

ANALYSIS OF OIL SPILL TRENDS IN THE UNITED STATES AND WORLDWIDE

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ABSTRACT: *This presentation examines trends in U.S. oil spillage, with respect to historical and current trends in the United States and worldwide, and analyzes potential influences on spill frequencies. Contrary to popular perceptions, the numbers of oil spills, as well as the amount spilled, have decreased significantly over the last two decades, particularly in the last few years despite overall increases in oil transport. Decreases are pronounced for vessels. U.S. pipelines now spill considerably more than tankers. Overall, U.S. oil spillage decreased 57% since the 1970s and 35% since the 1980s. This decrease mirrors international trends and can likely be attributed to reduced accident rates, due to preventive measures and increased concerns over escalating financial liabilities.*

Methodology

Oil spill data used in this study are from the Environmental Research Consulting Spill Databases, which collate data from a large number of sources and databases, including information from the U.S. Coast Guard (USCG), U.S. National Response Center (NRC), U.S. Environmental Protection Agency (EPA), U.S. Office of Pipeline Safety (OPS), U.S. Minerals Management Service (MMS), various U.S. state databases, Environment Canada, Oil Spill Intelligence Report, International Maritime Organization, International Tanker Owners Pollution Federation, Tanker Advisory Center, and other national and regional environmental agencies. On a continuously updated basis, the data are cross-checked and corrected with current information and new information on past events. U.S. data are subject to reporting errors, occasional duplications of records of events, and other anomalies. Worldwide data largely reflect trends in reporting, both over time and on a regional basis, and should be treated as underestimates, particularly for smaller-sized spill events (under 100,000 gallons or 340 t), for spills from regions where reporting is compromised for political or logistical reasons, and for spills from nonvessel sources.

An "oil spill" is defined as discrete event in which oil is discharged through neglect, by accident, or with intent over a relatively short time. It does not include an event in which oil leaks slowly over a long period of time, nor does it include operational spillages allowed by international or national regulations (such as MARPOL discharges from tankers) or that occur over a relatively long period of time (such as >5 ppm oil discharges in refinery effluents) even if those discharges violate pollution regulations. "Oil" is defined as a petroleum-derived substance as defined in MARPOL Annex I, and does not include BTEX (benzene,

xylylene, ethylene, and toluene), or liquefied natural or petroleum gas. "Facilities" include oil terminals, storage tanks, refineries, industrial facilities, utilities, and other stationary sources with the exception of pipelines.

U.S. oil spill trends

Vessels. Oil spills from vessels in U.S. waters have followed a pattern of increase from 1985 through 1993, followed by a decline from 1993–1995, and gradual increase from 1995–1999. Vessels other than tankers and barges that carry oil as cargo drive much of this trend (Figure 1). Tanker and barge spills decreased during 1985–1999, with a particularly significant drop since 1990 (Etkin, 2000a). The number of spills from tankers and barges in 1999 was only 12% the number in 1990. Much of this decrease can be attributed the decrease in oil transport by tankers and barges through U.S. waters over the last several years. At the same time, freight transport has increased somewhat, increasing the likelihood of spills from freighters. Overall, oil movement to and from the United States has increased by over 42% since 1988.

Spills from tankers and barges comprise only 13% of the total annual spill number, but, since the largest vessel spills tend to be from oil cargo vessels, 78% of the volume of oil spilled from vessels comes from tankers and barges (Figure 2). Barge spills have exceeded tanker spills in number and amount spilled. Since 1990, the average barge spill has been larger than the average tanker spill, and barges overall have spilled more than tankers (except for 1997) (Etkin, 2000a).

The frequency distribution of spill size classes shows that spills under 100 gallons represent 92% of the total spill number, but only about 1% of the total spill volume from vessels (Figure 3). The total volume from spills of less than 100,000 gallons has not changed appreciably since 1985, with spills of at least 100,000 gallons contributing the most to annual fluctuations of total vessel spillage (Figure 4). Tanker spills show similar trends to barge spills over the last 15 years (Figure 5), as is the case when the spills in the different size classes are analyzed as a percentage of the total spill number. Both tankers and barges show no appreciable change in frequency of the largest size classes, an apparent decrease in spills of 100–999 gallons (0.34–3.4 t), and an increase in the percentage in the 1- to 9-gallon size class.

