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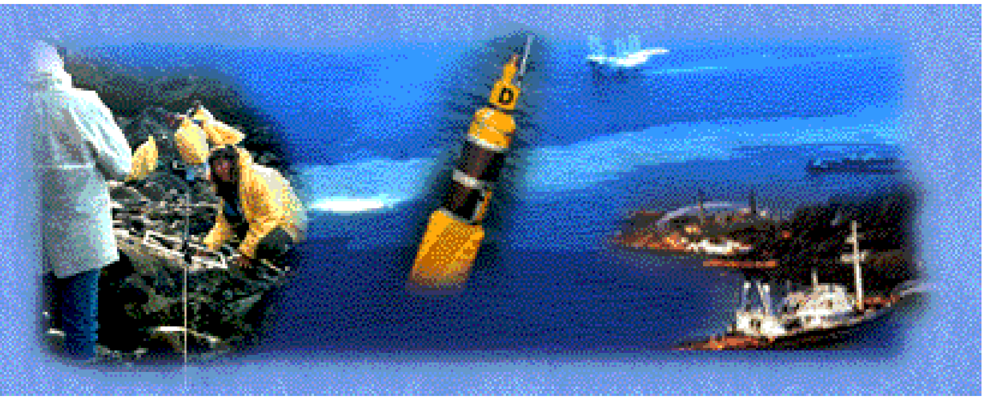

Several thousand accidental spills of oil and chemical materials occur in coastal waters each year. Over the past decade, the Nation has developed a response strategy that involves all levels of government and the private sector. This strategy includes specific contingency plans, a large network of response organizations with their equipment, and highly trained personnel in constant readiness. Although some spills are inevitable, recent emphasis on spill prevention is reducing the total volume of spilled material.

The following reference format is suggested:

National Oceanic and Atmospheric Administration (NOAA). 1998 (on-line). "Managing Spills of Oil and Chemical Materials" by Debra Scholz, Janet Kucklick, Ann Hayward Walker, and Robert Pavia. NOAA's State of the Coast Report. Silver Spring, MD: NOAA.

URL: http://state_of_coast.noaa.gov/bulletins/html/hms_15/hms.html

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INTRODUCTION

The 1989 *Exxon Valdez* oil spill in Prince William Sound, Alaska, left an indelible mark on the American environmental consciousness. Images of oiled shorelines, dead and dying wildlife, and thousands of workers mobilized to clean beaches reflected what many people felt was a major ecological insult to a pristine and biologically rich area.

Photo 1. The *Exxon Valdez* founders in the waters of Prince William Sound, Alaska (March 1989).

Each year, millions of gallons of oil and other hazardous chemicals are released into U.S. waters and sensitive habitats from vessels, oil wells, pipelines,and facilities across the nation. Some accidental releases are a result of natural disasters, (e.g., a flood or earthquake that causes a storage tank to rupture). Much more often, unintentional releases result from human error and equipment failures.

Most oil spills in U.S. waters involve fewer than 100 gallons. Of the 170,000 U.S. oil spills from 1973 through 1993, over 90% involved fewer than 100 gallons. Less than 1% were spills of 100,000 gallons or more. Over the same 20-year period, the number of spills occurring each year has remained fairly constant at 5,000 to 7,000 spills per year (Figure 1). The total volume of oil spilled is on a downward trend, however. For example, in 1973, there were about 2,000 spills of more than 100 gallons; in 1993, only about 500 such spills. This downward trend is due primarily to an increase in prevention and preparedness, especially legislation enacted following the *Exxon Valdez* oil spill (USCG historical pollution incidents Web site, 1997).

Photo 2. Oiled seabirds and marine mammals are highly visible images of the effects of large oil spills.

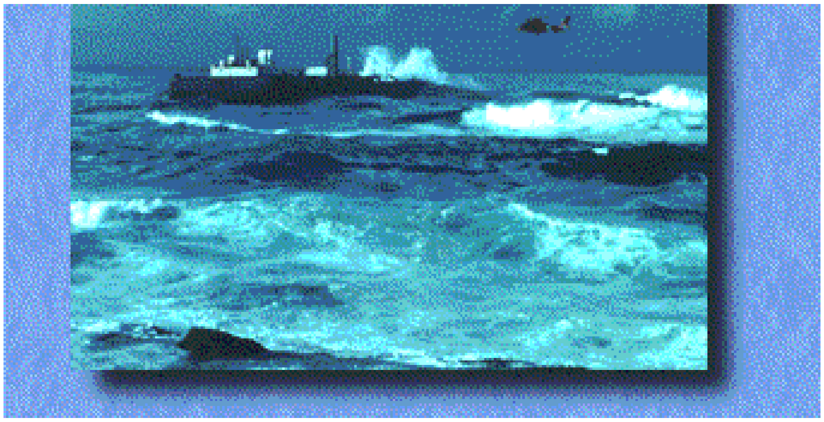

Photo 3. Each year, 5,000 to 7,000 spills of hazardous materials occur.

Are we any better prepared than we were when the *Exxon Valdez* grounded on Bligh Reef almost 10 years ago? Will we do a better job at the next major spill when it occurs? There are no simple answers to these questions. As long as we continue to use products that depend on oil and other chemicals, spills will continue to occur. Even with the best prevention programs in place, people make mistakes. There are no simple anwers to these questions, but we are better prepared.

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NATIONAL PICTURE

Our national oil spill response strategy is based on the National Oil and Hazardous Substances Pollution Contingency Plan (National Contingency Plan) (US EPA, 1993). The first National Contingency Plan was issued in 1968, partly in reaction to the grounding of the tanker *Torrey Canyon* , which discharged its entire cargo off Great Britain in 1967, and the oil well blowout in the Santa Barbara Channel, which occurred off the coast of California in 1968.

The National Contingency Plan provides the institutional framework that:

- defines responsibilities of Federal, state and local governments;
- describes resources available for response;
- establishes a hierarchy of response teams;
- specifies a command structure to oversee spill response;
- requires Federal, regional and area contingency plans;
- summarizes state and local emergency planning requirements, as well as response priorities, phases and procedures; and
- provides procedures for the use of chemicals (e.g., dispersants, shoreline cleaning agents) in removing spilled hazardous materials.

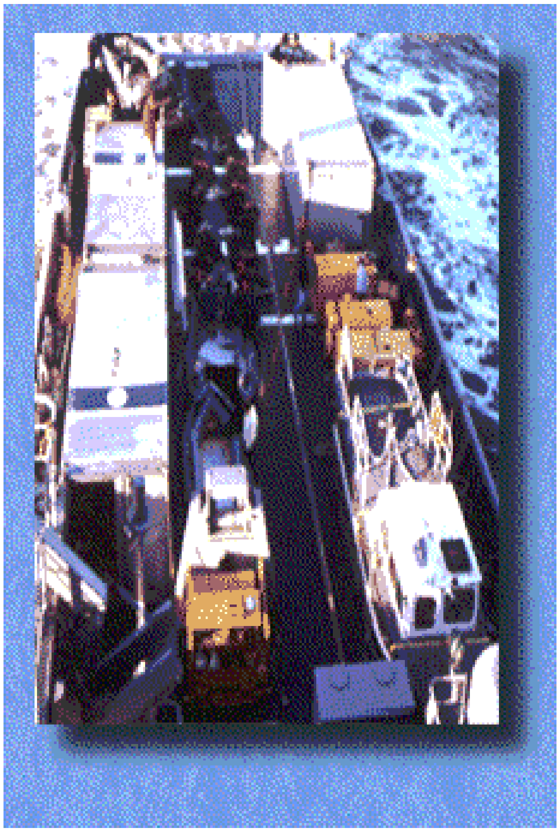
This general framework has been retained throughout periodic revisions over the past 30 years.

The Basic Framework

The structure established for planning and response to a spill of oil or other hazardous substance takes into account the collective resources of Federal and state agencies, as well as those of the private sector. During a spill incident, the rapid coordination of various entities is absolutely critical. The National Contingency Plan identifies the Federal on-scene coordinator (FOSC) as the individual responsible for directing response efforts and coordinating all other efforts at the scene of a discharge or release. In coastal areas, the U.S. Coast Guard provides the FOSC; for inland areas, the U.S. Environmental Protection Agency does so.

Photo 4. The U.S. Coast Guard is the agency responsible for coordinating spill response in coastal areas.

