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RECONSTRUCTION OF MARINE FISHERIES CATCHES FOR TUNISIA (1950-2010)

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ABSTRACT

The reconstructed total domestic marine catches for Tunisia's fisheries, including large-scale and small-scale commercial catches and recreational catch, as well as major discards, have been estimated for the 1950-2010 period, and increased from approximately 14,500 t·year⁻¹ in the 1950s to over 98,800 t·year⁻¹ in the 2000s. The estimated total domestic catches within Tunisia's EEZ are 1.13 times the national data. Foreign flag industrial catches were estimated to increase from almost 7,800 t in 1950 to a peak of just under 19,200 t in 1975, and then decline to 560 t in 2010. Domestic landings were obtained from official reports of the department of fisheries at the Tunisian agricultural ministry and from the Tunisian National Institute of Statistics. Foreign flag catches and domestic discards were estimated based on independent studies and recreational catches were reconstructed based on information provided by the Tunisian Federation of Sport Fishing and other surveys.

INTRODUCTION

Tunisia is a North African country, part of the Maghreb. It has a total area of approximately 164,000 km² and is bordered by Algeria in the west, Libya in the southern-east and the Mediterranean Sea in the north and the east. Relative to its size, Tunisia has a long coastline, which is indented by three important embayments: the Gulf of Tunis in the north, of Hammamet near the center and the Gulf of Gabès in the south.

Tunisia can be divided into three main geographical regions according to climate, quality of soils and topography, i.e., the North, the Center and the South (Nelson 1986). The northern region is isolated

from the rest of the country by the Atlas Mountains and is characterized by heavier rainfall and richer soils than the rest of the country; thus, most of Tunisia's agriculture production originates from the North. The Center, in contrast, has poorer soils with little vegetation and insufficient rainfall, and its littoral forms what is called *Sahel*, i.e. "the Coast". Its agriculture emphasizes wheat and other grains, pasture and the intensive cultivation of olive. The South includes *chotts*, i.e. salt marshes, oases with date palms, but mainly sand desert, i.e., the *Sahara* (Nelson 1986). The climate is mostly Mediterranean except in the southern part of the country, the *Sahara*, where there is extreme diurnal variation in temperature. Tunis, the capital and main city of the country since the 13th century, is situated in the north-east of Tunisia (Nelson 1986; Boularès 2012).

A 2013 census estimated the Tunisian population at 10.8 million (www.ins.nat.tn). Various people settled on the Tunisian coast, e.g., Phoenicians, Romans, Turkish, Arabs, etc. The French colonized the country until its independence in 1956. Habib Bourguiba became the first president of the new Tunisian republic. In 1987, a *coup d'état* brought a second president to Tunisia who was overthrown, following the events which initiated the "Arab Spring" of 2011 (Boularès 2012).

The sea and fish are extremely important in the Tunisian culture and traditions, particularly due to the geography of the country.

The Tunisian fishing industry

Tunisia has a wide continental shelf of over 66,000 km², and in 2005, it claimed an Exclusive Economic Zone (EEZ), of 102,300 km² (Official journal of the Tunisian Republic 2005; www.seaaroundus.org) (Figure 1). The large extension of soft bottoms has contributed to the development of artisanal and industrial fisheries in the Gulf of Gabès, where over 40% of total landings are generated (Najar *et al.* 2010).

The artisanal sector, consisting of a fishing fleet of around 10,300 boats (in 2008), is well developed along the Tunisian coast, and it is mainly performed by about 4,500 small boats, of which 66% were motorized (in 2008); they use a wide variety of fishing techniques and target high value species. However, for the last few decades, the number of artisanal boats has been decreasing because of the development of industrial fisheries.

Data collection is made by officials on a daily basis in each fishing port, who control the size and the quantities of fishes caught by each boat before allowing them to sell the fish at the wholesale market. Considerable catch amounts are exported, mainly to European markets. Indeed, after olive oil, marine products (i.e., fresh and frozen fish, cephalopods and other seafood) are Tunisia's most important export products.

