	Barro <i>et al.</i> (1989)
1988	550	Kébé and Njock (1995)	401	Kébé and Njock (1995)	149	Jul-Larsen (1994a, 1994b)
1989	515	Kébé and Njock (1995)	355	Kébé and Njock (1995)	160	Kébé and Njock (1995)
1990	520	Kébé and Njock (1995); Bazon and Ngouembe (1995)	360	Kébé and Njock (1995); Bazon and Ngouembe (1995)	160	Kébé and Njock (1995)
1991	500	Kébé and Njock (1995)	380	Kébé and Njock (1995)	120	Jul-Larsen (1994a, 1994b)
1992	530	Kébé and Njock (1995)	395	Interpolation	120	Interpolation
1993	490	Kébé and Njock (1995)	410	Interpolation	120	Interpolation
1994	545	Kébé and Njock (1995); Jul-Larsen (1994a)	425	Kébé and Njock (1995); Jul-Larsen (1994a)	120	Kébé and Njock (1995); Jul-Larsen (1994a)
2000	518	Koumba (2012)	336	Koumba (2012)	182	Koumba (2012)
2001	532	Koumba (2012)	343	Koumba (2012)	189	Koumba (2012)
2002	720	Koumba (2012)	464	Koumba (2012)	256	Koumba (2012)
2003	506	Kibelolo (2003) ^b	594	Interpolation	180	Koumba (2012); Kibelolo (2003)
2004	506	Koumba (2012) ^b	724	Interpolation	180	Koumba (2012)
2005	588	Anon. (2011a) ^c	853	Interpolation	254	Koumba (2012)
2006	1199	Anon. (2011a)	983	Anon. (2011a)	216	Koumba (2012)
2007	1173	Anon. (2011a); InfoPêche (2008)	919	Anon. (2011a)	254	Koumba (2012)
2008	1171	Anon. (2011a)	811	Anon. (2011a)	360	Koumba (2012)
2009	1193	Anon. (2011a)	929	Anon. (2011a)	264	Koumba (2012)
2010	1193	Anon. (2011a)	929	Anon. (2011a)	264	Koumba (2012)

^a 'Foreign' fishers were expelled (i.e., fishers of irregular status in the Congo) since 1960 until 1977, and fishers migrated again to Congo in 1979 (Gobert 1985); After the death of President Marien Nhouabi in May 1977, around 4/5 of the Popo community were repatriated and 166 outboard engines confiscated (the fishers had no residence permits, and their engines no import permits). The government also decided that the remaining Popo should "refrain from fishing" unless it was for subsistence (Jul-Larsen 1994a);

^b This number was not taken into consideration as it was too low compared to the previous and later years;

^c This number was adjusted upwards as a total of 1,347 pirogues was reported by Bignouma (2010) of which 254 are Popo.

The effort time series for both fisheries, expressed in number of canoes, was rebuilt using different literature sources (Dhont 1963; Lagoin and Salmon 1970; Le Gall 1975; Fontana 1980; Gobert 1985; Barro *et al.* 1989; Chaboud and Charles-Dominique 1991; Nguinguiri 1991; Jul-Larsen 1994a, 1994b; Kébé and Njock 1995; Kibelolo 2003; Anon. 2011a; Koumba 2012) and adjusted when necessary³ (Table 1). We interpolated linearly to fill in the gaps.

The catch per unit of effort was provided by Dhont (1963) at 750 kg·canoe⁻¹·month⁻¹ for the *villi* canoes for around 11.5 days fishing per month (Gobert 1985, 1986), i.e., 65.2 kg·canoe⁻¹·day⁻¹ for 1958. Similarly, the author provided a CPUE of 66.7 kg·canoe⁻¹·day⁻¹ for the dry season and 44.4 kg·canoe⁻¹·day⁻¹ for the wet season, i.e. 55.6 kg·canoe⁻¹·day⁻¹ for 1962 on average. For 1993, we estimated the CPUE of the *villi* at 84.3 kg·unit⁻¹·day⁻¹ by calculating the weighted average of the CPUE of motorized and unmotorized pirogues provided by Kébé and Njock (1995). We assumed the CPUE remained relatively constant between 1950 and 1958, and that it decreased linearly by 30% between 1993 and 2003 to reflect the over-exploitation, declining catches and declining fish sizes (Fontana 1980; Nguinguiri 1991; Nguinguiri and Katz 1996). We then interpolated linearly to fill in the time series of *villi*-type canoes CPUE.