The focus of organization for planning and response at the state level is on the coastal states. In an effort to further protect their natural resources, approximately 10 coastal states have enacted comprehensive oil spill legislation to supplement Federal prevention and response options. Most states have designated a lead state agency, bureau or branch for spill response and have identified state on-scene coordinators (OSCs) to represent the interests of the state and coordinate available resources.



The party responsible for a spill figures prominently in the response structure in the United States. Even before the *Torrey Canyon* incident, Congress mandated that spillers take action to remove oil from navigable waters. Following the *Exxon Valdez, American Trader* and *Mega Borg* incidents in 1989 and 1990, Congress passed Public Law 101-380, referenced as the Oil Pollution Act of 1990 (OPA 90), to "establish limitations on liability for damages resulting from oil pollution, and to establish a fund for the payment of compensation for such damages" (OPA, 1990).

Enacted to strengthen the National Response System and provide for better coordination among Federal, state and local authorities, OPA 90 has changed the way we respond to spills in the United States. Under OPA 90, each owner or operator of a tank vessel or facility operating in a U.S. jurisdiction must submit a response plan outlining all measures to be taken in the event of a spill. When a spill does occur, the responsible party is required to:

- immediately begin containment and collection procedures;
- initiate notification procedures, which includes the prompt notification of
  - the National Response Center,
  - contracted oil spill removal organizations, and
  - Federal, state and local authorities with vested interests in the potential spill zone as identified in the response plan; and
- begin preliminary assessment and cleanup action.

In most cases, the responsibility for the cleanup falls to the party responsible for the spill, unless the discharge poses a substantial threat to public health or welfare. In the majority of spill incidents, the responsible party conducts and pays for the cleanup.

(top)

Photo 5. Response equipment (booms, skimmers, etc.) is transported to an oil spill site.

(top)

Organization in Teams

Major government resources and responsibilities for spill management are organized in a hierarchy of teams with three different geographic scopes. The National Response Team is responsible for national preparedness planning and for the coordination of regional planning for the nation; in addition, it provides policy guidance and support to regional response teams. There are 13 separate regional response teams in the United States, one each for the 10 standard federal regions (Figure 2) and one each for Alaska, the Caribbean and the Pacific Basin. The regional teams are planning, policy and coordinating bodies that also provide assistance to the OSCs during incidents.

Photo 6. Response teams ready booms to help contain floating oil during a spill.

The third type of team is the area committee, which is the real foundation of planning and response activities. There are over 50 area committees around the United States developing plans that include:

- identification of area of responsibility, area spill history, sensitive resources, and fisheries and wildlife;
- health and safety guidelines and strategies;
- protection strategies for sensitive environmental areas;
- area-appropriate strategies for mechanical recovery;
- chemical countermeasure application jurisdictions;
- protection, rescue and rehabilitation of fisheries and wildlife; and
- cleanup strategies for various shoreline habitats.

Each area plan is a framework that provides a measure for evaluating shortfalls and weaknesses in the response structure. It also serves as a guide for reviewing the response plans of vessel and facility owners and operators.
(top)

Infrastructure, Training and Research

In the U.S. coastal zone, the Coast Guard has the primary responsibility for ensuring preparedness for responses to oil and hazardous substance spills, regardless of their source. In carrying out this charge, the Coast Guard administers the $1 billion Oil Spill Liability Trust Fund, which can be used to pay for oil spill cleanup and to restore the environment when a spiller is unwilling or unable to respond effectively. The Coast Guard has already issued regulations requiring each vessel and facility that transports, stores or handles oil of any kind to have a spill response plan in place. Similar regulations are being drafted for hazardous substances.

The required response plans must provide evidence that each plan holder (i.e., each vessel and facility) has in place sufficient equipment to respond to and clean up any spill that may occur. To comply with that requirement, a multibillion-dollar network of more than 105 privately owned oil spill response organizations around the United States is ready to provide response equipment in the event of any incident, wherever it may occur in U.S. waters. These organizations are most heavily concentrated in areas where spills are most likely to occur.

The Coast Guard maintains response equipment at 19 sites around the nation to supplement private efforts, as well as three "strike teams" made up of specialized equipment and specially trained personnel capable of responding quickly to oil and hazardous substance incidents. The U.S. Navy Superintendent of Salvage maintains a large fleet of pollution response vessels and specialized response and vessel salvage equipment, primarily for Navy use, but available for response to any emergency when requested by the Coast Guard.

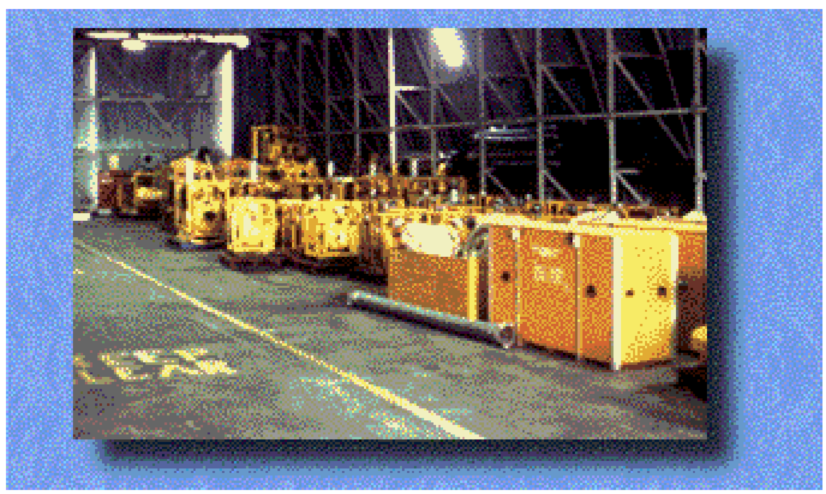


Photo 7. Warehouse storing response equipment. There are 105 private oil spill response organizations around the nation with equipment in constant readiness.

The Coast Guard has 1,200 personnel assigned to its strike teams and to the approximately 50 units around the nation whose task is to be ready to respond to spills of oil and hazardous substances. All of these personnel receive both classroom and field training in spill response. The National Oceanic and Atmospheric Administration (NOAA) provides personnel to advise the Coast Guard on scientific and technological matters related to response (Figure 3). The Environmental Protection Agency and the natural resource trustee agencies in the Departments of Commerce and the Interior have personnel in every region trained in pollution emergencies. Every state has a department or agency that houses dedicated spill response personnel.

The National Contingency Plan and the response plan regulations require all government and industry spill response personnel to participate in periodic refresher training and to engage in exercises at least annually to maintain their skills.

Traditional spill response countermeasure technologies (e.g., containment booms, skimmers) have been in use for many years, and advances are likely only on the periphery. Nontraditional response methods (e.g., chemical countermeasures, *in-situ* burning, bioremediation) have offered a multitude of research opportunities aimed at improving our ability to mitigate the impacts of spill incidents. Recent research related to dispersant formulations, effects and effectiveness have produced several products that can be applied to oil slicks in marine waters greater than 10 meters in depth. Responders must evaluate the relative environmental benefits of using chemical dispersants versus relying solely on the mechanical recovery of surface slicks.

Likewise, through analysis of smoke plume trajectory and composition, burning agents and the efficiency of fire-resistant containment booms, *in-situ* burning is gaining acceptance as a viable response technique under certain conditions. Bioremediation, both the addition of oil-eating bacteria and the addition of nutrients to stimulate the growth of indigenous or naturally occurring oil-eating bacteria, is becoming an option of choice under certain conditions for eliminating the last traces of oil from beaches and similar habitats.

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REGIONAL CONTRASTS

The types and quantities of materials transported and used, as well as the environmental resources at risk from accidental spills, vary considerably from region to region of the United States. Port areas that have the largest volumes of hazardous materials, including oil, transported in bulk include Houston-Galveston, New Orleans, New York, Boston, Delaware Bay/Philadelphia, San Francisco, Puget Sound (Washington state) and Prince William Sound (Alaska).

Partly as a result of regional differences, individual states or regions have established their own, more detailed spill response planning efforts. The following are three examples of different spill preparedness approaches.

Florida

In Florida, spill response efforts have focused on community-based hazardous materials planning. In 1986, the state established a State Emergency Response Commission (SERC) whose primary mission is to direct the Department of Community Affairs in the ongoing implementation of the Emergency Planning and Community Right-To-Know Act (EPCRA). SERC consists of 28 members from public and private organizations, including industry, first responders and emergency management officials, who designate emergency planning districts and appoint members to Local Emergency Planning Committees. Not only do these committees facilitate preparation and implementation of hazardous materials emergency plans, they also provide information to the public regarding chemical- and facility-specific information, assist with outreach to increase awareness and understanding of the EPCRA, and conduct hazardous materials training exercises (Florida DCA, 1996).