MATERIAL AND METHODS

Total landings were assembled by sector, year and group of species, for the 1977-2010 time period, from official reports of the Tunisian Department of Fisheries. For the period from 1950 to 1976, we used data from national Statistical Bulletins. However, the earlier statistical data do not have the same level of detail. Notably, they did not use the same taxonomic breakdown and reporting format from one year to the next, often due to transfers of management responsibilities. Thus, alternative information sources (e.g., scientific reports, local expert knowledge) were used to improve on the earlier statistics. Then, official data and those reported by FAO on behalf of Tunisia were compared to evaluate the quality of data transfer. Finally, the official data were used as the reported baseline because it has overall a better taxonomic disaggregation than the FAO data.

The Tunisian department of fisheries has applied correction factors to the landings data since the end of the 1970s in order to take into account subsistence and unreported commercial catches, which amount to considerable quantities of fishing products sold directly to hotels and restaurants or in local markets without being accounted by the statistical agents. These correction factors account for 42% of total commercial catches in the artisanal fishery, 17% in the trawl fishery and 15% in the small pelagic fishery. These correction factors are still used today with the same coefficients. Tunisia should be applauded for the foresight of using adjustment factors, something used also by some other countries to account for unmonitored subsistence and commercial catches (e.g., Khalfallah *et al.* 2015), but not all (Zeller *et al.* 2006; Zeller *et al.* 2015).

Reported commercial fishery

The artisanal sector is multi-species and multi-gear. It includes non-motorized and motorized boats (length <12m). The industrial fishery involves trawlers, *lampara*, i.e., a type of purse seines fishing with lights and targeting small pelagic fishes, longliners and other purse seiners which target both demersal and pelagic resources. In the national data that were used in this study as the reported

baseline, landings were classified by gears. However, due to the incoherence of the gear classification among the national data, for the 1950-2010 periods, landings had to be reclassified into the appropriate gear categories based on the targeted species.

Recreational fishery

With the sophistication of the recreational fishing gears, which became cheaper and more affordable to a wider public, the recreational fishery in Tunisia is gaining in popularity. However, there is almost no data or studies on fisheries catches by this sector. The most important organization of the recreational fishery is the Tunisian Federation of Sport fishing, which was created in 2005 for better controls and regulations, as well as promotion of activities within the sector, e.g., underwater fishing, line fishing, etc. This organization thus became a hub for recreational fishing clubs of the country (www.ftps.org.tn). To estimate recreational fishery catches, we used information from previous works on recreational fishing in Tunisia, surveys of recreational fishers, as well as information provided directly by the Tunisian Federation of Sport Fishing.

Based on the number of recreational fishers who are members of Tunisian recreational fishing clubs in 2013 and on the recreational fishing effort, i.e., numbers of trips per season and mean catch per trip, we estimate the recreational catch for the year 2013, when the fishing clubs had 3,000 members (Tunisian Federation of Sport fishing pers. comm.). Earlier catches were interpolated between the 2013 estimate and a catch of zero in 1960, assuming that recreational fishing started in the early 1960s.

There are two different fishing seasons for this sector: summer (June/July/August) and “non-summer”. Recreational fishers go fishing on average twice a week in summer and once a month in “non-summer”. However, on average each fisher returns empty-handed following 3 trips out of 5 in summer and 1 trip out of 5 in “non-summer”. During the trips where there are catches, the average catch amount per trip per fisher in summer is 3.5 kg and in “non-summer” 1.8 kg (Khalfallah 2013).

Following Khalfallah (2013), we consider (A) number of recreational fishers in 2013; (B) number of trips per fisher in summer; (C) number of trips per fisher in “non-summer”; (D) recreational catch amounts per trip per fisher in summer; (E) recreational catch amounts per trip per fisher in “non-summer”; and (F) total estimated recreational catch amounts in 2013, i.e., $F = A \cdot [(B \cdot D) + (C \cdot E)]$.

Discards

Industrial discards included mainly discards of trawlers. These discards were estimated based on the results of scientific surveys of the National Institute of Marine Sciences and Technology (INSTM), and other scientific reports (Gharbi and Zaarah 2001; Jarboui *et al.* 2005; Salsabil 2008). These estimates were made separately for the northern and eastern coast of Tunisia, as well as for the southern coast including the Gulf of Gabès.

