

The Coming of Age of Controlled In-Situ Burning

Transition from Alternative Technology to A Conventional Offshore Spill Response Option

Néré Mabile - BP America
Nere.Mabile@bp.com

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ABSTRACT

Controlled in-situ burning (ISB) has a history of incident response, research and testing, and increasing degrees of success that spans six decades. The very first recorded ISB on water occurred in 1958 on the icy MacKenzie River in Canada, and at least four controlled ISBs were performed on water in the 1970s with varying degrees of success. Perhaps the most noteworthy historical use of controlled ISB, however, was conducted in March 1989 in Prince William Sound, Alaska, following the grounding and spill of the T/V Exxon Valdez. That ISB operation consisted of one burn and the removal of approximately 350–700 barrels of oil. In the years following the Valdez incident, there have been numerous studies and tests of the effectiveness and potential impacts of controlled ISB of oil in different environments. These tests shed light on the science and operational potential for controlled ISB. One of the most successful demonstrations of controlled burning took place during the Deepwater Horizon (DWH) response in the Gulf of Mexico in 2010. Approximately 400 safe and effective controlled burns were conducted, removing an estimated 220,000 to 310,000 barrels (29,700 to 41,800 tons) of oil. These controlled burns have proven that vast amounts of spilled oil can be removed safely and quickly, using existing technology, and with minimal impact upon the environment. They also confirmed that, in the right conditions (involving oil properties, wind and sea conditions, proximity to populated areas, and overall net environmental benefit),

controlled burning can now be considered a conventional, primary offshore response tactic. Because of the safe and effective DWH experience and other successful ISB events, industry regulators and the general public can transition away from considering controlled ISB an alternative technology and now recognize its full potential as a proven, safe, and effective oil spill response option.

INTRODUCTION

In the 1950s and 60s, the petroleum industry expanded their scope in the search for and acquisition of hydrocarbon fuels. The industry began drilling in arctic and subarctic regions; they began using semi-submersible rigs in offshore environments; and they generated a spider web of shipping networks and pipelines around the globe. Worldwide consumption grew from 11 million barrels per day in 1950 to 80 million barrels per day in 2010 (Wright 2007; Brown 2010; Behrens 2011).

The most turbulent decade for the petroleum industry in terms of oil spill incidents was the 1970s. Although oil consumption in the U.S. tripled from 1949 to 1978 (spiking dramatically in 1973 and 1978), U.S. production of oil increased relatively slowly through 1970 and then began to decline; therefore, to meet demand, imports of oil from other countries surged—from 0.3 to 8.5 million bbl/day during the same 1949-1978 timeframe. This exponential increase in imports—with the greatest spike from about 1970 to 1977—led to increased oil spill incidents from tankering, thereby prompting agencies to start tracking the numbers more carefully. About 55% of all recorded oil spill incidents occurred in the 1970s (**Figures 1 and 2**), and the ensuing environmental concern led the petroleum industry to begin directing research capital toward spill prevention and spill response. Contributing to this energy anxiety of the 1970s was market instability and fear of shortages because of

world events, such as the 1973 Arab oil embargo, which was placed on the U.S. in response to U.S. policies supporting Israel. The resulting increase in non-OPEC oil exploration and production also encouraged oil companies to direct resources toward research in spill prevention and response (*Oil Spill Science and Technology* 2011; International Tanker Owners Pollution Federation Ltd. [ITOPF] 2010; U.S. Energy Information Administration 2012).

The amount of oil spilled steadily decreased through 2007 (**Figures 1 and 2**), dropping 77% since the 1970s. In the tanker industry alone, the number of spills dropped from 253 incidents in the 1970s to 33 incidents in the early 2000s (**Figure 2**) (Etkin [API] 2009; ITOPF 2010). Additional details in support of improved spill prevention can be found in **Appendix A**.

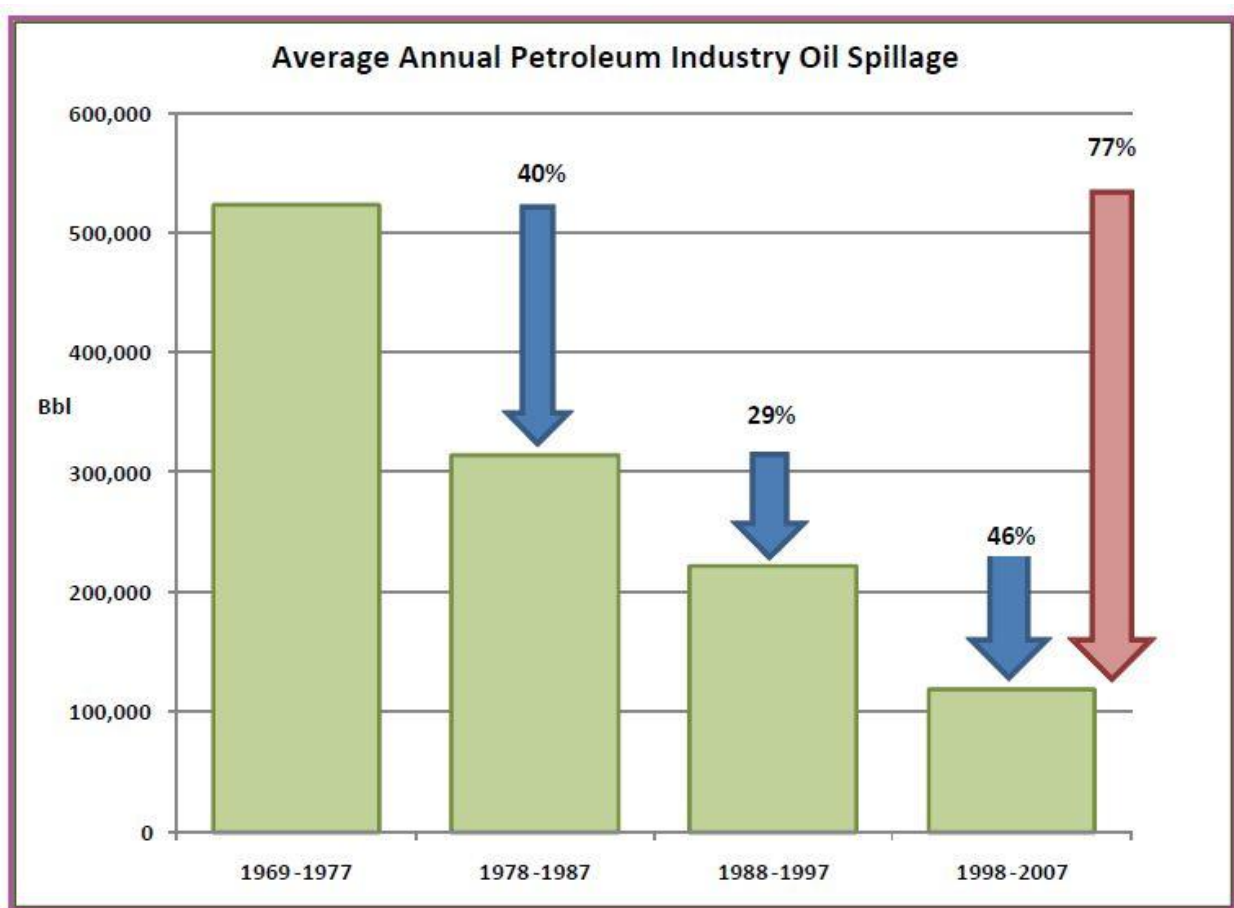


Figure 1: Petroleum industry spillage reductions (bbl) from 1969 to 2007. (Etkin [API] 2009)

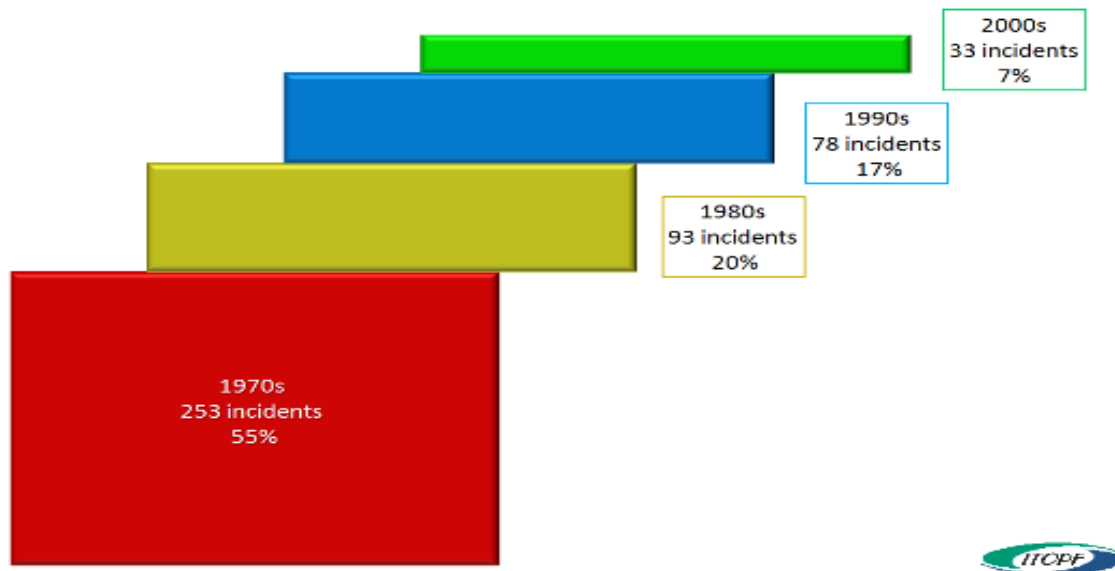


Figure 2: A comparison of individually reported incidents of tanker spills by decade. (ITOPF 2010)

In addition to increased attention on spill prevention, efforts to remove spilled oil (during both accidental and test spills) have allowed researchers to build on the industry's knowledge base and determine which methods are more effective for specific conditions.

