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## **Abstract**

The total marine catches made by Montenegrin fisheries between 1950 and 2010 were reconstructed using landings reported for Montenegro by the FAO as a baseline to account for unreported catches made within Montenegro's Exclusive Economic Zone. Catches were attributed to fisheries sectors (i.e., industrial, artisanal, subsistence, and recreational), by catch type (i.e., reported landings, unreported landings and discards) and by taxa. The total reconstructed catches between 1950 and 2010 were 2.6 times the officially reported landings.

## **Introduction**

The Republic of Montenegro lies on the Mediterranean coast of Southeastern Europe, in the western part of the Balkan peninsula, with a land area of 14,000 km<sup>2</sup> (<http://www.faoadriamed.org>). Historically, Montenegro has seen many changes in politics and undergone associated conflicts. Montenegro was a monarchy during the Middle Ages until falling to the Ottoman Empire around 1499. Later, Montenegro became a theocracy and in 1878, its independence as a principality was recognized. The country became a kingdom in 1910, but was merged with Serbia following WW I. After WW II, it became part of Socialist Yugoslavia. After the dissolution of Socialist Yugoslavia in 1992, Montenegro and Serbia remained part of the Federal Republic of Yugoslavia. On May 21, 2006, the results from the referendum on Montenegrin independence dictated that Montenegro become an independent country. The independence of the current Republic of Montenegro was officially recognized on June 3, 2006.

Montenegro has a relatively short coast, with a shelf area of about 3,620 km<sup>2</sup> and an Exclusive Economic Zone of 7,400 km<sup>2</sup> (<http://www.seaaroundus.org>; Figure 1). The north-western area of Montenegro (i.e., Herceg Novi-Budva) is characterized by a rocky geography and its seafloor reaches depths greater than 120m from about three nautical miles offshore. The remaining coastline (i.e., Budva-Bar-Ulcinj), and particularly the mouth of the Bojana river, consists mainly of sandy and muddy sediment (Serena and Barone 2008).



Figure 1. Exclusive Economic Zone (EEZ) and shelf area (< 200 m) for Montenegro.

Marine fisheries in Montenegro saw little development between WW II and the 1990s, contrary to what was observed in neighboring areas of the former Yugoslavia, such as Croatia (Basioli 1986). However, after 1992-93 there was a rapid increase in the number of Montenegrin fishing vessels (Serena and Barone 2008). By 1998, there were 196 vessels registered for professional fishing. During the 1990s, intensive exploitation of demersal resources took place; likely leading to habitat damage of the underlying ecosystems (Serena and Barone 2008). For example, the catch per unit effort of trawlers decreased from  $60 \text{ kg} \cdot \text{hr}^{-1}$  to  $20 \text{ kg} \cdot \text{hr}^{-1}$  (Serena and Barone 2008). The Maximum Sustainable Yield (MSY) of Montenegrin marine resources was estimated at 600 tonnes per year, with an optimal fishing effort of 1190 fishing days per year (Serena and Barone 2008).

Montenegro has been negotiating for membership in the European Union since 2005, and as of 2013 has been granted the status of an official candidate. However, Montenegro has a small fishing industry, compared to its neighbouring countries of Italy and Croatia. Thus, the legislative and institutional progress of Montenegrin marine fisheries will be crucial, especially with respect to the Common Fisheries Policy of the European Union (Simovic 2009).

It is believed that many marine resources, especially demersal resources targeted by the trawl fisheries, are exploited at or above the maximum sustainable yield (FAO 2004) In contrast, industrial fishing for both small and large pelagics is relatively light (FAO 2004).

Based on FAO (2004), the following was the registered fishing fleet in 2002:

- 16 trawlers (9.5 to 25 m LOA, 419.64 total GRT, total engine power 2,748.3 kW);
- 11 vessels for coastal purse seining and beach seining with artificial lights (7.5 m LOA on average, 21.19 total GRT, total engine power 73 kW); and
- 169 boats fishing with artisanal gears (gillnets, trammel nets, short bottom longlines, traps, etc.), (4.5 m LOA on average, 279.89 total GRT, total engine power 1,389.3 kW).

