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Understanding Oil Spills And Oil Spill Response

Understanding Oil Spills In Freshwater Environments

Introduction

OIL SPILLS endanger public health, imperil drinking water, devastate natural resources, and disrupt the economy. In an increasingly technological era, the United States has become more dependent upon oil-based products to help us maintain our high standard of living. Products derived from petroleum, such as heating oil and gasoline, provide fuel for our automobiles, heat for our homes, and energy for the machinery used in our industries. Other products derived from petroleum, including plastics and pharmaceuticals, provide us with convenience and help to make our lives more comfortable.

Additionally, non-petroleum oils, such as vegetable oils and animal fats, are increasingly being consumed in the United States. These oils can contain toxic components and can produce physical effects that are similar to petroleum oils. Because they have toxic properties and produce harmful physical effects, spills of non-petroleum oils also pose threats to public health and the environment.

Because we use vast quantities of oils, they are usually stored and transported in large volumes. During storage or transport, and occasionally as the result of exploration activities, oils and other oil-based products are sometimes spilled onto land or into waterways. When this occurs, human health and environmental quality are put at risk. Every effort must be made to prevent oil spills and to clean them up promptly once they occur.

The U.S. Environmental Protection Agency's Oil Spill Program plays an important role in protecting the environment through prevention of, preparation for, and response to oil spills. Several U.S. EPA offices and other organizations deserve special recognition for their contributions to the revision of this booklet. They are EPA Regions III and V, the EPA Environmental Response Team, the EPA Office of Research and Development, the U.S. Fish and Wildlife Service, the State of Alaska Department of Environmental Conservation, the State of Wisconsin Department of Natural Resources, the University of California Wildlife Health Center, and BP Amoco Corporation.

The purpose of this booklet is to provide information about oil spills. It contains chapters that outline and explain oil spills, their potential effects on the environment, how they are cleaned up, and how various agencies prepare for spills before they happen. Details about five oil spills are provided to show different types of spills and the complexities and issues involved in responding to them. This oil spill discussion includes the *Exxon Valdez* spill of March 1989; the Ashland oil spill of January 1988; the Wisconsin fire and butter spill in May 1991; the Colonial Pipeline spill of March 1993; and the Lake Lanier soybean oil spill in Atlanta in 1994.

Table Of Contents

Title ***Page***

1. The Behavior and Effects of Oil Spills in Aquatic Environments 5
2. Mechanical Containment and Recovery of Oil Following a Spill 9
3. Alternative Countermeasures for Oil Spills 13
4. Shoreline Cleanup of Oil Spills 17
5. Wildlife and Oil Spills 21
6. Preparing for Oil Spills: Contingency Planning 27
7. Responding to Oil Spills: The National Response System 31
8. Response to Oil Spills 37

Glossary 45

For Further Information 47

The Behavior and Effects Of Oil Spills In Aquatic Environments

1

INTRODUCTION

WHEN WE THINK of oil spills, we usually think of oil tankers spilling their cargo in oceans or seas. However, oil spilled on land often reaches lakes, rivers, and wetlands, where it can also cause damage. Oceans and other saltwater bodies are referred to as marine environments. Lakes, rivers, and other inland bodies of water are called freshwater environments. The term aquatic refers to both marine and freshwater environments.

When oil is spilled into an aquatic environment, it can harm organisms that live on or around the water surface and those that live under water. Spilled oil can also damage parts of the *food chain*, including human food resources.

The severity of the impact of an oil spill depends on a variety of factors, including characteristics of the oil itself. Natural conditions, such as water temperature and weather, also influence the behavior of oil in aquatic environments. Various types of habitats have differing sensitivities to oil spills as well.

PHYSICAL PROPERTIES OF OIL

THE TERM *OIL* describes a broad range of *hydrocarbon*-based substances. Hydrocarbons are chemical compounds composed of the elements hydrogen and carbon. This includes substances that are commonly thought of as oils, such as crude oil and refined petroleum products, but it also includes animal fats, vegetable oils, and other non-petroleum oils. Each type of oil has distinct physical and chemical properties. These properties affect the way oil will spread and break down, the hazard it may pose to aquatic and human life, and the likelihood that it will pose a threat to natural and man-made resources.

The rate at which an oil spill spreads will determine its effect on the environment. Most oils tend to spread horizontally into a smooth and slippery surface, called a *slick*, on top of the water. Factors which affect the ability of an oil spill to spread include *surface tension, specific gravity*, and *viscosity*.

- *Surface tension* is the measure of attraction between the surface molecules of a liquid. The higher the oil's surface tension, the more likely a spill will remain in place. If the surface tension of the oil is low, the oil will spread even without help from wind and water currents. Because increased temperatures can reduce a liquid's surface tension, oil is more likely to spread in warmer waters than in very cold waters.
- *Specific gravity* is the density of a substance compared to the density of water. Since most oils are lighter than water, they float on top of it. However, the specific gravity of an oil spill can increase if the lighter substances within the oil evaporate. Heavier oils, vegetable oils, and animal fats may sink and form *tar balls* or may interact with rocks or sediments on the bottom of the water body.
- *Viscosity* is the measure of a liquid's resistance to flow. The higher the viscosity of the oil, the greater the tendency for it to stay in one place. (Honey is an example of a highly *viscous* liquid.)

THE FATE OF SPILLED OIL

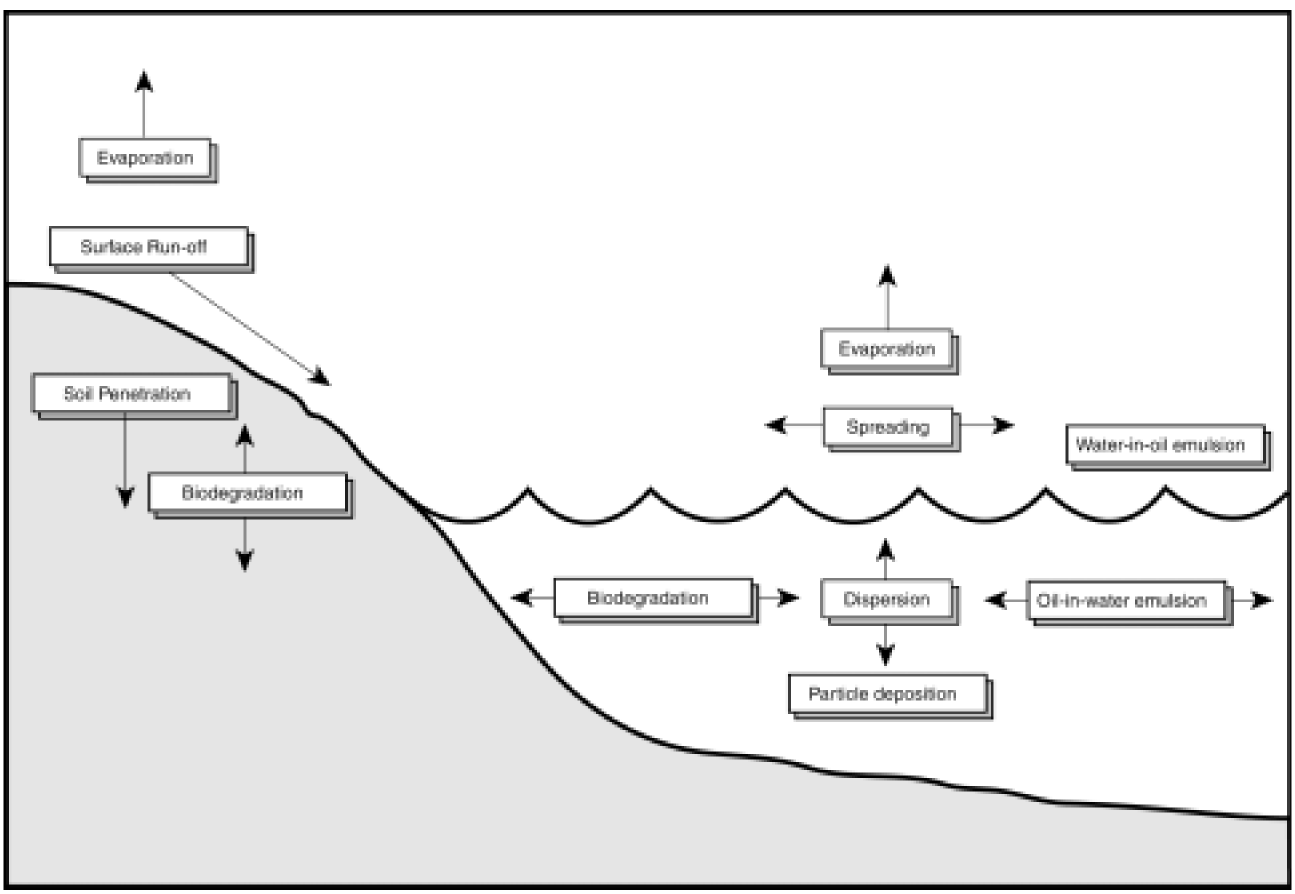
NATURAL ACTIONS are always at work in aquatic environments. These can reduce the severity of an oil spill and accelerate the recovery of an affected area. Some natural actions include *weathering, evaporation, oxidation, biodegradation*, and *emulsification*.

- *Weathering* is a series of chemical and physical changes that cause spilled oil to break down and become heavier than water. Wave action may result in natural *dispersion*, breaking a slick into droplets which are then distributed vertically throughout the water column. These droplets can also form a secondary slick or thin film on the surface of the water.

- *Evaporation* occurs when the lighter or more volatile substances within the oil mixture become vapors and leave the surface of the water. This process leaves behind the heavier components of the oil, which may undergo further weathering or may sink to the bottom of the ocean floor. Spills of lighter refined products, such as kerosene and gasoline, contain a high proportion of flammable components known as light ends. These may evaporate within a few hours, causing minimal harm to the aquatic environment. Heavier oils, vegetable oils, and animal fats leave a thicker, more viscous residue. These types of oils are less likely to evaporate.
- *Oxidation* occurs when oil contacts the water and oxygen combines with the oil hydrocarbons to produce water-soluble compounds. This process affects oil slicks mostly around their edges. Thick slicks may only partially oxidize, forming *tar balls*. These dense, sticky black spheres may linger in the environment, washing up on shorelines long after a spill.
- *Biodegradation* occurs when microorganisms, such as bacteria, feed on oil hydrocarbons. A wide range of microorganisms is required for a significant reduction of the oil. To sustain biodegradation, nutrients such as nitrogen and phosphorus are sometimes added to the water to encourage the microorganisms to grow and reproduce. Biodegradation tends to work best in warm-water environments.
- *Emulsification* is the process that forms *emulsions*, which are mixtures of small droplets of oil and water. Emulsions are formed by wave action, and they greatly hamper weathering and cleanup processes. Two types of emulsions exist: water-in-oil and oil-in-water. Water-in-oil emulsions are frequently called "chocolate mousse," and they are formed when strong wave action causes water to become trapped inside viscous oil. Chocolate mousse emulsions may linger in the environment for months or even years. Oil and water emulsions cause oil to sink and disappear from the surface, giving the visual illusion that it is gone and the threat to the environment has ended.

These natural actions occur differently in freshwater versus marine environments. Freshwater environmental impacts can be more severe because water movement is minimized in these habitats. In standing water bodies, oil tends to pool and can remain in the environment for long periods of time. In flowing streams and rivers, oil tends to collect on plants and grasses growing on the banks. Oil can also interact with the sediment at the bottom of the freshwater bodies, affecting organisms that live in or feed off of sediments.

Fate of spilled oil.



EFFECTS OF OIL ON PLANTS AND ANIMALS

SOME TOXIC SUBSTANCES in an oil spill may evaporate quickly. Therefore, plant, animal, and human exposure to the most toxic substances are reduced with time, and are usually limited to the initial spill area. Although some organisms may be seriously injured or killed very soon after contact with the oil in a spill, non-lethal toxic effects can be more subtle and often longer lasting. For example, aquatic life on reefs and shorelines is at risk of being smothered by oil that washes ashore. It can also be poisoned slowly by long-term exposure to oil trapped in shallow water or on beaches.

Both petroleum and non-petroleum oil can affect the environment surrounding an oil spill. All types of oil share chemical and physical properties that produce similar effects on the environment. In some cases, non-petroleum oil spills can produce more harmful effects than petroleum oil spills.

Chapter five discusses in greater detail how oil spills impact wildlife .

Sensitivity of Aquatic Habitats

Aquatic environments are made up of complex interrelations between plant and animal species and their physical environment. Harm to the physical environment will often lead to harm for one or more species in a food chain, which may lead to damage for other species further up the chain. Where an organism spends most of its time—in open water, near coastal areas, or on the shoreline—will determine the effects an oil spill is likely to have on that organism.

In open water, fish and whales have the ability to swim away from a spill by going deeper in the water or further out to sea, reducing the likelihood that they will be harmed by even a major spill. Aquatic animals that generally live closer to shore, such as turtles, seals, and dolphins, risk contamination by oil that washes onto beaches or by consuming oil-contaminated prey. In shallow waters, oil may harm sea grasses and kelp beds, which are used for food, shelter, and nesting sites by many different species.

Spilled oil and cleanup operations can threaten different types of aquatic habitats, with different results.

- *Coral reefs* are important nurseries for shrimp, fish, and other animals as well as recreational attractions for divers. Coral reefs and the aquatic organisms that live within and around them are at risk from exposure to the toxic substances within oil as well as smothering.
- *Exposed sandy, gravel, or cobble beaches* are usually cleaned by manual techniques. Although oil can soak into sand and gravel, few organisms live full-time in this habitat, so the risk to animal life or the food chain is less than in other habitats, such as tidal flats.

Crews work to keep oil from entering a marsh.

- *Sheltered beaches* have very little wave action to encourage natural dispersion. If timely cleanup efforts are not begun, oil may remain stranded on these beaches for years.
- *Tidal flats* are broad, low-tide zones, usually containing rich plant, animal, and bird communities. Deposited oil may seep into the muddy bottoms of these flats, creating potentially harmful effects on the ecology of the area.
- *Salt marshes* are found in sheltered waters in cold and temperate areas. They host a variety of plant, bird, and mammal life. Marsh vegetation, especially root systems, is easily damaged by fresh light oils.
- *Mangrove forests* are located in tropical regions and are home to a diversity of plant and animal life. Mangrove trees have long roots, called *prop roots*, that stick out well above the water level and help to hold the mangrove tree in place. A coating of oil on these prop roots can be fatal to the mangrove tree, and because they grow so slowly, replacing a mangrove tree can take decades.
- *Marshes and swamps* with little water movement are likely to incur more severe impacts than flowing water. In calm water conditions, the affected habitat may take years to restore.
- *Other standing water bodies,* such as inland lakes and ponds, are home to a variety of birds, mammals, and fish. The human food chain can be affected by spills in these environments.
- *River habitats* may be less severely affected by spills than standing water bodies because of water movement. However, spills in these water bodies can affect plants, grasses, and mosses that grow in the environment. When rivers are used as drinking water sources, oil spills on rivers can pose direct threats to human health.

Sensitivity of Birds and Mammals

An oil spill can harm birds and mammals in several ways: *direct physical contact, toxic contamination*, *destruction of food sources and habitats*, and *reproductive problems*.

- *Physical contact* – When fur or feathers come into contact with oil, they get matted down. This matting causes fur and feathers to lose their insulating properties, placing animals at risk of freezing to death. For birds, the risk of drowning increases, as the complex structure of their feathers that allows them to float or to fly becomes damaged.
- *Toxic contamination* – Some species are susceptible to the toxic effects of inhaled oil vapors. Oil vapors can cause damage to the animal's central nervous system, liver, and lungs. Animals are also at risk from ingesting oil, which can reduce the animal's ability to eat or digest its food by damaging cells in the intestinal tract.
- *Destruction of food resources and habitats* – Even species which are not directly in contact with oil can be harmed by a spill. Predators that consume contaminated prey can be exposed to oil through ingestion. Because oil contamination gives fish and other animals unpleasant tastes and smells, predators will sometimes refuse to eat their prey and will begin to starve. Sometimes a local population of prey organisms is destroyed, leaving no food resources for predators. Depending on the environmental conditions, the spilled oil may linger in the environment for long periods of time, adding to the detrimental effects. In calm water conditions, oil that interacts with rocks or sediments can remain in the environment indefinitely.
- *Reproductive problems* – Oil can be transferred from birds' plumage to the eggs they are hatching. Oil can smother eggs by sealing pores in the eggs and preventing gas exchange. Scientists have also observed developmental effects in bird embryos that were exposed to oil. Also, the number of breeding animals and the of nesting habitats can be reduced by the spill. Long-term reproductive problems have also been shown in some studies in animals that have been exposed to oil.