Early in the investigations into oil spill response technologies, three technologies gained recognition for their potential in offshore emergency oil spill response and, therefore, received increased research and development (R&D) interest:

- Mechanical recovery—skimming
- Dispersant application
- Controlled in-situ burning (ISB)

In the 30+ years following the tumultuous 70s, oil spill response has become a coordinated, science-based effort (ARPEL 2006, 2007; ASTM 2003; Buist 1998, 1999; Consortium for Ocean Leadership 2008; Danenberger 1997; ExxonMobil 2008; Fingas 1997, 2000; API JITF 2011; McKenzie 1999; White 1998; U.S. Army Corps of Engineers 2005). Advances in response technology were key to the

effectiveness of the Deepwater Horizon (DWH) response efforts in the Gulf of Mexico in 2010. For offshore oil spills, a combination of methods and tactics is always recommended, but the focus of this paper is the progress made in increasing the effectiveness and understanding of controlled ISB, as well as the timeliness of characterizing this tool as a primary response option, particularly after its success in removing oil from the Gulf of Mexico.

HISTORY OF CONTROLLED IN-SITU BURNING (ISB)

Early Controlled ISB Attempts

The first recorded attempt to perform a controlled ISB of spilled oil was carried out successfully on the ice-covered Mackenzie River in NWT, Canada, in the spring of 1958. A broken pipeline led to an undetermined amount of escaped crude oil, which was contained by log booms and then burned. Experts estimate that 120 tons of oil was removed from the river during this ISB (McLeod 1972; ARPEL 2006).

After this first controlled ISB, similar attempts were made over the next few decades in the UK (1967), Sweden and Finland (1970s), many locations in Canada (1970s), and the U.S. (1976-77). However, ISB had many obstacles to overcome in the beginning. As noted ISB expert Merv Fingas explains in his 1998 paper on the historical perspective of ISB, people are conditioned to believe that “burning is bad and results in negative effects on the situation and on the environment” (ASTM 2003; Schrier 1978; Fingas 1998).

Separately, engineers and researchers began investigating new techniques in the late 1960s and throughout the 70s. During this early period, somewhat ill-equipped and sometimes initially undocumented efforts to burn spilled oil with rudimentary techniques led to an impetus to better understand the mechanics and improve the processes through research and testing. After a number of accidental

ISBs and a few successful test burns (particularly the success of controlled ISB during the Exxon Valdez response in 1989), responders began to acknowledge the potential benefits of the controlled ISB response tool and recognize areas for improvement. The engineers and researchers finally joined forces, working with manufacturers to develop fire-resistant boom and with environmentalists and meteorologists to measure particulates and better understand how conditions affect the burn success. Many of the tests were conducted at OHMSETT (the National Oil Spill Response Test Facility in Leonardo, New Jersey) beginning in 1984 and at NOBE (the Newfoundland Offshore Burn Experiment) in 1993 (Evans 1990; Fingas 1997, 1998; Environment Canada 1997; Buist 2001; U.S. Minerals Management Service 1998).

The “Fathers” of ISB

Efforts to explore the full potential of controlled burning in both the U.S. and Canada can be traced back to the 1970s when, building on the research of people like D. Burgess, oil spill specialists such as Al Allen, Ian Buist, Dave Dickins, Merv Fingas, Ed Twardus, and Doug Walton (separately) began conducting important groundbreaking research and field trials. Knowing that burning is one of the most efficient ways to eliminate spilled oil quickly and safely in the right conditions, these researchers examined the physical and chemical properties of spilled oil and assessed the effects of wind and waves on the spreading of oil. They determined how environmental factors influence the feasibility of burning oil at sea and on/in snow and ice. Over a 40-year period, they worked to understand the pros and cons of burning, the requirements for successful ignition and sustained combustion of oil, ways to enhance controlled burning with fire-resistant booms, and the nature and

magnitude of various products of combustion (NIST 2010; Walton 1979; Twardus 1978; S.L. Ross 2007; Fingas 1979; DF Dickins no date provided; Burgess 1961).

These efforts and the contributions of others—more recently endeavoring to focus field trials on broken ice conditions, to measure the fate and effects of combustion byproducts, and to improve ISB techniques and equipment—have helped to build the case for using ISB as a primary response tool. Because of the success of many controlled ISB field trials and the results of burns during actual oil spills (e.g., Exxon Valdez, 1989), numerous countries have followed the lead of the U.S. and Canada in enhancing preparedness for burning of oil in response to an oil spill. Efforts are underway to acquire equipment, train personnel, and promote the use of controlled burning through industry, agency, and public education, as well as through the creation of government guidelines and regulations for the pre-authorization or expedited approval of controlled burning (U.S. Coast Guard 1999, 2003, 2008; U.S. Congress 1985; *RRT VI: In-Situ Burn Plan* 1994; *Northwest Area Contingency Plan* 1995; NOAA 1997; National Response Team 1997; Allen 1990; Allen 2011).

Engaged in a seemingly paradoxical pursuit—to sustain fire on water—the research of these “fathers” of controlled ISB contributed enormously to the success of the deliberate burning of oil on a large scale at sea during the DWH response.

Evolving Public and Industry Perception: Case Studies

Oil spills have been documented for at least 100 years, but the attention and perception of the public has changed toward these events because of increasing access to news through various media. In an effort to provide nearly immediate images of response activities, as well as to explain highly technical information for public consumption, the news media faced its own large-scale response that

stretched resources. Between April 20 and mid-August, 2010, the DWH response accounted for 29 to 42 percent of all news coverage in the mainstream and cable news outlets, and according to recent studies, the public paid very close attention as events unfolded. The unprecedented attention paid to this event dwarfs that of all other oil spill incidents—even though there were some similar incidents historically. A true comparison of the sizes of some of these past oil spills is provided in **Figure 3** (U.S. Department of Commerce 1992; West [no date]; White 1998; Pew Research Center 2010).

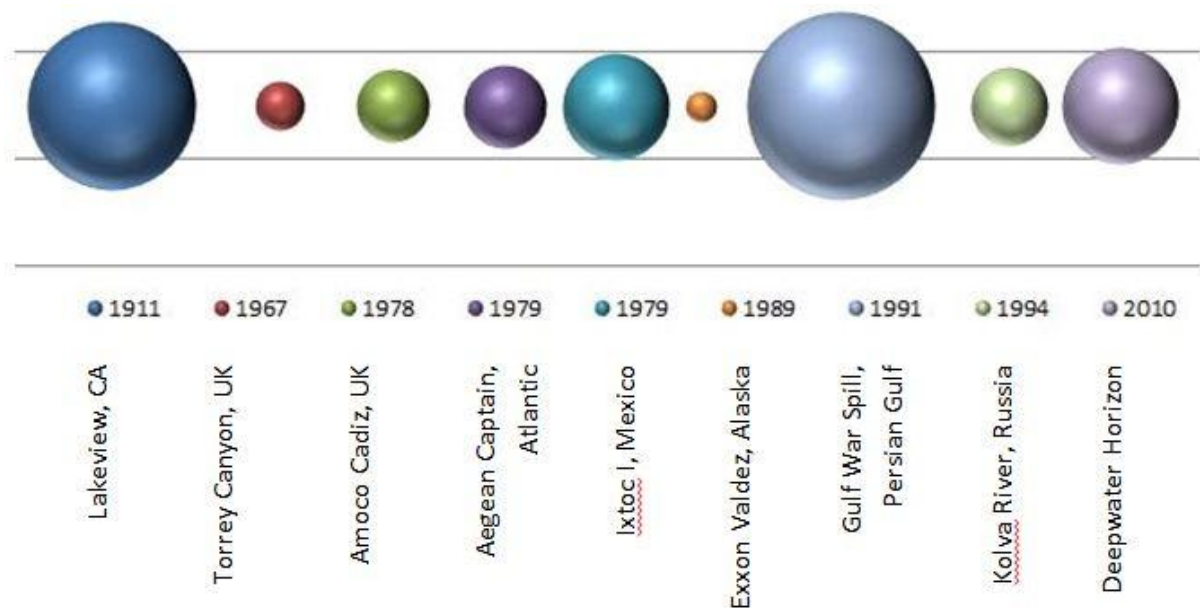


Figure 3: A size comparison of historical oil spills—both offshore and onshore—and their estimated spill amounts.

Along with increased attention on the effects of oil spills, the dozens of recent ISB photographs available online suggest that the public has also become more aware of oil spill response technology. The black smoke plume depicted in these photographs can cause concern (without a clear understanding of air quality effects and monitoring), but over time ISB has proven itself to be an efficient, cost-effective, and relatively environmentally friendly response tool when weighing risks and benefits during an offshore oil spill response. The best example of this occurred in

the summer of 2010 in the Gulf of Mexico as multiple ISB teams burned an estimated 220,000 to 310,000 barrels of sweet Louisiana crude to minimize the oil's effect on coastlines and wildlife (MSRC 2010; Allen 2011; USCG 2011).