The smallest size classes usually are associated with bunkering, lightering, and loading, or to structural and equipment failures not attributable to accidents. This generally holds true for barges, tankers, and freight vessels (Etkin, 2000a). Freighters

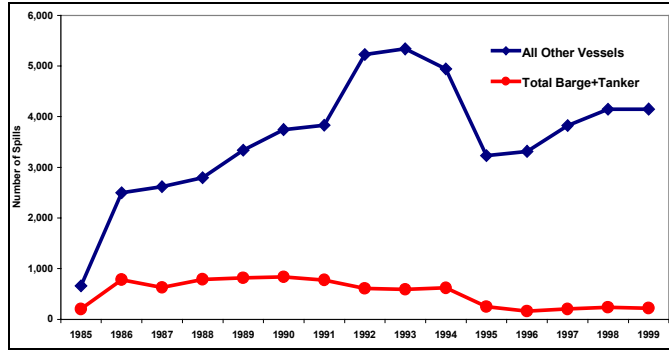


Figure 1. Annual number of oil spills (1 gallon and over) from vessels in U.S. waters: Barges and tankers versus other vessels (1985–1999) (Environmental Research Consulting Database).

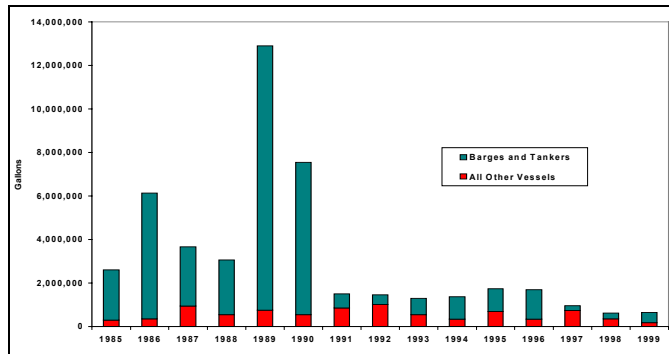


Figure 2. Annual amount of oil spilled by vessels in U.S. waters in spills of 1 gallon and over (1985–1999) (Environmental Research Consulting Database).

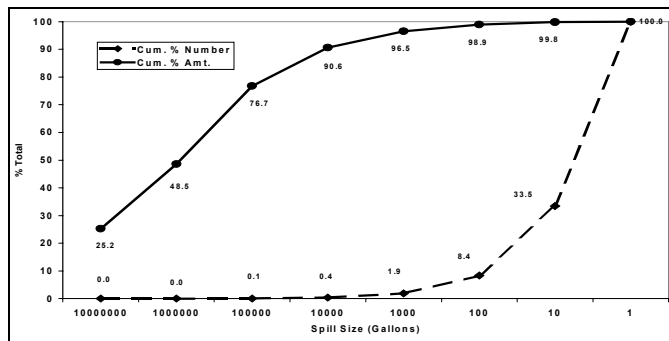


Figure 3. Cumulative percentage of total oil spillage (number of spills and amounts) by size class: U.S. vessel spills (1985–1999) (Environmental Research Consulting Database).

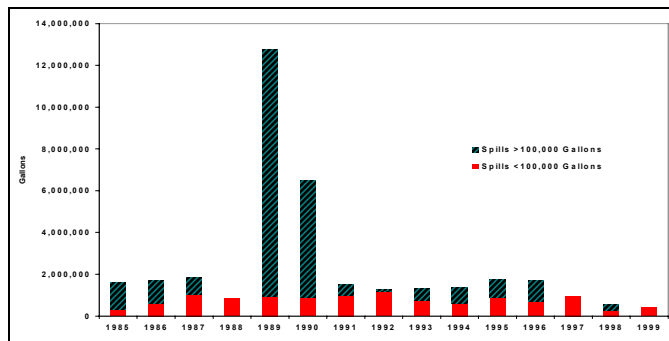


Figure 4. Total amount of oil spilled from vessels into U.S. waters (1985–1999) spill amounts from spills over and under 100,000 gallons (Environmental Research Consulting Database).

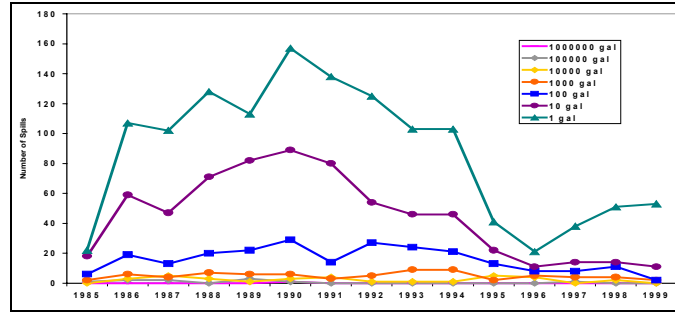


Figure 5. Annual Number of Tanker Oil Spills In US Waters By Spill Size Class (1985-1999) (Environmental Research Consulting Database)

tend to have lower overall spill sizes, since the oil originates from fuel tanks and machinery spaces rather than from cargo holds. Accidents and errors during bunkering, lightering, and loading caused 57% of tanker spills, 71% of barge spills, and 53% of freighter spills.

