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# 1993 SPILL OFF TAMPA BAY, A CANDIDATE FOR BURNING?

by

Robert P. LaBelle[1], Jerry A. Galt[2],
Edward J. Tennyson[1], Kevin B. McGrattan[3]
1. U.S. Minerals Management Service, Herndon, VA.
2. National Oceanic and Atmospheric Administration, Seattle, WA.
3. National Institute of Standards & Technology, Gaithersburg, MD.

## ABSTRACT

On August 10, 1993, the Tank Barge Ocean 255 and the Tank Barge Bouchard B-155 collided with the freighter Balsa 37 near the entrance of Tampa Bay, Florida. Jet fuel from the Ocean 255 caught fire and burned for approximately 18 hours. Barge B-155, carrying 5 million gallons of No. 6 fuel oil, ruptured a port tank and spilled an estimated 328,000 gallons. Much of the discharged oil was initially carried offshore by winds and tidal currents and moved northward, parallel to the adjacent barrier island beaches.

By August 14 and 15, a storm system bringing winds from the west pushed oil onshore onto several beaches and into and through tidal inlets. Subsequent oiling of sand beaches, shallow embayments, and fringing wetlands occurred during the second week of the spill event. Estimates are that about 14.5 miles of sand beaches were oiled, along with approximately 6 acres of mangrove wetlands, 2.5 acres of seagrass beds, and 1.5 acres of saltmarshes. Areas of submerged oil were also present in bays and bay passes.

This paper outlines the general behavior and movements of the spilled oil and the sea and weather conditions prevalent before the oil moved ashore. The possibility of removing portions of the spill by ignition and combustion is discussed, and results of smoke plume model runs are presented. Given the highly successful in-situ test burning of spills off Newfoundland in August 1993, this response measure deserves serious evaluation in future emergencies. Presently, spill responders must consider both actual and publicly perceived hazards associated with the at-sea burning of oil.

## INTRODUCTION

The premise of this paper is that in situ burning of offshore oil spills is now feasible and may be preferable, in some cases, as an oil-spill response tool. Given advances in technology and research, coupled with recent successful large- scale experimental burns, this tool should now be made more available to spill responders. As a hypothetical example, the 1993 oil spill off Tampa Bay was examined. Weather and sea conditions were quite favorable for in-situ burning of large portions of the slicks for a period of 2 days after the spill. This response method would have reduced the volume of oil that eventually came ashore, thus reducing impacts. In this case, smoke plume modeling indicates minimal risk to coastal populations from particulate deposition if such burns had taken place. However, public perception of risks inherent in burning oil must be acknowledged and addressed.

## SPILL EVENT AND BEHAVIOR

On August 10, 1993, the outbound freighter Balsa 37 collided with two inbound barge-tug combinations in Tampa's main shipping channel, about 2.5 miles west of the Sunshine Skyway Bridge.(1) The barge Ocean 255, carrying jet A fuel, suffered an explosion and fire that was finally extinguished early the next day. The Balsa 37 was intentionally grounded southeast of Egmont Key. The remaining barge, the Bouchard B-155, spilled an estimated 328,000 gallons of No. 6 fuel oil from its ruptured No. 1 port tank. A rapid transfer of the fuel oil from the ruptured tank helped to minimize the amount spilled.

Although some oil washed ashore on Egmont and Mullet Key, winds and currents carried most of the spill out into the Gulf of Mexico (Fig. 1) in long streamers along surface convergence lines.(2) An August 11 spill overflight showed the oil in a 17-mile slick initially heading west and slightly north (Fig 2). The winds, as shown in Table 1, were generally light and in the offshore direction over August 11 and 12th. Thus, conditions were excellent to boom and burn oil all along the distribution about 7 or 8 miles offshore.

Table 1. Wind Data for Tampa Spill
(NOAA/Hazardous Material Response Branch)

| Observation Point | Date | Time (EDT) | Direction (From) | Speed (Knots) |
|---|---|---|---|---|
| St. Petersburg Airport | 8/11/93 | 0500 | 140 | 7 |
| | 8/12/93 | 0500 | CALM | CALM |
| | 8/13/93 | 0500 | CALM | CALM |
| | 8/14/93 | 0500 | 170 | 5 |
| | 8/15/93 | 1300 | W | 9 |
| Tampa Bay, Tampa | 8/14/93 | 0500 | CALM | CALM |
| | 8/15/93 | 1300 | WSW | 9 |
| Sunshine Skyway (Bridge) | 8/12/93 | 0500 | ENE | 15 |
| | 8/12/93 | 1500 | WSW | 5 |
| | 8/13/93 | 1500 | W | 5 |
| | 8/14/93 | 1215 | SSE | 9 |
| | 8/15/93 | 1315 | W | 12 |
| West of Egmont Key | 8/11/93 | 2000 | NW | 9 |