The DWH response was undeniably the most successful use of controlled ISB in history, but several other spill responses are worth mentioning because of their influence on perceptions or methodology and/or for their unique characteristics:

- Buzzard's Bay, MA, spills in 1969 and 1977
- The Argo Merchant spill in 1976
- The Ixtoc I spill in 1979
- The Exxon Valdez spill in March 1989
- The New Carissa spill in February 1999

A world map showing the location and date of 12 historically significant ISBs on water is provided in **Figure 4**.

Buzzard's Bay Spills 1969 and 1977

In September 1969, the barge Florida ran aground in Buzzard's Bay, MA, and spilled almost 680,000 liters of No. 2 fuel oil. The response effort was minimal and the effect on fish and shellfish was significant (Schrier [EPA] 1978).

The Bouchard No. 65 barge ran aground in Buzzard's Bay, MA, and spilled about 318,000 liters of No. 2 fuel oil in January of 1977, one of the coldest, iciest winters on record for that area. This event alerted responders to the special problems presented by free-flowing ice and snow that covered oil onshore within days of the spill. Cleanup crews led by the U.S. Coast Guard recovered 28 percent of the pollutant, mostly using "shore-based vacuum skimming." The EPA noted that efforts to burn the oil "showed some promise" although the available equipment was out of date. This incident appears to have been a watershed event in oil spill

response because responders recognized the need to support further research on the effects of harsh conditions during a spill response and the need to stage up-to-date response equipment where it could be of most use (Schrier [EPA] 1978; Ruby 1978).

Argo Merchant 1976

In December 1976, the Argo Merchant ran aground southeast of Nantucket Island, MA. Eventually, all of its cargo of 183 bbl of No. 6 fuel oil spilled as the tanker broke apart during a storm. The USCG experimented with ISB twice as the spill was blown away from land by heavy winds, but they were unable to sustain a successful burn despite the use of wicking agents, jet fuel, and explosives, as reported by the National Oceanic Atmospheric Association's (NOAA) Incident News website. According to the NOAA's "Preliminary Scientific Report," "The grounding of the Argo Merchant triggered intense scientific activity" through February 1977 to assess the impact of the spill on valuable fishing areas. NOAA recognized that, in 1976, "there was virtually no organized plan for conducting research on the spilled oil." The report goes on to say that "the usefulness of having an operational burning system can be envisioned in this situation" and that the ISB may have been enormously valuable if the Argo Merchant had been authorized to dump fuel following its initial grounding (www.incidentnews.gov [a]; NOAA 2011a).

Ixtoc I 1979

The Mexican-owned Ixtoc I exploratory well released 3.5 million barrels of heavy crude oil into the Gulf of Mexico's Bay of Campeche after the platform facility exploded in June 1979. The semi-submersible platform, leased by Pemex, caught fire after a loss of drilling fluid circulation and then collapsed onto the wellhead, and engineers executed a multi-layered effort to cap the well and drill two relief wells.

The only burning that took place was that of the free gas coming up with the emulsified oil directly over the blow out. Burning continued for many months. There was no record of any ignition of the emulsion (typically >70% water in oil) on the surface. The Ixtoc I incident is significant to a study of ISB history because it was the largest offshore oil spill in history, and the response made it clear to all involved that more research and testing was needed to enhance oil spill response technology (www.incidentnews.gov [b]; Melina 2010; U.S. Department of Commerce 1992; Allen, personal communication 2012).

Exxon Valdez 1989

The Exxon Valdez oil tanker hit a reef in Prince William Sound, AK, and spilled about 260,000 bbl (11 million gallons, 37,000 tons) of crude oil into the water. Within 2 days of the spill, responders were able to contain and burn 15,000 – 30,000 gallons of the oil using fireproof boom. Only one burn was possible because of delays in getting authorization to burn and because of a very brief window of opportunity to burn; a storm hampered response operations beginning on Day 3 of the event. This spill's significance in the development of ISB technology had more to do with changing public perception than changing processes, confirming the importance of preparing for oil spill response and of building a response mechanism that could be initiated at a moment's notice (Hunt 2009; NOAA 2011b; Exxon Valdez Oil Spill Trustee Council 2011; Allen 1990).

New Carissa 1999

In 1999, a Panamanian freighter called the New Carissa ran aground in Coos Bay, OR, during a storm. About 230 tons of heavy fuel oil and diesel was spilling onto the beach. Before the freighter broke apart, which would have spilled even more fuel, Unified Command for the incident decided to burn the fuel to prevent

further environmental damage. The U.S. Navy was successful in igniting the fuel tanks with 39 well-placed shaped charges and burned an estimated 200,000 gallons. The bow section was then towed out to sea and sunk, but the stern remained on the beach. This incident was significant in that it provided unusual conditions (onshore near populated areas), required extraordinary measures for burning (incendiary devices), allowed response teams to use the Special Monitoring of Applied Response Technologies (S.M.A.R.T.) program in the field for the first time, and proved to be a resounding success that people could actually see because of its location. The USCG's annual report for 1999 stated, "While some oil did spill out of the vessel, the Unified Command's efforts [using ISB] greatly reduced the potential environmental damage to the Oregon coast" (U.S. Fish and Wildlife Service 2006; Hall 1999; Mauseth 2001; USCG 1999).

On-Water Spills involving ISB At Accidental Spill Sites

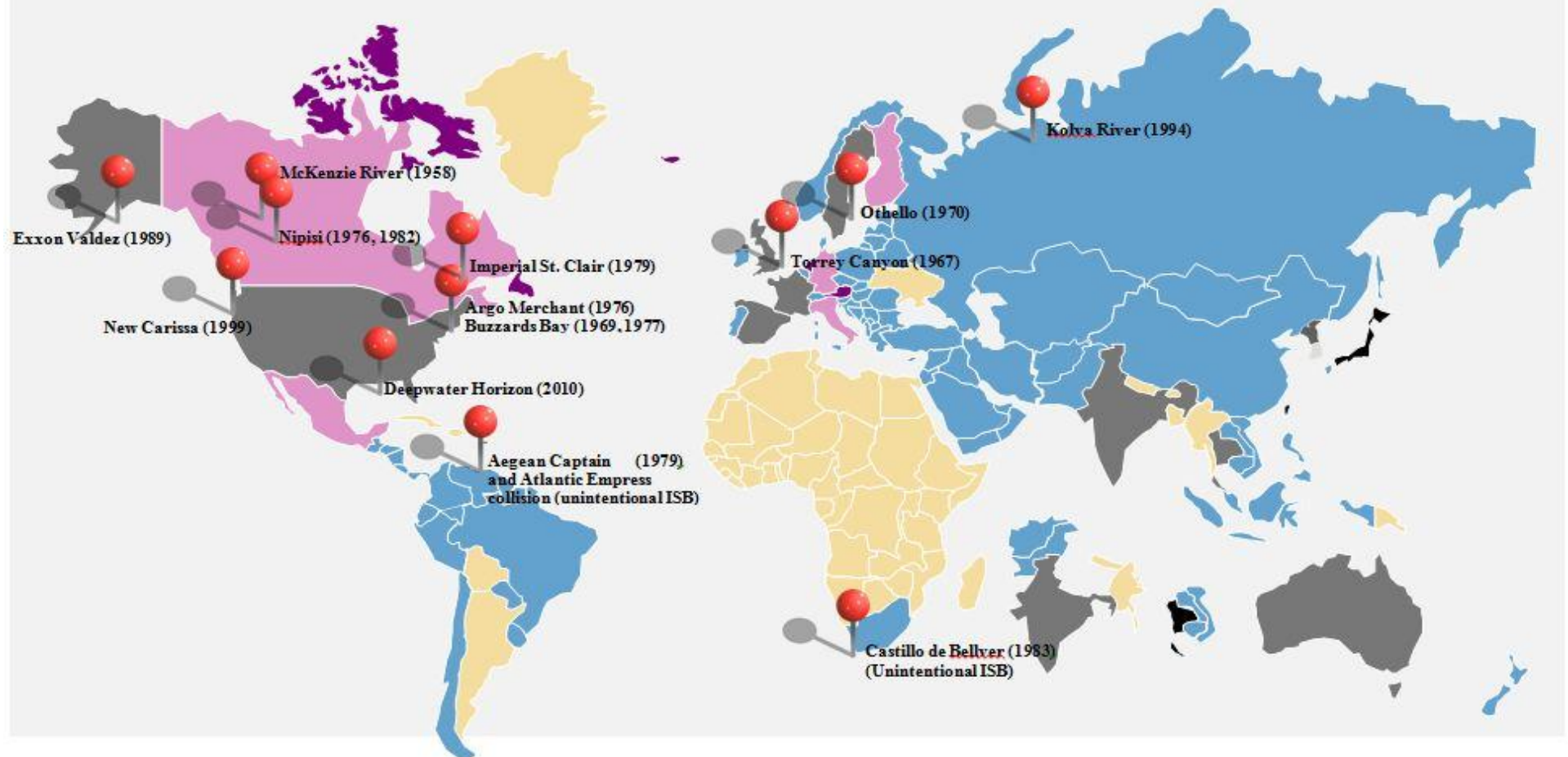


Figure 4: Map of historically significant spills and ISBs on water since 1958.

