

Fisheries Centre

The University of British Columbia



Working Paper Series

Working Paper #2015 - 62

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Year: 2015

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This working paper is made available by the Fisheries Centre, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.

BRITISH COLUMBIA MARINE FISHERIES CATCH RECONSTRUCTION: 1873 TO 2010

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ABSTRACT

An estimation of the total fisheries withdrawals from the Canadian Exclusive Economic Zone in the Pacific (i.e., along the coast of the province of British Columbia) is presented for the years since 1873, with some emphasis on 1950 to 2010, including by industrial and artisanal, recreational and subsistence fisheries, and discarded by-catch. Reconstructed total catches, in the order of 534,000 t·year⁻¹ in the 1950s and almost 250,000 t·year⁻¹ in the 2000s, accounted, from 1950 to 2010, for almost 24.4 million t, which is around 84% higher than the 13.3 million t officially reported by national and international (FAO) data sources on behalf of Canada. These discrepancies are higher than those previously reported for some other developed countries. While non-commercial fisheries account for only a small component of total withdrawals, subsistence and recreational fisheries need more comprehensive accounting and reporting in official statistics provided to the national and international community, as do discards, given the predominance of ecosystem considerations in fisheries and ocean management.

INTRODUCTION

Having an accurate estimation of total fisheries removals is essential for developing population models used in fisheries management and, generally, for understanding the impacts of human beings on marine ecosystems. Unfortunately, few fishing sectors, even in the developed world (Zeller *et al.* 2011a; Zeller *et al.* 2011b), are able or required to compile a comprehensive catch record, leaving a large portion of catch unaccounted for in official government statistics. Moreover, illegal or unregulated fisheries can represent a significant fraction of removals. These missing data are often referred to as 'illegal, unreported and unregulated' (IUU) catch (Bray 2000). IUU catches could, if considered, profoundly alter predicted stock dynamics in exploited species and ecosystems, and potentially help explain observed ecological trends. Fisheries management that fails to consider IUU catches may put fish stocks at risk of overfishing or extinction. The presence of IUU catches also devalues catch information obtained from compliant and well-managed fisheries, often at their own expense.

This short contribution synthesizes available catch information for Canada's Pacific coast (i.e., province of British Columbia) marine fisheries from 1873 to present. All data originate from Canada's Exclusive Economic Zone (Figure 1), embedded in FAO Statistical Area 61. Recent and historical catch data for industrial and recreational sectors are collated from governmental and non-governmental sources. Previous catch estimates provide data on catch prior to 1950 and estimates of IUU catches, which are comprised of discarded catch and unreported subsistence, artisanal and recreational landings. The data have been assembled using the format and conventions of the *Sea Around Us* project catch database¹ and are available online at <http://www.searoundus.org/> or from the author.

¹ For the purposes of the global catch database of the *Sea Around Us* project, only data for 1950-2010, as derived here, are utilized. Furthermore, catches of whales and other marine mammals during the 1950s, 1960s and 1970s were also excluded.

METHODS

A catch database in MS Excel is developed using the following data fields: 1) CountryFishing, 2) EEZarea, 3) SubAreaEEZ, 4) FAOarea, 5) Otherarea, 6) Year, 7) TaxonName, 8) Original FAO name, 9) CatchAmount, 10) Sector, 11) CatchType, 12) Input, 13) Notes. The 'Notes' field includes references(s) for each data point.

The database separates fishing sectors (field 'Sector') into four categories: industrial, artisanal, recreational and subsistence. 'Industrial' fisheries capture large-scale commercial fisheries, and represent the majority of recorded catch. All industrial landings data prior to 1950 are taken from Wallace (1999), who compiled historical landings from 26 separate articles and databases covering all major industrial fisheries in British Columbia (see also Pauly *et al.* 2001). Salmon and herring landings from 1951 to 1995 are provided by historic catch statistics available online from the Pacific Regional Data Unit (PRDU, DFO 2012b), while information for more recent years is provided by online commercial catch statistics summaries (DFO 2012d). Historical groundfish landings from 1951 to 1995 are available in the PRDU historical catch statistics on CD-ROM (DFO 2004). DFO (2012d) supplied information from 1996 to 2011 for 18 additional fish groups including several species of flatfish, rockfish and demersal fish. Halibut (*Hippoglossus stenolepis*) data from 1951 onwards are taken from the International Pacific Halibut Commission (Hare 2010). However, these data represent 'head-off' and 'gutted' fish, so a 25% wet-weight correction factor was applied based on PFMC (2010). Information on sardines from 2006 onwards is provided by (DFO 2012c).

