
# TRENDS IN OIL SPILLS FROM LARGE VESSELS IN THE US AND CALIFORNIA WITH IMPLICATIONS FOR ANTICIPATED OIL SPILL PREVENTION AND MITIGATION BASED ON THE WASHINGTON OIL TRANSFER RULE

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**Trends In Oil Spills From Large Vessels in the US and California**
**With Implications for Anticipated Oil Spill Prevention and Mitigation**
**Based on the Washington Oil Transfer Rule**

## EXECUTIVE SUMMARY

Overall, oil spillage from vessels throughout the US has decreased significantly since 1990 and the enactment of the Oil Pollution Act of 1990 (OPA 90). Nearly 20 times more oil was being spilled annually by vessels in before 1990 than is currently being spilled. The number of spills of 500 gallons or more have decreased since 1990. The reporting of smaller spills has increased since 1985, but the incidence of these spills has decreased since 1990. The reasons for spill reductions with OPA 90 are varied and complex. There are reductions noted even before some of the prevention measures associated with OPA 90 have been implemented. There is speculation that these spill reductions may be related to the increasing costs of oil spills and unlimited liability, and the resulting greater "care" that vessel owners and operators are exercising, as well as the higher class of vessels transiting US waters based on financial and insurance requirements.

The vast majority of vessel spills are very small. Nearly 65 percent of spills are less than 10 gallons, 90 percent are less than 100 gallons. Smaller spills (under 100 gallons) make up only 0.7 percent of the total volume spilled. The very rare larger spills of one million gallons or more (less than one tenth of one percent in frequency) make up over 42 percent of the total volume spilled.

Over 67 percent of spills fall into the category of "other operations". The next largest category in terms of spill number is oil transfer operations, making up 20 percent of all spills. The relative proportion of oil transfer-related spills has decreased from about 50 percent of incidents before 1990 to only 2 or 3 percent of incidents currently.

The largest volume of spillage is attributable to accidents, most notably the Exxon Valdez spill that makes up 78 percent of the volume spilled in this category. The average accident-related spill is nearly 46,000 gallons in volume.
Oil transfer-related spills average 1,270 gallons, though this includes on large transfer-related spill of 3.9 million gallons from the T/V Mega Borg in the Gulf of Mexico in 1990. Average annual oil transfer-related spill volumes and average annual numbers of incidents in this category have both decreased by 96 percent since before 1990.

The patterns seen throughout the US are echoed in Washington State, though overall Washington vessel spills have been shown in a previous study (Etkin and Neel 2001) to occur at a lower rate than in the US as a whole and in comparison to busy ports in California, Texas, and New York.

Spill volumes have been dominated by a few large (over 200,000-gallon) spills, the 1985 T/V Arco Anchorage spill of 239,000 gallons and the 1988 T/B Nestucca spill of 227,000 gallons. The very rare larger spills of 200,000 gallons or more (one tenth of one percent in frequency) make up over 65 percent of the total volume spilled. The vast majority of spills are very small. Over 73 percent of spills are less than 10 gallons, 94 percent are less than 100 gallons. Smaller spills (under 100 gallons) make up only 1.6 percent of the total volume spilled.

Spills in Washington related to oil transfer operations make up 15 percent of all large-vessel spills in Washington. Oil transfer-related spills averaged 144 gallons. The largest spill related to oil transfers was 7,500 gallons. Average annual oil transfer-related spill volumes have decreased by over 99 percent and average annual numbers of incidents in this category have decreased by 92 percent since before 1990.

In California, there are also similar patterns. The spill volumes are dominated by two large spills – the 1990 T/V American Trader spill of 397,000 gallons and the 1987 spill of 339,000 gallons from the M/V Pac Baroness. Nearly 13 percent of oil spills were related to oil transfers. Only six percent of the volume spilled was from oil transfer-related incidents. The average volume for oil transfer spills is 148 gallons.

The average annual volume of oil transfer spills decreased by 80 percent in California, compared with a two percent decrease in the rest of the US after the implementation of the California oil transfer rule. Spill volumes shifted to smaller size classes in California after the rule was implemented. Spill rate reduced as well. In California, prior to 1996, the spill rate averaged 0.0134 spills per transfer. After 1995, the spill rate averaged 0.0046 spills per transfer – a reduction of 34%.

In Washington, an average of $3.3 \times 10^{-7}$ gallons of oil are spilled for each gallon of oil transferred. There are, on average, $4 \times 10^{-4}$ spills for every transfer. Each transfer has a probability of 0.04% chance of an oil spill. If the reduction in number of spills seen in California after the implementation of its oil transfer rule is applied to Washington transfer spills, one might expect that there would be only 0.00026 ($2.6 \times 10^{-4}$) spills per transfer after the implementation of a spill transfer rule.

The percentage of transfer spills entering the water (or escaping containment) in California decreased from a high of 33 percent in 1999 to less than 5 percent in the 2000s. A similar pattern might also be seen in Washington.

The annual costs associated with oil transfer-related spills throughout the US over the last 20 years are estimated to be an average of $98 million in response, environmental, and socioeconomic costs. In Washington, these costs average $1.8 million annually.

Though the average spill volume for a transfer-related spill in Washington is 144 gallons, and the largest transfer-related spill on record in the state is 7,500 gallons, there is still the potential for a significantly larger transfer-related spill. A previous study (Etkin 2001b) had estimated that a most likely-worst-case discharge from oil transfers would be 155,000 gallons. If a catastrophic transfer event involving explosions and fire, such as the T/V Mega Borg spill were to occur in Washington waters, an estimated three million gallons might spill. This type of event has occurred once in 20 years in the US after an estimated three million vessel transits (with a probability of 0.000003 percent). A spill of this magnitude could cause $170 million to $800 million in costs and impacts in Washington.

**Trends In Oil Spills From Large Vessels in the US and California**
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## SYNOPSIS

Washington Department of Ecology would like to assess the potential impacts of its proposed Oil Transfer Rule [Vessel Oil Transfer Rule (WAC 317-40) and the oil transfer requirements of the Facility Standards Rule (WAC 173-180A)] in terms of preventing oil spillage and minimizing damages from oil spills during oil transfers that occur in open waters (between vessels) and at facilities (between vessels and facilities during offloading, loading, or refueling). As part of this, Ecology requires an analysis of potential reductions in oil spills that might be seen in Washington waters with this rule in effect so that an appropriate cost-benefit analysis can be conducted[1]. This study focuses on oil transfer spills from vessels of at least 300 gross registered tons (GRT).

## APPROACH

To determine the potential spill reductions with the implementation of the Oil Transfer Rule, the following data are required:

- Probability of transfer-related spillage per each vessel transfer in Washington
- Frequency distribution of spill volumes for oil transfer-related spills in Washington
- Frequency distribution of oil types for oil transfer-related spills in Washington
- Frequency distribution of cargo *vs*. fuel transfer-related incidents in Washington
- Estimates of costs associated with oil transfer-related spills

This data will provide a picture of the current situation or risk assessment for Washington and provide the template for the analysis of the way in which the Oil Transfer Rule might change spill risks. Additional analyses required will determine:

- Potential reductions in spills in Washington waters with the implementation of the Oil Transfer Rule (based on an analysis of the California Oil Transfer Rule)
- Potential changes in impacts from spills based on better response and pre-booming requirements in Washington waters with the implementation of the Oil Transfer Rule
- Changes in potential spill types in future with changes in vessel traffic in Washington waters (changes in vessel types, oil types, vessel routes?)

The interrelationship between these various analyses and the way in which they relate to the Oil Transfer Rule is summarized in the flowchart in Figure A.

[1] The Technical Analysis of Benefits study is being conducted by Gretchen Greene and Barbara Wyse of Northwest Economic Associates (part of Entrix, Inc).

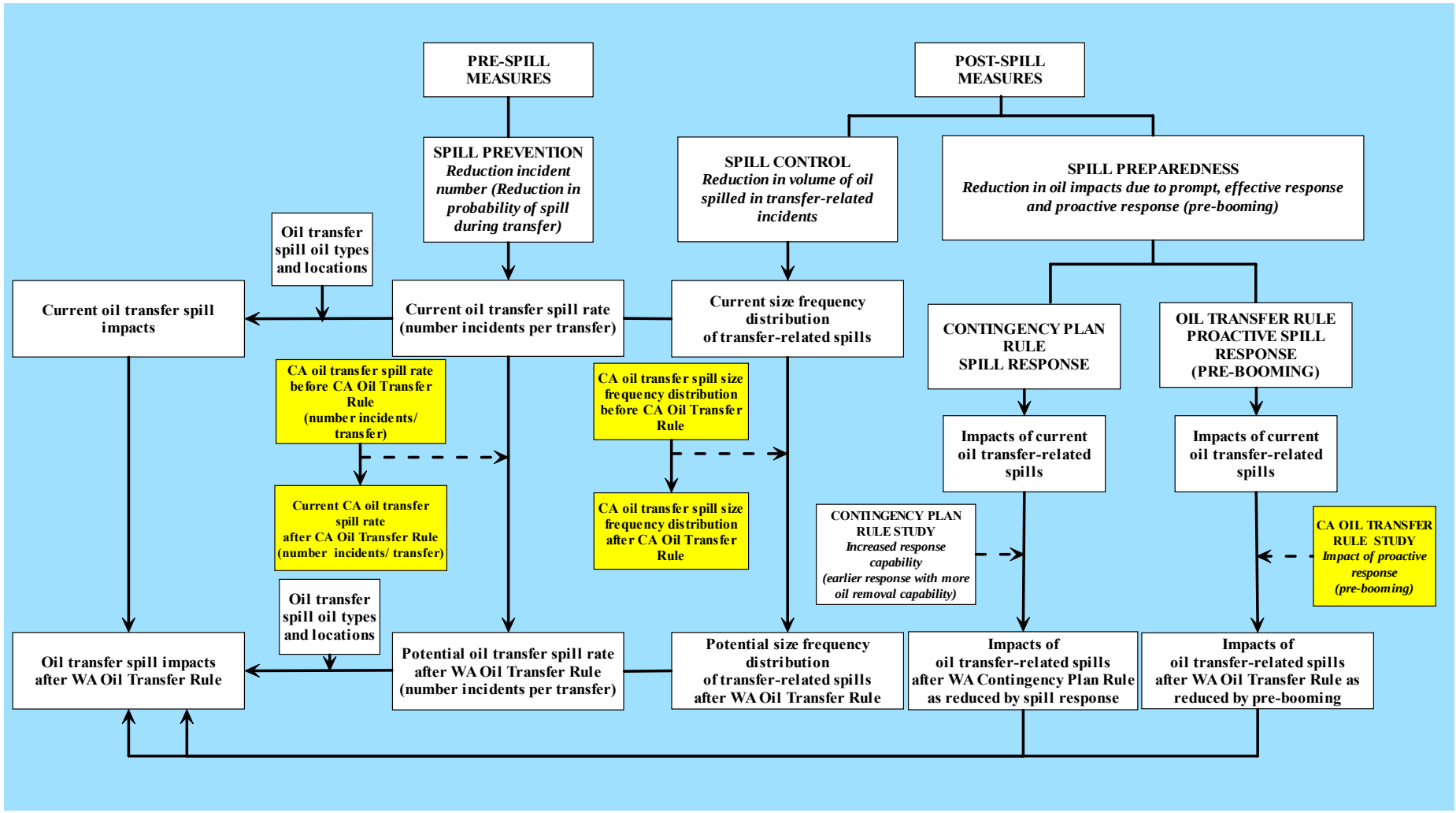


**Figure A: Oil Transfer Rule Study. This diagram shows the connection between the current study (including California Oil Transfer Rule study) and the Washington Oil Transfer Cost-Benefit Analysis**

The important factors of potential spill reduction and changes in spill impacts with the implementation of the Oil Transfer Rule could best be estimated by a thorough examination of the effect that a similar rule has had in another state, California. That state enacted an oil transfer rule with pre-booming requirements in 1995.

An analysis of pre- and post-oil transfer rule spill rates, probabilities, and patterns would reveal the potential changes that occurred in California as a result of its oil transfer rule (see Figure B). These rates of change could then be applied to Washington's oil transfer spill data to estimate the rate of spills and impacts before and after the implementation of the Oil Transfer Rule. The latter could then be used in the benefits analysis.

In analyzing changes in oil transfer spills in California, it is essential to examine other factors[2] that have led to an overall decrease in oil spills from vessels and facilities (Etkin 2001, 2002, 2003a, 2004b; NRC 2003) and separate these factors from those that directly impacted oil transfer spill rates. Analyzing spill data for the US as a whole and for specific other states that have similarly high rates of vessel traffic but that do not have oil transfer regulations in place will help to separate the influence of the oil transfer rule in particular. For example, if other states have shown a 5% reduction in spills from oil transfers *without* the benefit of an oil transfer rule as part of an overall effect of oil prevention or deterrent[3] measures in OPA 90 and various other regulations, and California shows a 20% decrease, the additional 15% decrease in spills might be attributed specifically to the oil transfer rule.

Another analysis conducted for vessel spills in Washington (Etkin and Neel 2001) conducted by ERC in conjunction with Ecology in which Washington spill rates were contrasted with the US as a whole, and California, Texas, and New York, in particular, was also be examined with regard to relevance to this study. In this study, it was concluded that Washington's spill prevention measures had led to a decrease in vessel spill rates relative to the US as a whole as well as the other states examined.

[2] For example, the federal Oil Pollution Act of 1990 (OPA 90), EPA's Spill Prevention, Control, and Countermeasures (SPCC) regulations for facilities, and various state regulations aimed at preventing oil spills. ERC conducted a benefits analysis for EPA with regard to spill prevention from its SPCC regulations. The preliminary findings are summarized in: Etkin 2004a,b.

[3] Unlimited liability components of OPA 90 and associated state regulations and the increasingly high costs of oil spills in the US have apparently led to greater vigilance on the part of oil shippers and handlers. High insurance coverage requirements for tankers in US waters has led to a higher grade of vessels in US waters.

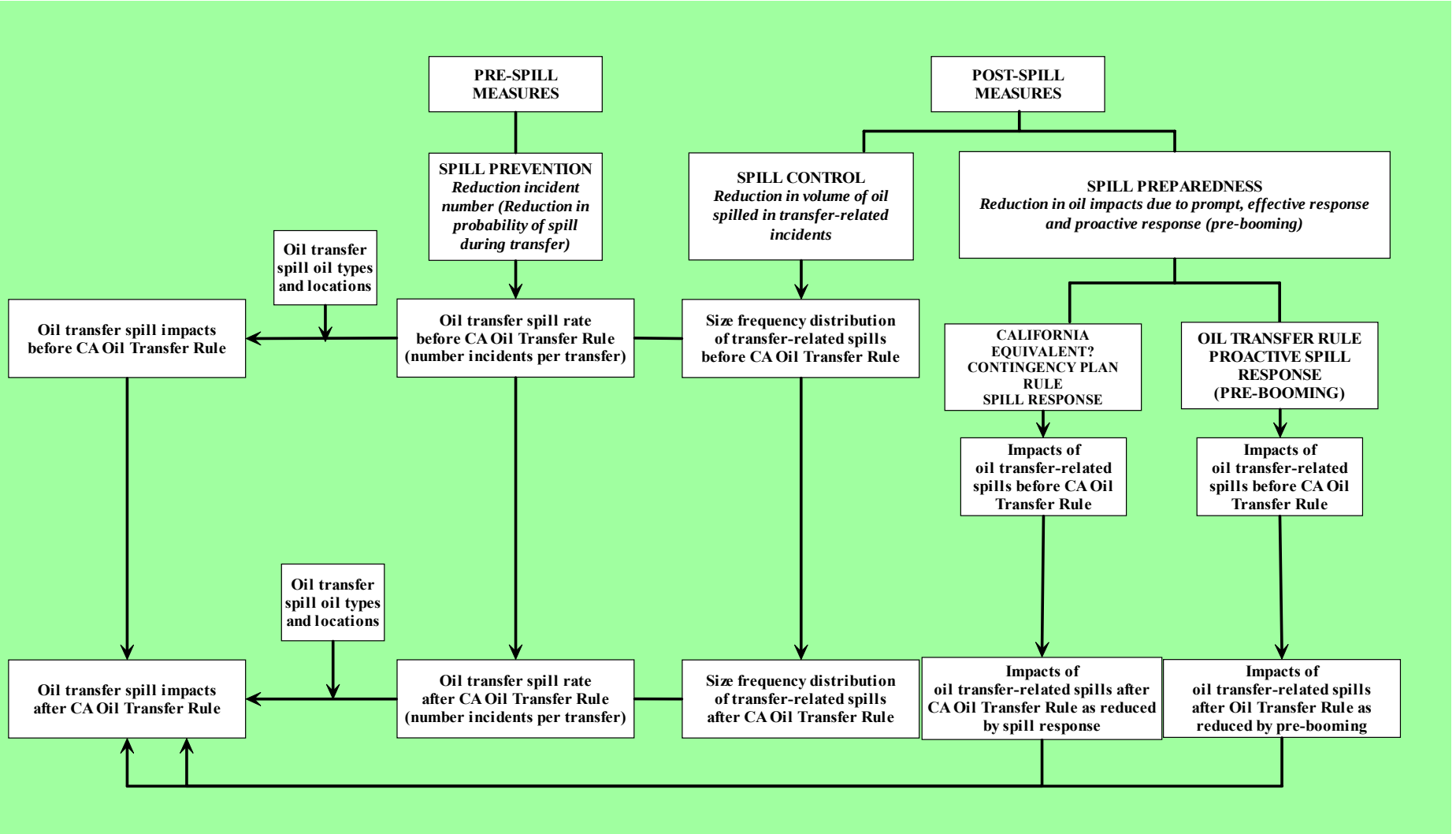


**Figure B: California Oil Transfer Rule Study**

## METHODOLOGY

Data for oil spills of at least one gallon into navigable waters[4] from large vessels (300 GRT and higher) for the US during the years 1985 through 2004 were extracted from Environmental Research Consulting's (ERC) databases[5]. The years 1985 through 2004 were selected for study because provide a 20-year time span for which there would be sufficient data before the enactment and implementation of the Oil Pollution Act of 1990 (OPA 90). The year 2005 was not included because data for this year were still incomplete at the time of the analysis.

Each spill record contained information on the date, spill location, vessel characteristics, spilled volume, oil type, spill cause, and operation at the time of the spill. The vessel spill data were grouped into three sub-categories: all spills throughout the US, oil spills in California only, and oil spills in Washington only. Spills were also grouped according to time periods (annual, pre-OPA 90, post-OPA 90, post-OPA 90 and pre-California Oil Transfer Rule, and post-California Oil Transfer Rule).

Oil spill trends were analyzed based on spill numbers and spill volumes for all spill causes (US as a whole, US without California, California only, and Washington only), as well as spillage per oil transfer rates.

[4] "Navigable waters" was construed to mean waters through which a vessel (of 300 GRT or higher) can be navigated, as is typically used by the US Coast Guard. The definition typically used by the US Environmental Protection Agency, which includes dry pavements, ditches, and wetlands through which water *may* flow at some point is not used in this context.

[5] ERC's spill databases incorporate data from federal, state, industry, and private sources. Data are cross-checked and corrected for errors, duplications, and omissions, as well as updated with new and additional information as it becomes available. ERC's data has been used for studies at the National Academy of Sciences, UN, International Maritime Organization, US Coast Guard, US Environmental Protection Agency, Pipeline and Hazardous Materials Safety Administration, Washington Department of Ecology, and other organizations.

## RESULTS FOR US OIL SPILLS

Oil spillage from 300 GRT+ vessels for the US as a whole is shown in Figures 1 – 3.

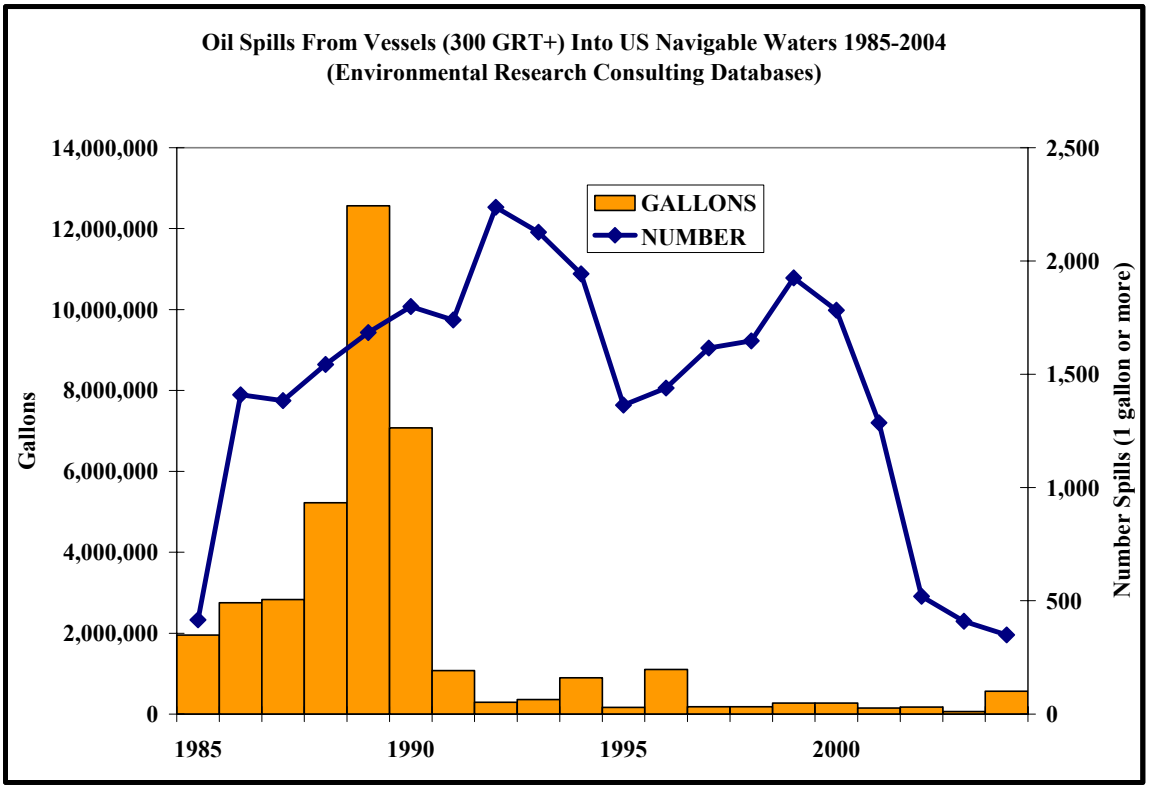


**Figure 1: Oil Spills from 300 GRT+ Vessels into US Navigable Waters 1985 – 2004.**

The dramatic decrease in oil volume spilled after 1990 is apparent is Figure 2. Nearly 20 times more oil was being spilled annually by vessels in before 1990 than is currently being spilled. Much of the spillage in this time period is attributed to the 10,500,000 gallons spilled from the T/V Exxon Valdez in 1989. Nearly 42 percent of the oil spilled during 1985 – 1989 was from that single incident. But even without that spill, there was over 10 times the spillage being experienced today.

The pre-1990 increase in oil spill numbers, as seen in Figure 3, is likely attributable to an increasing rate of reporting of smaller spills with greater public awareness and changes in state and federal regulations requiring reporting of smaller spills. This can be seen by examining spill rates for spills of at least 500 gallons, as shown in Figure 4. After an initial increase in spills between 1985 and 1986, which is likely an artifact of the data due to changes in some of the larger federal databases (*e.g.*, US Coast Guard MSIS) at that time that increased record-keeping efficiency, the number of 500-gallon and larger spills decreases with each five-year interval. The numbers of spills of 500 gallons or more during the last five years is only 20 percent of what was spilling during the years before 1990.

The small number of spills of 500 gallons and larger compared to the total spill numbers in Figures 1 and 3 give an indication of how few larger spills there are. The vast majority of spills are very small. Table 1 and Figure 5 show the distribution of spill sizes for US vessel spills. Relative proportions of spills by size class pre- and post-OPA 90 are shown in Figure 6.