The state has also designated "areas to be avoided" within the Florida Keys in conjunction with the National Marine Sanctuaries. Avoiding these areas prevents tankers and other large (>50 m) vessels from disturbing the coral reefs and their associated resources through such events as collision, accidental grounding and unintentional discharges. Florida also uses a variety of regulatory techniques, including speed limits and exclusion areas, to protect the West Indian manatee.

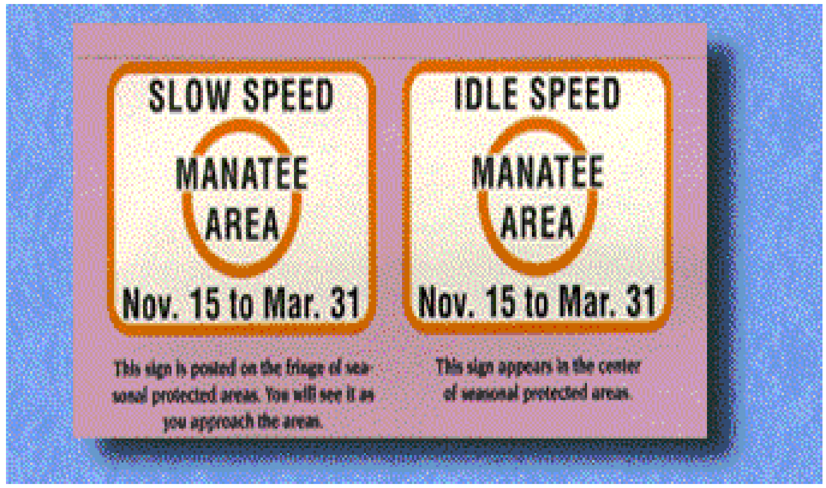

Photo 8. Florida requires tankers and other vessels to use caution when traveling through protected areas.

(top)

Photo 9. Data from this Texas Automated Buoy System buoy are used in modeling trajectories of oil spills.

Texas

A large number of accidental releases occur in Texas waters. To stress prevention and natural resource protection, the Texas General Land Office (TGLO), the lead state agency for oil spill management, places its oil spill response equipment in high traffic and environmentally sensitive locations along the Texas coast.

TGLO's Oil Spill Prevention and Response Division recently announced the September 1997 formation of the Preparedness Partnership Project, which will examine a variety of spill-related issues. Eleven "work teams" made up of industry and government spill responders will attempt to develop solutions to issues ranging from dispersant delivery capability, *in-situ* burning and response in remote areas to risk identification. The goal is to develop formal, binding agreements between entities in lieu of regulations. A draft final report should be ready by January 1, 1998.

TGLO also focuses on the research and development of new technology to reduce accidental spills. In coordination with other state agencies and private industry, TGLO continues to develop new scientific resources for oil spill response, including the Texas Automated Buoy System (TABS) and the Coastal Oil Spill Simulation System (COSS) (Texas General Land Office, 1996).

TABS provides critical, real-time offshore surface current information to drive trajectory models that predict the movement of oil spills. With its present network of five buoys placed strategically along the Texas Coastline (and the planned future deployment of five additional buoys and the addition of a meteorological package), TABS provides the spill response community with 30-minute current measurements four times daily under normal conditions; during spills, the data are updated every two under normal conditions; during spills, the data are updated every two hours. The currents along the coast often change, and the modelers can determine the change within two hours of its occurrence. During the *Buffalo 292* oil spill in March 1996, this system allowed the NOAA and TGLO trajectory modeling teams to forecast the movement of the oil to an unprecedented level of accuracy. The benefit to cleanup and protection operations was that the incident command could refocus efforts to the new predicted point of impact a full day earlier than would have normally been possible. This prevented the expenditure of time and effort in areas where they were not needed (TGLO, 1996).

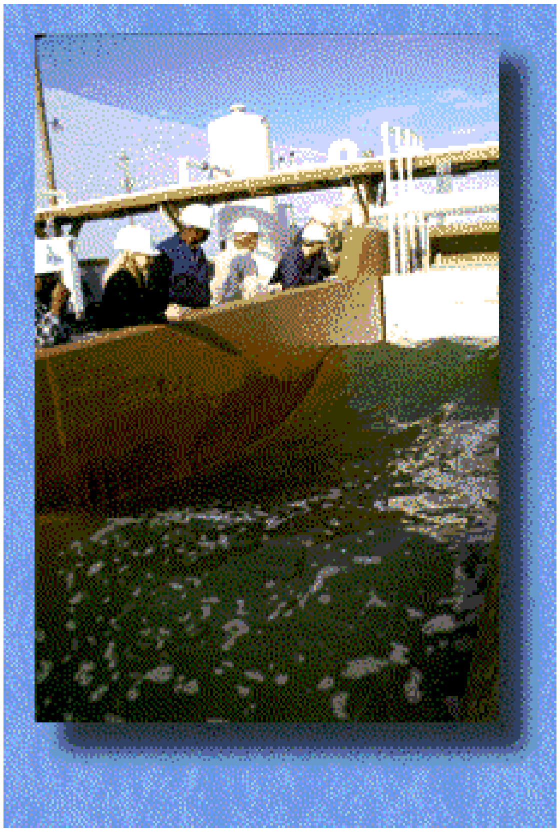

Photo 10. This wave tank at the Coastal Oil Spill Simulation System facility allows researchers to experiment with spill response technologies.

The COSS facility in Corpus Christi, sponsored by TGLO, the Marine Spill Response Corporation and Texas A&M University (TAMU), provides swimming-pool-sized experimental platforms for large-scale testing of a wide variety of oil spill response technologies. The facility is available to test the effectiveness and safety of oil spill technologies, including, but not limited to, chemical dispersants and dispersed oil, bioremediation and the ecological effects of other alternative chemical agents. Eventually, this facility will consist of nine large-scale wave tanks capable of simulating waves, tides and various types of environments (e.g., beaches, tidal flats, marshes). The large-scale tank testing provides a critical link between laboratory and field studies. It allows researchers to identify appropriate response agents, apply strategies, determine their effectiveness, and efficiently coordinate chemical and biological response strategies with traditional mechanical collection methods. It also overcomes the expense and difficulty of field studies and the lack of sufficient environmental realism in a small-scale laboratory or in controlled field studies (TGLO, 1996).

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California

The Office of Oil Spill Prevention and Response (OSPR), established in 1990, is California's lead agency charged with oil spill prevention and response within the state's marine environment. Part of the California Department of Fish and Game, the OSPR retains the Department's public trustee and custodial responsibility for protecting and managing the state's fish, wildlife and plants. It is one of the few state agencies in the United States that has both major pollution response authority and public trustee authority for fish, wildlife and habitat resources.

Photo 11. Unlike most states, California handles both oil spill prevention and response, and protection of natural marine resources, through a single office.

The OSPR is involved in developing and revising oil spill prevention and response regulations, handling technical aspects of protection, and accounting for the state's natural marine resources through such activities as environmental sensitivity area mapping, establishment of a comprehensive geographic information system, assessment of impact on natural resources, and sponsorship of needed research. The OSPR is also involved in planning; for example, it oversees the preparation and review of state-required oil spill contingency plans for all marine facilities and all vessels carrying petroleum cargo. The OSPR has established five harbor safety committees that have developed plans to reduce the risk of accidents near major harbor facilities by identifying impediments to the safe navigation of oil tankers and barges, as well as all other vessels, and recommending solutions to these navigational problems (OSPR, in prep.).

California has focused a significant portion of its efforts on oil spill prevention and preparedness activities. The state supports Federal requirements for double-hull construction of tankers, as well as adherence to shipping traffic lanes and separation zones to prevent collisions. To that end, California has joined with the U.S. Coast Guard and the Marine Exchange of Los Angeles/Long Beach (LA/LB) Harbor, Inc. to develop, fund and manage the Vessel Traffic Information Service (VTIS). This system provides information on vessel traffic and ship locations so that vessels can avoid collisions, rammings and groundings in the approaches to LA/LB Harbor. The partnership is a unique and effective approach that has gained acceptance from the maritime community. The system is owned by the Marine Exchange and operated jointly by the Marine Exchange and the Coast Guard under the oversight of the OSPR and the LA/LB Harbor Safety Committee.
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CASE STUDIES

The following case studies provide an understanding of the vastly different types of hazardous material spill response issues that can be encountered during an accidental release. These summaries provide insight into:

- present-day spill responses;
- the significance of a long-term study to assess the effects of spilled oil and the effectiveness of various response techniques; and
- the results of scientific study and technological advances that lead to new technology designed to prevent future accidental releases.

