Health Hazard Evaluation of Deepwater Horizon Response Workers

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and Doug Trout

Health Hazard Evaluation Interim Report 8
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The cover photo shows response workers cleaning boom used to collect oil during the Deepwater Horizon response in the Gulf of Mexico: June 2010.

DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

National Institute for Occupational
Safety and Health
Robert A. Taft Laboratories
4676 Columbia Parkway
Cincinnati OH 45226-1998

25 October 2010

HETA 2010-0129

Fred Tremmel

Deepwater Horizon ICP

1597 Highway 311

Houma, LA 70395

Dear Mr. Tremmel:

On May 28, 2010, the National Institute for Occupational Safety and Health (NIOSH) received a request from BP for a health hazard evaluation (HHE). The request asked NIOSH to evaluate potential exposures and health effects among workers involved in Deepwater Horizon Response activities. NIOSH sent an initial team of HHE investigators on June 2, 2010, to begin the assessment of off-shore activities. To date, more than three dozen HHE investigators have been on-scene.

This letter is the eighth in a series of interim reports. As this information is cleared for posting, we will make it available on the NIOSH website (www.cdc.gov/niosh/hhe). When all field activity and data analyses are complete we will compile the interim reports into a final report.

This report (Interim Report #8) provides background, describes methods, reports findings, and provide conclusions and, where appropriate, interim recommendations for our evaluation of vessel and equipment decontamination and waste management workers. This report has two attachments:

8A— Evaluation of August 10, 2010, Decontamination Tasks at Port Fourchon, Louisiana

8B— Evaluation of Equipment and Boat Repair/Decontamination, and Waste Management Workers, Alabama, Florida, Louisiana, and Mississippi, July and August, 2010

Thank you for your cooperation with this evaluation. If you have any questions, please do not hesitate to contact me at 513.841.4382 or atepper@cdc.gov.

Sincerely yours,

Allison Tepper

Allison Tepper, PhD
Chief
Hazard Evaluations and Technical
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2 Enclosures

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Interim Report #8A
Evaluation of August 10, 2010, Decontamination Tasks at Port Fourchon, Louisiana

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Introduction

Four National Institute for Occupational Safety and Health (NIOSH) industrial hygienists assessed exposures during boom and vessel decontamination operations on August 10, 2010, in Port Fourchon, Louisiana. At the time of the evaluation, vessels that had been booming and skimming surface oil in the Gulf of Mexico were returning to port because of a declining quantity of oil. These vessels and the boom used to collect the surface oil often were heavily soiled and in need of cleaning and decontamination prior to being released from oil spill response activities. Decontamination operations were on-going in several locations throughout the Gulf states. Decontamination operations evaluated by NIOSH industrial hygienists in Port Fourchon, Louisiana, included two sites: C-Port (570 Dudley Bernard Road, Golden Meadow, Louisiana) and Charlie Company (25770 Highway 1, Golden Meadow, Louisiana).

C-Port

Two NIOSH industrial hygienists evaluated the decontamination of oil boom and metal pipe by contract personnel at C-Port in Port Fourchon, Louisiana. Oil-contaminated boom and pipe were unloaded manually from large metal containers at the north end of an enclosed decontamination pool created by laying a rubber membrane over the concrete shipping dock. The boom and pipe were arranged along parallel rows of wooden pallets within the decontamination pool to await manual cleaning using water and OMI 500, a cleaning liquid manufactured by JMN Specialties, Inc. (Westwego, Louisiana). The material safety data sheet (MSDS) for OMI 500 lists propylene glycol t-butyl ether and nonionic surfactants as two major components.

At the time of this evaluation, decontamination contract personnel worked one 12-hour shift (6:00 a.m. to 6:00 p.m.) but plans were underway to have two 12-hour shifts per day. The decontamination workers were divided into three groups of 10–11. Only one group was permitted to work in the decontamination area at any given time. To minimize heat stress, a group spent 15–20 minutes working in the decontamination area and 40–45 minutes resting outside the decontamination area. This work/rest rotation was rigorously enforced by the contractor and continued throughout the 12-hour workday with the exception of a lunch break between approximately 11:30 am and 1:00 pm. Workers could choose to rest in either an air-conditioned tent approximately 30 feet from the decontamination area or in any of three designated outdoor smoking areas that were shaded and provided with seating.