Fishing gears in 2002 (excluding bottom trawls) were (Table 1):

- 11 small purse seines for small pelagic fish (*Sardina pilchardus*, *Engraulis encrasicolus*, *Scomber scombrus*, *Scomber japonicus*, and *Sarda sarda*);
- 8 beach seines for small pelagic fish (sardines and anchovies);
- 62 beach seines, for Sparidae, Mullidae, Centracanthidae, Trachinidae, Mugilidae, Scorpaenidae, squid (*Loligo vulgaris*), etc.;
- 1,068 trammel nets and gillnets;
- Bottom longlines with 75,400 hooks (200 hooks per longline on average); and
- 214 traps for various purposes (eels, other fish species, crustaceans, etc.).

The approximate breakdown of catch by gear in 2002 was: 17.3% from trawlers, 33.08% from purse seines and beach seines for small pelagic fish, and 49.62% from artisanal gears (FAO 2004).

### *Industrial fisheries*

The number of trawlers (16 vessels) and coastal purse seiners (11 vessel) accounted for less than 15% of registered fishing vessels in 2002 (Serena and Barone 2008).

The bottom trawl fisheries of the Mediterranean are multispecies. According to Simovic (2009), the most important commercial species include hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), rays (*Raja* spp.), musky octopus (*Eledone moscata*), cuttlefish (*Sepia officinalis*), and deep water rose shrimp (*Parapenaeus longirostris*). The continental shelf waters (to 200 m depth) are the target area for bottom trawlers. Most trawling takes place on sandy bottoms at 80-200 m depths (FAO 2004).

More diverse fishing activities (e.g., trawl and purse-seine) occur in inshore, territorial waters. This includes a directed trawl fishery inside the 3 nm limit between January to April when vessels are allowed to fish for shrimp (gambas). However, Norway lobster (*Nephrops norvegicus*) is targeted by Italian vessels outside the 12 nm limit (Simovic 2006).

Pelagic trawl and purse seine nets are used in the industrial pelagic fishery. The main target species are (Simovic 2009) European pilchard (*Sardina pilchardus*), European anchovy (*Engraulis encrasicolus*) and mackerel (*Scomber scombrus*). Fisheries targeting small pelagic fish (sardine and anchovy), tunas, swordfish, and/or Norway lobster (*N. norvegicus*) are currently being promoted in Montenegro (FAO 2004).

### *Artisanal fisheries*

In 2002, 85% of registered fishing vessels were less than 6 m LOA (i.e., 169 vessels, average LOA: 4.5 m) and operated with artisanal gear (FAO 2004). About 70 licenses were given to artisanal fishers in 2005 (Simovic 2006). The artisanal fishery includes the use of entangling nets at the mouth of Boka Kotorska Bay and coastal areas. Artisanal fishing incorporates the use of small boats and a variety of gear (e.g., nets, traps) to catch species of Sparidae, Scombridae, Triglidae, Clupeidae, and Engraulidae (Simovic 2009).

In the Bay of Boka Kotorska, where trawling is forbidden, small pelagics (mainly juvenile sardines and anchovies) are targeted by artisanal fishers at night using small purse seines and beach seines with artificial lights. Other gears include trammel nets, gillnets, beach seines for bonito (*Sarda sarda*), bottom longlines, various gears with hooks, harpoons with artificial light, and traps. The majority of catches in the Bay of Boka Kotorska are sardines and anchovies, and about 95% of the total annual catch of these two species in Montenegrin waters comes from this area (FAO 2004).