Similarly, the CPUE of Popo-type canoes was estimated by dividing the total observed catch for the Popo-type canoes by the number of these canoes (Kebe and Njock 1995), i.e. 387 kg·canoe⁻¹·day⁻¹ for 1993. Popo fishers observed that the time spent fishing increased because of declining catches; they catch in the 1990s the same amount of fish in one night than what they used to catch in 2 hours in the 1960s (Nguinguiri and Katz 1996). Moreover, although fishers used more rudimentary fishing gear in the 1960s, they used to catch more fish than today, even with increasing fishing net sizes (Nguinguiri and Katz 1996). This translates into the CPUE of 1960 being 6 times higher than the CPUE of 1990s, i.e. 2,322 kg·canoe⁻¹·day⁻¹ for 1960, which is still below the capacity of a typical Popo-type canoe. We assumed the CPUE declined by 15% between 1993 and 2010 and then filled in the gaps by performing a series of linear interpolations.

We obtained *vili* and Popo catches by multiplying the number of canoes of each type by their respective CPUE.

Artisanal catches included mainly sardinellas (*Sardinella aurita*, *S. maderensis*) and bonga shad (*Ethmalosa fimbriata*) (Anon. 2011b), with the remaining evenly distributed between Southern meager (*Argyrosomus holopedium*), chub mackerel (*Scomber japonicus*) and Atlantic bumper (*Chloroscombrus chrysurus*) (Fontana 1980).

Industrial domestic fisheries

Industrial fishing in Congo began (in Pointe Noire) as early as the 1940s (Vennetier 1968), with the first industrial trawlers arriving in 1948 (Dhont 1963; Fontana 1980).

The number of shrimp trawlers, other demersal trawlers and small-pelagic purse-seiners were obtained from different literature sources which retrace the fishing effort between 1950 to 2010 (Dhont 1963; Crosnier and Tanter 1968; Vennetier 1968; Lagoin and Salmon 1970; Fontana 1980; Bazon and Ngouembe 1995; Kébé and Njock 1995; Cochrane and Tandstad 2000; Binet *et al.* 2001; InfoPêche 2008; Anon. 2011a, 2011b; Koumba 2012). Reported landings were often reported by the same sources as an aggregate of all industrial fishing segments and/or separated into demersal, shrimp and small-pelagic (*Sardinella* spp.) landings (Le Gall 1975; Cayre and Fontana 1977; Fontana 1980; COREP 2012).

Since ORSTOM staff started monitoring sardinella catches as soon as the fishery began (Fontana 1980), we assumed sardinella catches were reported properly and added 4% for the by-catch.

On the other hand, given the scattered nature of the demersal and shrimp trawl fisheries, operating between Gabon and Angola (Crosnier and Tanter 1968; Cochrane and Tandstad 2000), we reconstructed catches using a different method relying on the CPUE and the number of boats for every segment.

The CPUE for shrimp trawlers was estimated using the observed catch data by Fontana (1980) provided by kg·hour⁻¹ for target species: deep-water rose shrimp (*Parapenaeus longirostris*), striped red shrimp (*Aristeus varidens*) and the deep-water shrimp (*Plesiopenaeus edwardsianus*), converted to catch per day using the conversion rate provided by the author, and estimated a CPUE of 5.85 t·boat⁻¹·day⁻¹ of retained species and 4.27 t·boat⁻¹·day⁻¹ of discarded species for 1975. Bazon and Ngouembe (1995) estimated a CPUE of 1 t·boat⁻¹·day⁻¹ for 1986 and 0.4 t·boat⁻¹·day⁻¹ for 1993. Given evidence of declining trawler CPUE (Bazon and Ngouembe 1995), we assumed the CPUE in 1950 was 30% higher than in 1975, and that of 2010, 15% lower than the CPUE of 1993. Similarly, Bazon and Ngouembe (1995) estimated a CPUE of 4.5 t·boat⁻¹·day⁻¹ for demersal trawlers for 1971, 3.7 t·boat⁻¹·day⁻¹ for 1979, 2.4 t·boat⁻¹·day⁻¹ for 1982 and 1 t·boat⁻¹·day⁻¹ for 1990, we assumed that the CPUE in 1950 was 30% higher than the CPUE of 1971, and that of 2010, 15% lower than that of 1990. We interpolated linearly between the CPUE estimates and multiplied them by the respective number of boats.

In 1967, fishing in Angola declined because of its declaration of territorial waters (12 miles zone). On the other hand, in 1970, fishing by Congolese boats in Gabonese waters was prohibited; it was only in 1972 that an access agreement allowed Congolese trawlers to operate again in Gabon, if to a smaller extent. Maps included in the study of Fontana (1980) suggest a third of trawl catches landed in Congo were taken from Angola, a sixth from the democratic Republic of the Congo (ex-Zaire), another sixth from Gabon up to 1974; then, their operation shifted North to Gabon and Congo, up to 1980 (Fontana 1980). The domestic industrial fleets targeting mainly shrimp (Crosnier and Tanter 1968; Cochrane and Tandstad 2000) reduced its fishing zone from Angola and Gabon in the 1980s to only Congo today (Nguinguiri and Katz 1996).