Artisanal fisheries for butter clams, lingcod (*Ophiodon elongatus*) and abalone (Haliotidae) are defined in FAO catch statistics (FAO 2012). 'Recreational' fisheries data are compiled from the Department of Fisheries and Oceans creel and logbook surveys (DFO 2012a) for salmon and some groundfish, from Wallace (1999) for some groundfish, and Hare (2010) for halibut. 'Subsistence' fisheries are documented for five species of salmon (Wallace 1999), halibut (Hare 2010) and herring roe (DFO 2012d). Catch in subsistence fisheries is estimated for the years after 1995 by extrapolating trends in Wallace (1999), assuming a constant fraction with respect to recorded catch, where the fraction is calculated using an average of 1990 to 1994 data.

Catch type (field 'CatchType') is divided into reported landings, unreported landings and discards. Consistent with the *Sea Around Us* catch database, catch amounts for each species reported to FAO were considered the maximum amount of 'reported' data, while any additional catch beyond that amount (originating for example from IUU estimates or governmental landings data not appearing in FAO records) were aggregated into the 'unreported' category. Consequently, a search in this database for 'reported' data will yield a total catch amount equal to FAO recorded quantities but have finer taxonomic resolution than the FAO records (since disaggregated national-level data were preferred over FAO). A search for 'unreported' data will yield all information absent from FAO records. All IUU, including subsistence, artisanal and recreational catch as well as discards, was categorized as 'unreported'. Discard information originates mainly from observer programs, e.g., in the halibut (Hare 2010) and groundfish trawl fleets (see Ainsworth and Pitcher 2004; 2005 for various source articles). Discard values also include estimates from Ainsworth and Pitcher (2004, 2005), who used a subjective methodology based on relative IUU influence trends and anchor point estimates.

RESULTS AND DISCUSSION

Total catch

Annual extractions from the ecosystem increased slowly and consistently after the 1870s for about 80 years and then jump sharply after World War II, reaching a maximum of almost 703,000 t in 1963 (Figure

2). Catches subsequently dropped to an average level of about 300,000 to 400,000 t·year⁻¹ and held steady at that rate until the late 1980s. A second rapid increase occurred in the early 1990s, with a peak of almost 700,000 t in 1991. This is followed by a sharp decline in catch in the late 1990s leading to the current catch levels of about 200,000 to 300,000 t·year⁻¹ (Figure 2).

Unreported catch

Over the last 60+ years, a large portion of the catch came from unregulated fisheries, so unreported catches were high until the mid to late 1990s (Figure 3a). Unreported catch constituted about 50% of total extractions from 1950 to about 1970. After that, better reporting mechanisms were brought into place (Ainsworth and Pitcher 2005) and unreported catch gradually fell to about 35-40% of total extractions by the late 1990s. Subsequently, the fraction of unreported catch declined to about 20% of total extractions, a rate that has been maintained to the present.

Non-industrial fisheries

Recreational, artisanal and subsistence fisheries together capture only a small amount of catch relative to the industrial fleets (Figure 3a). Throughout the 1950s and 1960s, that fraction was consistently between 2-5%. Throughout the 1970s and 1980s, a significant increase in recreational fishing increased that fraction to between 5-7%, peaking in 1986 at 8%. In the mid-1990s, the total amount of recreational catch dropped to about 1/3 of its value in the previous two decades. Since the mid-1990s, recreational, artisanal and subsistence fisheries have accounted for about 4-5% of total extractions.