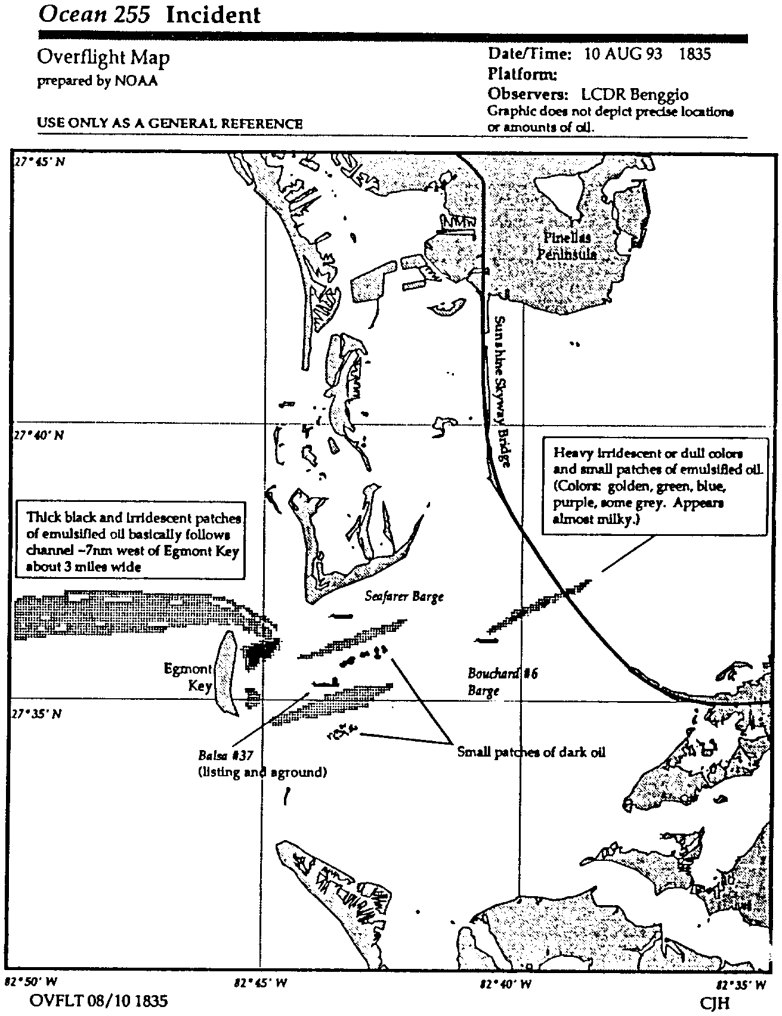

Figure 1. Spill overflight map for August 10, 1993

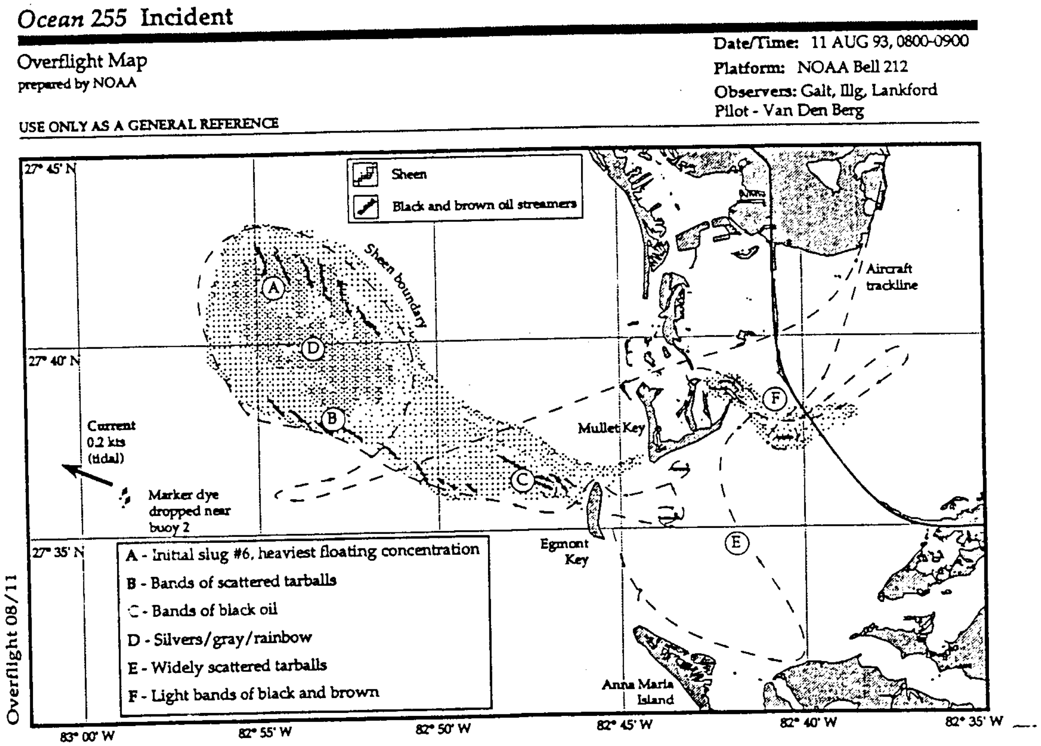

Figure 2. Spill overflight map for August 11, 1993

By August 13, the oil had begun to more widely distribute itself (Fig. 3), becoming patchy with slicks spread over very large areas and picking up water content estimated at about 50 percent. At this point, burning may have become more difficult due to emulsification. After August 13, the winds changed to out of the west and the oil began to move ashore. Figure 4 shows the path of a Minerals Management Service (MMS) "oil-following" surface drifter deployed by NOAA HAZMAT on August 12 near the heavy patches of oil.(3) The satellite-tracked drifter is shown moving ashore along with the oil over the August 13 to 15 period.

On August 14, tarballs began coming ashore. In the next few days, most of the offshore oil had beached, was carried into and through tidal inlets, or was in the nearshore areas (Fig. 5). This secondary oil (following the tar balls ashore) had been in the streamers described above and, therefore, might have been reduced in volume if offshore burning had been available as a response tool.

Before the wind shifted to onshore, spill response was mainly a skimming operation. After oil came ashore, response concentrated on beach cleanup. Overall, the response went well in terms of cleaning up a large quantity of oil and rapidly mobilizing people and equipment. The total amount of oil recovered was estimated at over 147,000 gallons in offshore skimming operations and more than 130,000 gallons of oil/water mixture in inshore operations.(4)

## IMPACTS TO COASTLINE

Tampa Bay is Florida's largest open-water estuary. Popular for sport, tourism and recreation, the bay supports one of the world's most productive natural systems. Nursery grounds are present for young fish, shrimp and crabs. These include grouper, pompano, Gulf Whiting, redfish, shrimp, crabs, oysters, clams, scallops, snook, tarpon, flounder and mullet.(5) As many as 50,000 pairs of birds of some 25 species (including pelicans, herons, egrets, ibis, terns and skimmers) nest on Tampa Bay islands and coastal areas. Loggerhead, green and leatherback sea turtles commonly nest along the coastline.

As a result of the spill, fish and wildlife resources and their habitats in the St. Petersburg Beach area, Boca Ciega Bay and lower Tampa Bay were adversely affected. No. 6 fuel oil is a viscous, heavy molecular weight oil of moderate toxicity and is extremely persistent when spilled into protected, poorly-flushed ecosystems. The estimated areas of affected habitat included about 6 acres of mangroves, which contain one active brown pelican and one wading bird rookery. Also affected were approximately 14.5 miles of sand beaches, 2.5 acres of submerged seagrass beds, and 1.5 acres of salt marsh.(5)

