NOAA/HMRAD OIL SPILL CASE HISTORY

Name	Exxon Valdez					Spill Date	03/24/89
Location	Bligh Reef, Prince William Sound, Alaska						
Latitude	61 02 N	Longitude	146 05 W				
Oil Product	Prudhoe Bay Crude						
Oil Type	Type 3	Barrels	240500			Source	Tank Vessel
Dispersants	Yes	Bioremediation	Yes	In-situ Burning	Yes	Last Edit	9/21/92

Incident Summary

On March 24, 1989, the tanker Exxon Valdez, en route from Valdez, Alaska to Los Angeles, California, ran aground on Bligh Reef in Prince William Sound, Alaska. The vessel was traveling outside normal shipping lanes in an attempt to avoid ice. Within six hours of the grounding, the Exxon Valdez spilled approximately 10.9 million gallons of its 53 million gallon cargo of Prudhoe Bay Crude. Eight of the eleven tanks on board were damaged. The oil would eventually impact over 1,100 miles of non-continuous coastline in Alaska, making the Exxon Valdez the largest oil spill to date in U.S. waters.

The response to the Exxon Valdez involved more personnel and equipment over a longer period of time than did any other spill in U.S. history. Logistical problems in providing fuel, meals, berthing, response equipment, waste management and other resources were one of the largest challenges to response management. At the height of the response, more than 11,000 personnel, 1,400 vessels and 85 aircraft were involved in the cleanup.

Shoreline cleanup began in April of 1989 and continued until September of 1989 for the first year of the response. The response effort continued in 1990 and 1991 with cleanup in the summer months, and limited shoreline monitoring in the winter months. Fate and effects monitoring by state and Federal agencies are ongoing.

Behavior of Oil

Prudhoe Bay crude oil has an API gravity of 27.0, and a pour point of 0 degrees C. The bulk of the oil spilled from the Exxon Valdez was released within 6 hours of the ship's grounding. The general trend of the oil was south and west from the point of origin. For the first few days after the spill, most of the oil was in a large concentrated patch near Bligh Island. On March 26, a storm, which generated winds of over 70 mph in Prince William Sound, weathered much of the oil, changing it into mousse and tarballs, and distributed it over a large area. By March 30, the oil extended 90 miles from the spill site. Ultimately, oil would extend more than 500 miles from Bligh reef, oiling shorelines in Prince William Sound, the Kenai peninsula, the Alaskan peninsula and Kodiak island. Oil impacts in the Prince William Sound region were the most severe.

In addition to the storm of March 26, the spill occurred at a time of year when the spring tidal fluctuations were nearly 18 feet. This tended to deposit the oil onto shorelines above the normal zone of wave action.

The diversity in shoreline types in the affected areas led to varied oiling conditions. In some cases, oil was present on sheer rock faces making access and cleanup difficult, or rocky beaches with grain size anywhere from coarse sand to boulders, where the oil could percolate to a sub-surface level. The spill affected both sheltered and exposed (to high wave/weather action) shorelines. Once oil landed on a shoreline it could be floated off at the next high tide, carried to and deposited in a different location, making the tracking of oil migration and shoreline impact very difficult. This migration ended by mid-summer 1989, and the remaining cleanup dealt with oiled shorelines, rather than oil in the water.

Cleanup operations continued during the summer months of 1990 and 1991. By 1990, surface oil, where it existed, had become significantly weathered. Sub-surface oil, on the other hand, was in many cases much less weathered and still in a liquid state. The liquid sub-surface oil could give off a sheen when disturbed. Cleanup in 1991 concentrated on the remaining reduced quantities of surface and sub-surface oil.

Countermeasures and Mitigation

The Alyeska Pipeline Service Company was immediately notified of the incident and sent a tug to the site to assist in stabilizing the vessel. At the time of the incident, the Alyeska spill response barge was out of service being re-outfitted. It arrived on scene by 1500 on 24 March. Alyeska was overwhelmed by the magnitude of the incident; by March 25, Exxon had assumed full responsibility for the spill and cleanup effort.

Deployment of boom around the vessel was complete within 35 hours of the grounding. Exxon conducted successful dispersant test applications on March 25 and 26 and was granted permission on March 26 to apply dispersants to the oil slick. Due to the large storm that began the evening of March 26, much of the oil turned into mousse. As dispersants aren't generally able to dissipate oil in the form of mousse, it was no longer practical to use dispersants on floating oil during this response.