³ Some references reported very low effort numbers in contrast to some others, in which case the highest number was taken into consideration as the effort was actually observed.

We assumed 70% of the shrimp catch was taken from Angola, the remaining distributed evenly between Gabon, the Congo (ex-Zaire) and the Congo between 1950 and 1967 when Angola claimed its territorial waters. In 1974, a third of shrimp trawl catches were taken from Angola and 17% from the Democratic Republic of the Congo (ex-Zaire), 17% from Gabon and the remaining from the Congo. For 1980, when fishing in Angola ceased, we allocated 50% of the catch as taken from the Congo and 50% from Gabon, which were then kept at zero from 1989 on.

Reported catches often include only the targeted groups such as penaeid shrimps, crabs and other high value species for shrimp trawlers. Therefore, using the bycatch data provided by the authors (Fontana 1980), catches must be corrected.

The number of Chinese vessels is often included in the 'total' number of domestic vessels, thus causing a large increase in the latter. China started fishing in the Congo in 2000 (Kibelolo 2003). In 2006, 26 Chinese bottom trawlers were operating in the Congo (Anon. 2011a, 2011b; Koumba 2012). We obtained the number of Chinese vessels operating for the later years by subtracting the number of domestic demersal trawlers from the total provided in the literature (InfoPêche 2008; Anon. 2011a; Koumba 2012). We interpolated linearly to fill in the gaps and multiplied the effort by the CPUE calculated for demersal trawlers for 300 days, which we then adjusted by +20% for the difference in efficiency.

Between 1958 and 1961, other trawlers operated in Congo, but statistics were available (Poinsard 1969); thus, any estimate generated based on a CPUE and effort, as is the case here, is likely to be conservative.

We disaggregated shrimp trawl catches using the catch description of target species by Fontana (1980) and demersal trawl catches by combining the species disaggregation provided by different references (Poinsard 1969; Lagoin and Salmon 1970; Chardy and Le Guen 1971; Cayre and Fontana 1977; Fontana 1980). We assumed the species composition provided by Poinsard (1969) remained unchanged between 1950 and 1963, and similarly for that provided by Fontana (1980) from 1980 and 2010, and interpolated between them.

Illegal fisheries

“Unregulated and unsustainable industrial fisheries are the most significant threat. Increasing numbers of domestic and foreign fishing boats venture into coastal waters to fish illegally. Fish are caught at unsustainable levels” (WCS 2011). Chinese boats are often accused of illegal fishing in Congo; thus we assume illegal fishing by China began around the time China started operating in the area. Specifically, assumed that illegal Chinese catches started at zero in 2000, increased to 58% of the legal catch (MRAG 2005) in 2005 and further increased by 20% in 2010, given the evidence of an increasing pattern of illegal catches (MRAG 2005).

Discards

Although sharks were targeted for their fins for over 20 years (since the fishery began until the fishery was prohibited in the early 2000), discards were minimal because the carcasses were also used in local markets (Maloueki 2005).

Discards by the shrimp fleet were between 1,500-2,000 t·year⁻¹ (Bazon and Ngouembe 1995), which is equivalent of 3.43 times the landed (estimated catch) for 1993. For 1975, using the data on non-target species catch provided by Fontana (1980), which was equivalent of 73% of landings. We assumed discards were constant between 1950 and 1975, and decreased by 50% between 1993 and 2010, to reflect upon over-exploitation which might have led vessels to increasingly keep by-catch. We then multiplied the resulting rates by the estimated shrimp trawl catch.

Documents assessing discards by demersal fish trawlers in the waters of the Congo were not available. Therefore, to estimate domestic discards, we used the discard rate estimated by (Belhabib *et al.* 2014b) for the Congo (ex-Zaire) of 1.8% for domestic demersal trawl and 66% of landed catches for foreign discards.

Discards include soles (*Cynoglossus* spp.), porgies (*Pagellus* spp., *Pagrus* spp. and *Dentex* spp.), i.e., fishes that are not appreciated by Congolese consumers (Poinsard 1969). Shrimp discards were disaggregated using the data presented by Fontana (1980) for the contribution of non-targeted species to the shrimp trawl catch.

