

Analysis of U.S. Oil Spillage

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Prepared by:

Dagmar Schmidt Etkin, PhD
Environmental Research Consulting
41 Croft Lane
Cortlandt Manor, NY 10567-1160



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Executive Summary

As shown in Figure A, total petroleum industry spillage has decreased consistently over the last 40 years. Seventy-seven percent less oil is spilling since the 1970s and 46% less since the previous decade.

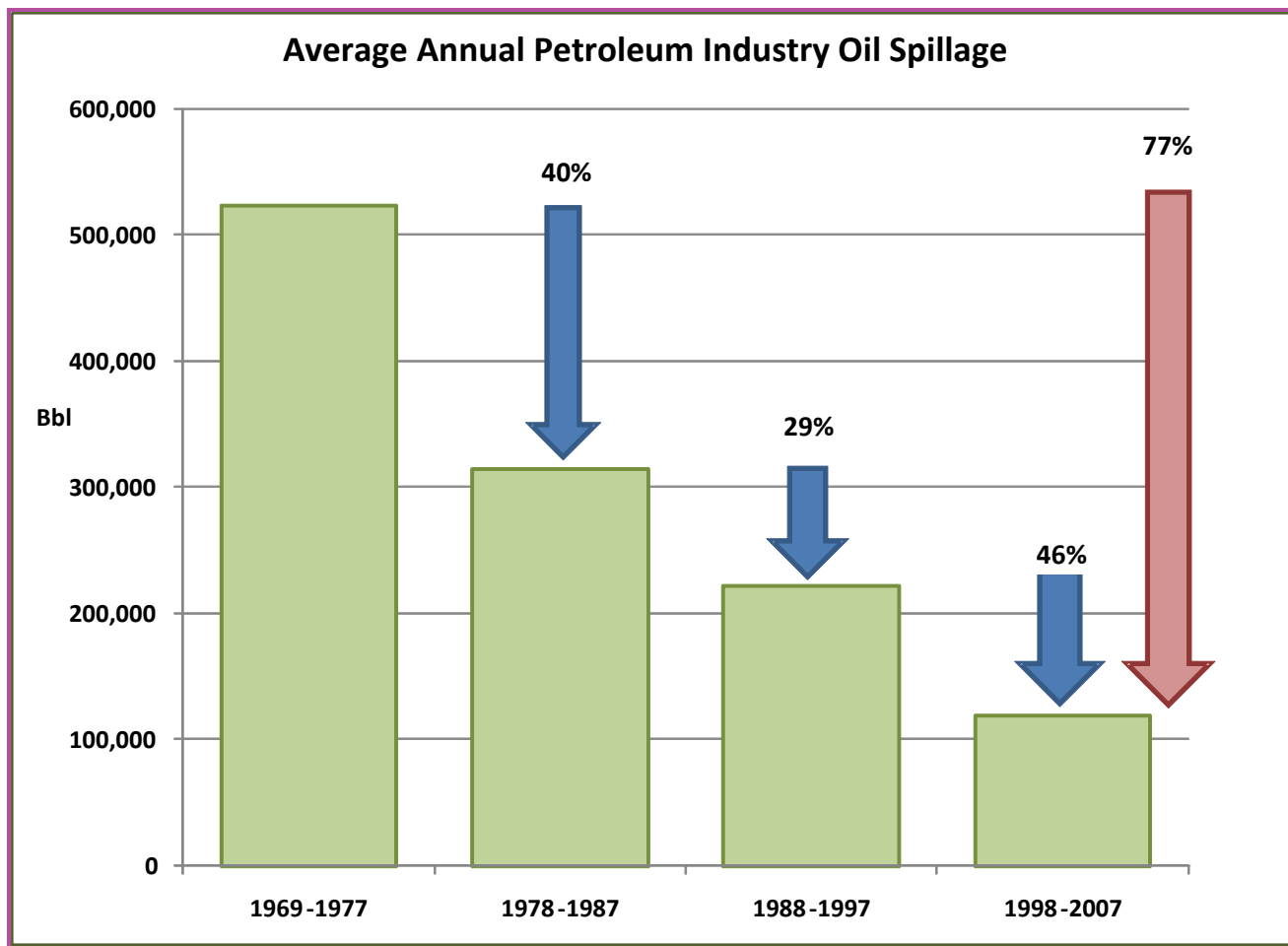


Figure A: Average Annual Oil Spillage from Petroleum Industry Sources by Decade

Average annual oil spillage from petroleum industry sources, including: spillage related to oil exploration and production platforms and offshore pipelines; spillage from coastal and inland pipelines, spillage from oil transport by tank vessels, railroads, and tanker trucks; spillage from oil refineries; and spillage at gas stations.

In the last decade, on average, 2.017 billion barrels of crude oil were produced domestically, and 4.082 billion barrels of crude oil and petroleum products were imported annually. *For each barrel of crude oil either domestically produced or imported from foreign sources, 0.00003 barrels spilled from all sources – of which 60.8%, or 0.00002 barrels, spilled from petroleum industry sources.*

In the last decade, an average of 7.3 billion barrels¹ of oil were “consumed” each year in the U.S. Oil consumption can be viewed as a measure of the amount of oil that is transported, stored, and handled each year. *In the last decade, for every barrel of oil “consumed” in the U.S., 0.000027 barrels² spilled from all sources and 0.000016 barrels spilled from petroleum industry sources.*

In the Upstream sector, oil spillage from offshore platforms has decreased by 30% from the previous decade and by 95% since the 1970s. Overall average annual oil spillage from offshore exploration and production

¹ Based on Energy Information Administration data.

² This is the equivalent of 3/1000th of an ounce for every gallon of oil consumed.

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activities has decreased by 61% from the previous decade and 87% from the 1970s. On the basis of unit production, oil spillage has decreased by 71% since the previous decade and 87% from the 1970s. Had the rate of spillage from 1969-1970 continued, an additional 516,000 barrels of oil would have spilled.

In the Marine sector, oil spillage from tankers has decreased by 91%, and from tank barges by 76% since the previous decade. Spillage from tank vessels (tankers and tank barges combined) per unit oil transported has decreased by 71% from the last decade.

In the Pipeline sector, oil spillage has decreased 35% since the previous decade, with even greater reductions in pipeline rights-of-way.

In the Refining sector, oil spillage from refineries has decreased by 19% from the last decade, and 27% when taken on the basis of per-unit oil processing or throughput.