Decontamination job tasks included spraying OMI 500 cleaner onto oil-contaminated equipment using a standard hand-held garden-type sprayer, scrubbing the equipment with brushes, and rinsing the oil-contaminated equipment with water supplied by a diesel-operated pressure washer. In each group, a worker held the pressure washer hose and stood approximately 10 feet behind the pressure washer as the boom and pipe was pressure-washed. Personal protective equipment (PPE) worn by all workers entering the decontamination pool included Lakeland TyChem® Polycoat coveralls (the built-in hood was cut off and the coveralls slit in the back to increase ventilation for the wearer), steel-toed rubber safety boots, double gloves (inner: N-Dex® nitrile gloves by Best, Inc.; outer: Solvex® nitrile gloves by Ansel Edmont), safety glasses, hard hat, and face shield. The pressure washer and pressure wash hose holder also wore metal shin guards over their rubber boots. After cleaning, the boom was rolled up manually, and then boom and pipe were loaded manually to shipping containers located on the south end of the decontamination pool.

Charlie Company
Two NIOSH industrial hygienists evaluated the decontamination of oil boom and Vessels of Opportunity (VOOs) by contract personnel at Charlie Company. Oil-contaminated boom was arranged and laid out in shallow, self-contained decontamination pools located on two parallel piers; these piers were separated by a contained bay in which the external sides of small VOOs were decontaminated. Both the boom and VOO decontamination at this site used high pressure water washes and manual scrubbing using the same OMI 500 detergent used at C-Port.

The work schedule at the time of the evaluation consisted of one 12-hour workday (6:00 a.m. to 6:00 p.m.). Workers were organized into three teams of six men each. Each team worked for 20 minutes then rested for 40 minutes in an air-conditioned tent. At the 15th minute in each 20-minute work period, a work captain sounded a whistle to announce 5 minutes of work left in the period. At this time, the team of workers whose work period was next began the process of donning protective boots, gloves, and suits. At the 20th minute, a second whistle was sounded to indicate the end of the work period and switching of the work teams. As the workers who had just completed their work rotation doffed their protective gear, they were required to be observed drinking a bottle of water or other rehydration fluids before retiring to the air-conditioned tent to rest for 40 minutes. Workers could choose to spend their rest period in a covered outdoor area where smoking was allowed. All workers were given a lunch break from 11:30 am to 1:00 pm.

Decontamination procedures at Charlie Company were similar to those at C-Port. Three workers were stationed on each pier decontaminating oil boom. One worker used a hand-held sprayer to spray the OMI 500 detergent onto the boom. A second worker scrubbed the oil off the boom manually. A third worker washed the detergent and oil off the boom using a diesel-fuel powered, high-pressure water sprayer. Similar work tasks were observed for decontaminating the external sides of VOOs. During these work periods, all individuals wore protective steel-toed boots, an inner nitrile glove (West Chester PosiShield™) under an outer chemical resistant glove (Best Inc.), full-body coverall (West Chester Posiwear® UB™), hardhat, safety glasses, and face shield.

Evaluation

The NIOSH industrial hygienists conducted personal breathing zone (PBZ) air monitoring at the two Port Fourchon decontamination sites on August 10, 2010. At the C-Port site, longer-term PBZ air samples (sampling times ranged from 73 to 506 minutes) were collected on 12 workers tasked with moving and cleaning the boom and pipe. At the Charlie Company site, longer-term PBZ air samples (sampling times ranged from 86 to 558 minutes) were collected on 12 workers decontaminating oil boom and one VOO. Samples were analyzed for components of the oil and cleaning products including volatile organic compounds (VOCs), glycol ethers, benzene soluble total particulate fraction, and polynuclear aromatic hydrocarbons (PAHs).