Additional information regarding these and other incidents is provided in the list of References and Additional Reading.

Present-day Response: The *Buffalo 292* Barge Spill

On March 18, 1996, the *Buffalo 292* , a 275-foot bunker barge loaded with 17,000 barrels (714,000 gallons) of Intermediate Fuel Oil 380, was heading south through the Houston Ship Channel, Texas. High winds, rough seas and a catastrophic structural failure in the No. 3 port and starboard cargo tanks caused the barge to buckle and spill 126,000 gallons into Galveston Bay, and, ultimately, the Gulf of Mexico (Eldridge et al., 1997).

Photo 12. The potential damage from the *Buffalo 292* spill was largely averted by using the Texas Automated Buoy System and other observation methods to track the oil's movement.

The spill had the potential for contaminating hundreds of miles of Texas coastline. Essential for a damage-limiting response were accurate and timely forecasts of oil movement along the coast and a network of ocean current sensors (TABS), aerial surveillance by trained observers and AIREYE-equipped Falcon jets, and careful trajectory analyses by oceanographers provided these forecasts. Spill response contractors used the Galveston Bay Area Contingency Plan to determine the appropriate placement of protective, deflective and containment booms along several environmentally sensitive and historically significant areas near the spill site. This incident required over 600 response personnel, five offshore skimmers, six shallow water skimmers, 34,000 ft of containment boom, and more than 150,000 ft of sorbent boom and viscous sweep. A barge lightering and salvage plan was simultaneously developed to minimize the amount of additional oil that would enter the environment, as well as to move the severely damaged barge to a repair facility as soon as possible (Eldridge et al., 1997).

The first oiling impacts, recorded on March 19, affected the Big Reef area at the eastern end of Galveston Island, the area of greatest oil impact. Most of the oil remained floating, heading out into the Gulf of Mexico. There were additional impacts along the eastern end of Galveston Island and the western end of Bolivar Peninsula, however. As predicted by the trajectory analyses, the oil moved south along the Texas coast and began to come ashore again on Matagorda Island, St. Joseph Island, Mustang Island and Padre Island 12 days after the initial release. The impacts were described as trace (less than 1% shoreline coverage) to sporadic (1% to 10% coverage) in a 0.3- to 3-meter band of oiling consisting primarily of tar balls and tar patties. Manual techniques were used to remove the oil (both surface and buried oil) from all oiled areas identified (Eldridge et al., 1997).
(top)

Understanding Impacts: *Exxon Valdez* Long-term Monitoring

Since the *Exxon Valdez* oil spill in 1989, teams of biologists, geologists and chemists have compared oiled beaches to unoiled beaches in Prince William Sound. These studies have provided and continue to provide a better understanding of the way in which a natural system responds to and recovers from an incident like the *Exxon Valdez* spill, and the various spill response options that can be used.

Photo 13. Scientists continue to monitor the long-term effects of the *Exxon Valdez* oil spill on beaches in Prince William Sound.

In 1989, many oiled rocky beaches around Prince William Sound, both exposed and sheltered, underwent hot-water treatments. In general, studies have shown little outward difference over time between rocky areas that were unoiled and rocky areas that were oiled, but not treated with high-pressure hot-water washes. The hot-water treatments appeared to have severe, short-term impacts on intertidal species that lived among and on the rocks, however, some areas were completely stripped of naturally occurring species. By 1995, these severely affected areas showed very slow recolonization. Rocky intertidal areas that did not undergo high-pressure hot-water washing during the oil spill response appeared to be nearly completely recovered by 1991, although oscillations in species abundance have exceeded those on unoiled beaches. Significant species population changes are still taking place in areas where hot-water washing occurred. It is expected that the natural species balance will reestablish itself within the next four to five years (Houghton et al., 1997).

Photo 14. These rocks at Mussel Beach in Prince William Sound were black with heavy oil approximately 45 days after the *Exxon Valdez* spill.

Photo 15. After four years of recovery, seaweed and other biota have returned to the Mussel Beach site.

(top)

Emphasis on Prevention: San Francisco Bay

The San Francisco Bay area is home to seven major shipping ports, oil refineries, petroleum-blending facilities and a variety of other industries (Figure 4). It is the fifth largest U.S. port, handling vessel-based crude oil transfer with approximately 750 fuel oil tankers passing under the Golden Gate Bridge every year. The continued growth of this maritime commerce is vital to the region's economic health. In 1996, a technologically advanced navigation system, the Physical Oceanographic Real-Time System (PORTS), was installed to assist large vessel traffic.

With PORTS, captains and pilots of large tanker ships have access to the real-time nautical data required to plan their arrivals and departures to maximize the efficiency of their time in port. PORTS measures currents, water levels and other physical conditions on a 24-hour basis to allow ship captains and pilots to use the Bay's channels to their fullest extent, while simultaneously increasing safety and minimizing the need for additional dredging–a complex and expensive issue faced by all major ports. In conjunction with established travel lanes, PORTS is a vital step in preventing oil spills; it removes much of the potential for human error for large oil tanker traffic (NOAA, 1996).
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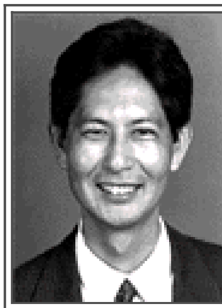
EXPERT INTERPRETATION

The four individuals below are experts in the topic of Managing Spills of Oil and Chemical Materials. Here they voice their opinions on two questions relevant to that topic.

Question 1 – In the last 25 years, there has been a major effort to mitigate adverse impacts from oil and hazardous materials spills in our country. Has this effort been effective?

Question 2 – Is additional effort needed in the years ahead? And what are realistic expectations? What will be the cost to society?

Experts

			
Rod Fujita	**Mark Johnson**	**Thomas Leschine**	**Alexis Steen**

Rod Fujita

Senior Scientist and Marine Ecologist, Environmental Defense Fund

For the last 10 years, Dr. Fujita has been attempting to influence changes in environmental policy in order to protect and restore marine ecosystems. He has also conducted laboratory and field research on a variety of topics, including salt marsh ecology, nutrient dynamics, seaweed physiology and coral reef ecology.

Response to Question 1

Response to Question 2

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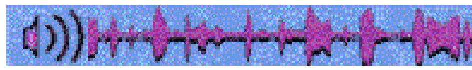
Question 1. In the last 25 years, there has been a major effort to mitigate adverse impacts from oil and hazardous materials spills in our country. Has this effort been effective?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I think that there has been a major increase in awareness and concern regarding such spills. Also, progress has been made in the technical aspects of how to clean up spills and how to limit their areal extent. There was a major effort to develop bioremediation techniques to clean up the *Exxon Valdez* oil spill, for example. Coastal communities all around the country have developed, or are developing, stormwater pollution reduction programs and facilities that are designed to get at nonpoint sources of oil and hazardous materials, ranging from highway runoff to containment facilities in boatyards. There have also been large educational efforts, such as campaigns to label strom drains with signs that say "Don't Dump &endash; Drains to the Bay."
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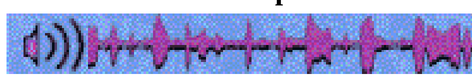
Question 2. Is additional effort needed in the years ahead? And what are realistic expectations? What will be the cost to society?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My sense is that more effort is needed in the future, because the emphasis of past and current efforts on the mitigation of adverse impacts is misplaced; far greater emphasis should be placed on prevention. Once oil and hazardous materials make their way onto ocean-going vessels, monitoring and prevention become much more difficult. The key to good environmental policy in this area is to focus on source reduction, including the creation of incentives for the reduction and re-use of toxic materials in manufacturing, and a reduction of demand for oil through increases in energy use efficiency and a shift to alternative energy sources. Such policies have many ancillary benefits, such as reductions in cost (due to reduced waste), reduction of greenhouse gas emissions, etc. The costs of implementing these policies may be substantial, but the costs may be outweighed by both the short-term and long-term benefits to industry, human health and the environment.