In the Downstream sector, oil spillage from petroleum industry gas stations and truck stops has been reduced by nearly 48% from the previous decade.

For the last decade, production-related spillage was less than 0.9% of the amount released from natural seeps. Total spillage from all sources was less than 11% of the amount released in natural seeps. In other words, over nine times as much oil was released from natural seeps as was spilled from all sources.

Overall, petroleum industry-related spillage represented 60.8% of total spillage from all sources (including non-industry sources related to oil consumption and usage) during the last decade. Over the last decade, total petroleum industry spillage was 10.6% of the amount released in natural seeps. Natural seeps released nearly nine times as much oil as the total of petroleum industry spillage.

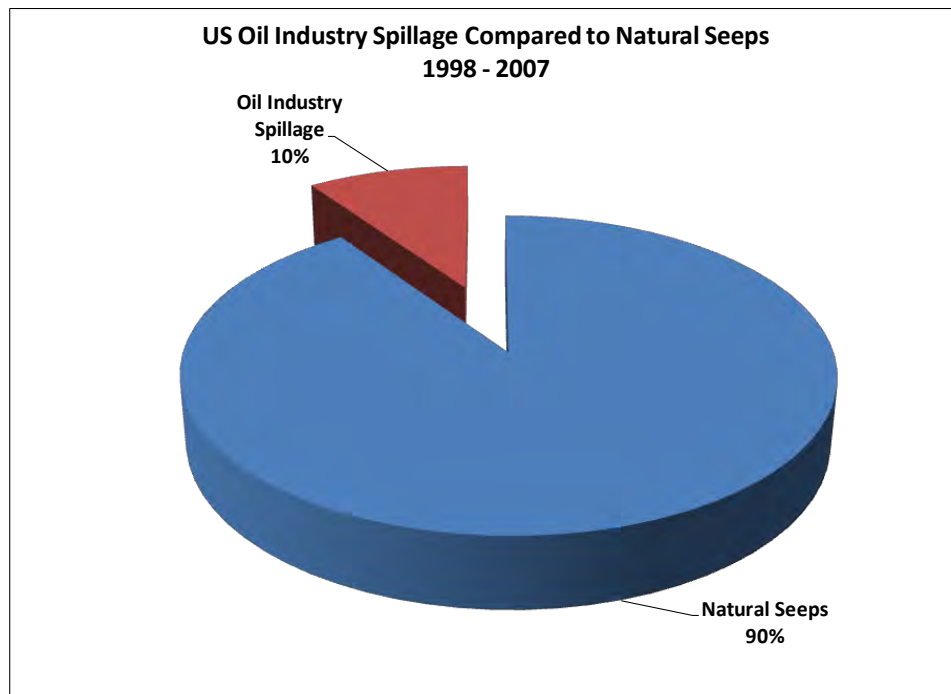


Figure B: U.S. Oil Industry Spillage Compared to Natural Seeps

Introduction

Public awareness and concern about oil spills has been high over the last two decades. Periodically, public distress heightens with media coverage of incidents in the U.S., such as the *M/V Cosco Busan* spill³ in San Francisco Bay, or even with events outside the U.S., such as the Prestige spill off the coast of France. Potential plans for opening U.S. offshore and Arctic regions for oil exploration and production have again caused great concern. The best approach to rationally evaluating the merits of these concerns is to look at the facts.

Having just passed the fortieth anniversary of the Santa Barbara well blowout that was a major impetus for the environmental movement in the U.S., and just after the twentieth anniversary of the *Exxon Valdez* spill on 24 March 2009, there is a great deal of *good news* with regard to oil spills. Despite the publicity of the recent *Cosco Busan* spill, spill rates are down across the board. The implementation of prevention-oriented regulations and voluntary industry initiatives has combined to reduce spillage dramatically. *But these facts do not often reach the level of public awareness.*

The analyses in this report examine oil spillage and other oil inputs into U.S. waters from all angles – from the spills of greatest public concern, those from the oil industry’s tankers and offshore production platforms, to the spills attributable to public consumers – from leaking automotive oils, which input more than oil into U.S. waterways annually than the *Exxon Valdez* spill did. The spillage from all industry and consumer sources is put into perspective with natural seepage of oil in offshore and coastal waters, which adds the equivalent of 11 Santa Barbara well blowouts worth of oil to U.S. marine waters annually. Legally-permitted operational oil inputs from refinery effluents and offshore produced water are also analyzed.

These data analyses will provide factual scientific perspectives for rational decision-making and public education.

Note: Key terms of reference and definitions of “waterways”, as applied in this report, are presented in the Appendices.

Note: Table data are rounded to produce whole figures; any apparent arithmetic errors in sums are the result of such rounding.

³ The container vessel *Cosco Busan* spilled bunker fuel after a collision with a bridge. This vessel carried oil as fuel and for operations only. It was not an oil tanker and not a petroleum industry source. This spill appears under the “consumption of oil” as a non-tank vessel in these analyses.

Natural Oil in the Environment: Seeps

The U.S. has proved oil reserves⁴ of about 21.32 to 30.46 billion barrels.⁵ Some of this crude oil is naturally discharged each year from “natural seeps”, natural springs from which liquid and gaseous hydrocarbons (hydrogen-carbon compounds) leak out of the ground. Oil seeps are fed by natural underground accumulations of oil and natural gas (U.S. Geological Service).⁶ Oil from U.S. sub-marine (and inland subterranean) oil reservoirs comes to the surface each year, as it has for millions of years due to geological processes (Figure 1).