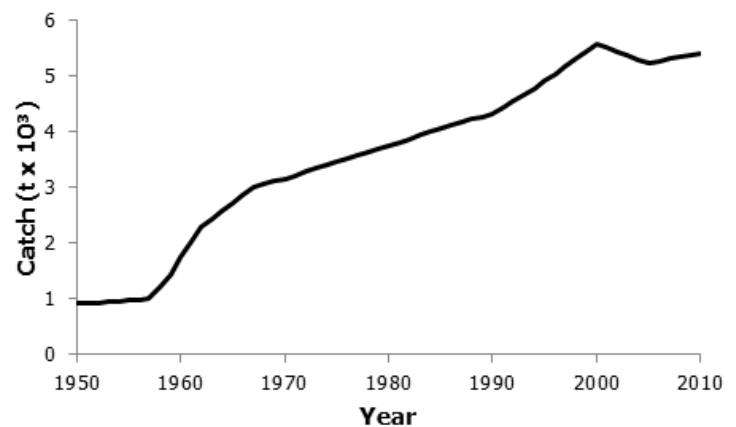


Figure 3. Reconstructed total subsistence catches from the Congo, 1950-2010.

RESULTS

Subsistence fisheries

Subsistence catches were estimated at 950 t·year⁻¹ on average from 1950 to 1957 (Figure 3). Subsistence catches increased since the early 1960s to a peak of 5,600 t in 2000, followed by a slight decrease to 5,400 t in 2010 (Figure 3).

Artisanal fisheries

Artisanal catches were estimated at around 6,600 t·year⁻¹ on average in the 1950s, before they increased drastically to a peak of 52,300 t in 1966 driven by increasing Popo fisher catches and migrations into the Congo (Figure 4). Artisanal catches collapsed to less than 13,000 t in 1967 mainly due to the major decrease in Popo catches as fishers were expelled and their fishing gear confiscated (Figure 4). Catches increased thereafter to 37,300 t in 1976 and then increased again with the Popo fishers returning to the Congo (Figure 4). Catches declined slowly since the 1980s to less than 18,000 t in 2001 and then increased slightly with the increasing number of canoes to around 32,400 t in 2008 before they decline to 27,600 t in 2010 (Figure 4).

Industrial domestic fisheries

Industrial catches from the EEZ of the Congo increased from 2,300 t in 1950 to a peak of around 38,400 t in 1975 driven by increasing shrimp trawl catches and a high number of shrimp trawlers (Figure 5). Industrial catches from the coast of the Congo decreased thereafter, with a decreasing catch to less than 11,000 t in 2010, dominated by purse-seiners catches (Figure 5). In contrast, Congolese catches from outside the Congolese EEZ increased to a peak of around 37,400 t in 1968 before declining to very low levels by the late 1980s (Figure 6), after which the fleet operated mainly within Congolese waters.

Domestic discards

Discards by the Congolese fleets followed the same pattern than demersal and shrimp trawl catches, increasing from low levels in the 1950s to a peak of around 62,000 t in 1980, and then matching the decline of the demersal and shrimp trawl fisheries, and reaching less than 1,100 t in 2010 (Figure 7).

Industrial foreign catches (China)

Industrial catches by the Chinese fleet unauthorized to operate in Congo increased from low levels when the fishery began in 2001 to around 14,800 t in 2010 (Figure 8). Similarly, legal catches by China, i.e., catches by vessels authorized to operate within the Congolese EEZ, and discards increased from low levels in 2001 to around 21,200 t and 13,900 t in 2010 respectively (Figure 8).

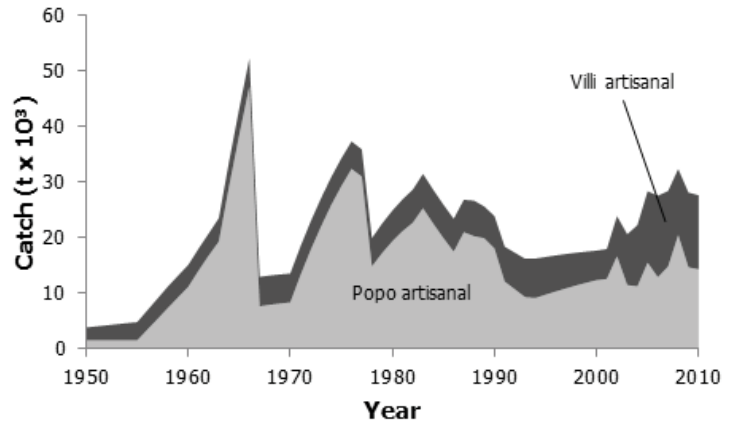


Figure 4. Reconstructed total artisanal Popo and villi catches from the Congo, 1950-2010.