The practicality of implementing improved policies to deal with oil and hazardous materials depends on how much leadership government and industry are willing to provide. In the absence of leadership, the status quo defines practicability, and any improvement appears to be impractical because it threatens the status quo. Leadership, in the sense of performance standards and other enlightened forms of regulation that allow industry to respond flexibly and in a cost-effective manner, can force technology and make performance gains practical quite quickly. For example, government proposals to require seatbelts in cars were met with severe opposition on the grounds that they would be too costly. However, after standards were imposed, costs came down as a result of technological innovation, saving lives.

(top)

Commander Mark Johnson

Chief, Response Operations Division, U.S. Coast Guard Headquarters, Washington, DC

Commander Johnson has been an officer with the U.S. Coast Guard's Marine Safety and Environmental Protection Program for the last 20 years. During that time, he has responded to thousands of spills, including a nine-million gallon hazardous material spill in Savannah, Georgia in 1995.

Response to Question 1

Response to Question 2

(top)

Question 1. In the last 25 years, there has been a major effort to mitigate adverse impacts from oil and hazardous materials spills in our country. Has this effort been effective?

Click here for audio response

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Mitigation efforts have been very successful in this country. Mitigation takes two forms: prevention of spills in the first place and, secondly, more effective and efficient response, once a spill has occurred. While no oil or hazardous material spill is palatable to the public, they are particularly incensed over large discharges. In this vein, U.S. coastal oil spills of greater than 10,000 gallons have decreased from 178 in 1974 to 12 in 1996.

The biggest reason for that dramatic drop can be attributed to the passage of the Oil Pollution Act of 1990 with its stricter liability, structural protection requirements and economic reinforcement not to spill. Regarding response to spills, equipment improvements for spill response have led to greater recovery rates of floating oil. But recovery is still very much dependent on weather conditions at the spill site. So the greatest predictable improvements occur in the realm of response management. Here, adoption of the Incident Command System and broad use of unified command (Coast Guard or EPA, state, spiller) has led to greater efficiencies in spill cleanup. Historical differences of opinion among stakeholders have been ameliorated through an Area Committee planning process where consensus drives cleanup priorities. The result has been the ability to contain the extent of damage through more aggressive, coordinated cleanup efforts.
(top)

Question 2. Is additional effort needed in the years ahead? And what are realistic expectations? What will be the cost to society?

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Whether more effort is needed in the years ahead depends largely on the answer to the third question, 'What will be the cost to society?'– or more importantly, 'What is the cost that society is willing to bear?' While the number of large spills should continue to decline as older tank ships leave service and are replaced by new double-hulled ships, there will still be large, accidental oil spills.

The marginal rate of mitigation will approach a cost to society (read: cost of energy) that is too high to bear. That will define our plateau. We are not there yet, so more effort is needed over the next several years. This effort is in research and development, spill response simulation, refinements to response planning, and continued focus on the prevention of spills.

Statistics tell us the overwhelming cause of oil and chemical spills is human error. Yet the majority of prevention has historically been equipment-focused. We in government have begun to shift that emphasis to the human element in oil and chemical storage and transportation. Realistically, we can expect smaller drops in the number of large oil and chemical spills than have occurred over the last 20 years.

But we can and should expect significant improvements in response techniques that will lead to faster restoration of damaged natural areas and continued lessening of the extent of coastal damage from spills. These improvements will be made as a result of utilization of alternate cleanup technology (bioremediation, dispersants, *in-situ* burning), and also by improvements in information management and decision-making during a spill response. Society's cost for these improvements will be an increase in direct and indirect petroleum prices, as oil and chemical producers and carriers bear the legal responsibility to underwrite spill prevention and response costs.
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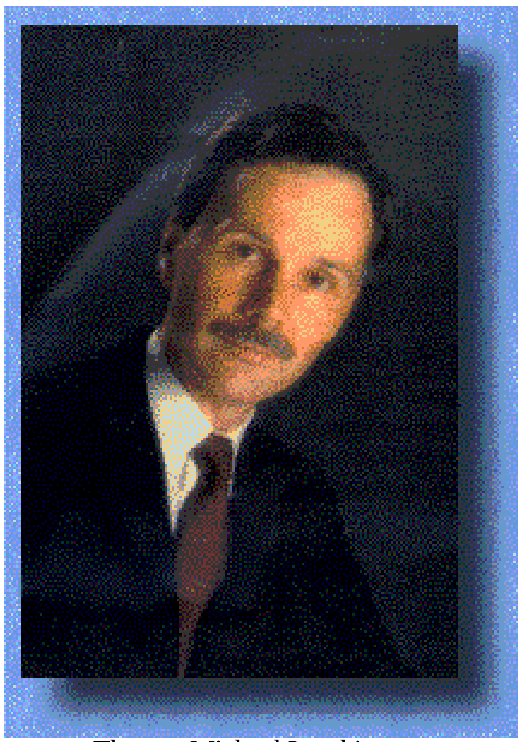


Thomas Michael Leschine

Associate Professor of Marine Affairs, School of Marine Affairs, University of Washington

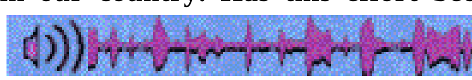
Professor Leschine's primary research interest is environmental decision-making related to marine pollution control. In 1992-93 he headed the team that prepared the Federal On-scene Coordinator's report for the *Exxon Valdez* oil spill for the U.S. Coast Guard. He has been a member of the Washington State Board of Pilotage Commissioners since 1994, and is also a member of the National Research Council Marine Board's Committee on Risk Assessment and Management of Marine Systems.

Response to Question 1

Response to Question 2

(top)

Question 1. In the last 25 years, there has been a major effort to mitigate adverse impacts from oil and hazardous materials spills in our country. Has this effort been effective?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Efforts to mitigate adverse spill impacts can move in many directions. First and foremost, spill prevention can reduce the occurrence of those events that have resulted in spills into marine waters in the past. Second, improvements in spill and emergency response capabilities can reduce the chance that mishaps at sea or land-based facilities will result in large amounts of oil or hazardous materials coming into contact with sensitive resources. Third, improvements in the efficiency and effectiveness of cleanup can reduce the damage that spills do to sensitive aquatic resources, as well as the collateral damage that has sometimes been an unfortunate by-product of cleanup. Lastly, improved ability to restore environmental resources damaged by spills can speed recovery and decrease the time over which services provided by the injured resources are unavailable to human use and enjoyment.

There is no question that we are further along in our ability to avoid spills and mitigate their injurious effects than we were 25 years ago. Progress has been greatest in the areas of prevention and shoreline cleanup. On-water recovery remains problematic, and we are just beginning to understand the barriers and opportunities for environmental restoration following spills. Advances in prevention have moved in fits and starts, primarily in response to major spill events. A big leap forward occurred following the *Exxon Valdez* spill, which is also when much of the advance in shoreline cleanup capabilities occurred. Investment in prevention and response appears to ebb and flow with public perceptions of how threatening spills are, and public attention has proved to be very much keyed to how recently the last major spill into U.S. waters has occurred.

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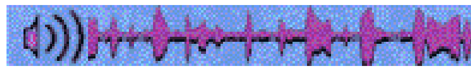
Question 2. Is additional effort needed in the years ahead? And what are realistic expectations? What will be the cost to society?

Click here for audio response

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This problem will demand attention for the foreseeable future. New technologies, new chemical products, and the spread of oil exploration into regions where it has not previously occurred, will all present new challenges to those charged with spill prevention and response. All areas of investment need attention, but prevention is the key to avoiding the inevitable shortcomings on the other dimensions of our efforts to deal with this problem. Within that spectrum, we have increasingly come to appreciate the limits on technology, no matter how sophisticated, to prevent or successfully respond to spills. Human and organizational performance are increasingly recognized as the areas that hold the ultimate key to dramatically reducing the mishaps that lead to releases of oil and hazardous materials to the marine environment.

The recent emergence of environmental and other management auditing systems, particularly those developed by the international certification societies, represents an interesting new approach to getting at the fundamental problems that affect the way humans interface with complex technologies. These relatively low-cost approaches to improving management oversight and human performance, if successful in significantly reducing spill incidence and improving response effectiveness, would represent a "win-win" solution to a problem that has traditionally pitted the environmental community against industry. Should they prove to be of more limited utility in reducing the risk and consequences of spills, as I believe they will, the costs to society of addressing these problems can escalate rapidly. The problems posed by the threat of oil spills are compounded cheap energy prices that continue to be a fundamental part of the nation's economic policy. Only life-style changes seem capable of dramatically reducing our dependence on oil that is extracted from sensitive environments and moved to markets by sea, and Americans seem unwilling or unable to make connections between their individual aspirations and the risks to the environment thus entailed.