SUMMARY

SPILLED OIL immediately begins to move and weather, breaking down and changing its physical and chemical properties. As these processes occur, the oil threatens surface resources and a wide range of subsurface aquatic organisms linked in a complex food chain. Many different types of aquatic habitats exist, with varied sensitivities to the harmful effects of oil contamination and different abilities to recuperate from oil spills. In some areas, habitats and populations can recover quickly. In other environments, however, recovery from persistent or stranded oil may take years. These detrimental effects are caused by both petroleum and non-petroleum oil.

Mechanical Containment

And Recovery of Oil Following A Spill

2

INTRODUCTION

TWO MAJOR STEPS involved in controlling oil spills are containment and recovery. This chapter outlines some of the techniques and equipment that are used to conduct oil spill control efforts.

CONTAINMENT

WHEN AN OIL SPILL occurs on water, it is critical to contain the spill as quickly as possible in order to minimize danger and potential damage to persons, property, and natural resources. Containment equipment is used to restrict the spread of oil and to allow for its recovery, removal, or dispersal. The most common type of equipment used to control the spread of oil is floating barriers, called *booms*.

Booms

Containment booms are used to control the spread of oil to reduce the possibility of polluting shorelines and other resources, as well as to concentrate oil in thicker surface layers, making recovery easier. In addition, booms may be used to divert and channel oil slicks along desired paths, making them easier to remove from the surface of the water.

Although there is a great deal of variation in the design and construction of booms, all generally share four basic characteristics:

- An above-water "freeboard" to contain the oil and to help prevent waves from splashing oil over the top of the boom
- A flotation device
- A below-water skirt to contain the oil and help reduce the amount of oil lost under the boom
- A "longitudinal support," usually a chain or cable running along the bottom of the skirt, that strengthens the boom against wind and wave action; may also serve as a weight or ballast to add stability and help keep the boom upright

Booms can be divided into several basic types. Fence booms have a high freeboard and a flat flotation device, making them least effective in rough water, where wave and wind action can cause the boom to twist. Round or "curtain" booms have a more circular flotation device and a continuous skirt. They perform well in rough water, but are more difficult to clean and store than fence booms. Non-rigid inflatable booms come in many shapes. They are easy to clean and store, and they perform well in rough seas. However, they tend to be expensive, more complicated to use, and puncture and deflate easily. All boom types are greatly affected by the conditions at sea; the higher the waves swell, the less effective booms become.

Booms can be used to control the spread of oil.

Booms can be fixed to a structure, such as a pier or a buoy, or towed behind or alongside one or more vessels. When stationary or moored, the boom is anchored below the water surface.

It is necessary for stationary booms to be monitored or tended due to changes produced by shifting tides, tidal currents, winds, or other factors that influence water depth and direction and force of motion. People must tend booms around the clock to monitor and adjust the equipment.

The forces exerted by currents, waves, and wind may impair the ability of a boom to hold oil. Loss of oil occurring when friction between the water and oil causes droplets of oil to separate from the slick and be pulled under the boom is called entrainment. Currents or tow speeds greater than three-quarters of a knot may cause entrainment. Wind and waves can force oil over the top of the boom's freeboard or even flatten the boom into the water, causing it to release the contained oil. Mechanical problems and improper mooring can also cause a boom to fail.

While most booms perform well in gentle seas with smooth, long waves, rough and choppy water is likely to contribute to boom failure. In some circumstances, lengthening a boom's skirt or freeboard can help to contain the oil. Because they have more resistance to natural forces such as wind, waves, and currents, oversized booms are more prone to failure or leakage than smaller ones. Generally, booms will not operate properly when waves are higher than one meter or currents are moving faster than one knot per hour. However, new technologies, such as submergence plane booms and entrainment inhibitors, are being developed that will allow booms to operate at higher speeds while retaining more oil.

Other Barriers: Improvised Booms

When a spill occurs and no containment equipment is available, barriers can be improvised from whatever materials are at hand. Although they are most often used as temporary measures to hold or divert oil until more sophisticated equipment arrives, improvised booms can be an effective way to deal with oil spills, particularly in calm water such as streams, slow-moving rivers, or sheltered bays and inlets.

Improvised booms are made from such common materials as wood, plastic pipe, inflated fire hoses, automobile tires, and empty oil drums. They can be as simple as a board placed across the surface of a slow-moving stream, or a berm built by bulldozers pushing a wall of sand out from the beach to divert oil from a sensitive section of shoreline.

RECOVERY OF OIL

ONCE AN OIL SPILL has been contained, efforts to remove the oil from the water can begin. Three different types of equipment—*booms, skimmers,* and *sorbents*—are commonly used to recover oil from the surface.

Booms

When used in recovering oil, booms are often supported by a horizontal arm extending directly off one or both sides of a vessel. Sailing through the heaviest sections of the spill at low speeds, a vessel scoops the oil and traps it between the angle of the boom and the vessel's hull. In another variation, a boom is moored at the end points of a rigid arm extended from the vessel, forming a "U"- or "J"-shaped pocket in which oil can collect. In either case, the trapped oil can then be pumped out to holding tanks and returned to shore for proper disposal or recycling.

Skimmers

A *skimmer* is a device for recovery of spilled oil from the water's surface. Skimmers may be self-propelled and may be used from shore or operated from vessels. The efficiency of skimmers depends on weather conditions. In moderately rough or choppy water, skimmers tend to

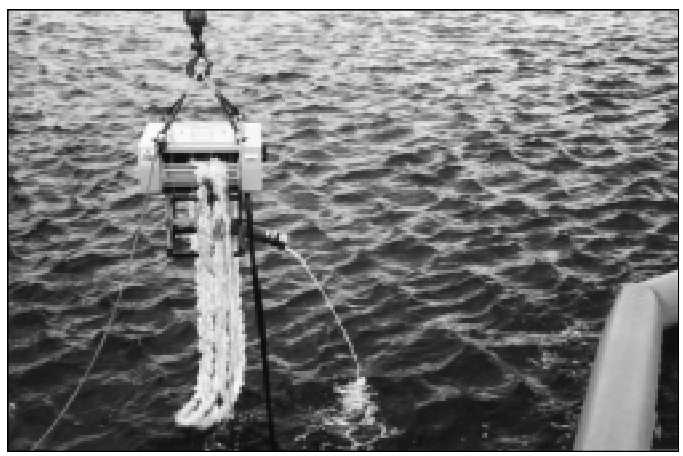


Photo courtesy of RO-CLEAN DESMI

Oleophilic skimmer.

Photo courtesy of RO-CLEAN DESMI

Suction skimmer.

recover more water than oil. Three types of skimmers—*weir, oleophilic,* and *suction*—are described below. Each type offers advantages and drawbacks, depending on the type of oil being cleaned up, the conditions of the sea during cleanup efforts, and the presence of ice or debris in the water.

Weir skimmers use a dam or enclosure positioned at the oil / water interface. Oil floating on top of the water will spill over the dam and be trapped in a well inside, bringing with it as little water as possible, The trapped oil and water mixture can then be pumped out through a pipe or hose to a storage tank for recycling or disposal. These skimmers are prone to becoming jammed and clogged by floating debris.

Oleophilic (oil-attracting) skimmers use belts, disks, or continuous mop chains of oleophilic materials to blot the oil from the water surface. The oil is then squeezed out or scraped off into a recovery tank. Oleophilic skimmers have the advantage of flexibility, allowing them to be used effectively on spills of any thickness. Some types, such as chain or “rope-mop” skimmers, work well on water that is choked with debris or rough ice.

A suction skimmer operates like a household vacuum cleaner. Oil is sucked up through wide floating heads and pumped into storage tanks. Although suction skimmers are generally very efficient, they are vulnerable to becoming clogged by debris and require constant skilled observation. Suction skimmers operate best on smooth water where oil has collected against a boom or barrier.

Sorbents

Sorbents are materials that soak up liquids. They can be used to recover oil through the mechanisms of absorption, adsorption, or both. Absorbents allow oil to penetrate into pore spaces in the material they are made of, while adsorbents attract oil to their surfaces but do not allow it to penetrate into the material. To be useful in combating oil spills, sorbents need to be both oleophilic and hydrophobic (water-repellant). Although they may be used as the sole cleanup method in small spills, sorbents are most often used to remove final traces of oil, or in areas that cannot be reached by skimmers. Once sorbents have been used to recover oil, they must be removed from the water and properly disposed of on land or cleaned for re-use. Any oil that is removed from sorbent materials must also be properly disposed of or recycled.

Sorbents can be divided into three basic categories: natural organic, natural inorganic, and synthetic. Natural organic sorbents include peat moss, straw, hay, sawdust, ground corncobs, feathers, and other carbon-based products. They are relatively inexpensive and usually readily available. Organic sorbents can soak up from 3 to 15 times their weight in oil, but they do present some disadvantages. Some organic sorbents tend to soak up water as well as oil, causing them to sink. Many organic sorbents are loose

Photo courtesy of US Coast Guard

Application of sorbents.

particles, such as sawdust, and are difficult to collect after they are spread on the water. Adding flotation devices, such as empty drums attached to sorbent bales of hay, can help to overcome the sinking problem, and wrapping loose particles in mesh will aid in collection.

Natural inorganic sorbents include clay, perlite, vermiculite, glass, wool, sand, and volcanic ash. They can absorb from 4 to 20 times their weight in oil. Inorganic substances, like organic substances, are inexpensive and readily available in large quantities.

Synthetic sorbents include man-made materials that are similar to plastics, such as polyurethane, polyethylene, and nylon fibers. Most synthetic sorbents can absorb as much as 70 times their weight in oil, and some types can be cleaned and reused several times. Synthetic sorbents that cannot be cleaned after they are used can present difficulties because they must be stored temporarily until they can be disposed of properly.

The following characteristics must be considered when choosing sorbents for cleaning up spills:

- Rate of absorption—The rate of absorption varies with the thickness of the oil. Light oils are soaked up more quickly than heavy ones.
- Oil retention—The weight of recovered oil can cause a sorbent structure to sag and deform. When it is lifted out of the water, it can release oil that is trapped in its pores. During recovery of absorbent materials, lighter, less viscous oil is lost through the pores more easily than heavier, more viscous oil.
- Ease of application—Sorbents may be applied to spills manually or mechanically, using blowers or fans. Many natural organic sorbents that exist as loose materials, such as clay and vermiculite, are dusty, difficult to apply in windy conditions, and potentially hazardous if inhaled.

SUMMARY

THE PRIMARY tools used to respond to oil spills are mechanical containment, recovery, and cleanup equipment. Such equipment includes a variety of booms, barriers, and skimmers, as well as natural and synthetic sorbent materials. A key to effectively combating spilled oil is careful selection and proper use of the equipment and materials most suited to the type of oil and the conditions at the spill site. Most spill response equipment and materials are greatly affected by such factors as conditions at sea, water currents, and wind. Damage to spill-contaminated shorelines and dangers to other threatened areas can be reduced by timely and proper use of containment and recovery equipment.

CLEANING UP AN OIL SPILL: AN EXPERIMENT YOU CAN DO AT HOME

THIS EXPERIMENT is designed to help you to understand the difficulties with oil spill cleanups. You will need the following equipment:

- two aluminum pie pans, each half-filled with water
- a medicine dropper full of used motor oil
- cotton balls (use real cotton)
- nylon string
- paper towels
- liquid detergent
- feathers

Before you begin, make a list of predictions about the action of oil and water. You might want to answer the following questions in your list:

- What will happen to the oil when you drop it on the water?
- Will it sink, float, or mix in?
- Which material will clean up the oil in the least amount of time? Cotton, nylon, paper towel, or string?
- How might wind and waves affect the combination of oil and water?

Complete each of the following steps, and observe what happens.

1. Put five drops of motor oil into one of the “oceans” (your aluminum pie pans). Observe the action of the oil, and record what happens. Was your prediction correct?
2. One at a time, use the different materials (nylon, cotton, string, and paper towels) to try to clean up the oil from the water, keeping track of the amount of oil each material was able to clean up and how fast it worked. (These materials are what booms and skimmers are made of.) Which cleaned up the oil the fastest? The best?
3. Add five drops of oil to the second pan. Add five drops of liquid detergent. (This represents the chemical dispersants.) Observe what happens. Where do you think the oil would go in the “real” oceans?
4. Dip a feather directly into some oil. What happens to it? How do you think this might affect a bird’s behaviors, such as flying, preening, and feeding?

Used with permission from Jane O. Howard, “Slick Science,” *Science and Children,* vol. 27, no. 2 (October 1989).

Alternative Countermeasures

For Oil Spills

3

INTRODUCTION

SEVERAL METHODS exist for containing and cleaning up oil spills in aquatic environments. Chapter two describes how mechanical equipment, such as *booms* and *skimmers*, is used to block the spread of oil, concentrate it into one area, and remove it from the water. Chemical and biological treatment of oil can be used in place of mechanical methods, especially in areas where untreated oil may reach shorelines and sensitive habitats where a cleanup becomes difficult and environmentally damaging. This chapter describes some of the chemical and biological methods that are used by response personnel to contain and clean up oil spills in aquatic environments. Alternative treatment typically involves adding chemical or biological agents to spilled oil and also includes in-situ burning.

Helicopters are often used to apply dispersants to large areas.

TYPES OF SUBSTANCES USED

TWO TYPES of substances commonly used in responding to an oil spill are (1) *dispersing agents* and (2) *biological agents*.

Dispersing Agents

Dispersing agents, also called *dispersants*, are chemicals that contain *surfactants*, or compounds that act to break liquid substances such as oil into small droplets. In an oil spill, these droplets disperse into the *water column*, where they are subjected to natural processes—such as wind, waves, and currents—that help to break them down further. This helps to clear oil from the water surface, making it less likely that the oil slick will reach the shoreline.

The effectiveness of a dispersant is determined by the composition of the oil it is being used to treat and the method and rate at which the dispersant is applied. Heavy crude oils do not disperse as well as light- to medium-weight oils. Dispersants are most effective when applied immediately following a spill, before the lightest components in the oil have evaporated.

Environmental factors, including water salinity and temperature, and conditions at sea influence the effectiveness of dispersants. Studies have shown that many dispersants work best at salinity levels close to that of normal seawater. While dispersants can work in cold water, they work best in warm water.

Some countries rely almost exclusively on dispersants to combat oil spills because frequently rough or choppy conditions at sea make mechanical containment and cleanup difficult. However, dispersants have not been used extensively in the United States because of difficulties with application, disagreement among scientists about their effectiveness, and concerns about the toxicity of the dispersed mixtures. Dispersants used today are much less toxic than those used in the past, but few long-term environmental effects tests have been conducted after a dispersant application. The EPA encourages the monitoring of areas that may see increased dispersant use.

These problems are being overcome, however. New technologies that improve the application of dispersants are being designed. The effectiveness of dispersants is being tested in laboratories and in actual spill situations, and the information collected is being used to help design more effective dispersants. In addition, the EPA maintains an authorized list of chemical and biological agents for use on oil spills.

Biological Agents

Biological agents are nutrients, enzymes, or *microorganisms* that increase the rate at which natural *biodegradation* occurs. Biodegradation is a process by which microorganisms such as bacteria, fungi, and yeasts break down complex compounds into simpler products to obtain energy and nutrients.

Biodegradation of oil is a natural process that slowly—over the course of weeks, months, or years—removes oil from the environment. However, rapid removal of spilled oil from shorelines and wetlands may be necessary in order to minimize potential environmental damage to these sensitive habitats.

Bioremediation technologies can help biodegradation processes work faster. Bioremediation refers to the act of adding materials to the environment, such as fertilizers or microorganisms, that will increase the rate at which natural biodegradation occurs. Furthermore, bioremediation is often used after all mechanical oil recovery methods have been used. Two bioremediation approaches have been used in the United States for oil spill cleanups—*biostimulation* and *bioaugmentation*.

Biostimulation is the method of adding nutrients such as phosphorus and nitrogen to a contaminated environment to stimulate the growth of the microorganisms that break down oil. Limited supplies of these necessary nutrients usually control the growth of native microorganism populations. When nutrients are added, the native microorganism population can grow rapidly, potentially increasing the rate of biodegradation.

Bioaugmentation is the addition of microorganisms to the existing native oil-degrading population. Sometimes species of bacteria that do not naturally exist in an area will be added to the native population. As with nutrient addition, the purpose of *seeding* is to increase the population of microorganisms that can biodegrade the spilled oil. This process is seldom needed, however, because *hydrocarbon*-degrading bacterial exist almost everywhere and non-indigenous species are often unable to compete successfully with native microorganisms.

During the *Exxon Valdez* oil spill cleanup and restoration activities, the Alaska Regional Response Team authorized the use of bioremediation products, including biostimulation and bioaugmentation. Nutrient addition use was approved for approximately 100 miles of the Prince William Sound shoreline. Data collected through a monitoring protocol required by the State of Alaska indicated that nutrient addition accelerated the natural degradation of oil with no observed eutrophication or toxicity.