At the C-Port site, area air samples (sampling times ranged from 179 to 606 minutes) were also collected for elemental carbon (EC), a surrogate indicator for diesel exhaust, and to screen for VOCs. Noise measurements at this location were made using a Quest model 2400, type-2 sound level meter approximately 4 feet from an employee who was pressure-washing (sampling time 10 minutes). At the Charlie Company site, area air monitoring for carbon monoxide (CO) in the vicinity of the diesel-fuel pressure washer was also conducted.

For VOC exposures, air samples were collected using multi-sorbent thermal desorption tubes. These samples were analyzed by thermal desorption/gas chromatography-mass spectrometry (NIOSH Method 2549). Results from these thermal desorption tubes were used to select specific VOCs for quantitation from PBZ air samples collected using activated charcoal tubes [NIOSH 2010]. Other chemicals measured in PBZ and area air samples using integrated air sampling techniques included diesel exhaust, PAHs, glycol ethers, and the benzene soluble fraction of total particulate samples. Direct reading measurements were made for CO and noise. Direct reading measurements were also recorded for temperature and heat index. See Table 1 for a complete listing of the sampling and analytical methods used.

At the end of the day of sampling, the NIOSH industrial hygienists calibrated the sampling pumps and refrigerated samples collected during that day. (All samples were also kept cold during shipment to the laboratories prior to analysis.)

Results and Discussion

Table 2 contains a summary of the relevant occupational exposure limits (OELs) to which results were compared. Table 3 presents temperature and heat index measurements made during the day of the evaluation. Temperatures ranged from 85^{o}F–97^{o}F, with a heat index ranging up to 108^{o}F.

Volatile Organic Compounds

A combined total of six thermal desorption tube air samples were collected to screen for VOCs at the C-Port and Charlie Company sites. The typical C_9–C_{16} aliphatic hydrocarbons seen as major components in previous NIOSH evaluations of Deepwater Horizon response workers were not the major compounds detected in these samples. Rather, the compounds detected in all or most samples included 2-butoxyethanol (also known as ethylene glycol monobutyl ether) and limonene. Examples of other compounds detected on at least one sample included 2-ethyl-1-hexanol, decamethylcyclopentasiloxane, ethylene glycol, propylene glycol, and glycerol. An unidentified glycol ether was also detected on a few of these screening samples. Further investigation has subsequently determined this unidentified glycol ether to be propylene glycol t-butyl ether, one of the components listed on the MSDS for the OMI 500 cleaning compound. (Small peaks of this unidentified glycol ether were also present on the PBZ charcoal tube air samples. Quantification of these small peaks is ongoing to determine if they are also from propylene glycol t-butyl ether and if so, to estimate their concentration which is expected to be very low based on the preliminary analyses.)

Based on the results of the thermal tube screening samples, the PBZ charcoal tube air samples were quantitated for 2-butoxyethanol and other glycol ethers and for limonene, benzene, ethyl benzene, toluene, xylenes, and total hydrocarbons (THC) (as hexane). Results are shown in Tables 4 and 5. All air concentrations were well below the relevant OELs. 2-butoxyethanol was detected above the minimum quantifiable concentration (MQC) in all four PBZ air samples collected at the C-Port site (range: 0.048–0.16 parts per million [ppm]) and in two of three PBZ air samples collected at the Charlie Company site (range: 0.076–0.11 ppm). Limonene, a common component of cleaning agents, was measured above the MQC in four of five PBZ air samples collected at the C-Port site (range: 0.020–0.066 ppm) and in all three PBZ air samples collected at the Charlie Company site (0.013–0.020 ppm). All levels of benzene, ethyl benzene, toluene, and xylenes measured on eight PBZ air samples collected at the two sites were below the MQC. All total hydrocarbon time-weighted average (TWA) concentrations were equal to or less than 0.54 milligrams per cubic meter (mg/m^3). Although there is no OEL specifically for THCs, OELs for petroleum distillates and kerosene (two mixtures containing a range of hydrocarbons) are 350 mg/m^3 as a work shift TWA (Table 2).