The rocky part of the coastal zone out to 2-3 nm can reach depths of about 80 m. In this zone, the main gears deployed are artisanal, such as trammel nets, gillnets, beach seines and gillnets for bonito (*S. sarda*), bottom longlines, various gear with hooks (with or without rods), harpoons with artificial light, and traps. According to FAO (2004), dominant taxa in this zone are hake (*M. merluccius*), conger eel (*Conger conger*), Sparidae, Moronidae, Scorpenidae, Mugilidae, red mullets (*M. barbatus* and *M. surmuletus*), Centrarchidae, sharks of the Triakidae, Squalidae and Squatinidae families, rays from the Rhinobatidae and Rajidae families, stingrays from Dasyatidae, Gymnuridae, Myliobatidae and Rhinopteridae families, and lobster (*Palinurus elephas*).

The area around the Bojana estuary consists of sandy bottoms and beaches. The main gears used to fish in this area are gillnets and traps for eels and mullets (*Chelon* spp., *Liza* spp., *Mugil* spp. and *Oedalechilus* spp.). Other gears (nets and hooks) may also be used to target Carangidae (e.g., *Lichia amia*), Sciaenidae (e.g., *Argyrosomus regius*), Moronidae (e.g., *Dicentrarchus labrax*), Citharidae, Scophthalmidae, Pleuronectidae and Soleidae (FAO 2004).

### *Recreational fisheries*

Recreational fishing is very popular in Montenegro and has been increasingly so in the last 10 years. In 2003, in the marine recreational sector, there were 1,500 registered sport fishers organized in 12 clubs. The national umbrella associations of marine sport fishers are the 'Association for Underwater Activities and Sport Fishing', with its main office in Podgorica, and the 'Association of Marine Sport Fishermen', with its main office in Baosici (FAO 2004).

Tunas such as Atlantic bluefin tuna (*Thunnus thynnus*), albacore tuna (*T. alalunga*), and little tunny (*Euthynnus alletteratus*) are the most common fishing targets in the Adriatic, but big game fish also include sharks, swordfish (*Xiphias gladius*), amberjacks (*Seriola* spp.), and dorados (*Coryphaena* spp.). Little tunas moving in shoals averaging 10-15 kg in weight are often seen in April. The end of May and the beginning of June marks the shark hunting season (blue sharks and thresher sharks). Bluefin tunas are caught at the beginning of August when they can average

between 70-80 kg up to 500 kg in weight. The season for bluefin tunas fall in the best season for recreational fishing (August to November) when chances of catching big game targets are high.<sup>1</sup>

**Table 1.** Fishing gears used by Montenegrin fisheries. Sectors: IF: Industrial, AF: Artisanal, RF: Recreational, SF: Subsistence.

Gear	Sector	Target species
Bottom trawl	IF	Hake, red mullet, deep water rose shrimp, rays, musky octopus, cuttlefish
Pelagic trawl	IF	European pilchard, European anchovy, mackerel
Purse seine	IF	Small pelagics, grey mullet
Small purse seine	AF	Small pelagic
Beach seine	AF	Bonito ( <i>Sarda sarda</i> ) and tunas
Gillnets	AF	Bonito, Atherinidae, bogues, pickerels ( <i>Spicara</i> spp.), lobsters, grey mullet, <i>Squatina</i> spp.
Traps	AF	Fish and crustaceans (lobsters)
Surface longline	AF, RF	
Bottom longline	AF	
Harpoons	AF	
Troll Pendula	AF	
Angler Pusca	AF	Squid
Visoka tool	RF	
Chinese net	RF	Grey mullet, eel
Heavy trolling	RF	Swordfish, tuna, barracuda
Light trolling	RF	Sparidae ( <i>Dentex</i> spp.), sea bream, small tuna, barracuda
Night drifting	RF	Shark, tuna, barracuda, swordfish

## Methods

To reconstruct catches made by Montenegro's fisheries between 1950 and 2010, landings data reported for the country by the FAO was used as the baseline. FAO reported landings attributable to Montenegro were previously disaggregated from the FAO data for the former Yugoslavia for years 1950 to 1991 by Rizzo and Zeller (2007). Additionally, catch data reported between 1992 and 2005 were originally labelled as 'Montenegro and Serbia', but due to present day Serbia being land-locked, these catches were attributed solely to Montenegro.