Proof of the effectiveness of bioremediation as an oil spill cleanup technology was developed on the shoreline of Delaware Bay in 1994. This EPA-funded study, which involved an intentional release of light crude oil onto small plots, demonstrated a several-fold increase in biodegradation rate due to the addition of fertilizer compared to the unfertilized control plots. Bioaugmentation or seeding with native microorganisms did not result in faster biodegradation.

IN-SITU BURNING

IN-SITU BURNING of oil involves the ignition and controlled combustion of oil. It can be used when oil is spilled on a water body or on land. The National Oil and Hazardous Substances Contingency Plan authorizes in-situ burning as a cleanup method but requires approval from the regional response team (RRT) before it can be used. RRT can provide approval through pre-authorization plans and agreements among the federal and state agencies. In-situ burning is typically used in conjunction with mechanical recovery on open water. Fire resistant booms are often used to collect and concentrate the oil into a slick that is thick enough to burn.

Many factors influence the decision to use in-situ burning on inland or coastal waters. Elements affecting the use of burning include water temperature, wind direction and speed, wave amplitude, slick thickness, oil type, and the amount of oil *weathering* and *emulsification* that have occurred. Weathering is a measure of the amount of oil already having escaped to the atmosphere through *evaporation*. Emulsification is the process of oil mixing with water. Oil layer thickness, weathering, and emulsification are usually dependent upon the time period between the actual spill and the start of burn operations. For many spills, there is only a short “window of opportunity” during which in-situ burning is a viable option.

General guidelines for the use of in-situ burning on a water body are as follows:

- Wind speeds of less than 23 mph,
- Waves less than 3 feet in height,
- Minimum slick thickness of 2-3 mm, depending upon oil type,
- Less than 30 percent evaporative loss, and
- Emulsification of less than 25 percent water content.

The major issues for in-situ burning of inland spills are proximity to human populations (burning must take place at least three miles away from population at risk), soil type, water level, erosion potential, vegetation species and condition, and wildlife species presence. Burning may actually allow oil to penetrate further into some soils and shoreline sediments.

Because it releases pollutants into the air, in-situ burning requires careful air quality monitoring. Devices are pre-deployed near populations to measure particulate levels. If air quality standards are exceeded, the burn will be terminated.

Because in-situ burning uses intense heat sources, it poses additional danger to response personnel. Igniting an oil slick requires a device that can deliver an intense heat source to the oil.

Vessel-deployed ignition devices are soaked with a volatile compound, lit, and allowed to drift into an oil slick. During the *Exxon Valdez* cleanup effort, plastic bags filled with gelled gasoline were ignited and placed in the path of oil being towed in a containment fire-boom. Hand-held ignition systems can be thrown into oil slicks but require personnel to be in close proximity to the burning oil. A recently developed ignition device called the "Helitorch," delivers a falling stream of burning fuel from a helicopter, allowing personnel to maintain a safer distance from the burning slick and distribute ignition sources over a wider area.

Although it can be effective in some situations, in-situ burning is rarely used on marine spills because of widespread concern over atmospheric emissions and uncertainty about its impacts on human and environmental health. However, burning of inland spills is frequently used in a number of states. All burns produce significant amounts of particulate matter, dependent on the type of oil being burned. Burning oil delivers polycyclic aromatic hydrocarbons, volatile organic compounds, carbon dioxide, and carbon monoxide into the air in addition to other compounds at lower levels. In addition, when circumstances make it more difficult to ignite the oil, an *accelerant* such as gasoline may need to be added, possibly increasing the toxicity of the volatilizing particles. Lack of data regarding the environmental and human health effects of burning has also discouraged its use.

In-situ burning will be used more often as federal response agencies learn from its behavior and effects. As in the case of the *New Carissa*, a Japanese freighter that ran aground at the entrance to Coos Bay in Oregon on February 4, 1999, the conditions were favorable for burning. The ship was carrying approximately 360,000 gallons of bunker fuel. Early assessment of the vessel revealed that it was leaking fuel. In order to reduce the potential for oil to spill from the vessel during impending storms, responders ignited the grounded ship with incendiary devices in an attempt to burn the fuel in the cargo holds.

Despite its drawbacks, in-situ burning may be an efficient cleanup method under certain conditions where there are few negative effects on humans or the environment. These conditions include remote areas, areas with herbaceous or dormant vegetation, and water or land covered with snow or ice. In these circumstances, burning can quickly prevent the movement of oil to additional areas, eliminate the generation of oily wastes, provide a cleanup means for affected areas with limited access for mechanical or physical removal methods, or provide an additional level of cleanup when other methods become ineffective. When oil is spilled into water containing a layer or chunks of ice, burning can often remove much more oil than conventional means. Burning can also help to eliminate some volatile compounds that might otherwise evaporate off a slick.

Photo courtesy of MMS

In-situ burning can remove oil quickly.

Although limited, research and development for in-situ burning in the areas of training, fire-resistant booms, and ignition systems have increased in recent years. Investigation into inland environments and vegetative species that are more tolerant of burns is also yielding results which can aid responders. As data regarding the effects of burning oil on the environment and human population increase, consideration and use of in-situ burning may become more frequent when spills occur.

SUMMARY

CHEMICAL AND BIOLOGICAL methods can be used in conjunction with mechanical means for containing and cleaning up oil spills. Dispersants are most useful in helping to keep oil from reaching shorelines and other sensitive habitats. Biological agents have the potential to assist recovery in sensitive areas such as shorelines, marshes, and wetlands. In-situ burning has shown the potential to be an effective cleanup method under certain circumstances. Research into these technologies continues in the hope that future oil spills can be contained and cleaned up more efficiently and effectively.

Shoreline Cleanup

Of Oil Spills

4

INTRODUCTION

FRESHWATER and marine shoreline areas are important public and ecological resources. However, their cleanliness and beauty, and the survival of the species that inhabit them, can be threatened by accidents that occur when oil is produced, stored, and transported. Oil is sometimes spilled from vessels directly into waterways; spills from land-based facilities can flow into waters and foul shorelines. These accidents affect both oceans and freshwater environments. Despite the best efforts of response teams to contain spilled oil, some of it may contaminate shorelines of oceans and lakes, banks of rivers and streams, and other ecologically sensitive habitats along the water's edge. To help protect these resources from damage and to preserve them for public enjoyment and for the survival of numerous species, cleaning up shorelines following oil spills has become an important part of oil spill response.

SHORELINES: PUBLIC AND ENVIRONMENTAL RESOURCES

FRESHWATER and *marine* shoreline areas serve as homes to a variety of wildlife during all or part of the year. Many bird species build their nests on sand or among pebbles, while others regularly wander the shoreline searching for food. Marine mammals, such as elephant seals and sea lions, come ashore to breed and bear their pups. Fish, such as salmon, swim near shorelines on their upriver migrations during spawning season, and their offspring swim through these same areas on their trips to the sea in the following year. In addition, freshwater environments are important to human health as they are often used for drinking water and are home to many different mammals, aquatic birds, fish, insects, *microorganisms*, and vegetation.

Freshwater and marine shorelines also provide public recreation throughout the world. Rivers, streams, and other freshwater bodies are known for their fishing activities, while many beaches are famous for their wide expanses of beautiful sand and rugged rocky cliffs, providing opportunities for sports such as swimming, boating, and windsurfing. When response teams develop strategies for cleaning up a shoreline after an oil spill, they must consider the characteristics of the shoreline and the natural and recreational resources it provides.

FACTORS AFFECTING CLEANUP DECISIONS

FREQUENTLY, oil spills will start on land and reach shore areas. Whenever possible, control and cleanup of an oil spill begins immediately. If the oil spill can be controlled, it is less likely that it will reach sensitive freshwater or marine habitats. If the oil does reach the shore, however, decisions about how best to remove it must be made. These decisions will be based on factors such as the following:

- Type of oil spilled
- Geology of the shoreline and rate of water flow
- Type and sensitivity of biological communities likely to be affected

Each of these factors is described below.

Type of Oil Spilled

Lighter oils tend to evaporate and degrade (break down) very quickly; therefore, they do not tend to be deposited in large quantities on banks and shorelines. Heavier oils, however, tend to form a thick oil-and-water mixture called *mousse*, which clings to rocks and sand. Heavier oils exposed to sunlight and wave action also tend to form dense, sticky substances known as *tar balls* and *asphalt* that are very difficult to remove from rocks and sediments. Therefore, deposits from heavy oils generally require more aggressive cleanup than those from lighter ones. Shoreline clean-up of inland spills usually involves lighter oils. Inland oil spills often involve refined petroleum products, although spills of other types of oil are not uncommon. Spills in marine ecosystems often involve crude oils and heavy fuel oils originating from accidents during tanker operations.

Geology of the Shoreline and Rate of Water Flow

Shorelines can vary dramatically in their forms and compositions. Some marine shorelines are narrow, with beaches formed from rounded or flattened cobbles and pebbles; some are wide and covered in a layer of sand or broken shell fragments; and still others are steep cliffs with no beach at all. Generally, freshwater shorelines are composed of sediments and may be lined with trees or heavy vegetation. The composition and structure of the bank will determine the potential effects of oil on the shoreline.

Oil tends to stick to sediments and to the surfaces of cobbles and pebbles. It also flows downward in the spaces between cobbles, pebbles, and sand grains, and accumulates in lower layers of sediments. Oil that sticks to sediment particles suspended in the water column, or to cobbles and pebbles along the bank, is exposed to sunlight and waves, which help it to degrade and make it less hazardous to organisms that come into contact with it. Oil that sticks to rocks and pebbles can be wiped or washed off. Oil that flows onto sandy banks, however, can "escape" downward into sand, making it difficult to clean up and reducing its ability to degrade.

The effects of an oil spill on marine and freshwater habitats varies according to the rate of water flow and the habitat's specific characteristics. Standing or slow-moving water, such as marshes or lakes, are likely to incur more severe impacts than flowing water, such as rivers and streams, because spilled oil tends to "pool" in the water and can remain there for long periods of time. In calm water conditions, affected habitats may take years to recover. When oil spills into a flowing river, the impact may be less severe than in standing water because the river current acts as a natural cleaning mechanism. Currents tend to be the strongest along the outside edge of a bend in a river where the current tends to flow straight into the outside bank before being deflected downstream. Oil contamination is usually heavy in this area because currents drive the oil onto the bank.

The type of environment needs to be considered when devising a cleanup plan.

In marine environments and on large lakes and rivers, waves affect the movement and spreading of oil spills in several different ways. Initially, the oil spreads to form a thin film, called an oil *slick*. The slick appears smooth compared to the water around it. Momentum is then transferred from the waves to the oil slick. Small waves tend to push oil slicks in the direction of wave propagation. This makes oil slicks move slightly faster than the surface of the water that they are floating on. Short, relatively steep waves can result in a surface current that will move the oil in a downwind direction. As waves break, the resulting plunging water creates a turbulent wake, carrying particles of oil down into the water column.

Type and Sensitivity of Biological Communities

Biological communities differ in their sensitivity to oil spills and the physical intrusion that may be associated with various cleanup methods. Some ecosystems seem to recover quickly from spills, with little or no noticeable harm, while others experience long-term harmful effects.

Animals and plants may be affected by the physical properties of spilled oil, which prevent respiration, photosynthesis, or feeding. Animals, such as elephant seals, which depend on the marine environment for breeding and pupping, can lose their ability to stay warm in cold water when their skin comes into contact with oil. Birds lose their ability to fly and to stay warm when their feathers are coated with oil, and fish can suffocate when their gills are covered with oil. An oil spill can disrupt an ecosystem's food chain because it is toxic to some plants which other organisms may depend on for food. In addition, oil in sediments like those that are common in freshwater shorelines may be very harmful because sediment traps the oil and affects the organisms that live in, or feed off, the sediments.

CLEANUP PROCESSES AND METHODS

BOTH NATURAL processes and physical methods aid in the removal and containment of oil from shorelines. Sometimes physical methods are used to enhance naturally occurring processes. Examples of a technology that uses both natural processes and physical methods to clean up an oil spill are *biodegradation* and *bioremediation*, which are described later.

Natural Processes

Natural processes that result in the removal of oil from the natural environment include *evaporation, oxidation*, and biodegradation.

Evaporation occurs when liquid components in oil are converted to vapor and released into the atmosphere. It results in the removal of lighter-weight substances in oil. In the first 12 hours following a spill, up to 50 percent of the light-weight components may evaporate. Since the most toxic substances in oil tend to be those of lightest weight, this evaporation decreases the toxicity of a spill over time.

Oxidation occurs when oxygen reacts with the chemical compounds in oil. Oxidation causes the complex chemical compounds in oil to break down into simpler compounds that tend to be lighter in weight and more able to dissolve in water, allowing them to degrade further.

Biodegradation occurs when naturally occurring bacteria living in the water or on land consume oil, which they can use to provide energy for their various biological needs. When oil is first spilled, it may be toxic to some bacteria, which makes the initial rate of biodegradation quite slow. As the oil evaporates and the more toxic substances are removed, the population of bacteria grows and biodegradation activity accelerates.

In nature, biodegradation is a relatively slow process. It can take years for a population of microorganisms to degrade most of the oil spilled onto a shoreline. However, the rate at which biodegradation occurs can be accelerated by the addition of nutrients, such as phosphorus and nitrogen, that encourage growth of oil-degrading bacteria. This process is called *biostimulation*. Biodegradation rates can also be increased by adding more microorganisms to the environment, especially species that are already used to consuming the type of oil spilled. Adding microorganisms is referred to as *bioaugmentation*. The use of nutrients or the addition of microorganisms to encourage biodegradation is called bioremediation.

When oil spill response personnel develop bioremediation strategies, they have to consider the effects of waves, tides, and currents on the nutrients and microorganisms they are applying to oil-contaminated areas. Contamination of coastal areas by oil from offshore spills usually occurs in the intertidal zone where waves and tides can quickly carry away dissolved nutrients. Adding nutrients may not be effective on beaches with a great deal of wave action and tidal flows because most of the nutrients will be lost to dilution. On calmer shorelines, adding nutrients may be an effective bioremediation strategy.

With respect to freshwater shorelines, an oil spill is most likely to have the greatest impact on wetlands or marshes rather than on a wide shoreline zone like a marine intertidal zone. Less research has been conducted in these types of environments, so it is not yet known how well bioremediation enhances oil removal. The same principals apply to this environment as a marine environment, namely, that nutrients should be applied in ways that will keep them from washing away from the affected areas long enough to affect the enhanced treatment. In wetlands, bioremediation may not work as well because there is less oxygen in the sediments than there is on a sandy beach; even with added nutrients, microorganisms may not have enough oxygen to effectively combat the spill.

EPA is currently studying the biodegradability of *non-petroleum oils* (vegetable oils and animal fats) and their impacts on freshwater and marine environments during biodegradation.

Chapter three discusses bioremediation and other alternative cleanup approaches.

Physical Methods

Physical removal of oil from shorelines, and especially beaches, is time-consuming and requires much equipment and many personnel. Methods used to physically clean oil from shorelines include the following:

- Wiping with absorbent materials
- Pressure washing
- Raking or bulldozing

Before physical cleaning methods are used, booms made of absorbent material are often set up in the water along the edge of the bank. Booms prevent oil released during bank cleanup activities from returning to the water and contain the oil so that it can be skimmed from the water for proper disposal.

Wiping with Absorbent Materials

Materials that are capable of absorbing many times their weight in oil can be used to wipe up oil from contaminated shorelines. These materials are often designed as large squares, much like paper towels, or shaped into "mops." The squares or mops are used to wipe the shoreline or oily rocks during which time the absorbents are filled with as much oil as they can hold.

There are advantages to the use of absorbents. They can be used to clean up any kind of oil on any shoreline that can be reached by response personnel. The use of absorbents is generally not harmful to the shoreline itself or to the organisms that live on it, and no material is left behind following the cleanup effort. Some sorbents are reusable, reducing the need for disposal after a spill.

Wiping with absorbent materials requires the use of a large quantity of material and several personnel. Personnel must wear proper protective clothing to minimize direct contact with the oil as they are removing it. Oil-filled absorbents and protective clothing that are used by response personnel must be properly disposed of following cleanup, which can be costly. In addition, the intrusion of many people onto an isolated shoreline may disrupt animal behaviors such as breeding or nesting.

Pressure Washing

Pressure washing involves rinsing oiled shorelines and rocks using hoses that supply low- or high-pressure water streams. Hot or cold water can be used to create these streams. The oil is flushed from the shoreline into plastic-lined trenches, then collected with sorbent materials and disposed of properly. Since many river banks, and some lakes, have vegetation extending down into or growing in the water, plants may have to be cleaned or removed. Depending on the type of oil, low-pressure washing will usually remove most of the oil from the vegetation. In a marine ecosystem, high-pressure washing usually does more harm than good by driving the oil deeper into the beach and by killing many of the organisms on the beach. Additionally, high-pressure water streams can accelerate bank erosion and dislodge organisms, such as algae and mussels, from the rocks and sediments on which they live, or can force oil deeper into sediments, making cleanup more difficult.