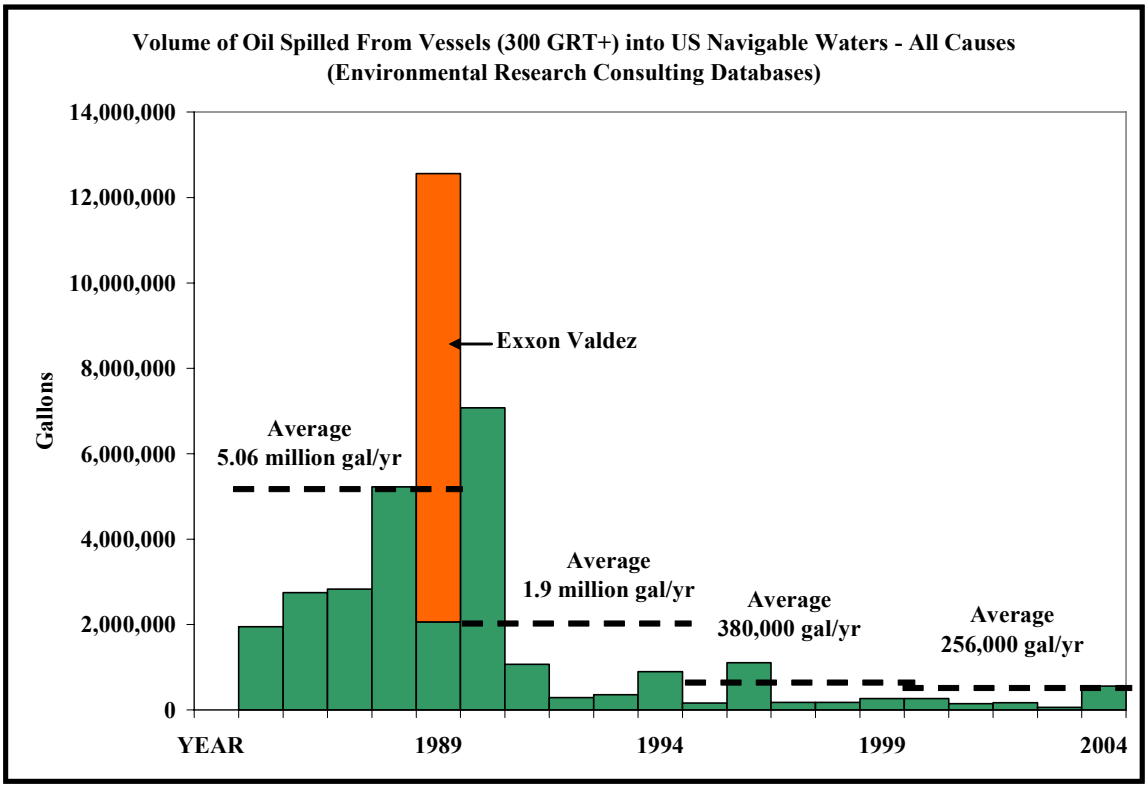


**Figure 2: Average Volume of Oil Spilled in Five-Year Intervals from 300 GRT+ Vessels**

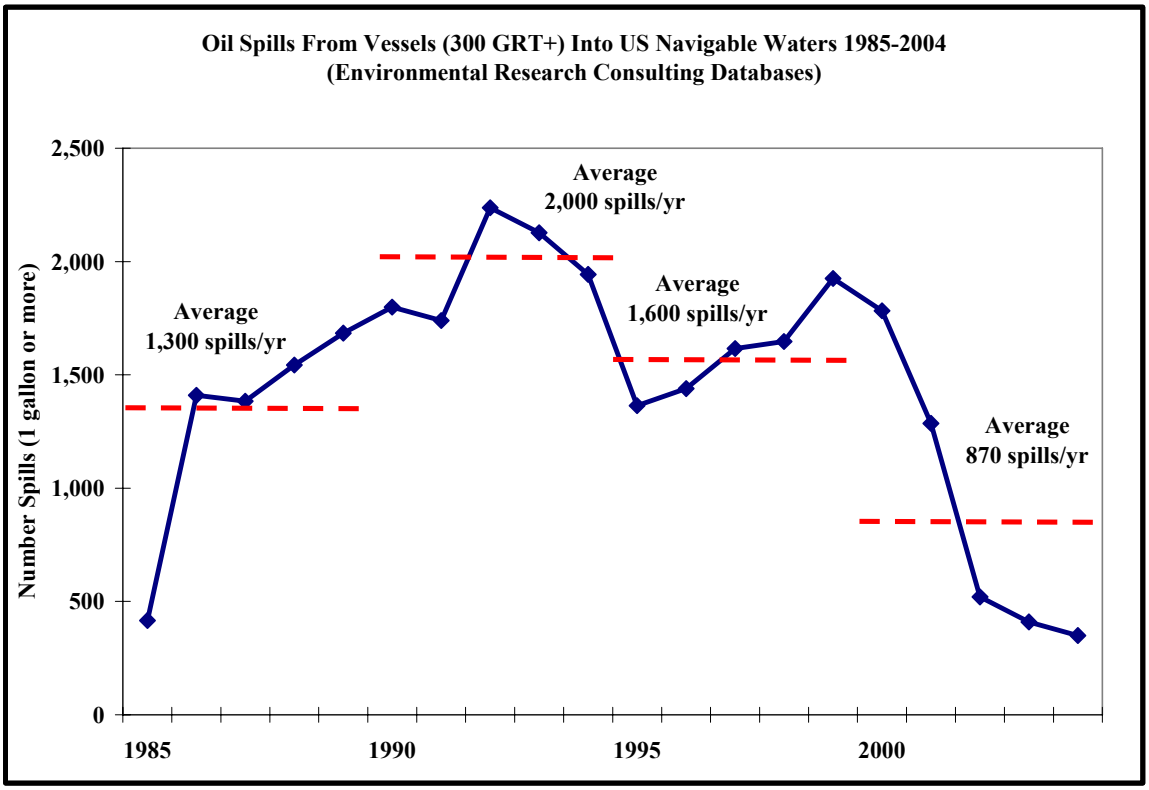


**Figure 3: Average Annual Number of Oil Spills in Five-Year Intervals from 300 GRT+ Vessels**

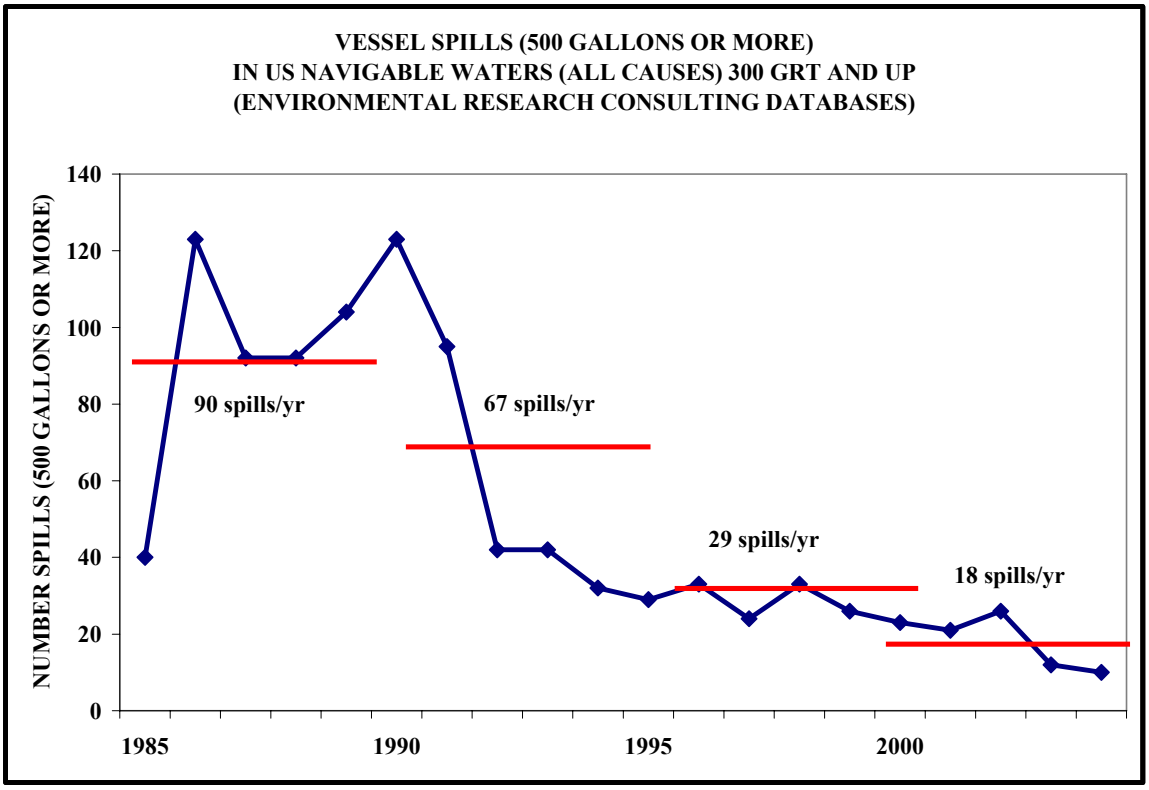


**Figure 4: 300 GRT+ Vessel Spills of 500 Gallons or More into US Waters.**

| Table 1: Size Classes for Oil Spills From Vessels Into US Navigable Waters (All Causes) (Environmental Research Consulting Databases) | | | | |
|---|---|---|---|---|
| **Spill Volume** | **Number Spills** | **% Total Number** | **Volume** | **% Total Volume** |
| **1-9 gallons** | 18,535 | 64.8% | 38,223 | 0.1% |
| **10-99 gallons** | 7,325 | 25.6% | 210,235 | 0.6% |
| **100-999 gallons** | 2,063 | 7.2% | 556,359 | 1.5% |
| **1,000-9,999 gallons** | 486 | 1.7% | 1,444,653 | 3.8% |
| **10,000-99,999 gallons** | 167 | 0.6% | 5,274,128 | 14.0% |
| **100,000-999,999 gallons** | 44 | 0.2% | 14,187,852 | 37.6% |
| **1,000,000-9,999,999 gallons** | 2 | 0.0% | 5,491,662 | 14.6% |
| **10,000,000 gallons +** | 1 | 0.0% | 10,500,000 | 27.8% |
| **TOTAL** | **28,623** | **100.0%** | **37,703,112** | **100.0%** |

Nearly 65 percent of spills are less than 10 gallons, 90 percent are less than 100 gallons. But these smaller spills make up only 0.7 percent of the total volume spilled. The very rare larger spills of one million gallons or more (less than one tenth of one percent in frequency) make up over 42 percent of the total volume spilled.

A probability distribution function for spill sizes for spills from large vessels into US waters for the years 1985 though 2004 is shown in Figure 7 and summarized in Table 2. This graph shows the percentage probability that a spill will be *smaller* than the size shown. For example, a spill of 100 gallons is larger than 90 percent of the spills. The chance is 90 percent that a spill will be smaller and there is only a ten percent chance that a spill will be larger than that volume.

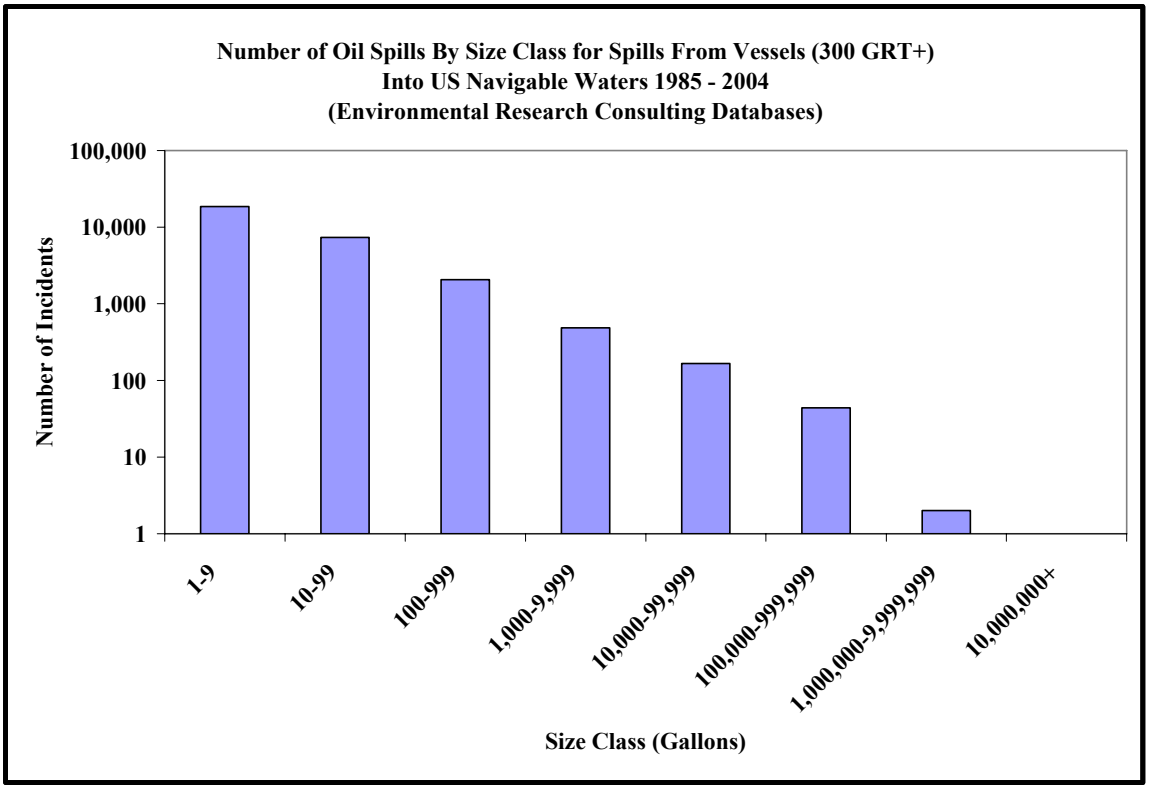


**Figure 5: Size Classes of Oil Spills from Vessels. Note the logarithmic scales.**

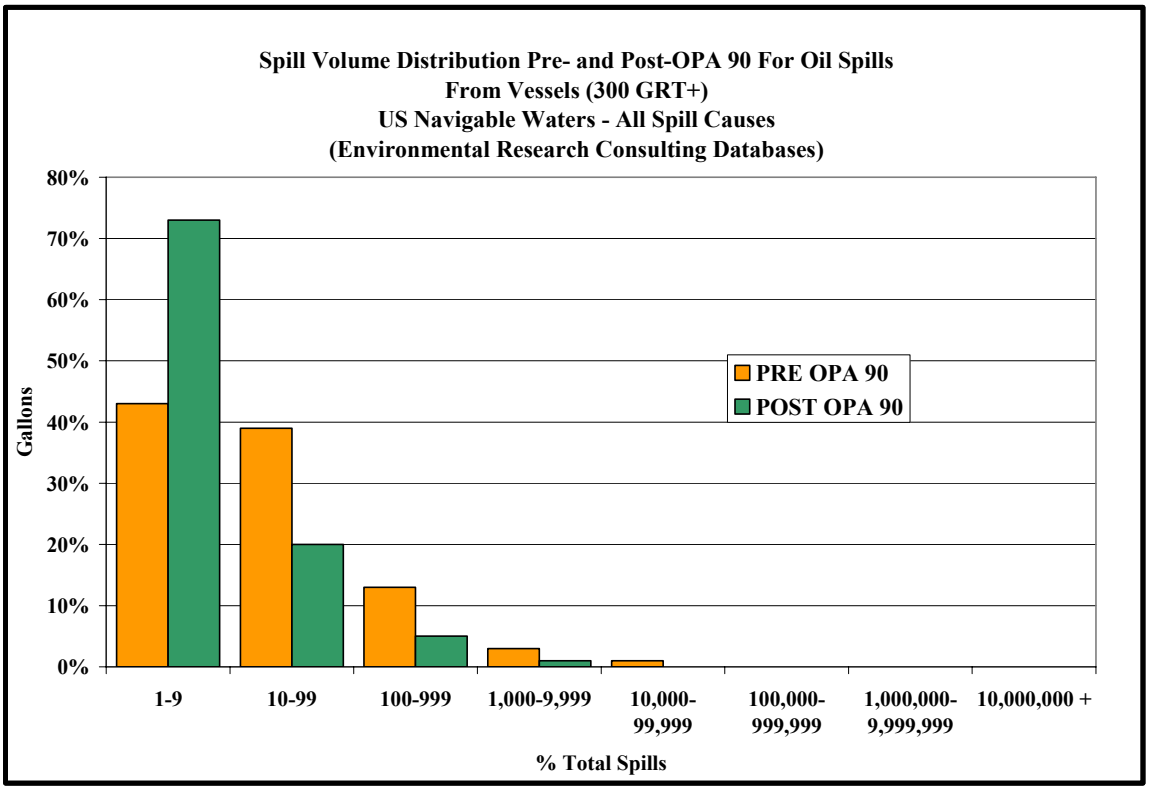


**Figure 6: Spill Volumes for Large Vessel Spills Pre- and Post-OPA 90**

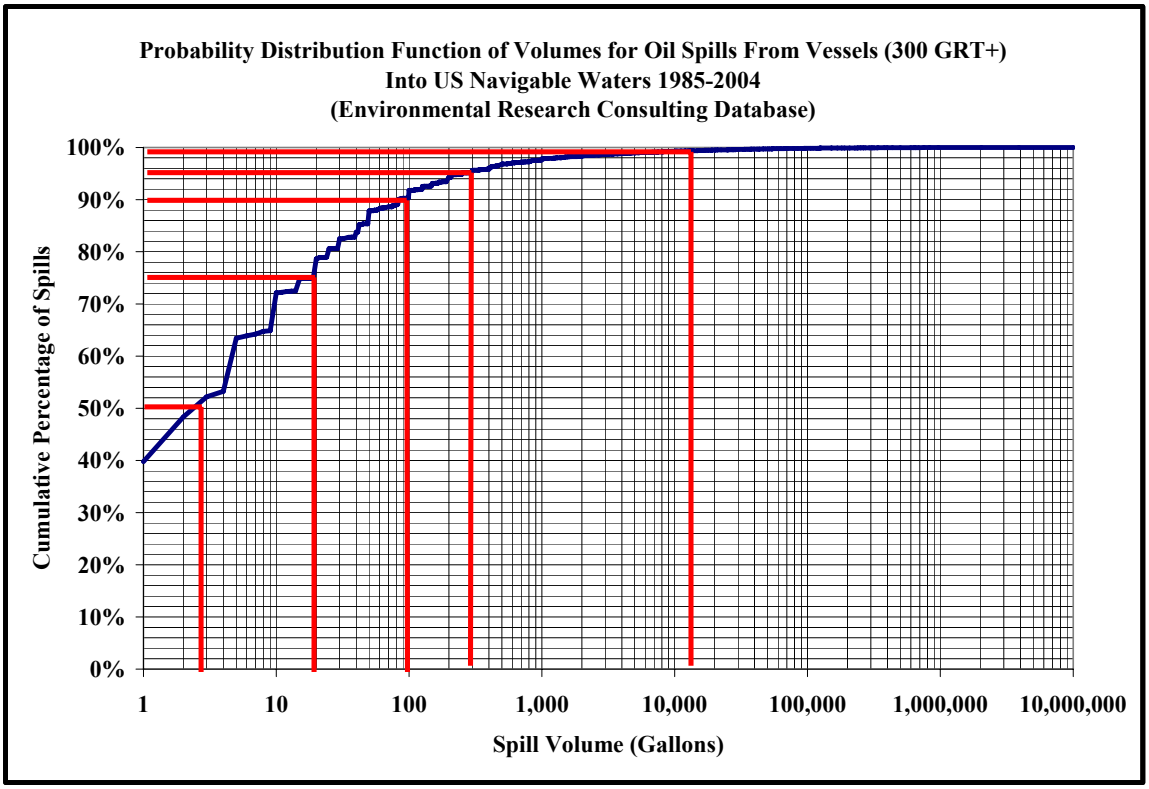


**Figure 7: Probability Distribution Function of Volumes for Large Vessel Spills - probability that spill is *smaller* than size, *e.g.*, 100-gallon spill is larger than 90% of spills, only 10% larger.**

| **Table 2: Spill Volume Probability Distribution - ALL SPILL CAUSES<br>Oil Spills From Vessels (300 GRT+) Into US Navigable Waters 1985 – 2000** | |
|---|---|
| **Percentile Spill[6]** | **Spill Volume** |
| **25th** | 1 gallon |
| **40th** | 1 gallon |
| **50th** | 3 gallons |
| **60th** | 4 gallons |
| **70th** | 10 gallons |
| **75th** | 11 gallons |
| **80th** | 12 gallons |
| **90th** | 100 gallons |
| **95th** | 300 gallons |
| **99th** | 12,000 gallons |
| **100th (worst discharge)** | 10,500,000 gallons |

Spills from large vessels to US waters were divided into categories based on general causes and operations at the time of the spill incident:

- Accidents (groundings, collisions, and allisions[7])

[6] The $n^{th}$ percentile is the spill volume at which *n* percent of spills are smaller and 100 – *n* percent are larger. The 50th percentile is the median impact situation in which 50 percent of the spills are smaller and 50 percent are larger. The 95th percentile spill volume is larger than 95 percent of cases. Only 5 percent are larger.

[7] An allision occurs when a vessel hits a stationary object, such as a dock.

- Dockside operations (repairs, maintenance, ballast tank discharges[8], tank stripping)
- Fires and explosions
- Non-Oil Cargo Transfers (dockside transfers of cargoes other than oil)
- Oil Transfers
- Other Operations (fishing, trawling, dredging, oil production, unknown operations)
- Structural Failures (breaking apart, sinking, flooding)

Annual spill numbers and relative percentages by cause are shown in Tables 3 and 4 and Figure 8. The corresponding volumes and average volumes per spill are shown in Tables 5 through 7. The largest number of spills is attributed to other operations. Over 67 percent of spills fall into this category. Since this category includes all "unknown" causes, it should be noted that some of these spills may actually fit into another category. The numbers and volumes for the other categories are under-estimates for this reason. The next largest category in terms of spill number is oil transfer operations, making up 20 percent of all spills. As can be seen in Table 4, the relative proportion of oil transfer-related spills has decreased from about 50 percent of incidents before 1990 to only 2 or 3 percent of incidents currently.

The largest volume of spillage is attributable to accidents, most notably the Exxon Valdez spill that makes up 78 percent of the volume spilled in this category. The average accident-related spill is nearly 46,000 gallons in volume. Dockside operation-related spills tend to be considerably smaller, averaging 261 gallons. Oil transfer-related spills averaged 1,270 gallons, though this includes a spill of 3.9 million gallons from the T/V Mega Borg in the Gulf of Mexico in 1990. Oil spills related to transfer operations in US waters are shown in Figures 9 – 10. The probability distribution function of oil transfer spills is shown in Figure 11 and summarized in Table 8.

[8] Offshore ballast discharges are included in this category.

| Table 3: Numbers of Oil Spills (1 Gallon or More) from Large Vessels (≥300 GRT) into US Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 6 | 60 | 1 | 4 | 213 | 100 | 32 | 416 |
| **1986** | 15 | 183 | 8 | 9 | 735 | 362 | 98 | 1,410 |
| **1987** | 17 | 217 | 5 | 10 | 645 | 374 | 116 | 1,384 |
| **1988** | 21 | 246 | 16 | 9 | 727 | 393 | 131 | 1,543 |
| **1989** | 35 | 296 | 8 | 9 | 777 | 439 | 120 | 1,684 |
| **1990** | 25 | 278 | 6 | 17 | 792 | 532 | 149 | 1,799 |
| **1991** | 27 | 312 | 10 | 7 | 756 | 520 | 108 | 1,740 |
| **1992** | 22 | 67 | 15 | 12 | 222 | 1,875 | 24 | 2,237 |
| **1993** | 13 | 75 | 1 | 14 | 204 | 1,792 | 28 | 2,127 |
| **1994** | 17 | 78 | 2 | 14 | 205 | 1,603 | 24 | 1,943 |
| **1995** | 8 | 36 | 1 | 5 | 86 | 1,212 | 16 | 1,364 |
| **1996** | 10 | 29 | 1 | 3 | 44 | 1,342 | 10 | 1,439 |
| **1997** | 13 | 16 | 2 | 4 | 68 | 1,487 | 26 | 1,616 |
| **1998** | 12 | 26 | 3 | 5 | 76 | 1,500 | 25 | 1,647 |
| **1999** | 15 | 27 | 1 | 10 | 70 | 1,778 | 24 | 1,925 |
| **2000** | 11 | 30 | 2 | 5 | 64 | 1,649 | 22 | 1,783 |
| **2001** | 6 | 18 | 0 | 2 | 37 | 1,213 | 10 | 1,286 |
| **2002** | 6 | 2 | 2 | 0 | 11 | 463 | 36 | 520 |
| **2003** | 4 | 0 | 1 | 0 | 11 | 383 | 11 | 410 |
| **2004** | 13 | 0 | 2 | 0 | 4 | 313 | 18 | 350 |
| **TOTAL** | **296** | **1,996** | **87** | **139** | **5,747** | **19,330** | **1,028** | **28,623** |

| Table 4: Percent Number of Oil Spills from Large Vessels (≥300 GRT) into US Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 1.4% | 14.4% | 0.2% | 1.0% | 51.2% | 24.0% | 7.7% |
| **1986** | 1.1% | 13.0% | 0.6% | 0.6% | 52.1% | 25.7% | 7.0% |
| **1987** | 1.2% | 15.7% | 0.4% | 0.7% | 46.6% | 27.0% | 8.4% |
| **1988** | 1.4% | 15.9% | 1.0% | 0.6% | 47.1% | 25.5% | 8.5% |
| **1989** | 2.1% | 17.6% | 0.5% | 0.5% | 46.1% | 26.1% | 7.1% |
| **1990** | 1.4% | 15.5% | 0.3% | 0.9% | 44.0% | 29.6% | 8.3% |
| **1991** | 1.6% | 17.9% | 0.6% | 0.4% | 43.4% | 29.9% | 6.2% |
| **1992** | 1.0% | 3.0% | 0.7% | 0.5% | 9.9% | 83.8% | 1.1% |
| **1993** | 0.6% | 3.5% | 0.0% | 0.7% | 9.6% | 84.3% | 1.3% |
| **1994** | 0.9% | 4.0% | 0.1% | 0.7% | 10.6% | 82.5% | 1.2% |
| **1995** | 0.6% | 2.6% | 0.1% | 0.4% | 6.3% | 88.9% | 1.2% |
| **1996** | 0.7% | 2.0% | 0.1% | 0.2% | 3.1% | 93.3% | 0.7% |
| **1997** | 0.8% | 1.0% | 0.1% | 0.2% | 4.2% | 92.0% | 1.6% |
| **1998** | 0.7% | 1.6% | 0.2% | 0.3% | 4.6% | 91.1% | 1.5% |
| **1999** | 0.8% | 1.4% | 0.1% | 0.5% | 3.6% | 92.4% | 1.2% |
| **2000** | 0.6% | 1.7% | 0.1% | 0.3% | 3.6% | 92.5% | 1.2% |
| **2001** | 0.5% | 1.4% | 0.0% | 0.2% | 2.9% | 94.3% | 0.8% |
| **2002** | 1.2% | 0.4% | 0.4% | 0.0% | 2.1% | 89.0% | 6.9% |
| **2003** | 1.0% | 0.0% | 0.2% | 0.0% | 2.7% | 93.4% | 2.7% |
| **2004** | 3.7% | 0.0% | 0.6% | 0.0% | 1.1% | 89.4% | 5.1% |
| **TOTAL** | **1.0%** | **7.0%** | **0.3%** | **0.5%** | **20.1%** | **67.5%** | **3.6%** |

| Table 5: Volume of Oil Spilled from Large Vessels (≥300 GRT) into US Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Volume Oil Spilled (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 265,490 | 12,895 | 10 | 87 | 164,671 | 1,175,630 | 336,514 | 1,955,297 |
| **1986** | 37,896 | 106,852 | 431 | 130 | 1,319,543 | 1,225,097 | 59,886 | 2,749,835 |
| **1987** | 6,519 | 85,880 | 121 | 124 | 166,774 | 1,340,124 | 1,232,012 | 2,831,554 |
| **1988** | 7,192 | 211,399 | 1,260 | 840 | 190,852 | 4,395,623 | 414,226 | 5,221,392 |
| **1989** | 10,794,484 | 13,975 | 1,200 | 423 | 317,218 | 879,293 | 558,477 | 12,565,070 |
| **1990** | 644,778 | 17,615 | 50 | 205 | 4,459,097 | 1,237,118 | 714,880 | 7,073,743 |
| **1991** | 237,148 | 48,565 | 476 | 230 | 147,654 | 569,658 | 68,404 | 1,072,135 |
| **1992** | 76,847 | 6,963 | 392 | 1,126 | 117,457 | 74,473 | 16,382 | 293,640 |
| **1993** | 134,845 | 1,315 | 10 | 533 | 75,488 | 146,067 | 2,161 | 360,419 |
| **1994** | 780,875 | 5,982 | 310 | 160 | 37,426 | 68,050 | 6,666 | 899,469 |
| **1995** | 23,666 | 1,056 | 1,500 | 136 | 8,252 | 129,149 | 672 | 164,431 |
| **1996** | 72,710 | 3,050 | 828,000 | 10 | 112,552 | 88,302 | 266 | 1,104,890 |
| **1997** | 30,035 | 178 | 6 | 59 | 53,360 | 93,220 | 1,458 | 178,316 |
| **1998** | 687 | 977 | 2,002 | 10 | 14,805 | 162,532 | 238 | 181,251 |
| **1999** | 20,029 | 2,717 | 10 | 51 | 25,017 | 223,781 | 897 | 272,502 |
| **2000** | 66,527 | 739 | 90 | 32 | 79,849 | 62,703 | 60,480 | 270,420 |
| **2001** | 37,111 | 447 | 0 | 25 | 8,281 | 94,155 | 12,729 | 152,748 |
| **2002** | 2,215 | 63 | 63 | 0 | 177 | 160,407 | 14,081 | 177,006 |
| **2003** | 17,252 | 0 | 10 | 0 | 562 | 40,385 | 5,498 | 63,706 |
| **2004** | 238,796 | 0 | 54,890 | 0 | 166 | 6,400 | 265,038 | 565,289 |
| **TOTAL** | **13,495,102** | **520,668** | **890,831** | **4,181** | **7,299,200** | **12,172,167** | **3,770,964** | **27,653,113** |

| Table 6: Percent Volume of Oil Spilled from Large Vessels (≥300 GRT) into US Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 13.6% | 0.7% | 0.0% | 0.0% | 8.4% | 60.1% | 17.2% |
| **1986** | 1.4% | 3.9% | 0.0% | 0.0% | 48.0% | 44.6% | 2.2% |
| **1987** | 0.2% | 3.0% | 0.0% | 0.0% | 5.9% | 47.3% | 43.5% |
| **1988** | 0.1% | 4.0% | 0.0% | 0.0% | 3.7% | 84.2% | 7.9% |
| **1989** | 85.9% | 0.1% | 0.0% | 0.0% | 2.5% | 7.0% | 4.4% |
| **1990** | 9.1% | 0.2% | 0.0% | 0.0% | 63.0% | 17.5% | 10.1% |
| **1991** | 22.1% | 4.5% | 0.0% | 0.0% | 13.8% | 53.1% | 6.4% |
| **1992** | 26.2% | 2.4% | 0.1% | 0.4% | 40.0% | 25.4% | 5.6% |
| **1993** | 37.4% | 0.4% | 0.0% | 0.1% | 20.9% | 40.5% | 0.6% |
| **1994** | 86.8% | 0.7% | 0.0% | 0.0% | 4.2% | 7.6% | 0.7% |
| **1995** | 14.4% | 0.6% | 0.9% | 0.1% | 5.0% | 78.5% | 0.4% |
| **1996** | 6.6% | 0.3% | 74.9% | 0.0% | 10.2% | 8.0% | 0.0% |
| **1997** | 16.8% | 0.1% | 0.0% | 0.0% | 29.9% | 52.3% | 0.8% |
| **1998** | 0.4% | 0.5% | 1.1% | 0.0% | 8.2% | 89.7% | 0.1% |
| **1999** | 7.4% | 1.0% | 0.0% | 0.0% | 9.2% | 82.1% | 0.3% |
| **2000** | 24.6% | 0.3% | 0.0% | 0.0% | 29.5% | 23.2% | 22.4% |
| **2001** | 24.3% | 0.3% | 0.0% | 0.0% | 5.4% | 61.6% | 8.3% |
| **2002** | 1.3% | 0.0% | 0.0% | 0.0% | 0.1% | 90.6% | 8.0% |
| **2003** | 27.1% | 0.0% | 0.0% | 0.0% | 0.9% | 63.4% | 8.6% |
| **2004** | 42.2% | 0.0% | 9.7% | 0.0% | 0.0% | 1.1% | 46.9% |
| **TOTAL** | **48.8%** | **1.9%** | **3.2%** | **0.0%** | **26.4%** | **44.0%** | **13.6%** |

| Table 7: Average Spill Size for Oil Spills from Large Vessels (≥300 GRT) into US Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Average Spill Size (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 44,248 | 215 | 10 | 22 | 773 | 11,756 | 10,516 | 4,700 |
| **1986** | 2,526 | 584 | 54 | 14 | 1,795 | 3,384 | 611 | 1,950 |
| **1987** | 383 | 396 | 24 | 12 | 259 | 3,583 | 10,621 | 2,046 |
| **1988** | 342 | 859 | 79 | 93 | 263 | 11,185 | 3,162 | 3,384 |
| **1989** | 308,414 | 47 | 150 | 47 | 408 | 2,003 | 4,654 | 7,461 |
| **1990** | 25,791 | 63 | 8 | 12 | 5,630 | 2,325 | 4,798 | 3,932 |
| **1991** | 8,783 | 156 | 48 | 33 | 195 | 1,095 | 633 | 616 |
| **1992** | 3,493 | 104 | 26 | 94 | 529 | 40 | 683 | 131 |
| **1993** | 10,373 | 18 | 10 | 38 | 370 | 82 | 77 | 169 |
| **1994** | 45,934 | 77 | 155 | 11 | 183 | 42 | 278 | 463 |
| **1995** | 2,958 | 29 | 1,500 | 27 | 96 | 107 | 42 | 121 |
| **1996** | 7,271 | 105 | 828,000 | 3 | 2,558 | 66 | 27 | 768 |
| **1997** | 2,310 | 11 | 3 | 15 | 785 | 63 | 56 | 110 |
| **1998** | 57 | 38 | 667 | 2 | 195 | 108 | 10 | 110 |
| **1999** | 1,335 | 101 | 10 | 5 | 357 | 126 | 37 | 142 |
| **2000** | 6,048 | 25 | 45 | 6 | 1,248 | 38 | 2,749 | 152 |
| **2001** | 6,185 | 25 | 0 | 13 | 224 | 78 | 1,273 | 119 |
| **2002** | 369 | 32 | 32 | 0 | 16 | 346 | 391 | 340 |
| **2003** | 4,313 | 0 | 10 | 0 | 51 | 105 | 500 | 155 |
| **2004** | 18,369 | 0 | 27,445 | 0 | 41 | 20 | 14,724 | 1,615 |
| **TOTAL** | 45,592 | 261 | 10,239 | 30 | 1,270 | 630 | 3,668 | 966 |