(top)

Alexis Steen

Water Program Coordinator, Health and Environmental Sciences Department, American Petroleum Institute

Ms. Steen provides scientific and technical support to the petroleum industry on the effects of petroleum industry discharges to the environment. She has also worked in government and as an industry consultant on environmetal questions related to nuclear power and ocean disposal of sewage sludge and dredged material. She is a member of the Society of Environmental Toxicology and Chemistry and a past member of the editorial board for the Environmental Toxicology and Chemistry journal.

Response to Question 1

Response to Question 2

(top)

Question 1. In the last 25 years, there has been a major effort to mitigate adverse impacts from oil and hazardous materials spills in our country. Has this effort been effective?

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We're reducing harm from oil spills in two ways. We're cutting the amount of oil spilled, and we're improving our ability to clean it up. The total amount of oil spilled in U.S. waters on average in the last five years of the decade ending in 1995 was about 74% less than what was spilled during the preceding five years. Less oil is spilled because of better education and training. We're now phasing in double-hulled oil tankers. Also, a better job is done of cleaning up oil spills thanks to improved techniques and more equipment and ships ready to respond–and to scientific research that helps us know which cleanup techniques are most effective in different environments.
(top)

Question 2. Is additional effort needed in the years ahead? And what are realistic expectations? What will be the cost to society?

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In comparison to the total amount of oil consumed by Americans (281 billion gallons in 1996), only a tiny fraction is spilled in U.S. waters–in 1995, only about four ten-thousandths of one percent (0.0004 percent). Of course, we can do better and we should. That's why industry commits substantial resources each year for spill response equipment, training and exercises, as well as for more sophisticated communications networks. Industry is also conducting the research necessary to support acceptance of alternative cleanup options, such as dispersant use and *in-situ* burning. The more we know–and the more we improve our training and technology–the better we'll be at preventing spills and responding to those that do occur.
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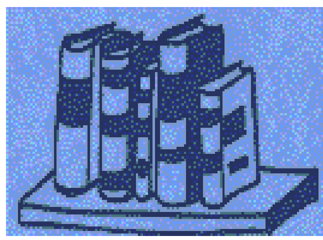

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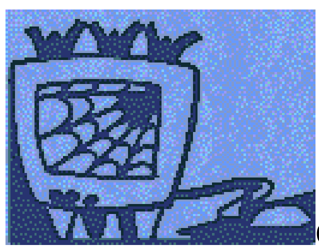

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University of Chicago Library. Chemical Safety Collection Bibliography.

http://www.lib.uchicago.edu/~atbrooks/safety/saftybib.html

Contains bibliographic information on hazardous substances and toxic materials, as well as citations on legislation, chemical safety, protective clothing and equipment, and laboratory design.

Marine Hazardous Material Spills

The Academy of Natural Sciences. Marine Oil Spills.

http://www.acnatsci.org/erd/ea/marine_oil.html

Fact sheet on sources, fates and effects of marine oil spills, as well as methods of cleanup, economic impacts and methods of prevention.

The Great Lakes Information Network. Oil and Hazardous Materials in the Great Lakes.

http://www.great-lakes.net/pollution/hazsub.html

Provides information on source, fate and effects of oil and other hazardous materials released into the Great Lakes. Has links to information on oil and hazardous materials spills, pollution, Superfund, as well as other information about the Great Lakes region.

U.S. Department of Transportation, U.S. Coast Guard. USCG historical pollution incidents.

http://www.dot.gov/dotinfo/uscg/hq/g-m/nmc/response/stats/aa.htm

Provides a 25-year compendium of marine pollution data accumulated by the U.S. Coast Guard. Summary statistics for oil spills in the U.S. Waters between 1969 and 1993 are graphically presented by total number, volume, water body, location, source, Coast Guard District, and type of oil.

Hazardous Material Spill Response Programs

Texas General Land Office. TGLO Oil Spill Prevention and Response Program.

http://www.glo.state.tx.us/oilspill/

Highlights the Texas General Land Office's Oil Spill Prevention and Response Program. Topics include a program overview, list of response activities, research and development, prevention strategies, compliance issues, the Texas Coastal Natural Resources Inventory Program, the Texas Automated Buoy System, regional activities and a calendar of events.

U.S. Department of Commerce, NOAA, ORCA, Hazardous Materials Response and Assessment Division. Oil and Chemical Spill Response and Planning Home Page.

http://www-orca.nos.noaa.gov/projects/hazmat/.

Provides information regarding NOAA HAZMAT's oil spill emergency response and planning roles and responsibilities. Many of the important reference materials generated by this division are also accessible from this location.

U.S. Department of Transportation, U.S. Coast Guard. United States Coast Guard Home Page.

http://www.dot.gov/dotinfo/uscg/

Offers an overview of the services and programs the U.S. Coast Guard provides, including the USCG's 1997 annual report, auxiliary and reserve affairs,issues of boating safety, human resource services, international training efforts, law enforcement issues and many more.

U.S. Department of Transportation, U.S.Coast Guard. National Response Center Home Page.

http://www.dot.gov/dotinfo/uscg/hq/nrc/

Describes the National Response Center, the Federal agency responsible for receiving reports on oil and chemical spills. Provides information on procedures and forms for reporting hazardous spills as well as legislative mandates governing spills, and other environmental activities within the United States. Gives statistics on spill incidents by year and transportation mode and notification by involved agency. Also, links to some of the constituent agencies that make up the National Response Team.

U.S. Environmental Protection Agency. U.S. EPA Oil Spill Program.

http://www.epa.gov/superfnd/oerr/er/oilspill/oilhome.htm

Presents information on the EPA's Oil Spill Prevention, Preparedness, and Response program. Gives the history of the agency's past response to notable spills such as the *Exxon Valdez* and information on the nature of more recent hazardous material spills via the EPA's Emergency Response Notification System reports and also Cable News Network coverage. Also provides access to EPA's Spill Prevention Control and Countermeasures facility survey results.

U.S. National Response Team.

http://www.nrt.org/nrt/home.nsf/

Provides a detailed review of the U.S. National Response Team's role and responsibilities, including information on NRT member agencies, standing committees, NRT publications and upcoming events. Provides a listing of more than 100 NRT-related Web sites for preparedness and response issues. A Responders' Toolbox is also available, which makes it possible to query and search associated Web sites for additional information on spill logistics, health and safety, media and public relations, weather, references and various other resource sites.
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NOTE: Many of the following definitions are adapted from the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (U.S. Environmental Protection Agency, 1994).

AIREYE: a specialized airplane used for monitoring the spilled product during a response.

bioremediation: the process in which nutrients (generally, nitrogen and phosphorus) and/or living microorganisms with oil-degrading abilities are introduced to an oiled shoreline to stimulate microbial growth and accelerate the rate of loss of oil hydrocarbons due to natural microbial (biodegradation) processes.

boom: a device that controls the movement of floating oil by containment, diversion, deflection or exclusion. It may be used to concentrate oil to facilitate recovery or in situ burning. The ultimate goal is to recover the oil.

chemical countermeasures: products that coagulate, disperse, dissolve, emulsify, foam, neutralize, precipitate, reduce, solubilize, oxidize, concentrate, congeal, entrap, fix, make the pollutant mass more rigid or viscous, or otherwise facilitate the mitigation of deleterious effects or the removal of the pollutant from the water. To be used in the United States, a chemical countermeasure must be listed on the National Product Schedule of the NCP and be approved for use by the affected regional response team and area committee.

coastal zone: all U.S. waters subject to the tide, U.S. waters of the Great Lakes, specified ports and harbors on inland rivers, waters of the contiguous zone, other waters of the high seas subject to the NCP, and the land surface or land substrata, ground waters, and ambient air proximal to those waters. For spill response purposes, the U.S. Coast Guard has responsibility for response actions in the coastal zone; EPA has that responsibility in the inland zone.

control: part of the scientific method for experiments. Control sites or samples are identical to experimental sites or samples, except for the presence of oil.

discharge: any spilling, leaking, pumping, pouring, emptying or dumping of oil.

dispersant: also referred to as a "chemical dispersant"; a chemical countermeasure that assists in the dispersion of oil from the water's surface into the water column.

Environmental Sensitivity Index (ESI) mapping: a

NOAA-developed technique used to provide detailed resource information on maps as a spill response and planning tool. These maps provide shoreline descriptions as well as biological and human resource information. In addition, they establish a ranking system in terms of the expected impact from exposure to oil and other hazardous materials.

geographic information system: GIS; a computer system capable of assembling, storing, manipulating and displaying geographically referenced information (i.e., data identified according to its location on a map).

hazardous chemical: a substance or material that the Secretary of Transportation has determined to be capable of posing an unreasonable risk to health, safety and property when transported in commerce.