The taxonomic resolution of the reported FAO landings data had to be improved for 2005 to 2010, as around 33% were presented as the very uninformative and analytically useless 'marine fishes nei' category. To disaggregate the 'marine fishes nei' category, the taxonomic composition from 2004 was applied and assumed to have stayed identical from 2005 to 2010.

The reported landings baseline data were separated into landings assigned to the industrial (i.e., large-scale, commercial) and artisanal (small-scale, commercial) sectors. Due to a near absence of readily available local data and local expertise for this reconstruction, we made the simplifying

<sup>1</sup> <http://biggamemontenegro.com/en/offer/deep-sea-fishing.html> [accessed August 2013]

assumption that patterns and trends in neighbouring Croatia (as per Matic-Skoko *et al.* in press) were also representative for Montenegro. The separation of reported landings into industrial and artisanal sectors was based on a ratio between these two sectors for every year between 1950 and 2010 based on neighbouring Croatia (Matic-Skoko *et al.* in press). Thus, on average, the industrial sector was assumed to be responsible for 87% of the landings, whereas the artisanal sector was responsible for 13%. The taxonomic breakdown of industrial and artisanal landings was taken from the taxonomic composition reported in the FAO baseline data.

Unreported landings and discards were estimated for the industrial and artisanal sectors also based on patterns in Croatia. The amount of unreported landings in comparison to landings reported for Croatia was determined and the proportion was assumed to be identical for industrial and artisanal fisheries in Montenegro. Specifically, IUU catches made by Croatian industrial fisheries corresponded to an average of 34% of reported landings from 1950 to 2010, and 300% of reported landings for the artisanal fisheries. Furthermore, the taxonomic composition for unreported catches made in Montenegro was assumed to be identical to Croatian unreported catches.

As discards are directly related to total catch, as opposed to just reported catch, the tonnage discarded by industrial and artisanal fisheries of Montenegro were estimated based on the sum of landings and unreported catch. In Croatia, industrial fisheries were treated with varying discard rates over the time period (Matic-Skoko *et al.* in press). The time series of discard rates was applied to Montenegro's industrial landings unaltered except for the period of 1950-1960. In Croatia a discard rate of 50% was applied from 1950-1960 which was to account for a developing trawl fishery in the eastern Adriatic Sea. It was assumed that this did not apply to Montenegro and the rate of 6.0% in 1961 was carried back to 1950. For the artisanal sector, the constant discard rate of 20% from the Croatia reconstruction (Matic-Skoko *et al.* in press) was applied to the artisanal landings. All discards were assumed to be taxonomically identical to Croatian discards and were considered at the family level only.

Subsistence and recreational fishing in Montenegro was estimated as entirely unreported catches based on the *per capita* subsistence and recreational catch made by coastal residents in Croatia from 1950 to 2010 (Matic-Skoko *et al.* in press). For the purposes of this report, residents living within 10 km of the coast were considered to engage in subsistence and recreational fishing. Coastal population data for Montenegro for 1990, 2000 and 2010 were taken from CIESIN (CIESIN 2012) and used as anchor points for a time series interpolation. For all years prior to 1990, the 1990 percentage of coastal to total Montenegro population was assumed to be constant. Furthermore, as no single source presented complete population data for Montenegro between 1950 and 2010, two sources were used. For 1950 to 1959, the total population of Montenegro was taken from the United States Census Bureau (<http://www.census.gov>) and for 1960 to 2010, data were taken from The World Bank (<http://www.worldbank.org/>). The taxonomic breakdown of catches made in the subsistence and recreational sectors were considered on the family level and assumed to be identical to taxa caught in Croatia.

## **Results/Discussion**

Reconstructed total marine fisheries catches by Montenegro's fisheries between 1950 and 2010 were 2.6 times the landings officially reported by the FAO on behalf of Montenegro (or disaggregated from former Yugoslavia by Rizzo and Zeller 2007) (Figure 2, Appendix Table A1). Total catches increased from 550 t·year<sup>-1</sup> in the early 1950s to a peak catch of just under 1,800 t

in the late 1980s, before declining to a low of around 950 t in 1992 (Figure 2a). Thereafter, catches increased again to almost 1,600 t by 2010. Overall, reconstructed total catches mirrored trends in reported landings (Figure 2a).