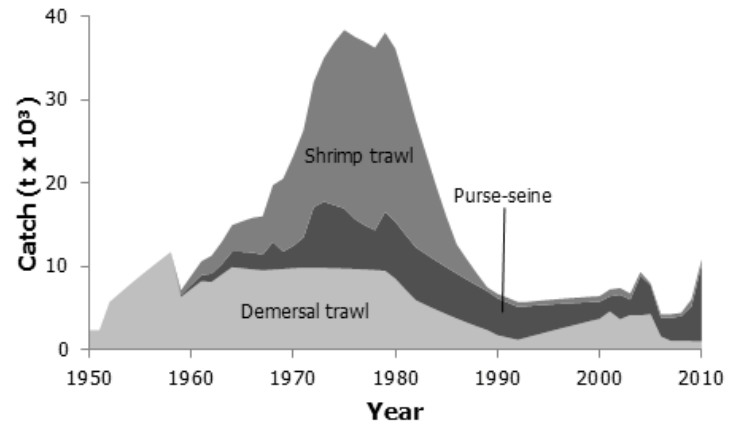


Figure 5. Reconstructed total industrial catches by gear type from the Congo.

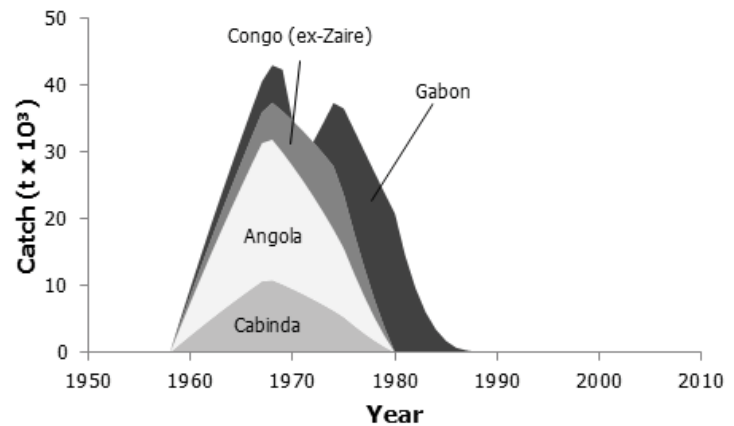


Figure 6. reconstructed total industrial catches by EEZ of the Congolese shrimp trawl fleet, 1950-2010.

Reconstructed total catch

Reconstructed total domestic catches from the Congolese EEZ increased from around 7,100 t in 1950 compared to 5,000 t reported to the FAO to a peak of 99,300 t in 1977 compared to around 15,400 t reported to the FAO, driven by high shrimp and demersal trawl catches (Figure 9a). Catches declined thereafter to remain relatively constant at 30,500 t·year⁻¹ on average during the 1990s and then increased slowly to 45,000 t in 2010 compared to around 34,700 t reported to the FAO (Figure 9a). Overall reconstructed domestic catches from the Congolese EEZ illustrate a declining pattern as opposed to increasing reported landings illustrated by the FAO data (Figure 9a).

Taxonomically, African spider shrimp (*Nematocarcinus africanus*; 13%) and other crustaceans (13%) along with *sardinella* spp. (25%) represented most of the catch in the past. More recently, *sardinella* spp. still compose a high proportion of the catch along with some other 70 demersal and small pelagic species (Figure 9b).

DISCUSSION

Reconstructed total catches from the Congo within its EEZ were on average 2.8 times the data supplied to the FAO. Under-reporting was at its highest in the 1970s and 1980s, before the creation of the catch statistics division by ORSTOM. Clearly, this under-reporting contributed to biasing the trend illustrated by official data which showed continuous increase in catch, despite major signs of over-exploitation (WCS 2011).

Indeed, while migrant fisheries catches (mainly by ethnic Popo fishers) were limited by governmental restrictions and entry permits, the size of migrant pirogues has shown a steady increase from around 8 m in the mid-1950s, to 9.3 m in the mid-1970s and 11.35 m in the early 1980s, along with the generalization of the motorization in 1960 for migrant pirogues (Gobert 1985, 1986). This is a common strategy used by fishers to expand their fishing grounds and capacity, as it also occurs elsewhere in West Africa (Belhabib *et al.* 2014a). Similarly, the length of the fishing net increased from 135 m in the mid-1950s to 275 m in the 1972 to around 1,000 m today (Gobert 1985). This extension is an adaptation to decreasing catches (Kibelolo 2003; InfoPêche 2008; Anon. 2011b). Despite expanding effort, artisanal fisheries in Congo are facing reduced catches per fisher and shrinking fish sizes (Nguinguiri and Katz 1996). Moreover, finding new fishing grounds today is very difficult because of coastal development and oil production facilities (Watson and Morato 2013), which reduced the exploitable areas by 2/3 (Maloueki 2005). This certainly contributes to the unsustainable levels of small-scale fisheries resources that the Congo face today (WCS 2011). Not only does this raise concerns for Congolese fisheries management, but it also place additional pressures on other food alternatives as people seek to replace seafood in their diet, i.e., people find alternatives in bush-meat, they put “additional pressure on hippopotamus, crocodiles, turtles and dolphins” (WCS 2011).