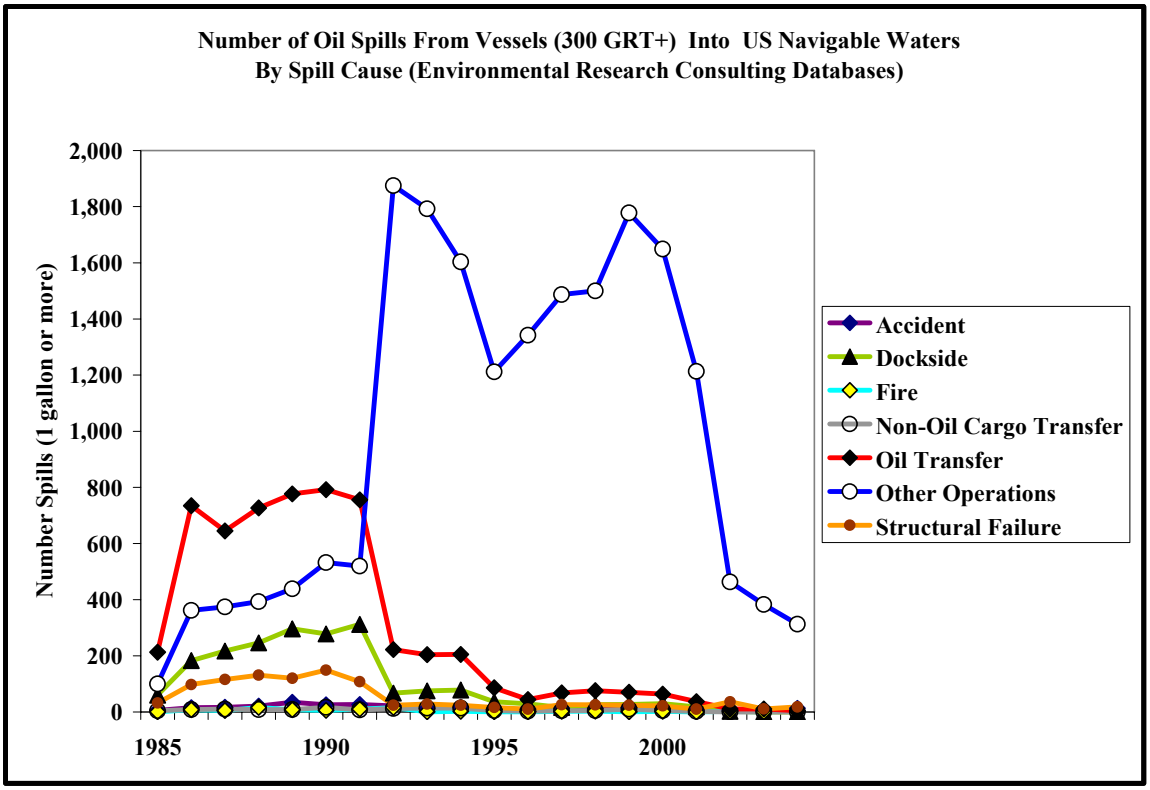


**Figure 8: Number of Oil Spills from Large Vessels into US Waters by Cause**

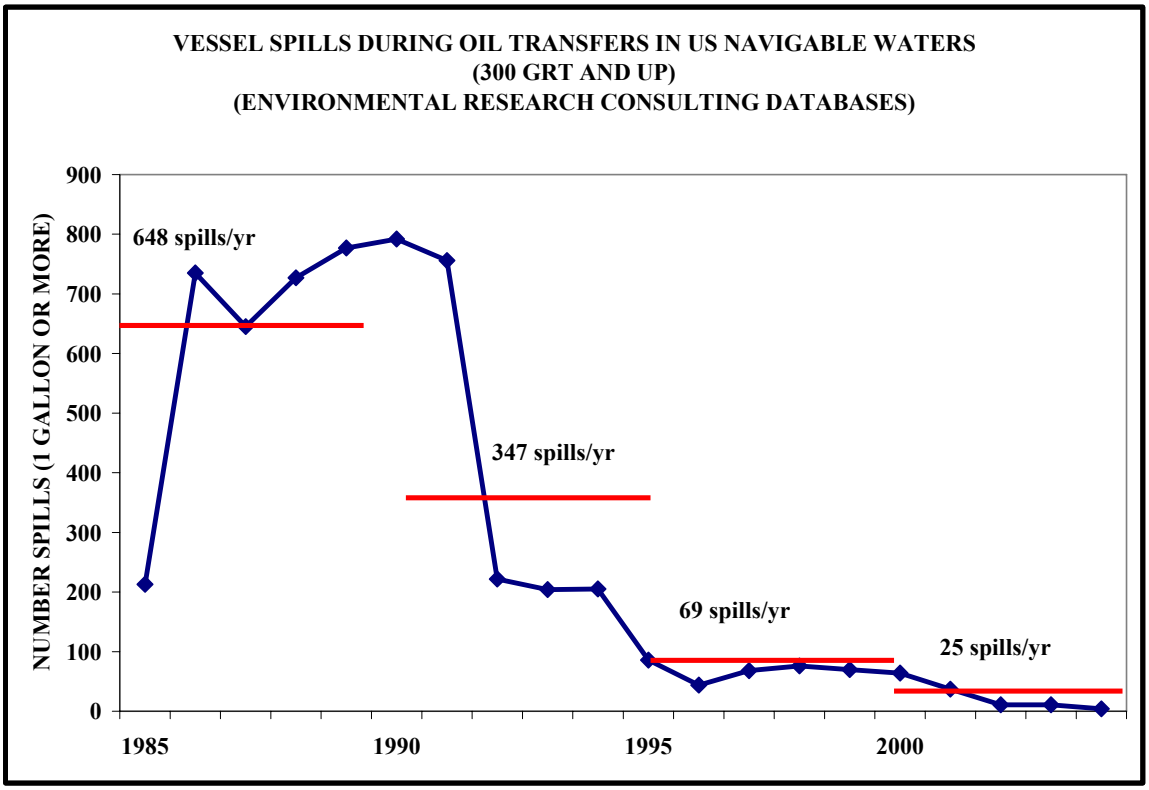


**Figure 9: Numbers of Large-Vessel Oil Spills During Oil Transfer Operations in US Waters**

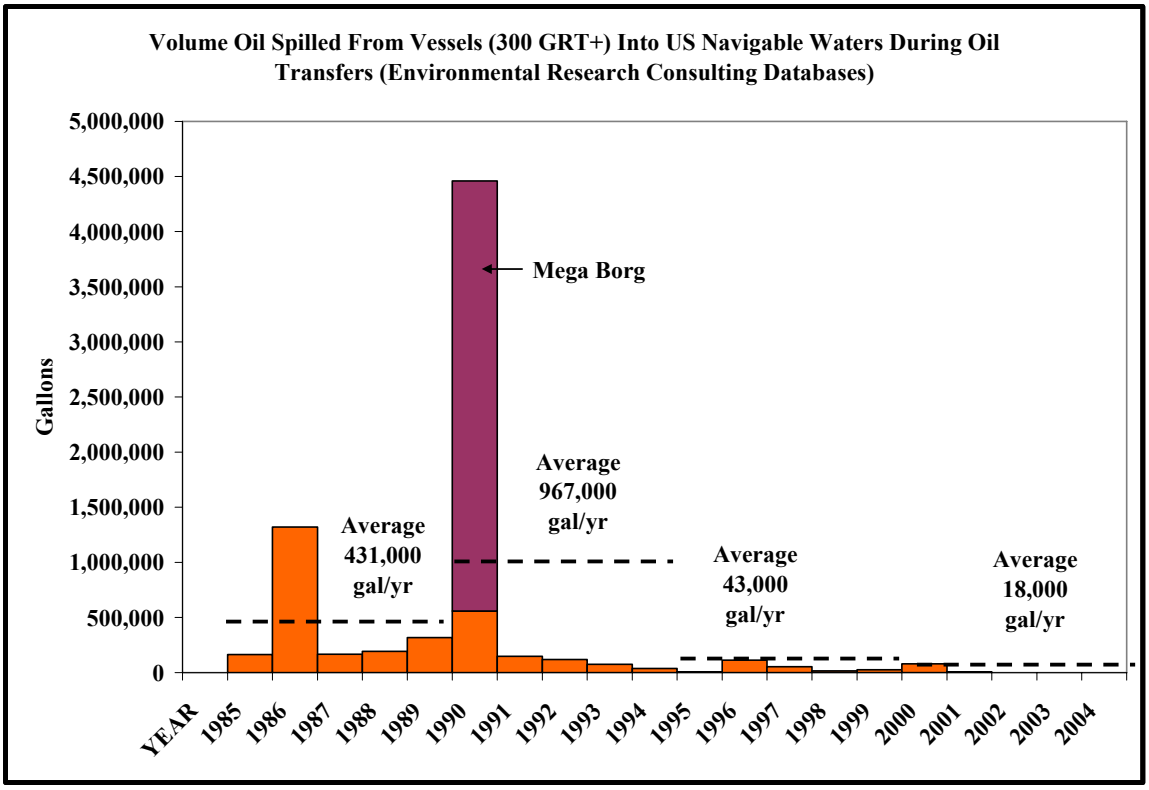


**Figure 10: Annual Volume of Large-Vessel Oil Spills During Oil Transfer Operations in US Waters**

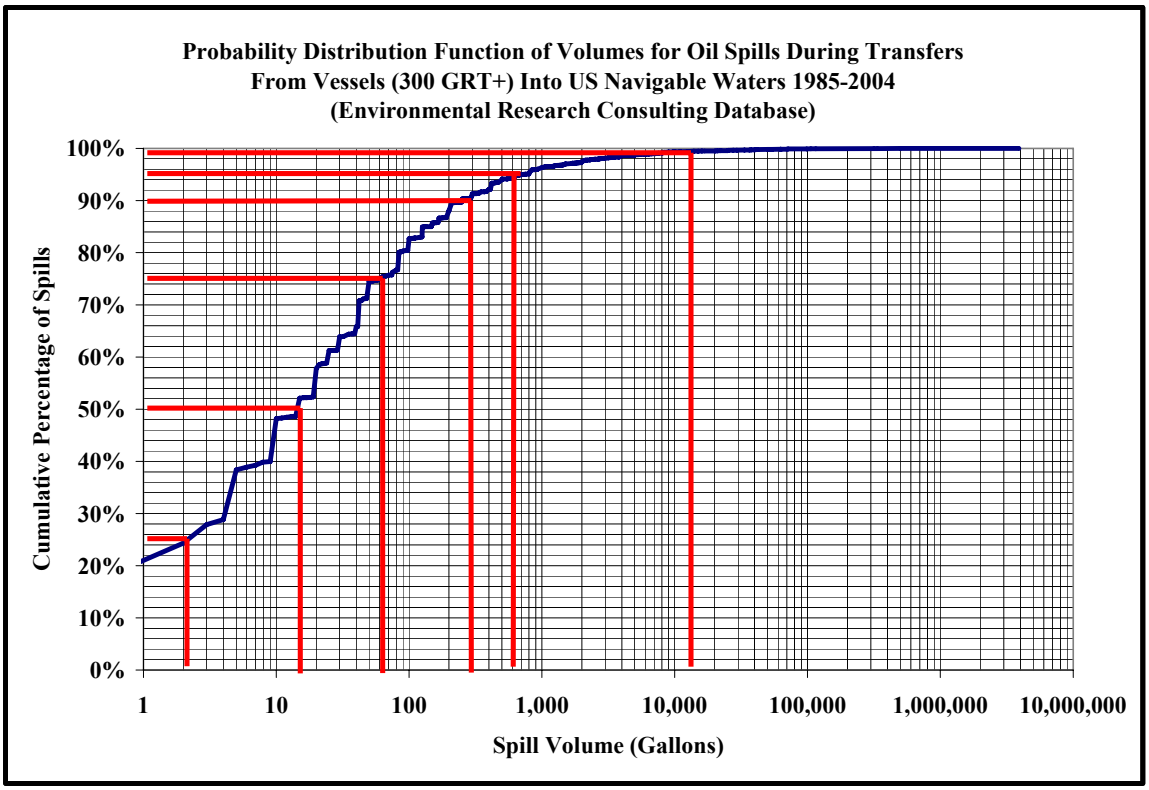


**Figure 11: Probability Distribution Function of US Oil Transfer Spills from Large Vessels**

| Table 8: Spill Volume Probability Distribution - OIL TRANSFER SPILLS ONLY<br>Oil Spills From Vessels (300 GRT+) Into US Navigable Waters 1985 – 2000 | |
|---|---|
| **Percentile Spill** | **Spill Volume** |
| **25th** | 2 gallons |
| **40th** | 8 gallons |
| **50th** | 20 gallons |
| **60th** | 30 gallons |
| **70th** | 60 gallons |
| **75th** | 70 gallons |
| **80th** | 100 gallons |
| **90th** | 300 gallons |
| **95th** | 600 gallons |
| **99th** | 10,000 gallons |
| **100th (worst discharge)** | 3,900,000 gallons |

Half of oil transfer spills were 20 gallons or less. Ninety percent were 300 gallons or less. Five percent of incidents are larger than 600 gallons, one percent over 10,000 gallons.

The conclusions that can be drawn from the analyses of US large-vessel spills as a whole are:

- Oil spillage from large vessels has decreased significantly since 1990. Nearly 20 times more oil was being spilled annually by vessels in before 1990 than is currently being spilled.
- The numbers of spills of 500 gallons or more have decreased since 1990.
- The reporting of smaller spills has increased since 1985, but the incidence of these spills has decreased since 1990.
- The vast majority of spills are very small. Nearly 65 percent of spills are less than 10 gallons, 90 percent are less than 100 gallons.
- Smaller spills (under 100 gallons) make up only 0.7 percent of the total volume spilled.
- The very rare larger spills of one million gallons or more (less than one tenth of one percent in frequency) make up over 42 percent of the total volume spilled.
- Over 67 percent of spills fall into the category of "other operations". Since this category includes all "unknown" causes, it should be noted that some of these spills may actually fit into another category. The numbers and volumes for the other categories are under-estimates for this reason.
- The next largest category in terms of spill number is oil transfer operations, making up 20 percent of all spills. The relative proportion of oil transfer-related spills has decreased from about 50 percent of incidents before 1990 to only 2 or 3 percent of incidents currently.
- The largest volume of spillage is attributable to accidents, most notably the Exxon Valdez spill that makes up 78 percent of the volume spilled in this category. The average accident-related spill is nearly 46,000 gallons in volume.
- Dockside operation-related spills tend to be considerably smaller, averaging 261 gallons.

- Oil transfer-related spills average 1,270 gallons, though this includes on large transfer-related spill of 3.9 million gallons from the T/V Mega Borg in the Gulf of Mexico in 1990.

- Average annual oil transfer-related spill volumes and average annual numbers of incidents in this category have both decreased by 96 percent since before 1990.

## RESULTS FOR WASHINGTON OIL SPILLS

A similar analysis was conducted for large-vessel spills in Washington. Figure 12 shows annual spillage rates from 1985 – 2003 for vessels of 300 GRT and larger. Spills in Washington show an increase in the late 1990s and another decrease after 2000, but otherwise mirror what occurred in the rest of the US.

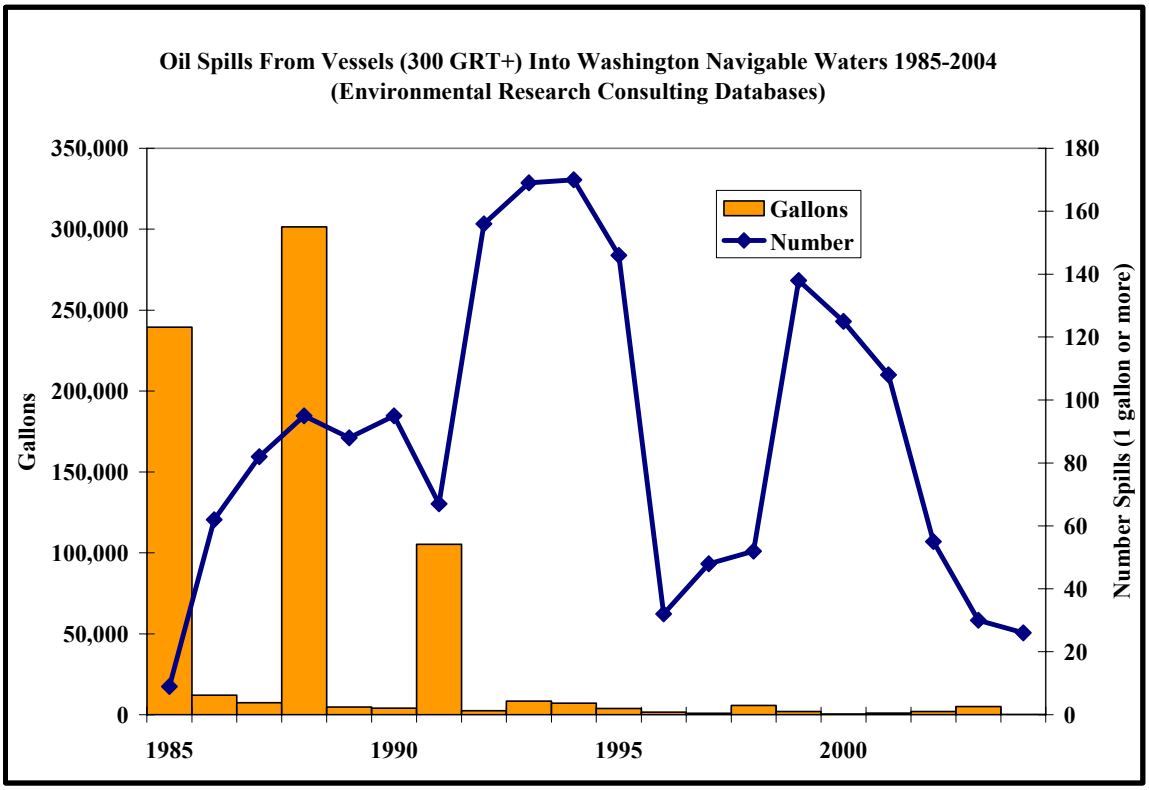


**Figure 12: Oil Spills from Large Vessels into Washington Waters.**

Tables 9 through 13 show detailed data on annual spill numbers, percentages, volumes, and average spill sizes by spill cause. Nearly 15 percent of oil spills were related to oil transfers. The average volume for oil transfer spills is 144 gallons. The largest volume of spillage is attributable to accidents and structural failures. Only 5.2 percent of the volume spilled was from oil transfer-related incidents.

Size classes for oil spills from all sources are shown in Table 14 and Figure 13. Probability distribution functions of all oil spills and oil-transfer related spills are shown in Figures 14 and 15 and summarized in Tables 15 and 16. Over 94 percent of spills from large vessels in Washington over the last 20 years have involved less than 100 gallons. Only 1.3 percent of spills have been over 1,000 gallons in volume.

| Table 9: Numbers of Oil Spills (1 Gallon or More) from Large Vessels (≥300 GRT) into Washington Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 1 | 0 | 0 | 6 | 1 | 1 | **9** |
| **1986** | 0 | 9 | 2 | 0 | 22 | 22 | 7 | **62** |
| **1987** | 0 | 15 | 1 | 1 | 35 | 20 | 10 | **82** |
| **1988** | 2 | 23 | 0 | 3 | 37 | 19 | 11 | **95** |
| **1989** | 0 | 23 | 0 | 1 | 27 | 30 | 7 | **88** |
| **1990** | 0 | 15 | 0 | 1 | 41 | 34 | 4 | **95** |
| **1991** | 2 | 11 | 0 | 1 | 26 | 24 | 3 | **67** |
| **1992** | 1 | 3 | 0 | 1 | 12 | 139 | 0 | **156** |
| **1993** | 0 | 10 | 0 | 0 | 12 | 146 | 1 | **169** |
| **1994** | 0 | 6 | 0 | 2 | 12 | 150 | 0 | **170** |
| **1995** | 0 | 6 | 0 | 1 | 5 | 130 | 4 | **146** |
| **1996** | 0 | 1 | 0 | 0 | 0 | 31 | 0 | **32** |
| **1997** | 0 | 1 | 0 | 0 | 3 | 43 | 1 | **48** |
| **1998** | 0 | 1 | 0 | 1 | 4 | 45 | 1 | **52** |
| **1999** | 1 | 5 | 0 | 2 | 7 | 121 | 2 | **138** |
| **2000** | 0 | 3 | 0 | 0 | 10 | 112 | 0 | **125** |
| **2001** | 0 | 0 | 0 | 0 | 2 | 106 | 0 | **108** |
| **2002** | 0 | 0 | 0 | 0 | 0 | 52 | 3 | **55** |
| **2003** | 0 | 0 | 0 | 0 | 0 | 29 | 1 | **30** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 24 | 2 | **26** |
| **TOTAL** | **6** | **133** | **3** | **14** | **261** | **1,278** | **58** | **1,753** |

| Table 10: Percent Number of Oil Spills from Large Vessels (≥300 GRT) into Washington Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 0.0% | 11.1% | 0.0% | 0.0% | 66.7% | 11.1% | 11.1% |
| **1986** | 0.0% | 14.5% | 3.2% | 0.0% | 35.5% | 35.5% | 11.3% |
| **1987** | 0.0% | 18.3% | 1.2% | 1.2% | 42.7% | 24.4% | 12.2% |
| **1988** | 2.1% | 24.2% | 0.0% | 3.2% | 38.9% | 20.0% | 11.6% |
| **1989** | 0.0% | 26.1% | 0.0% | 1.1% | 30.7% | 34.1% | 8.0% |
| **1990** | 0.0% | 15.8% | 0.0% | 1.1% | 43.2% | 35.8% | 4.2% |
| **1991** | 3.0% | 16.4% | 0.0% | 1.5% | 38.8% | 35.8% | 4.5% |
| **1992** | 0.6% | 1.9% | 0.0% | 0.6% | 7.7% | 89.1% | 0.0% |
| **1993** | 0.0% | 5.9% | 0.0% | 0.0% | 7.1% | 86.4% | 0.6% |
| **1994** | 0.0% | 3.5% | 0.0% | 1.2% | 7.1% | 88.2% | 0.0% |
| **1995** | 0.0% | 4.1% | 0.0% | 0.7% | 3.4% | 89.0% | 2.7% |
| **1996** | 0.0% | 3.1% | 0.0% | 0.0% | 0.0% | 96.9% | 0.0% |
| **1997** | 0.0% | 2.1% | 0.0% | 0.0% | 6.3% | 89.6% | 2.1% |
| **1998** | 0.0% | 1.9% | 0.0% | 1.9% | 7.7% | 86.5% | 1.9% |
| **1999** | 0.7% | 3.6% | 0.0% | 1.4% | 5.1% | 87.7% | 1.4% |
| **2000** | 0.0% | 2.4% | 0.0% | 0.0% | 8.0% | 89.6% | 0.0% |
| **2001** | 0.0% | 0.0% | 0.0% | 0.0% | 1.9% | 98.1% | 0.0% |
| **2002** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 94.5% | 5.5% |
| **2003** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 96.7% | 3.3% |
| **2004** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 92.3% | 7.7% |
| **TOTAL** | **0.3%** | **7.6%** | **0.2%** | **0.8%** | **14.9%** | **72.9%** | **3.3%** |

| Table 11: Volume of Oil Spilled from Large Vessels (≥300 GRT) into Washington Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Volume Oil Spilled (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 5 | 0 | 0 | 337 | 40 | 238,980 | **239,362** |
| **1986** | 0 | 184 | 11 | 0 | 10,922 | 341 | 578 | **12,036** |
| **1987** | 0 | 796 | 40 | 1 | 5,063 | 1,306 | 222 | **7,428** |
| **1988** | 6 | 2,668 | 0 | 54 | 3,074 | 588 | 295,088 | **301,478** |
| **1989** | 0 | 758 | 0 | 1 | 1,037 | 2,930 | 98 | **4,824** |
| **1990** | 0 | 266 | 0 | 1 | 2,519 | 1,277 | 13 | **4,076** |
| **1991** | 100,000 | 120 | 0 | 5 | 1,302 | 3,900 | 31 | **105,358** |
| **1992** | 15 | 11 | 0 | 2 | 205 | 2,308 | 0 | **2,541** |
| **1993** | 0 | 57 | 0 | 0 | 4,272 | 3,923 | 100 | **8,352** |
| **1994** | 0 | 8 | 0 | 7 | 2,555 | 4,545 | 0 | **7,115** |
| **1995** | 0 | 126 | 0 | 15 | 141 | 3,301 | 291 | **3,874** |
| **1996** | 0 | 3 | 0 | 0 | 0 | 1,604 | 0 | **1,607** |
| **1997** | 0 | 10 | 0 | 0 | 260 | 635 | 1 | **906** |
| **1998** | 0 | 5 | 0 | 1 | 5,003 | 769 | 2 | **5,780** |
| **1999** | 10 | 21 | 0 | 3 | 744 | 1,143 | 41 | **1,962** |
| **2000** | 0 | 4 | 0 | 0 | 23 | 372 | 0 | **399** |
| **2001** | 0 | 0 | 0 | 0 | 11 | 1,016 | 0 | **1,027** |
| **2002** | 0 | 0 | 0 | 0 | 0 | 1,956 | 52 | **2,008** |
| **2003** | 0 | 0 | 0 | 0 | 0 | 228 | 4,800 | **5,028** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 146 | 20 | **166** |
| **TOTAL** | **100,031** | **5,042** | **51** | **90** | **37,468** | **32,327** | **540,317** | **715,326** |