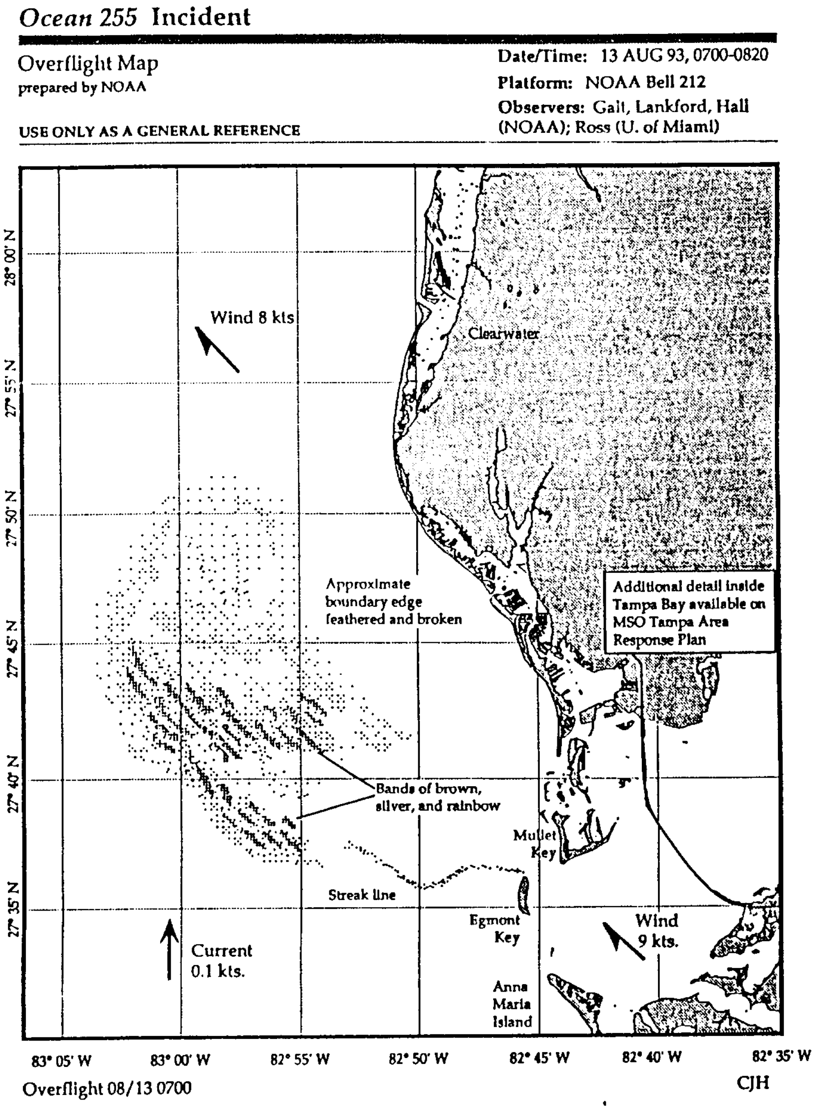

Figure 3. Spill overflight map for August 13, 1993

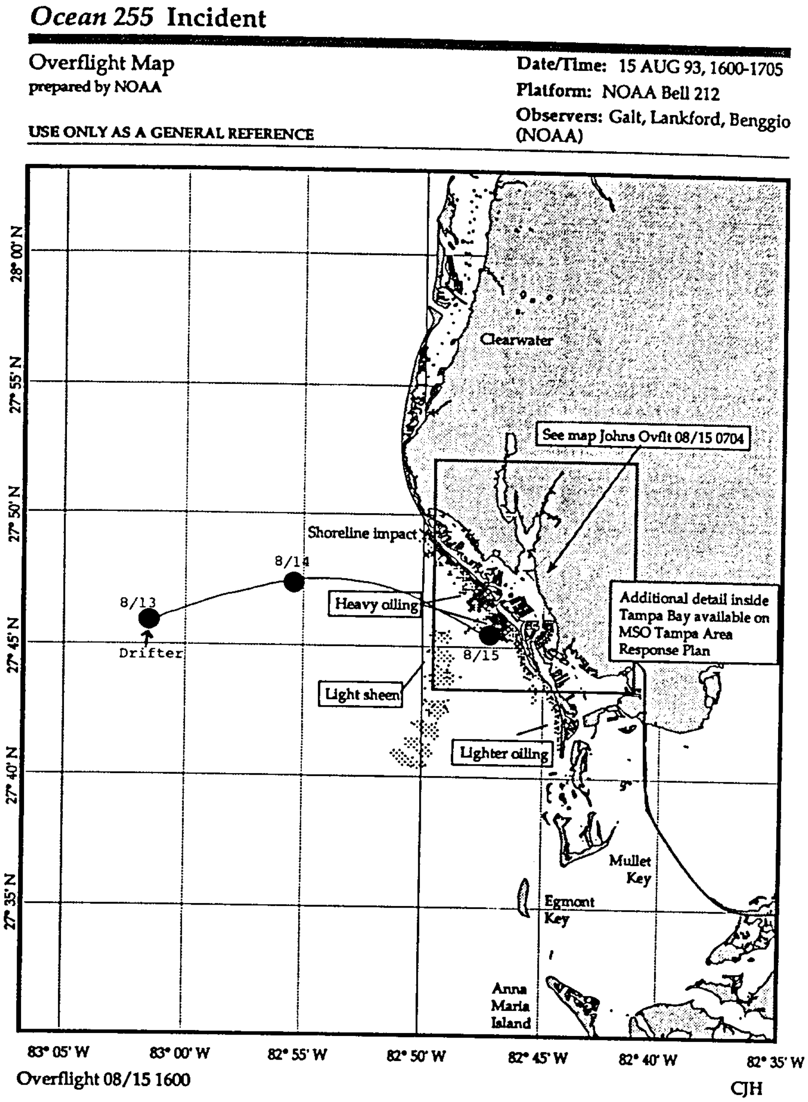

Figure 4. Movement of satellite-tracked drifter deployed near large slicks, from August 13-15. 1993