ISB TODAY: PREPARATION AND PRECISION

Alliances for Enhanced Research Capabilities

In the U.S., the Bureau of Ocean Management, Regulation, and Enforcement (BOEMRE, previously called the Minerals Management Service [MMS]) has spent almost 20 years initiating and participating in joint-venture research projects to determine best practices in the following areas (Mullin 2011):

- Locating and determining the extent of spilled oil
- Predicting the weathering and movement of the oil
- Testing equipment and identifying the best equipment for the job
- Identifying needs for new methods and equipment

In 2011, the BOEMRE was divided into two organizations: the Bureau of Ocean Energy Management (BOEM) and the Bureau of Safety and Environmental Enforcement (BSEE). The BSEE now oversees U.S. oil spill response and removal.

New alliances have been made in just the last several years among regulatory agencies, universities, global stakeholders, and industry. Particularly as a result of the DWH response, the various groups have a better understanding of the capabilities of collaborators in response and research. The DWH response learnings have resulted in a renewed awareness of the benefit of even further controlled burning research and development. Industry technical work groups are currently identifying and prioritizing ISB R&D projects, and a few of the more active organizations are the American Petroleum Institute (API), the Oil and Gas Producers' Association (OGP), and the International Maritime Organization (IMO) (U.S. Coast Guard 2011; MSRC 2010; *Joint Industry Task Force Report* 2011).

ISB Results from the DWH Response

The ISB response performance from the DWH incident clearly illustrates the potential environmental benefits and cost-effectiveness of controlled ISB as a primary response tool for hydrocarbon spills offshore in the right conditions. In about 400 successful ISBs, multiple ISB teams burned approximately 220,000 to 310,000 barrels of sweet Louisiana crude to minimize the oil's potential effect on Gulf of Mexico marine life, coastlines, and wildlife (**Figure 5**). Most of the burns were 3 to 15 miles from the Macondo 252 spill source (**Figure 6**). The first ISB Task Force for the DWH response was conducting a burn within 48 hours of notification that the ISB response tool was needed (Allen 2011).

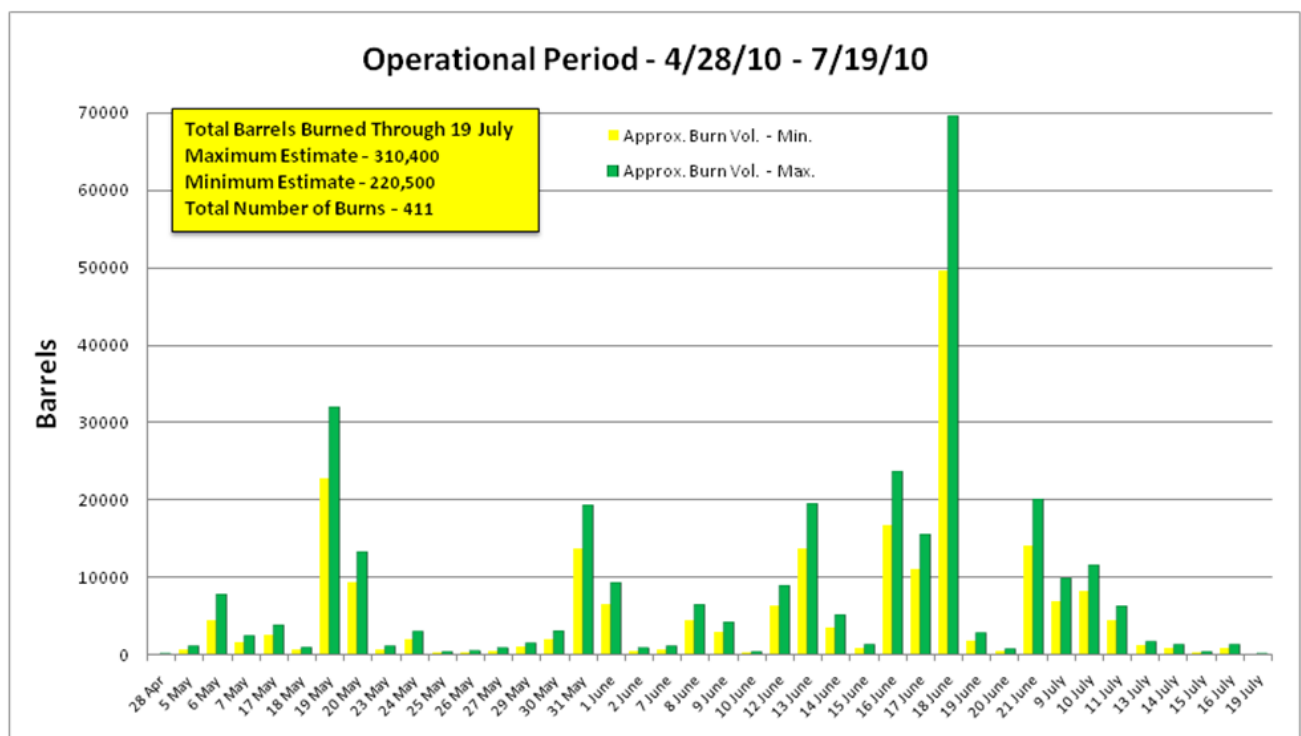


Figure 5: Daily Burn Volume Report.

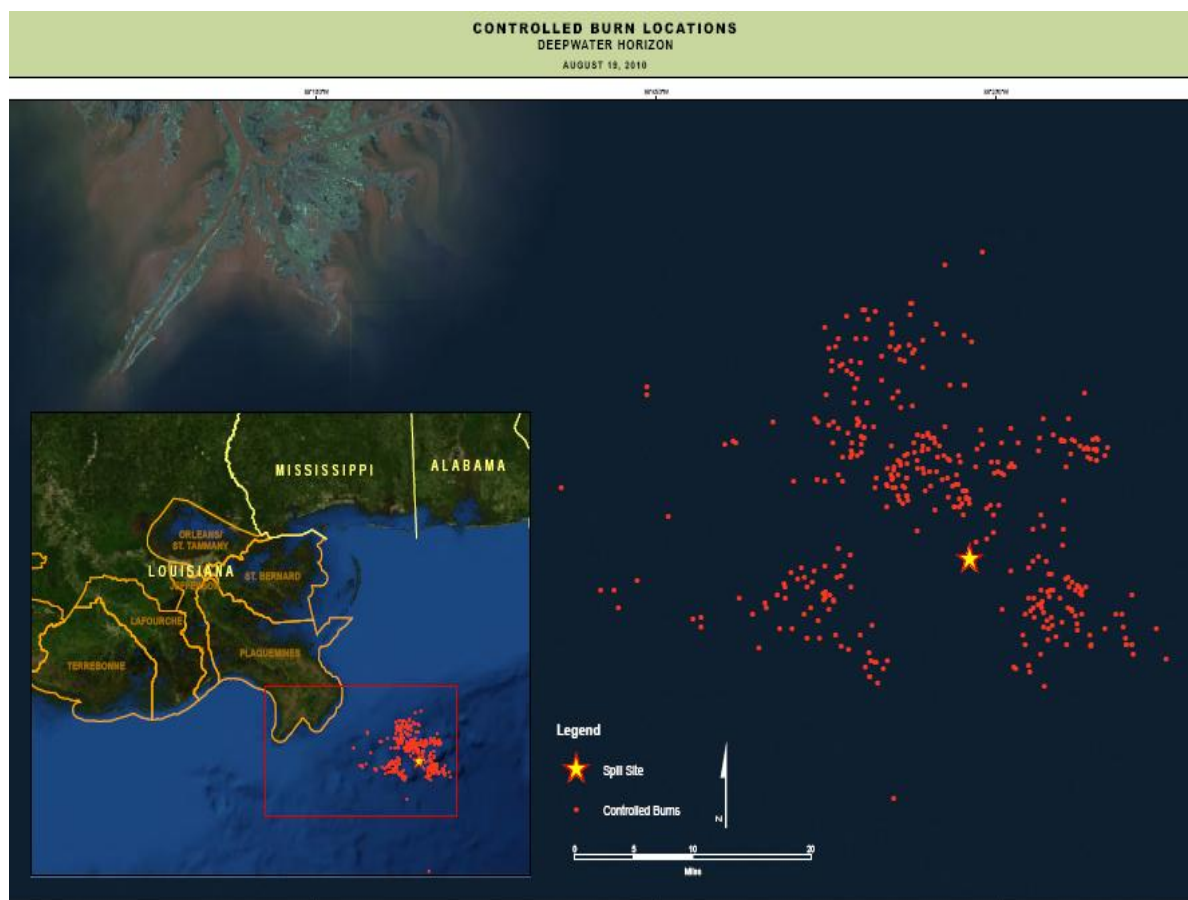


Figure 6: Controlled ISB burn locations, DWH response.