| Table 12: Percent Volume of Oil Spilled from Large Vessels (≥300 GRT) into Washington Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 0.0% | 0.0% | 0.0% | 0.0% | 0.1% | 0.0% | 99.8% |
| **1986** | 0.0% | 1.5% | 0.1% | 0.0% | 90.7% | 2.8% | 4.8% |
| **1987** | 0.0% | 10.7% | 0.5% | 0.0% | 68.2% | 17.6% | 3.0% |
| **1988** | 0.0% | 0.9% | 0.0% | 0.0% | 1.0% | 0.2% | 97.9% |
| **1989** | 0.0% | 15.7% | 0.0% | 0.0% | 21.5% | 60.7% | 2.0% |
| **1990** | 0.0% | 6.5% | 0.0% | 0.0% | 61.8% | 31.3% | 0.3% |
| **1991** | 94.9% | 0.1% | 0.0% | 0.0% | 1.2% | 3.7% | 0.0% |
| **1992** | 0.6% | 0.4% | 0.0% | 0.1% | 8.1% | 90.8% | 0.0% |
| **1993** | 0.0% | 0.7% | 0.0% | 0.0% | 51.1% | 47.0% | 1.2% |
| **1994** | 0.0% | 0.1% | 0.0% | 0.1% | 35.9% | 63.9% | 0.0% |
| **1995** | 0.0% | 3.3% | 0.0% | 0.4% | 3.6% | 85.2% | 7.5% |
| **1996** | 0.0% | 0.2% | 0.0% | 0.0% | 0.0% | 99.8% | 0.0% |
| **1997** | 0.0% | 1.1% | 0.0% | 0.0% | 28.7% | 70.1% | 0.1% |
| **1998** | 0.0% | 0.1% | 0.0% | 0.0% | 86.6% | 13.3% | 0.0% |
| **1999** | 0.5% | 1.1% | 0.0% | 0.2% | 37.9% | 58.3% | 2.1% |
| **2000** | 0.0% | 1.0% | 0.0% | 0.0% | 5.8% | 93.2% | 0.0% |
| **2001** | 0.0% | 0.0% | 0.0% | 0.0% | 1.1% | 98.9% | 0.0% |
| **2002** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 97.4% | 2.6% |
| **2003** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 4.5% | 95.5% |
| **2004** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 88.0% | 12.0% |
| **TOTAL** | **14.0%** | **0.7%** | **0.0%** | **0.0%** | **5.2%** | **4.5%** | **75.5%** |

| Table 13: Average Spill Size for Oil Spills from Large Vessels (≥300 GRT) into Washington Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Average Spill Size (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 5 | 0 | 0 | 56 | 40 | 238,980 | **26,596** |
| **1986** | 0 | 20 | 6 | 0 | 496 | 16 | 83 | **194** |
| **1987** | 0 | 53 | 40 | 1 | 145 | 65 | 22 | **91** |
| **1988** | 3 | 116 | 0 | 18 | 83 | 31 | 26,826 | **3,173** |
| **1989** | 0 | 33 | 0 | 1 | 38 | 98 | 14 | **55** |
| **1990** | 0 | 18 | 0 | 1 | 61 | 38 | 3 | **43** |
| **1991** | 50,000 | 11 | 0 | 5 | 50 | 163 | 10 | **1,573** |
| **1992** | 15 | 4 | 0 | 2 | 17 | 17 | 0 | **16** |
| **1993** | 0 | 6 | 0 | 0 | 356 | 27 | 100 | **49** |
| **1994** | 0 | 1 | 0 | 4 | 213 | 30 | 0 | **42** |
| **1995** | 0 | 21 | 0 | 15 | 28 | 25 | 73 | **27** |
| **1996** | 0 | 3 | 0 | 0 | 0 | 52 | 0 | **50** |
| **1997** | 0 | 10 | 0 | 0 | 87 | 15 | 1 | **19** |
| **1998** | 0 | 5 | 0 | 1 | 1,251 | 17 | 2 | **111** |
| **1999** | 10 | 4 | 0 | 2 | 106 | 9 | 21 | **14** |
| **2000** | 0 | 1 | 0 | 0 | 2 | 3 | 0 | **3** |
| **2001** | 0 | 0 | 0 | 0 | 6 | 10 | 0 | **10** |
| **2002** | 0 | 0 | 0 | 0 | 0 | 38 | 17 | **37** |
| **2003** | 0 | 0 | 0 | 0 | 0 | 8 | 4,800 | **168** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 6 | 10 | **6** |
| **TOTAL** | **16,672** | **38** | **17** | **6** | **144** | **25** | **9,316** | **408** |

| Table 14: Size Classes for Oil Spills From Vessels Into Washington Navigable Waters (All Causes) (Environmental Research Consulting Databases) | | | | |
|---|---|---|---|---|
| **Spill Volume** | **Number Spills** | **% Total** | **Volume** | **% Total** |
| **1-9 gallons** | 1,287 | 73.4% | 2,468 | 0.3% |
| **10-99 gallons** | 363 | 20.7% | 9,074 | 1.3% |
| **100-999 gallons** | 80 | 4.6% | 22,425 | 3.1% |
| **1,000-9,999 gallons** | 18 | 1.0% | 47,718 | 6.7% |
| **10,000-99,999 gallons** | 3 | 0.2% | 167,357 | 23.4% |
| **100,000-999,999 gallons** | 2 | 0.1% | 466,284 | 65.2% |
| **1,000,000-9,999,999 gallons** | 0 | 0.0% | 0 | 0.0% |
| **10,000,000 gallons +** | 0 | 0.0% | 0 | 0.0% |
| **TOTAL** | **1,753** | **100.0%** | **715,326** | **100.0%** |

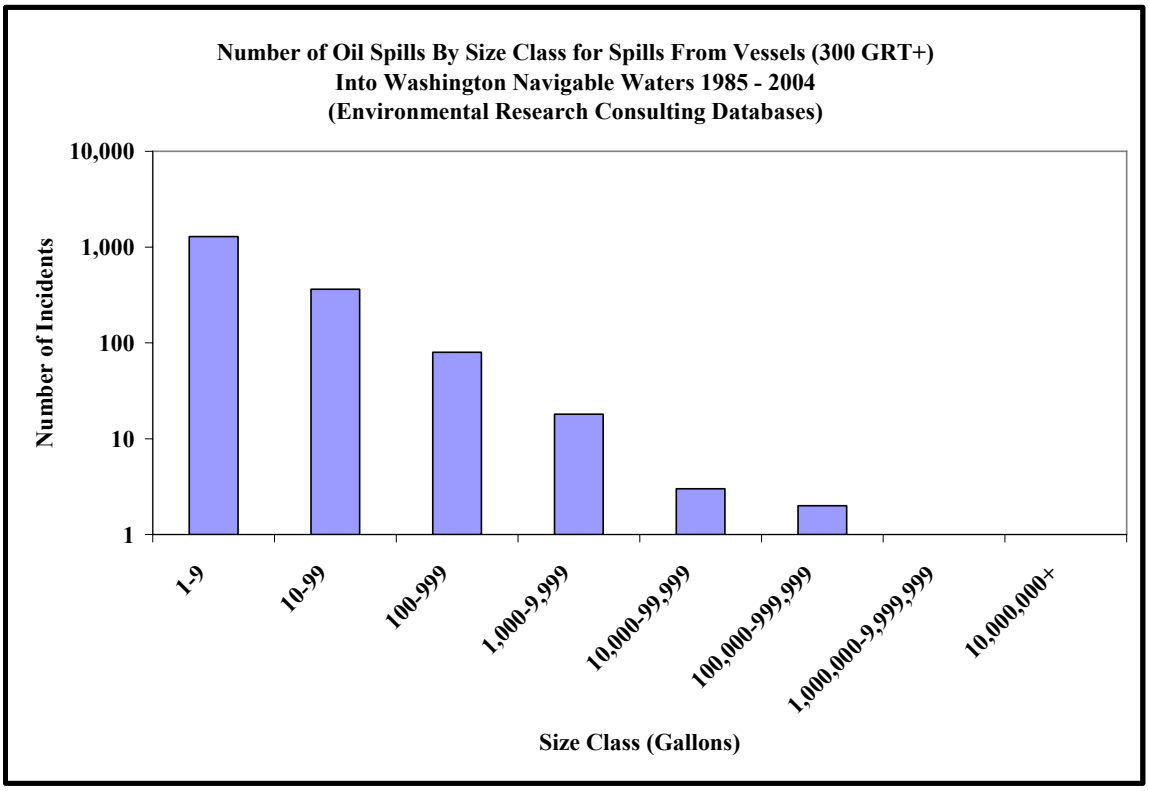


**Figure 13: Oil Spill Size Classes for Washington Large-Vessel Spills 1985 – 2004.**

| Table 15: Spill Volume Probability Distribution –ALL CAUSES Oil Spills From Vessels (300 GRT+) Into Washington Navigable Waters 1985 – 2000 | |
|---|---|
| **Percentile Spill** | **Spill Volume** |
| **25th** | 1 gallon |
| **40th** | 1 gallon |
| **50th** | 1.5 gallons |
| **60th** | 3 gallons |
| **70th** | 5 gallons |
| **75th** | 9.5 gallons |
| **80th** | 10 gallons |
| **90th** | 40 gallons |
| **95th** | 100 gallons |
| **99th** | 3,500 gallons |
| **100th (worst discharge)** | 239,000 gallons |

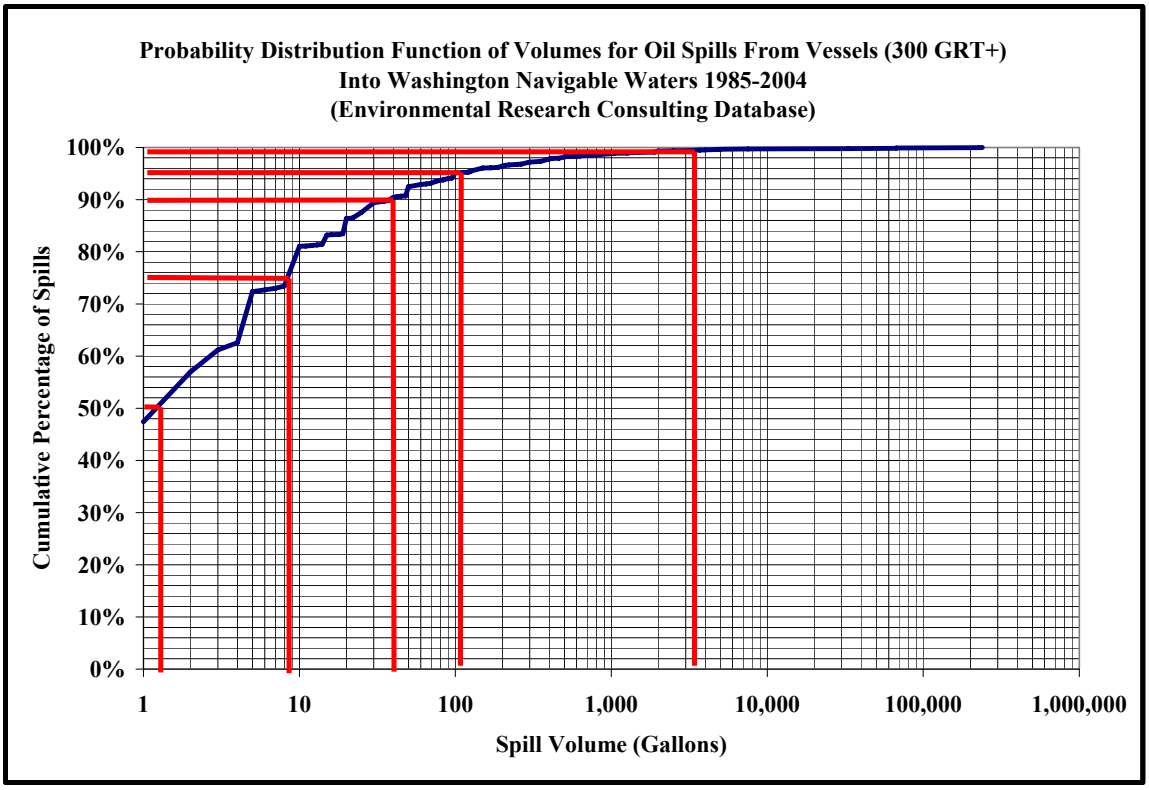


**Figure 14: Probability Distribution Function of Spill Volumes for Washington Large-Vessel Spills.**

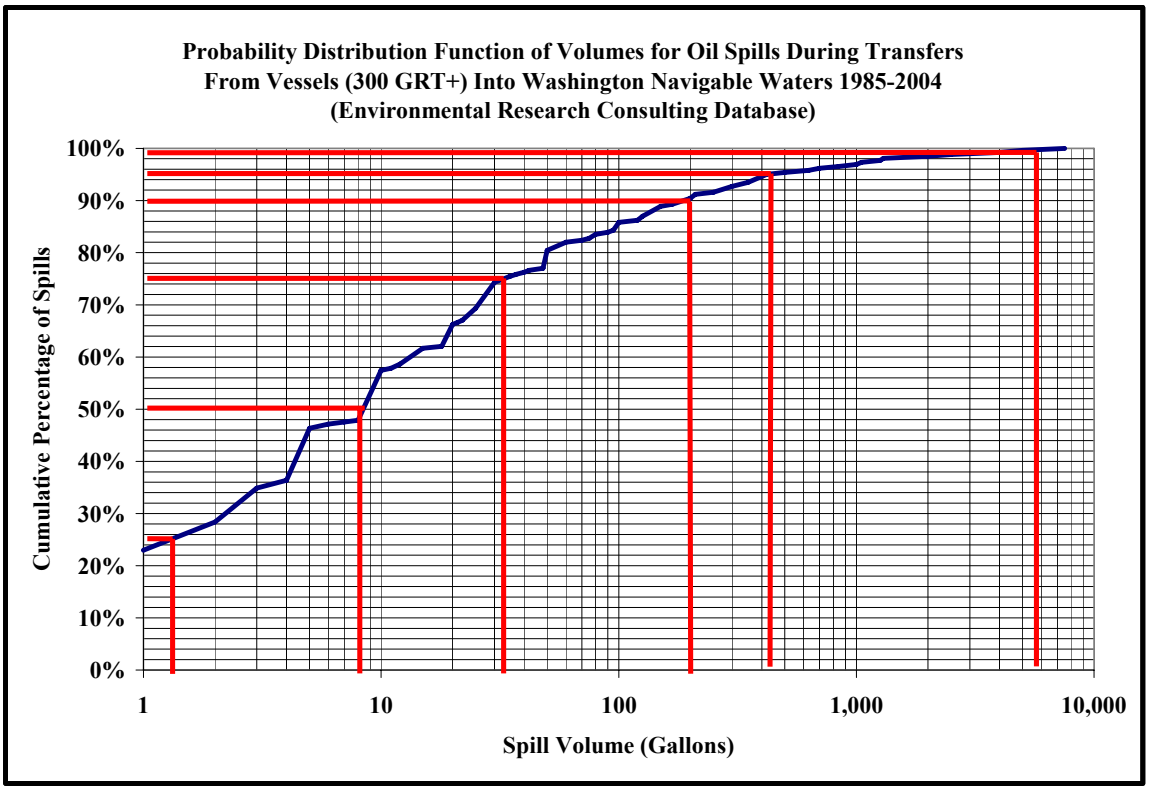


**Figure 15: Probability Distribution Function of Spill Volumes for Washington Large-Vessel Oil Transfer Spills.**

| Table 16: Spill Volume Probability Distribution - OIL TRANSFER SPILLS ONLY<br>Oil Spills From Vessels (300 GRT+) Into Washington Navigable Waters 1985 – 2000 | |
|---|---|
| **Percentile Spill** | **Spill Volume** |
| **25th** | 1 gallon |
| **40th** | 4.5 gallons |
| **50th** | 8 gallons |
| **60th** | 15 gallons |
| **70th** | 25 gallons |
| **75th** | 32 gallons |
| **80th** | 50 gallons |
| **90th** | 200 gallons |
| **95th** | 420 gallons |
| **99th** | 2,000 gallons |
| **100th (worst discharge)** | 7,500 gallons |

Oil transfer-related spillage is shown in Figure 16. There has been a 92 percent reduction in the number of spills and over 99 percent reduction in average annual volume spilled since 1985.

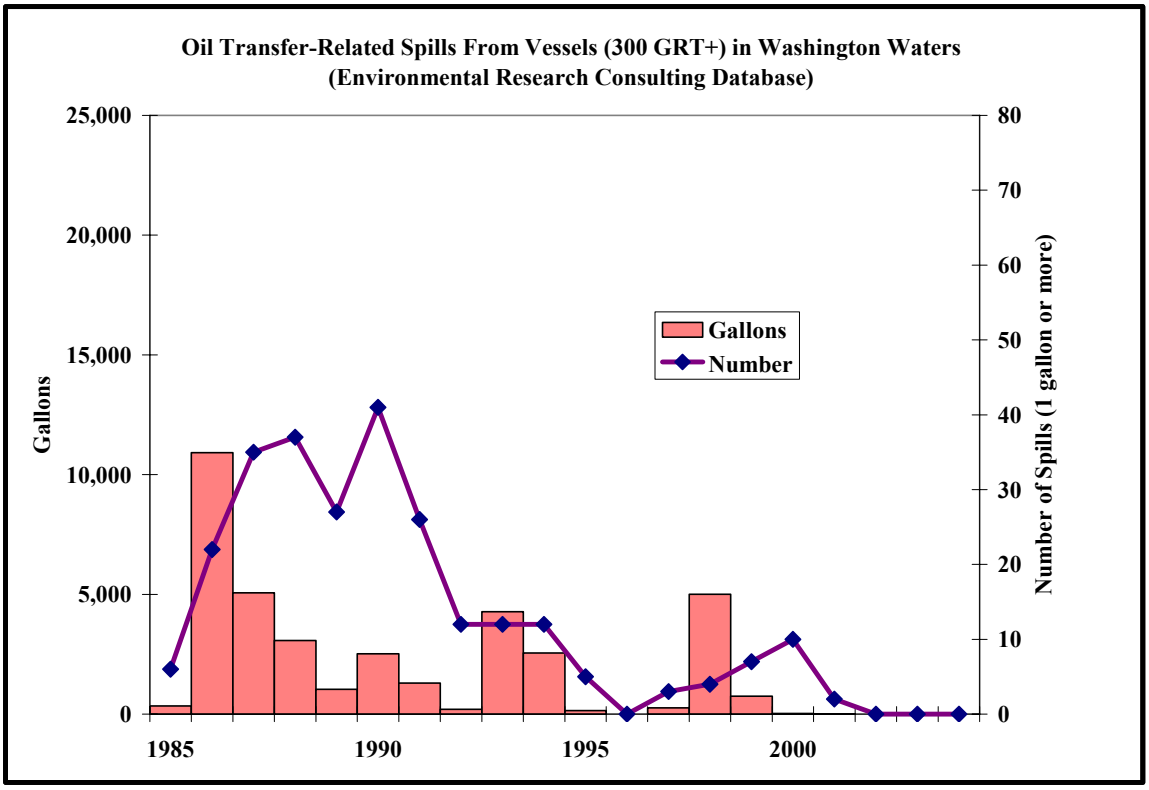


**Figure 16: Oil-Transfer Spills from Large Vessels in Washington Waters**

The conclusions that can be drawn from the analyses of Washington large-vessel spills are:

- Oil spillage from large vessels has decreased significantly since 1990.
- Spill volumes have been dominated by a few large (over 200,000-gallon) spills, the 1985 T/V Arco Anchorage spill of 239,000 gallons and the 1988 T/B Nestucca spill of 227,000 gallons. The very rare larger spills of 200,000 gallons or more (one tenth of one percent in frequency) make up over 65 percent of the total volume spilled.

- The vast majority of spills are very small. Over 73 percent of spills are less than 10 gallons, 94 percent are less than 100 gallons. Smaller spills (under 100 gallons) make up only 1.6 percent of the total volume spilled.

- After "other operations", which includes spills of unknown cause, the next largest category in terms of spill number is oil transfer operations, making up 15 percent of all large-vessel spills in Washington.

- Oil transfer-related spills averaged 144 gallons. The largest spill related to oil transfers was 7,500 gallons. Average annual oil transfer-related spill volumes have decreased by over 99 percent and average annual numbers of incidents in this category have decreased by 92 percent since before 1990.

**RESULTS FOR CALIFORNIA OIL SPILLS**

A similar analysis was conducted for spills in California waters. Figure 17 shows large-vessel spills in California waters from all causes.

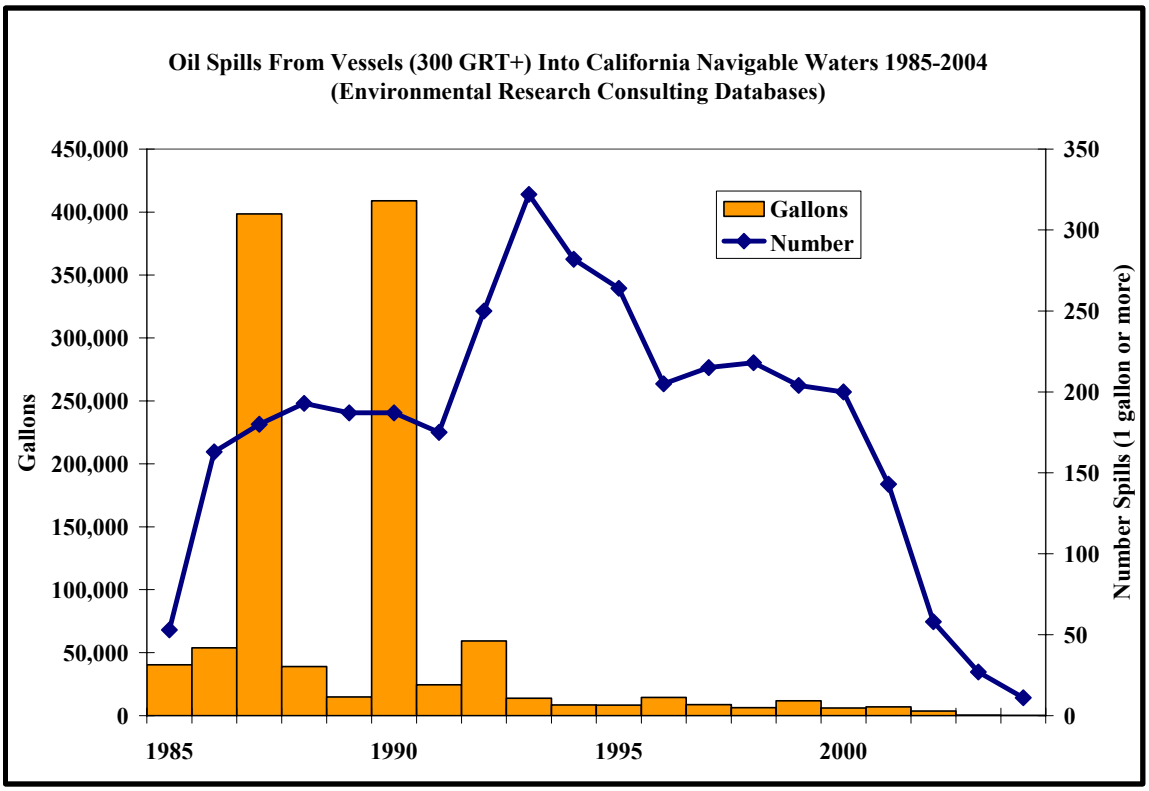


**Figure 17: Oil Spills from Large Vessels in California Waters.**

The spill volumes are dominated by two large spills – the 1990 T/V American Trader spill of 397,000 gallons and the 1987 spill of 339,000 gallons from the M/V Pac Baroness. Spill numbers rose until 1993 and then reduced sharply thereafter. Tables 17 through 21 show detailed data on annual spill numbers, percentages, volumes, and average spill sizes by spill cause. Nearly 13 percent of oil spills were related to oil transfers. The average volume for oil transfer spills is 148 gallons. The largest volume of spillage is attributable to accidents and structural failures. Only six percent of the volume spilled was from oil transfer-related incidents.

| Table 17: Numbers of Oil Spills (1 Gallon or More) from Large Vessels (≥300 GRT) into California Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 13 | 0 | 0 | 21 | 14 | 5 | **53** |
| **1986** | 3 | 26 | 0 | 2 | 67 | 59 | 6 | **163** |
| **1987** | 5 | 31 | 1 | 2 | 51 | 72 | 18 | **180** |
| **1988** | 4 | 31 | 6 | 0 | 63 | 64 | 25 | **193** |
| **1989** | 6 | 45 | 2 | 1 | 56 | 53 | 24 | **187** |
| **1990** | 4 | 39 | 0 | 3 | 66 | 44 | 31 | **187** |
| **1991** | 1 | 31 | 1 | 0 | 53 | 69 | 20 | **175** |
| **1992** | 1 | 3 | 0 | 0 | 8 | 238 | 0 | **250** |
| **1993** | 0 | 5 | 0 | 1 | 12 | 304 | 0 | **322** |
| **1994** | 0 | 4 | 0 | 1 | 10 | 266 | 1 | **282** |
| **1995** | 1 | 4 | 0 | 1 | 9 | 245 | 4 | **264** |
| **1996** | 0 | 5 | 0 | 0 | 10 | 190 | 0 | **205** |
| **1997** | 0 | 5 | 1 | 0 | 5 | 203 | 1 | **215** |
| **1998** | 2 | 4 | 2 | 0 | 8 | 198 | 4 | **218** |
| **1999** | 1 | 8 | 0 | 0 | 8 | 186 | 1 | **204** |
| **2000** | 1 | 8 | 0 | 1 | 5 | 181 | 4 | **200** |
| **2001** | 1 | 7 | 0 | 0 | 3 | 132 | 0 | **143** |
| **2002** | 0 | 0 | 0 | 0 | 1 | 54 | 3 | **58** |
| **2003** | 0 | 0 | 1 | 0 | 2 | 24 | 0 | **27** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 11 | 0 | **11** |
| **TOTAL** | **30** | **269** | **14** | **12** | **458** | **2,607** | **147** | **3,537** |

| Table 18: Percent Number of Oil Spills from Large Vessels (≥300 GRT) into California Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 0.0% | 24.5% | 0.0% | 0.0% | 39.6% | 26.4% | 9.4% |
| **1986** | 1.8% | 16.0% | 0.0% | 1.2% | 41.1% | 36.2% | 3.7% |
| **1987** | 2.8% | 17.2% | 0.6% | 1.1% | 28.3% | 40.0% | 10.0% |
| **1988** | 2.1% | 16.1% | 3.1% | 0.0% | 32.6% | 33.2% | 13.0% |
| **1989** | 3.2% | 24.1% | 1.1% | 0.5% | 29.9% | 28.3% | 12.8% |
| **1990** | 2.1% | 20.9% | 0.0% | 1.6% | 35.3% | 23.5% | 16.6% |
| **1991** | 0.6% | 17.7% | 0.6% | 0.0% | 30.3% | 39.4% | 11.4% |
| **1992** | 0.4% | 1.2% | 0.0% | 0.0% | 3.2% | 95.2% | 0.0% |
| **1993** | 0.0% | 1.6% | 0.0% | 0.3% | 3.7% | 94.4% | 0.0% |
| **1994** | 0.0% | 1.4% | 0.0% | 0.4% | 3.5% | 94.3% | 0.4% |
| **1995** | 0.4% | 1.5% | 0.0% | 0.4% | 3.4% | 92.8% | 1.5% |
| **1996** | 0.0% | 2.4% | 0.0% | 0.0% | 4.9% | 92.7% | 0.0% |
| **1997** | 0.0% | 2.3% | 0.5% | 0.0% | 2.3% | 94.4% | 0.5% |
| **1998** | 0.9% | 1.8% | 0.9% | 0.0% | 3.7% | 90.8% | 1.8% |
| **1999** | 0.5% | 3.9% | 0.0% | 0.0% | 3.9% | 91.2% | 0.5% |
| **2000** | 0.5% | 4.0% | 0.0% | 0.5% | 2.5% | 90.5% | 2.0% |
| **2001** | 0.7% | 4.9% | 0.0% | 0.0% | 2.1% | 92.3% | 0.0% |
| **2002** | 0.0% | 0.0% | 0.0% | 0.0% | 1.7% | 93.1% | 5.2% |
| **2003** | 0.0% | 0.0% | 3.7% | 0.0% | 7.4% | 88.9% | 0.0% |
| **2004** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 100.0% | 0.0% |
| **TOTAL** | **0.8%** | **7.6%** | **0.4%** | **0.3%** | **12.9%** | **73.7%** | **4.2%** |

| Table 19: Volume of Oil Spilled from Large Vessels (≥300 GRT) into California Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Volume Oil Spilled (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 192 | 0 | 0 | 4,052 | 36,002 | 70 | **40,316** |
| **1986** | 307 | 36,443 | 0 | 11 | 4,119 | 13,005 | 60 | **53,945** |
| **1987** | 385 | 2,602 | 30 | 52 | 5,003 | 11,147 | 379,306 | **398,525** |
| **1988** | 121 | 154 | 297 | 0 | 4,861 | 30,213 | 3,480 | **39,126** |
| **1989** | 131 | 1,351 | 125 | 5 | 7,672 | 3,444 | 2,148 | **14,876** |
| **1990** | 397,269 | 1,887 | 0 | 31 | 8,335 | 995 | 560 | **409,077** |
| **1991** | 1 | 462 | 20 | 0 | 20,940 | 2,429 | 648 | **24,500** |
| **1992** | 35,000 | 12 | 0 | 0 | 815 | 23,648 | 0 | **59,475** |
| **1993** | 0 | 363 | 0 | 1 | 447 | 13,024 | 0 | **13,835** |
| **1994** | 0 | 12 | 0 | 1 | 263 | 8,253 | 3 | **8,532** |
| **1995** | 2 | 63 | 0 | 10 | 1,914 | 6,309 | 132 | **8,430** |
| **1996** | 0 | 23 | 0 | 0 | 2,132 | 12,446 | 0 | **14,601** |
| **1997** | 0 | 58 | 1 | 0 | 272 | 8,377 | 25 | **8,733** |
| **1998** | 27 | 34 | 2 | 0 | 566 | 5,678 | 34 | **6,341** |
| **1999** | 1 | 2,143 | 0 | 0 | 809 | 8,826 | 50 | **11,829** |
| **2000** | 100 | 112 | 0 | 3 | 83 | 5,684 | 74 | **6,056** |
| **2001** | 1 | 422 | 0 | 0 | 5,510 | 963 | 0 | **6,896** |
| **2002** | 0 | 0 | 0 | 0 | 42 | 3,649 | 21 | **3,712** |
| **2003** | 0 | 0 | 10 | 0 | 9 | 279 | 0 | **298** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 144 | 0 | **144** |
| **TOTAL** | **433,345** | **46,333** | **485** | **114** | **67,844** | **194,515** | **386,611** | **1,129,247** |