Discards

From the 1950s to the early 1970s, discarded catch is estimated to have been less than 1% of total industrial landings (Figure 3a). The fraction increased to 2-3% throughout the 1980s and 1990s, driven primarily by increases in the amount of benthic trawling (Ainsworth and Pitcher 2005); this is evidenced by a proportional increase in the amount of groundfish discards relative to landings. By the 2000s, the discards had grown to constitute 4-5% of industrial landings, where it has remained until the present.

Taxonomic composition

Until the mid-1960s, catches were dominated by herring, and only secondarily by halibut and several salmon species (mainly chum and pink salmon, Figure 3b). After the decline of herring stocks, salmon dominated until hake, pink and sockeye salmon became substantial in the total catch in the mid-late 1980s. Since the 2000s, hake dominates in terms of tonnage among all other taxa (Figure 3b).

Total reconstruction

Total reconstructed catches from 1950 to 2010 accounted for over 24.4 million t, which is around 84% higher than the 13.3 million t officially reported by national and international (FAO) data sources on behalf of Canada (Figure 3a). These discrepancies are higher than those previously reported for some other developed countries (e.g., Zeller *et al.* 2011b), yet better than Canada's record for its own arctic waters (Zeller *et al.* 2011a). There are few data available on foreign fishing that occurred inside British Columbia waters. In addition to a Russian fur trade for sea otters that operated in the late 1800s, it is known that Russian, Japanese and Polish trawl vessels targeting hake, rockfish and Pacific ocean perch operated in British Columbia waters (Wallace 1999). The earliest data available are from 1965, and indicate a peak catch in 1969 when 115,000 t of fish were landed (Wadell and Ware 1995). By 1979 landings were only 9,000 t.

Conclusion

Officially reported statistics currently account for around 70% of the actual fishery catches from BC waters (including discards). Thus, in the earlier time periods (e.g., 1950s), the catches missing from official statistics amounted to around 277,000 t·year⁻¹, while in recent years (i.e., 2000s) this has declined to just under 60,000 t·year⁻¹ (Figure 3a). Such volumes are likely sufficient to alter population dynamics

in predictive fisheries and ecosystem models and introduce a bias in management indices. In particular, retrospective methods requiring long time series, such as cohort analysis and model fitting, are likely to be affected, since the rate of misreporting was significantly higher in past decades. During the 1950s to 1970s, less than 50% of total extractions were recorded by FAO. In the 1980s and 1990s only 60% of removals were documented. Statistics reported by Canada to FAO are therefore inconsistent in trends as well as volumes, and should be considered a lower bound of fisheries catch and unreliable for ecological modelling. Finally, while non-commercial fisheries account for only a small component of total catches, subsistence and recreational fisheries need more comprehensive accounting and reporting in official statistics provided to the national and international community, as do discards, given the predominance of ecosystem considerations in fisheries and ocean management.