The largest vessel spills arise from accidents involving tankers, and occasionally barges, carrying large amounts of oil cargo. The actual number of tanker accidents (allisions, collisions, and groundings) has decreased to about 30 per year since reaching a peak of nearly 180 accidents in 1990 (Etkin, 2000a), undoubtedly contributing to the decrease in tanker spillage. Annually, only 0.2% of the more than 41,000 tanker transits result in accidents, and of these accidents less than 2% result in oil spills. The spill rate for tanker accidents has decreased since 1990, likely due to improved safety regulations and tanker construction. The percentage of tanker accidents resulting in oil spills of 1 gallon or more decreased sharply since 1990 (Etkin, 2000a).

Land-based facility spills. Spills impacting U.S. marine and navigable waterways and originating from fixed facilities (not pipelines) have decreased dramatically since peaking in 1991 (Figure 6), following a pattern similar to vessel spills. The total amount spilled is dominated by a tiny fraction (0.05%) of the spill number that represents spills of 100,000 gallons or more (Figure 7). Water-impacting facility spills follow the same frequency distribution pattern as vessel spills. The smallest spill size classes represent a large fraction of the spill number but only a small fraction of the total spill amount. Spills of over 100 gallons, while representing only 8.46% of the spill number, make up over 98% of the amount of oil spilled between 1987 and 1999.

Spills from U.S. land-based sources (pipelines, storage facilities, fixed industrial facilities, air transport facilities, railways, and motor vehicles) not impacting marine and navigable waterways decreased by 56% in the last 6 years (Figures 8–10) to an average of 4,800 spills of one gallon or more annually. These

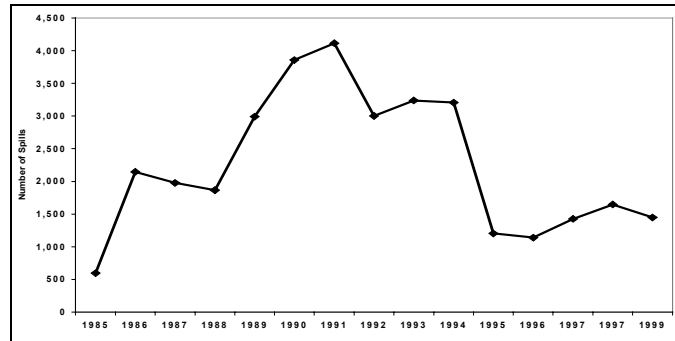


Figure 6. Annual number of facility spills of 1 gallon and over (excluding pipelines) impacting U.S. waters (1985–1999) (USCG data with analysis by Environmental Research Consulting).

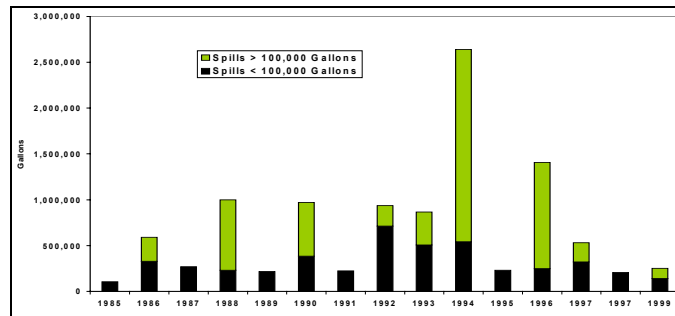


Figure 7. Annual amount of oil spilled from facilities (excluding pipelines) into U.S. waters (1985–1999) (USCG data with analysis by Environmental Research Consulting).



Figure 8. Total annual number of U.S. land-based oil spills of 1 gallon or more (1987–1999) (EPA data with analysis by Environmental Research Consulting).

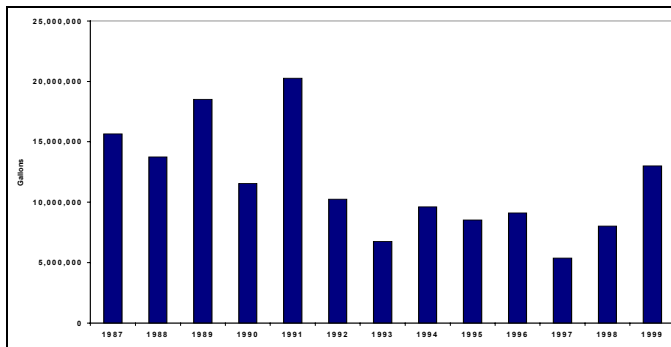


Figure 9. Total amount of oil spilled onto land in the United States in spills of 1 gallon or more (1987–1999) (EPA data with analysis by Environmental Research Consulting).