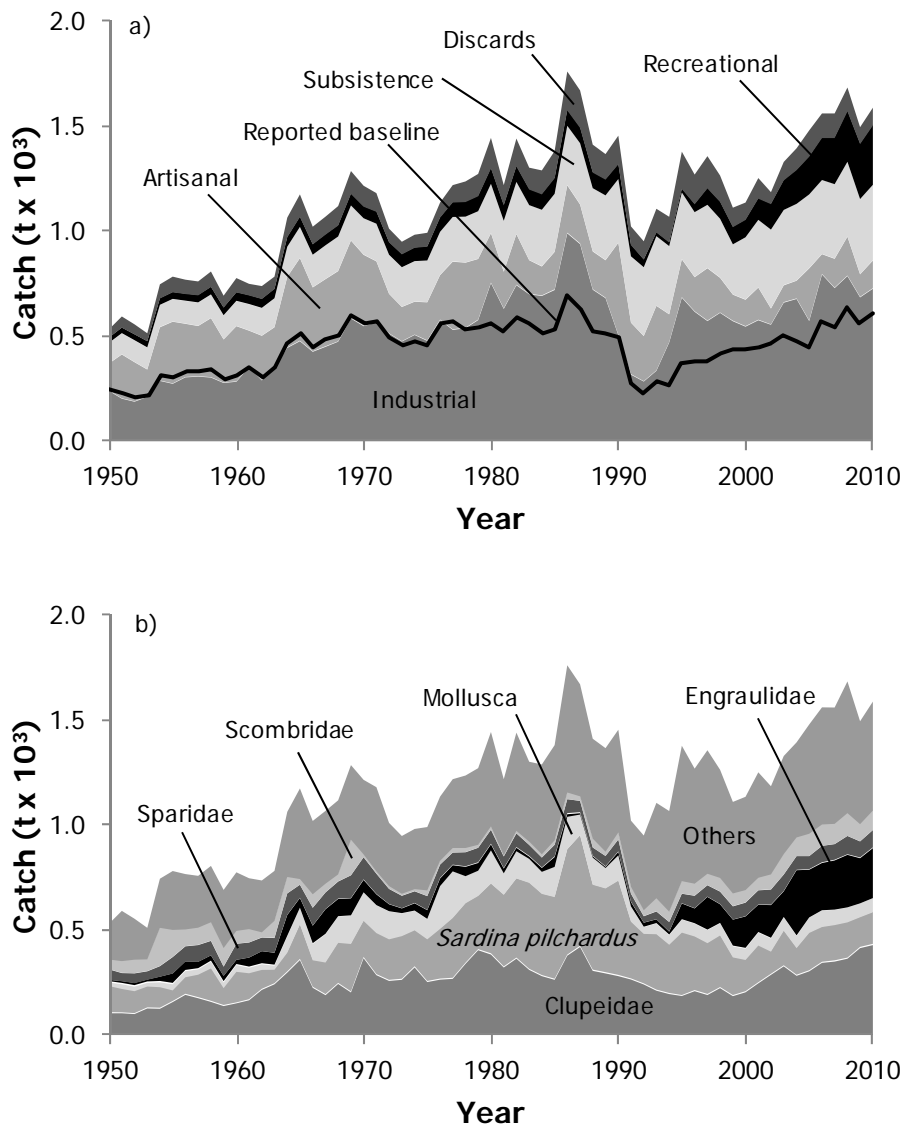


Figure. 2 Total reconstructed catches for Montenegro between 1950 and 2010, a) by fisheries sectors and discards, with FAO data reported by or allocated to Montenegro (Rizzo and Zeller 2007) overlaid as a line graph; and b) by major taxonomic category with ‘others’ representing ‘marine fishes nei’ and 35 taxonomic categories with lesser contributions.