HAZMAT: acronym for the Hazardous Materials Response and Assessment Division of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration.

in situ burning: ISB; a technique in which oil is removed from the water surface or habitat by burning.

lightering: off-loading of material from one vessel to another vessel offshore, or to an onshore vehicle, rail car or tank.

manual recovery or removal: removing oil from an area with hand tools and manual labor.

mechanical recovery or removal: removing oil from an area with mechanical equipment (e.g., skimmers, booms).

National Response Center: the primary point of contact for reporting oil and chemical spills. Immediate reporting to NRC (by calling 1-800-424-8802) is mandated by laws.

natural resource: land, fish, wildlife, biota, air, water, groundwater, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to or otherwise controlled by the United States (including the resources of the Exclusive Economic Zone), any state or local government, Indian tribe, or foreign government.

oil: oil of any kind or in any form, including, but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged spoil; does not include petroleum, including crude oil or any fraction thereof, that is specifically listed or designated as a hazardous substance under subparagraphs (A) through (F) of section 101(4) of the Comprehensive Environmental Response, Compensation, and Liability Act (42 USC. 9601), and which is subject to the provisions of that Act.

Oil Pollution Act of 1990: OPA 90; public law 101-380; this Act amended the Clean Water Act to raise the liability limit requirements for responsible parties and the size of the U.S. Coast Guard Pollution Fund, which was established to cover cleanup costs and damages not covered by the spiller. Furthermore, this Act requires new contingency planning by both industry and government and sets new construction, manning and licensing requirements.

permitted discharge: a planned release of a material within the scope of relevant operating or treatment systems. The permit is issued under section 402 of the Clean Water Act.

release: any spilling, leaking, pumping, pouring, emptying, discharging, injecting, escaping, leaching, dumping or disposing into the environment of a hazardous substance.

responsible party: RP; a person described or potentially described in one or more of the categories set forth in section 1001(32) of OPA 90.

shoreline cleaning agent: a chemical countermeasure that is applied to oil stranded on the shoreline. It increases the efficiency of flushing the shoreline with water.

skimmer: a mechanized piece of equipment placed at the oil-water interface to recover floating oil from the water surface.
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Others were contributed from outside of NOAA, and we gratefully thank the following institutions and individuals:

Photo 8. A Boater's Guide to Lee County
Photo 9. Robert Martin, TGLO, Oil Spill Division
Photo 10. Robert Martin, TGLO, Oil Spill Division

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About the Authors

Debra Scholz, Janet Kucklick, and Ann Hayward Walker are with Scientific and Environmental Associates, Incorporated (SEA) headquartered in Cape Charles, Virginia. They have over 40 years combined experience in operational issues affecting marine and freshwater environments with a focus on integrating multidisciplinary technical information to enhance and support operational decision making. Specific areas of expertise include: oil and hazardous materials; vessel and facility operations; hazardous waste site assessment; chemical countermeasures for treating oil spills; offshore oil and gas development; response and information management; and coastal zone management. They have considerable experience in preparing technical reports and plans; conducting training, exercises and workshops; and emergency response.

Ms. Scholz is an Environmental Affairs Specialist with SEA. Prior to joining SEA she was Associate with Research Planning, Inc., an environmental consulting firm that provides environmental support to NOAA's Hazardous Materials Response and Assessment Division and Damage Assessment Center personnel during oil and hazardous material releases. As a member of the spill response and rapid assessment teams, she worked on a range of topics pertaining to hazardous chemical releases, assessing damages from spilled chemicals in the nearshore marine environment, preparing Environmental Sensitivity Indices (ESIs) for biological and human-use resources, conducting specialized training courses on topics specific to oil spill response and damage assessment, as well as developing emergency response plans for coastal facilities. She has extensive experience in laboratory and field coastal ecology research and the teaching of undergraduate and graduate students in the marine sciences. She has authored numerous technical publications and ESI atlases. Ms. Scholz has a Bachelor of Art degree in Biology/Marine Science from West Virginia University and a Master of Science degree in Marine Science from the University of South Carolina.

Ms. Kucklick, Environmental Affairs Manager, was formally an Associate with Research Planning, Inc., an environmental consulting firm that provides environmental support to NOAA's Hazardous Materials Response and Assessment Division personnel during oil and hazardous material releases. She has extensive prior experience in laboratory and field coastal biology research and teaching of undergraduate and graduate students in biology and geology. Since 1988, she has authored over thirty-five peer-reviewed and technical reports ranging from ecological effects of dispersant and *in-situ* burning use to the affect of oil on sea turtles to a survey of protocols for testing effectiveness and toxicity of chemical oil spill treating agents. In addition, Ms. Kucklick has managed or supported numerous technical projects and workshops on a variety of oil spill issues including the use of dispersants, *in-situ* burning, and alternative chemicals in response. She has a Bachelor of Science degree in Biology from The College of William and Mary and a Master of Science degree in Marine Biology from The University of North Carolina at Wilmington.

Ms Walker, President and Founder of SEA, served as Scientific Support Coordinator for NOAA in the mid-Atlantic region from 1980-1990, where she participated in responses to over 250 oil and hazardous materials incidents. She has been a member of several Federal Regional Response Team Workgroups and a number of technical review boards, program committees and has authored numerous papers. In addition, she has developed and conducted a number of unique courses on oil spill contingency planning, dispersant and other chemical treating agents, and training and exercises for spill management teams. Prior to forming SEA, Ms. Walker was an environmental planner at the Virginia Institute of Marine Science and University of Hawaii where she helped develop the technical basis for the Virginia and Hawaii Coastal Zone Management Programs. She has conducted extensive research in siting oil pipeline construction to the outer continental shelf and has taught graduate courses in Environmental Contingency Planning. Ms. Walker has a Bachelor of Fine Arts degree in Architecture and Environmental Planning from the University of Hawaii and a Master of Business Administration in Management from Golden Gate University.

Dr. Robert Pavia is the Chief of the Scientific Support Coordination Branch of the Hazardous Materials Response and Assessment Division within the National Ocean Service of the National Oceanic and Atmospheric Administration (NOAA) in Seattle, Washington. He currently directs NOAA's program for providing scientific support during oil and hazardous chemical spills in coastal waters of the United States. The Scientific Support Coordination Branch provides and coordinates scientific support to the Federal On-scene Coordinator under the NCP, including environmental characterization, hazard evaluation, information management, and spill trajectory modeling, to minimize environmental damages from spills of oil and hazardous materials. Dr. Pavia has worked for NOAA since 1978. Past responsibilities included Program Manager for the Hazardous Waste Site, Scientific Support Coordinator for the West Coast of the US, and Assistant Scientific Support Coordinator for the Gulf of Mexico. He has a Bachelor of Science degree in Marine Biology from the University of Rhode Island, a Master of Science degree in Marine Resources from Oregon State University, and a Doctor of Philosophy degree in Natural Resources from the University of Washington.

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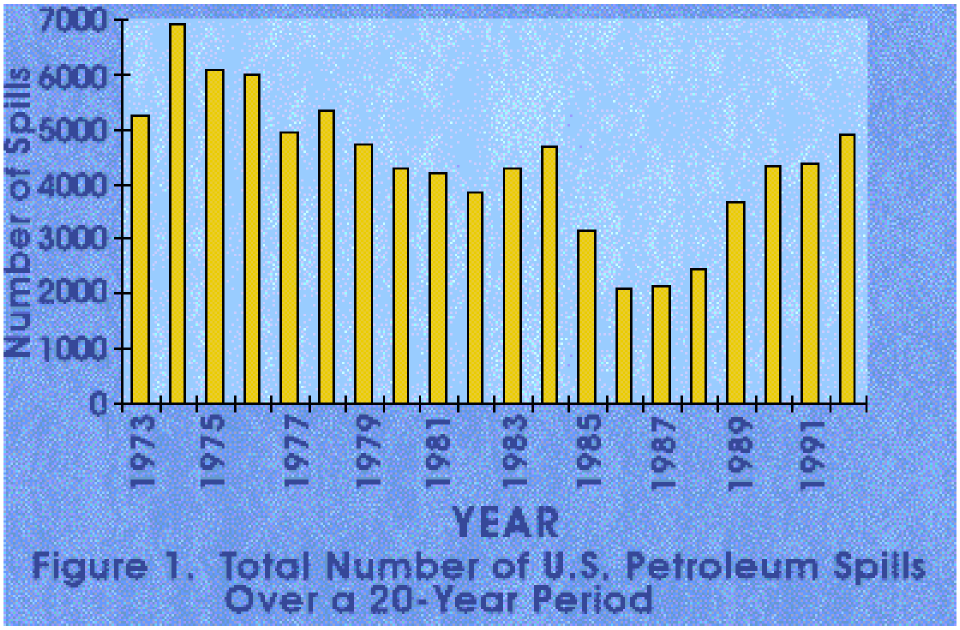