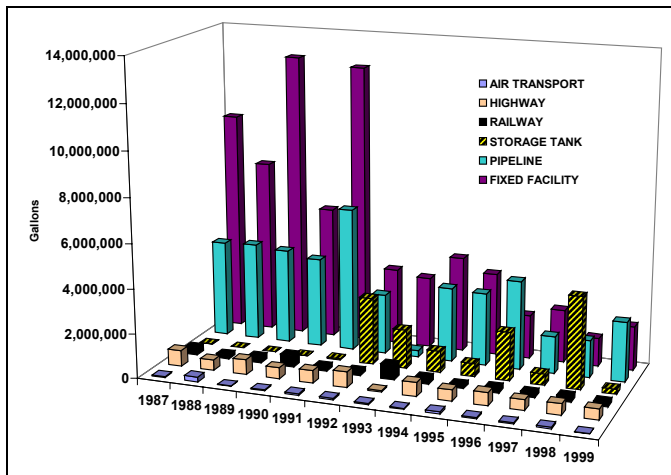


Figure 10. Annual amount of oil spilled onto land in the United States by source type (1987–1999) (EPA data with analysis by Environmental Research Consulting).

spills contribute over 9 million gallons of oil to U.S. land and groundwater resources each year. Fixed and storage facilities, and pipelines, make up the bulk of this spillage. Most of this input is from a small number of spills of at least 100,000 gallons (Figure 11). Spills of at least 100 gallons represent 47% of spill *number* and 99.6% of total spill *volume*. Spills of 1,000 gallons and over represent 16% of spill *number* and 97% of spill *volume*.

Pipelines. Since 1985, U.S. pipelines have spilled more oil than tankers and barges combined. Since 1991, pipelines have annually spilled 37 times as much as tankers. The change in the proportion U.S. pipeline spillage is largely due to the fact that since 1990, pipelines transport more oil across more miles than

water carriers (Figure 12) though the actual pipeline *mileage* has not increased appreciably. U.S. pipelines now carry 69.3% of oil transported, compared to 30.3% carried by vessels (tankers and barges). The annual number of pipeline spills has decreased by 500% over the last 30 years (Figure 13). Spill amounts are dominated by a small number of large events. Over 74% of pipeline spills involve 100 gallons or less, while spills in these smaller size classes contribute only 0.8% of the total amount spilled. 90% of spills are under 1,000 gallons. Overall, the amount spilled has decreased (Figure 14).

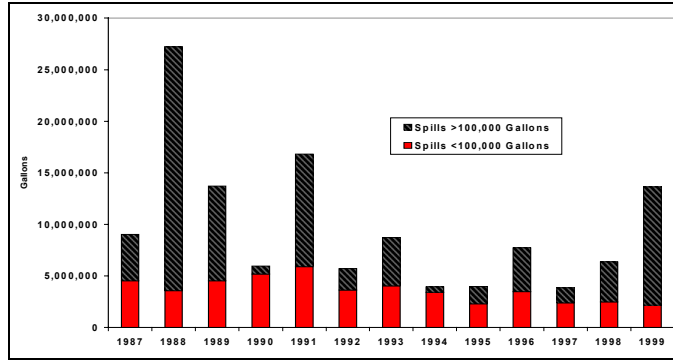


Figure 11. Total annual oil spillage onto land in the United States: Spills over and under 100,000 gallons (EPA data with analysis by Environmental Research Consulting).

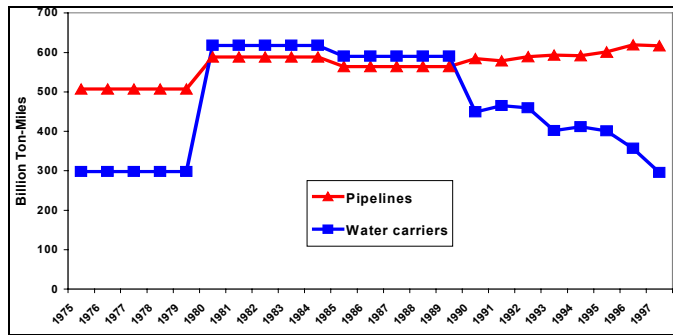


Figure 12. U.S. oil transport by pipelines and water carriers (1975–1999) (Bureau of Transportation Statistics data with analysis by Environmental Research Consulting).

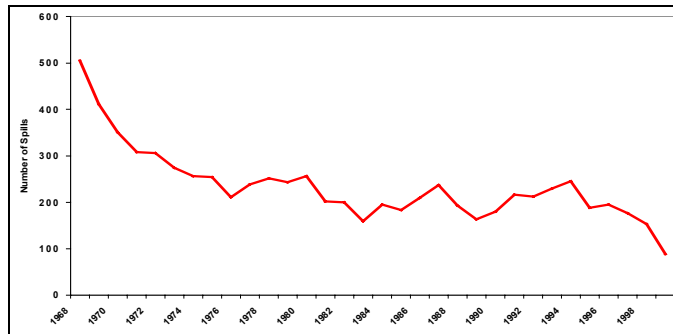


Figure 13. Number of oil transport pipeline spills in United States (1968–1999) (Environmental Research Consulting Database).