Discards of the artisanal fishery were estimated by Harrabi (2003) for the east coast of Tunisia, i.e., regions of Monastir and Mehdia, during the 2000s. Based on these estimates, the percentages of discards by gear compared to the total landings were calculated (Table 1). These estimates were then applied to the entire period, from 1950 to 2010.

Table 1. Percentages of artisanal discards by gear from total landings for Tunisia (Anon. 1989; Harrabi 2003).

Fishing gear	Discards (%)
Monofilament fishing net	2
Trammel net for shrimp	38
Trammel net for cuttlefish	22

Species disaggregation

Taxonomic disaggregations for each of the artisanal and industrial commercial fisheries were available for the periods 1978-1982 and 1995-2010 in reports of the Department of Fisheries. We calculated the percentages of each taxa group for the years 1978 and 1982 and applied these percentages to the total industrial landings for the 1950-1977 and 1983-1994 time periods, respectively. As the fishery for shrimp, which generates copious discards, began only in 1978, the discard percentages were adjusted to exclude this fishery before 1978.

The taxonomic disaggregation of artisanal discards and recreational catches, which includes individual species, was pooled to the family level. Then, the percentage of each family was applied to the artisanal catches for the 1950-2010 time period, while the percentages of families for the recreational catches were adjusted according to the popularity of some species of fish among recreational fishers.

Foreign fishing

Foreign industrial catches were estimated separately and were obtained from reports supplied by the National Institute of Marine Sciences and Technology (INSTM; Anon. 1978). Similarly, the

taxonomic desegregation of foreign (industrial) catches was brought up to a family level. Then we applied the percentages of families to the foreign catches.

RESULTS

Reconstructed marine fisheries catches were estimated for Tunisia for the 1950-2010 time period. Although the FAO catches were sometimes higher than the national data, they have the very similar trajectories (Figure 2). However the national data have a better taxonomic disaggregation, and they were thus used as the baseline, to which previously unreported small-scale and large-scale commercial, recreational, and illegal foreign catches, as well as major discards were added (note that subsistence catches as well as unreported commercial catches are implicitly included in the reported data because of the application of correction factors, and thus are deemed “reported”; see above). The estimated total domestic catches are 1.13 times the official reported landings. Catches increased steadily from 13,000 t in 1950 to the peak of 111,200 t in 1988 (Figure 2a). Catches then leveled out and averaged 95,200 t-year⁻¹ from 1990-2010. Reconstructed total catch was dominated by the industrial sector with 66%, followed by artisanal (34%) and recreational (0.1%; Figure 2a). Discards contributed 11% of the catch with almost 92% coming from the industrial sector and only 8% from artisanal. The main fish families of the reconstructed total domestic catch are Clupeidae (24%), Sparidae (13%) and Carangidae (8.4%) followed by Mullidae (7.2%), Scombridae (5.1%) and Octopodidae (5.1%; Figure 2b).

Foreign flag industrial landings were estimated to increase from almost 7,800 t in 1950 to a peak of just under 19,200 t in 1975, and then decline to 560 t in 2010. Catches were dominated by Clupeidae (29%), Sparidae (14%), Carangidae (11%), Mullidae (8.8%) and Octopodidae (6.2%).

In the 1970s, the Government of Tunisia started to invest heavily in the fishery sector, which led to the intensification of fishing effort. By the late 1980s, first signs of overexploitation became visible, i.e., landings decreased while fishing effort was still increasing. This led to the reinforcement of the fisheries regulations. Thus, between the mid-1990s to the mid-2000s, the fishery recovered.

Our estimations of artisanal and industrial discards as well as recreational catches remain conservative. For the discards, we did not take into account all type of gears, e.g., pelagic trawl or purse seiners. Estimates of recreational catches were based only on catches by fishers, who are members of the Tunisian Federation of Sport Fishing, i.e., independent anglers are excluded.

Overall, fisheries management in Tunisia is well developed. The correction factors applied to the different fisheries take into account subsistence and unreported commercial catches. However, these factors have been put in place at the end of the 1970s and need to be updated (Khalfallah 2013).