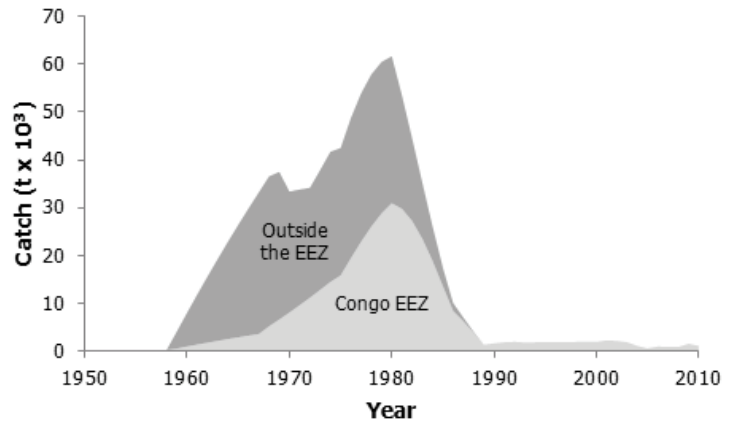


Figure 7. Reconstructed discards by the Congolese fleet, 1950-2010.

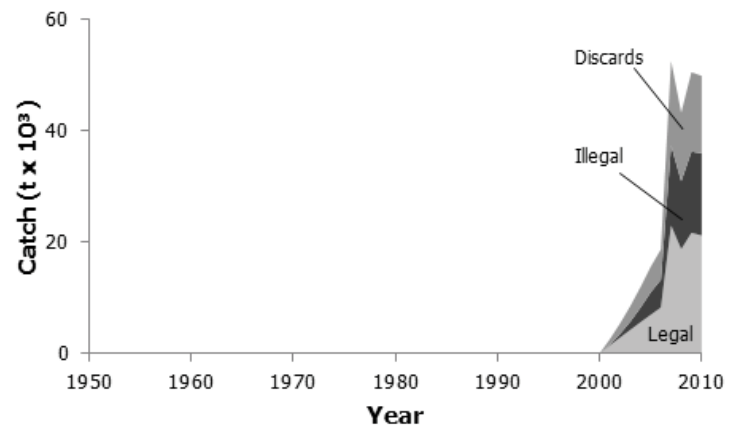


Figure 8. Reconstructed total industrial foreign catches by China in the EEZ of Congo, 1950-2010.

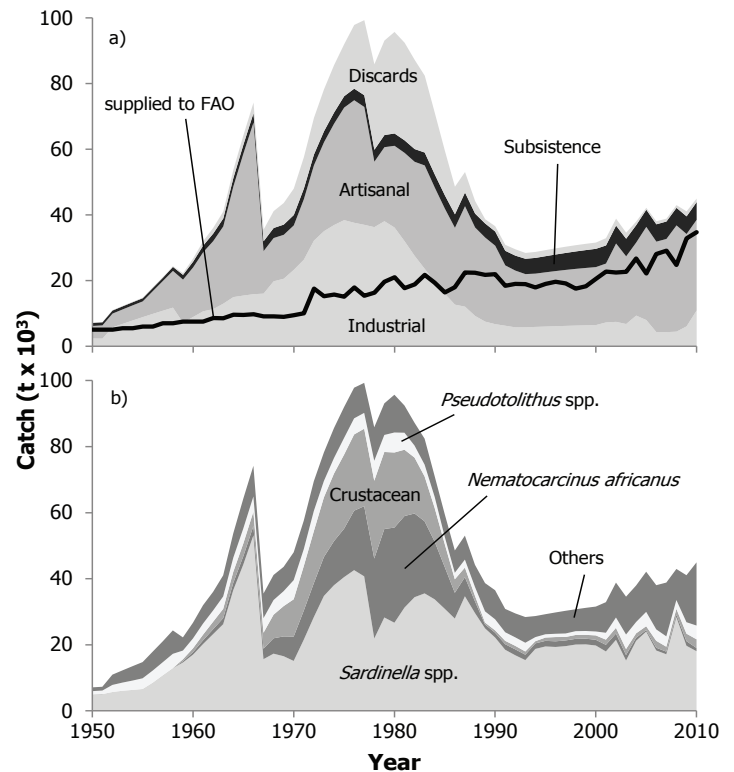


Figure 9. Reconstructed total catches for the Congo a) by sector and b) major taxa, 1950-2010.