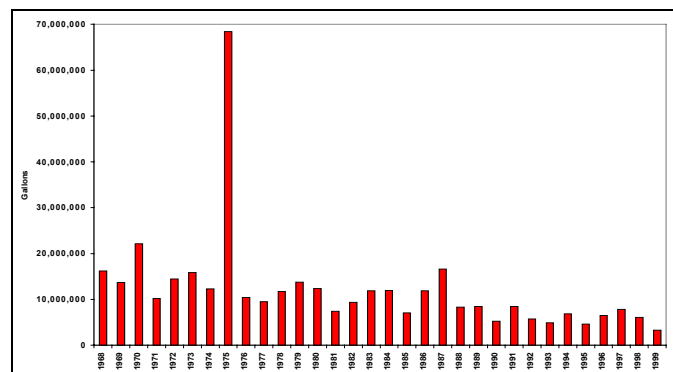


Figure 14. Amount of oil spilled from U.S. oil transport pipelines (1968–1999) (Environmental Research Consulting Database).

Structural failures are the most common cause of U.S. pipeline spills, representing 40% of spills. 75% of structural failure is attributed to corrosion, 15% to defective pipes, and 10% to defective welds. With an aging pipeline infrastructure in the United States—46% of pipelines are over 30 years old, 16% are over 50 years old, and over 2% are over 70 years old—more spills caused by structural failure may be expected in the future. “Outside force damage”—ramming by bulldozers or other equipment or natural damage from floods or earthquakes—cause 27% of spills.

Offshore spills. While 98% of U.S. pipeline spills occur onto land, occasional spills (less than 10 per year) from nearshore and offshore pipelines contribute to marine oil input (Figure 15). Spills from Outer Continental Shelf (OCS) exploration and production (E&P) facilities have also decreased significantly since U.S. offshore E&P activities began (Figure 16). Nearly 94% are spills of less than 50 barrels (2,100 gallons). On average, 80% of OSC spills are from platforms as opposed to OCS pipelines (Figure 17). Total OCS spillage has averaged 200,000 gallons per year, much of this is due to a small number of very large spills (Figure 18).

Overall 1990s oil spillage in the United States. Overall U.S. spill amounts for 1990–1999 are shown in Figure 19. The total amount spilled in the 1990s was 134 million gallons, a significant decrease from the previous two decades where 305 million gallons and 206 million gallons of oil spilled (Figure 20). Most of the oil spilled in the 1990s came from fixed facilities and land pipelines. Vessels contributed only 15%. OCS E&P facilities contributed only 1.4% of the total oil spillage.

Worldwide oil spill trends

Reductions in U.S. oil spillage largely mirror international trends (Figures 21–22). Spill numbers and amounts have decreased since 1990, though very large spills can skew oil amounts. The decrease is encouraging in light of a 46% increase in oil movement worldwide since 1988. Data presented (Figure 23–25) are *underestimates* for both numbers and amounts, since data collected on an international basis are subject to serious reporting errors and omissions, particularly for spills from particular regions, for smaller spills, and for spills from non-vessel sources. For example, vessel spills receiving media coverage because of their high-profile location or particular circumstances are more likely to be reflected than smaller pipeline spills in remote areas.

Assuming spills internationally follow similar patterns of spill size frequency distributions to U.S. spills, spills of at least 10,000 gallons represent 90% of the amount spilled, but only 5% of the actual numbers of spills. This logic was applied in analyzing the data shown in Figure 26. International estimates for the amount spilled and spill number in marine waters were derived by estimating the number of spills *under* 10,000 gallons and the amounts spilled in those size classes based on size class frequency distributions for more well-documented U.S. spill data sets (based on the methodology in Etkin, 1998a, 1999).

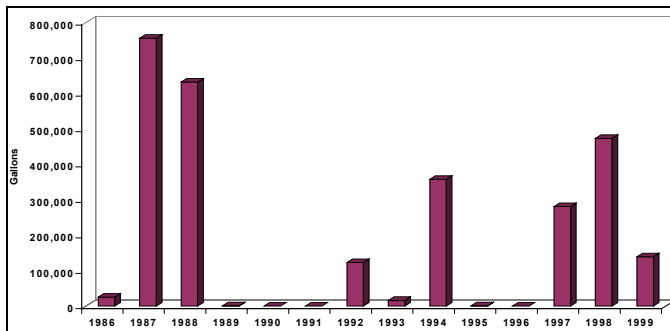


Figure 15. Annual amount of oil spilled into U.S. waters by marine pipelines (1986–1999) (Office of Pipeline Safety data with analysis by Environmental Research Consulting).