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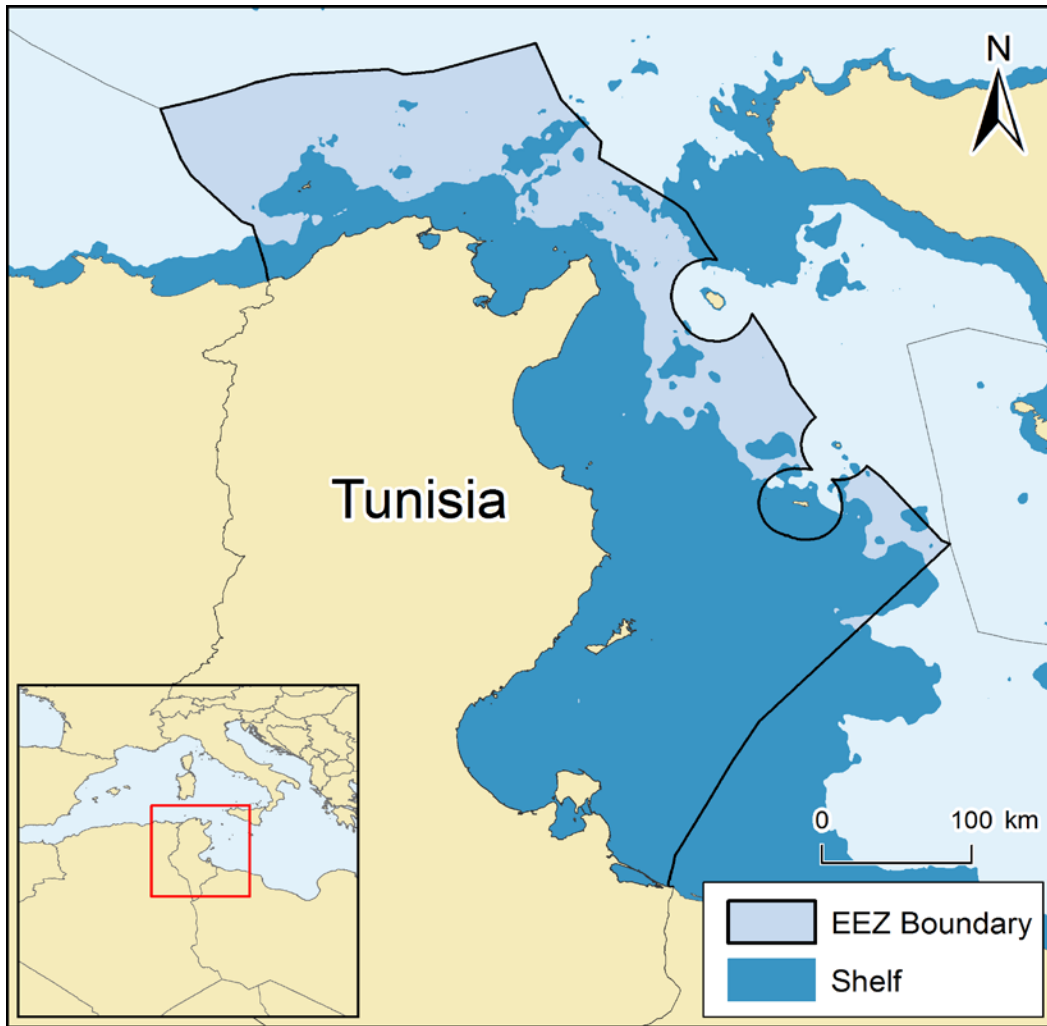


Figure 1. Exclusive Economic Zone (EEZ) and shelf area (to 200 m depth) of Tunisia.