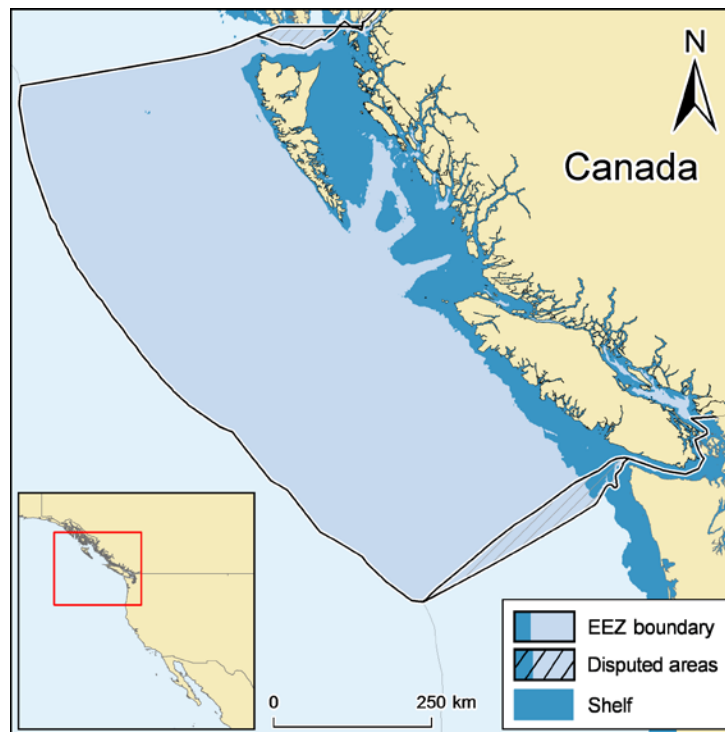


Figure 1: Map of Canada west coast with Exclusive Economic Zone (EEZ)

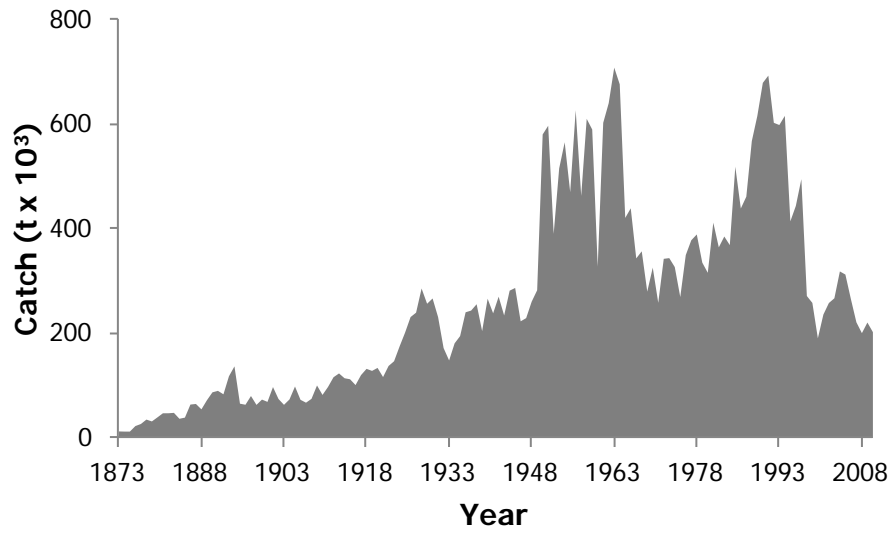


Figure 2. Total estimated catches from British Columbia waters, Canada, between 1873 and 2010.