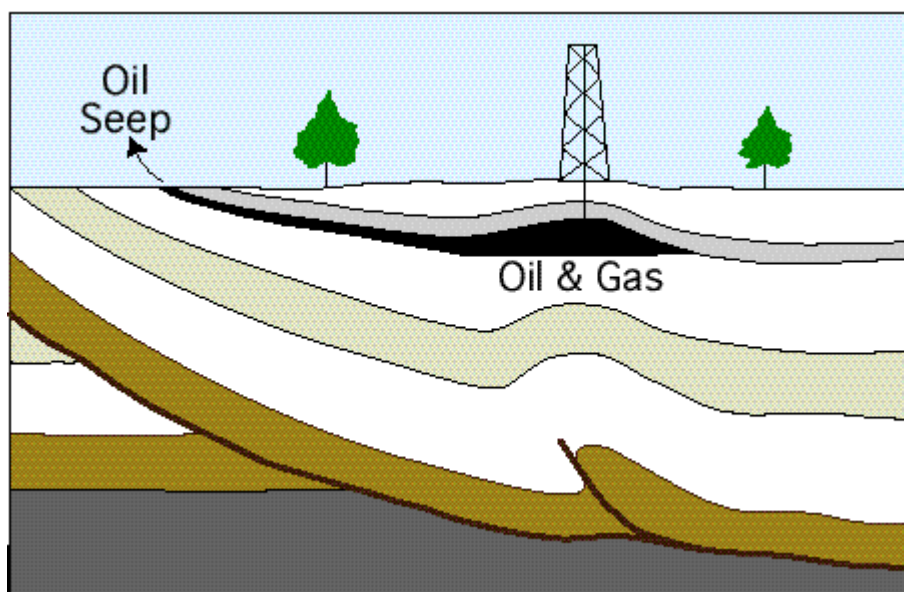


Figure 1: Seepage of oil to surface

Oil and gas seeps are natural springs where liquid and gaseous hydrocarbons (hydrogen-carbon compounds) leak out of the ground. Whereas freshwater springs are fed by underground pools of water, oil and gas seeps are fed by natural underground accumulations of oil and natural gas (U.S. Geological Service diagram).

Natural discharges of petroleum from submarine seeps have been recorded throughout history going back to the writings of Herodotus⁷ and Marco Polo.⁸ Archaeological studies have shown that products of oil seeps were used by Native American groups living in California - including the Yokuts, Chumash, Achomawi, and Maidu tribes - well before the arrival of European settlers.⁹

In recent times, the locations of natural seeps have been used for exploration purposes to determine feasible locations for oil extraction. The magnitude of natural seeps is such that, according to prominent geologists, Kvenvolden and Cooper (2003), “*natural oil seeps may be the single most important source of oil that enters the ocean, exceeding each of the various sources of crude oil that enters the ocean through its exploitation by humankind.*” Worldwide, natural seepage totals from about 4.2 million barrels to as much as 14 million barrels annually. In U.S. waters, natural seeps are also the largest source of oil inputs.

⁴ Proved oil reserves are estimated quantities that analysis of geologic and engineering data demonstrates with reasonable certainty are recoverable under existing economic and operating conditions.

⁵ BP Statistical Review 2008 estimates 30.46 billion barrels (for year end 2007); Oil & Gas Journal estimates 21.317 billion barrels (1 January 2009).

⁶ <http://geomaps.wr.usgs.gov/seeps>.

⁷ Lees 1950.

⁸ Levorson 1954.

⁹ Hodgson 1987.

Each year an estimated 1,123,000 barrels of crude oil¹⁰ seeps from geologic formations below the seafloor into U.S. waters, mainly in the Gulf of Mexico and off southern California. This estimate is detailed in Table 1.

Table 1: Natural Seepage of Oil in U.S. Waters			
U.S. Region	Estimated Annual Barrels of Seepage (NRC 2003)		
	Low	High	"Best Estimate"
Alaska	2,520	8,400	2,800
Pacific Ocean (South California)	119,000	140,000	140,000
Gulf of Mexico	560,000	1,400,000	980,000
Total	681,520	1,548,400	1,122,800

Figure 2 shows reported oil seeps in the Gulf of Mexico. Figures 3 and 4 show reported oil seeps off southern California. Figure 5 shows reported oil seeps off Alaska.

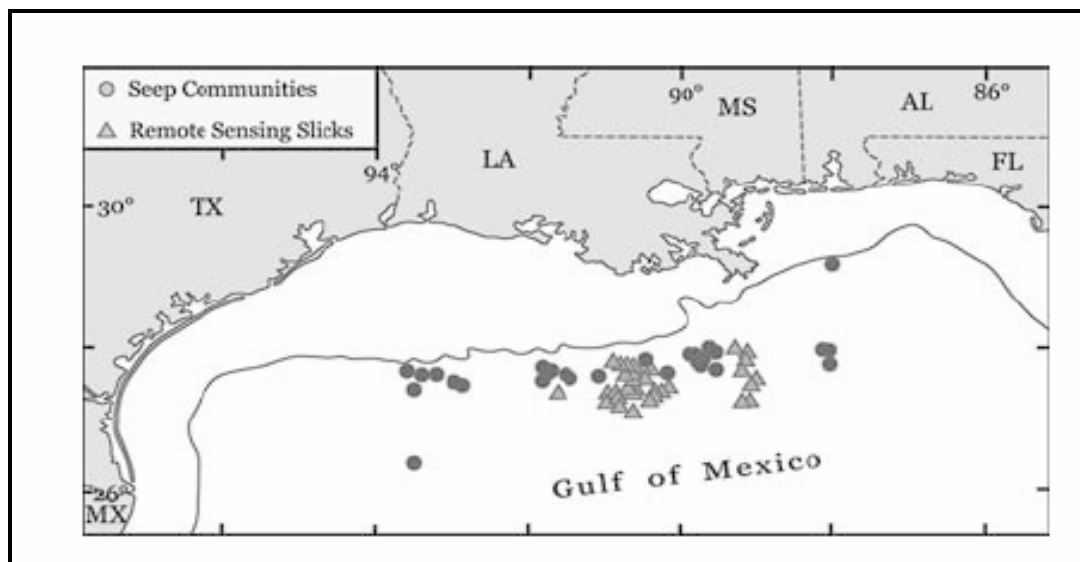


Figure 2: Reported Oil Seeps in the Gulf of Mexico¹¹

A number of natural seeps have been identified in the Gulf of Mexico off of Louisiana and Texas.

While regional assessments of natural seepage have been conducted in some locations, particularly nearshore in California,¹² the Indian Ocean,¹³ and in the U.S. Gulf of Mexico,¹⁴ the most comprehensive worldwide assessment of natural seepage is still the study conducted by Wilson et al. (1974). Even the two more recent international assessments of oil inputs into the sea¹⁵ relied heavily on the estimates of natural oil seepage conducted by Wilson et al. (1974), having found no more recent comprehensive studies.

Assessments for natural oil seepage involve few actual measurements, though certain seep locations along the southern California Pacific coast have been studied to some extent. Natural seep studies have also included identification of hydrothermally-sourced hydrocarbons (especially polycyclic aromatic hydrocarbons) in sediments. The most well-known studies have relied on estimation methodologies based on field data, observations, and various basic assumptions.