At the height of the response, three ISB Task Forces were deployed, each supporting four to five burn teams. Each team comprised two shrimp boats for pulling boom; one or two larger vessels for Command, safety/fire control, and boom supply/repair; and multiple smaller boats for ignition and repairs (**Figure 7 and 8**). Supporting these teams were about 10 members of the spotting team, which managed the operation of King Air aircraft to search for and initially assess oil slicks. A key to the success of ISB effectiveness was the utilization of fixed-wing aircraft to not only spot where the larger oil concentrations were, but to monitor the oil flow and guide the ISB tactical teams to keep them in the concentrated surface oil. The ISB teams were also supported by a number of specialists onshore and in the field, such as those involving wildlife, geographical information, burn volume calculation, data processing,

meteorology, etc. The average burn volume per controlled ISB was approximately 750 bbl, and the average burn duration was 58 min. On one calm-water day (June 18), the ISB teams burned an estimated 50,000 to 70,000 bbl of oil. **Table 1 and 2** provide summaries of DWH-response totals (Allen 2011).

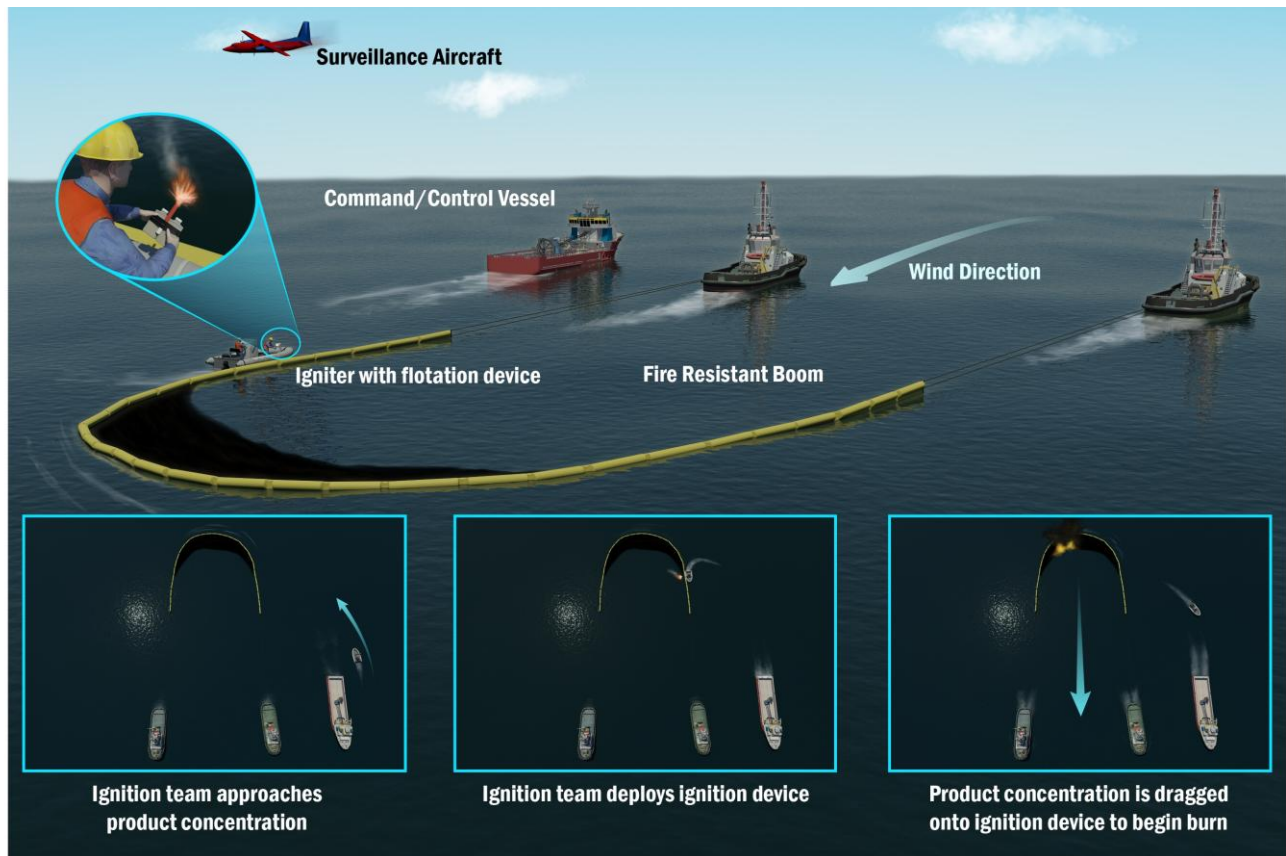


Figure 7: Typical ISB team configuration and operations tactics—collection and ignition.

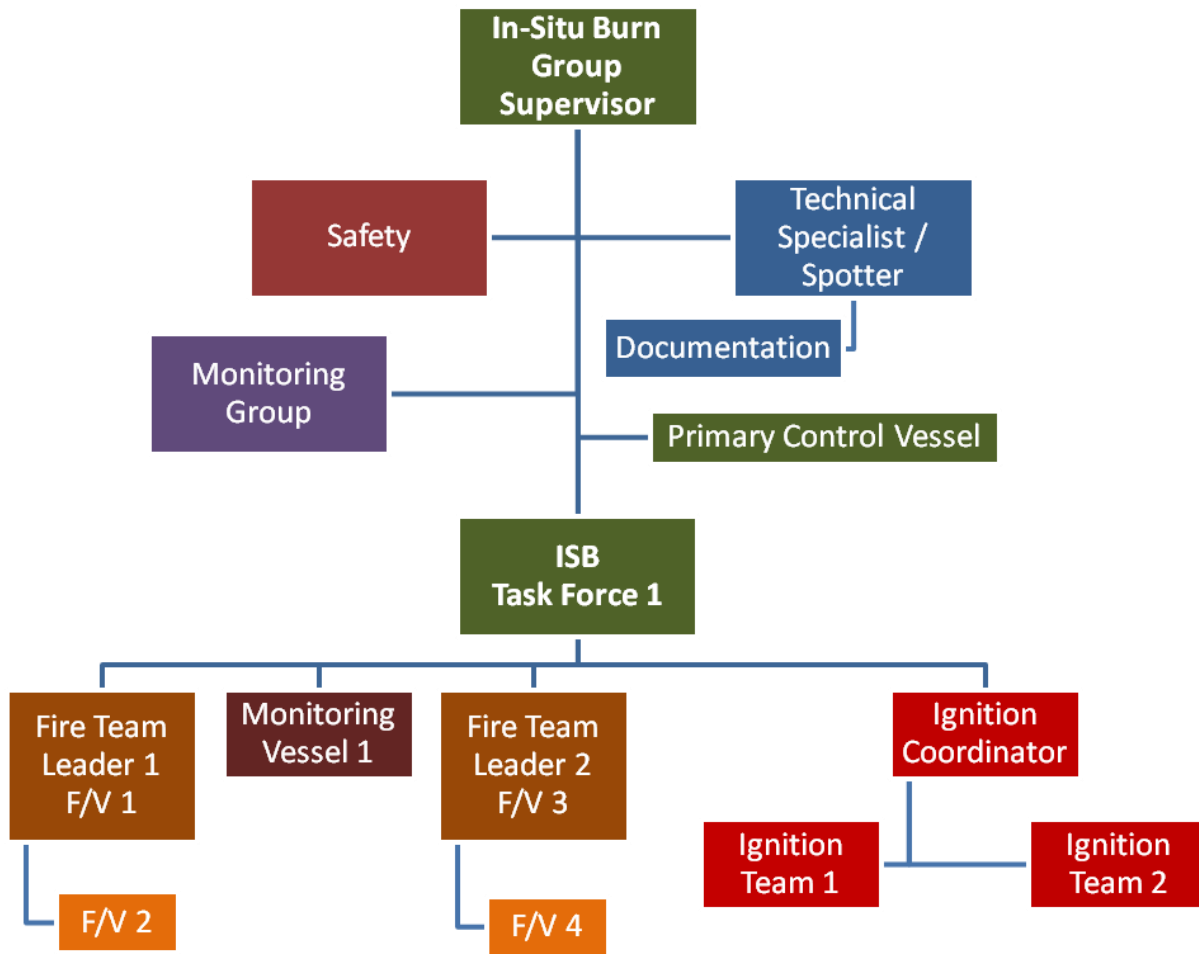


Figure 8: Typical ISB team structure (with one Task Force).