Industrial fisheries, notably foreign Chinese fleets operating in the Congo, are often regarded as culprits when discussing issues of over-exploitation. This goes in hand with anecdotal evidence that the industrial effort is too high in the Congo. While the number of industrial domestic vessels and their capacity remains within the boundaries established for sustainable industrial fisheries, i.e., less than 30 vessels (Maloueki 2005), China deploys on average 70 fishing vessels (legally) in Congolese EEZ, which may render moot the management strategy for sustainable fisheries in the Congo. Indeed, industrial fisheries along with climate change are likely to be the strongest challenge for Congolese fishers in the next few years (Bassi and Lombardi 2013) and efforts to control are required.

The small-scale fisheries of the Congo operate within the context of strong traditional beliefs, which contribute to reshaping the fishing effort of the migrant artisanal fishers (Boungou 1986). Yet, despite strong traditional regulations aimed at maximizing fisheries output while maintaining the resource and continuous adaptive efforts, artisanal fishing households are among the poorest in the Congo (Brugère *et al.* 2008). Moreover, declining fisheries put further pressure on education and health of children in the Congo, in spite of fishmongers (mainly women) putting a particular focus on their children's education (Tati 2005) and health (Horemans and Kebe 2006).

It is perhaps encouraging that alternative livelihoods, as perceived by the most vulnerable fishing coastal households all exclude fishing (Brugère *et al.* 2008), as it may allow for moving excess fishers onto non-fishing activities. But the main task for Congolese fisheries management is to control foreign industrial fishing remains, without which all their other efforts will be in vain.

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

Year	FAO landings	Reconstructed total catch	Industrial	Artisanal	Subsistence	Discards
1950	5,000	7,110	2,340	3,820	907	42
1951	5,000	7,290	2,310	4,020	916	42
1952	5,000	10,960	5,720	4,210	928	103
1953	5,500	12,250	6,790	4,400	940	122
1954	5,500	13,520	7,830	4,600	953	141
1955	6,000	14,760	8,850	4,790	967	159
1956	6,000	17,920	9,840	6,920	982	177
1957	7,000	21,050	10,800	9,050	998	194
1958	7,000	24,350	11,740	11,190	1,216	211
1959	7,500	22,240	7,130	13,140	1,444	521
1960	7,500	26,680	8,890	15,090	1,756	938
1961	7,500	31,980	10,620	17,990	2,024	1,346
1962	8,600	36,030	11,290	20,710	2,305	1,727
1963	8,500	41,030	12,950	23,530	2,432	2,118
1964	9,600	53,720	14,950	33,700	2,565	2,500
1965	9,500	64,270	15,420	43,290	2,705	2,856
1966	9,700	74,190	15,830	52,300	2,851	3,204
1967	9,100	35,500	16,010	12,940	3,003	3,543
1968	9,100	41,140	19,760	13,180	3,054	5,149
1969	8,900	43,590	20,540	13,380	3,106	6,570
1970	9,401	48,000	23,250	13,540	3,161	8,047
1971	10,013	57,570	26,350	18,420	3,219	9,575
1972	17,527	69,510	32,150	22,940	3,279	11,151
1973	15,204	78,230	35,030	27,090	3,340	12,772
1974	15,719	85,600	36,900	30,870	3,401	14,437
1975	15,104	91,950	38,390	34,280	3,460	15,816
1976	17,870	97,830	37,580	37,330	3,519	19,407
1977	15,365	99,300	36,960	35,900	3,577	22,860
1978	16,297	85,850	36,260	19,920	3,634	26,036
1979	19,630	93,090	38,060	22,550	3,692	28,783
1980	20,966	95,700	36,140	24,890	3,751	30,921
1981	17,665	92,440	31,960	26,920	3,812	29,743
1982	18,836	87,210	27,500	28,660	3,874	27,174
1983	21,708	82,400	23,550	31,490	3,936	23,416
1984	19,308	71,030	19,650	28,640	3,997	18,750
1985	16,340	59,520	15,950	25,940	4,056	13,575
1986	17,993	48,560	12,650	23,400	4,114	8,397
1987	22,469	53,040	12,040	30,600	4,169	6,227
1988	22,378	44,210	9,210	26,950	4,224	3,825
1989	21,708	38,680	7,480	25,610	4,277	1,304
1990	21,954	36,520	6,710	23,890	4,328	1,598
1991	18,371	30,860	6,230	18,370	4,442	1,815
1992	18,944	29,500	5,730	17,290	4,556	1,933
1993	18,899	28,400	5,750	16,200	4,671	1,777
1994	17,913	28,700	5,870	16,230	4,790	1,815
1995	18,965	29,260	5,970	16,530	4,912	1,847
1996	19,600	29,790	6,080	16,800	5,040	1,871
1997	19,095	30,290	6,180	17,050	5,173	1,890
1998	17,500	30,760	6,270	17,280	5,307	1,902
1999	18,241	31,180	6,350	17,480	5,438	1,907
2000	20,520	31,570	6,430	17,660	5,564	1,907
2001	22,729	32,900	7,230	17,940	5,506	2,228
2002	22,433	38,830	7,410	23,870	5,440	2,109
2003	22,683	34,570	6,750	20,610	5,370	1,841
2004	26,686	37,950	9,320	22,250	5,304	1,080
2005	22,116	42,120	7,960	28,370	5,243	553
2006	28,082	38,040	4,280	27,560	5,275	929
2007	29,096	38,840	4,270	28,390	5,313	868
2008	24,742	42,960	4,430	32,360	5,350	817
2009	32,833	41,060	6,040	28,120	5,380	1,516
2010	34,686	44,960	10,870	27,620	5,401	1,068