¹⁰ Estimates based on analyses in NRC 2003.

¹¹ Kvenvolden and Cooper 2003.

¹² Allen et al. 1970; Hornafius et al. 1999; Kvenvolden and Simoneit. 1990.

¹³ Chernova et al. 2001; Gupta et al. 1980; Venkatesan et al. 2003.

¹⁴ MacDonald, 1998.

¹⁵ GESAMP 2007; NRC 2003.

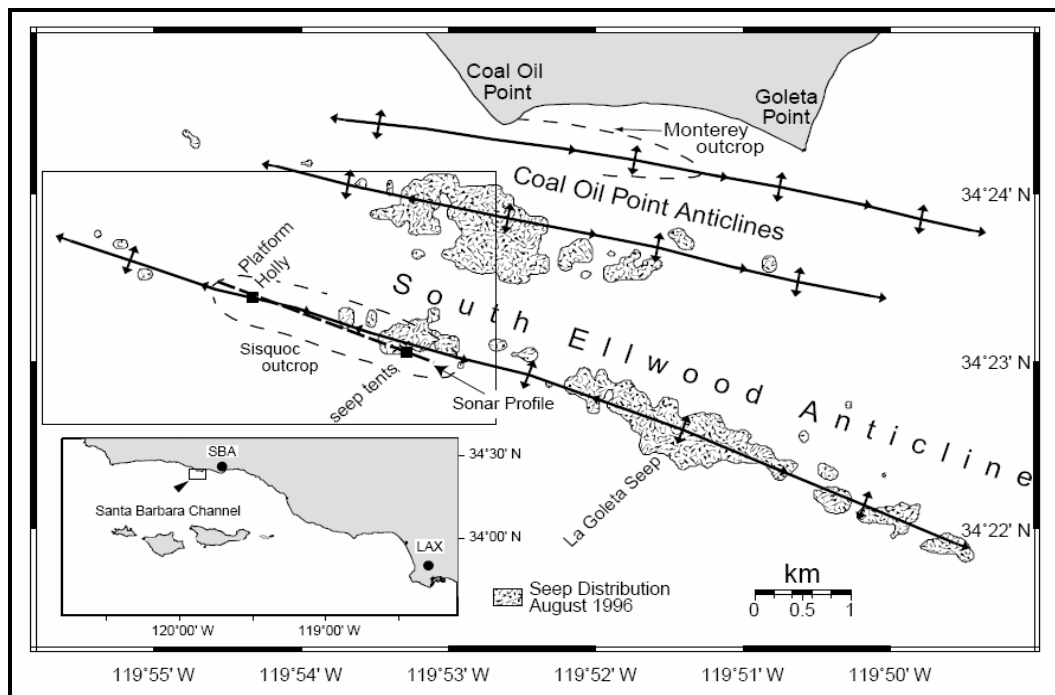


Figure 3: Oil seeps off Santa Barbara, California¹⁶

Perhaps the most studied oil seeps in the world are those off the coast of Santa Barbara, California.

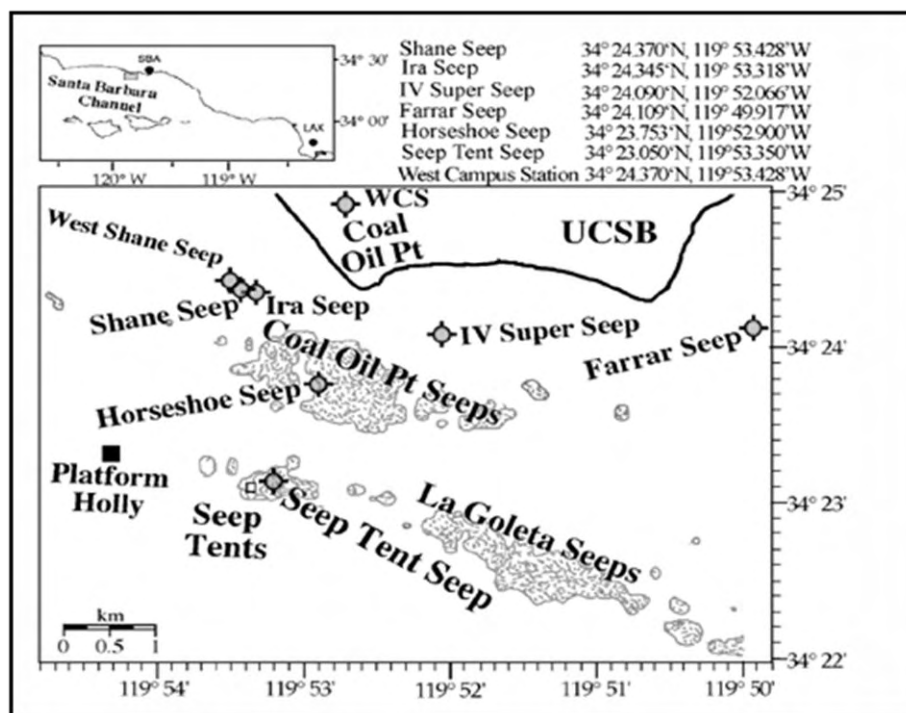


Figure 4: Detail of oil seeps off Coal Oil Point, California¹⁷

The oil seeps off of Coal Point have been the source of many oil slicks and continuous oiling and tar ball deposition on California shorelines.

¹⁶ Quigley et al. 1999.

¹⁷ Leifer et al. 2003.

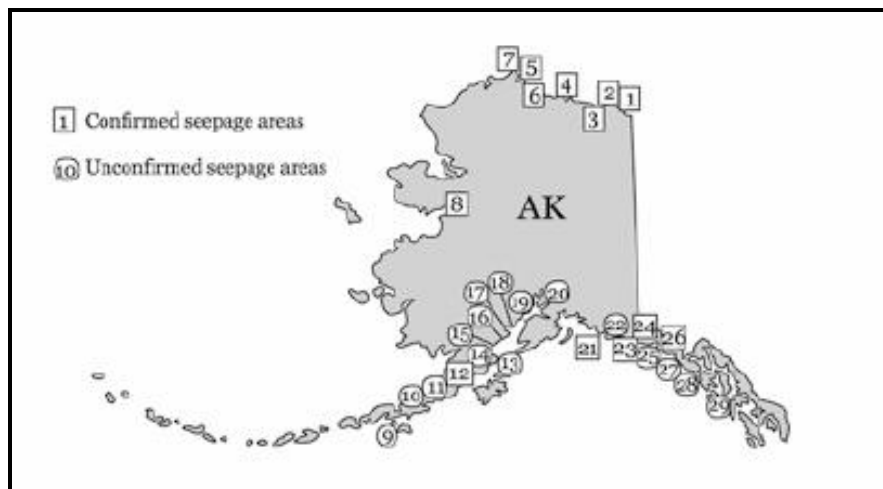


Figure 5: Oil seepage areas around Alaska¹⁸

Oil seeps in and around Alaska have been reported.