Diesel Exhaust

Emissions from diesel engines used to power the pressure washers are complex mixtures of gases and particulates. NIOSH uses EC as a surrogate index of exposure because the sampling and analytical method for EC is very sensitive, and a high percentage of diesel particulate (80%–90%) is EC. In comparison, tobacco smoke particulate (a potential interference when measuring diesel exhaust) is composed primarily of organic carbon (OC). Although the Occupational Safety and Health Administration (OSHA) and NIOSH have established OELs for some of the individual components of diesel exhaust (i.e., nitrogen dioxide, CO), neither agency has established an OEL for EC. However, the California Department of Health Services' Hazard Evaluation System & Information Service (HESIS) guideline for diesel exhaust particles (measured as EC) is 20 micrograms per cubic meter ($\mu g/m^3$) for an 8-hour TWA. Six area air samples were collected for diesel exhaust at the C-Port site and analyzed for the components described above. As shown in Table 4, EC concentrations during decontamination tasks ranged from 0.90–2.5 $\mu g/m^3$; all were below the HESIS guideline.

Benzene Soluble Total Particulate Fraction

A total of nine PBZ air samples were collected at the two work sites for total particulates. The particulate fraction was analyzed for benzene soluble components (to separate out contributions from substances such as salts from the sea water) as an indicator of oil mist exposures (Tables 4 and 5). Total particulate TWA concentrations ranged from below the MQC to 0.14 mg/m^3 at the C-Port site and 0.091–0.12 mg/m^3 at the Charlie Company site. None of the samples contained detectable concentrations of benzene soluble particulates.

Carbon Monoxide

One CO monitor was placed in the proximity of the diesel-fuel power washer at the Charlie Company site from 3:06 p.m. to 5:02 p.m. CO was not detected except for a 5-minute period when the monitor was placed within 1 foot of the diesel exhaust pipe. During this period, CO concentrations ranged up to 9 ppm. Removal of the monitor from the exhaust stream returned CO levels to zero.

Noise

Area sound levels were measured throughout the day at the C-Port site. Levels ranged from 92 decibels A-weighted (dBA) to 95 dBA during pressure washing of the boom, and from 94 to 96 dBA during pressure washing on the wooden pallets directly next to the boom. These activities were the primary noise sources during decontamination activities. Intermittent sound level peaks of 98 dBA were measured.

Based on the sound level measurements and the total amount of time workers pressure washed (90 to 110 total minutes following the work/rest cycle in use during this evaluation), full-shift TWA noise exposure estimates ranged from 85 dBA to 90 dBA using NIOSH noise measurement criteria and from 80 dBA to 85 dBA using OSHA noise measurement criteria. Both the NIOSH recommended exposure limit

(REL) and OSHA action level for noise are 85 dBA, as 8-hour TWAs. The OSHA permissible exposure limit for noise is 90 dBA as an 8-hour TWA.

Polynuclear Aromatic Hydrocarbons

To measure the concentration of PAHs, PBZ air samples were collected on four workers at the C-Port site and on five workers at the Charlie Company site (Tables 4 and 5). Total PAHs were calculated as the sum of all PAH compounds present in the chromatograms. Total PAHs (as naphthalene) ranged from 0.0022–0.0055 mg/m^3 in samples collected at the C-Port site and from 0.0030–0.0046 mg/m^3 in samples collected at the Charlie Company site. For both sites, five individual PAHs were measured above their respective MQCs: anthracene (range: below MQC to 0.0029 mg/m^3), chrysene (range: 0.0014–0.011 mg/m^3), naphthalene (range: below MQC to 0.00019 ppm), phenanthrene (range: 0.00077–0.0029 mg/m^3), and pyrene (range: below MQC to 0.00074).

Summary

During this evaluation of two decontamination work sites in Port Fourchon, Louisiana, the NIOSH industrial hygienists found that PBZ and area air concentrations of the compounds measured were all below applicable OELs.