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***Ocean* 255 Incident**

Johns Pass
prepared by NOAA

USE ONLY AS A GENERAL REFERENCE

**Date/Time:** 15 AUG 93, 0704-0830
**Platform:** NOAA Bell 212
**Observers:** Galt, Lankford, Michel (NOAA); Harbert (USCG OSC)

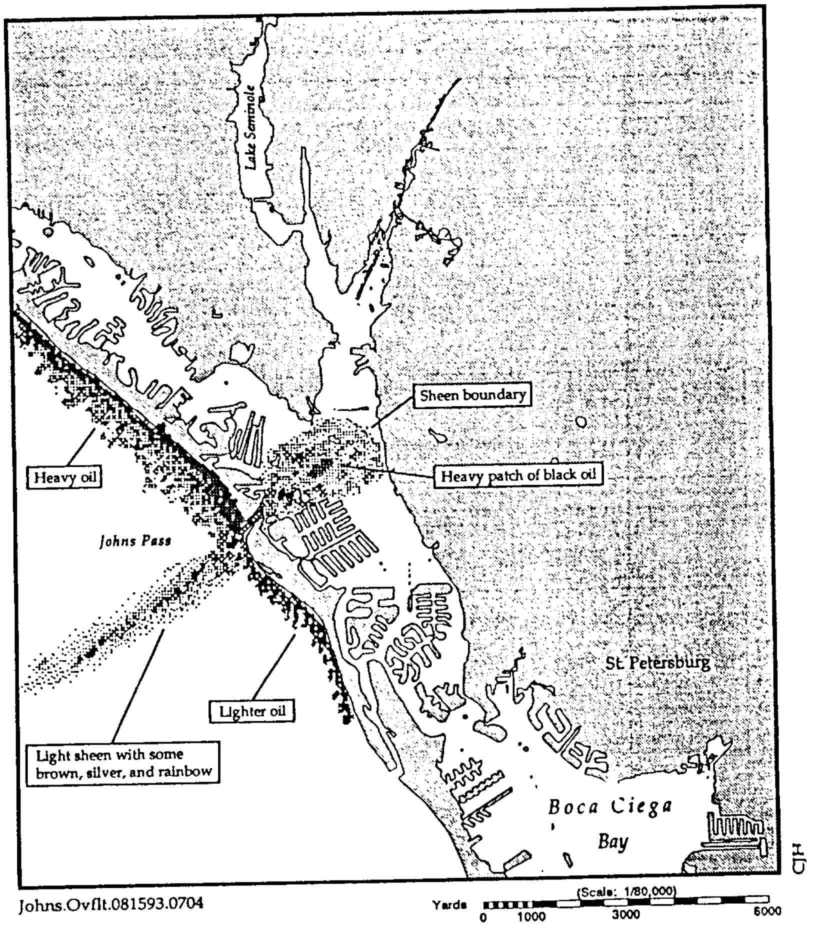

Figure 5. Spill overflight map for August 15, 1993

All of the affected habitats function as nursery areas for recreationally and commercially important finfish and shellfish species.

During the spill and cleanup, numerous species of migratory, shore, and wading birds were affected and their habitats disturbed. Bird rescue efforts accounted for the recovery of 357 oiled birds, with 80 mortalities.(5) A total of five sea turtles were known to have been exposed to oil. These included four loggerhead hatchlings, a threatened species, which were beginning to emerge from nests on the beaches around Egmont and Mullet Keys at the time of the spill. Ninety-six of the 115 known loggerhead nests were on beaches that could have been potentially affected by the spill. Twenty-nine of these nests hatched turtles during the spill response and had to be protected.

Ongoing studies are documenting the effects of the spill on surf-zone fishes, seagrass finfish and invertebrates, and larval fish.(5) Mortality to crab and oyster larvae and larval/juvenile fish in the tidal passes and channels is also a concern. Several areas of sunken oil were observed in the subtidal areas just off Treasure Island beaches, and also in seagrasses, mud flats, the Intra-Coastal Waterway and are likely in deeper areas of Boca Ciega Bay. In October 1993, Treasure Island beaches were re-exposed to oil from this benthic source, requiring additional cleanup of those areas.(5)

## POTENTIAL OF OFFSHORE BURNING

The use of in situ burning as a spill response measure has several advantages over other methods. Large amounts of oil on the water can be converted rapidly to small amounts of residue with a small percentage of smoke particulate yield. By removing the oil before it spreads, burning can reduce shoreline contamination with its attendant damage to sensitive environmental resources.