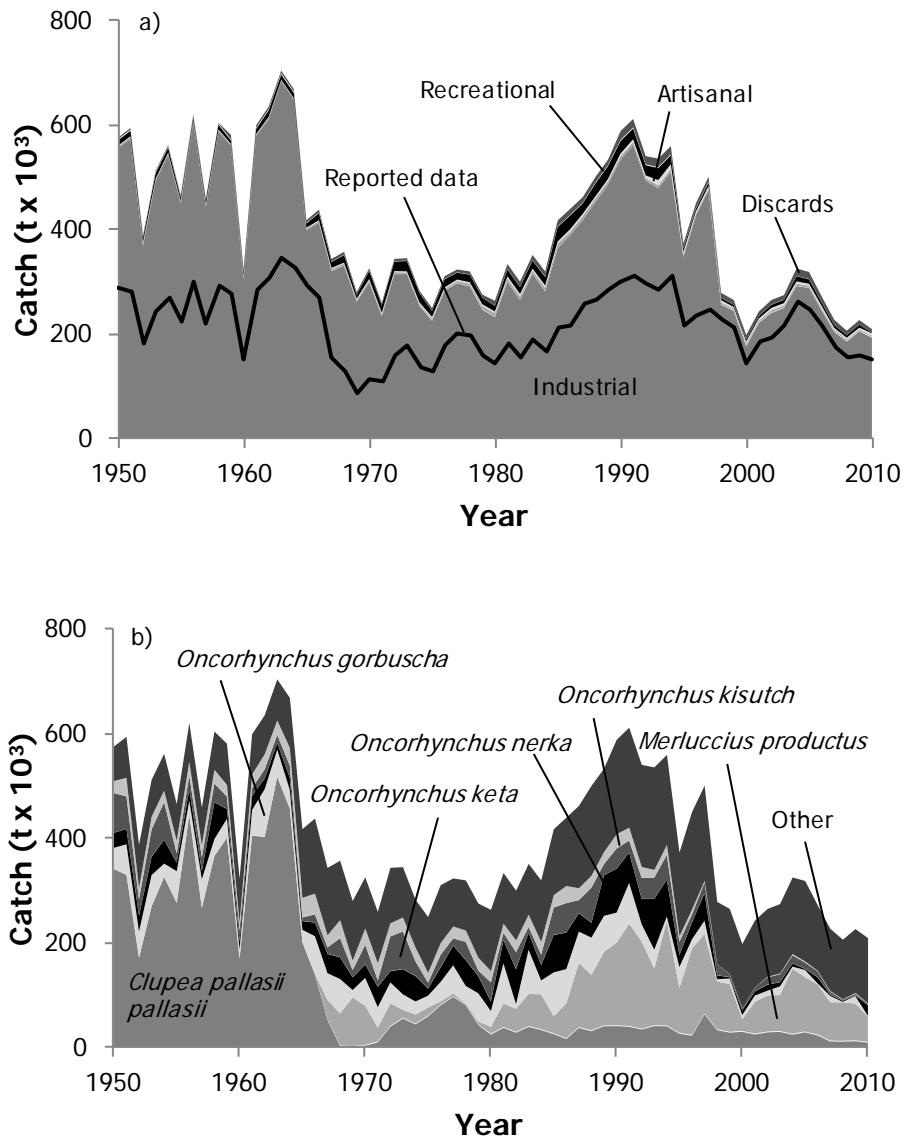


Figure 3: Total reconstructed catch by Canada in its Pacific Coast EEZ, 1950-2010, a) by sector, with reported landings overlaid as line graph. Note the predominance of the industrial sector; and b) by major taxa. 'Other' represents 41 additional taxonomic categories.

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Appendix Table A1. Total reconstructed catch vs. FAO landings (in tonnes) for the western Canada EEZ (British Columbia coast), 1950-2010, by sector.