Pressure washing has the advantage of being relatively inexpensive and simple to apply; however, it requires many people.

Raking or Bulldozing

When oil moves downward into the sands or between pebbles and cobbles on a shoreline, it becomes more difficult to remove. If the oil has moved downward only a short distance, tilling or raking the sand can increase evaporation of the oil by increasing its exposure to air and sunlight. If the oil has penetrated several inches into the sand, bulldozers may be brought in to remove the upper layers of sand and pebbles. This allows the oil to be exposed so it can be collected and removed from the site, washed with pressure hoses, or left to degrade naturally.

Raking and bulldozing are simple methods for helping to remove oil that might otherwise escape into sediments. However, these methods can disturb both the natural shape of the shoreline and the plant and animal species that live on and in the sediments. In addition, the use of bulldozers requires specially trained operators who can maneuver them without damaging the shoreline unnecessarily; raking and tilling are time-consuming and require many people.

Response crews using high pressure hose to wash an oil covered beach.

DISPOSAL OF OIL AND DEBRIS

CLEANUP FROM an oil spill is not considered complete until all waste materials are disposed of properly. The cleanup of an oiled shoreline can create different types of waste materials, including liquid oil, oil mixed with sand, and tar balls. Oil can sometimes be recovered and reused, disposed of by *incineration,* or placed in a landfill. States and the federal government strictly regulate the disposal of oil.

Reuse or recovery of oil requires that the oil be processed and separated from the other materials, such as water, that are mixed in with it. The recovered oil can then be blended with other fuels for use in power plants or boilers.

Incineration uses extremely high temperatures to convert compounds, such as oil, into carbon dioxide and water. When a mobile incinerator is used at a remote spill site, the need for transporting large volumes of oiled wastes to distant disposal sites is eliminated. This can be a practical and efficient method to manage large volumes of waste generated during a cleanup. Because incineration can potentially produce air pollution, it is important that it be used in strict compliance with air pollution laws.

Landfilling is another method of disposing of oiled debris. The oil is mixed with chemicals, such as calcium oxide (“quicklime”), that stabilize the oil and make it less able to leak into groundwater or soils. Mixtures of quicklime and oil must sometimes be taken to specially designed landfills for disposal.

SUMMARY

CLEANING shorelines after an oil spill is a challenging task. Factors that affect the type of cleanup method used include the type of oil spilled, the geology of the shoreline and rate of water flow, and the type and sensitivity of biological communities in the area. Natural processes, such as evaporation, oxidation, and biodegradation, help to clean the shoreline. Physical methods, such as wiping with sorbent materials, pressure washing, and raking and bulldozing, can be used to assist these natural processes. Oil collected during cleanup activities must be reused or disposed of properly, using such methods as incineration or landfilling. Choosing the most effective yet potentially least damaging cleaning methods helps to ensure that the natural systems of shorelines and the recreational benefits they offer will be preserved and protected for future generations.

5 Wildlife And Oil Spills

INTRODUCTION

IN THE UNITED STATES there are more than 70 spills reported on an average day. When oil spills occur, plants and animals will be contaminated and some will be unable to survive. Whether they occur in oceans, estuaries, rivers, lakes, ponds, or on land, they can affect algae, plants, invertebrates, fish, amphibians and reptiles, birds, and mammals. These species and communities are at risk of smothering, hydrocarbon toxicity, hypothermia, and chronic long-term effects.

Planning ahead is one of the best ways to minimize the impacts of oil spills on wildlife. *Contingency planning* at the local area level helps both planners and responders identify protection strategies and response options for fish, wildlife, and sensitive environments. The following chapter describes how contingency plans are used to help prepare for oil spills.

EPA, along with other planners and responders, is working to develop a thorough understanding of how oil spills affect fish, wildlife, and environmental resources. Knowing the species and communities that might be affected by a spill and their susceptibilities to oil contamination helps planners choose the best response options. These response concerns are addressed in pre-spill response planning so that they can be implemented more easily during actual response efforts.

When a spill occurs, wildlife responders try to minimize injuries to fish, wildlife, and sensitive environments. By working with the response agencies that contain and clean up spills, wildlife responders can reduce the negative effects an oil spill has on natural resources.

WILDLIFE AND SENSITIVE ENVIRONMENTS' SUSCEPTIBILITY TO OIL SPILLS

MOST BIOLOGICAL communities are susceptible to the effects of oil spills. Plant communities on land, marsh grasses in estuaries, and kelp beds in the ocean; microscopic plants and animals; and larger animals, such as fish, amphibians and reptiles, birds, and mammals, are subject to contact, smothering, toxicity, and the chronic long-term effects that may result from the physical and chemical properties of the spilled oil. The primary effects of oil contamination include loss of the insulative capability of feathers and fur which can lead to hypothermia; dehydration resulting from lack of uncontaminated water; stomach and intestinal disorders and destruction of red blood cells resulting from ingestion of oil; pneumonia resulting from inhalation of oil vapors; skin and eye irritation from direct contact with oil; and impaired reproduction. Animals can also suffer during capture and rehabilitation operations; potential ailments include infectious diseases, skin problems, joint swellings, and lesions. In addition, eggs and juveniles are particularly susceptible to contamination from oil. Very small quantities of oil on bird eggs may result in the death of embryos.

EFFECTS OF OIL ON FISH, BIRDS, AND MAMMALS

Fish

Fish may be exposed to spilled oil in different ways. They may come into direct contact and contaminate their gills; the *water column* may contain toxic and volatile components of oil that may be absorbed by their eggs, larvae, and juvenile stages; and they may eat contaminated food. Fish that are exposed to oil may suffer from changes in heart and respiratory rate, enlarged livers, reduced growth, fin erosion, a variety of biochemical and cellular changes, and reproductive and behavioral responses. Chronic exposure to some chemicals found in oil may cause genetic abnormalities or cancer in sensitive species. If chemicals such as dispersants are used to respond to a spill, there may be an increased potential for tainting of fish and shellfish by increasing the concentration of oil in the water column. This can affect humans in areas that have commercial and recreational fisheries. (*Chapter three discusses dispersants and other alternative oil spill response techniques.*)

Birds

Birds are very susceptible to oil spills. Seabirds, for example, spend a lot of time on the ocean's surface, dive when disturbed, and have low reproductive rates, making them particularly vulnerable to oil spills. In addition, the populations of species with small numbers of individuals, a restricted geographic range, or threatened and endangered species may be very adversely affected by oil spill contamination.

A bird's feathers overlap to trap air and provide the bird with warmth and buoyancy. Birds that contact an oil slick may get oil on their feathers and lose their ability to stay waterproof, they may ingest oil while trying to clean their feathers or when they try to eat contaminated food, and they may suffer long-term reproductive effects.

Birds can be smothered by oil.

Mammals

Mammals that may be affected include river otters, beavers, sea otters, polar bears, manatees, seals, sea lions, walrus, whales, porpoises, and dolphins. The sensitivity of mammals to spilled oil is highly variable. The amount of damage appears to be most directly related to how important the fur and blubber are to staying warm, which is called thermoregulation. River otters, beavers, sea otters, fur seals, polar bears, and land mammals need clean fur to remain warm.

Direct exposure to oil can result in temporary eye problems. Ingestion of oil can result in digestive tract bleeding and in liver and kidney damage. Ingestion of oil is of greater concern for species that groom themselves with their mouth, such as sea otters and polar bears. Breathing hydrocarbon vapors can result in nerve damage and behavioral abnormalities to all mammals.

Capturing and cleaning oiled marine mammals generally is not feasible. While procedures for dealing with oiled birds have been developed, no such procedures have been developed for marine mammals except for sea otters and, to a more limited extent, polar bears.

Procedures for capturing, treating, and releasing animals may hurt them more than the oil does. For example, manatees are particularly susceptible to secondary fungal and bacterial infections following capture or transportation.

OIL SPILLS EFFECTS ON SPECIFIC TYPES OF MAMMALS

Pinnipeds and Cetaceans

The most common *pinnipeds* are harbor seals, fur seals, sea lions, and walrus. The most common *cetaceans* are porpoises, dolphins, and whales. Except for fur seals, both the pinnipeds and the cetaceans have blubber for insulation and do not groom or depend on fur to stay warm. This characteristic makes them less susceptible to oil spills than other mammals. The pinnipeds are associated with coastal environments, as they must venture onto land to reproduce and often inhabit beaches and rocky shores at various times of the year. This may make them more at risk to oil spills than cetaceans, which are generally more nomadic and migratory. Contact with oil has similar effects on both pinnipeds and cetaceans. When they come to the surface to breathe they may inhale *hydrocarbon* vapors that may result in lung injuries; oil that comes in contact with the animals' sensitive mucous membranes and eyes may produce irritations. Young pinnipeds and cetaceans may be injured due to ingestion of oil from contaminated teats when nursing. There may be long-term chronic effects as a result of migration through oil-contaminated waters.

Manatees

The effects of discharged oil on adult manatees' body temperature as a result of direct contact with oil is negligible because they have a layer of blubber for insulation. Also, they exhibit no grooming behavior that would contribute to ingestion. However, manatees may be affected by inhaling volatile hydrocarbons while they are breathing on the surface, and it is very likely that exposure to petroleum would irritate sensitive mucous membranes and eyes.

As with most animals, the young are the most at risk. Nursing pups may be injured due to ingestion of oil from contaminated teats. There may be long-term chronic effects as a result of migration through oil-contaminated waters, and there is a substantial possibility of consuming contaminated plant material and other incidental organisms. Manatees may not be severely affected by the oil spill through direct contact, but they are sensitive to habitat disturbances and injury, such as collisions with boats and barges and propeller strikes, that may occur during response actions.

Sea Otters

Because sea otters spend a great deal of time on the ocean's surface and depend exclusively on their fur for insulation and buoyancy, they are highly susceptible to oil contamination. Sea otters are considered vulnerable to oil spill contamination during their entire life cycle. The most harmful effect from direct exposure to oil is the fouling of fur, which may lose its ability to insulate. In addition, breathing hydrocarbon vapors and ingesting oil as they groom themselves or feed on contaminated prey can damage their lungs, cause digestive tract bleeding, and result in liver and kidney damage. Indirect effects may include loss of habitat and food resources.

Polar Bears

Polar bears rely on blubber, guard hair, and a dense underfur for thermoregulation and insulation. Polar bears may groom oil-contaminated fur; swallowing oil during grooming has killed several bears in Canada. There is some evidence that oil's toxic effects on polar bears include an inability to produce red blood cells and kidney damage.

RESPONSE OPTIONS TO PROTECT WILDLIFE

WHEN A SPILL OCCURS, the severity of injuries to fish, wildlife, and sensitive environments depends on the location and the quantity and type of oil. Oils tend to spread rapidly whether spilled on land or water, but the spreading will be enhanced if the spill reaches groundwater, lakes, streams, rivers, and the ocean. Currents, winds, and temperatures may complicate response efforts. Once the spill reaches the environment, fish, wildlife, and sensitive environments are at risk. Three categories of response options have been developed to meet the needs of responders trying to minimize injuries to the environment.

Containing Spilled Oil

The first response strategy for fish, wildlife, and environmental protection emphasizes controlling the release and spread of spilled oil at the source to prevent or reduce contamination of potentially affected species, their habitats, and sensitive environments. In addition, primary response strategies include the removal of oiled debris, including contaminated fish and wildlife carcasses, in water and on land. These response options are often limited in their application and effectiveness, making it necessary to try to maneuver healthy wildlife out of the path of the spill.

Keeping Animals Away from Spilled Oil

The second response option for protecting wildlife emphasizes keeping unoiled wildlife away from oiled areas through the use of deterrents and pre-emptive capture. Like first response options, second response options also prevent healthy and clean wildlife from becoming oiled, but they may not be effective unless conditions are nearly perfect. The techniques, often called hazing, use a variety of visual, auditory, and experimental sensory deterrent methods. Visual deterrents include shiny reflectors, flags, balloons, kites, smoke, scarecrows, and model predators. Auditory methods often rely on loud noises generated from propane cannons, alarms, model wildlife distress calls, predator recordings, and other noise makers. These techniques have been used with mixed success by airport personnel to keep flocks of birds away from runways. A combination of visual and auditory devices may be used, including herding with aircraft or helicopters, and boats. One promising experimental deterrent is the use of the chemical that produces grape flavoring. When the grape flavoring is used in conjunction with bird feed, it appears to effectively deter birds from landfills and public parks where birds pose a health threat to humans. It might be used to create a buffer around the slick to preclude birds from swimming into it. The application would only have an effect on birds that swim on the surface and less so on diving birds, which continue to present extensive operational problems for recovery during spill response.

Cases involving endangered species may warrant the use of unusual or heroic secondary response options. Two unique applications involving fish employ a visual method and an auditory method.

1. Many fish have a sensitivity to bright lights. For example, walleyes in Lake Michigan collide with rocks or beach themselves in an attempt to escape automobile floodlights at close range. Lighting may be manipulated to restrict fish movement in specific areas.
2. Most bony fish have the ability to detect vibrations. High frequencies have been used to keep fish away from the turbines at hydroelectric dams. While these methods have not been proven successful for all species, the method does hold promise for some.

If a spill occurs on land, a combination of deterrent devices might be employed to keep wildlife from entering the spill area. Deterrence is more difficult if a spill occurs on water and the slick is moving. It is very difficult to keep the devices actively scaring wildlife from the area. Untended or misdirected hazing of wildlife could result in accidently moving them into oiled areas. Noises and visual deterrents work best in a smaller, well-defined spill area, which may

Volunteers wash a seabird coated with a mixture of vegetable oils.

Photo courtesy of Marine Wildlife Veterinary Care & Research Center

be ringed with devices to make it unappealing for wildlife to enter. Often, just the activities of oil spill cleanup workers on beaches, in boats, in vehicles, or in aircraft provide good deterrent effects for as long as they are in the area.

Another way to keep wildlife from becoming oiled is to capture clean animals before they come in contact with oil. However, this approach is complex and requires good planning. The capture, handling, transportation, and release of uncontaminated wildlife is labor and equipment intensive and should be reserved for animals that can be captured easily and species of particular concern. Preemptive capture should only be attempted when the threat of oiling is very high. Small populations of endangered or critically sensitive wildlife may be captured with nets or traps that do not hurt the animals. Careful consideration must be given to finding clean release sites, which should be determined before capturing animals.

Rescuing Oiled Animals

The third response option is capturing and treating animals that have already been oiled; this option is used only as a last resort. Typically only a small percentage of wildlife that are highly sensitive to the effects of oiling will be captured. Even very oiled animals are often able to evade capture until they are very ill. Of those captured, only a portion will survive the treatment process and be released back into the wild. Some will survive, but their injuries will require them to live under the care of aquariums and zoological parks.

The fate of animals released back into the wild has been questioned and requires additional investigation to determine if these efforts are warranted. The decision to capture and treat oiled wildlife, and the decision to release them back to the wild or retain treated wildlife in captivity must be based on spill-specific criteria. The criteria must be based on the best available science and focus on the protection and maintenance of healthy wild populations of the species affected or potentially affected by the spill.

Major Considerations in Oiled Animal Rescue

It is necessary to locate facilities that are capable of handling the water, sewage, and solid waste requirements of the operation. It is particularly important to ensure that the facility, personnel, and operations are in compliance with all laws, regulations, and permit requirements prior to initiating operation of the facility.

In addition, responders must ensure that facilities operate within established guidelines and that all wildlife operations are conducted under qualified veterinary supervision.

Finally, in order to have the best chance for success, the capture effort must be initiated rapidly and efficiently, using trained and qualified managers and responders, including rehabilitation workers.

OILED WILDLIFE CARE: A VETERINARIAN'S OVERVIEW

MANY GOVERNMENT AGENCIES, universities and private organizations help rescue animals and birds that have been exposed to oil pollution. While the government is responsible for animal rescue efforts, many private organizations assist in rescuing injured wildlife. Before any person or organization can handle or confine birds or mammals for rescue, however, they must get special permits that are issued by state and federal officials. It is unlawful for any person or organization to capture and handle oiled wildlife without training or permits. This training prepares them to capture, handle, and treat injured wildlife without causing pain and suffering to the animals or causing injury to themselves as they treat wildlife.

Rescue parties usually will contact rehabilitation workers even before they arrive to make sure that they are prepared to care for the captured birds immediately. This ensures that the birds are treated as quickly as possible. Birds that are most likely to be affected by oil spills are those that remain in, dive in, or feed in the water, such as ducks, loons, grebes, cormorants, gulls, terns, herons, murres, pelicans, coots, auklets, bald eagles, and ospreys.