Burning also requires far less equipment and labor than other techniques. For example, the response to the Tampa Bay spill included removing over 33,000 cubic yards of oiled sand and solid waste, representing over 2,000 dump truck loads.(6) Other equipment used included 12 vacuum trucks, 87 heavy equipment vehicles, 62,000 feet of boom, 14 barges, 10 skimmers, and 59 supply boats.(7) More than 1,800 response personnel participated in the effort. On some days, due to the extreme heat and humidity, contracted workers took 15-minute breaks every 30 minutes. Despite this precaution, about 20 percent of the workers suffered from varying degrees of heat stress.(6)

Burning oil spills produces a visible smoke plume containing particulates and other products which may persist far downwind from the burn. A human health risk may result from inhalation of the fine particulate material that is produced as a byproduct of combustion. Public health is therefore a prime concern, especially in vicinities of aged populations with attendant respiratory problems. Research programs have been designed to study how burning large spills would affect air quality by quantifying the products of combustion and developing methods to predict the downwind airborne smoke particulate concentrations.(8)

## NEWFOUNDLAND OFFSHORE BURN EXPERIMENT (NOBE)

A consortium of over 25 agencies from Canada and the United States conducted two experimental burns offshore Newfoundland on August 12, 1993 (coincidentally 2 days after the Tampa Bay spill). Each experiment involved the release of about 50 tons of Alberta sweet crude oil into a fireproof boom.(9) Each burn lasted over an hour and was monitored for emissions and physical parameters. Over 200 sensors and samplers were employed, and the data return exceeded expectations. Overall, the experiments indicated that burning oil at sea is a feasible and practical oil-spill countermeasure.

Data analyzed to date show that emissions from the burns were low. Beyond about 150 m from the fire, all compounds and parameters measured were below health concern levels, and very little material of any type was detected beyond 500 m. Particulates in the air were measured by several means and found to be minimal beyond 150 m downwind at sea level. No respirable particles (less than 10 micrometers in size) were detected at ground level. Volatile organic compounds (VOCs) in the smoke plume were, nevertheless, lower than those emitted from the non-burning spill.(9)

The two burns left a total of about 0.5 $m^3$ of oily residue, which is less than 1 percent of the volume of oil released. Thus, burn removal approached 99-percent efficiency. The residue resembled a highly weathered oil and was generally lighter than water. No toxic compounds were found in the water samples taken directly beneath the burning oil, nor from later toxicity tests using those samples. The performance of the fireproof boom indicated a need for further research on at-sea burns.

## SMOKE PLUME MODELING

Since 1985, the National Institute of Standards and Technology (NIST), supported by MMS, has studied in situ burning of crude oil to provide information in support of oil-spill response. Along with development of smoke plume measurement techniques, NIST has developed a Large Eddy Simulation (LES) model for calculating smoke plume trajectories and estimating the "footprint" of soot particle deposition downwind of a burn.(10) The model was designed to differ from other (typically smokestack) models by encompassing larger sizes and types of combustion sources.

The LES model has shown that smoke production from crude oil fires varies with the area of the burn and the type of crude oil. It appears that 10 to 15 percent of the mass of crude oil burned in large areas is converted to particulates that are carried in the smoke plume. A comprehensive evaluation of many burn scenarios for the state of Alaska (10) showed that for a 465-$m^2$ burn (800-900 megawatts), the 150 $\mu g/m^3$ one-hour-average smoke particulate concentrations were not found at distances greater than 5 km downwind of the burn at ground level and did not extend beyond a width of 1 km. (The level of the national primary and secondary 24-hour ambient air quality standards for particulate matter is 150 $\mu g/m^3$, 24-hour-average concentration; ref: 40 CFR, S. 50.6(a).)

The LES model was run for two scenarios of hypothetical oil spill burns of portions of the spill of fuel oil No. 6 off Tampa Bay. Both runs modeled burns in the confines of a fireproof boom at the rate of 40 $m^3$/hr. The fraction of fuel that was converted into particulate matter, or smoke yield, was assumed to be about 13 percent, based on previous work and the NOBE burns.

The model runs were based on actual slick locations (Fig. 2) and weather conditions observed on August 11 and 12, 1993, offshore Tampa Bay. The first run assumed a U.S. standard daytime temperature lapse rate of -6.5°C/km, an onshore wind speed of 4 m/s, and lateral and vertical wind fluctuations over water of 3° and 1°, respectively; and over land of 10° and 6°. Wind fluctuation values were hour-averaged standard deviations which correspond to clear, sunny conditions. The smoke plumes were generated over water, but were assumed to blow over land 10 km away.