Year	Reported (FAO and National)	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	287,800	574,000	555,000	3,900	1,390	10,100	3,080
1951	279,400	593,000	574,000	4,200	1,180	10,510	3,080
1952	181,901	386,000	369,000	4,900	1,470	8,210	2,550
1953	242,801	510,000	492,000	3,400	1,250	10,110	2,960
1954	269,301	560,000	543,000	3,500	1,070	9,740	2,870
1955	221,701	464,000	450,000	3,800	1,170	6,450	2,580
1956	299,501	619,000	605,000	3,900	1,080	6,070	3,440
1957	219,301	457,000	443,000	4,000	1,150	7,230	1,540
1958	293,101	603,000	588,000	3,000	1,160	9,020	1,490
1959	277,101	579,000	560,000	3,100	1,090	6,180	8,610
1960	149,801	321,000	305,000	4,100	1,020	6,960	4,410
1961	284,501	597,000	579,000	3,200	1,340	9,380	4,770
1962	305,901	634,000	611,000	3,700	1,290	12,280	5,090
1963	346,501	703,000	684,000	2,900	1,510	9,780	4,760
1964	327,001	667,000	649,000	2,400	1,260	9,690	4,800
1965	291,501	416,000	398,000	3,400	1,180	8,110	4,860
1966	269,501	436,000	412,000	3,800	1,190	13,490	5,460
1967	155,101	342,000	320,000	4,000	990	11,070	5,220
1968	128,001	355,000	330,000	4,100	1,210	14,250	5,570
1969	85,301	278,000	262,000	3,300	1,180	7,410	4,770
1970	113,901	324,000	299,000	3,600	1,430	15,310	4,330
1971	109,801	257,000	234,000	3,400	1,390	14,210	4,140
1972	158,001	342,000	314,000	3,600	1,360	18,030	4,410
1973	178,601	343,000	314,000	2,600	1,590	19,860	4,600
1974	137,416	281,000	254,000	3,250	1,850	17,590	4,380
1975	129,901	248,000	225,000	3,570	1,890	11,600	5,090
1976	177,819	309,000	283,000	3,350	1,880	15,110	5,510
1977	201,485	322,000	297,000	3,940	2,180	13,050	5,590
1978	197,939	318,000	291,000	4,780	1,950	14,470	5,580
1979	157,690	273,000	247,000	6,320	2,380	12,660	5,460
1980	141,620	261,000	232,000	6,600	2,350	10,610	9,480
1981	180,647	332,000	300,000	6,090	3,050	12,860	9,970
1982	156,160	298,000	265,000	5,930	3,870	13,200	9,750
1983	189,033	349,000	315,000	5,520	3,300	15,330	10,010
1984	166,220	318,000	282,000	6,390	3,480	16,200	10,060
1985	211,120	416,000	364,000	8,660	3,900	27,890	11,300
1986	216,907	438,000	389,000	6,860	4,160	26,060	11,620
1987	256,762	460,000	418,000	8,220	3,930	19,860	10,650
1988	266,806	499,000	452,000	8,010	3,470	24,620	10,840
1989	283,681	532,000	485,000	7,600	3,970	24,340	10,550
1990	299,602	587,000	533,000	7,590	4,920	23,870	16,920
1991	312,235	610,000	562,000	6,890	4,960	20,420	16,130
1992	295,024	539,000	493,000	5,700	4,910	19,350	15,720
1993	286,283	534,000	478,000	6,590	9,590	22,970	16,380
1994	309,848	558,000	510,000	6,370	9,300	16,720	15,880
1995	217,121	371,000	347,000	5,520	4,180	5,800	9,140
1996	235,074	449,000	427,000	3,930	3,930	5,080	8,990
1997	247,384	499,000	475,000	2,910	5,260	6,400	9,310
1998	226,014	277,000	256,000	3,500	3,880	4,140	9,320
1999	212,576	263,000	244,000	3,470	2,110	3,980	9,210
2000	143,072	196,000	177,000	3,990	2,650	3,770	8,650
2001	183,886	241,000	221,000	3,620	2,820	4,360	8,720
2002	194,416	263,000	240,000	4,040	3,890	5,940	8,860
2003	217,581	272,000	250,000	3,990	3,770	5,980	8,910
2004	260,323	323,000	292,000	4,060	3,590	9,950	14,030
2005	246,447	317,000	288,000	3,940	2,790	8,630	13,340
2006	214,905	270,000	245,000	3,240	3,600	6,220	11,730
2007	175,792	225,000	204,000	3,180	2,120	5,470	9,970
2008	155,341	204,000	186,000	3,020	1,900	4,630	8,870
2009	158,787	225,000	205,000	2,640	1,950	5,760	8,760
2010	150,861	207,000	193,000	2,160	3,690	1,260	6,860

Appendix Table A2. Total reconstructed catch (in tonnes) for the western Canada EEZ (British Columbia coast), 1950-2010, by major taxa. Other represents 41 additional taxonomic categories.