Once a bird has been brought to a rehabilitation center, certain basic procedures are followed. First, birds are given complete physical exams, including checking body temperature, respiratory rates, and heart rates. Birds are examined for broken bones, skin burns and abrasions. Oil is flushed from birds' eyes and nares. Heavily oiled birds are wiped with absorbent cloths to remove patches of oil. Pepto Bismol™ or Toxiban™ is administered orally to prevent additional absorption of oil inside the bird's stomach and to help remove internal oil from the bird. The bird is then warmed and placed in a quiet area. Curtains, towels, and sheets are often hung to limit visual contact with people.

Nutrition is essential for the recovery of oiled birds. Birds are fed and rehydrated using a rehydration solution (Pedialyte™) and gruel (fish, vitamins, minerals) until they are washed. Birds need up to five days to rehydrate and strengthen themselves before being washed.

After a bird is alert, responsive, and stable, it can be washed. Dawn™ dishwashing detergent diluted with water has been found to be the most effective washing agent for oiled birds. Beads of water will roll freely from the feathers, and down will begin to fluff up and appear dry when a bird has been acceptably rinsed. Failure to properly rinse birds is one of the most common causes of unsuccessful rehabilitation.

After its feathers are completely rinsed, the bird is placed in a clean holding pen lined with meshed nets and a ceiling made of sheets or towels. The pen is warmed with pet dryers, and, again, minimizing human contact is important. If behavior appears normal and a bird's condition remains stable, it is placed in a recovery pool and allowed to swim. The bird then begins to preen and realign its feathers to restore them to their original structure, helping the bird to become waterproof again.

Before a bird is released, it must pass the waterproofing test; it must demonstrate buoyancy (the ability to float) and water-repellency (the ability to keep water away from its body). Once a bird passes this test, it is slowly exposed to temperatures comparable to outside weather. Its weight should be close to the average for the species, and it should show no signs of abnormal behavior. Rehabilitated birds are banded by the U.S. Fish and Wildlife Service, and are released early in the day into appropriate habitat. Release location is a very important element in rehabilitation. Birds must not be allowed to return to oiled areas nor should they be released into an unsuitable habitat.

After extensive washing, birds still have oil coated feathers.

Photo courtesy of Marine Wildlife Veterinary Care & Research Center

GOVERNMENT AGENCIES RESPONSIBLE FOR PROTECTING WILDLIFE

THE U.S. FISH and Wildlife Service (FWS) has management authority for fish species that live in both freshwater and marine environments, coastal fishes, and inland threatened or endangered species.

The National Oceanic and Atmospheric Administration (NOAA) has management authority over marine and estuarine fishes. It is authorized to manage or protect marine fish during oil discharges and releases of hazardous materials.

Individual states have responsibility for all wildlife within their state boundaries unless federal law gives the authority to another agency (such as NOAA or FWS).

Post-release Survival Studies

In the past, oil spill success has been measured by release rates. However, it has become apparent that release does not mean that birds will necessarily survive. In order to evaluate survival after release, several techniques have been used. In the United States, birds are routinely banded with federal stainless steel bands. If birds die and they are recovered, or if birds are recaptured at a later date, based on banding records maintained by the Bird Banding Laboratory (National Biological Survey, Department of the Interior), it is possible to know the duration of survival. Unfortunately, many banding studies rely on recovery of very few banded birds.

Outside the US, and with different species of birds (penguins), color bands are attached to the wings of birds making them visible from long distances even when birds are in large congregations. Through resighting of wing placed color bands, some of the best information on long-term survival and breeding success has been documented.

More recently, technological advances in radio-marking aquatic avian species has made radio-tracking a valuable tool for post-release survival monitoring. In these studies, oiled and rehabiliated birds are radio-marked upon release and both their survival and behavior can be evaluated. This technique can provide daily, weekly or monthly information on habitat use, movement patterns, and survival, as well as determine survival rates of oiled and rehabilitated birds.

SUMMARY

OIL SPILLS can harm wildlife in a number of ways. The toxic effects of inhaling vapors and ingesting oil when grooming or feeding can make animals sick. Oil can also coat an animal's fur or feathers, leading to hypothermia and a loss of buoyancy. Preventing spills is the best way to protect wildlife from oil spills. When oil is spilled, however, responders try to (1) prevent it from reaching animals and sensitive environments, (2) keep animals away from the oil, and (3) capture and rehabilitate oiled animals.

Spill responders have learned a great deal since the *Exxon Valdez* ran aground in Prince William Sound, Alaska, in 1989. There are new laws providing additional protection for natural resources that may be affected by oil spills. Area contingency planning is becoming the primary tool for preparing for an effective spill response. Wildlife and sensitive environmental resources must be identified and prioritized. Communication and cooperation between response agencies and other agencies that protect wildlife will ensure that when a spill occurs the fish and wildlife response operations will effectively minimize injuries to natural resources.

Preparing For Oil Spills:

Contingency Planning

6

INTRODUCTION

OIL SPILLS ARE, unfortunately, common events in many parts of the United States. Most of them are accidental, so no one can know when, where, or how they will occur. Spills can happen on land or in water, at any time of day or night, and in any weather condition. Preventing oil spills is the best strategy for avoiding potential damage to human health and the environment. However, once a spill occurs, the best approach for containing and controlling the spill is to respond quickly and in a well-organized manner. A response will be quick and organized if response measures have been planned ahead of time.

THE ROLE OF CONTINGENCY PLANS

A *CONTINGENCY PLAN* is like a “game plan,” or a set of instructions that outlines the steps that should be taken before, during, and after an emergency. A contingency plan looks at all the possibilities of what could go wrong and, “contingent” upon actual events, has the contacts, resource lists, and strategies to assist in the response to the spill.

ELEMENTS OF A CONTINGENCY PLAN

AT FIRST GLANCE, an oil spill contingency plan may appear complicated because it provides many details about the numerous steps required to prepare for and respond to spills. It also covers many different spill scenarios and addresses many different situations that may arise during or after a spill. Despite its complexity, a well-designed contingency plan should be easy to follow. Although they are different in many respects, contingency plans usually have four major elements in common:

- Hazard identification
- Vulnerability analysis
- Risk assessment
- Response actions

Planners use hazard identification and vulnerability analysis to develop a risk assessment. The risk assessment is then used as the basis for planning specific response actions. Each of the four elements is described below.

Hazard Identification

It is impossible to know when an oil spill is going to happen and how much oil is likely to be spilled. However, it is possible to identify where oil is stored, the corridors through which it travels, and the industries that use large quantities of oil.

Different situations can affect the ability of response personnel to contain and clean up an oil spill, such as weather conditions, geographic isolation, and spill size. Private companies and local, state, and federal agencies design their contingency plans to address spills from many locations and under many different conditions. The following information is usually collected as part of the hazard identification:

- Types of oils frequently stored in or transported through that area
- Locations where oil is stored in large quantities and the mode of transportation used to move the oil, such as pipelines, trucks, railroads, or tankers
- Extreme weather conditions that might occur in the area during different times of the year
- The location of response equipment and personnel trained to use the equipment and respond to the spill

Vulnerability Analysis

The vulnerability analysis section of a contingency plan provides information about resources and communities that could be harmed in the event of a spill. This information helps personnel involved in cleaning up a spill make reasonable, well-informed choices about protecting public health and the environment. Vulnerability analysis information might include the following:

- Lists of public safety officials in the community
- Lists of facilities such as schools, nursing homes, hospitals, and prisons
- Lists of recreational areas, such as campgrounds
- Lists of special events and when they take place
- Identification of parts of the environment that are particularly susceptible to oil or water pollution

Risk Assessment

Contingency planners compare the hazard and the vulnerability in a particular location to see the kind of risk that is posed to a community. The plan then addresses those problems by determining how best to control the spill, how to prevent certain populations or environments from exposure to oil, and what can be done to repair the damage done by the spill.

Response Actions

Response actions are developed to address the risks that are identified in the risk assessment. A carefully designed contingency plan will describe major actions that need to be taken when a spill occurs. These actions should take place immediately following a spill so as to minimize hazards to human health and the environment. The following response actions should be included in a contingency plan:

- Notifying all private companies or government agencies that are responsible for the cleanup effort
- Getting trained personnel and equipment to the site quickly
- Defining the size, position, and content of the spill; its direction and speed of movement; and its likelihood of affecting sensitive habitats
- Ensuring the safety of all response personnel and the public
- Stopping the flow of oil from the ship, truck, or storage facility, if possible, and preventing ignition
- Containing the spill to a limited area
- Removing the oil
- Disposing of the oil once it has been removed from the water or land

TESTING THE PLAN

AFTER THE PLAN is developed, it is important to test it to see if it works as anticipated. Testing usually takes the form of an exercise or drill to practice responding to a spill. Exercises can range from a discussion around a table about how things would occur to a full-scale deployment of equipment and mobilization of staff. Exercises can take a few hours or several days. Exercises provide the following benefits:

- Training of response staff in the procedures developed for the plan
- A test of the plan to see what needs to be improved
- A low-stress environment where new techniques and procedures may be tried without adverse consequences

Exercises are also a time for responders from different organizations to meet in a low-stress environment. This builds familiarity and teamwork, which can make response more effective during real spills.

IMPROVING CONTINGENCY PLANS

AFTER AN OIL SPILL has been controlled and cleaned up, or after an exercise, the companies, as well as the local, state, and federal agencies that were involved in the emergency or exercise, should assess the usefulness of their contingency plans. Information gathered during the assessment, such as problems that had not been considered in the original plan and the successes or failures of cleanup techniques used, is used to revise and improve contingency plans.

Lessons learned during oil spills and exercises are also shared with other private, state, regional, and federal agencies so that they too may learn from oil spills to improve their contingency plans.

Improving Plans with GIS

Contingency planners in EPA and other response organizations are now using geographic information systems (GIS) to make contingency plans better and easier to use. GIS make electronic maps that can focus attention on the locations of things that are important to planners and oil spill responders. For example, planners can make maps that show the locations of sensitive environments, drinking water intakes, roads, oil storage and production facilities, pipelines, and boat launches. GIS can also provide detailed information about each of the items shown on a map, such as how large an oil storage facility or pipeline is, whether a road is paved, or the times of the year that sensitive species are in the area.

Having all of this data easily accessible in one place and being able to see these things in relation to each other can make planning more effective. It allows planners to know where spills are most likely to happen and how bad they might be and lets them prioritize actions to protect the most sensitive resources first. It can also help planners know what kind of resources (booms, skimmers, vacuum trucks, etc.) they may need in a given area and how much of a specific resource may be needed. GIS can also help to determine the best way to get to potential spill sites and identify areas that responders might have difficulty accessing.

EXAMPLES OF CONTINGENCY PLANS

SOME CONTINGENCY plans are designed to deal with oil spills that might occur at specific places, such as oil storage or refining facilities. Others are designed to address spills that might occur anywhere within a large geographic region. In fact, the federal government has designed a national plan that establishes the process for dealing with any spill that occurs in the United States.

The National Contingency Plan

The federal government has designed a spill response plan, called the National Oil and Hazardous Substances Pollution Contingency Plan, also called the *National Contingency Plan* or NCP. The NCP ensures that the resources and expertise of the federal government would be available for those relatively rare, but very serious, oil spills that require a national response. This plan was designed primarily to assist with coordinating the various federal agencies that are responsible for dealing with oil spill emergencies. The following chapter discusses the roles of the different federal agencies and how the NCP fits in with the *National Response System*.

Area Contingency Plans

Because a single plan cannot address the unique conditions of all areas, EPA and other organizations have developed many plans for smaller areas. These plans, known as Area Contingency Plans, may cover only a few counties. These plans describe the area covered by the plan; describe the responsibilities of an owner or operator and of government agencies in removing, mitigating, or preventing a discharge; and list all equipment, dispersants, or other mitigating substances and devices available to an owner or operator and government agencies to ensure effective and immediate removal, mitigation, or prevention of a discharge.

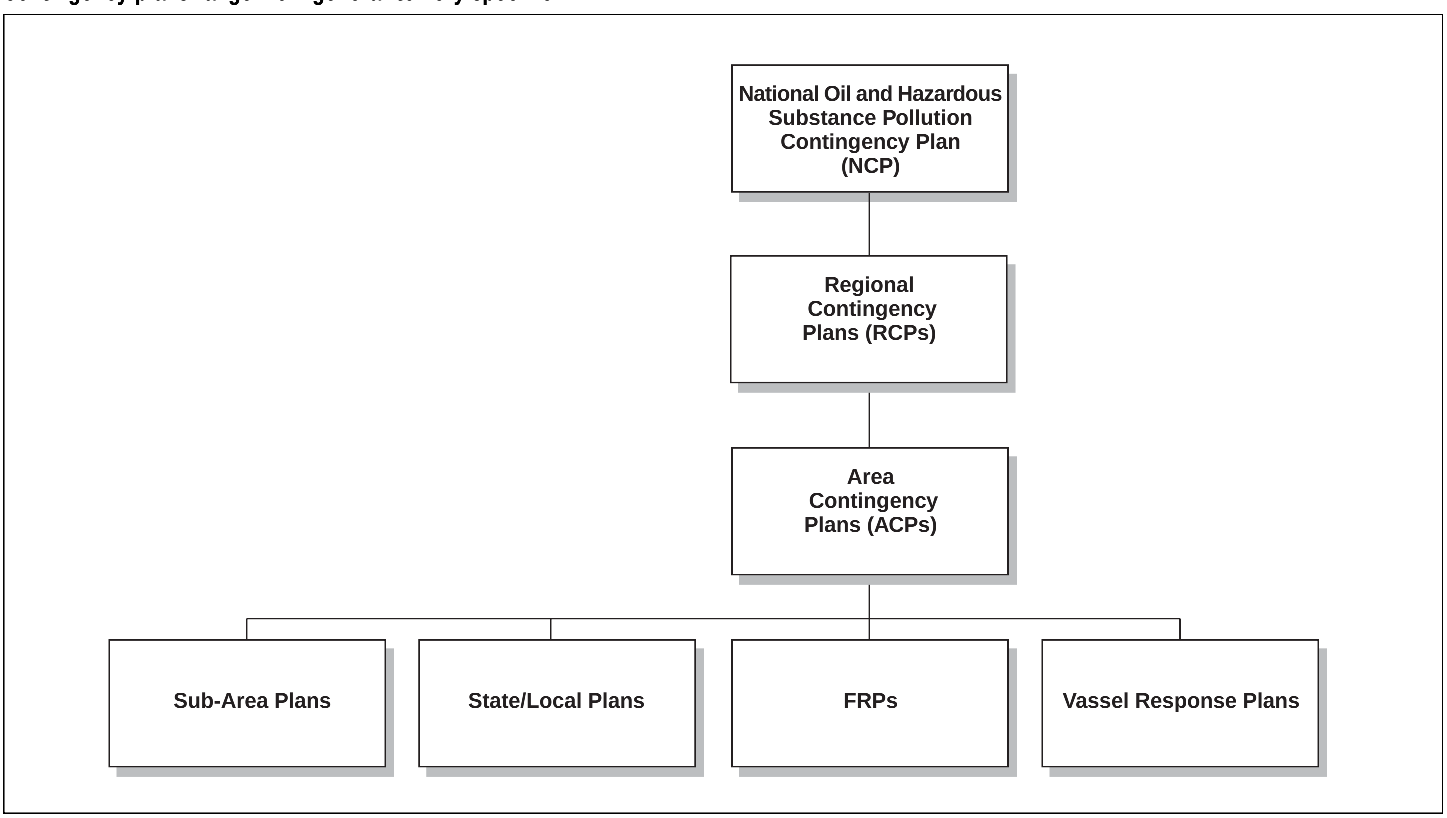
Area Contingency Plans may be broken into sub-areas based on higher risk, such as busy transportation corridors and environmentally sensitive areas.

Area and sub-area contingency plans are prepared with the involvement of the local, state, and federal governments, as well as with state and federal Natural Resource Trustees. Natural Resource Trustees are federal, state, or tribal officials who act on behalf of the public for resources under their control. They are important to contingency planning because they often have special knowledge about areas where oil might be spilled and resources that might be affected.

Facility Contingency Plans

Every facility in the United States that stores or refines oil products, whether owned by a private company or operated by a government agency, is required to develop a plan for dealing with an accidental release of oil on its property.

Contingency plans range from general to very specific.



SUMMARY

PLANNING FOR an oil spill emergency helps to minimize potential danger to human health and the environment by ensuring a timely and coordinated response. Well-designed local, state, regional, and national contingency plans can assist response personnel in their efforts to contain and clean up oil spills by providing information that the response teams will need before, during, and after spills occur. Developing and exercising the plan provides opportunities for the response community to work together as a team and develop the interpersonal relationships that can mean so much to the smooth functioning of a response.