| Table 20: Percent Volume of Oil Spilled from Large Vessels (≥300 GRT) into California Waters By Cause (Environmental Research Consulting Databases) | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Year** | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** |
| **1985** | 0.0% | 0.5% | 0.0% | 0.0% | 10.1% | 89.3% | 0.2% |
| **1986** | 0.6% | 67.6% | 0.0% | 0.0% | 7.6% | 24.1% | 0.1% |
| **1987** | 0.1% | 0.7% | 0.0% | 0.0% | 1.3% | 2.8% | 95.2% |
| **1988** | 0.3% | 0.4% | 0.8% | 0.0% | 12.4% | 77.2% | 8.9% |
| **1989** | 0.9% | 9.1% | 0.8% | 0.0% | 51.6% | 23.2% | 14.4% |
| **1990** | 97.1% | 0.5% | 0.0% | 0.0% | 2.0% | 0.2% | 0.1% |
| **1991** | 0.0% | 1.9% | 0.1% | 0.0% | 85.5% | 9.9% | 2.6% |
| **1992** | 58.8% | 0.0% | 0.0% | 0.0% | 1.4% | 39.8% | 0.0% |
| **1993** | 0.0% | 2.6% | 0.0% | 0.0% | 3.2% | 94.1% | 0.0% |
| **1994** | 0.0% | 0.1% | 0.0% | 0.0% | 3.1% | 96.7% | 0.0% |
| **1995** | 0.0% | 0.7% | 0.0% | 0.1% | 22.7% | 74.8% | 1.6% |
| **1996** | 0.0% | 0.2% | 0.0% | 0.0% | 14.6% | 85.2% | 0.0% |
| **1997** | 0.0% | 0.7% | 0.0% | 0.0% | 3.1% | 95.9% | 0.3% |
| **1998** | 0.4% | 0.5% | 0.0% | 0.0% | 8.9% | 89.5% | 0.5% |
| **1999** | 0.0% | 18.1% | 0.0% | 0.0% | 6.8% | 74.6% | 0.4% |
| **2000** | 1.7% | 1.8% | 0.0% | 0.0% | 1.4% | 93.9% | 1.2% |
| **2001** | 0.0% | 6.1% | 0.0% | 0.0% | 79.9% | 14.0% | 0.0% |
| **2002** | 0.0% | 0.0% | 0.0% | 0.0% | 1.1% | 98.3% | 0.6% |
| **2003** | 0.0% | 0.0% | 3.4% | 0.0% | 3.0% | 93.7% | 0.0% |
| **2004** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 100.0% | 0.0% |
| **TOTAL** | **38.4%** | **4.1%** | **0.0%** | **0.0%** | **6.0%** | **17.2%** | **34.2%** |

| Table 21: Average Spill Size for Oil Spills from Large Vessels (≥300 GRT) into California Waters (Environmental Research Consulting Databases) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Year** | **Average Spill Size (Gallons)** | | | | | | | |
| | **Accident** | **Dockside Operations** | **Fire/Explosion** | **Non-Oil Cargo Transfer** | **Oil Transfer** | **Other Operations** | **Structural Failure** | **All** |
| **1985** | 0 | 15 | 0 | 0 | 193 | 2,572 | 14 | **761** |
| **1986** | 102 | 1,402 | 0 | 6 | 61 | 220 | 10 | **331** |
| **1987** | 77 | 84 | 30 | 26 | 98 | 155 | 21,073 | **2,214** |
| **1988** | 30 | 5 | 50 | 0 | 77 | 472 | 139 | **203** |
| **1989** | 22 | 30 | 63 | 5 | 137 | 65 | 90 | **80** |
| **1990** | 99,317 | 48 | 0 | 10 | 126 | 23 | 18 | **2,188** |
| **1991** | 1 | 15 | 20 | 0 | 395 | 35 | 32 | **140** |
| **1992** | 35,000 | 4 | 0 | 0 | 102 | 99 | 0 | **238** |
| **1993** | 0 | 73 | 0 | 1 | 37 | 43 | 0 | **43** |
| **1994** | 0 | 3 | 0 | 1 | 26 | 31 | 3 | **30** |
| **1995** | 2 | 16 | 0 | 10 | 213 | 26 | 33 | **32** |
| **1996** | 0 | 5 | 0 | 0 | 213 | 66 | 0 | **71** |
| **1997** | 0 | 12 | 1 | 0 | 54 | 41 | 25 | **41** |
| **1998** | 14 | 9 | 1 | 0 | 71 | 29 | 9 | **29** |
| **1999** | 1 | 268 | 0 | 0 | 101 | 47 | 50 | **58** |
| **2000** | 100 | 14 | 0 | 3 | 17 | 31 | 19 | **30** |
| **2001** | 1 | 60 | 0 | 0 | 1,837 | 7 | 0 | **48** |
| **2002** | 0 | 0 | 0 | 0 | 42 | 68 | 7 | **64** |
| **2003** | 0 | 0 | 10 | 0 | 4 | 12 | 0 | **11** |
| **2004** | 0 | 0 | 0 | 0 | 0 | 13 | 0 | **13** |
| **TOTAL** | **14,445** | **172** | **35** | **10** | **148** | **75** | **2,630** | **319** |

Spill size classes are shown in Table 22 and Figure 18.

| Table 22: Size Classes for Oil Spills From Vessels Into California Navigable Waters (All Causes) (Environmental Research Consulting Databases) | | | | |
|---|---|---|---|---|
| **Spill Volume** | **Number Spills** | **% Total Number** | **Volume** | **% Total Volume** |
| **1-9 gallons** | 2,467 | 4,986 | 69.7% | 0.4% |
| **10-99 gallons** | 800 | 23,667 | 22.6% | 2.1% |
| **100-999 gallons** | 214 | 59,185 | 6.1% | 5.2% |
| **1,000-9,999 gallons** | 45 | 105,908 | 1.3% | 9.4% |
| **10,000-99,999 gallons** | 9 | 198,905 | 0.3% | 17.6% |
| **100,000-999,999 gallons** | 2 | 736,596 | 0.1% | 65.2% |
| **1,000,000-9,999,999 gallons** | 0 | 0 | 0.0% | 0.0% |
| **10,000,000 gallons +** | 0 | 0 | 0.0% | 0.0% |
| **TOTAL** | **3,537** | **1,129,247** | **100.0%** | **100.0%** |

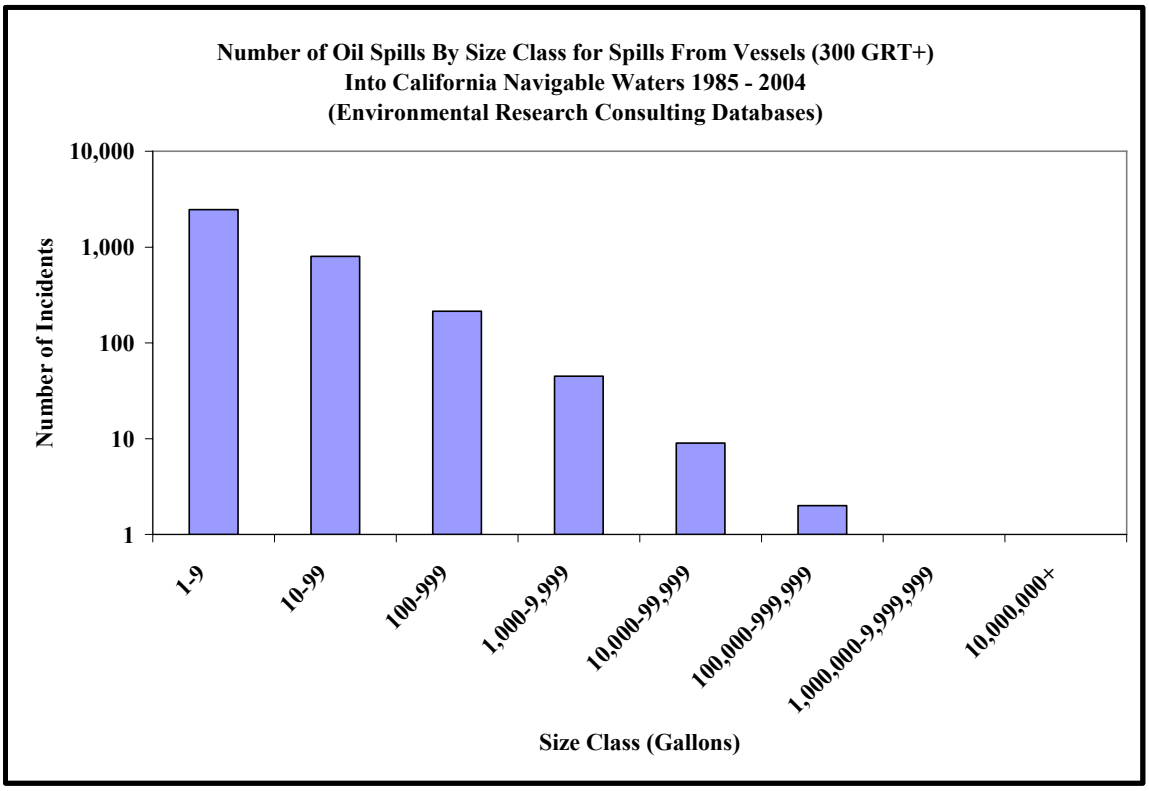


**Figure 18: Number of Oil Spills by Size Class for California Large-Vessel Spills 1985 – 2004.**

Nearly 70 percent of spills involve less than 10 gallons, 92 percent less than 100 gallons. These small spills make up only 2.5 percent of the total volume spilled. The rare (occurring one tenth of one percent of the time) spills of over 300,000 gallons make up 65 percent of the total volume spilled since 1985.

The probability distribution function of spill volumes for large-vessel spills in California is shown in Figure 19 and summarized in Table 23.

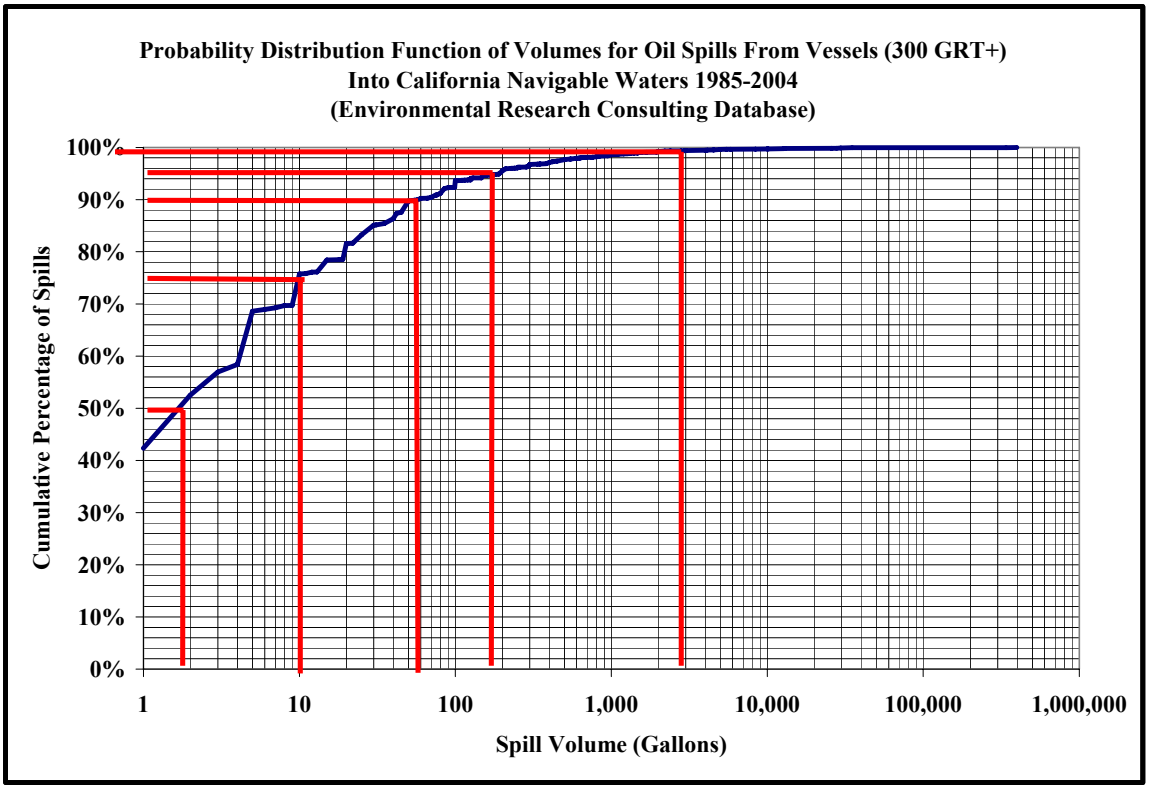


**Figure 19: Probability Distribution Function of Large-Vessel Oil Spills in California 1985 – 2004.**

| **Table 23: Spill Volume Probability Distribution - ALL SPILL CAUSES<br>Oil Spills From Vessels (300 GRT+) Into California Navigable Waters 1985 – 2000** | |
|---|---|
| **Percentile Spill** | **Spill Volume** |
| **25th** | 1gallon |
| **40th** | 1 gallon |
| **50th** | 2 gallons |
| **60th** | 4 gallons |
| **70th** | 9 gallons |
| **75th** | 10 gallons |
| **80th** | 20 gallons |
| **90th** | 60 gallons |
| **95th** | 160 gallons |
| **99th** | 3,000 gallons |
| **100th (worst discharge)** | 397,000 gallons |

Spillage related to oil transfers is shown in Figure 20. There is a sharp drop in both volume and number of oil transfer-related spills in 1993. A probability distribution for spill volumes related to oil transfer spills in California is shown in Figure 21 and Table 24. Half of oil transfer spills in California in the last 20 years were less than 12 gallons in volume. Ninety percent were less than 200 gallons. The largest oil transfer-related spill involved the spillage of 13,000 gallons.

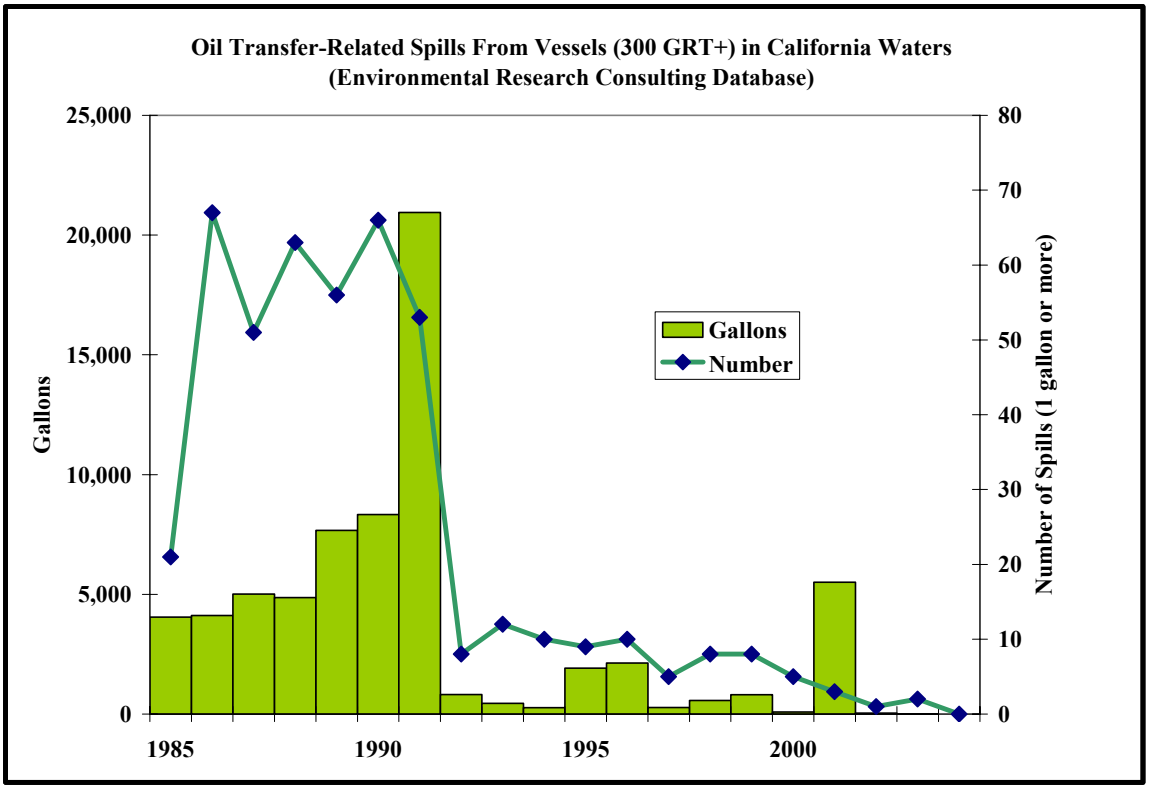


**Figure 20: Oil Spillage from Large Vessels During Oil Transfers in California Waters.**

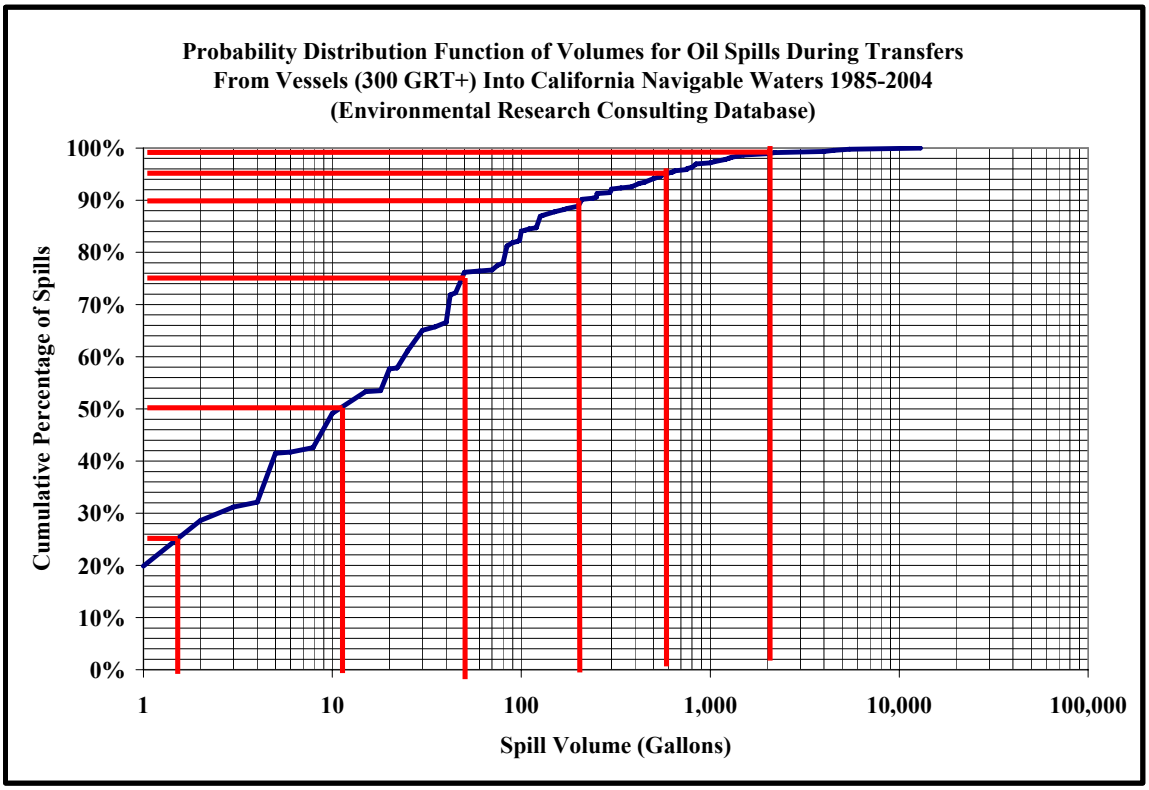


**Figure 21: Probability Distribution Function of Oil Transfer Spills from Large Vessels in California 1985 – 2004.**

| Table 24: Spill Volume Probability Distribution - OIL TRANSFER SPILLS ONLY<br>Oil Spills From Vessels (300 GRT+) Into California Navigable Waters 1985 – 2000 | |
|---|---|
| **Percentile Spill** | **Spill Volume** |
| **25th** | 1.5 gallons |
| **40th** | 5 gallons |
| **50th** | 12 gallons |
| **60th** | 24 gallons |
| **70th** | 40 gallons |
| **75th** | 50 gallons |
| **80th** | 80 gallons |
| **90th** | 200 gallons |
| **95th** | 500 gallons |
| **99th** | 2,000 gallons |
| **100th (worst discharge)** | 13,000 gallons |

The conclusions that can be drawn from the analyses of California large-vessel spills are:

- Spill numbers have decreased since 1993, while spill volumes have decreased since 1990.
- The spill volumes are dominated by two large spills – the 1990 T/V American Trader spill of 397,000 gallons and the 1987 spill of 339,000 gallons from the M/V Pac Baroness.
- Nearly 13 percent of oil spills were related to oil transfers. Only six percent of the volume spilled was from oil transfer-related incidents.
- The average volume for oil transfer spills is 148 gallons.
- The largest volume of spillage is attributable to accidents and structural failures.

**OIL TRANSFER SPILLAGE ANALYSIS FOR CALIFORNIA, US, AND WASHINGTON**
Oil transfer spills were compared for California, Washington, and the US as a whole. When spill rates were normalized[9], as in Figure 22, it is apparent that relative spill rates for oil transfer spills have followed roughly the same pattern in the US and in both Washington and California.

Table 25 shows the average annual volume of oil spilled from vessels due to all causes and during oil transfers for the US as a whole, for California, and for Washington. This same data was normalized relative to the average volume of the 20-year period, as shown in Table 26. Table 27 shows the percent changes in average annual oil spillage due to all causes and during the course of oil transfers.

The best measure of spill *prevention* is the *number* of spill incidents, rather than total volume spilled. Spill volume is usually more a reflection of the degree to which source control or spill containment reduced the amount of oil that left the source and entered the water. The number of spills is seen to increase after OPA 90, but this is due to the increase in reporting of small spills. This can be corrected for by considering only spills of 500 gallons or more.

[9] Numbers and rates are "normalized" to make comparisons more equivalent. The spill number is divided by the average or total of all spills in a category to get a relative proportion of total spills for each spill category – US, California, and Washington.

The volume of oil spilled after OPA 90 decreased in the US and in both states. The average spill volume also decreased to 10 percent of the previous volume.

For oil transfer spills, the number of incidents decreased after OPA 90, but also decreased from the post-OPA 90, pre-California transfer rule (1990 – 1994) time period to after the 1995 rule time period throughout the US by 86 percent. In California, the reduction in the number of oil transfer incidents was 76 percent. In Washington, the reduction was 81 percent. In terms of a reduction in the volume of spillage, there was a 68 percent reduction in the volume spilled from oil transfers in the US. In California and Washington, there were 80 percent and 70 percent reductions in volume, respectively. Thus, there was no decrease in California in the number of incidents relative to the rest of the US, but there was a greater reduction in volume. Washington also had a much higher reduction in spill volume from transfers than the US overall in this time period, though not as high as California (Tables 25 – 27). Spill Volume distributions are shown in Table 28 – 31.

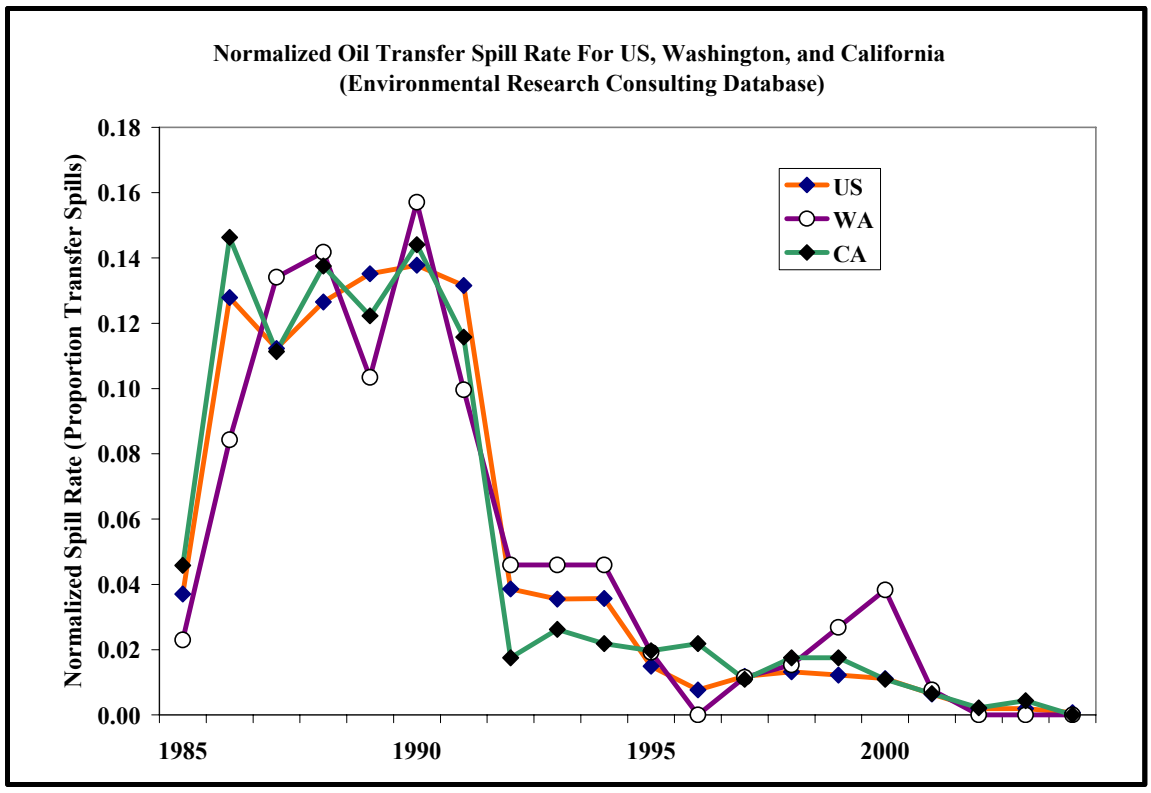


**Figure 22: Normalized Oil Transfer Rates for Large-Vessel Spills in the US, California, and Washington.**

Comparing California and all the states except California, as shown in Figure 23 and Table 32, it can be seen that the number of oil transfer-related spills decreased by 81 percent in California, compared to 79 percent in the rest of the US after OPA 90. The reduction in spills from the post-OPA 90, but pre-California transfer rule time period (*i.e.*, 1991 – 1994) was higher in the rest of the US than in California. The total volume of spillage from oil transfer spills showed a significantly higher decrease in the California than the rest of the US. The average annual volume of oil transfer spills decreased by 80 percent in California, compared with a two percent decrease in the rest of the US.