On the evening of March 25, a test in-situ burn of oil on water was conducted. Approximately 15,000 to 30,000 gallons of oil were collected using 3M Fire Boom towed behind two fishing vessels in a U-shaped configuration, and ignited. The oil burned for a total of 75 minutes and was reduced to approximately 300 gallons of residue that could be collected easily. It was estimated that the efficiency of this test burn was 98 per cent or better. Again, continued in-situ burning was not possible because of the change in the oil's state after the storm of March 26.

Five dispersant trials took place between March 25 and March 28. Corexit 9527 was used for the trials. Four of the tests used C-130 aircraft with ADDS packs, and one test was applied from a DC-6 aircraft. By March 29 the Regional Response Team (RRT) decided that dispersants were no longer feasible.

Because there was not enough equipment to protect all the shorelines that could be impacted, Federal, state and local agencies collaborated to establish shoreline protection priorities. The agencies decided that fish hatcheries and salmon streams had the highest priority; accordingly, containment booms were deployed to protect these areas. Five fish hatcheries in Prince William Sound and two in the Gulf of Alaska were boomed, with the largest amount of boom deployed at the Sawmill Bay hatchery in Prince William Sound. On April 15, the Sawmill Bay hatchery was boomed with 30,500 feet of sorbent boom and 28,600 feet of containment boom in multiple layers. As many as 15 to 20 boats were used daily for tending the boom and oil recovery by towing sorbent boom. Overall, the deflection of oil from the hatcheries was very successful.

At the height of containment efforts, it is estimated that a total of 100 miles of boom was deployed. Almost all the types of boom available on the market were used and tested during the spill response.

Due to the size of the spill, it was necessary to employ inexperienced workers to deploy and tend booms, and this led to some boom being incorrectly used or handled, and sometimes damaged. Some boom sank because of improper deployment, infrequent tending, or leakage and/or inadequacy in the buoyancy system. Other problems included fabric tears in boom due to debris, and tearing at anchorage points from wave action. In some cases, ballast chains were ripped off during boom recovery if the boom was lifted by the chain. One estimate suggests that 50 per cent of the damage to larger boom came during boom recovery. For self-inflating booms, it was important to keep the inflation valves above the water during deployment so that the boom did not become filled with water and have to be replaced.

Since most of the containment boom was in 50 to 100 feet long sections, several lengths of boom usually needed to be connected for deployment. When several types of boom were used in one operation, there were often problems with incompatible connectors between different types of boom. Bailing wire and other adaptations were used in the field for these situations. A universal type of connector (ASTM connector) came with some booms, but these were difficult to handle and hook up at sea and were hard to open once they had been submerged in cold water. Booms to be re-used were hand cleaned early on in the spill, and as the spill progressed were cleaned in one of the two barges with mechanical washing facilities.

To contain oil on the open water, containment boom was towed between two vessels (usually fishing boats) to surround the oil and then the two ends of the boom were drawn together to close the loop and await collection by a skimmer.

Aerial surveillance was used to direct the deployment of booms and skimmers for open water oil recovery. Visual overflight observations as well as ultraviolet/infrared (UV/IR) surveys were used by the USCG and Exxon to track the floating oil. Satellite imagery was also tested as a method to track oil but was not very useful because of the infrequency of satellite passes over Prince William Sound (every 7 to 8 days), cloud cover, and lengthy turn around time for results.

The primary means of open water oil recovery was with skimmers. In general, most skimmers became less effective once the oil had spread, emulsified and mixed with debris. To save time, it was most practical to keep skimmer offloading equipment and oil storage barges near the skimmers.

Weir skimmers were useful for collecting fresh oil that was present in a thick layer on the water. As the oil became weathered and laden with debris, however, it was the simple weir skimmers that were the first to clog. Some of the larger weir skimmers had auger pumps with cutters for chopping debris and were able to collect oil for a longer time than the simple models.

Oleophilic disc skimmers also worked well while the oil was fairly fresh. Once the oil became viscous and associated with debris, these skimmers were not very effective.

An Egmolap brand paddle belt skimmer (Egmolap II) was used and was effective for heavy mousse and debris.

It collected very little water under light sea conditions. A different paddle belt skimmer that was supplied by the Canadian Coast Guard clogged easily when working with viscous oil.

When using rope mop skimmers, it was important to maintain the smallest angle possible when lifting the skimmer out of the water, so that the oil did not run down the mop and back into the water. In situations where the oil was viscous, it was useful to cut down the diameter of the mop from nine to six inches and inject diesel oil into the ringers as the mop was being rung out.