Because the approaches and methods for responding to oil spills are constantly evolving and each oil spill provides an opportunity to learn how to better prepare for future incidents, contingency plans are also constantly evolving and improving—ensuring increased protection for human health and the environment from these accidents.

7 Responding To Oil Spills:

The National Response System

INTRODUCTION

WHEN A MAJOR oil spill occurs in the United States, coordinated teams of local, state, and national personnel are called upon to help contain the spill, clean it up, and ensure that damage to human health and the environment is minimized. Without careful planning and clear organization, efforts to deal with large oil spills could be slow, ineffective, and potentially harmful to response personnel and the environment. In the United States, the system for organizing responses to major oil spills is called the *National Response System*. This chapter describes the origins of the National Response System and outlines the responsibilities of the teams and individuals who plan for and respond to major oil spills in navigable waters.

THE NATIONAL RESPONSE SYSTEM

UNTIL 1967, the United States had not formally addressed the potential for major oil or hazardous substance spills. On March 18, 1967, a 970-foot oil tanker, the *Torrey Canyon*, ran aground 15 miles off Land's End, England, spilling 33 million gallons of crude oil that eventually affected more than 150 miles of coastline in England and France. The spill had negative impacts on beaches, wildlife, fishing, and tourism.

Recognizing the possibility of a similar spill in the United States, the federal government sent a team of representatives from different federal agencies to Europe to observe the cleanup activities and bring back lessons learned. Based on what the team learned from the *Torrey Canyon* spill and response, several federal agencies developed the National Oil and Hazardous Substances Pollution Contingency Plan, or *National Contingency Plan* (NCP) for short.

The NCP, which was signed into law on November 13, 1968, established the National Response System, a network of individuals and teams from local, state, and federal agencies who combine their expertise and resources to ensure that oil spill control and cleanup activities are timely, efficient, and minimize threats to human health and the environment.

The three major components of the National Response System are the (1) *On-Scene Coordinators,* (2) *National Response Team,* and (3) *Regional Response Teams.* A fourth component, *Special Forces*, are organizations with special skills and knowledge that can be called upon to support a response.

The National Response System is activated when the *National Response Center* receives notification of an oil spill. The National Response Center, located in Washington, D.C., is one of the first organizations to be notified when an oil spill occurs. It is staffed by officers and marine science technicians from the U.S. Coast Guard, and serves as the national communications center responsible for notifying On-Scene Coordinators (OSCs) who oversee cleanup efforts at a spill site.

ON-SCENE COORDINATORS

ON-SCENE COORDINATORS have the most prominent role in the National Response System. They are federal officials responsible for directing response actions and coordinating all other efforts at the scene of a discharge or spill. In addition, OSCs work in partnership with other federal, state, local, and private response agencies. OSCs' duties also include providing support and information to regional response committees.

Four federal agencies have staff that serve as OSCs: the Coast Guard, the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy, and the U.S.

Department of Defense. Among these agencies, the Coast Guard and EPA have the greatest responsibility for responding to oil spill emergencies. There are 48 OSCs in the Coast Guard and 215 OSCs in EPA. OSCs are stationed in locations across the country to allow for quick and efficient response to spills. When a spill occurs in coastal waters, the local Coast Guard Port Commander is the OSC. When a spill occurs in an inland area, such as a spill from a pipeline or rail tank car, a regional EPA official is assigned as the OSC. The OSC is responsible for four main tasks during an oil spill response: (1) assessment, (2) monitoring, (3) response assistance, and (4) reporting.

Assessment

As part of a response to a spill, an OSC must evaluate the size and nature of a spill and its potential hazards. The OSC who is in charge also estimates the resources needed to contain the oil and clean it up and assesses the ability of the responsible party or local authorities to handle the incident. Collectively these activities are called assessment. OSCs typically conduct assessment activities at the beginning of a response. The assessment determines the need for personnel, equipment, and other resources to promptly and effectively combat the spill.

Monitoring

Throughout an oil spill response, OSCs monitor the actions being taken to control and clean up a spill to make sure they are appropriate. All spills of a legally defined minimum size must be monitored by an OSC, even though most spills are small and are cleaned up by the responsible party or local fire or police departments. Monitoring can be conducted from the site when necessary, or from an agency office if the situation appears to be under control.

Response Assistance

Once a spill has been assessed, an OSC determines whether federal assistance will be necessary to help control and contain the spill. If an OSC decides that federal assistance is required, he or she will obtain needed resources such as personnel and equipment. If sufficient resources are not available at or near the spill site, an OSC can secure them using a special fund—the Oil Spill Liability Trust Fund—that the federal government established for this purpose. (See the box on this page for more information). The fund is intended to ensure that oil spill cleanups will not be hindered by a lack of personnel or equipment.

Reporting

As required by the NCP, OSCs report all activities that take place during and after a spill. For example, following a spill, the OSC is required to file a summary report that outlines the actions taken to remedy the spill and the level of assistance provided by local, state, and federal agencies. These reports can be used to identify problem areas and improve spill response plans. They can also be shared with other agencies who may make recommendations about how to respond more effectively in future incidents or how to prevent more spills.

Planning

Under the NCP guidelines, OSCs also participate in the inland / coastal area planning committees. These committees support the OSC in preparing area contingency plans for emergency incidents. (Chapter six discusses contingency planning in greater detail.)

THE OIL SPILL LIABILITY TRUST FUND

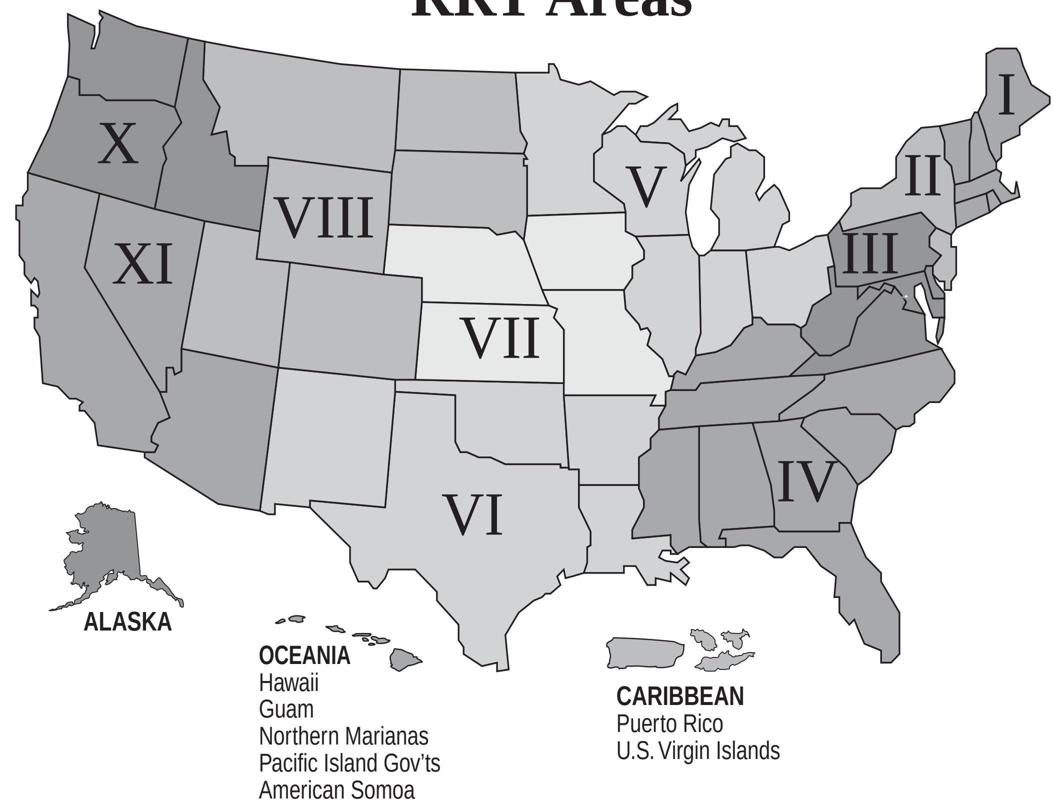
THE COMPANY or individual responsible for an oil spill—known as a responsible party—is legally responsible for expenses related to containment and cleanup of the spill. However, when the responsible party is unable to pay for cleanup, funds from the Oil Spill Liability Trust Fund can be used to pay for removal costs or damages resulting from discharges of oil into U.S. waters. Up to one billion dollars from the Fund may be expended on a spill incident. The Fund, created by Congress in 1990, is administered by the U.S. Coast Guard. The money comes from a five-cent per barrel fee on oil.

REGIONAL RESPONSE TEAMS

REGIONAL RESPONSE TEAMS (RRTs) are another major component of the National Response System. There are 13 RRTs in the United States, each representing a particular geographic region of the United States (including Alaska, the Caribbean, and the Pacific Basin). RRTs are composed of representatives from states and from field offices of the federal agencies that make up the National Response Team. The RRTs provide assistance when it is requested by OSCs and may respond on-scene. The four major responsibilities of RRTs are (1) response, (2) planning, (3) training, and (4) coordination.

Response

Regional Response Team members do not respond directly to spills like OSCs do, but they may be called upon to provide technical advice, equipment, or manpower to assist with a response. RRTs provide a forum for federal agency field offices and state agencies to exchange information about their abilities to respond to OSCs' requests for assistance.



Planning

Each RRT develops a Regional Contingency Plan to ensure that during an actual oil spill the roles of federal and state agencies are clear. Following an oil spill, the RRT reviews the OSC's reports to identify problems with the Region's response to the incident and improves the plan as necessary.

Training

Regional Response Teams provide simulation exercises of regional plans to test the abilities of federal, state, and local agencies to coordinate their responses to oil spills. Any major problems identified as a result of these exercises may be addressed and changed in the Regional Contingency Plans so the same problems do not arise during an actual oil spill response.

Coordination

The RRTs are responsible for identifying the resources available from each federal agency and state in their regions. Such resources include equipment, guidance, training, and technical expertise for dealing with oil spills. When there are too few resources in a Region, the RRT can request assistance from federal or state authorities to ensure that sufficient resources will be available during a spill. This coordination by the RRTs ensures that resources are used as wisely as possible and that no Region is lacking what it needs to protect human health and the environment from the effects of an oil spill.

THE NATIONAL RESPONSE TEAM

THE THIRD MAJOR component of the National Response System is the National Response Team (NRT). It is an organization composed of 16 federal agencies, each of which has responsibilities in environmental areas and expertise in various aspects of emergency response to pollution incidents. EPA serves as the NRT's chair and the Coast Guard serves as the vice chair. Although the NRT does not respond directly to incidents, it is responsible for three major activities relating to managing oil spill response: (1) distributing information, (2) planning for emergencies, and (3) training for emergencies.

Distributing information

The NRT is responsible for ensuring that technical, financial, and operational information about oil spills is available to all members of the team. NRT committees focus attention on specific issues, then collect and disseminate information on those issues to other members of the team.

NATIONAL AND REGIONAL RESPONSE TEAM MEMBER AGENCIES

ONE REPRESENTATIVE from each of the following 16 federal agencies sits on the NRT. The RRTs are composed of representatives from the field offices of these agencies along with representatives from each state within the Region.

Environmental Protection Agency	Department of Justice
Coast Guard	Department of Labor
Department of Agriculture	Department of State
National Oceanic and Atmospheric Administration	Department of Transportation
Department of Defense	Federal Emergency Management Agency
Department of Energy	General Services Administration
Department of Health and Human Services	Nuclear Regulatory Commission
Department of the Interior	Department of the Treasury

Planning for Emergencies

The NRT ensures that the roles of federal agencies on the team for oil spill emergency response are clearly outlined in the NCP. After a major spill event, the effectiveness of the response is carefully assessed by the NRT. The NRT may use information gathered from the assessment to make recommendations for improving the NCP and the National Response System. The NRT may be asked to help Regional Response Teams (see below) develop Regional Contingency Plans. The NRT also reviews these plans to ensure that they comply with federal policies on emergency response.

Training for Emergencies

One important aspect of any emergency response is preparedness, which is best developed by training. Although most training is actually performed by state and local personnel, the NRT develops training courses and programs, coordinates federal agency training efforts, and provides information to regional, state, and local officials about training needs and courses.

Supporting RRTs

The NRT supports RRTs by reviewing Regional Contingency Plans and ensuring that they are consistent with national policies on oil spill cleanup. The NRT also supports RRTs by monitoring and assessing RRT effectiveness during an oil spill cleanup activity. The NRT may ask an RRT to focus on specific lessons learned from an incident and to share those lessons with other members of the National Response System. In this way, the RRTs can improve their own Regional Contingency Plans while helping to solve problems that might occur elsewhere within the National Response System.

SPECIAL FORCES

SPECIAL FORCES are national resources with unique expertise. When responders face difficult problems, they can call on special forces for assistance. The NCP designates five special force components: (1) the Coast Guard National Strike Force (NSF), (2) the Coast Guard Public Information Assist Team (PIAT), (3) the EPA Environmental Response Team (ERT), (4) the National Oceanic and Atmospheric Administration's Scientific Support Coordinators (SSCs), and (5) National Resource Trustees.

National Strike Force

The NSF provides specially trained personnel equipped to handle major oil spills and chemical releases and maintains a national inventory of spill response equipment. In addition, the NSF aids development and implementation of exercises and training for the National Response System.

Public Information Assist Team

The PIAT is a team of skilled public affairs specialists that supplements the existing public information capabilities of OSCs.

Environmental Response Team

The scientists and engineers who make up the ERT provide expertise in sampling and analysis, hazard assessment, cleanup techniques, and technical support.

Scientific Support Coordinators

Scientific Support Coordinators lead the scientific teams that provide support to OSCs in the areas of chemistry, natural resources, pollutant transport modeling, contingency planning, and environmental tradeoffs. SSCs also serve as liaisons to natural resources trustees and the scientific community.

Natural Resource Trustees

Natural Resource Trustees are federal, state, or tribal officials who act on behalf of the public for resources under their control. They are important to oil spill response because they often have special knowledge and technical expertise about areas where oil is spilled. Trustees also cooperate with the OSC in coordinating assessments, investigations, planning, and response.

SUMMARY

THE NATIONAL Response System is the mechanism established by the federal government to respond to discharges of oil into navigable waters of the United States. This system functions through a cooperative network of federal, state, and local agencies. The primary mission of the system is to provide support to state and local response activities.

The major components of the National Response System are the On-scene Coordinators, the National Response Team, and the 13 Regional Response Teams, with supplementary support from Special Forces. These individuals and teams work together to develop detailed contingency plans to outline responses to oil spill emergencies before they occur and to develop or engage in training that prepares responders for actual emergencies. During oil spill events, they cooperate to ensure that all necessary resources such as personnel and equipment are available and that containment, cleanup, and disposal activities are timely, efficient, and effective. Four Special Forces components provide specialized support to OSCs during spill response. It is through this cooperation that the National Response System protects human health and the environment from potential harm from oil spills in navigable waters.

Response To Oil Spills

8

INTRODUCTION

RESPONSE TO OIL spills requires the combined efforts of the owner or operator of the facility or vessel that spilled the oil, the federal *On-Scene Coordinator* (OSC), and state and local government officials. The specific steps taken to respond to a spill depend on the type of oil discharged, the location of the discharge, the proximity of the spill to sensitive environments, and other environmental factors.

Oil spills do not occur only in coastal areas. Various types of oils are also spilled in inland areas. Many of the same problems associated with cleanup efforts found in conjunction with coastal spills are created when spills occur in inland areas from sources such as storage tank rupturing, pipeline leaks, and oil transport accidents.

Because they usually occur closer to areas where people live and work, inland spills typically have a more direct impact on human populations than marine and coastal spills do. Inland oil spills are more likely to have negative impacts on drinking water sources, metropolitan areas, recreational waterways, and shoreline industry and facilities. Also, species affected by coastal and inland spills are likely to differ because freshwater and marine ecosystems are different.

There are many sources of oil spills. Vessels are major sources for both coastal and inland spills. Offshore facilities such as oil rigs are also large contributors to coastal spills. Fixed facilities such as gas stations and oil tank farms are responsible for a large percentage of inland releases.

The *Exxon Valdez* oil spill is probably the best known and most widely reported of all spills. Another very large spill, the Ashland oil spill, happened the year before the *Exxon Valdez* spill, when a giant inland storage tank ruptured. Although these events were catastrophic, responders learned a great deal from them. The lessons they learned have helped to prevent more oil spills and to make response more effective when spills do occur. This chapter describes these spills and the responses to them. It also describes three other spills that highlight a variety of types of oil spills and response activities.