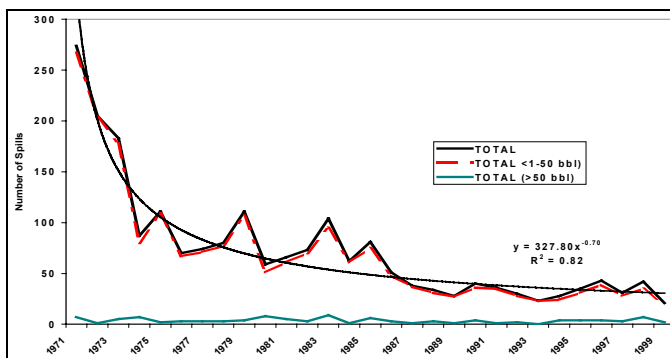


Figure 16. Annual number of oil spills from U.S. OCS exploration and production facilities (1971–1999) (MMS data with analysis by Environmental Research Consulting).

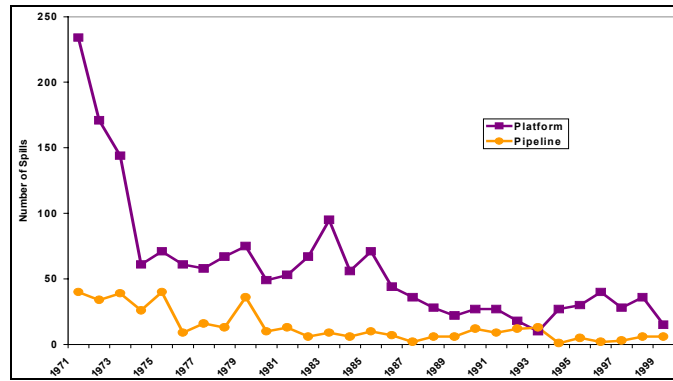


Figure 17. Annual number of U.S. OCS platform and pipeline spills (1971–1999) (MMS data with analysis by Environmental Research Consulting).

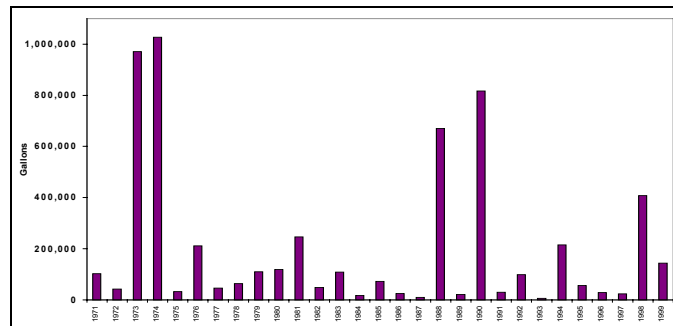


Figure 18. Total annual spillage from U.S. OCS facilities (1971–1999) (MMS data with analysis by Environmental Research Consulting).

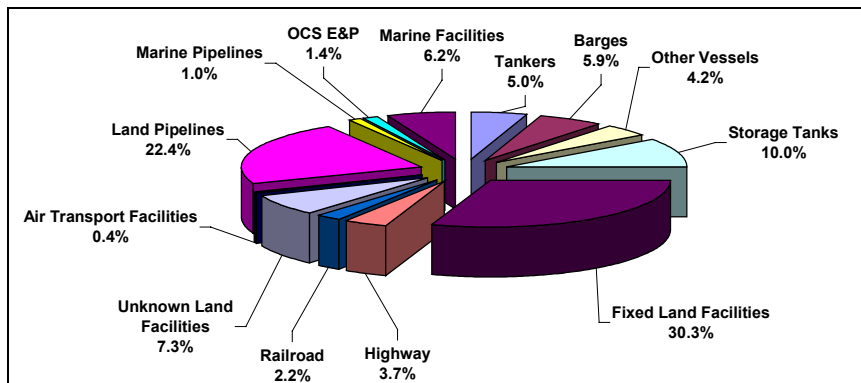


Figure 19. Sources of U.S. oil spillage (amount spilled from 1990–1999) (Environmental Research Consulting Database).