| Table 25: Average Annual Oil Spillage From Vessels (300 GRT+) Into Navigable Waters (Environmental Research Consulting Database) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | Spills All Causes | | | | | | | | | Oil Transfer Spills Only | | | | | | | | |
| | Number Spills | | | Volume (gal) | | | Average Volume (gal) | | | Number Spills | | | Volume (gal) | | | Average Volume (gal) | | |
| | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA |
| 1985 – 1990 Pre-OPA 90 | 1,373 | 161 | 72 | 5,399,482 | 159,311 | 94,867 | 3,912 | 963 | 5,025 | 648 | 54 | 28 | 1,103,026 | 5,674 | 3,825 | 1,521 | 115 | 147 |
| 1991 – 2004 Post-OPA 90 | 1,456 | 184 | 94 | 411,159 | 12,384 | 10,437 | 358 | 61 | 152 | 133 | 10 | 7 | 48,646 | 2,414 | 1,037 | 489 | 222 | 151 |
| 1991 – 1994 Pre-CA Rule | 2,012 | 257 | 141 | 656,416 | 26,586 | 30,842 | 345 | 113 | 420 | 347 | 21 | 16 | 94,506 | 5,616 | 2,084 | 319 | 140 | 159 |
| 1995 – 2004 Post-CA Rule | 1,234 | 155 | 76 | 313,056 | 6,704 | 2,276 | 363 | 40 | 45 | 47 | 5 | 3 | 30,302 | 1,134 | 618 | 557 | 255 | 148 |
| 1985 – 2004 All Years | 1,431 | 177 | 88 | 1,907,656 | 56,462 | 35,766 | 1,424 | 331 | 1,614 | 287 | 23 | 13 | 364,960 | 3,392 | 1,873 | 799 | 190 | 150 |

| Table 26: Average Annual Oil Spillage From Vessels (300 GRT+) Into Navigable Waters – Normalized Data[10] (Environmental Research Consulting Database) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | Spills All Causes | | | | | | | | | Oil Transfer Spills Only | | | | | | | | |
| | Number Spills | | | Volume (gal) | | | Average Volume (gal) | | | Number Spills | | | Volume (gal) | | | Average Volume (gal) | | |
| | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA |
| 1985 – 1990 Pre-OPA 90 | 0.96 | 0.91 | 0.82 | 2.83 | 2.82 | 2.65 | 2.75 | 2.91 | 3.11 | 2.26 | 2.35 | 2.15 | 3.02 | 1.67 | 2.04 | 1.90 | 0.61 | 0.98 |
| 1991 – 2004 Post-OPA 90 | 1.02 | 1.04 | 1.07 | 0.22 | 0.22 | 0.29 | 0.25 | 0.18 | 0.09 | 0.46 | 0.43 | 0.54 | 0.13 | 0.71 | 0.55 | 0.61 | 1.17 | 1.01 |
| 1991 – 1994 Pre-CA Rule | 1.41 | 1.45 | 1.60 | 0.34 | 0.47 | 0.86 | 0.24 | 0.34 | 0.26 | 1.21 | 0.91 | 1.23 | 0.26 | 1.66 | 1.11 | 0.40 | 0.74 | 1.06 |
| 1995 – 2004 Post-CA Rule | 0.86 | 0.88 | 0.86 | 0.16 | 0.12 | 0.06 | 0.25 | 0.12 | 0.03 | 0.16 | 0.22 | 0.23 | 0.08 | 0.33 | 0.33 | 0.70 | 1.34 | 0.99 |
| 1985 – 2004 All Years | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

[10] Normalized to average of 1985 – 2004.

| Table 27: Changes in Average Annual Oil Spillage From Vessels (300 GRT+) Into Navigable Waters With OPA 90 and California Transfer Rule (1995) (Environmental Research Consulting Database) | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Years** | **Spills All Causes** | | | | | | | | | **Oil Transfer Spills Only** | | | | | | | | |
| | **Number Spills** | | | **Volume (gal)** | | | **Avg. Volume (gal)** | | | **Number Spills** | | | **Volume (gal)** | | | **Avg. Volume (gal)** | | |
| | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** |
| **1985 – 1990 Pre-OPA 90** | 1,373 | 161 | 72 | 5,399,482 | 159,311 | 94,867 | 3,912 | 963 | 5,025 | 648 | 54 | 28 | 1,103,026 | 5,674 | 3,825 | 1,521 | 115 | 147 |
| **1991 – 2004 Post-OPA 90** | 1,456 | 184 | 94 | 411,159 | 12,384 | 10,437 | 358 | 61 | 152 | 133 | 10 | 7 | 48,646 | 2,414 | 1,037 | 489 | 222 | 151 |
| **% Change** | **6%** | **14%** | **31%** | **-92%** | **-92%** | **-89%** | **-91%** | **-94%** | **-97%** | **-79%** | **-81%** | **-75%** | **-96%** | **-57%** | **-73%** | **-68%** | **93%** | **3%** |
| **1991 – 1994 Pre-CA Rule** | 2,012 | 257 | 141 | 656,416 | 26,586 | 30,842 | 345 | 113 | 420 | 347 | 21 | 16 | 94,506 | 5,616 | 2,084 | 319 | 140 | 159 |
| **1995 – 2004 Post-CA Rule** | 1,234 | 155 | 76 | 313,056 | 6,704 | 2,276 | 363 | 40 | 45 | 47 | 5 | 3 | 30,302 | 1,134 | 618 | 557 | 255 | 148 |
| **% Change** | **-39%** | **-40%** | **-46%** | **-52%** | **-75%** | **-93%** | **5%** | **-65%** | **-89%** | **-86%** | **-76%** | **-81%** | **-68%** | **-80%** | **-70%** | **75%** | **82%** | **-7%** |
| **1985 – 2004 All Years** | 1,431 | 177 | 88 | 1,907,656 | 56,462 | 35,766 | 1,424 | 331 | 1,614 | 287 | 23 | 13 | 364,960 | 3,392 | 1,873 | 799 | 190 | 150 |

| Table 28: Oil Spills From Vessels (300 GRT+) Into Navigable Waters – ALL CAUSES<br>Total Spills By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** |
| **1-9 gallons** | 3,552 | 469 | 225 | 14,938 | 1,998 | 1,062 | 5,373 | 750 | 441 | 9,610 | 1,248 | 621 | 18,535 | 2,467 | 1,287 |
| **10-99 gallons** | 3,190 | 350 | 156 | 4,135 | 450 | 207 | 2,050 | 217 | 98 | 2085 | 233 | 109 | 7,325 | 800 | 363 |
| **100-999 gallons** | 1,087 | 115 | 38 | 976 | 99 | 42 | 491 | 51 | 15 | 485 | 48 | 27 | 2,063 | 214 | 80 |
| **1,000-9,999 gallons** | 266 | 21 | 9 | 220 | 24 | 9 | 103 | 8 | 6 | 117 | 16 | 3 | 486 | 45 | 18 |
| **10,000-99,999 gallons** | 102 | 6 | 1 | 65 | 3 | 2 | 27 | 3 | 2 | 38 | 0 | 0 | 167 | 9 | 3 |
| **100,000-999,999 gallons** | 36 | 0 | 2 | 8 | 0 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 44 | 2 | 2 |
| **1,000,000-9,999,999 gallons** | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| **10,000,000 gallons +** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **TOTAL** | **8,236** | **961** | **431** | **20,342** | **2,574** | **1,322** | **8,047** | **1,029** | **562** | **12,340** | **1,545** | **760** | **28,623** | **3,537** | **1,753** |

| Table 29: Oil Spills From Vessels (300 GRT+) Into Navigable Waters – OIL TRANSFER SPILLS ONLY<br>Total Spills By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** |
| **1-9 gallons** | 1,421 | 131 | 72 | 877 | 65 | 49 | 615 | 37 | 32 | 262 | 28 | 17 | 2,298 | 195 | 125 |
| **10-99 gallons** | 1,667 | 136 | 65 | 657 | 46 | 30 | 542 | 32 | 22 | 115 | 14 | 8 | 2,324 | 182 | 95 |
| **100-999 gallons** | 645 | 51 | 21 | 249 | 16 | 9 | 180 | 11 | 6 | 69 | 5 | 3 | 894 | 67 | 32 |
| **1,000-9,999 gallons** | 125 | 6 | 6 | 65 | 6 | 3 | 45 | 2 | 2 | 20 | 4 | 1 | 193 | 13 | 9 |
| **10,000-99,999 gallons** | 25 | 0 | 0 | 10 | 1 | 0 | 5 | 1 | 0 | 5 | 0 | 0 | 32 | 1 | 0 |
| **100,000-999,999 gallons** | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 |
| **1,000,000-9,999,999 gallons** | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **10,000,000 gallons +** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | **3,889** | **324** | **164** | **1,858** | **134** | **91** | **1,387** | **83** | **62** | **471** | **51** | **29** | **5,747** | **458** | **261** |

| Table 30: Oil Spills From Vessels (300 GRT+) Into Navigable Waters – ALL CAUSES<br>Percent Total Spills By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** |
| **1-9 gallons** | 43% | 49% | 52% | 73% | 78% | 80% | 67% | 73% | 78% | 78% | 81% | 82% | 65% | 70% | 73% |
| **10-99 gallons** | 39% | 36% | 36% | 20% | 17% | 16% | 25% | 21% | 17% | 17% | 15% | 14% | 26% | 23% | 21% |
| **100-999 gallons** | 13% | 12% | 9% | 5% | 4% | 3% | 6% | 5% | 3% | 4% | 3% | 4% | 7% | 6% | 5% |
| **1,000-9,999 gallons** | 3% | 2% | 2% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 0% | 2% | 1% | 1% |
| **10,000-99,999 gallons** | 1% | 1% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 0% | 0% |
| **100,000-999,999 gallons** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **1,000,000-9,999,999 gallons** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **10,000,000 gallons +** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **TOTAL** | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

| Table 31: Oil Spills From Vessels (300 GRT+) Into Navigable Waters – OIL TRANSFER SPILLS ONLY<br>Percent Total Spills By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** | **US** | **CA** | **WA** |
| **1-9 gallons** | 37% | 40% | 44% | 47% | 49% | 54% | 44% | 45% | 52% | 56% | 55% | 59% | 40% | 43% | 48% |
| **10-99 gallons** | 43% | 42% | 40% | 35% | 34% | 33% | 39% | 39% | 35% | 24% | 27% | 28% | 40% | 40% | 36% |
| **100-999 gallons** | 17% | 16% | 13% | 13% | 12% | 10% | 13% | 13% | 10% | 15% | 10% | 10% | 16% | 15% | 12% |
| **1,000-9,999 gallons** | 3% | 2% | 4% | 3% | 4% | 3% | 3% | 2% | 3% | 4% | 8% | 3% | 3% | 3% | 3% |
| **10,000-99,999 gallons** | 1% | 0% | 0% | 1% | 1% | 0% | 0% | 1% | 0% | 1% | 0% | 0% | 1% | 0% | 0% |
| **100,000-999,999 gallons** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **1,000,000-9,999,999 gallons** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **10,000,000 gallons +** | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| **TOTAL** | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |

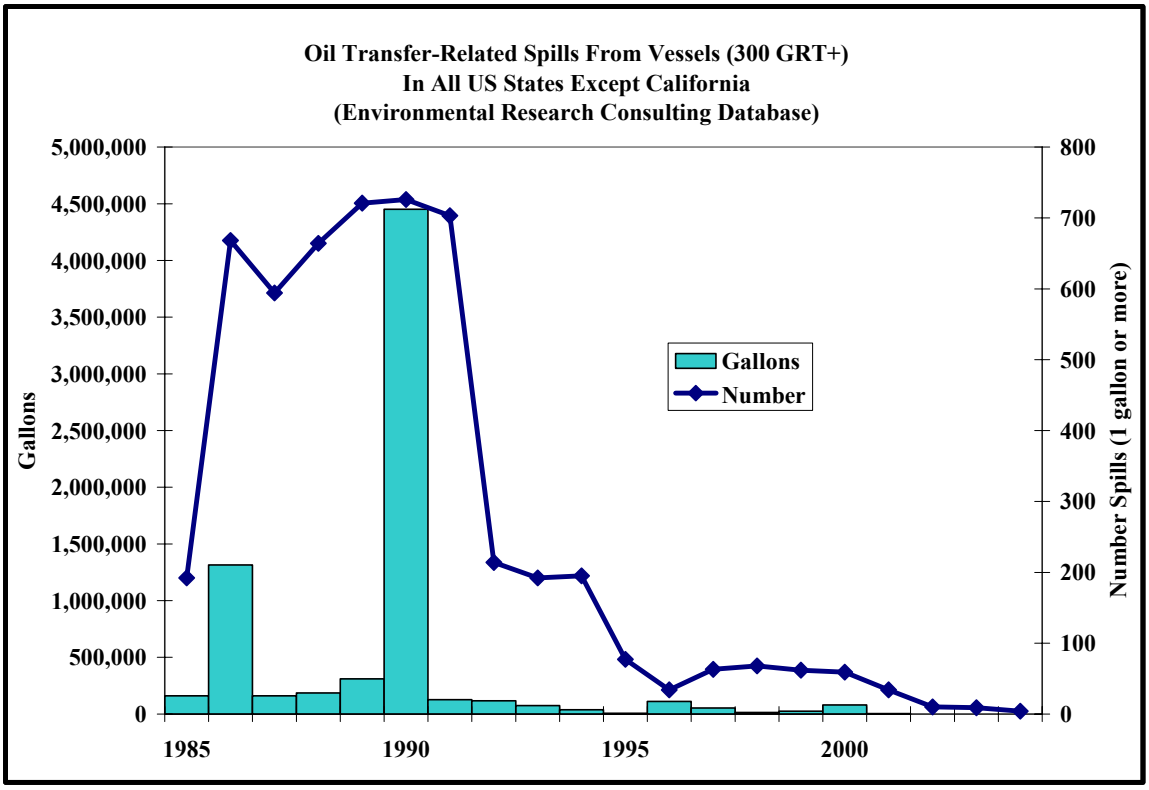


**Figure 23: Oil Transfer-Related Spills from Large Vessels for All US States Except California**

**Table 32: Average Annual Oil Transfer-Related Spillage from Vessels (300 GRT+)**
**(Environmental Research Consulting Database)**

| Years | Number Spills | | Volume (gal) | | Average Volume (gal) | |
|---|---|---|---|---|---|---|
| | CA | US w/o CA | CA | US w/o CA | CA | US w/o CA |
| **1985 – 1990 Pre-OPA 90** | 54 | 594 | 5,674 | 1,097,352 | 115 | 1,653 |
| **1991 – 2004 Post-OPA 90** | 10 | 123 | 2,414 | 1,091,701 | 222 | 1,544 |
| **% Change With OPA 90** | **-81%** | **-79%** | **-57%** | **-1%** | **93%** | **-7%** |
| **1991 – 1994 Pre-CA Rule** | 21 | 326 | 5,616 | 891,904 | 140 | 1,306 |
| **1995 – 2004 Post-CA Rule** | 5 | 42 | 1,134 | 877,449 | 255 | 1,326 |
| **% Change With CA Rule** | **-76%** | **-87%** | **-80%** | **-2%** | **82%** | **2%** |
| **1985 – 2004 All Years** | 23 | 264 | 3,392 | 852,645 | 190 | 1,311 |

The pre- and post- California transfer rule distribution of spill volumes in California is shown in Figure 24 and Table 33. There were more smaller spills (1 – 9 gallons) after the rule. There was also a slight increase in the relative number of spills of 100 – 999 gallons, but no spills of 1,000 gallons or more, compared to the rest of the US, which had nearly 5 percent of spills involving more 1,000 gallons or more and 2.4 percent involving 10,000 gallons or more (Tables 36 and 37).

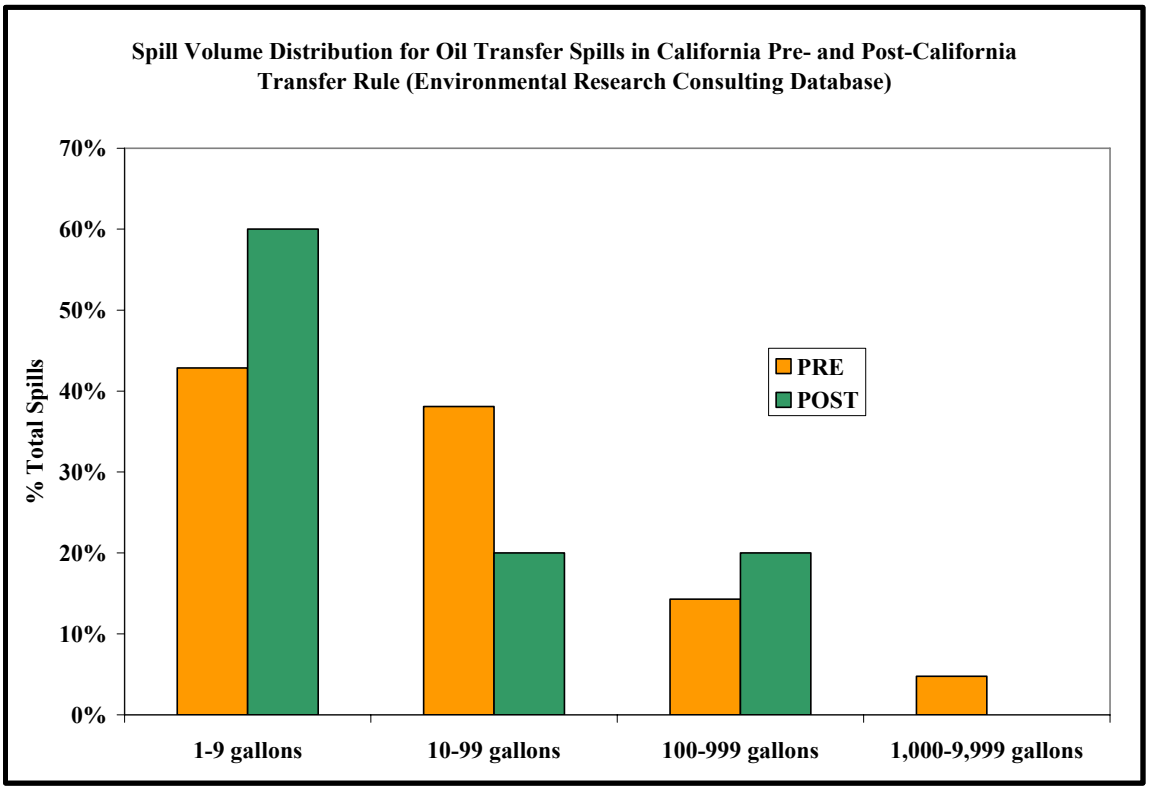


**Figure 24: Spill Volume Distribution of Oil Transfer-Related Spills from Large Vessels – Comparison of California and All Other States Pre- and Post-California Transfer Rule**

| Table 33: Spill Volume Distribution for Oil Transfer Spills in California Waters (Environmental Research Consulting Database) | | | | | | |
|---|---|---|---|---|---|---|
| Spill Volume | Pre-CA Rule 1991 – 1994 | | | Post-CA Rule 1995 – 2004 | | |
| | US | CA | US w/o CA | US | CA | US w/o CA |
| **1-9 gallons** | 44.4% | 42.9% | 44.5% | 55.3% | 60.0% | 54.8% |
| **10-99 gallons** | 39.2% | 38.1% | 39.3% | 25.5% | 20.0% | 23.8% |
| **100-999 gallons** | 13.0% | 14.3% | 12.9% | 14.9% | 20.0% | 14.3% |
| **1,000-9,999 gallons** | 3.2% | 4.8% | 3.4% | 4.3% | 0.0% | 4.8% |
| **10,000-99,999 gallons** | 0.3% | 0.0% | 0.3% | 2.1% | 0.0% | 2.4% |
| **100,000-999,999 gallons** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **1,000,000-9,999,999 gallons** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **10,000,000 gallons +** | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |

| Table 34: Annual Average Number of Oil Spills From Vessels (300 GRT+) Into Navigable Waters – ALL CAUSES<br>By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** |
| **1-9 gallons** | 592 | 78 | 514 | 1,067 | 143 | 924 | 1,343 | 188 | 1,156 | 961 | 125 | 836 | 927 | 123 | 803 |
| **10-99 gallons** | 532 | 58 | 473 | 295 | 32 | 263 | 513 | 54 | 458 | 209 | 23 | 185 | 366 | 40 | 326 |
| **100-999 gallons** | 181 | 19 | 162 | 70 | 7 | 63 | 123 | 13 | 110 | 49 | 5 | 44 | 103 | 11 | 92 |
| **1,000-9,999 gallons** | 44 | 4 | 41 | 16 | 2 | 14 | 26 | 2 | 24 | 12 | 2 | 10 | 24 | 2 | 22 |
| **10,000-99,999 gallons** | 17 | 1 | 16 | 5 | 0 | 4 | 7 | 1 | 6 | 4 | 0 | 4 | 8 | 0 | 8 |
| **100,000-999,999 gallons** | 6 | 0 | 6 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 2 |
| **1,000,000-9,999,999 gallons** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **10,000,000 gallons +** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | 1,373 | 160 | 1,213 | 1,453 | 184 | 1,269 | 2,012 | 257 | 1,755 | 1,234 | 155 | 1,080 | 1,431 | 177 | 1,254 |

| Table 35: Annual Average Number of Oil Spills From Vessels (300 GRT+) Into Navigable Waters – OIL TRANSFER SPILLS ONLY<br>By Size Class<br>(Environmental Research Consulting Database) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Spill Volume** | **Pre-OPA 90** | | | **Post-OPA 90** | | | **Pre-CA Rule** | | | **Post-CA Rule** | | | **All Years** | | |
| | **1985 – 1990** | | | **1991 – 2004** | | | **1991 – 1994** | | | **1995 – 2004** | | | **1985 – 2004** | | |
| | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** | **US** | **CA** | **US w/o CA** |
| **1-9 gallons** | 237 | 22 | 215 | 63 | 5 | 58 | 154 | 9 | 145 | 26 | 3 | 23 | 115 | 10 | 105 |
| **10-99 gallons** | 278 | 23 | 255 | 47 | 3 | 44 | 136 | 8 | 128 | 12 | 1 | 10 | 116 | 9 | 107 |
| **100-999 gallons** | 108 | 9 | 99 | 18 | 1 | 17 | 45 | 3 | 42 | 7 | 1 | 6 | 45 | 3 | 41 |
| **1,000-9,999 gallons** | 21 | 1 | 20 | 5 | 0 | 4 | 11 | 1 | 11 | 2 | 0 | 2 | 10 | 1 | 9 |
| **10,000-99,999 gallons** | 4 | 0 | 4 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 2 |
| **100,000-999,999 gallons** | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **1,000,000-9,999,999 gallons** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **10,000,000 gallons +** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **TOTAL** | 648 | 54 | 594 | 133 | 10 | 123 | 347 | 21 | 326 | 47 | 5 | 42 | 287 | 23 | 264 |

## SPILLAGE PER OIL TRANSFER ANALYSIS

### Washington

Accurate and complete data on oil transfers in Washington waters was not available. According to a study conducted by Reichert (2005) of self-reported data from facility and vessel operators, annual fixed facility transfers performed 2,706 transfers and vessels handled 847 transfers in six months[11], totaling 7,106 transfers between vessels, and between vessels and facilities each year.

These estimates of oil transfers totaled 3.37 billion gallons of oil over six months or 6.74 billion gallons over one year. Of this, 38.5 percent was crude oil, 21 percent was heavy oil, and 40.5 percent was light refined products. This self-reported data is likely an underestimate in terms of volume, because the Western States Petroleum Association reported that 11 billion gallons of oil (crude and refined) was transported to and from refineries in Washington in 2003.

Another estimation method is to look at vessel transits and the amount of oil (cargo and bunkers) being transported through Washington waters (Tables 36 – 37). In the year 2000, 9.5 billion gallons of oil was transported in 5,303 vessel trips through Puget Sound and 2.2 billion gallons through the Columbia River in 1,850 vessel trips for a total of 11.7 billion gallons

**Table 36 Vessel and Oil Movements Through Puget Sound (2000)**

| Vessel Type | Vessel Size | Oil Movement Per Transit (gallons) | | | Transits Per Year |
|---|---|---|---|---|---|
| | | Crude Oil | Refined | Bunker | |
| **Crude tankers (laden)** | <75,000 DWT | 16,844,000 | -- | 352,200 | 79 |
| | 75,000-110,000 DWT | 22,000,000 | -- | 396,300 | 81 |
| | >110,000 DWT | 32,718,000 | -- | 660,450 | 138 |
| **Crude tankers (ballast)** | avg. 67,000 DWT | -- | -- | 352,200 | 6 |
| **Product tankers (laden)** | avg. 22,000 DWT | -- | 4,376,000 | 330,200 | 12 |
| | avg. 55,000 DWT | -- | 10,941,000 | 176,100 | 23 |
| **Product tankers (ballast)** | avg. 22,000 DWT | -- | -- | 330,200 | 20 |
| | avg. 55,000 DWT | -- | -- | 176,100 | 179 |
| **Product barges (laden)** | avg. 6,000 DWT | -- | 1,910,000 | 47,000 | 5 |
| | avg. 12,000 DWT | -- | 3,819,000 | 47,000 | 18 |
| **Bulk carriers** | <50,000 DWT | -- | -- | 143,100 | 1,913 |
| | 50,000-100,000 DWT | -- | -- | 242,200 | 501 |
| | >100,000 DWT | -- | -- | 440,300 | 122 |
| **Bulk liquid carriers** | | -- | -- | 176,100 | 186 |
| **Containerships** | <2,500 TEU | -- | -- | 264,200 | 435 |
| | 2,500-4,000 TEU | -- | -- | 484,300 | 510 |
| | >4,000 TEU | -- | -- | 825,600 | 394 |
| **Vehicle carriers** | | -- | -- | 297,200 | 316 |
| **Factory fishing vessels** | 300-3,000 GRT | -- | -- | 54,000 | 59 |
| | >3,000 GRT | -- | -- | 165,100 | 112 |
| **Fishing boats** | >300 GRT | -- | -- | 26,400 | 167 |
| **Passenger vessels** | 300-3000 GRT | -- | -- | 52,800 | 16 |
| | >3,000 GRT | -- | -- | 140,900 | 11 |

Etkin 2001b, adapted from Herbert Engineering, et al. 1999. Some of the vessel transits through the Puget Sound go directly to the port of Vancouver, British Columbia, and do not involve any transfers within Washington waters.

[11] December 2004 through May 2005.

| Table 37: Vessel and Oil Movements Through Columbia River (to Portland, Oregon) (1999) | | | | | |
|---|---|---|---|---|---|
| **Vessel Type** | **Vessel Size** | **Transits Per Year** | **Estimated Oil Per Transit (gallons)** | | |
| | | | **Crude Oil** | **Refined** | **Bunker** |
| **Crude tankers (laden)** | <75,000 DWT | 12 | 16,844,000 | -- | 352,200 |
| | 75,000-110,000 DWT | 12 | 22,000,000 | -- | 396,300 |
| | >110,000 DWT | 0 | 32,718,000 | -- | 660,450 |
| **Crude tankers (ballast)** | avg. 67,000 DWT | 24 | -- | -- | 352,200 |
| **Product tankers (laden)** | avg. 22,000 DWT | 38 | -- | 4,376,000 | 330,200 |
| | avg. 55,000 DWT | 54 | -- | 10,941,000 | 176,100 |
| **Product tankers (ballast)** | avg. 22,000 DWT | 38 | -- | -- | 330,200 |
| | avg. 55,000 DWT | 54 | -- | -- | 176,100 |
| **Product barges (laden)** | avg. 6,000 DWT | 38 | -- | 1,190,000 | 47,000 |
| | avg. 12,000 DWT | 54 | -- | 3,819,000 | 47,000 |
| **Bulk carriers** | <50,000 DWT | 70 | -- | -- | 143,100 |
| | 50,000-100,000 DWT | 700 | -- | -- | 242,200 |
| | >100,000 DWT | 0 | -- | -- | 440,300 |
| **Bulk liquid carriers** | | 36 | -- | -- | 176,100 |
| **Containerships** | <2,500 TEU | 54 | -- | -- | 264,200 |
| | 2,500-4,000 TEU | 32 | -- | -- | 484,300 |
| | >4,000 TEU | 442 | -- | -- | 825,600 |
| **Vehicle carriers** | | 184 | -- | -- | 54,000 |
| **Factory fishing vessels** | 300-3,000 GRT | 0 | -- | -- | 54,000 |
| | >3,000 GRT | 0 | -- | -- | 165,100 |
| **Fishing boats** | >300 GRT | 0 | -- | -- | 26,400 |
| **Passenger vessels** | 300-3000 GRT | 8 | -- | -- | 52,800 |
| | >3,000 GRT | 0 | -- | -- | 140,900 |
| Etkin, 2001b, adapted from US Army Corps of Engineers Waterborne Transport 1999. | | | | | |

This amounts to 8.1 billion gallons of crude oil, 1.4 billion gallons of refined products, and 2.15 billion gallons of bunker fuel. About 82 percent of this oil is transported through Puget Sound. Some of this oil never reaches a Washington port or is never transferred in Washington waters, traveling through Puget Sound and the straits to Vancouver, British Columbia, or through the Columbia River to Portland, Oregon.