Table 1: Summary and Totals from Deepwater Horizon ISB Operations
(Allen 2011)

Personnel / Groups	Total Responders: <100 Task Forces: 2 – 3 Burn Teams: 4/5 per Task Force Each Burn Team: 7/8 people Spotting Teams: ~10 people ISB Managers: 4 people
Technology	Fire Boom: 23,000 ft from 5 manufacturers Igniters: 1,700 handheld, containing gelled diesel in plastic 1/2-gal bottle with float and road flare attached
Vessel(s) and Aircraft	Boats: ~30 boats Command/Safety = 1 Burn Team = 2 fishing vessels per burn team (about 20 total) Igniter boats = 4/5 Aircraft: 2 King Air
Date and/or Amount of Time	Dates: 4/28/10 – 7/19/10 (83-day window with 40 days suitable for ISB operations) Time per Burn: 10 min to nearly 12 hrs
Size / Amount and/or Location	Oil Burned: ~220,000 – 310,000 bbl Burn Attempts: 411 Significant ISBs: 376 Average Volume per Burn: 750 bbl Locations: ~3 – 15 miles from source (Approx. 50 miles from shore)

Table 2: Operational Details from the Deepwater Horizon ISB Group
(Allen 2011)

Operational Consideration	Details
Time from notification to deployment	48 hrs
First burn	4/28/10, ~ 1/2 hour, burned ~100 bbl of oil
Longest burn	6/16/10, 11 hrs and 48 min, burned 5,956 – 8,339 bbl (See burn volume estimation below)
Most oil burned in one day	6/18/10, burned 50,000 – 70,000 bbl
Average burn length	58 min
Boom manufacturers	Elastec/American Marine Inc.; Applied Fabric Technologies, Inc.; Kepner Plastics; and Oil Stop, Inc.
Fire boom lifespan	12 – 14 ISBs before repairs were needed, depending on manufacturer
Types of large vessels	200-ft supply boats to 100-ft fishing/shrimp vessels (vessels of opportunity)
Types of small vessels	Rigid-hull inflatable or aluminum skiffs
Communication/Surveillance technologies	Satellite imagery, onboard and air-to-ground radio communication links, Automatic Identification Systems (AIS), and live video coverage from shore-based and vessel-mounted systems
Length of boom per ISB	~150 meters (~500 ft) per 2 shrimp boats
Distance/Speed for U-boom configuration	Opening of ~50 meters (~150 ft), speed of ~1/2 – 3/4 knot
Length of tow lines	~100 meters (~300 ft)
Successful new methods used	Feeding oil into an ongoing ISB; allowing (under the direction of the USCG) controlled ISB outside of, but connected to, the fire boom to extend burn duration; conducting multiple controlled ISBs simultaneously; and using refined burn estimation protocols during a continuous spill.
Burn volume estimation	Developed a protocol to determine a range of potential burn volumes based on the higher value of ~0.07 gal/ft ² /min burn rate for fresh to lightly emulsified oils and a lower value of ~0.05 gal/ft ² /min for more highly emulsified oils. Since most crude oil burns have a thickness reduction rate of ~3mm/min, or about 5,000 liters/m ² /day (~100 gal/ft ² /day or ~0.07 gal/ft ² /min), the size and duration of a burn could be used to estimate the volume of oil eliminated during that burn.
Simultaneous operation safety	Required consolidation of spatial and temporal information from each of the response option teams (Mechanical Recovery, Burning, and Dispersant Application). Established operating zones (i.e., Burn Boxes, Mechanical Recovery Boxes, & Dispersant Application Zones) for each operating period so that vessels and aircraft could maintain safe operations while optimizing resources.

In total, typically fewer than 100 people, about 30 vessels, 2 aircraft, and 23,000 ft of fire boom from 5 manufacturers supported the ISB effort during the DWH response. These resources were minimal considering the amount of oil removed from the environment (Allen 2011).

Lessons Learned (DWH Response)

Most of the significant learnings during the ISB operations of the DWH response involved the benefit of being prepared in the areas of training, staging and availability of resources, and communication methods and equipment. **Table 3** provides a summary of training efforts during the DWH response.

One valuable message from the DWH experience was that controlled ISB has progressed to the point that it should no longer be considered an “alternative” response option for offshore oil spills; rather, under the right conditions, it should be considered a primary response tool at the very start. When conditions warrant, ISB teams should be activated as soon as possible once the Command Structure’s Incident Management Team is stood up. With a short operational window, the sooner a qualified team can get to the spill site with the right equipment, the quicker the hazard can be minimized (USCG 2011; API JITF 2011; Allen 2011; Mabile 2010).

Table 3: Training during Deepwater Horizon ISB Operations
(Allen 2011)

Training / Educational Meetings Conducted By	Type of Training / Education	Personnel Trained
<ul style="list-style-type: none"> Industry personnel Equipment manufacturers Fishing community (area experts) USCG--national and local USCG Reserve Specialists w/ fire control experience NOAA Unified Command personnel ISB Technical Advisers 	<ul style="list-style-type: none"> HAZWOPER Boom handling tactics Safe boat handling Basic ISB instruction Surveillance, monitoring Personal protection equipment (e.g., emergency breathing devices) Wildlife protection Identification and protection of sensitive resources Potential environmental impacts Aircraft safety 	<ul style="list-style-type: none"> Offshore Burn Team members (including local fishermen) Aerial Spotters Command Center Support Team Onshore Dock Logistics personnel Air Operations Support Team Media (e.g., CBS, CNN)

In responding to a major offshore oil spill, the key for effective ISB operations is to have a multi-layered approach, each layer with its own clear plan, and to take all environmental and safety factors into consideration before ignition. The general preparedness and response “layers” in the approach are as follows (Allen 2011):

Preparations before an Incident

- Contingency plan involving awareness training of ISB capabilities and net environmental benefits information for local stakeholders and decision makers
- Communication plan outlining tested protocols
- Safety Plan—outlining safety of operations and personnel monitoring
- Equipment pre-staging for quick deployment of aircraft, fire boom, and ignition systems, as well as access to adequate vessels for towing fire boom and for supporting command, safety, and control

- Pre-arranged emergency contracts for aircraft and vessel usage
- Quick access to regulatory agencies and other decision-makers for permitting and authorization
- A library of oil spill information and resources, including oil type (tendency to emulsify, volatility, burn rate, etc.); spreading and weathering phenomena; meteorological and oceanographic data; and air, water, and wildlife monitoring plans
- A carefully crafted training program for new responders and stakeholders who may become involved in ISB operations

Response to an Incident

- Ability to mobilize ISB experts, fire boom suppliers, trained spotters, and other personnel who have had previous training and/or experience with specific ISB operations
- Ability to mobilize trained wildlife responders who can help ensure that wildlife (for example, sea turtles) are not accidentally contained within the burn area, and who will monitor wildlife in the vicinity of burning operations
- Attention to simultaneous operations with a focus on safety and sustainability
- Redundant resources to enable the capability of initiating multiple burns simultaneously
- Preparedness for a variety of approaches that can be tailored to the specific situation encountered with each oil slick (e.g., feeding the burn, burning outside the fire boom, using ignition-enabling agents)

- Ability to predict the direction and behavior of the plume, as well as utilize best practices to estimate burn volume
- A support staff onshore that can manage air operations, set up the communications technology, provide real-time maps of spill locations, analyze and document data provided by on-scene observers, coordinate missions, and maintain a constant supply of resources

Preparedness, Obstacles, and Resources

During the DWH response, regulatory agencies and responders were reasonably prepared for and had some experience with the controlled ISB approach. Relationships had developed during prior training, workshops, and drill exercises. This made it relatively easy to get immediate approval for early implementation of ISB (*RRT VI: ISB Plan* 1994). In addition, the body of scientific knowledge in the area of controlled ISB was easily accessible. For instance, the USCG published a 156-page “In-Situ Burn Operations Manual” in 2003 and the American Society for Testing and Materials (ASTM) updated its “Standard Guide for In-Situ Burning” in 2007.

One leap forward in ISB knowledge occurred in 1998 when many of the top U.S. and Canadian researchers in ISB gathered at the *In-Situ Burning of Oil Spills Workshop* in New Orleans, LA, to share their recent experience and research. Oil spill drills and ISB experiments have also provided measurable data and helped improve processes and equipment (at least 30 tests since 1980, mostly in the US, Canada, and Norway). Recently, at least two significant, multi-agency endeavors were initiated to further the knowledge base on using ISB in arctic and subarctic areas in Europe and North America (*Advancing Oil Spill Response in Ice-Covered Waters* 2004; World Wildlife

Federation 2006). Using the copious information published on ISB, the industry began establishing its own plans and guidelines (ExxonMobil 2008; API 2004).

Recent Comparisons with other Methods

Merv Fingas compares ISB very favorably with other response methods in his 2011 textbook, *Oil Spill Science and Technology*. He says current research shows that “most, if not all, oils will burn on water if slicks are thick enough and if sufficient vapors can be produced by the ignition and subsequent fire.” Only the lighter, refined hydrocarbons exhibit a significant difference in “burning behavior.” For instance, diesel fuel tends to “atomize rather than vaporize.” The type of oil is not as significant in the decision-making process as once thought (Fritt-Rasmussen 2010). Rather, timing is the most important factor in predicting the success of an ISB. The longer it takes ISB teams to get in place, the more the oil will emulsify with water and the more the flammable ingredients in the oil will evaporate.

In their 2005 publication, the API also compares ISB favorably against other recovery methods for open-water oil spills. In one hypothetical 10-minute burn, ISB removed 18,000 gallons of oil, and mechanical recovery removed only 2,500 gallons. The ISB operation also required far fewer resources and was more feasible in ice-infested waters. According to the API’s “Decision-Maker’s Guide to In-Situ Burning,” “In-situ burning offers a practical method to remove large quantities of oil from the land or water surface very quickly” (Michel 2005).

The USCG concurs with the API assessment, calling ISB “efficient and quick” and “more cost effective” than other methods and asserting that ISB has “fewer logistical and personnel requirements” (USCG 2003).

The 2000 IPIECA report on “Choosing Spill Response Options to Minimize Damage” mentions ISB only as a viable option for ice-infested waters. The DWH response, however, shows that ISB is not only a viable option, but a primary consideration, in the initial response to an oil spill offshore.