Appendix Table A2. Reconstructed total catch (in tonnes) by major taxonomic group for the Republic of Congo, 1950-2010. "Others" contain 57 additional taxonomic categories.

Year	<i>Sardinella</i> spp.	<i>Nematocarcinus africanus</i>	Crustacean	<i>Pseudolithus</i> spp.	Others
1950	4,910	0	1	1,060	1,140
1951	5,080	0	1	1,070	1,140
1952	5,700	0	4	2,150	3,110
1953	6,080	0	5	2,470	3,690
1954	6,330	0	6	2,840	4,350
1955	6,610	0	6	3,240	4,900
1956	8,520	0	7	3,660	5,730
1957	10,760	0	8	3,960	6,320
1958	12,930	0	9	4,330	7,080
1959	14,640	381	588	2,640	3,990
1960	17,010	755	1,161	2,990	4,760
1961	20,230	1,121	1,722	3,350	5,550
1962	23,240	1,480	2,270	3,420	5,630
1963	26,240	1,830	2,808	3,760	6,390
1964	36,560	2,173	3,334	4,270	7,380
1965	44,320	2,509	3,848	4,570	9,030
1966	53,120	2,836	4,350	4,610	9,270
1967	15,650	3,156	4,839	4,420	7,440
1968	17,310	4,658	7,137	4,440	7,590
1969	16,550	5,987	9,172	4,530	7,360
1970	15,120	7,368	11,287	5,800	8,420
1971	21,530	8,797	13,476	5,140	8,630
1972	28,380	10,272	15,733	6,140	8,990
1973	34,790	11,791	18,054	4,960	8,640
1974	38,040	13,349	20,443	4,700	9,070
1975	40,490	14,641	22,420	5,050	9,350
1976	42,600	18,003	23,072	4,880	9,270
1977	40,730	21,236	23,459	4,790	9,080
1978	21,900	24,210	23,552	6,050	10,130
1979	28,280	26,782	23,318	5,160	9,560
1980	26,680	28,800	22,735	6,060	11,430
1981	31,260	27,719	20,077	5,140	8,230
1982	34,410	25,337	16,933	3,630	6,900
1983	35,560	21,828	13,573	3,580	7,850
1984	33,760	17,470	10,183	3,360	6,250
1985	30,890	12,635	6,958	2,220	6,820
1986	27,940	7,797	4,098	1,980	6,740
1987	34,700	5,774	2,908	2,420	7,240
1988	29,610	3,534	1,676	2,690	6,690
1989	24,970	1,181	577	3,380	8,560
1990	22,200	1,466	718	3,340	8,790
1991	18,500	1,674	1,034	2,600	7,060
1992	16,830	1,789	1,064	2,570	7,250
1993	15,360	1,637	980	2,640	7,780
1994	18,760	1,668	672	1,230	6,370
1995	19,500	1,692	999	1,000	6,070
1996	19,340	1,710	1,288	1,000	6,460
1997	19,600	1,722	1,048	1,060	6,860
1998	20,070	1,728	1,176	1,150	6,630
1999	20,130	1,728	1,155	1,170	7,000
2000	19,790	1,722	1,333	1,180	7,540
2001	17,980	2,008	1,572	2,080	9,260
2002	21,490	1,912	1,733	3,130	10,560
2003	15,240	1,653	1,820	4,400	11,460
2004	21,200	941	1,327	3,430	11,050
2005	24,000	446	1,181	4,340	12,160
2006	18,270	843	2,089	3,460	13,380
2007	17,130	795	1,490	3,140	16,280
2008	28,370	747	1,769	2,670	9,400
2009	19,700	1,401	2,269	3,470	14,220
2010	18,050	982	2,630	4,170	19,130