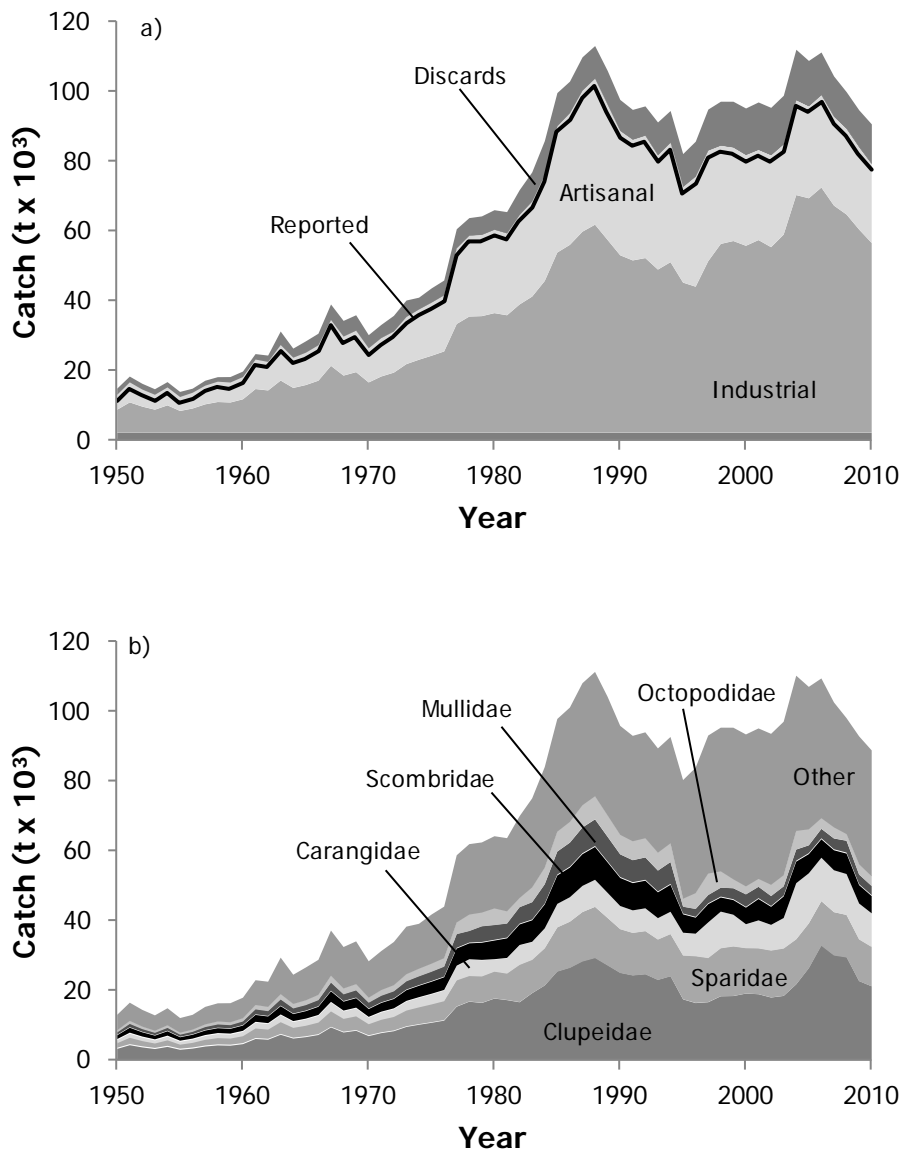


Figure 2. Total reconstructed catches for Tunisia, 1950-2010, by a) fisheries sector, plus discards shown separately, with landings reported nationally overlaid as line graph (note that recreational catches are too small to be visible); and b) by main taxonomic group. Note the 'others' category includes 44 additional taxonomic groups, family level or higher (see Appendix Table 2).

Appendix Table A1. Reported fisheries landings for Tunisia vs. total reconstructed catch (in tonnes), 1950-2010, as well as catch by sector with discards shown separately.