Figure 1. Total Number of U.S. Petroleum Spills Over a 20-Year Period

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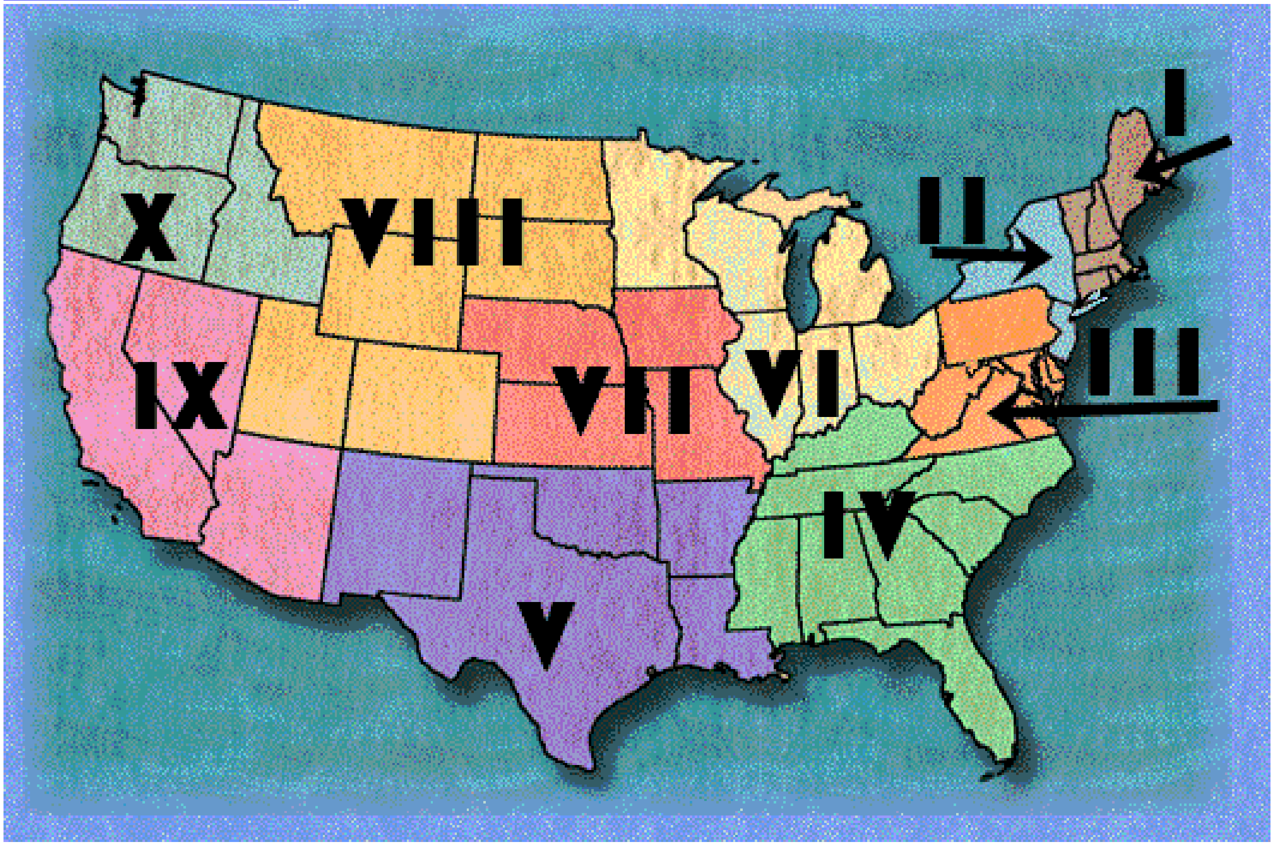

Figure 2. Federal Response Regions

Note: Hawaii, Samoa, and Guam are in Region IX; Puerto Rico and Virgin Islands are in Region III; Alaska is in Region X

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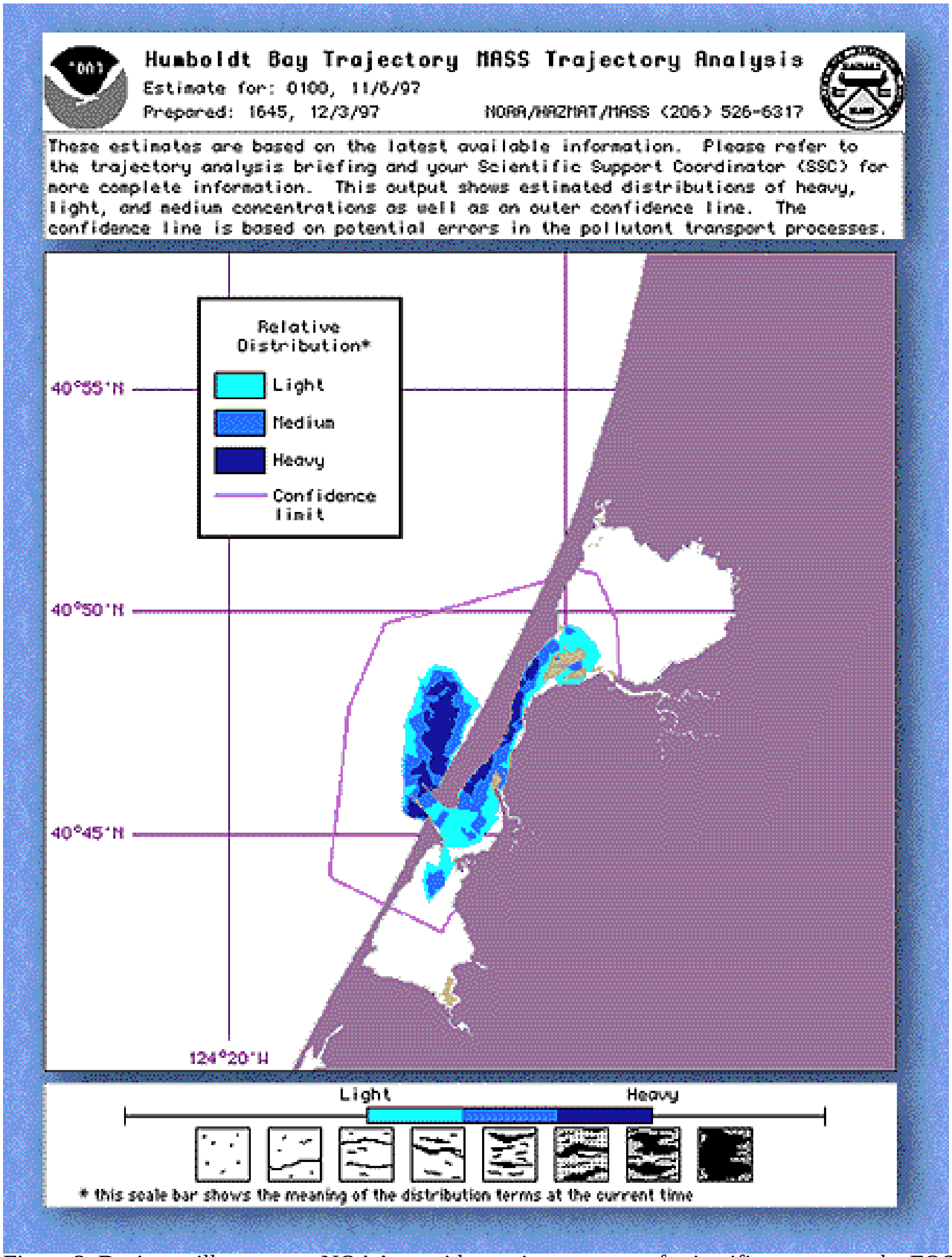

Figure 3. During spill response, NOAA provides various aspects of scientific support to the FOSC, including trajectory modeling of the spill to assist in directing the cleanup.

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Figure 4. Seven major Shipping Ports in the San Francisco Bay Area