Total catches (i.e., including discards) by the industrial sector (around 35,200 t) accounted for 51% of total marine catches from 1950-2010 (Figure 2a). The artisanal sector contributed 22% (15,600 t) of total catches. Catches in the subsistence sector amounted to 14,000 t which corresponds to 20% of total catches. Recreational fishing activities in Montenegro were responsible for 4,800 t, or 7%, of the total reconstructed marine catches.



Discarding by the industrial and artisanal sectors accounted for around 5,900 t for 1950-2010 (Figure 2a). Discards were just under 60 t·year<sup>-1</sup> in the 1950s, averaged 82 t·year<sup>-1</sup> through the 1960s and 1970s, increased slightly to an average of 130 t·year<sup>-1</sup> from the 1980s to 1990s, and finally decreased slightly to an average of 98 t·year<sup>-1</sup> in the 2000s (Figure 2a).

*Sardina pilchardus* was a major contributor (13,200 t, 19.0%) to Montenegro's total marine catches (Figure 2b, Appendix Table A2). Other small pelagics also dominated with other Clupeoids contributing another 22.7% of total reconstructed catches, and Engraulidae 6.3% (Figure 2b). Catches of Molluscs, Sparidae and Scombridae also contributed 7.1%, 5.6% and 5.2% of the total reconstructed catch, respectively. The 'others' category included 36 additional taxonomic categories of lesser contributions.

As shown here, officially reported fisheries statistics for Montenegro may account for less than half of actual total catches taken annually. Thus, consideration of only national landings data, which underestimates total catches, is insufficient for evaluating the health of marine stocks or assessing the remaining biomass in waters open to fishing activities. While the present study relied heavily on a more detailed reconstruction of fisheries catches in neighbouring Croatia, given similar histories and socio-political backgrounds, it is unlikely that Montenegrin fisheries development would differ substantially from Croatia. Nevertheless, a further historic reconstruction of catches for Montenegro, by local experts, and using local data and knowledge, may be beneficial.

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**Appendix Table A1.** Official landings disaggregated from former Yugoslavia (1950 – 1991) and ‘Montenegro and Serbia’ (1992 – 2005) and reconstructed catches for Montenegro (tonnes) from 1950 to 2010.

Year	Landings	Reconstructed total	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	246	635	240	128	96	25	40
1951	225	680	203	208	99	27	54
1952	208	636	188	186	101	29	49
1953	218	603	211	128	103	29	38
1954	313	871	288	253	104	32	68
1955	297	901	274	293	106	33	75
1956	326	900	304	252	108	34	69
1957	328	893	308	238	110	36	66
1958	336	939	303	280	111	37	74
1959	289	812	277	205	112	38	58
1960	311	899	283	262	118	41	69
1961	348	746	352	172	124	43	55
1962	298	736	290	210	130	44	62
1963	351	781	354	186	136	46	60
1964	468	1063	445	335	142	48	94
1965	507	1175	477	392	147	50	109
1966	447	1020	427	303	153	51	85
1967	480	1068	450	319	159	53	86
1968	499	1118	474	333	163	55	93
1969	595	1286	585	368	166	57	110
1970	558	1216	548	336	172	58	101
1971	566	1181	566	287	178	60	90
1972	495	1010	512	187	184	62	66
1973	453	948	475	162	187	64	61
1974	475	981	506	156	191	66	63
1975	456	990	478	181	197	68	66
1976	561	1136	577	211	204	70	73
1977	568	1219	531	322	211	72	84
1978	534	1236	539	308	218	73	99
1979	540	1272	578	287	226	75	107
1980	563	1444	753	234	233	77	146
1981	518	1219	630	174	241	77	97
1982	588	1441	743	240	247	77	134
1983	557	1302	700	159	261	77	105
1984	509	1289	693	137	268	77	114
1985	528	1382	721	178	275	77	131
1986	691	1762	991	225	283	77	187
1987	628	1672	939	184	291	78	180
1988	521	1412	722	179	299	78	134
1989	509	1367	681	178	307	78	122
1990	488	1455	505	436	302	74	138
1991	277	1021	318	244	314	56	90
1992	225	950	285	214	325	38	88
1993	279	1106	335	306	330	19	114
1994	262	1067	470	131	323	20	123
1995	370	1379	684	180	316	20	180
1996	381	1269	617	161	308	40	143
1997	374	1357	573	248	300	82	154
1998	418	1264	611	164	279	83	127
1999	432	1110	572	123	238	84	93
2000	431	1135	546	125	295	85	83
2001	446	1252	577	152	320	105	98
2002	466	1185	555	74	374	124	58
2003	498	1330	660	80	357	144	89
2004	477	1395	678	84	364	164	105
2005	443	1480	573	247	350	184	126
2006	568	1562	794	93	352	204	119
2007	539	1561	729	137	353	224	117
2008	638	1686	787	184	355	245	115
2009	563	1495	685	107	357	266	81
2010	610	1589	726	131	359	287	86