Wilson et al. (1974) estimated that total *worldwide* natural seepage ranged from 1.4 to 42.0 x 10⁶ barrels annually, with the best estimate being 0.6 x 10⁶ tonnes 4.2 x 10⁶ barrels, based largely on observations of seepage rates off California and western Canada. Estimates of the areas of ocean with natural seeps are shown in the table below. Estimates of seepage rates by ocean are shown in Tables 2 and 3.

Table 2: Seepage-prone Areas of the World's Oceans¹⁹			
Ocean	Number of 1,000-Square Kilometers		
	High-Potential Seepage	Moderate-Potential Seepage	Low-Potential Seepage
Pacific	1,943	9,285	4,244
Atlantic	1,303	10,363	11,248
Indian	496	7,928	3,010
Arctic	0	5,636	2,456
Southern	0	486	458
Total	3,741	33,697	21,416

Table 3: Summary of World Seepage Rates²⁰			
Ocean	Estimated Oil Seepage (bbl per year) ²¹		
	Case I, P ₁₆ ²²	Case II, P _{1.0} ²³	Case III, P _{0.3} ²⁴
Pacific	19,810,000	1,883,000	482,300
Atlantic	14,420,000	1,372,000	352,800
Indian	6,510,000	619,500	159,600
Arctic	1,498,000	16,100	36,400
Southern	131,600	121,800	3,157
Total	42,369,600	4,012,400	1,034,257

Wilson et al. (1974) based their estimates on five basic assumptions:

- More seeps exist in offshore basins than have been observed;

¹⁸ Based on Becker and Manen 1988, as presented in Kvenvolden and Cooper 2003.

¹⁹ Based on Wilson et al. 1974

²⁰ Based on Wilson et al. 1974

²¹ Three probability levels were examined.

²² Probability percentile 16 with a worldwide estimate of 42 x 10⁶ bbl annually, likely a high estimate.

²³ Probability percentile 1.0 with a worldwide estimate of 4.2 x 10⁶ bbl annually

²⁴ Probability percentile 0.3 with a worldwide estimate of 1.4 x 10⁶ bbl annually, likely a minimal estimate.

- Factors that determine seepage rate in a particular area are related to general geological structural type and the stage of sedimentary basin evolution;
- Seepage is dependent on the area of exposed rock rather than on rock volume;
- Most marine seeps are clustered at continental margins; and
- Seepage rates are log-normally distributed.

Kvenvolden and Harbaugh (1983) concluded that the minimal worldwide estimate (1.4×10^6 barrels annually) from the Wilson et al. (1974) study is most likely to be correct and that an error margin of an order of magnitude above and below this value should be applied (i.e., 0.14×10^6 to 14.0×10^6 barrels annually). Their theory was based on a reduced value for the assumed and known oil resources that would be available for seepage.

NRC 2003 presented a worldwide estimate of natural seepage into the marine environment of between 0.14×10^6 to 14.0×10^6 barrels annually, with a “best estimate” of 4.2 million barrels. These estimates²⁵ were made based on the Kvenvolden and Harbaugh (1983) reassessment of the estimates made by Wilson et al. (1974), as well as an acceptance of the original estimates of Wilson et al. (1974), resulting from a “new appreciation” for the magnitude of natural seepage, particularly in the Gulf of Mexico. Relying largely on the Wilson et al. (1974) and Kvenvolden and Harbaugh (1983) studies, the 2007 GESAMP also included an estimate of the range of natural seepage as 0.14×10^6 to 14.0×10^6 barrels annually.

With the technology available today a more comprehensive assessment of natural seepage, or at least a verification of the Wilson et al. (1974) study or the Kvenvolden and Harbaugh (1983) re-evaluation of that study, is theoretically possible. Due to the considerable resources that might be required to conduct this on a global or even regional scale, the most likely funding would, however, come from industry sources interested in exploration of any areas that contain potentially high levels of oil rather than for the purpose of assessing impacts to the world’s oceans. Figure 6 shows areas of oil seepage potential in and around the U.S.

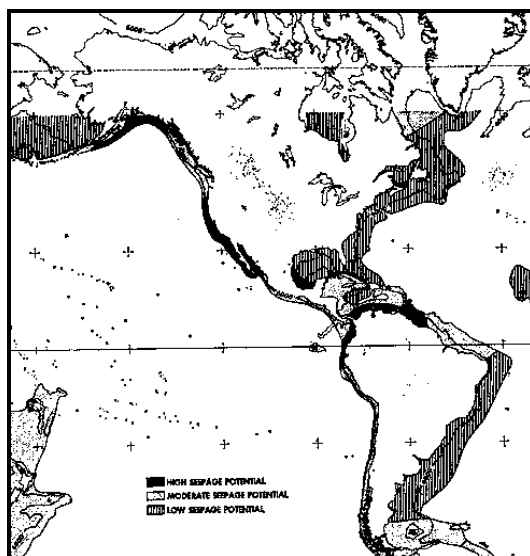


Figure 6: Oil Seepage Potential²⁶

This figure shows the potential for natural oil seepage in and around U.S. waters.

²⁵ The Oil in the Sea III natural seep estimates were made by Dr. Keith Kvenvolden, one of the co-authors of the Kvenvolden and Harbaugh (1983) reassessment.

²⁶ Wilson, R.D., P.H. Monaghan, A. Osanik, L.C. Price, and M.A. Rogers. 1974. Natural marine oil seepage. *Science* Vol. 184 (4,139): pp. 857 – 865.