The Decision-Making Process for ISB Operations

In-situ burning typically has three phases of decision-making (Merten 2008; Michel 2005; Bassey 2011; Buist 1998; IPIECA 2000; *RRT VI: In-Situ Burn Plan* 1994; USCG 2003):

- The pre-authorization phase that may apply to specific offshore locations. Regulatory agencies (typically the Regional Response Teams, or RRTs, in the U.S.) are responsible for this decision, which can be made at the beginning of an incident response, but is more prudently done prior to a potential incident occurring.
- The initial decision made by members of the command structure that a burn is likely to be successful for a specific incident. This decision may apply to each burn as conditions change, or to an entire operational period if conditions are favorable.
- The decision made in the field that safe conditions are as expected and the outlook continues to be favorable for safe and successful operations. Each ISB Task Force Team Leader makes this decision based on actual conditions that are encountered upon arriving at the site of an intended burn.

Conclusion: Early Response Consideration vs. Alternative Technology

Every spill incident is different and all response tools need to be considered to minimize environmental impacts. Each method has its place depending on the specific

conditions of the event. In the past, ISB has usually been considered an “alternative” response option; however, a paradigm shift is clearly called for. Because of the success of controlled burning during the DWH response, and the significant safety and tactical effectiveness learnings, controlled ISB should now have a prominent place in the responders’ “tool box” from the very beginning of a response, especially in the case of a deepwater, offshore oil spill.

As summarized above, controlled ISB has had a history of application over the past six decades involving dozens of successful burn operations. Twelve on-water, historically significant ISBs are graphically depicted in **Figure 4**, with nine of these occurring offshore. As the documented ISB knowledge base and experiences mature, it has become increasingly clear that controlled ISB can be conducted safely and can be particularly effective if it is initiated by experienced personnel as soon as safely possible. Under the appropriate conditions, the sooner an ISB Task Force can mobilize, the greater the chances for success.

As recommended in several post-DWH response reports, industry and regulatory agencies are already revising ISB operations manuals and guidelines (e.g., API 2004) through joint industry programs involving organizations such as the API, OGP, TGLO, and IMO to name a few. One of the purposes of this paper is to get this message out to the global oil spill response community.

APPENDIX A: DETAILS ON OIL SPILL COMPARISONS OVER TIME

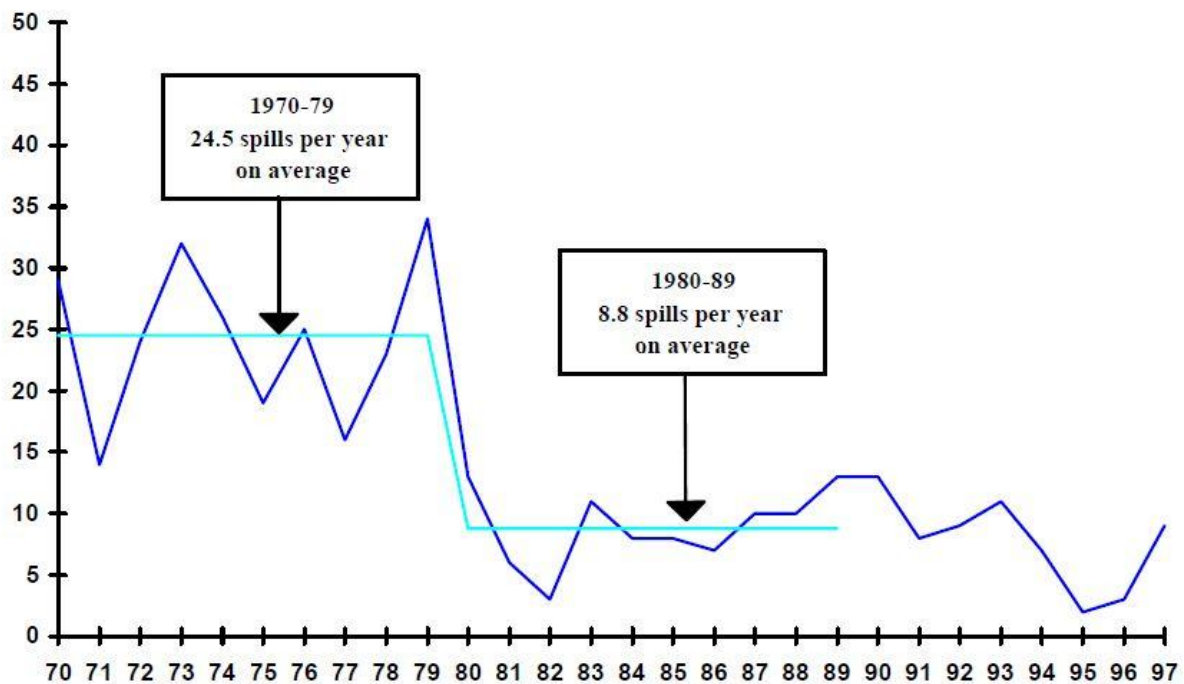


Figure A-1: A review of tanker spills from 1970 to 1997 further illustrates improvements in spill prevention. (ITOPF 1999)

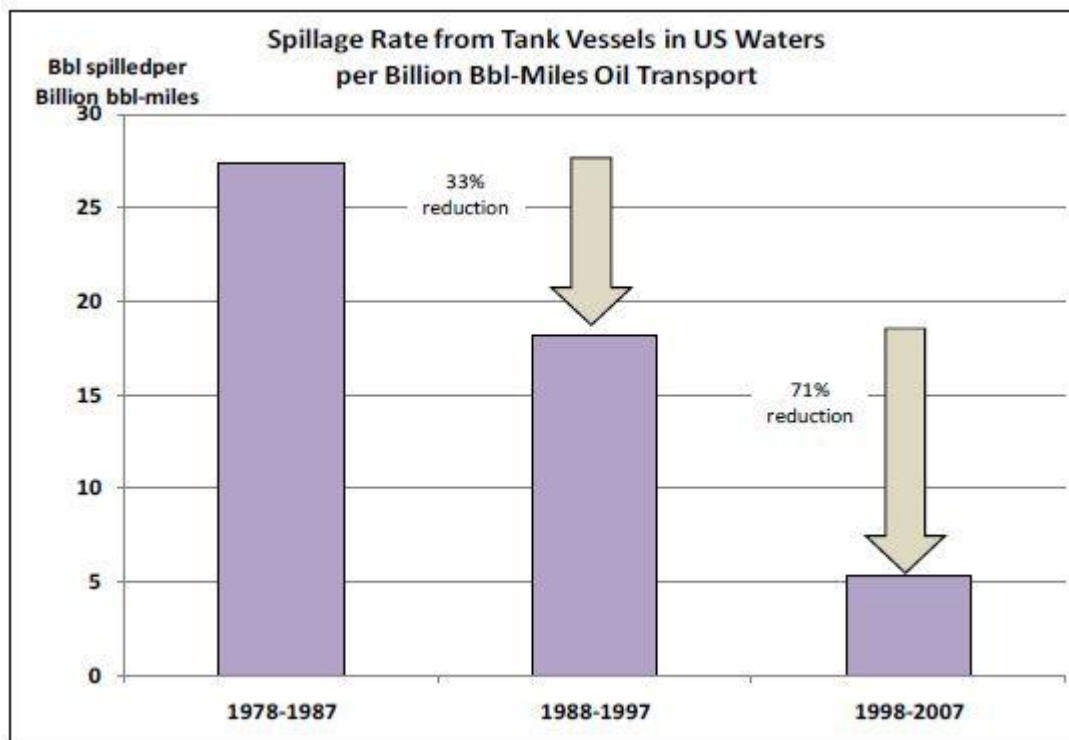


Figure A-2: A review of tanker spill rates from 1978 to 2007 per billion bbl-miles of oil transported. (Etkin 2009)

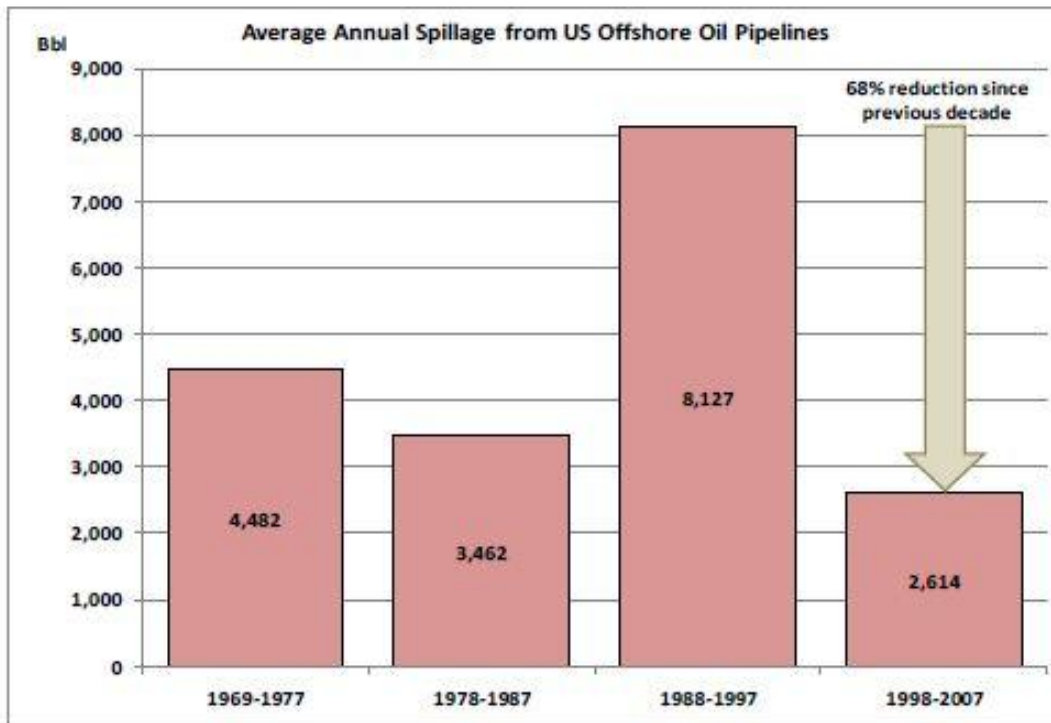


Figure A-3: A summary of U.S. offshore pipeline spill rates from 1969 to 2007. (Etkin 2009)