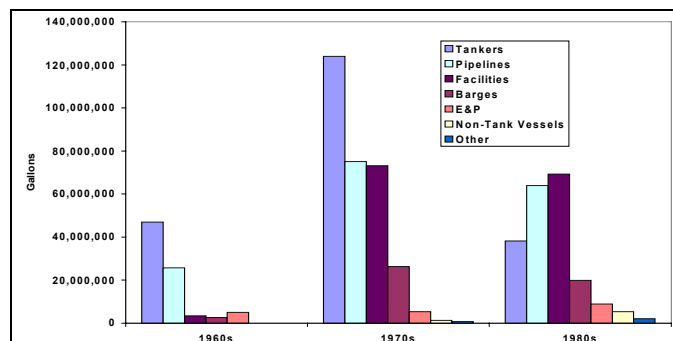


Figure 20. Estimated annual amount of oil spilled in the United States by source (Environmental Research Consulting Database).

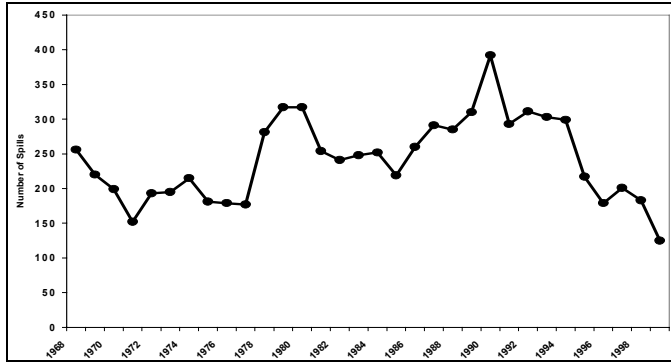


Figure 21. Annual number of oil spills of 10,000 gallons (34 tons) or more worldwide (1968–1999) (Environmental Research Consulting Database).

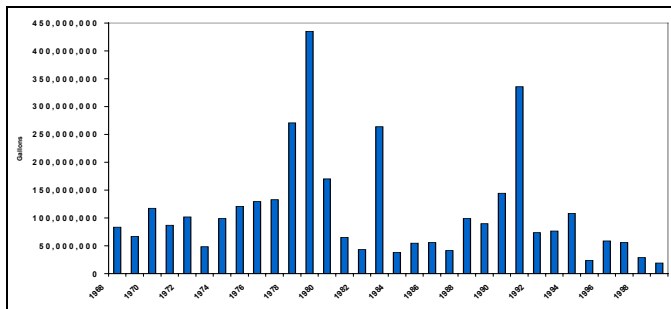


Figure 22. Annual amount of oil spilled worldwide (1968–1999) (Environmental Research Consulting Database).

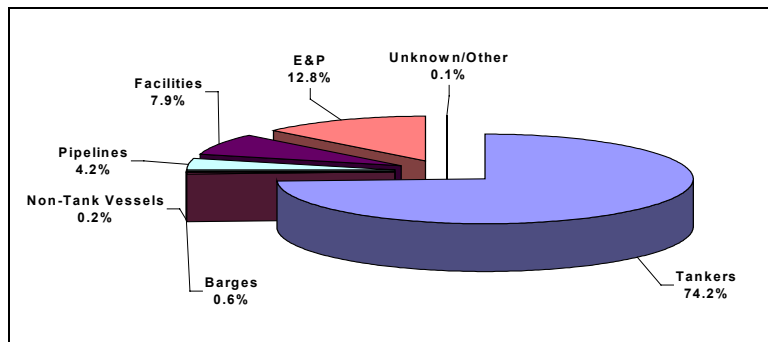


Figure 23. Estimated total amount of oil spilled into marine waters worldwide (1970–1979). Total amount spilled: 1,465,500,000 gallons (4,985,000 tons) (Environmental Research Consulting Database).

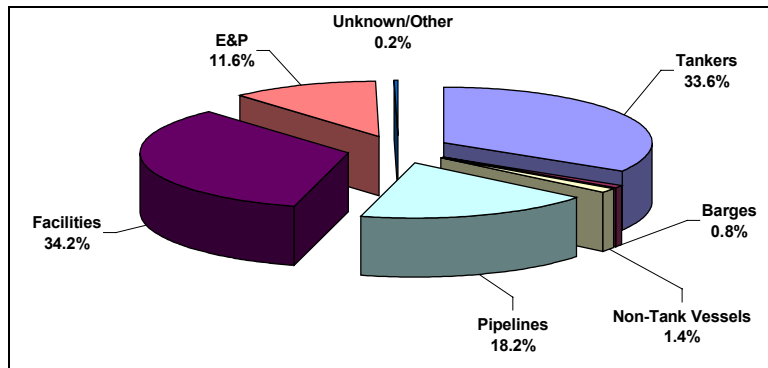


Figure 24. Estimated total amount of oil spilled into marine waters worldwide (1980–1989). Total amount spilled: 844,970,000 gallons (2,874,000 tons) (Environmental Research Consulting Database).