EXXON VALDEZ SPILL

AT TWO YEARS OLD, the oil tanker *Exxon Valdez*, with a capacity of 1.46 million barrels (62 million gallons) of oil, was the newest and largest of Exxon's 19-ship fleet. On the evening of March 23, 1989, 1.26 million barrels of oil (54 million gallons) were loaded onto the ship in Valdez, Alaska. The ship left the port at 9:10 p.m., bound for Long Beach, California.

Chunks of ice from the nearby Columbia Glacier were sitting low in the water, so the ship's captain tried to turn into an empty inbound shipping channel to avoid them. The ship was moving at approximately 12 miles per hour when it struck the rocks of Bligh Reef in Prince William Sound. The underwater rocks tore huge holes in 8 of the vessel's 11 giant cargo holds, releasing a flood of oil into the Sound. More than 11 million gallons of oil spilled within 5 hours of the event. Seven hours after the spill was reported, the resulting oil *slick* was 1,000 feet wide and 4 miles long.

In addition to the spilled oil, there were other immediate dangers. About 80 percent of the ship's oil cargo remained on board; the ship was resting in an unstable position and was in danger of capsizing. Removing the remaining oil from the ship and cleaning the spilled oil were top priorities.

Since the incident occurred in coastal waters, the U.S. Coast Guard's OSC had authority over all activities relating to the cleanup effort. Once the OSC was notified of the spill, he immediately closed the Port of Valdez to all traffic. A Coast Guard investigator, along with a representative from the Alaska Department of Environmental Conservation, visited the scene of the incident to assess the damage caused by the spill. By noon on Friday, March 25th, the Alaska *Regional Response Team* was brought together by teleconference. The *National Response Team* was activated soon thereafter. The National Response Team is based in Washington, D.C. It is composed of representatives from 14 different federal agencies, with either the U.S. Environmental Protection Agency (EPA) or the U.S. Coast Guard taking primary responsibility for coordinating oil-spill cleanup activities.

The Alyeska Pipeline Service Company first assumed responsibility for the cleanup. Alyeska operates the trans-Alaska pipeline and the shipping terminal at Valdez. Exxon and the other oil companies that operate in Alaska each own part of the pipeline company. Alyeska is responsible for carrying out plans for oil-spill emergencies in the area. The company opened an emergency communications center in Valdez shortly after the spill was reported and set up a second operations center in Anchorage, Alaska.

The OSC, in cooperation with the Exxon Corporation, established several goals for the response. The most important goal was to prevent additional spilling of oil. Because the *Exxon Valdez* was unstable and in danger of capsizing, the 43 million gallons of oil still onboard the tanker threatened the environmentally sensitive Prince William Sound. The first priority was to protect four fish hatcheries that were threatened by the spill. In addition, there were concerns about the safety of response personnel, since highly flammable and toxic fumes made response actions difficult.

Numerous equipment problems slowed down the response to the spill. Alyeska had *booms* and other mechanical containment equipment available, but there was not enough equipment to contain an 11 million-gallon spill. Because of the remote location of the spill, equipment had to be moved over great distances to reach the accident scene. The barge that Alyeska's response team normally used had been stripped for repairs and was not immediately available. It took ten hours to prepare and load the barge and another two hours to reach the *Exxon Valdez*.

In addition, the remote location of the incident presented many logistical problems. Because the spill site was located two hours by boat from the port of Valdez, every task was time-consuming. The response had to be staged from mobile platforms, and equipment had to be air-dropped or delivered by boat.

Other problems became apparent as the emergency teams began to arrive to help with the cleanup. Only limited lodging was available in Valdez, a small village of only 4,000 people. The small airstrip at Valdez could not handle large planes carrying the cleanup equipment. These planes were forced to land in Anchorage, a nine-hour drive from Valdez. The Federal Aviation Administration, the agency responsible for all air traffic control, had to set up a temporary tower to manage increased flights to the area.

At the start of the spill, necessary communications between response personnel were difficult because there was limited phone service in Valdez. The Coast Guard OSC was the only person with a direct telephone line out of the community. The lack of phone lines delayed requests for resources that response teams needed to combat the spill; it took time for the phone company to increase the number of phone lines. Radio communication was also troublesome. The large number of boats working the area led to multiple simultaneous radio transmissions. The mountainous terrain also made radio communication difficult. The Coast Guard established a news office and requested more communications staff because many news reporters and crews were arriving in Valdez every day.

On the second day of the spill, Exxon assumed responsibility for the cleanup and its costs. Exxon activated its emergency center in Houston, Texas, which sent equipment to stabilize the ship. The company directed another ship, the *Exxon Baton Rouge*, to remove the remaining oil from the stricken *Exxon Valdez*. In taking responsibility for the cleanup operations, Exxon set out to address the problems mentioned earlier. The company opened a communications network that allowed information about the spill and the cleanup efforts to be shared with state and federal government officials, private company representatives, and others who were interested in the events surrounding the spill. The company, in cooperation with the Coast Guard, installed four weather stations around Prince William Sound to provide weather forecasts that were critical to planning cleanup efforts. A refueling station for helicopters was set up in Seward, Alaska. More than 274 tons of additional equipment, including *skimmers*, booms, and *dispersants*, arrived at the site by the fourth day.

Maxi-barge hoses down the shoreline.

Wildlife can become heavily oiled.

Hundreds of people were brought to the area to help conduct the cleanup effort within two days of the spill. More than 1,000 Coast Guard personnel, along with employees of the National Oceanic and Atmospheric Administration, the U.S. Fish and Wildlife Service, and EPA helped with the response. Nine additional Coast Guard cutters and eight aircraft were brought to the scene. Specialists from the Hubbs Marine Institute of San Diego, California, set up a facility to clean oil from otters, and the International Bird Research Center of Berkeley, California, established a center to clean and rehabilitate oiled waterfowl.

Three methods were attempted in the effort to clean up the spill: in-situ burning, chemical dispersants, and mechanical cleanup.

A trial burn was conducted during the early stages of the *Exxon Valdez* spill. A fire-resistant boom was placed on tow lines, and the two ends of the boom were each attached to a ship. The two ships, with the boom between them, moved slowly through the main portion of the slick until the boom was full of oil. The ships then towed the boom away from the slick, and the oil was ignited. The fire did not endanger the main slick or the *Exxon Valdez* because of the distance separating them. Because of unfavorable weather conditions, however, no additional burning was attempted in this cleanup effort.

Soon after the spill, dispersants were sprayed from helicopters. Mechanical cleanup was started using booms and skimmers. The use of dispersants proved to be controversial. Alyeska had less than 4,000 gallons of dispersant available at its terminal in Valdez and no application equipment or aircraft. A private company applied dispersants on March 24 with a helicopter and dispersant bucket. Because there was not enough wave action to mix the dispersant with the oil in the water, the Coast Guard representative at the site concluded that the dispersants were not working.

Skimmers, devices that remove oil from the water's surface, were not readily available during the first 24 hours following the spill. Thick oil and heavy kelp tended to clog the equipment. Repairs to damaged skimmers were time-consuming. Transferring oil from temporary oil storage vessels into more permanent containers was also difficult because of the oil's weight and thickness. Continued bad weather slowed down the recovery efforts.

Efforts to save delicate areas began early in the cleanup. Sensitive environments were identified, defined according to degree of damage, and then ranked for their priority for cleanup. Seal pupping locations and fish hatcheries were given highest priority; special cleaning techniques were approved for these areas. Despite the identification of sensitive areas and the rapid start-up of shoreline cleaning, wildlife rescue was slow. Adequate resources for this task did not reach the accident scene quickly enough. Through direct contact with oil or because of a loss of their food resources, many birds and mammals died.

On June 12, 1992, more than three years after the spill, the Coast Guard announced that the cleanup activities should end. Although the cleanup activities ceased, there were still pools of oil left in some areas. The harm caused to the ecosystem by the oil left in these areas was considered too small to justify the cost of further cleanup.

During the years after the *Exxon Valdez* oil spill, cleanup and environmental restoration of the affected shorelines and islands continues. The cost of the cleanup has amounted to billions of dollars, and the cost of legal settlements has resulted in millions more.

The *Exxon Valdez* incident and the environmental impact caused by the spill attracted the attention of political, scientific, and environmental groups from around the world. The scientific groups include those from Exxon

Workers use pressure hoses to clean the shoreline.

Corporation and EPA that were involved in efforts to use experimental technologies, such as bioremediation, to clean up the spill. The National Oceanic and Atmospheric Administration provided weather forecasts for Prince William Sound. This allowed the cleanup team to know what type of cleanup technology would be compatible with the changing weather conditions in the sound. Some of the groups formed a trustee council. This council is made up of representatives from numerous federal and Alaskan state agencies that deal with environmental issues. This trustee council has been successful in promoting more scientific research on the *Exxon Valdez* incident.

The *Exxon Valdez* incident also prompted the U.S. Congress to pass the *Oil Pollution Act of 1990*. This law required EPA and the Coast Guard to strengthen regulations on oil tank vessels and oil tank owners and operators. As of July 17, 1992, all tank vessels of 20,000 tons or greater are required to carry special equipment that will enable the vessel captain and the vessel traffic center in Valdez to communicate better for safer sailing through that area.

Projects to restore affected areas to their original conditions have been ongoing. A legal settlement has helped to fund restoration efforts. On September 30, 1991, Exxon agreed to pay $900 million to the U.S. and Alaska governments in 10 annual payments. The agreement requires that the funds be used first to reimburse the federal and state governments for the costs of cleanup, damage assessment, and litigation. The remaining funds are to be used for restoration. The settlement also has a provision allowing the governments to claim up to an additional $100 million to restore resources that suffered a substantial loss.

The *Exxon Valdez* oil spill caused injury to the environment at virtually all levels. However, the extent and degree of injury was uneven across the oiled landscape. Some species were only slightly affected, for example, the brown bear and Sitka blacktail deer. Other species, like the common murre and the sea otter, suffered population-level injuries, with possible long-term consequences.

The complex issue of determining injury from the *Exxon Valdez* spill is highly controversial and is still being argued in the courts, at scientific meetings, and in scholarly and professional journals. Both the oil that reached the shore and the efforts to clean it up severely impacted intertidal habitats and biota. Seabirds and marine mammals, which are especially vulnerable to floating oil, suffered heavy mortalities. Some of the studies done to determine the damage estimated that between 100,000 and 300,000 birds were killed. Studies also reported that populations of some common murre colonies in the affected area were reduced by one-half. One study estimated a loss of 2,650 sea otters in Prince William Sound. The spill severely impaired south-central Alaska's fisheries, which are the foundation for most of the region's small communities. The spill also had severe social and psychological consequences for the area's human population.

The *Exxon Valdez* Oil Spill Trustee Council concluded that natural resource injuries from exposure to the spill or from the cleanup included the following:

- *Mortality*: Death caused immediately or after a period of time by contact with oil, cleanup activities, reductions in critical food sources caused by the spill, or other causes
- *Sub-lethal effects*: Injuries that affect the health and physical condition of organisms (including eggs and larvae), but do not result in the death of juvenile or adult organisms
- Degradation of habitat: Alteration or contamination of flora, fauna, and the physical components of the habitat

The Trustee Council also acknowledged that some environmental damage might persist for generations. Other resources that the Trustee Council listed as injured included archeological sites that may have been oiled or affected by cleanup activities on sensitive sites. Areas designated by the state or federal governments as Wilderness Areas were considered to be injured because the spill damaged the public's perception that these areas were pristine. The Trustee Council also found that services (human uses) were injured by the spill.

Services were considered reduced or lost if the spill caused any of the following:

- Reduced the physical or biological functions performed by natural resources that support services
- Reduced aesthetic and intrinsic values, or other indirect uses provided by natural resources
- Reduced the desire of people to use a natural resource or area

Each year after the incident, the *Exxon Valdez* Oil Spill Trustee Council has funded research and monitoring projects. Information from these projects helps to define the status and condition of resources and services—whether they are recovering, whether restoration activities are successful, and what factors may be constraining recovery. Recovery monitoring projects have tracked the rate and degree of recovery of resources and services injured by the spill. They may also determine when recovery has occurred or detect reversals or problems with recovery. Research projects have provided information needed to restore an injured resource or service or information about *ecosystem* relationships. Results of restoration monitoring studies suggest that affected ecosystems and populations may regain normal species composition, diversity, and functional organization through natural processes.

Exxon's annual payments to the restoration fund end in September 2001. To ensure funding for continued restoration activities, the Trustee Council places a portion of the annual payments into a restoration reserve fund.

ASHLAND OIL SPILL

Photo courtesy of US EPA Region III

The Ashland storage tank split when filled to capacity.

ON THE AFTERNOON of January 2, 1988, a four million-gallon oil storage tank owned by Ashland Oil Company, Inc., split apart and collapsed at an oil storage facility located in Floreffe, Pennsylvania, near the Monongahela River. The tank split while being filled to capacity for the first time after it had been dismantled and moved from an Ohio location and reassembled at the Floreffe facility. The split released diesel oil over the tank's containment dikes, across a parking lot on an adjacent property, and into an uncapped storm drain that emptied directly into the river. Within minutes, the oil slick moved several miles down river, washing over two dam locks and dispersing throughout the width and depth of the river. The oil was carried by the Monongahela River into the Ohio River, temporarily contaminating drinking water sources for an estimated one million people in Pennsylvania, West Virginia, and Ohio. The Ashland oil spill is the largest inland oil spill in U.S. history. Although it was less than half the size of the *Exxon Valdez* spill, the Ashland spill highlights the direct impact inland spills can have on large populations—in this case, one million people were affected.

The fuel contaminated river ecosystems, killing thousands of animals, such as waterfowl and fish. Two oil impact studies designed by aquatic toxicologists from the Pennsylvania Department of Natural Resources took mussel samples and a census before and after the spill. Pennsylvania and West Virginia authorities conducted shoreline counts to determine the number of fish killed. In the week following the spill, several counts of dead and stressed fish were taken in dam pools along the river. Fish collection surveys conducted by a local contractor in conjunction with state agencies yielded further information regarding ecological effects. Several groups, including the Pennsylvania Game Commission, the Audubon Society, and dozens of volunteers, were involved in capturing oiled waterfowl. This effort had only limited success due to weather conditions; ice and very low temperatures kept rescue workers on shore, hampering the recovery effort. Although many birds were saved, waterfowl mortality estimates ranged from 2,000 to 4,000 ducks, loons, cormorants, and Canada geese, among others.

After local authorities executed the initial on-scene response during the night, EPA took control of cleanup operations. Response personnel from EPA were dispatched to the site immediately following the incident, and an EPA OSC assumed the lead role in the spill response. The OSC was responsible for delegating tasks and responsibilities to the agency best qualified to perform them.

The Incident-Specific Regional Response Team (RRT) was formally activated two days after the incident. The RRT consisted of many environment- and health-related agencies from the federal level, as well as from the states of Pennsylvania, Ohio, and West Virginia. These agencies worked cooperatively to provide advice and guidance to the OSC regarding environmental and response matters as well as political and legal issues.

Contractors employed by Ashland performed the actual cleanup duties. The contractors used booms, vacuum trucks, and other equipment to retrieve the spilled oil, recovering about 20 percent of the oil that flowed into the river.

EPA, in cooperation with other agencies, monitored the cleanup process and river conditions. State personnel set up a river monitoring system to track the spill, as well as a sampling and analysis process to protect water supplies. EPA also performed follow-up activities, such as compliance inspections and a spill prevention control and countermeasures (SPCC) plan inspection of the facility.

Several important lessons were learned from this spill response. The quick notification by Ashland to the local response authorities and the *National Response Center* (NRC) was fundamental to the establishment of the command post on the evening of the spill.

Photo courtesy of US EPA Region III

The Monongahela and Ohio Rivers converge.

Although there was prompt notification, responders concluded that establishment of a central command post sooner would have improved the response coordination. However, communication was enhanced by the positive presence of the media throughout the incident. This was instrumental in keeping the public informed of the cleanup operations. Evaluators of the response recommended that inventories of locally available equipment be prepared so that emergency responders might locate needed equipment quickly. It was also recommended that, to protect public water sources in future emergencies, water suppliers should plan for the availability of contingency water supplies and equipment.

COLONIAL PIPELINE SPILL

ON MARCH 28, 1993, a rupture occurred in an oil pipeline in Fairfax County, Virginia, sending a 100-foot plume of fuel oil into the air. The high-pressure pipeline, owned by the Colonial Pipeline Company, released an estimated 477,436 gallons of No. 2 heating oil into the environment before it could be shut down and fully drained. One of the largest inland oil spills in recent history, the oil affected nine miles of the nearby Sugarland Run Creek as well as the Potomac River.

The Fairfax County Fire Department conducted the initial response to the release, quickly notifying the NRC. The federal response was initiated by the OSC from EPA. Because many organizations were involved in the response, a unified command was established to coordinate the efforts of federal, state, and local authorities, as well as Colonial Pipeline representatives.