The most used skimmers during the response were the Marco sorbent lifting-belt skimmers that were supplied by the U. S. Navy. Once oil became viscous, the sorbent part of the skimmer was removed and the conveyor belt alone was sufficient to pull the oil up the ramp. The pump that came with the skimmer had difficulty offloading viscous oil, so that other vacuum equipment was used to unload the collected oil. The Marco skimmers were generally not used close to shore because they drawbetween three and four feet. In general, the paddle belt and rope mop skimmers were the most useful for recovery of oil from the shoreline. The skimmers were placed on self-propelled barges with a shallow draft.

Sorbents were used to recover oil in cases where mechanical means were less practical. The drawback to sorbents was that they were labor intensive and generated additional solid waste. Sorbent boom was used to collect sheen between primary and secondary layers of offshore boom, and to collect sheen released from the beach during tidal flooding. Pompoms were useful for picking up small amounts of weathered oil. Towing of sorbent boom in a zigzag or circular fashion behind a boat was used to collect oil and was more efficient than towing the boom in a straight line. Sorbent booms made of rolled pads were more effective than booms made of individual particles because these absorbed less water and were stronger, and did not break into many small particles if they came apart.

During the Exxon Valdez spill response, a hopper dredge was used to collect oil for the first time in the United States. The oil was gathered using a containment boom, and the draghead of the dredge was placed under the boom below the oil surface. The oil was then sucked up and placed in storage containers on the dredge. The drawbacks to using the dredge were that it recovers large amounts of water with the oil and must be used offshore because of its deep draft.

To transfer the recovered oil, water, and debris mixture from the skimmers to temporary storage containers, vacuum equipment and positive-displacement pumps were used. Vacuum trucks on barges or air-conveyers were most useful when used with an open-ended suction hose with a diameter of 6 to 8 inches.

Early on in the response, storage space for recovered oil was in short supply. To combat the storage space problem, water was decanted from skimmers or tanks into a boomed area before offloading. As a result, the remaining viscous oil mixture was difficult to offload, the process sometimes taking up to 6 to 8 hours. High-capacity skimmer offloading pumps, in particular grain pumps, were the most useful in transferring viscous oil.

Because recovery equipment was in near constant use, several vessels were set up to perform field repairs and conduct preventive maintenance.

The oil remaining on the Exxon Valdez, was completely offloaded by the end of the first week in April 1989. After offloading operations were completed, the tanker was towed to a location 25 miles from Naked Island in Prince William Sound for temporary repairs. Later in the summer of 1989, the vessel was brought to California for further repairs.

Shoreline assessment was a prerequisite for the implementation of any beach cleanup. Assessment provided geomorphological, biological, archaeological and oiling information that was used for the development of site specific treatment strategies. Cleanup operations were scheduled around specific activities such as seal haulout activity, seal pupping, eagle nesting, fish spawning, fishing seasons, and other significant events as much as possible.

In 1989, hoses spraying seawater were used to flush oil from shorelines. The released oil was then trapped with offshore boom, and removed using skimmers, vacuum trucks (useful for thick layers of oil) and boom (sorbent, snare, pompoms). For hard to reach areas, or locations with weathered oil, heated seawater was used to flush oil from the shoreline.

Converted vessels and barges were used for beach washing operations. It would take several days to outfit a conventional barge with the equipment needed to heat and pump the water. Smaller vessels that were used for beach washing early in the spill were re-outfitted for bioremediation later in the response.

Along with the large scale beach washing, manual cleanup, raking and tilling the beaches, oily debris pickup, enhanced bioremediation and spot washing were used to cleanup the oil. In some locations, oil was thick enough to be picked up with shovels and buckets. In addition, mechanical methods were used on a few sites, including the use of bulldozers to relocate or remove the contaminated beach surfaces. Mechanical rock washing machines, which were manufactured for the spill, were not used to clean contaminated rocks and return them to the beach.

Oiled storm berm was mechanically relocated in some cases so that these areas, which normally would not receive much wave action, would be more exposed and cleaned by natural processes. If the oiling in the berm was significant or persistent it was tilled to free the oil or washed to optimize the cleaning. Recommendations were made to restrict the movement of berm to the upper third of the beach to ensure its return to the original location.

Beach applications of dispersants were tried in several locations. Corexit 7664 was applied on Ingot Island, followed by a warm water wash. No significant change in oil cover or the physical state of the oil was observed as a result of the treatment. Some ecological impacts were observed in the treated areas. It appeared that the effects were largely due to the intensive washing more that the use of Corexit 7664, and were evident in intertidal epibenthic macrobiota.