Year	National landings	Total reconstructed domestic catch	Industrial	Artisanal	Recreational	Discards (domestic)	Foreign industrial
1950	11,272	13,000	6,610	4,660		1,760	7,760
1951	14,840	16,500	8,700	6,140		1,650	8,200
1952	12,771	14,400	7,490	5,280		1,660	8,650
1953	11,277	12,900	6,610	4,670		1,580	9,090
1954	13,387	14,900	7,850	5,540		1,510	9,540
1955	10,636	12,100	6,240	4,400		1,460	9,980
1956	11,853	13,000	6,950	4,910		1,160	10,430
1957	13,883	15,300	8,140	5,740		1,410	10,870
1958	15,023	16,300	8,810	6,220		1,290	11,320
1959	14,781	16,300	8,660	6,120		1,570	11,760
1960	16,351	17,900	9,590	6,770		1,580	12,210
1961	21,366	22,900	12,530	8,840	3	1,560	12,650
1962	20,683	22,500	12,120	8,560	5	1,820	13,100
1963	25,530	29,400	14,970	10,560	8	3,860	13,540
1964	21,897	24,500	12,840	9,060	11	2,590	13,990
1965	23,323	26,600	13,670	9,650	13	3,240	14,430
1966	25,453	28,800	14,920	10,530	16	3,300	14,880
1967	32,710	37,100	19,180	13,530	18	4,420	15,940
1968	27,941	32,400	16,380	11,560	21	4,480	15,780
1969	29,631	34,100	17,370	12,260	24	4,400	16,360
1970	24,587	28,400	14,410	10,170	26	3,740	16,780
1971	27,504	31,300	16,120	11,380	29	3,750	15,420
1972	29,386	33,900	17,230	12,160	32	4,460	17,040
1973	33,559	38,300	19,670	13,890	34	4,690	18,240
1974	35,706	39,100	20,930	14,770	37	3,350	19,390
1975	37,646	41,700	22,070	15,580	40	4,060	19,180
1976	39,755	44,000	23,310	16,450	42	4,210	19,100
1977	53,210	58,700	31,200	22,010	45	5,470	18,550
1978	56,844	61,900	33,330	23,520	47	5,010	18,010
1979	57,047	62,400	33,440	23,600	50	5,300	17,460
1980	58,520	64,200	34,310	24,210	53	5,600	16,920
1981	57,471	63,600	33,690	23,780	55	6,090	16,370
1982	62,763	69,900	36,800	25,970	58	7,090	15,830
1983	66,615	75,000	39,050	27,560	61	8,340	15,280
1984	74,255	84,000	43,530	30,720	63	9,670	14,740
1985	88,195	97,800	51,710	36,490	66	9,500	14,190
1986	91,947	101,000	53,910	38,040	69	9,020	13,650
1987	98,391	108,000	57,690	40,700	71	9,550	13,100
1988	101,823	111,200	59,700	42,130	74	9,340	12,560
1989	94,338	104,100	55,310	39,030	76	9,680	12,010
1990	86,830	95,800	50,910	35,920	79	8,880	11,470
1991	84,307	92,900	49,430	34,880	82	8,530	10,920
1992	85,460	93,900	50,100	35,360	84	8,390	10,380
1993	79,823	89,300	46,800	33,020	87	9,410	9,830
1994	83,448	92,600	48,920	34,520	90	9,070	9,290
1995	70,775	80,300	43,050	27,720	92	9,390	8,740
1996	73,738	83,800	41,880	31,860	95	9,960	8,200
1997	81,194	93,000	49,200	31,990	98	11,720	7,650
1998	82,604	95,300	54,160	28,450	100	12,560	7,100
1999	82,058	95,300	54,990	27,070	103	13,100	6,560
2000	79,909	93,300	53,630	26,280	105	13,310	6,010
2001	81,385	95,000	55,260	26,130	108	13,560	5,470
2002	79,847	93,500	53,220	26,630	111	13,540	4,920
2003	82,955	97,000	56,830	26,120	113	13,890	4,380
2004	95,592	110,200	68,180	27,420	116	14,450	3,830
2005	93,855	107,000	67,260	26,590	119	12,980	3,290
2006	97,059	109,400	70,340	26,720	121	12,190	2,740
2007	90,886	102,500	65,150	25,730	124	11,490	2,200
2008	87,405	98,000	62,590	24,810	127	10,460	1,650
2009	82,136	92,800	58,280	23,850	129	10,520	1,110
2010	77,309	88,800	54,410	22,900	132	11,320	560

Appendix Table A2. Total reconstructed domestic catch (t) by major taxa for Tunisia, 1950-2010. 'Others' includes 44 additional taxa.