**Appendix Table A2.** Total catches of major taxa by Montenegrin fisheries between 1950 and 2010 with 'others' representing 36 additional taxa with lesser contributions.

Year	Clupeidae	<i>Sardina pilchardus</i>	Mollusca	Engraulidae	Sparidae	Scombridae	Others
1950	104	130	16	7	50	51	171
1951	104	117	22	8	39	61	240
1952	100	110	21	11	46	70	195
1953	127	105	17	9	40	60	151
1954	125	103	23	21	50	187	235
1955	158	56	28	45	78	134	281
1956	192	84	28	41	72	85	265
1957	176	112	25	31	80	86	248
1958	158	159	32	25	69	93	269
1959	139	86	26	25	44	93	277
1960	151	150	32	20	76	66	279
1961	166	129	25	44	71	69	243
1962	215	95	26	57	65	29	247
1963	242	69	19	57	70	86	238
1964	298	93	77	100	101	83	310
1965	358	166	80	45	61	32	432
1966	225	131	77	83	84	69	350
1967	191	154	133	118	78	46	348
1968	244	194	125	82	81	38	354
1969	204	229	134	82	108	175	356
1970	367	175	135	60	106	18	356
1971	286	199	131	52	96	16	402
1972	258	196	132	33	71	18	302
1973	264	206	107	22	59	14	275
1974	323	175	92	35	55	14	287
1975	253	202	95	42	66	32	302
1976	265	239	203	37	63	23	306
1977	268	286	222	30	57	26	328
1978	340	285	130	44	67	25	345
1979	405	255	121	37	69	19	366
1980	384	333	161	29	66	20	450
1981	322	343	103	22	55	10	363
1982	364	377	133	16	65	17	469
1983	311	411	116	11	52	20	381
1984	281	388	106	18	47	21	428
1985	264	391	145	47	55	25	455
1986	379	501	160	12	66	38	606
1987	420	526	104	6	54	27	535
1988	307	406	131	6	39	47	477
1989	294	401	98	6	49	25	494
1990	282	450	123	16	56	38	490
1991	265	273	72	21	38	38	316
1992	241	239	32	19	30	33	357
1993	212	267	51	17	37	67	455
1994	196	233	45	14	45	53	481
1995	186	300	61	75	45	65	646
1996	210	259	61	70	59	62	549
1997	191	245	61	157	54	60	589
1998	224	249	57	89	59	70	516
1999	186	184	52	124	63	65	437
2000	204	153	53	150	65	64	445
2001	247	179	61	131	67	64	504
2002	287	109	62	157	72	76	421
2003	328	167	63	123	78	102	468
2004	283	130	58	312	65	94	454
2005	304	181	72	229	62	111	522
2006	344	168	78	227	78	107	559
2007	351	171	72	236	74	102	555
2008	364	171	70	252	86	114	628
2009	415	144	65	217	76	87	491
2010	429	153	67	239	83	98	520