In addition, the dispersant BP1100X was applied to a test area on Knight Island. Toxicology studies indicated that the upper and lower intertidal biota were different from pre-application communities the day after dispersant application, and returned to pre-treatment levels after seven days.

Exxon also tested the dispersant Corexit 9580 in Prince William Sound. The decision to approve a large scale test of Corexit 9580 in August was reached after an extensive program aimed at evaluating shoreline cleaning technologies. The monitoring program addressed three major issues: migration of oil and Corexit in shoreline sediments, the migration of sediments and oil in the nearshore environments, and the migration of oil in the water column, each being evaluated in the monitoring program. The dispersant's effectiveness and impact were then compared to mechanical shoreline cleanup methods, and this information was used to determine whether Corexit 9580 should be used for shoreline treatment. The Research and Development Committee evaluating the proposal for dispersant use recommended against broad-scale application of the product because tests had not adequately demonstrated that removal and recovery efficiency outweighed possible adverse effects. The committee recommended using Corexit only on Smith Island, subject to continued review of the effectiveness of recovery procedures by on-scene monitors.

In May of 1989, the Environmental Protection Agency (EPA) and Exxon conducted bioremediation trials at two test sites on Knight Island in Prince William Sound. On the basis of these tests and other trials later in the summer, Exxon recommended the use of the bioremediation enhancement agents, Inipol (Inipol EAP22—manufactured by Elf Aquitaine of France) and Customblen (Customblen 28-8-0 —manufactured by Sierra Chemicals of California), and subsequently treated over 70 miles of shoreline in Prince William Sound with these agents.

Past scientific research had determined that sufficient numbers of hydrocarbon degrading bacteria existed naturally in Alaska. It was decided that the limiting factor in enhancing petroleum hydrocarbon degradation was the availability of nitrogen and phosphorus for the indigenous bacteria. As a result, bioremediation trials focused on agents that were basically "fertilizers", and contained no living microorganisms. Considerations in the selection of bioremediation agents included ease of application, the possibility of causing algal blooms and eutrophication in areas where nitrogen/phosphorus concentrations would remain elevated (such as sheltered bays and estuaries), the flushing of nutrients from the beach soon after application due to tidal action, and the possible toxicity associated with concentrations of nitrogen based compounds (such as ammonia).

Winter monitoring of the effects of bioremediation consisted of surveys of more than 20 beaches in Prince William Sound and the Gulf of Alaska. These studies determined that oil degradation had been enhanced on the shorelines monitored, but some debate existed over whether bioremediation was solely, or even largely, responsible.

Cleanup operations in 1989 ceased by the end of September. All parties involved in the response agreed that continuation of cleanup into the Alaskan winter would jeopardize the safety of cleanup crews. In addition, it was speculated that the winter storms in Alaska could significantly remove oil from shorelines, including sub-surface oil. By the end of the 1989 cleanup, more than 25,000 tons of oiled waste and several hundred thousand barrels of oil/liquid waste were collected and disposed of in landfills.

Cleanup in 1990 began in April and ended in September. Surveys in the spring of 1990 showed that oiling conditions had been reduced or changed over the winter. Surface oil in 1990 was significantly weathered but sub-surface oil was relatively fresh in some locations. Cleanup techniques in 1990 focused more on manual methods of treatment such as hand wiping and spot washing as well as bioremediation. Mechanical equipment was used on a few sites.

Bioremediation was more extensive in 1990, with 378 of the 587 shoreline segments treated that year receiving bioremediation application. In general, Inipol was applied in cases where surface oiling existed and Customblen slow release pellets were preferred for treating beaches with sub-surface oiling. Generally, beaches were given one to three treatments over several months. Concern over the possible toxicity of Inipol led to recommendations for application of only Customblen on some sites.

By the spring of 1991, the scope of the cleanup effort was greatly reduced. Manual cleanup, bioremediation, and very limited use of mechanical equipment were employed. Cleanup took place from May of 1991 through July of 1991.

An important observation that resulted from the Exxon Valdez oil spill was that natural cleaning processes, on both sheltered and exposed beaches, were in many cases very effective at degrading oil. It took longer for some sections of shoreline to recover from some of the invasive cleaning methods (hot water flushing in particular) than from the oiling itself.

Other Special Interest Issues

The Exxon Valdez oil spill aroused more media and public interest (both national and international) than any other spill in U.S. history. Alaska is considered by many to be a pristine environment that includes many species of elsewhere endangered wildlife.