Spillage from Offshore Oil Exploration and Production Activities

Areas in which natural seeps occur have provided opportunities for oil exploration and production. During the last decade (1998 – 2007), an estimated 1,273 barrels of crude oil spilled from offshore platforms into federal and state waters of the U.S. each year. An additional 2,614 bbl spilled annually from offshore pipelines, for a total of 3,887 bbl per year. This represents a nearly 66 percent reduction in spillage from the previous decade, and an 87 percent reduction in spillage since the 1970s.²⁷

Spills from Platforms

Oil spillage from offshore platforms in U.S. Outer Continental Shelf (OCS) and state waters is shown in Figure 7 for 1969 – 2007 and Figure 8 for the last decade.

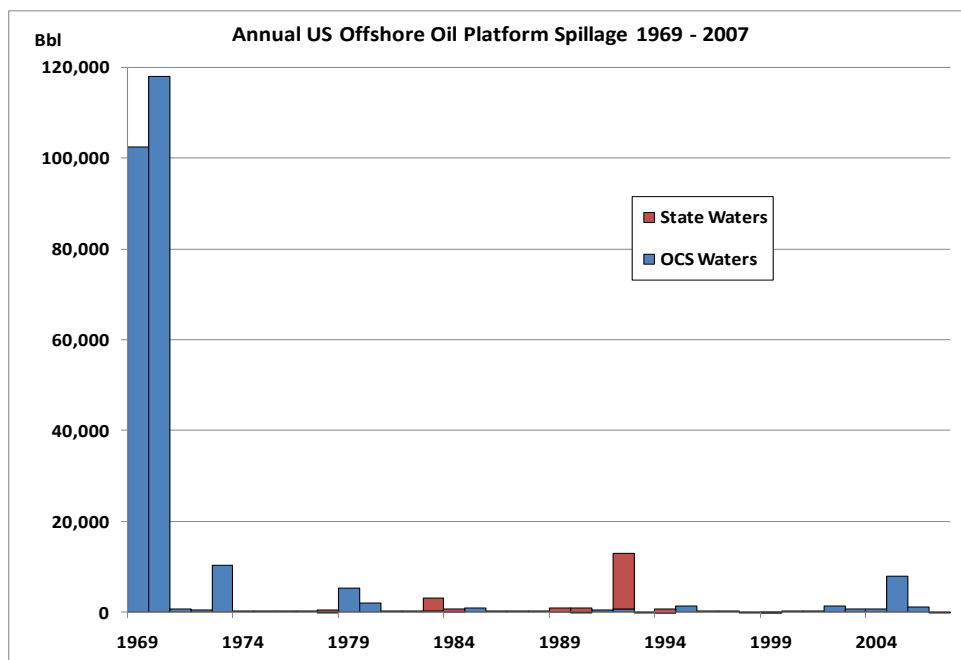


Figure 7: Annual U.S. Offshore Oil Platform Spillage 1969-2007

This graph of oil spillage from offshore oil platforms shows spillage in both state and OCS waters. Since 1971 spillage from platforms has been very low.

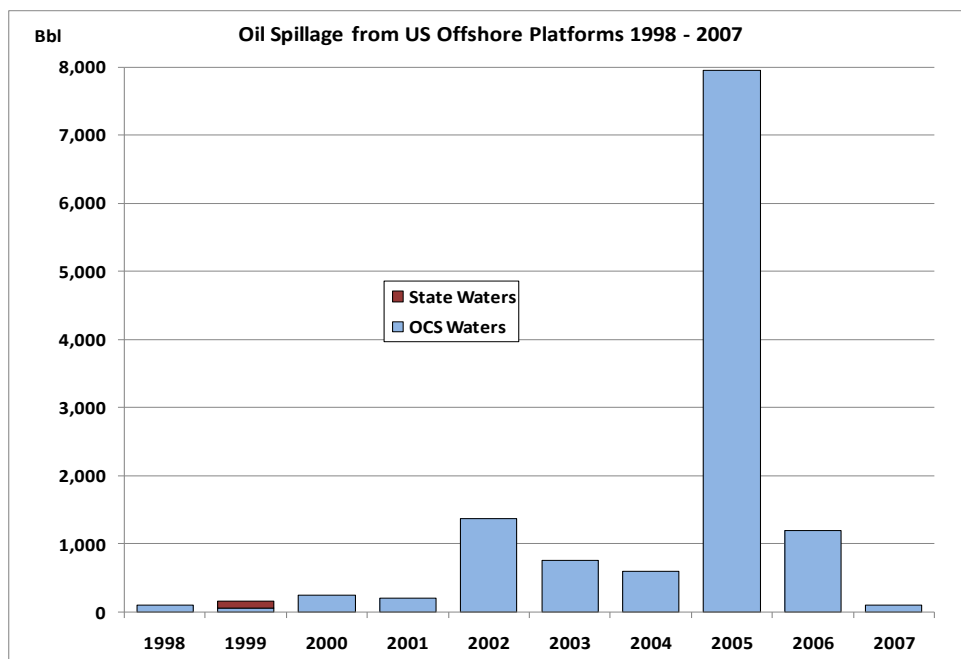


Figure 8: Annual Oil Spillage from U.S. Offshore Platforms 1998 – 2007

In 2005, there was some platform spillage associated with hurricane damage. Note that even the 2005 spill volumes are only 8 percent of the volumes of 1969 and 1970.

²⁷ 1969 – 1977.

Average platform spillage by decade is shown in Figure 9. There has been a 30% reduction in annual spillage since the last decade and a 95% reduction since the 1970s.