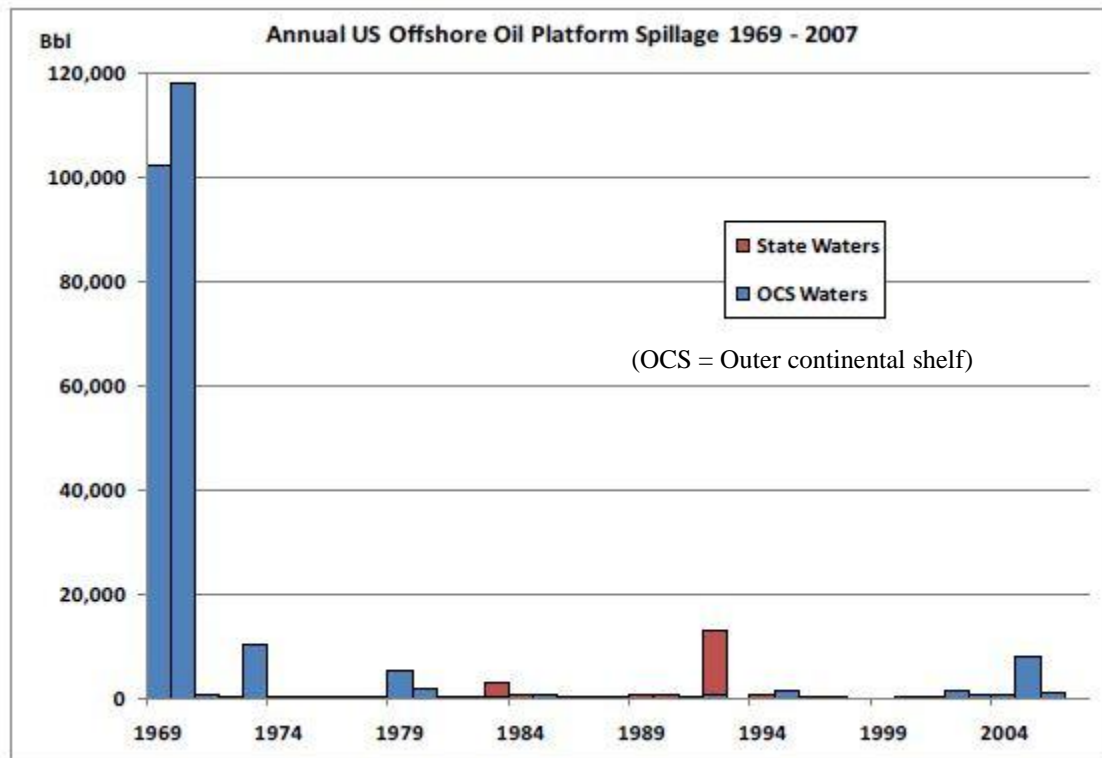


Figure A-4: A review of U.S. platform spill rates from 1969 to 2004. (Etkin 2009)

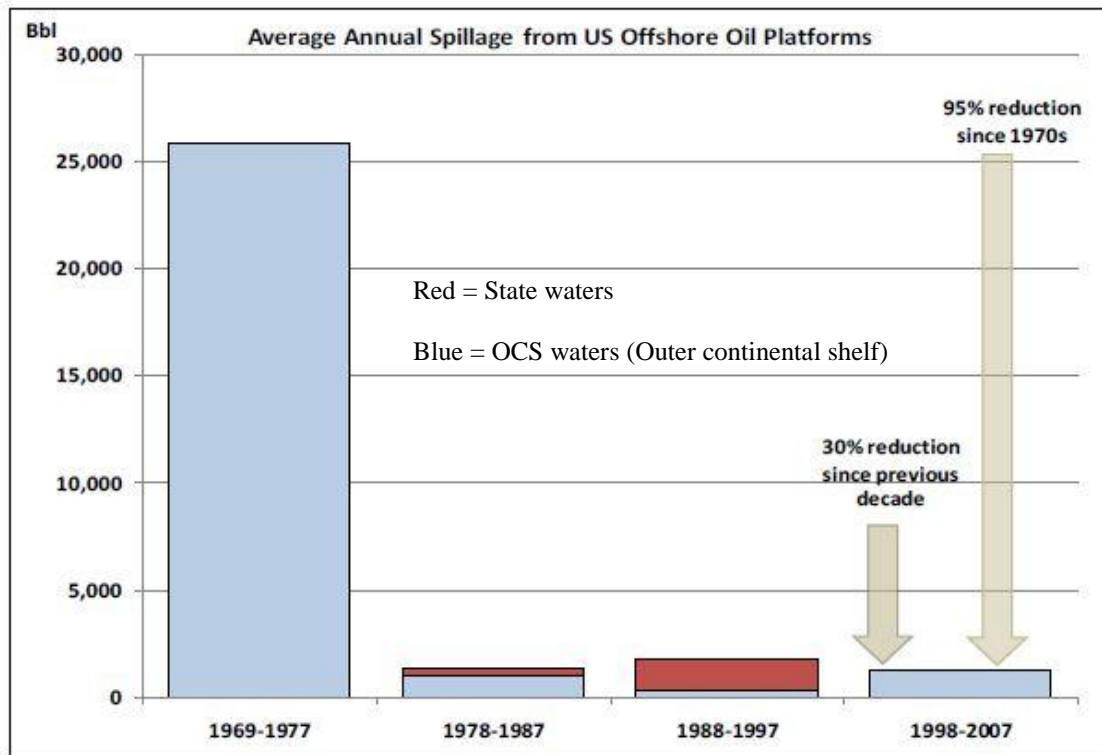


Figure A-5: A review of average annual spillage from U.S. platforms from 1969 to 2007.
(Etkin 2009)

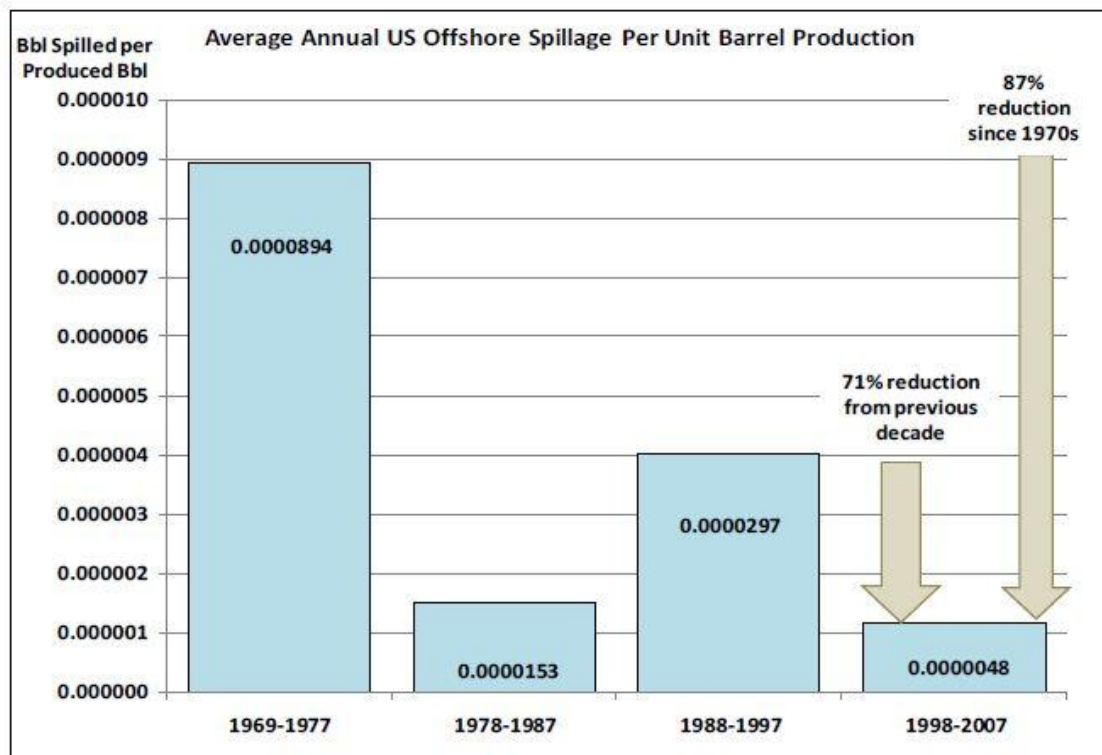


Figure A-6: Average annual spillage per bbl from U.S. platforms from 1969 to 2007.
(Etkin 2009)

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****Sources that reference the DWH response are noted with two asterisks and red text.**

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