In an effort to absorb and use input from the multitude of groups concerned with the effects of the spill, the Interagency Shoreline Cleanup Committees (ISCC) were formed to monitor beach cleanup progress. The ISCCs focused on identifying strategic resource planning needs and consisted of representatives from Exxon, environmental groups, private landowners, native groups and state and Federal agencies. There were ISCCs formed in Homer, Kodiak, Seward and Valdez.

Concern over oil related wildlife mortality was intense during the spill. The grounding occurred at the beginning of the bird migration season. The U.S. Fish and Wildlife service estimated that mortalities directly related to the spill range from 350,000 to 390,000 birds, especially common and thick-billed murres, assorted sea ducks, bald eagles, and pigeon guillemots, 3,500 to 5,500 sea otters and 200 harbor seals. In addition, killer whales may have been affected by the spill as their numbers in the area declined shortly after the spill. Of the 1,630 birds (over 36,000 dead birds were collected) and 357 Sea Otters that were trapped and treated by the International Bird Rescue Research Center (IBRRC)-run facilities (established in Homer, Kodiak, Seward and Valdez in response to this spill), the total survival rate was 50.7 per cent for birds, and 62 per cent for sea otters. These survival rates are considered very good for oil impacted animals.

Unlike birds, sea otters had to be anesthetized to be washed which increases the risk to the animal, and increases the cost of rehabilitation. The Sea Otter rehabilitation program was complex, with a total of 29 veterinarians, and 9 veterinarian technicians scheduled to provide 24 hour care. The resulting cost of the sea otter rehabilitation program was at least $51,000 per Sea Otter. The highest percentages of sea otter fatalities (60 per cent) were recorded in the first three weeks of the spill.

Due to the magnitude and remote location of the spill it was necessary to bring significant additional resources (equipment and personnel) to Alaska to respond to the spill. Most of the response equipment brought to Alaska early on in the spill had to be delivered by air. Since the Valdez airport could not handle aircraft larger than a DC-6 or a C-130, most large air cargo shipments went to Anchorage and were transferred to smaller planes. In addition, many of the facilities (such as barge hotels for personnel) and equipment (such as hot water beach washing barges) was designed specifically for this spill.

Most of the affected shorelines were inaccessible by land. Most of the cleanup operations were conducted from vessels. Initially, fishing boats and other available craft were used to house personnel. Later, a state ferry, Navy transport ships, camps established on deck barges, and a self-contained semi-submersible derrick barge was used for berthing.

Besides other logistical problems with assembling and organizing a large work force in a short time, the majority of the personnel involved in the cleanup effort had to be trained for their jobs as well as receive formal safety training.

There were commercial fisheries closings as a result of the spill and great concern over the potential negative effect on hatcheries. The Alaska Department of Environmental Conservation (ADEC) canceled the 1989 black cod season in Prince William Sound, banned fishing for Pacific herring and cut short the shrimp season as a result of the spill. It was determined in 1989 that at least 87 per cent of the herring spawning grounds in Prince William Sound were heavily oiled.

In the winter of 1989/1990 and again in 1990/1991 the National Oceanic and Atmospheric Administration (NOAA) conducted monitoring programs to determine the extent of the natural removal of oil over the winter, and identify treatment issues to be addressed in the coming cleanup seasons. These studies determined that removal of surface oil between September 1989 to February 1990, for exposed shorelines, was about 90 per cent; for sheltered shorelines and those with intermittent energy, the removal rates were 70 per cent. For sub-surface oil, the removal rate was approximately 55 per cent, though this varied with the depth of the sub-surface oil impacts.

Concern by Alaskan residents, in particular native villages, over the possible contamination of subsistence foods, led NOAA to conduct research addressing specific issues of subsistence food safety. In general, no quick method existed to quantitatively assess food safety, but the overall guideline was that if the food had no visible oiling or had no oily smell it was probably safe for consumption.

The results of the NOAA study indicated that in general, the aromatic contaminant level in fish, varied little between affected areas and the unaffected reference site (Angoon, in southeast Alaska). The level of aromatic contamination in mollusks was higher than normal (tissue levels exceeded 100 ppb) in the areas of Windy Bay, Kodiak, Chenega Bay, and Old Harbor, with the highest levels occurring in samples taken from Windy Bay and Kodiak. Mollusk samples taken in other areas affected by the oil spill were generally comparable in levels of aromatic contaminants to samples taken from the reference site.

At the time of the Exxon Valdez oil spill, there were no national guidelines established to indicate the levels of aromatic contaminants acceptable in food. Results from the subsistence studies indicated that higher levels of carcinogenic aromatic hydrocarbons were found in smoked fish, than in the unsmoked fish samples obtained after the Exxon Valdez spill.

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Keywords

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