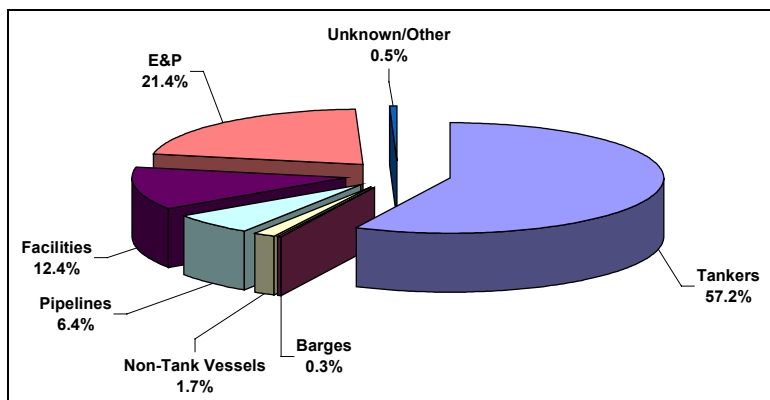


Figure 25. Estimated total amount of oil spilled into marine waters worldwide (1990–1999). Total amount spilled: 943,170,000 gallons (3,208,000 tons) (Environmental Research Consulting Database).

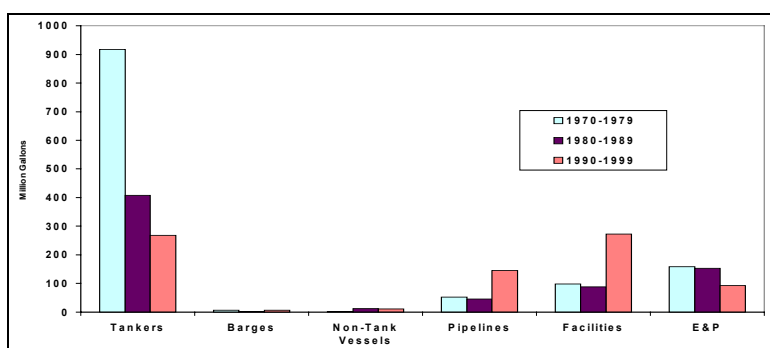


Figure 26. Estimated total oil spill amounts by source type (Environmental Research Consulting Database).

Worldwide, tanker spills dominated the oil spill picture until the 1990s when large pipeline and facility spills occurred. The percentage of oil contributed by tanker spills has decreased from 74% in the 1970s to 34% in the 1990s. Extremely large spills, such as the 1991 Gulf War spills and the 1979 Ixtoc I well blow-out, and large tanker spills in the 1970s, dominate spill amounts.

Discussion

Contrary to popular perceptions after recent catastrophic events, oil spill frequencies and total spillage have *decreased* significantly over the 20 years, particularly in the last few years, despite overall *increases* in oil movement. The decrease in oil spills worldwide, but in the United States in particular, may be attributed to a variety of influences. The impacts and repercussions of the 1989 *Exxon Valdez* spill, largely the impetus for passage of the Oil Pollution of 1990 (OPA 90), were watched worldwide. With OPA 90, the United States has the strictest tanker regulations. Improved safety standards, contingency planning, exercise programs, and other measures have helped reduce U.S. spillage. International conventions and national legislation have reduced worldwide oil spillage.

Much of this reduction, however, was realized *before* the implementation of OPA 90 and other regulations and conventions. Another important influence on spillage rates has been realization by tankers owners and other potential spillers that spills in the United States could result in *astronomical costs* for which the spiller could have *unlimited liability* (a result of OPA 90). Cleanup, penalty, and damage costs associated with the *Exxon Valdez* spill and other significant events in its aftermath have

seriously raised the stakes for potential oil spillers. Cleanup costs have risen dramatically in the last two decades even when corrected to current values (Etkin, 1998b, c). Implementation of pending increases in environmental damage liability nationally or as part of international liability and compensation conventions, along with increases in oil spill damage liability and penalties (Etkin, 2000b) for all spill sources, could change the oil spill picture on a worldwide basis.

While the statistics show encouraging downward trends, there is no room for complacency. An ill-timed oil spill that occurs in a sensitive location, regardless of spill size, can cause devastating damage to natural environments, property, and business, and, occasionally, to human lives. Aging pipeline and facility infrastructures, as well as aging vessel fleets, may be “ticking time bombs” especially as they become subjected to increasing oil throughput and transport in future years. Increased international attention to tanker safety has had a positive influence that is sorely needed in other vessel categories and for nonvessel sources, particularly pipelines.

Biography

Dagmar Schmidt Etkin received A.M. and Ph.D. degrees from Harvard University. Her environmental science experience includes: 12 years investigating population biology and ecology, and 11 years specializing in oil/chemical spill database development, data analysis, risk assessment, and cost analyses, most recently in her own independent consulting firm, Environmental Research Consulting.

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