Year	<i>Clupea pallasii pallasii</i>	<i>Merluccius productus</i>	<i>Oncorhynchus gorbuscha</i>	<i>Oncorhynchus nerka</i>	<i>Oncorhynchus keta</i>	<i>Oncorhynchus kisutch</i>	Other
1950	341,500		40,000	28,800	76,000	21,400	66,200
1951	330,300		58,000	29,100	62,500	34,000	78,600
1952	171,400		49,400	30,100	31,000	21,500	82,300
1953	269,600		59,500	34,500	52,700	22,900	70,700
1954	326,300		24,800	45,700	71,900	20,700	70,600
1955	276,400		60,200	16,200	17,500	23,300	70,100
1956	444,200		27,700	21,100	26,500	25,200	74,300
1957	267,100		54,200	15,400	25,900	22,700	71,800
1958	366,300		32,000	70,300	36,100	24,500	73,400
1959	401,400		35,900	18,500	23,500	20,900	79,100
1960	169,600		16,600	15,500	20,100	15,100	84,200
1961	405,400		49,100	26,600	14,500	25,000	77,000
1962	402,600		91,500	20,000	17,800	27,000	74,900
1963	517,600		52,500	12,400	15,200	25,900	78,900
1964	456,800		36,000	23,000	23,500	31,900	96,000
1965	201,400		22,600	16,500	6,700	37,100	131,400
1966	139,600		72,200	25,900	15,300	39,300	143,700
1967	53,000	36,700	51,000	37,000	12,100	23,000	128,900
1968	2,900	61,400	65,400	41,500	36,300	34,200	113,700
1969	2,000	92,600	13,700	24,400	13,300	18,000	114,200
1970	3,900	75,000	52,900	25,800	37,100	31,200	97,800
1971	10,000	26,700	38,900	38,900	12,100	32,600	98,200
1972	40,000	43,400	39,600	21,500	66,300	24,800	106,100
1973	55,600	15,100	29,400	48,000	72,000	26,500	96,400
1974	44,700	17,100	24,700	48,600	27,800	26,500	91,400
1975	59,600	15,700	22,300	13,400	10,800	19,000	106,800
1976	81,100	6,000	36,900	27,700	23,900	22,300	110,800
1977	97,200	5,200	53,500	37,800	13,300	22,500	92,000
1978	81,400	1,800	33,100	49,300	34,500	21,700	95,900
1979	43,500	5,100	53,600	32,700	10,400	24,400	103,800
1980	25,200	13,200	29,800	17,900	36,500	21,700	117,200
1981	38,000	45,000	76,500	44,700	13,500	17,300	97,000
1982	28,600	44,200	8,600	66,600	32,700	22,100	95,200
1983	39,800	61,500	84,500	32,300	10,800	23,200	97,300
1984	33,700	67,100	26,000	29,300	19,700	24,100	117,700
1985	26,000	32,700	83,600	71,600	52,600	23,300	125,900
1986	16,500	67,100	65,100	70,000	56,100	32,200	130,900
1987	37,800	123,000	59,900	35,200	24,700	22,000	157,800
1988	31,600	106,400	71,100	28,200	67,200	22,200	172,000
1989	41,000	141,000	68,900	78,000	21,000	22,300	159,700
1990	41,300	158,300	57,500	84,300	38,200	26,600	180,600
1991	40,000	196,200	77,800	58,100	22,800	23,600	191,500
1992	34,900	167,000	32,800	48,300	40,200	20,200	195,500
1993	41,300	108,900	35,600	97,300	40,700	13,800	196,300
1994	40,900	200,800	7,900	70,600	47,100	18,400	172,200
1995	26,800	85,900	40,000	22,400	25,500	10,400	160,200
1996	23,000	165,400	17,400	32,200	15,000	9,300	186,400
1997	64,000	152,400	25,300	52,300	20,400	2,700	182,000
1998	33,500	91,500	4,100	7,200	21,100	0	119,200
1999	28,800	91,700	10,100	2,300	5,400	100	124,800
2000	30,400	22,400	7,500	9,300	3,900	200	122,300
2001	25,200	61,000	11,500	7,800	6,800	600	128,000
2002	29,300	68,900	8,800	11,500	13,700	1,100	129,600
2003	30,300	69,100	16,200	7,800	14,700	1,500	132,800
2004	24,800	124,900	3,700	6,000	15,000	2,400	146,500
2005	29,400	104,200	13,300	2,100	11,600	2,000	154,100
2006	23,400	96,200	1,500	11,500	11,200	1,000	125,300
2007	12,000	73,400	11,600	2,400	5,200	1,400	119,200
2008	11,500	73,800	400	2,100	2,000	900	113,500
2009	12,300	70,700	13,800	1,100	2,800	1,700	122,100
2010	9,500	48,000	1,300	20,300	2,700	600	124,800