The second model run corresponded to stable meteorological conditions with a lapse rate of 0°C/km (isothermal profile), an onshore wind speed of 7 m/s, and wind fluctuations identical to the first run. These conditions were similar to those prevalent during the NOBE burns.

Figures 6 and 7 give summaries of each calculation. (Note difference in scale when making comparisons.) The figures show the temperature profile assumed and the crosswind extent of hour- averaged plume particulate concentrations of 50, 150, and 300 $\mu g/m^3$ at a plume cross section 5 km downwind of the burn site. The two runs showed 50 $\mu g/m^3$ contour widths of about 1.5 and 1.0 km, respectively, which is on the order of the width of visible smoke plumes at sea. Also shown are downwind extents of those concentration levels in the plume. Note that Figure 6 shows a "hole" along the centerline of the plume, which appears as a gap in the concentration contours. This is due to the generation of two counter-rotating vortices which entrain most of the particulate matter sent aloft. This phenomena was also observed during the NOBE burns.

The figures also display concentrations at ground level (first 10 to 20 m of the atmosphere) downwind from the burn. Because of increased mixing in the

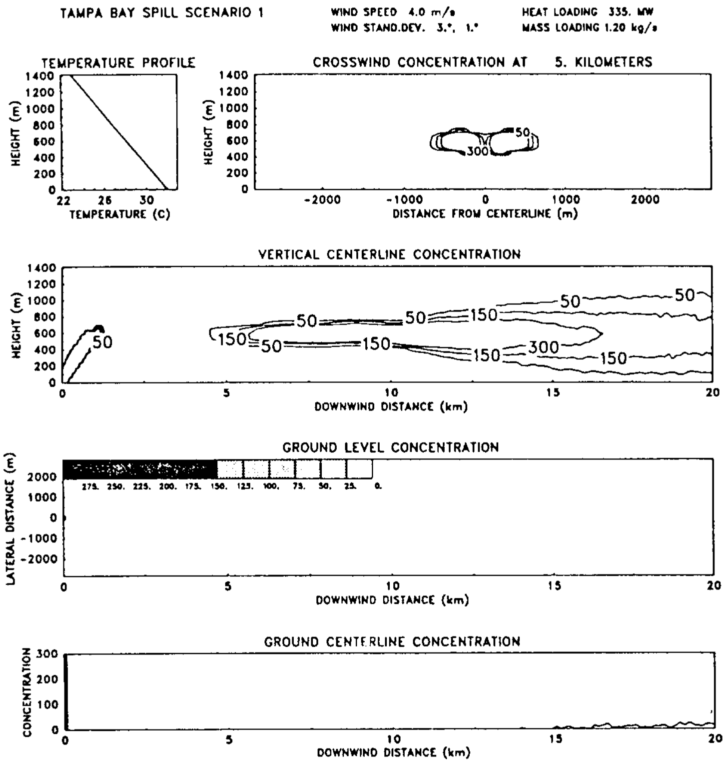

Figure 6. Summary of the Large Eddy Simulation (LES) model run for a simulated spill of fuel oil no. 6 off Tampa Bay, scenario 1 (all concentrations expressed in units of $\mu g/m^3$)

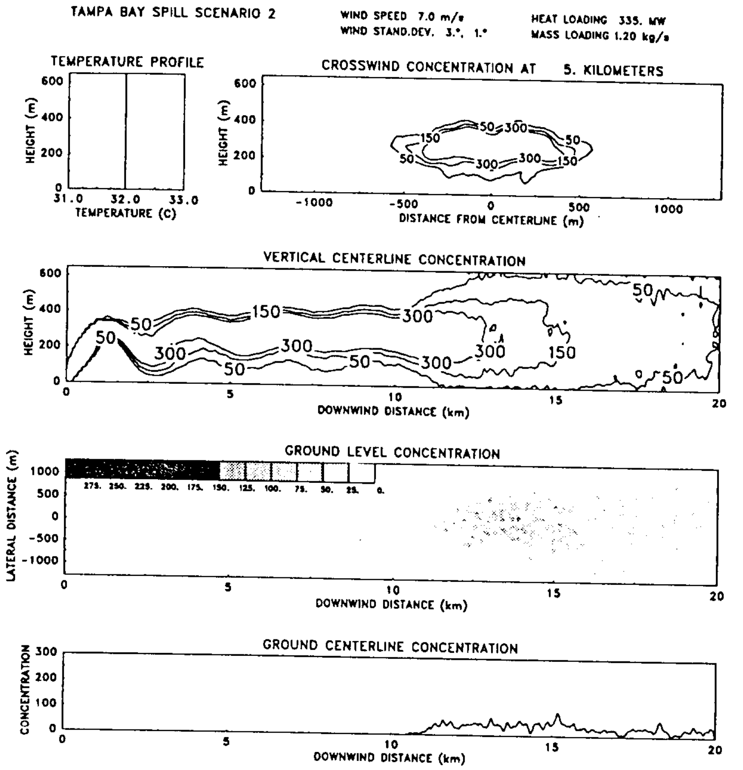

Figure 7. Summary of the Large Eddy Simulation (LES) model run for a simulated spill of fuel oil no. 6 off Tampa Bay, scenario 2 (all concentrations expressed in units of $\mu g/m^3$)