Analyzing the amount of oil transported through Washington waters that is taxed as part of the Oil Spill Tax (RCW 82.23B) (Table 38) can also provide an estimate of oil transferred in Washington waters. This tax is levied on all crude oil or petroleum products that are transported by ship or barge in navigable waters of the state and off-loaded at an in-state marine terminal.

| Table 38: Crude/Petroleum Product Transports Taxed Under Washington Oil Spill Tax (RCW 82.23B) | | | |
|---|---|---|---|
| **YEAR** | **Tax Collected** | **Barrels Transported** | **Gallons Transported** |
| **1995** | $6,151,000 | 123,020,000 | 5,166,840,000 |
| **1996** | $4,600,000 | 92,000,000 | 3,864,000,000 |
| **1997** | $4,600,000 | 92,000,000 | 3,864,000,000 |
| **1998** | $6,885,000 | 137,700,000 | 5,783,400,000 |
| **1999** | $3,055,000 | 61,100,000 | 2,566,200,000 |
| **2000** | $5,664,000 | 113,280,000 | 4,757,760,000 |
| **2001** | $5,955,000 | 119,100,000 | 5,002,200,000 |
| **2002** | $5,561,000 | 111,220,000 | 4,671,240,000 |
| **2003** | $5,537,000 | 138,425,000 | 5,813,850,000 |
| **2004** | $5,809,000 | 145,225,000 | 6,099,450,000 |
| **Average Annual** | **$5,381,700** | **113,307,000** | **4,758,894,000** |

Nearly 4.76 billion gallons of oil are transported annually based on the tax records. The problem with this approach is that this tax only applies to each barrel of oil once. In other words if crude oil is brought in, transferred at a refinery, refined, and then transferred to a vessel for export or movement to another port, it is only taxed once. The same barrel of oil could be involved in more than one vessel transit. If 11 billion gallons of oil is transported to and from Washington refineries, this comes to 2.3 transits for each barrel or gallon of oil. These 11 billion gallons of oil that is transported to refineries also does not include the estimated 2.15 billion gallons of oil transported as bunker fuel and involved in bunkering operations, which are also oil transfers.

If there are 7,106 oil transfers per year in Washington, with a total of 11 billion gallons of crude oil and products and 2.15 billion gallons of bunker fuel being transported, and there are three spills of an average of 144 gallons of oil being spilled each year[12], this means that an average of $3.3 \times 10^{-7}$ gallons of oil are spilled for each oil transferred. There are on average $4 \times 10^{-4}$ spills for every transfer. Each transfer has a probability of 0.04% chance of an oil spill.

**California**

For California, there are records of oil transfers from the California State Lands Commission Marine Facilities Division Field Operations Department against which oil transfer spills can be related (The O'Brien's Group 2005). Figure 25 shows the number of oil spills per transfer. Figure 27 and Table 39 show the number of transfer spills and the number of transfers[13]. The number of spills per transfer was higher before the 1995 transfer rule and then decreased and leveled off to about 0.0046 spills per transfer. This is over 10 times the spill rate in Washington waters.

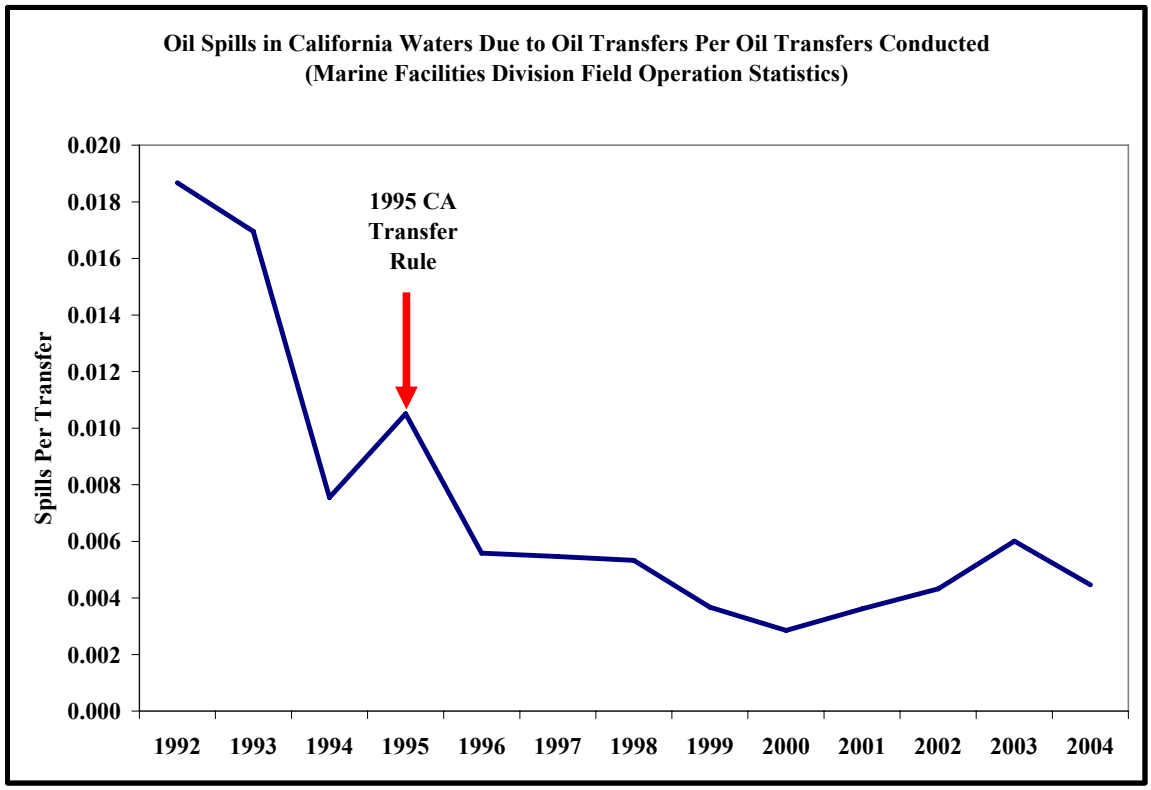


**Figure 25: Oil Spills in California Waters Related to Oil Spill Transfers (State Lands Commission Marine Facilities Division Field Operations Department Data)**

[12] Based on post 1995 Washington oil transfer spills and spill volumes (Table 27).
[13] This spill data differs from ERC data in that it includes spills that do not enter the water.

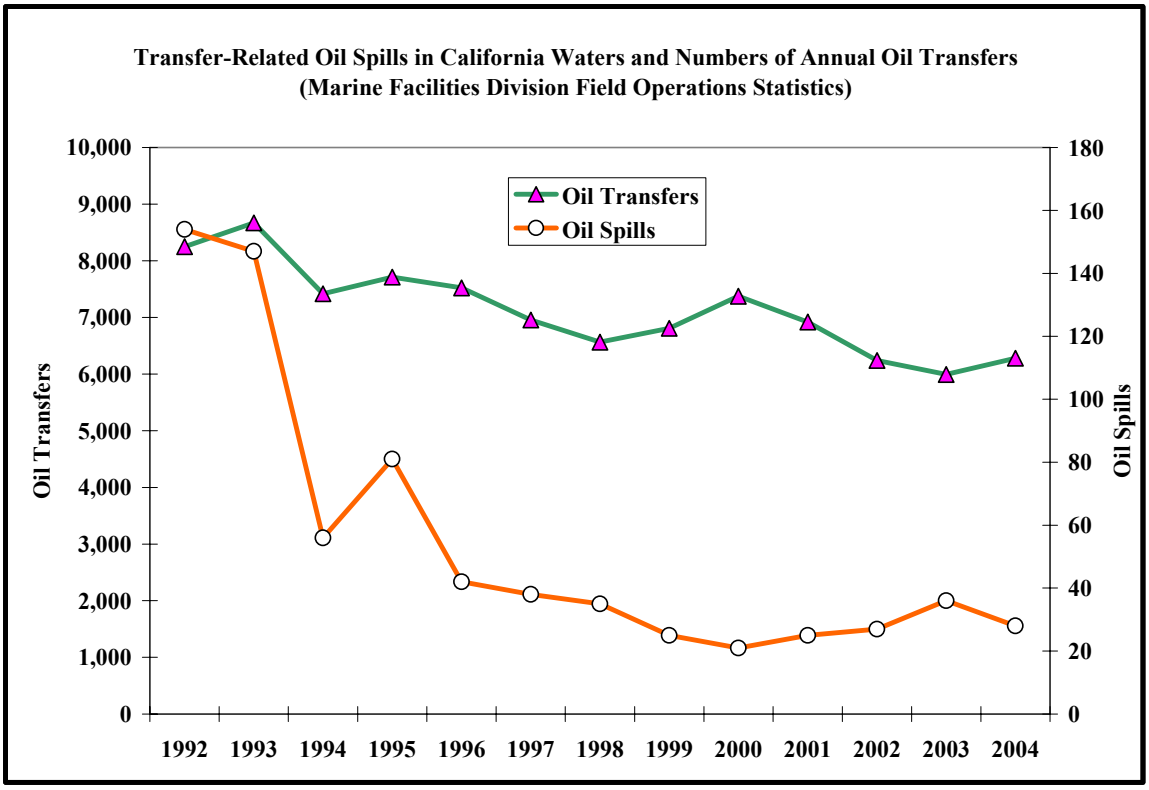


**Figure 26: Oil Spills and Oil Transfers in California Waters (Based on State Lands Commission Marine Facilities Division Field Operations)**

| Table 39: Oil Transfers and Oil Spills From Transfers in California Waters 1992 – 2004 (State Lands Commission Marine Facilities Division Field Operations) | | | |
|---|---|---|---|
| **Year** | **Oil Transfers** | **Oil Spills** | **Spills/Transfer** |
| **1992** | 8,248 | 154 | 0.0187 |
| **1993** | 8,669 | 147 | 0.0170 |
| **1994** | 7,418 | 56 | 0.0075 |
| **1995** | 7,711 | 81 | 0.0105 |
| **1996** | 7,523 | 42 | 0.0056 |
| **1997** | 6,955 | 38 | 0.0055 |
| **1998** | 6,564 | 35 | 0.0053 |
| **1999** | 6,807 | 25 | 0.0037 |
| **2000** | 7,374 | 21 | 0.0028 |
| **2001** | 6,920 | 25 | 0.0036 |
| **2002** | 6,242 | 27 | 0.0043 |
| **2003** | 5,993 | 36 | 0.0060 |
| **2004** | 6,281 | 28 | 0.0045 |

Prior to 1996, the spill rate averaged 0.0134 spills per transfer. After 1995, the spill rate averaged 0.0046 spills per transfer – a reduction of 34%. If this reduction in number of spills is applied to Washington transfer spills, one might expect that there would be only 0.00026 ($2.6 \times 10^{-4}$) spills per transfer after the implementation of a spill transfer rule.

Another important aspect of the transfer rule in California and the proposed rule in Washington, in addition to spill prevention, is the requirement for pre-booming measures during oil transfer

operations. Pre-booming would theoretically have two effects – reducing the amount of oil that enters the water or reducing the spread of oil on the water surface through proper containment.

The degree to which pre-booming during transfers is properly carried out in California is not precisely known. There are records of violations to the transfer rule regulations reported by the State Lands Commission (SLC), as shown in Table 40. There is also anecdotal evidence from vessel operators that the pre-booming requirements, in particular, are not regularly implemented.

Records of successful spill containment are not reliable. The only way to estimate the potential effect of the pre-booming regulations, in as much as they are enforced and implemented, is to look at the difference between oil spills reported to have occurred during oil transfers and those that actually enter the water and are noted by the US Coast Guard or state authorities. This was done by comparing the transfer-related spills reported by the SLC and those that are present in ERC's database, which is based on US Coast Guard and other records. The number of spills that entered the water per spills that occurred during transfers is shown in Figure 27. The percentage of spills that enters the water continues to increase until peaking at 33 percent in 1999. The rate then sharply decreases to 5 percent or less.

**Table 40: State Lands Commission Transfer Rule Violations Noted**

| Year | Annual/Spot Check | Monitoring | Booming Requirements |
|---|---|---|---|
| **1993** | 100 | 475 | 53 |
| **1994** | 63 | 1,191 | 79 |
| **1995** | 108 | 1,128 | 84 |
| **1996** | 62 | 950 | 81 |
| **1997** | 29 | 683 | 67 |
| **1998** | 22 | 644 | 42 |
| **1999** | 39 | 845 | 27 |
| **2000** | 21 | 488 | 18 |
| **2001** | 18 | 477 | 16 |
| **2002** | 30 | 310 | 13 |
| **2003** | 33 | 215 | 7 |
| **2004** | 53 | 213 | 15 |

Conclusions from the analysis of oil transfer-related spills with respect to oil transfer numbers and volumes are:

- The volume of oil spilled after OPA 90 decreased in the US, as in California and Washington. The average spill volume also decreased to 10 percent of the previous volume.

- For oil transfer spills, the number of incidents decreased after OPA 90, but also decreased from the post-OPA 90, pre-California transfer rule (1990 – 1994) time period to after the 1995 rule time period throughout the US by 86 percent.

- In California, the reduction in the number of oil transfer incidents was 76 percent. In Washington, the reduction was 81 percent.

- The reduction in the volume of transfer spillage, was 68 percent in the US. In California and Washington, there were 80 percent and 70 percent reductions in volume, respectively. Thus, there was no decrease in California in the number of incidents relative to the rest of the US.
- Washington also had a much higher reduction in spill volume from transfers than the US overall in this time period, though not as high as California

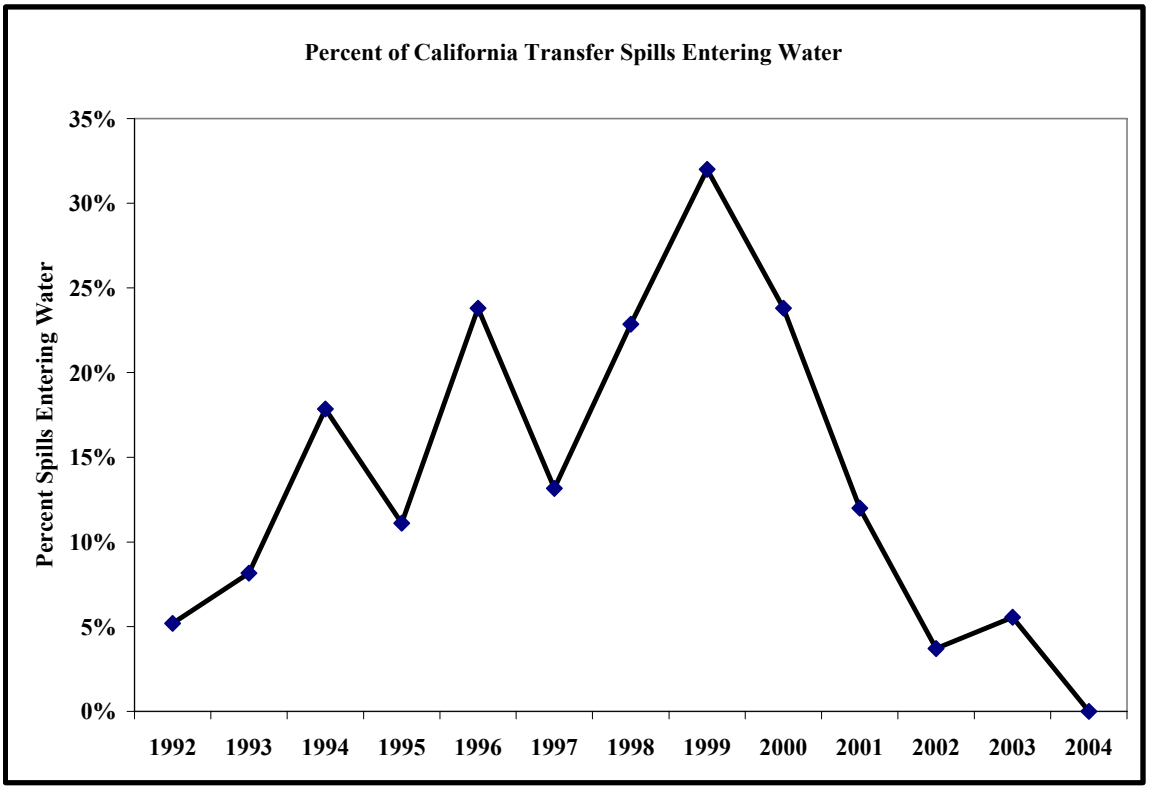


**Figure 27: Percent of California Transfer Spills Entering Water. This graph is based on a comparison of spills reported to have entered water (as in the ERC database) and the data from the Marine Facilities Division Field Operations that includes all transfer spills.**

- Comparing California and all the states except California, as shown in Figure 23 and Table 34, it can be seen that the number of oil transfer-related spills decreased by 81 percent in California, compared to 79 percent in the rest of the US after OPA 90.

- The average annual volume of oil transfer spills decreased by 80 percent in California, compared with a two percent decrease in the rest of the US after the oil transfer rule. Spill volumes shifted to smaller size classes in California after the rule was implemented.

- In Washington, an average of $3.3 \times 10^{-7}$ gallons of oil are spilled for each gallon of oil transferred. There are on average $4 \times 10^{-4}$ spills for every transfer. Each transfer has a probability of 0.04% chance of an oil spill.

- In California, prior to 1996, the spill rate averaged 0.0134 spills per transfer. After 1995, the spill rate averaged 0.0046 spills per transfer – a reduction of 34%.

- If this reduction in number of spills is applied to Washington transfer spills, one might expect that there would be only 0.00026 ($2.6 \times 10^{-4}$) spills per transfer after the implementation of a spill transfer rule.
- The percentage of transfer spills entering the water (or escaping containment) decreased from a high of 33 percent in 1999 to less than 5 percent in the 2000s.

## OIL TYPE ANALYSIS

Oil transfer spills were analyzed with respect to general oil types, as shown in Table 41 and Figures 28 – 33. The relative proportions of spill numbers by oil type are similar in California and the US as a whole. Washington has a somewhat higher percentage of light refined product spills with fewer crude oil spills from transfers.

Both California and Washington have higher percentage volume of refined products (heavy oil and light refined oil) spilled in transfer spills than the US as a whole. More than half of Washington's oil transfer spill volume involves heavy oils. This has implications for costs and damages with the greater persistence of persistent heavy oils.

**Table 41: Oil Types Spilled in Oil Transfer Spills 1985 – 2004 (Environmental Research Consulting Database)**

| Oil Type | Number Spills | | | % Number | | | Volume (gallons) | | | % Volume | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | US | CA | WA | US | CA | WA | US | CA | WA | US | CA | WA |
| **Crude** | 658 | 33 | 11 | 11% | 7% | 4% | 4,409,900 | 7,909 | 1,410 | 60.4% | 11.7% | 3.8% |
| **Heavy Oil** | 1,276 | 113 | 52 | 22% | 25% | 20% | 1,244,799 | 27,411 | 19,230 | 17.1% | 40.4% | 51.3% |
| **Light Refined** | 3,560 | 290 | 187 | 62% | 63% | 72% | 1,609,601 | 29,812 | 11,656 | 22.1% | 43.9% | 31.1% |
| **Waste Oil** | 91 | 7 | 2 | 2% | 2% | 1% | 22,931 | 66 | 5,001 | 0.3% | 0.1% | 13.3% |
| **Unknown Oil** | 161 | 16 | 9 | 3% | 3% | 3% | 11,969 | 2,646 | 171 | 0.2% | 3.9% | 0.5% |
| **Total** | **5,747** | **458** | **261** | **100%** | **100%** | **100%** | **7,299,200** | **67,844** | **37,468** | **100.0%** | **100.0%** | **100.0%** |