The OSC received support in the form of personnel and equipment from other federal agencies, primarily the Coast Guard Atlantic Strike Team. State officials provided technical support and information. The RRT, a group of representatives from a variety of federal agencies, provided valuable advice and guidance regarding recovery actions and policy questions which arose during the incident.

Colonial Pipeline carried out its duties as the responsible party, hiring contractors to perform containment and recovery actions. Under the direction of the OSC, contractors secured the source of the release by shutting down the pipeline. They then attempted to contain the oil flow along the creek through the use of booms, but a sheen had already developed on the Potomac River. As a precaution to protect public health, water intakes along the Potomac River were closed. Recovery of the oil involved use of skimmers, vacuum trucks, sorbents, and a temporary pipeline to direct recovered oil into tanker trucks. Through these actions, response personnel recovered 372,498 gallons of spilled oil.

Throughout the incident, authorities evaluated the oil's actual and potential impact on human health and the environment. The public water intakes along the rivers presented the greatest concern and were promptly shut down. Local drinking water wells were also feared to be contaminated, but sampling proved that they were not affected. The greatest problem for area residents turned out to be fuel odor. EPA received many complaints from citizens about strong odors. These concerns led the National Park Service to the close nearby Great Falls National Park. Forty-one residents were evacuated from their homes as a precautionary measure. EPA monitored air quality to identify and mitigate health risks associated with the oil fumes.

The U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration, and natural resource trustee agencies provided reports on the effects of the spill on fish, wildlife, and other environmental resources; shoreline evaluations; and rehabilitation of affected wildlife. County animal control set up shelters and recovery activities to restore any affected animals. Fish kills did occur in Sugarland Run, although no other serious impacts on area wildlife were reported.

Establishing a unified command was a key to the successful and timely response at the spill. It made the following critical contributions:

- Early and continued support of the Coast Guard Marine Safety Office and National Strike Force
- Coordination with the RRT, leading to rapid assembly of a large support team to assist the OSC
- Provision of a means of input from all levels of government in spill response
- Allowed EPA enforcement of efforts by the responsible party, along with elimination of duplicate efforts in assessment of the affected areas

The response to the Colonial Pipeline spill demonstrates the smooth operation of the National Response System. Federal, state, and local authorities were able to coordinate personnel and equipment in an efficient manner to recover the spilled oil.

Participants identified several areas for improvement. One suggestion was to develop a directory of water intakes in the area in order to better ensure that drinking water sources are not contaminated in the event of an oil release. A second recommendation addressed the need for better communication with personnel downstream from a release. Other technical issues concerned improvements in skimming and dam systems to increase the speed and ease of recovery.

WISCONSIN FIRE AND BUTTER SPILL

NOT ALL OIL spills involve petroleum oil. Animal fats and vegetable oils can also cause great harm to the environment when spilled. The butter spill described below demonstrates that oil spills can come from many different sources and that fires and other accidents can lead to spills.

A fire broke out at the Central Storage and Warehouse Company facility in Madison County, Wisconsin, around 3:30 p.m., May 3, 1991. The facility provided refrigerated storage space for the perishable goods of several food companies. Seventy firefighters responded to the four-alarm blaze, which burned for nearly three days and became the most costly fire in Madison County history. The fire was believed to have been started by the explosion of a forklift battery. Approximately 3,000 nearby residents were evacuated due to the threat of toxic fumes that might have escaped from tanks of anhydrous ammonia and sulfuric acid if the fire had reached them.

The fire destroyed roughly 50 million pounds of food, including nearly 16 million pounds butter. When the fire reached the butter and animal tallow in the warehouse storage facility, it became a hard-to-control grease fire. Melted butter spilled into roadways and ditches, increasing difficulty in fighting the fire and threatening the environment.

Six truckloads of sand were applied to the butter spill in an attempt to absorb it and prevent it from reaching Starkweather Creek. Engineers from the Wisconsin Department of Natural Resources dug a channel from the warehouse to a low-lying area beneath a highway overpass and built hundreds of feet of redirecting dikes to allowed the melted butter to flow into the depression and other lagoons. Water that collected in these areas along with the butter was pumped to the city's sewer treatment plant, while congealed material was skimmed from the surface.

Instead of incurring additional costs for disposal, a contractor was hired to attempt to salvage the butter and lard for use in animal feed. Collected material was dumped in a railcar fitted with steam tubes, melted, filtered, processed, and sold.

Very few contaminants were reported to have reached the creek. The area residences are connected to the municipal system's wells, which are deep and securely encased, so the spill did not present a threat to drinking water.

Quick and persistent response action performed by the local fire authorities and the Wisconsin Department of Natural Resources prevented severe environmental damage. It was hypothesized that, had the butter been able to reach the creek, the resulting loss of oxygen in the water would have affected the resident fish species and reversed the effects of a recent $1 million cleanup effort in the area's watershed.

Photo courtesy of WI DNR

Workers contain spilled butter with booms.

Photo courtesy of WI DNR

Warehouse scene two hours after start of fire.

LAKE LANIER SOYBEAN OIL SPILL

ON SEPTEMBER 26, 1994, north of Atlanta, Georgia, a tanker truck wrecked, releasing approximately 5,000 gallons of low-grade soybean oil. The oil entered a small stream, which allowed it to flow into a man-made impoundment on the Chattahoochee River called Lake Lanier.

Within two hours of the spill, the U.S. Army Corps of Engineers had contained the oil within a one-acre area by deploying a boom across a cove. The federal OSC began removal activities because the responsible party had failed to initiate a response. The oil was corralled to a collection point by boats towing a sorbent boom. Skimmers and vacuum trucks then extracted the oil from the surface of the water. The remaining oil was recovered using sorbent pads and sweeps, bringing the total response time to six days at a cost of nearly $43,000.

No environmental damage was recorded during response activities. Fish may have been forced to swim from the localized spill area, but no other effects on wildlife were apparent. Effects on the water body itself are unknown because no measurements of water quality criteria were made during the cleanup. The OSC decided not to use dispersants because they might have caused the oil to biodegrade very quickly, severely reducing dissolved oxygen levels in the water and damaging the local ecosystem. The primary effects of the spill were realized by property owners who dealt with unpleasant odors and oil coated boats and docks. Several thousand dollars worth of claims for cleaning were incurred; however, the damage would have been much more costly if reaction to the spill had not been as timely.

SUMMARY

OIL SPILLS, especially the *Exxon Valdez* spill, have increased public awareness about the risks involved in the storage and transport of oil. The location of a spill and a lack of necessary equipment often add to response problems. Prevention of spills is the first line of defense, and the oil industry, together with federal agencies, has taken steps to reduce the risks of oil spills. Once a spill occurs, however, improved response coordination between federal, state, and local authorities should produce more rapid and effective cleanup actions and decrease the environmental impact of the discharge. A program to provide better training of emergency response personnel is being prepared, and safety issues are being addressed. Cleaning techniques that are more effective and less labor-intensive are being developed. Studies of the long-term environmental effects of oil spills and their influence on food chains in oceans, freshwater, and on land are now underway. The costs of cleanup activities, ecosystem restoration, and legal settlements of oil spills are so high that the best strategy is to work to prevent discharges.

Glossary

Accelerant: A chemical used to intentionally speed up a fire; gasoline can be used as an accelerant to speed up oil fires.

Aquatic: Habitats and ecosystems that exist in bodies of water; refers to both *marine* and freshwater environments.

Asphalt: A brown to black residue formed from weathered petroleum products, consisting chiefly of a mixture of *hydrocarbons*; varies in texture from hard and brittle to plastic.

Bioaugmentation: The addition of *microorganisms* to the existing native oil-degrading population; also known as microbial *seeding*.

Biodegradation: The breaking down of substances by *microorganisms*, which use the substances for food and generally release harmless byproducts such as carbon dioxide and water.

Biological community: All of the living things in a given environment.

Bioremediation: The act of adding nutrients or *microorganisms* to the environment to increase the rate at which *biodegradation* occurs.

Biostimulation: Also known as nutrient enrichment, the method of adding nutrients such as phosphorus and nitrogen to a contaminated environment to stimulate the growth of the *microorganisms* capable of *biodegradation*.

Boom: A temporary floating barrier used to contain an oil spill.

Cetaceans: A group of related marine mammal species that includes whales, dolphins, and porpoises.

Contingency plan: A document that describes a set of procedures and guidelines for containing and cleaning up oil spills.

Deployment: Strategic placement of equipment and personnel.

Dispersants: Chemicals that are used to break down spilled oil into small droplets (See *surfactant*).

Dispersion: The spreading of oil on the water's surface and, to a lesser degree, into the *water column*.

Ecosystem: The interrelationships between all of the living things in an area.

Emulsification: The formation of a mixture of two liquids, such as oil and water, in which one of the liquids is in the form of fine droplets and is dispersed in the other.

Emulsions: A mixture of small droplets of oil and water.

Evaporation: The physical change by which any substance is converted from a liquid to a vapor or gas.

Facility Response Plan: A detailed plan which must be prepared in accordance with the Oil Pollution Prevention regulation (40 CFR 112.20) by facilities which may cause "substantial harm" to the environment or exclusive economic zone. The plan must contain an Emergency Response Action Plan (ERAP) and demonstrate that a facility has the resources to respond to a worst case scenario oil spill.

Fate: The outcome; the fate of an oil spill is what happens to the oil.

Fertilization: The method of adding nutrients, such as phosphorus and nitrogen, to a contaminated environment to stimulate the growth of *microorganisms* capable of *biodegradation*; also known as nutrient enrichment or *biostimulation*.

Freshwater spill: An oil spill that occurs in or affects bodies of freshwater, such as lakes and rivers.

Hydrocarbons: A large class of organic compounds containing only carbon and hydrogen; common in petroleum products and other oils.

Hydrophobic: Having a tendency to repel water; hydrophobic materials will not easily absorb water.

Incineration: The destruction of wastes by burning at high temperatures.

Marine: Relating to the seas and oceans.

Microorganism: A very small plant, animal, or bacteria; some microorganisms, like larger organisms can be hurt by oil spills; however, some microorganisms actually break oil down into less harmful substances.

Mortality: The proportion of deaths to population or to a specific number of the population.

Mousse: A thick, foamy oil-and-water mixture formed when petroleum products are subjected to mixing with water by the action of waves and wind.

National Response Center: An organization, staffed by officers and marine science technicians from the U.S. Coast Guard, that serves as the national communications center responsible for notifying *On-Scene Coordinators*.

National Response System: A network of individuals and teams from local, state, and federal agencies who combine their expertise and resources to ensure that oil spill control and cleanup activities are timely and efficient and minimize threats to human health and the environment.

National Response Team (NRT): An organization composed of 16 federal agencies, each of which has responsibilities and expertise in responding to oil spill and hazardous materials emergencies.

National Contingency Plan (NCP): A plan designed to ensure that resources and expertise of the federal government will be available in the event of a very serious oil spill. The full name of the NCP is the National Oil and Hazardous Substances Contingency Plan.

Non-petroleum oils: Oils that are not derived from petroleum; this group of oils includes vegetable oils and animal fats.

Oil: Crude oil and refined petroleum products (motor oils, fuels, lubricants, etc.), as well as vegetable oils, animal fats, and other *non-petroleum oils*.

Oil slick: A layer of oil floating on the surface of water.

Oleophilic: Having a strong affinity for oils; oleophilic materials absorb or stick to oils.

On-Scene Coordinator (OSC): The person responsible for overseeing the cleanup efforts at a spill; the OSC represents either the U.S. Environmental Protection Agency or the U.S. Coast Guard.

Oxidation: A chemical reaction that occurs when a substance is combined with oxygen; oxidation may lead to degradation or deterioration of the substance.

Polyaromatic hydrocarbons (PAHs): A family of chemical substances that are found in many types of oil; polyaromatic hydrocarbon vapors can cause harm to humans and animals that inhale them.

Pinnipeds: A group of related species of *marine* mammals that have flippers for all four limbs; pinnipeds include sea lions, seals, and walrus.

Regional Response Teams (RRTs): Thirteen teams (each representing a particular geographic region) that provide assistance to *OSCs*; RRTs are composed of representatives from field offices of the federal agencies that make up the *National Response Team*, as well as state representatives.

Seeding: Adding *microorganisms* to the environment to speed up *biodegradation* (also known as *bioaugmentation*).

Skimmers: Devices used to remove oil from the water's surface.

Slick: A thin film of oil on the water's surface.

Sorbents: Substances that take up and hold water or oil; sorbents used in oil spill cleanup are made of *oleophilic* materials.

Specific gravity: The ratio of the density of a substance to the density of water; substances with a specific gravity greater than one are denser than water and sink; substances that have a specific gravity less than one are less dense than water and float.

Sub-lethal effects: Injuries that affect the health and physical condition of organisms (including eggs and larvae) but do not result in the death of juvenile or adult organisms.

Surface tension: The attractive force exerted upon the surface molecules of a liquid by the molecules beneath the surface. When oil is spilled on water, this tension makes the oil behave as a continuous thin sheet that is difficult to separate or break up.

Surfactant: A substance that breaks oil into small droplets; this helps to increase the surface area of the oil spill, which increases the rate at which the oil can be degraded or weathered into less toxic substances (See *dispersant*).

Tar balls: Dense, black sticky spheres of *hydrocarbons*; formed from weathered oil.

Viscosity: Having a resistance to flow; substances that are extremely *viscous* do not flow easily.

Viscous: The tendency of a liquid to hold itself together; viscous liquids do pour freely and having the consistency of syrup or honey.

Volatile organic compounds (VOCs): A family of chemical compounds found in oils; VOCs evaporate quickly and can cause nerve damage and behavioral abnormalities in mammals when inhaled.

Water column: An imaginary cylinder of water from the surface to the bottom of a water body; water conditions, temperature, and density vary throughout the water column.

Weathering: Action of the wind, waves, and water on a substance, such as oil, that leads to disintegration or deterioration of the substance.

Weir: An underwater structure that controls the flow of water; weir-type oil *skimmers* use a dam-like underwater barrier that lets oil flow into the skimmer while holding back the water.

For Further Information

PUBLICATIONS

Exxon Valdez Oil Spill Trustee Council. *Legacy of an Oil Spill, 10 Years After Exxon Valdez*. March 1999.

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U.S. Environmental Protection Agency. *EPA Oil Spill Program Update*, vol. 2, no. 2, January 1999, and vol. 1, no. 4, July 1998. Special issue on vegetable oils and animal fats. The *Oil Spill Program Update* is available on line at *www.epa.gov/oilspill*

U.S. Environmental Protection Agency. *Evaluation of the Response to the Major Oil Spill at the Ashland Terminal, Floreffe, Pennsylvania, by the Incident-specific Regional Response Team*. U.S. Environmental Protection Agency, Region III, Philadelphia, Pennsylvania.

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WEB SITES

U.S. EPA Oil Program: *http://www.epa.gov/oilspill*

U.S. EPA Publications:
http://www.epa.gov/epahome/publications.htm

National Response Team: *http://www.nrt.org*

Exxon Valdez Oil Spill Trustee Council:
http://www.oilspill.state.ak.us/

National Response Center: *http://www.nrc.uscg.mil*

Oil Wildlife Care Network:
http://www.vetmed.ucdavis.edu/owcn/

Tri-State Bird Rescue and Research, Inc.:
http://www.tristatebird.org/

FEDERAL AGENCIES

U.S. Environmental Protection Agency
Oil Program Center
401 M Street, SW
Mail Code 5203G
Washington, DC 20460
http://www.epa.gov/oilspill

U.S. Coast Guard
2100 2nd Street, SW
Washington, DC 20593
http://www.uscg.mil

Department of the Interior
U.S. Fish and Wildlife Service
1849 C Street, NW
Washington, DC 20240
http://www.fws.gov

National Oceanic and Atmospheric Administration
Office of Response and Restoration
1305 East-West Highway
Silver Spring, MD 20910
http://response.restoration.noaa.gov/index.html

BIRD REHABILITATION

International Bird Rescue Research Center
699 Potter Street
Aquatic Park
Berkeley, CA 94710

Tri-State Bird Rescue and Research, Inc.
110 Possum Hollow Road
Newark, DE 19711

University of California, Davis
Oiled Wildlife Care Network
Wildlife Health Center
School of Veterinary Medicine
University of California, Davis
Davis, CA 95616

MAMMAL REHABILITATION

Center of Marine Conservation
312 Sutter Street, Suite 316
San Francisco, CA 94108

Defenders of Wildlife
1244 19th Street, NW
Washington, DC 20036

Friends of the Sea Otter
P.O. Box 221220
Carmel, CA 93922

Monterey Bay Aquarium
886 Cannery Row
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National Wildlife Federation
1412 16th Street, NW
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To Report Chemical And Oil Spills:

Call The National Response Center at 1-800-424-8802