surface layer of the atmosphere over land, dispersion of the plume is greater, but can yield higher particulate levels at the ground due to vertical transport. This is seen at downwind distances greater than 10 km. However, for both runs, concentrations of smoke particulate were well below 100 $\mu g/m^3$, from the source out to 20 km downwind over land.

## DISCUSSION

Tampa Bay is the seventh largest port in the United States, handling an average of 4 billion gallons of petroleum and related products annually. With over 20 piloted vessel trips per day, oil-spill responders should have access to as many tools as possible. In situ burning at sea has been demonstrated to be an effective oil-spill response method.

In situ burning is a relatively simple technique. For an excellent review of burning as a response technique, see Shigenaka and Barnea, 1993.(11) However, to be effective, at-sea burning of oil will probably have a short window of opportunity in which the oil composition and thickness, wind, and sea conditions must all be within certain parameters. It is crucial that spill responders have the authority and political backing to make quick decisions to take advantage of this time window. This would involve having rapid access to standardized fireproof boom, vessels, and appropriate training in operations and safety. Also, weather conditions would be monitored, and the public should be advised on smoke plume trajectory and content.

The extent to which inhalation of fine particulates presents a human health hazard during an in situ burn depends on the concentration and duration of exposure. These very small particulates do not settle readily and will be carried by prevailing winds for long distances, over which their concentrations will rapidly decline. However, public perception may be that smoke plumes pose an unacceptable risk to human health. When compared to the damage that beached oil has been shown to cause, as in the Tampa Bay spill, the alternatives are put in perspective.

## ACKNOWLEDGEMENTS

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## REFERENCES

1) World Information Systems, "Major Fire and Spill Following Collision off Tampa," Oil Pollution Bulletin, Vol. V, No. 18, pp. 1-4, (August 13, 1993).

2) National Oceanic and Atmospheric Administration, Information ManagementReport: Bouchard 155 Oil Spill Tampa Bay, Florida, August 10, 1993, for the Hazardous Materials Response and Assessment Division, Seattle, WA, Sept. 10, 1993.

3) Simecek-Beatty, Debra A., Tracking of Oil Spills by Argos-Satellite Drifters: A Comparison, Proc. 2nd Thematic Conf. on Remote Sensing for Marine and Coastal Environments, New Orleans, LA, Vol I, pp. 423-434, Jan. 31-Feb. 2, 1994.

4) Cutter Information Corp., "Crews Wrap Up Cleanup Activities in Tampa Bay," Oil Spill Intelligence Report, Vol. XVI, No. 36, pp. 2-3, (Sept. 16, 1993).

5) U.S. Department of the Interior, National Oceanic and Atmospheric Administration, and Florida Dept. of Environmental Protection, Preassessment Screen and Determination for August 10, 1993 Tampa Bay Florida Oil Spill, 1993.

6) World Information Systems, "Cleanup Force Peaks at 1,800 After Tampa Bay Collision," Oil Pollution Bulletin, Vol. V, No. 11, pp. 6-7, (Sept. 10, 1993).

7) Cutter Information Corp., "Responders Continue to Clean Up Oil from Tampa Spill," Oil Spill Intelligence Report, Vol. XVI, No. 32, p. 3, (Aug. 26, 1993).

8) Evans, D., W. Walton, H. Baum, et al. In-Situ Burning of Oil Spills: Mesoscale Experiments, Proc. 15th AMOP Tech. Seminar, June 1992, Edmonton, Canada, pp. 593-657, 1992.

9) Newfoundland Burn Experiment Committee, Newfoundland Offshore Burn Experiment, NOBE Facts Newsletter, Vol. 6, March 1994.

10) McGrattan, K., A. Putorti, W. Twilley, D. Evans, Smoke Plume Trajectory from In Situ Burning of Crude Oil in Alaska, NISTIR 5273, National Institute of Standards, Gaithersburg, MD., 1993.

11) Shigenaka, G. and N. Barnea, Questions about In-Situ Burning as an Open-Water Oil Spill Response Technique, HAZMAT Report 93-3, Seattle, WA., 42 pp., June 1993.