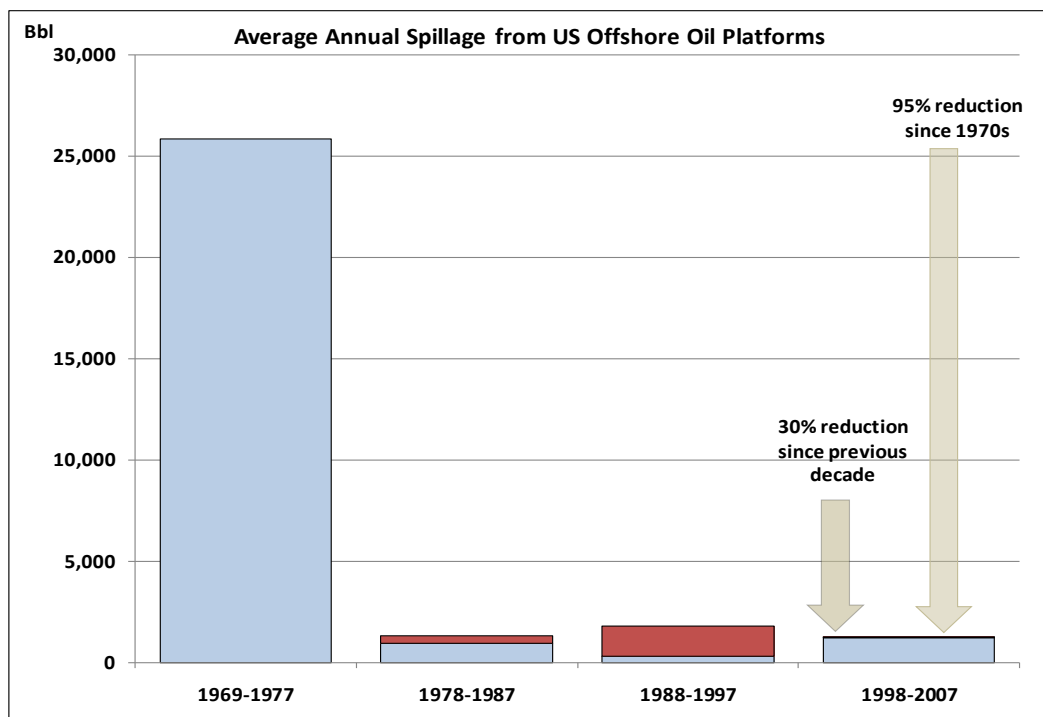


Figure 9: Annual Average Spillage from U.S. Offshore Platforms – Reductions by Decade

Average annual spillage from offshore platforms has reduced significantly. There is a 95% reduction since the 1970s and a 30% reduction since the previous decade.

Table 4 shows the numbers of incidents and volume spilled from offshore oil platforms by year. Table 5 gives the same annual results broken down by oil type. Table 6 gives the annual results broken down by location. The data are dominated by large crude spills in 1969 and 1970.

Table 4: Oil Spills from U.S. Offshore Oil Platforms				
Year	Number (1 bbl or more)	OCS (bbl)	State Waters (bbl)	Total (bbl)
1969	2	102,500	0	102,500
1970	2	118,095	0	118,095
1971	121	736	0	736
1972	86	418	0	418
1973	77	10,289	0	10,289
1974	38	267	0	267
1975	29	118	0	118
1976	25	129	0	129
1977	29	169	0	169
1978	26	104	524	628
1979	38	5,168	0	5,168
1980	29	2,042	0	2,042
1981	26	296	0	296
1982	26	115	0	115
1983	40	421	2,810	3,225
1984	25	126	690	816
1985	36	876	0	876
1986	20	141	0	141
1987	20	134	0	134
1988	15	252	0	252
1989	14	125	810	935
1990	17	65	953	1,018
1991	15	414	0	414

Table 4: Oil Spills from U.S. Offshore Oil Platforms

Year	Number (1 bbl or more)	OCS (bbl)	State Waters (bbl)	Total (bbl)
1992	16	746	12,262	13,008
1993	6	35	0	35
1994	14	0	740	740
1995	15	1,390	0	1,390
1996	17	231	0	231
1997	9	114	0	114
1998	15	108	0	108
1999	9	56	107	163
2000	10	252	0	252
2001	11	203	0	203
2002	23	1,377	0	1,377
2003	9	761	0	761
2004	18	603	0	603
2005	57	7,963	0	7,963
2006	32	1,193	0	1,193
2007	18	109	0	109
Total	1,035	258,139	18,896	277,029
Average 1969-1977	45	25,858	0	25,858
Average 1978-1987	29	942	402	1,344
Average 1988-1997	14	337	1,477	1,814
Average 1998-2007	20	1,262	11	1,273
Average 1969-2007	27	6,619	485	7,103

Table 5: Oil Spillage (bbl) from U.S. Offshore Oil Platforms by Oil Type

Year	Crude	Diesel	Condensate	Other Oil	Total Platform
1969	102,500	0	0	0	102,500
1970	118,095	0	0	0	118,095
1971	670	13	15	38	736
1972	379	10	6	23	418
1973	10,260	9	0	20	10,289
1974	258	5	0	4	267
1975	108	7	0	3	118
1976	115	3	3	8	129
1977	154	11	4	0	169
1978	620	3	5	0	628
1979	146	1,513	3,500	9	5,168
1980	1,529	504	4	5	2,042
1981	217	39	0	40	296
1982	52	17	3	43	115
1983	3,087	105	11	22	3,225
1984	810	3	0	3	816
1985	90	755	0	32	876
1986	48	0	0	93	141
1987	58	8	0	68	134
1988	86	6	10	151	252
1989	607	297	0	31	935
1990	574	27	413	4	1,018
1991	393	8	2	11	414
1992	13,007	0	1	0	13,008
1993	32	3	0	0	35
1994	87	0	602	51	740
1995	876	4	510	0	1,390
1996	121	17	22	72	231
1997	44	29	20	22	114
1998	60	29	0	19	108

Table 5: Oil Spillage (bbl) from U.S. Offshore Oil Platforms by Oil Type

Year	Crude	Diesel	Condensate	Other Oil	Total Platform
1999	31	107	19	5	163
2000	244	2	3	3	252
2001	153	45	0	4	203
2002	74	1,273	3	27	1,377
2003	50	707	1	3	761
2004	449	114	22	18	603
2005	3,618	3,655	599	91	7,963
2006	369	65	734	24	1,193
2007	80	2	6	21	109
Total	260,148	9,395	6,518	968	277,029
Average 1969-1977	25,838	6	3	11	25,858
Average 1978-1987	666	295	352	32	1,344
Average 1988-1997	1,583	39	158	34	1,814
Average 1998-2007	513	600	139	22	1,273
Average 1969-2007	6,671	241	167	25	7,103