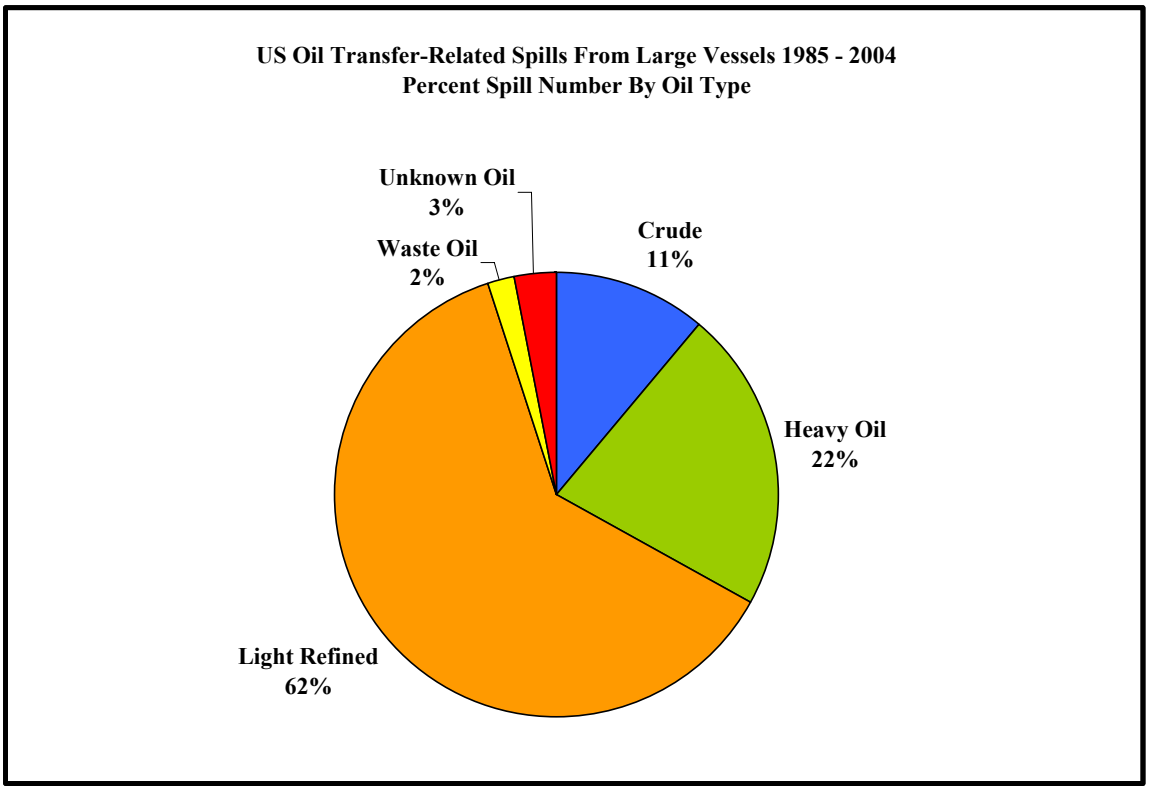


**Figure 28: Percentage of Oil Types for Numbers of US Oil Transfer-Related Spills**

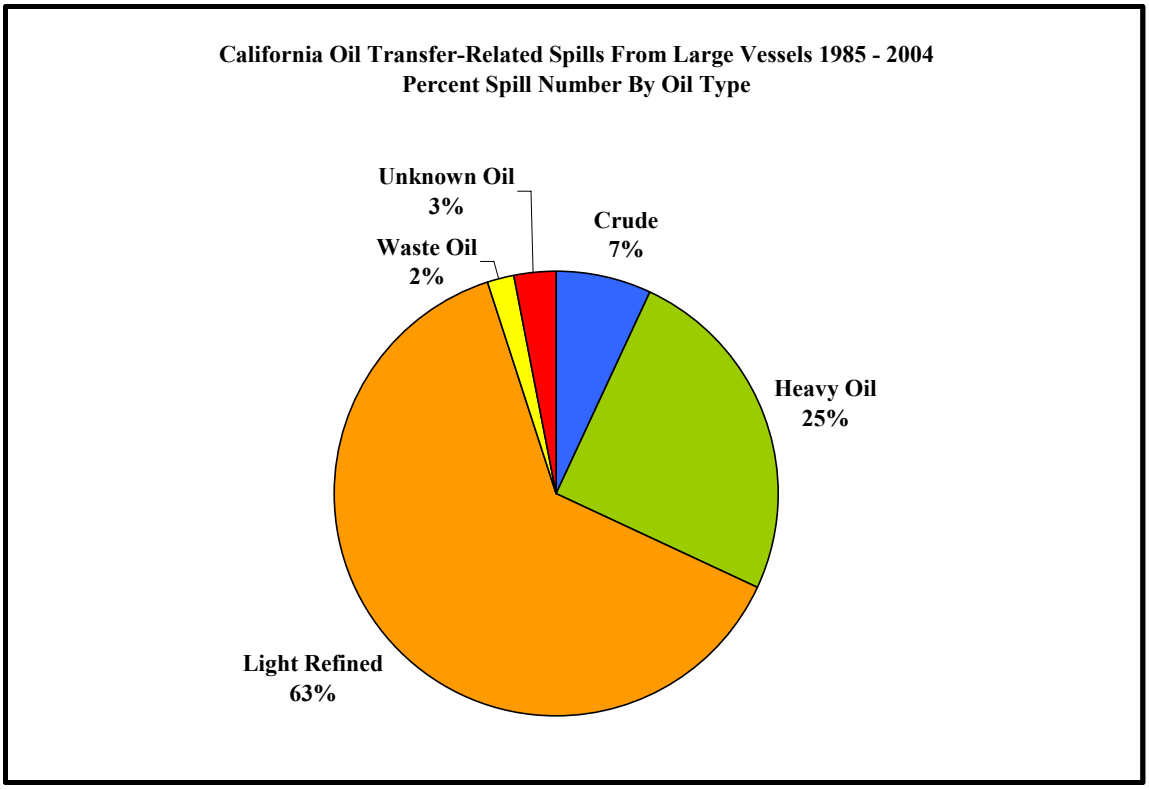


**Figure 29: Percentage of Oil Types for Numbers of California Oil Transfer-Related Spills**

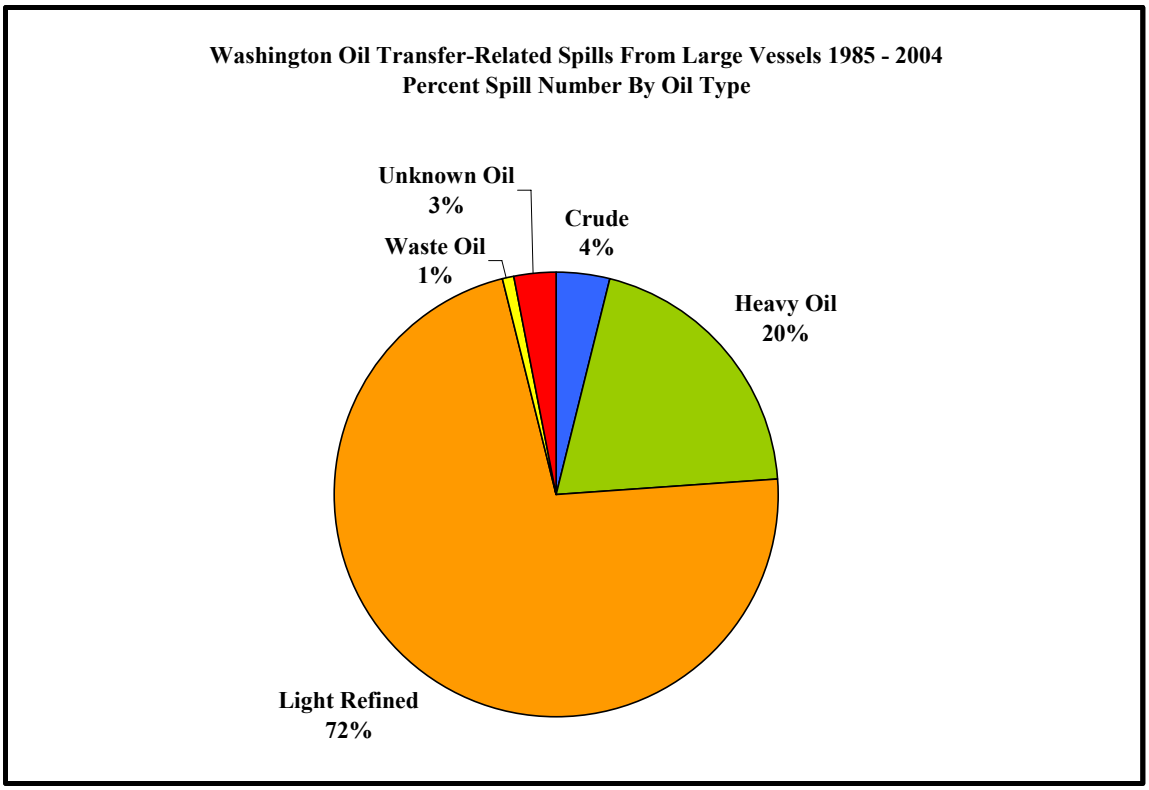


**Figure 30: Percentage of Oil Types for Numbers of Washington Oil Transfer-Related Spills**

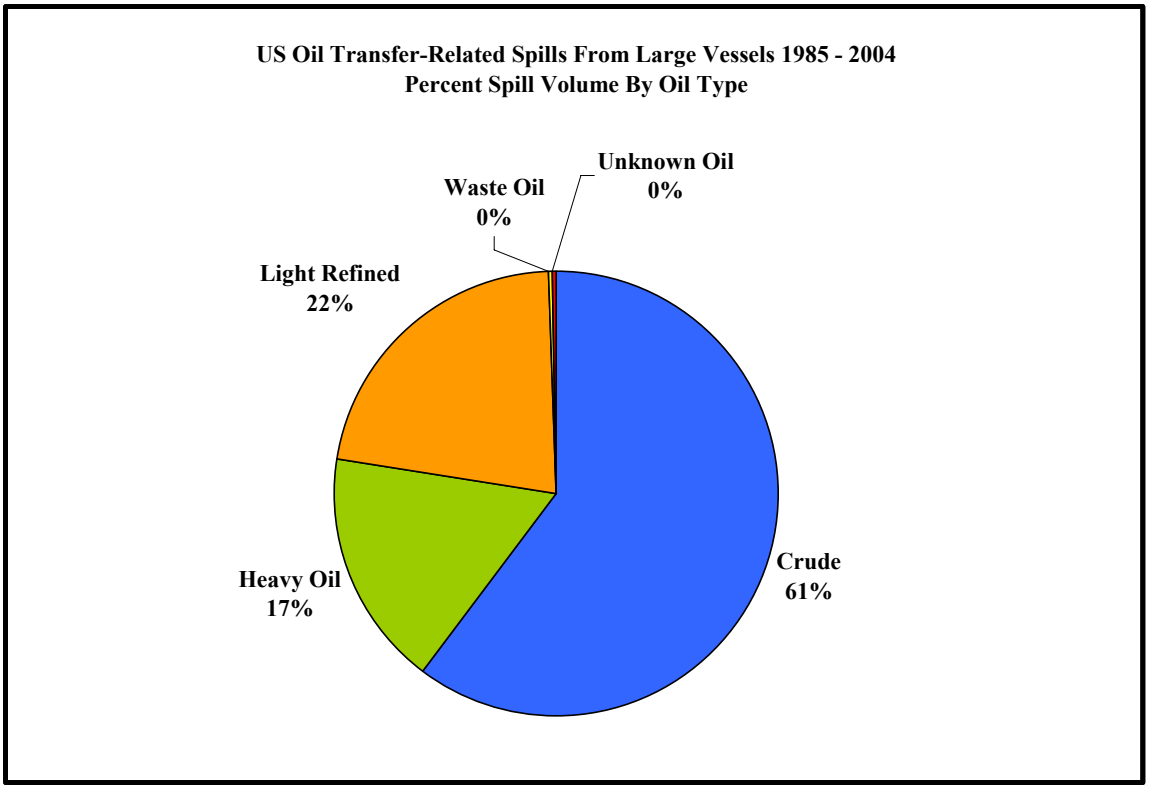


**Figure 31: Percentage of Oil Types for Spill Volumes of US Oil Transfer-Related Spills**

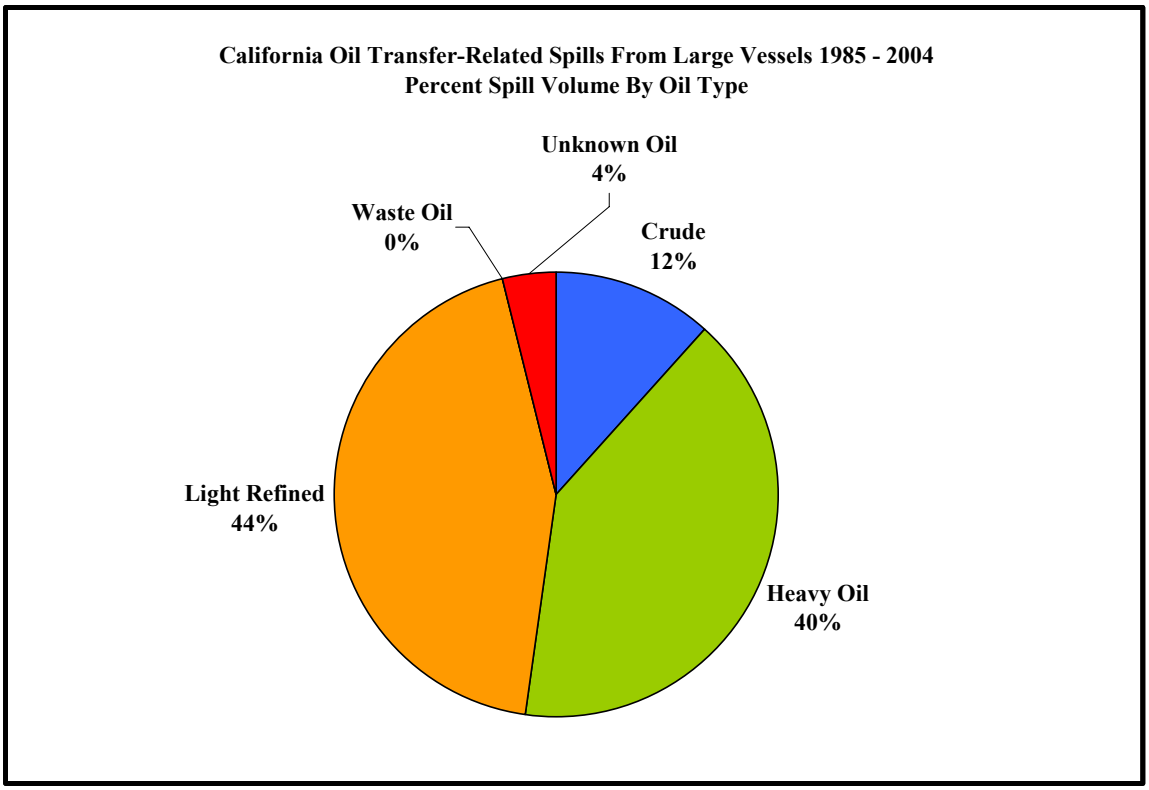


**Figure 32: Percentage of Oil Types for Spill Volumes of California Oil Transfer-Related Spills**

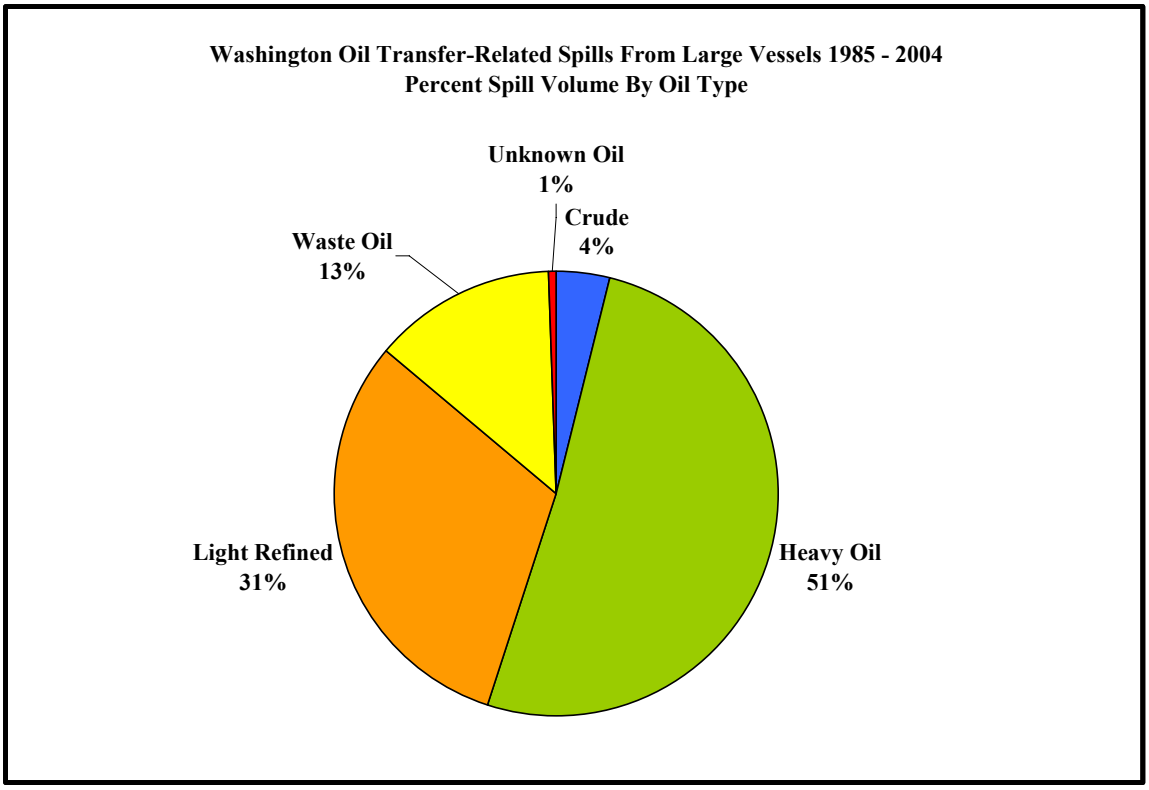


**Figure 33: Percentage of Oil Types for Spill Volumes of Washington Oil Transfer-Related Spills**

## COSTS AND DAMAGES ASSOCIATED WITH OIL TRANSFER SPILLS

Oil spill costs and damages for oil transfer-related spills were estimated using ERC's BOSCEM model (Figure 34) (Etkin 2004b), which allows for quick estimates of response costs, environmental damages, and socioeconomic damages based on factors known to have an impact on spill costs, including spill location type, oil type, spill size, and response methodology.

The cost estimates are based on actual costs reported for hundreds of oil spill incidents in ERC's spill cost databases and modeling of hypothetical spills in various locations in the US, including Washington waters. Actual costs may vary from estimated costs based on the specific impacts of an individual spill.

As was demonstrated in previous spill modeling work for Ecology[14], a spill of a particular amount and type of oil in one location can move in many directions and impact different resources and shorelines depending on the timing of tides, currents, wind speeds, and other factors that determine the trajectory and behavior of the oil.

These costs should be viewed as "ballpark" estimates rather than specific and accurate costs. Costs for spills in Washington waters may be higher than for spills in the waters of other states due to the highly-sensitive and highly-valued natural and socioeconomic resources in the state.

Using the ERC BOSCEM estimation model, the costs for oil transfer spills was estimated, as shown in Table 42. For the US as a whole, over 20 years oil transfer spills cost nearly $2 billion,

[14]Etkin 2004a, 2004b; Etkin *et al*. 2005a, 2005b, 2006; French-McCay *et al*. 2004a, 2004b, 2005a, 2004b.

including $681 million in response costs, $239 million in environmental damages, and over $1 billion in socioeconomic damages. This averages to about $98 million per year.

For the state of California, these costs amount to $18.4 million in response costs, $6.6 million in environmental damages, and $30.5 million in socioeconomic damages, for a total of $55.6 million in total costs, or $2.8 million per year.

For the state of Washington, the costs are estimated at $35.5 million, including $10.7 million in response costs, $3.5 million in environmental damages, and $21.3 million in socioeconomic damages. This amounts to an estimated $1.8 million in costs annually.

| Table 42: Estimated Costs of Oil Transfer-Related Spills Based on ERC BOSCEM | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | California ($,000) | | | | Washington ($,000) | | | | US ($,000) | | | |
| | Response | Environ-mental | Socio-economic | Total | Response | Environ-mental | Socio-economic | Total | Response | Environ-mental | Socio-economic | Total |
| **1985** | $1,366 | $393 | $2,829 | $4,588 | $143 | $42 | $56 | $241 | $23,068 | $6,955 | $33,044 | $63,067 |
| **1986** | $898 | $353 | $960 | $2,211 | $4,069 | $1,139 | $8,544 | $13,751 | $203,253 | $65,507 | $304,385 | $573,146 |
| **1987** | $1,589 | $660 | $1,959 | $4,208 | $1,482 | $461 | $2,835 | $4,778 | $28,997 | $11,964 | $57,315 | $98,276 |
| **1988** | $994 | $398 | $1,444 | $2,836 | $1,134 | $315 | $2,110 | $3,558 | $44,491 | $17,305 | $66,937 | $128,733 |
| **1989** | $1,793 | $807 | $2,058 | $4,658 | $106 | $68 | $76 | $250 | $81,289 | $28,826 | $115,046 | $225,161 |
| **1990** | $1,065 | $494 | $2,704 | $4,263 | $871 | $256 | $1,530 | $2,657 | $70,066 | $23,897 | $117,969 | $211,931 |
| **1991** | $7,226 | $1,973 | $11,023 | $20,222 | $179 | $94 | $108 | $381 | $35,065 | $12,337 | $61,398 | $108,800 |
| **1992** | $180 | $102 | $708 | $991 | $19 | $13 | $15 | $47 | $24,191 | $11,394 | $22,365 | $57,950 |
| **1993** | $44 | $29 | $33 | $106 | $390 | $203 | $1,780 | $2,373 | $22,374 | $6,922 | $37,145 | $66,441 |
| **1994** | $28 | $18 | $19 | $65 | $1,063 | $268 | $2,479 | $3,810 | $7,521 | $3,363 | $14,156 | $25,039 |
| **1995** | $523 | $163 | $1,266 | $1,952 | $23 | $11 | $13 | $47 | $1,946 | $880 | $2,400 | $5,227 |
| **1996** | $193 | $101 | $890 | $1,184 | $0 | $0 | $0 | $0 | $14,874 | $7,280 | $21,466 | $43,620 |
| **1997** | $85 | $33 | $29 | $147 | $28 | $17 | $20 | $64 | $6,092 | $3,055 | $14,749 | $23,895 |
| **1998** | $52 | $34 | $150 | $236 | $1,073 | $528 | $1,650 | $3,251 | $4,163 | $1,661 | $7,461 | $13,285 |
| **1999** | $1,793 | $807 | $2,058 | $4,658 | $106 | $68 | $76 | $250 | $81,289 | $28,826 | $115,046 | $225,161 |
| **2000** | $12 | $7 | $5 | $24 | $2 | $1 | $2 | $5 | $31,630 | $7,955 | $47,646 | $87,231 |
| **2001** | $497 | $255 | $2,421 | $3,172 | $1 | $1 | $1 | $3 | $1,016 | $513 | $3,185 | $4,714 |
| **2002** | $18 | $5 | $7 | $30 | $0 | $0 | $0 | $0 | $31 | $14 | $17 | $61 |
| **2003** | $2 | $1 | $1 | $3 | $0 | $0 | $0 | $0 | $54 | $36 | $40 | $130 |
| **2004** | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $36 | $14 | $17 | $68 |
| **TOTAL** | **$18,358** | **$6,632** | **$30,564** | **$55,553** | **$10,688** | **$3,483** | **$21,295** | **$35,466** | **$681,446** | **$238,706** | **$1,041,786** | **$1,961,937** |
| **Average** | **$918** | **$332** | **$1,528** | **$2,778** | **$534** | **$174** | **$1,065** | **$1,773** | **$34,072** | **$11,935** | **$52,089** | **$98,097** |

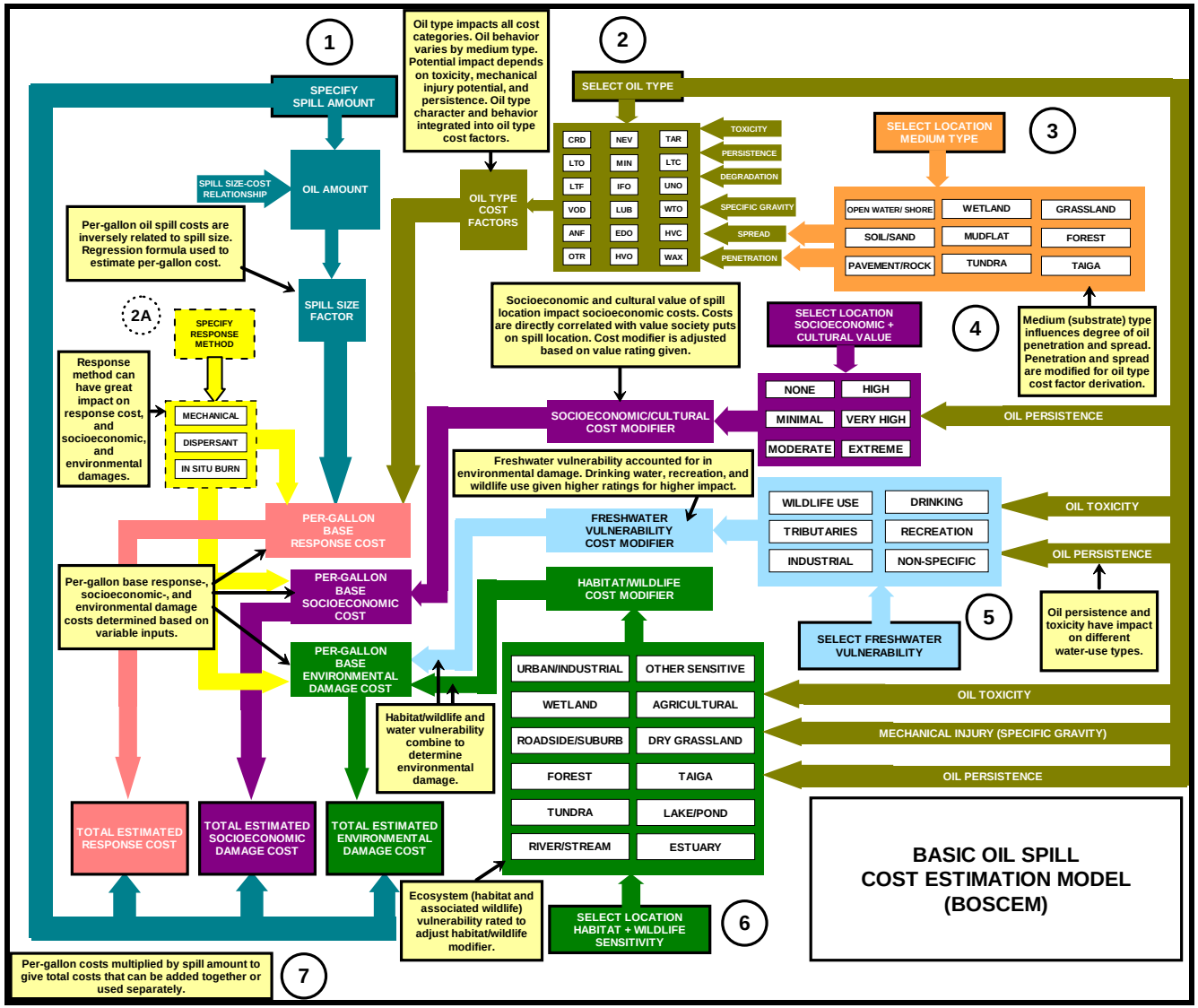


**Figure 34: ERC Basic Oil Spill Cost Estimation Model (BOSCEM) (Etkin 2004b)**

**POTENTIAL WORST-CASE SPILL SCENARIOS WITH OIL TRANSFERS**

The vast majority of oil transfer spills are small, but there is the possibility that a larger spill incident could occur. Based on the previous study conducted for Ecology on discharge scenarios for contingency planning (Etkin 2001b), the most-likely worst-case discharge[15] for tank barges in Washington was estimated to be 155,00 gallons, for tank ships (tankers) 100,000 gallons, for freight ships bunkering 23,300 gallons, and for fishing vessels refueling 35 gallons. That analysis was based on the vessel traffic in Washington waters and the relative proportion of oil lost during oil transfer- and lightering related spill incidents as seen in the US as a whole.

The T/V Mega Borg spill of 3.9 million gallons in the Gulf of Mexico about 60 miles off the Texas coast in 1990 was an incident that occurred during offshore lightering. There were a series of explosions that occurred during lightering operations. The spill of 3.9 million gallons of light crude oil burned over the course of eight days during which time firefighting response crews were unable to extinguish it. The burning and evaporation of the light crude oil left only 20 percent of the oil to impact the shoreline. The Louisiana coast was impacted with tarballs for 20 days following the spill. A total of 18 miles of shoreline were impacted. Total response costs totaled $5.5 million [$8.1 million in 2006 dollars] (Etkin 1998). Natural resource damages were negligible. The relatively low response costs and damages are attributable to the fact that so much of the oil burned and that shoreline impacts were limited to tarballs that could be manually removed and that had little impact on wildlife or socioeconomic features. If the oil had not burned and if the spill had occurred closer to shore there would likely have been considerably higher costs and damages.

This was a rare incident – one incident in 20 years in the US with an estimated three million vessel transits ($3 \times 10^{-7}$ or 0.0000003 incidents per transit per year). But, this type of a major oil transfer incident could potentially occur in Washington waters. The T/V Mega Borg was loaded with an estimated 38 million gallons of oil. The tanker lost an estimated 10 percent of its load during the incident. A tanker load of this size would not be allowed in Washington waters as there is a regulatory limit of 33 million gallons. But, if 10 percent of the largest tanker load in Washington did spill, it would amount to a three million-gallon spill.

A spill of three million gallons in Washington waters is somewhat larger than spills of 65,000 barrels (or 2.73 million gallons) modeled by ERC and Applied Science Associates, Inc., for Ecology[16]. The response costs for a spill of this magnitude would range from $100 million to $400 million, depending on the location of the spill, the trajectory that the oil takes with regard to winds, currents, and tides in the aftermath of the oil release, and the specific resources and shorelines impacted. Natural resource ore environmental damages might range from $30 million to $300 million, depending again on the location, trajectory, and specific impacts. Natural resource damages are also highly dependent on seasonal factors, including the specific locations and population numbers of various species. Total socioeconomic costs might range from $40

[15] The largest spill size that should be expected based on historical US national data on the maximum recorded percent cargo or fuel loss. This spill volume is generally less than the theoretical worst-case discharge (WCD) unless the total loss of cargo or fuel has occurred. This has not occurred in US waters to date. This analysis excludes the T/V Mega Borg incident, which occurred during a vessel-to-vessel transfer of oil in the Gulf of Mexico. It is unclear whether this incident should be characterized as a fire- or explosion-related incident or a spill that occurred during transfer operations. It was clearly an unusual circumstance, though one that could occur during oil transfers in other locations, including Washington. With the degree of burning that occurred (80 percent of the light crude burned or evaporated) and the length of time it took to extinguish the blaze (eight days) it is doubtful that conventional pre-booming would have successfully contained the oil.

[16] Etkin 2004a, 2004b; Etkin *et al*. 2005a, 2005b, 2006; French-McCay *et al*. 2004a, 2004b, 2005a, 2004b.

million to $100 million, with location, trajectory, and impacts again being important determinants of actual costs.

Oil spill costs and damages are also dependent on the effectiveness of spill response and the methodologies and strategies used for spill response. Washington's response guidelines are higher than the federal standards under most circumstances, calling for a more rapid response with more equipment and personnel. A more rapid and more vigorous response will mitigate costs and damages.

**REDUCTIONS IN OIL IMPACTS WITH PRE-BOOMING AND RAPID RESPONSE**

The impacts of an oil spill are greatly reduced when the oil is rapidly contained and removed from the water. This effect has not been specifically modeled for small oil transfer spills, but can be inferred from the modeling conducted for Ecology for larger spills. The more rapid and the more vigorous the response with regard to oil removal and preventive booming, the lower the costs are for shoreline cleanup and for natural resource and socioeconomic damages.

With an average spill volume of 148 gallons for an oil transfer-related spill in Washington, one could expect that this amount of oil contained in a pre-boomed containment area around a vessel could be cleaned up within hours if not sooner. This same amount of oil uncontained would rapidly spread to about 1.85 square kilometers or 0.7 square miles within a few hours. It would then be considerably more difficult to remove. The degree to which this would impact shorelines and sensitive resources would depend on a number of factors, including location of spill, oil type, timing with regard to currents and tides, and winds. Cleaning oil, particularly persistent heavier oil, off of a shoreline is considerably more expensive than removing if efficiently off the water surface.

**CONCLUSIONS**

Overall, oil spillage from vessels throughout the US has decreased significantly since 1990 and the enactment of the Oil Pollution Act of 1990 (OPA 90). Nearly 20 times more oil was being spilled annually by vessels in before 1990 than is currently being spilled. The number of spills of 500 gallons or more have decreased since 1990. The reporting of smaller spills has increased since 1985, but the incidence of these spills has decreased since 1990. The reasons for spill reductions with OPA 90 are varied and complex. There are reductions noted even before some of the prevention measures associated with OPA 90 have been implemented. There is speculation that these spill reductions may be related to the increasing costs of oil spills and unlimited liability, and the resulting greater "care" that vessel owners and operators are exercising, as well as the higher class of vessels transiting US waters based on financial and insurance requirements.

The vast majority of vessel spills are very small. Nearly 65 percent of spills are less than 10 gallons, 90 percent are less than 100 gallons. Smaller spills (under 100 gallons) make up only 0.7 percent of the total volume spilled. The very rare larger spills of one million gallons or more (less than one tenth of one percent in frequency) make up over 42 percent of the total volume spilled.

Over 67 percent of spills fall into the category of "other operations". The next largest category in terms of spill number is oil transfer operations, making up 20 percent of all spills. The relative proportion of oil transfer-related spills has decreased from about 50 percent of incidents before 1990 to only 2 or 3 percent of incidents currently.

The largest volume of spillage is attributable to accidents, most notably the Exxon Valdez spill that makes up 78 percent of the volume spilled in this category. The average accident-related spill is nearly 46,000 gallons in volume.

Oil transfer-related spills average 1,270 gallons, though this includes on large transfer-related spill of 3.9 million gallons from the T/V Mega Borg in the Gulf of Mexico in 1990. Average annual oil transfer-related spill volumes and average annual numbers of incidents in this category have both decreased by 96 percent since before 1990.

The patterns seen throughout the US are echoed in Washington State, though overall Washington vessel spills have been shown in a previous study (Etkin and Neel 2001) to occur at a lower rate than in the US as a whole and in comparison to busy ports in California, Texas, and New York.

Spill volumes have been dominated by a few large (over 200,000-gallon) spills, the 1985 T/V Arco Anchorage spill of 239,000 gallons and the 1988 T/B Nestucca spill of 227,000 gallons. The very rare larger spills of 200,000 gallons or more (one tenth of one percent in frequency) make up over 65 percent of the total volume spilled. The vast majority of spills are very small. Over 73 percent of spills are less than 10 gallons, 94 percent are less than 100 gallons. Smaller spills (under 100 gallons) make up only 1.6 percent of the total volume spilled.

Spills in Washington related to oil transfer operations make up 15 percent of all large-vessel spills in Washington. Oil transfer-related spills averaged 144 gallons. The largest spill related to oil transfers was 7,500 gallons. Average annual oil transfer-related spill volumes have decreased by over 99 percent and average annual numbers of incidents in this category have decreased by 92 percent since before 1990.

In California, there are also similar patterns. The spill volumes are dominated by two large spills – the 1990 T/V American Trader spill of 397,000 gallons and the 1987 spill of 339,000 gallons from the M/V Pac Baroness. Nearly 13 percent of oil spills were related to oil transfers. Only six percent of the volume spilled was from oil transfer-related incidents. The average volume for oil transfer spills is 148 gallons.

The average annual volume of oil transfer spills decreased by 80 percent in California, compared with a two percent decrease in the rest of the US after the implementation of the California oil transfer rule. Spill volumes shifted to smaller size classes in California after the rule was implemented. Spill rate reduced as well. In California, prior to 1996, the spill rate averaged 0.0134 spills per transfer. After 1995, the spill rate averaged 0.0046 spills per transfer – a reduction of 34%.

In Washington, an average of $3.3 \times 10^{-7}$ gallons of oil are spilled for each gallon of oil transferred. There are, on average, $4 \times 10^{-4}$ spills for every transfer. Each transfer has a probability of 0.04% chance of an oil spill. If the reduction in number of spills seen in California after the implementation of its oil transfer rule is applied to Washington transfer spills, one might expect that there would be only 0.00026 ($2.6 \times 10^{-4}$) spills per transfer after the implementation of a spill transfer rule.

The percentage of transfer spills entering the water (or escaping containment) in California decreased from a high of 33 percent in 1999 to less than 5 percent in the 2000s. A similar pattern might also be seen in Washington.

The annual costs associated with oil transfer-related spills throughout the US over the last 20 years are estimated to be an average of $98 million in response, environmental, and socioeconomic costs. In Washington, these costs average $1.8 million annually.

Though the average spill volume for a transfer-related spill in Washington is 144 gallons, and the largest transfer-related spill on record in the state is 7,500 gallons, there is still the potential for a significantly larger transfer-related spill. A previous study (Etkin 2001b) had estimated that a most likely-worst-case discharge from oil transfers would be 155,000 gallons. If a catastrophic transfer event involving explosions and fire, such as the T/V Mega Borg spill were to occur in Washington waters, an estimated three million gallons might spill. This type of event has occurred once in 20 years in the US after an estimated three million vessel transits (with a probability of 0.000003 percent). A spill of this magnitude could cause $170 million to $800 million in costs and impacts in Washington.

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