Year	Clupeidae	Sparidae	Carangidae	Mullidae	Scombridae	Octopodidae	Others
1950	3,320	1,670	890	1,070	870	770	4,450
1951	4,360	2,190	1,160	1,410	1,140	1,010	5,220
1952	3,730	1,870	1,000	1,200	970	870	4,790
1953	3,270	1,640	880	1,060	850	760	4,400
1954	3,880	1,940	1,040	1,250	1,010	900	4,880
1955	3,050	1,530	820	990	800	710	4,200
1956	3,400	1,710	910	1,100	890	790	4,230
1957	3,980	1,990	1,060	1,280	1,040	920	5,020
1958	4,300	2,150	1,150	1,390	1,120	1,000	5,210
1959	4,210	2,110	1,130	1,360	1,100	980	5,460
1960	4,660	2,340	1,250	1,510	1,220	1,080	5,880
1961	6,120	3,080	1,640	1,980	1,600	1,420	7,100
1962	5,900	2,980	1,580	1,910	1,540	1,370	7,220
1963	7,320	3,690	1,960	2,370	1,910	1,700	10,460
1964	6,230	3,150	1,670	2,010	1,630	1,450	8,370
1965	6,640	3,350	1,770	2,140	1,730	1,540	9,390
1966	7,250	3,640	1,940	2,340	1,890	1,680	10,040
1967	9,370	4,720	2,500	3,020	2,450	2,180	12,910
1968	7,950	4,010	2,120	2,570	2,070	1,850	11,880
1969	8,430	4,240	2,250	2,720	2,200	1,960	12,250
1970	6,930	3,490	1,850	2,240	1,810	1,610	10,420
1971	7,770	3,920	2,080	2,510	2,030	1,800	11,170
1972	8,310	4,190	2,220	2,680	2,170	1,930	12,370
1973	9,520	4,810	2,550	3,080	2,490	2,210	13,630
1974	10,140	5,100	2,710	3,270	2,650	2,360	12,870
1975	10,700	5,390	2,860	3,450	2,790	2,480	14,080
1976	11,300	5,700	3,020	3,650	2,950	2,630	14,760
1977	15,250	7,700	4,080	4,930	3,980	3,540	19,250
1978	16,670	7,520	4,680	4,580	3,380	4,910	20,170
1979	16,300	7,770	4,630	4,930	4,550	4,130	20,090
1980	17,550	7,900	3,460	5,360	4,280	4,960	20,680
1981	17,110	7,770	4,380	5,640	4,070	3,690	20,960
1982	16,500	10,870	5,610	5,920	4,750	2,840	23,430
1983	19,080	9,720	5,100	6,180	4,990	4,430	25,510
1984	21,270	10,820	5,690	6,890	5,560	4,940	28,820
1985	25,260	12,820	6,760	8,180	6,600	5,870	32,280
1986	26,340	13,370	7,040	8,530	6,890	6,120	32,750
1987	28,180	14,300	7,540	9,120	7,370	6,540	34,950
1988	29,170	14,810	7,800	9,440	7,630	6,770	35,610
1989	27,020	13,760	7,230	8,760	7,070	6,270	33,980
1990	24,870	12,700	6,660	8,070	6,510	5,780	31,210
1991	24,150	12,350	6,470	7,840	6,320	5,610	30,190
1992	24,480	12,530	6,550	7,950	6,410	5,690	30,330
1993	22,860	11,740	6,120	7,430	5,990	5,310	29,870
1994	23,900	12,260	6,400	7,760	6,260	5,550	30,460
1995	17,320	12,710	6,500	5,280	1,980	2,480	33,980
1996	16,270	13,560	6,410	4,610	2,290	4,730	35,920
1997	16,510	12,810	10,180	5,250	2,380	6,350	39,530
1998	18,200	13,910	10,490	4,070	2,570	4,880	41,150
1999	18,260	14,360	9,080	4,210	3,160	2,750	43,430
2000	18,960	13,180	6,840	4,760	3,590	2,470	43,530
2001	18,780	13,300	8,000	6,150	3,270	2,450	43,100
2002	17,840	13,610	7,340	5,180	2,860	3,420	43,250
2003	18,300	13,740	8,710	6,210	2,650	3,380	43,960
2004	21,600	13,060	16,140	6,200	3,180	5,520	44,450
2005	26,210	13,010	14,430	5,510	2,230	4,750	40,800
2006	32,700	12,910	12,520	5,290	2,700	3,210	40,040
2007	29,910	12,540	12,080	5,750	3,090	3,350	35,790
2008	29,350	12,300	11,790	5,880	3,380	2,080	33,200
2009	22,510	12,120	10,300	5,290	2,770	3,140	36,640
2010	21,030	11,440	9,630	4,980	2,620	2,990	36,070