Table 6: Oil Spillage (bbl) from U.S. Offshore Oil Platforms by Region

Year	Gulf of Mexico	Pacific	Alaska	Total
1969	2,500	100,000	0	102,500
1970	118,095	0	0	118,095
1971	736	0	0	736
1972	418	0	0	418
1973	10,289	0	0	10,289
1974	267	0	0	267
1975	118	0	0	118
1976	129	0	0	129
1977	165	4	0	169
1978	108	524	0	632
1979	5,168	0	0	5,168
1980	2,037	5	0	2,042
1981	245	51	0	296
1982	93	3	20	116
1983	3,225	0	0	3,231
1984	782	34	0	816
1985	871	5	0	876
1986	130	11	0	141
1987	123	11	0	134
1988	247	0	0	247
1989	406	5	524	935
1990	1,017	1	0	1,018
1991	413	1	0	414
1992	13,008	0	0	13,008
1993	35	0	0	35
1994	729	11	0	740
1995	1,390	0	0	1,390
1996	226	5	0	231
1997	114	0	0	114
1998	105	0	4	109
1999	163	0	0	163
2000	252	0	0	252
2001	203	0	0	203
2002	1,377	0	0	1,377
2003	761	0	0	761
2004	603	0	0	603
2005	7,963	0	0	7,963

Table 6: Oil Spillage (bbl) from U.S. Offshore Oil Platforms by Region

Year	Gulf of Mexico	Pacific	Alaska	Total
2006	1,193	0	0	1,193
2007	109	0	0	109
Total	175,812	100,670	548	277,036
Average 1969-1977	14,746	11,112	0	25,858
Average 1978-1987	1,278	64	2	1,345
Average 1988-1997	1,759	2	52	1,813
Average 1998-2007	1,273	0	0	1,273
Average 1969-2007	4,508	2,581	14	7,104

Spills from Offshore Pipelines

Annual oil spillage from pipelines²⁸ connected to offshore platforms is shown in Figure 10 and Table 7.

Average annual spillage by decade is shown in Figure 11. There has been a 68% reduction in offshore pipeline spillage since the previous decade. Spillage by region and by oil type is shown in Tables 8 and 9. Nearly 85% of the spillage is crude oil. Of the total offshore pipeline spillage, 96% is in the Gulf of Mexico.

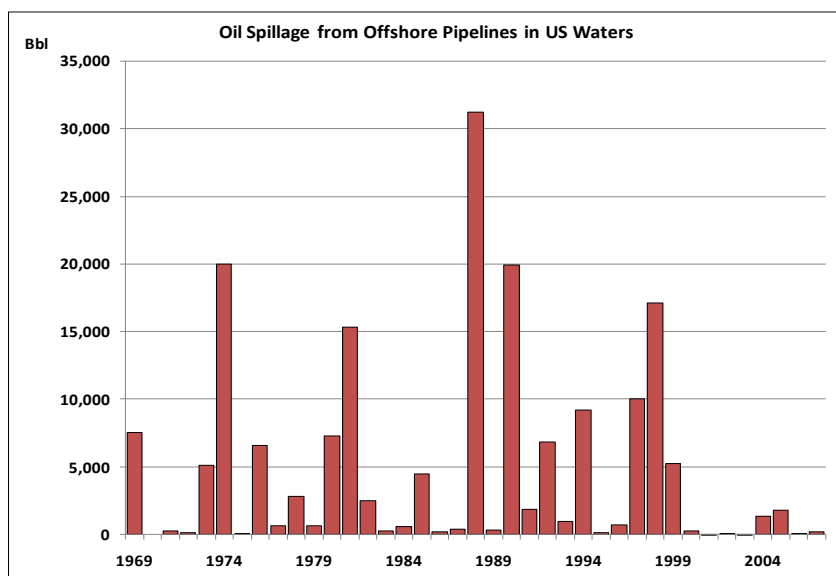


Figure 10: Annual Oil Spillage from Offshore Pipelines 1969 – 2007.

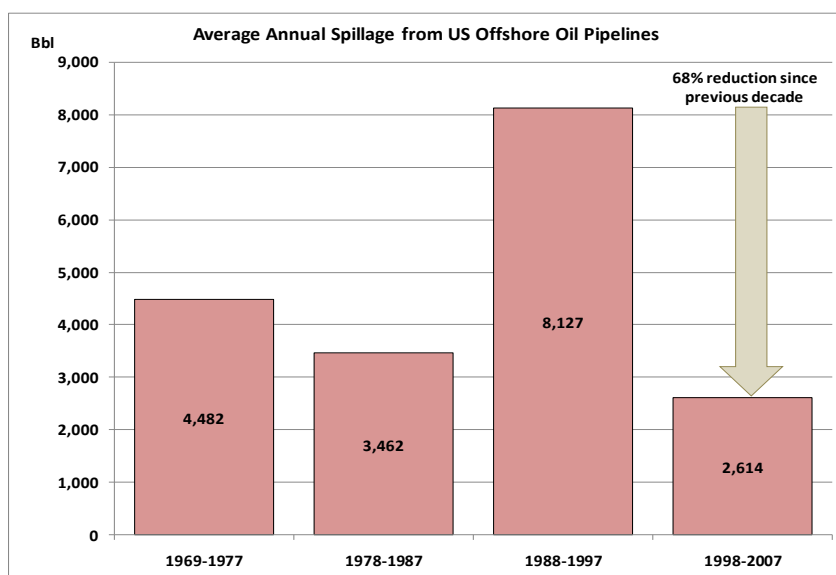


Figure 11: Average Annual Oil Spillage from Offshore Pipelines by Decade

There has been a 68% reduction in spillage from offshore pipelines in the last decade.

²⁸ This category includes pipelines that bring oil from offshore facilities to the coast, but does *not* include inland pipelines that transport crude oil to refineries or refined products from refineries to storage terminals or other locations.

Table 7: Oil Spills from U.S. Offshore Oil Pipelines		
Year	Number of Incidents (1 bbl or more)	Volume (bbl)
1969	1	7,524
1970	0	0
1971	29	258
1972	22	126
1973	29	5,119
1974	19	20,003
1975	17	51
1976	9	6,617
1977	13	637
1978	12	2,821
1979	17	646
1980	13	7,262
1981	12	15,367
1982	5	2,536
1983	8	269
1984	5	586
1985	13	4,513
1986	9	195
1987	4	421
1988	12	31,204
1989	9	358
1990	24	19,937
1991	17	1,894
1992	20	6,815
1993	12	942
1994	6	9,184
1995	7	156
1996	8	746
1997	20	10,028
1998	18	17,099
1999	10	5,259
2000	6	246
2001	6	31
2002	5	42
2003	1	15
2004	27	1,373
2005	55	1,788
2006	3	94
2007	3	193
Total	506	182,355
Average 1969-1977	15	4,482
Average 1978-1987	10	3,462
Average 1988-1997	14	8,126
Average 1998-2007	13	2,614
Average 1969-2007	13	4,676