The major cleaning chemical used at these sites was OMI 500, whose MSDS lists propylene glycol t-butyl ether and nonionic surfactants as two major compositional components. NIOSH investigators contacted the manufacturer of OMI 500 to determine if 2-butoxyethanol might be an unlisted component. The manufacturer indicated that the cleaning product was not formulated with 2-butoxyethanol but that the propylene glycol t-butyl ether used to produce OMI 500 contained a trace amount of 2-butoxyethanol. The storage tank that held propylene glycol t-butyl ether had previously held 2-butoxyethanol; when filling the tank with propylene glycol t-butyl ether, a small quantity of 2-butoxyethanol was still present in the tank. The amount of 2-butoxyethanol the manufacturer determined to be present in the OMI 500 used at these work sites was estimated to be less than 1% [King 2010].

The PPE used by the decontamination workers (eye protection, coveralls, rubber chemical boots, hardhats, and nitrile gloves) minimized the potential for dermal contact with oil and cleaning agents while decontaminating vessels, boom, and pipe. Likewise, the work/rest regimen used by the contractor during this evaluation was effectively enforced, thus reducing the potential for workers to develop heat-related illness. However, monitoring did show the potential for noise exposures above the NIOSH REL.

Recommendations

The NIOSH industrial hygienists observed heat stress as a significant issue for workers; risk was exacerbated by the use of PPE. While air sampling did not identify airborne exposure levels above relevant OELs, the possibility of dermal exposures to oil and cleaning chemicals was observed to be considerable, necessitating the use of this PPE. Observations of work practices showed that employees recognized the potential heat stress hazard and took appropriate steps, such as an enforced 40-minute rest/cooling period and hydration after the 20-minute work period. New employees involved in decontamination operations in hot environments and PPE should continue to be trained in the recognition of the heat stress hazard, potential symptoms associated with heat stress, and the importance of hydration.

Because TWA noise exposures for the pressure washer and other employees working near the pressure washer (e.g., employee holding pressure-washing hose) are likely to be greater than the NIOSH REL, these employees should wear hearing protection during pressure washing; the use of such hearing protection should be included within the context of a hearing conservation program. Before providing hearing protection, workers should be trained on the how to properly insert hearing protectors. Site safety officers should monitor these and other work practices for potential noise exposure hazards.

Acknowledgments

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References

ACGIH [2010]. 2010 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

AIHA [2009]. AIHA 2009 Emergency response planning guidelines (ERPG) & workplace environmental exposure levels (WEEL) handbook. Fairfax, VA: American Industrial Hygiene Association.

CDHS [2002]. Health hazard advisory: diesel engine exhaust. Oakland, CA: California Department of Health Services, Hazard Evaluation System & Information Service. [http://www.cdph.ca.gov/programs/hesis/Documents/diesel.pdf]. Date accessed: October 2010.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

King B [2010]. Email correspondence on August 25, 2010, between Bradley King, Division of Surveillance, Hazard Evaluations, and Field Studies, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, and Joe Neathamer, JMN Specialties, Inc.

NIOSH [2005]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005-149. [http://www.cdc.gov/niosh/npg/]. Date accessed: October 2010.

NIOSH [2010]. NIOSH manual of analytical methods. 4th ed. Schlecht PC, O'Connor PF, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 94-113 (August 1994); 1st Supplement Publication 96-135, 2nd Supplement Publication 98-119, 3rd Supplement Publication 2003-154. [http://www.cdc.gov/niosh/nmam].

Table 1. Analytical methods used for substances evaluated during decontamination operations in Port Fourchon, Louisiana, on August 10, 2010

Analyte	Method
Benzene	NMAM 1501*†
Benzene soluble fraction of total particulate	NMAM 5042
Carbon monoxide	Direct reading—GasAlert CO Extreme, BW Technologies Ltd., Calgary, Canada
Diesel exhaust (elemental carbon, organic carbon, total carbon)	NMAM 5040
Ethyl benzene	NMAM 1501†
Glycol ethers (including 2-butoxyethanol)	NMAM 1403†
Limonene	NMAM 1501†
Naphthalene	NMAM 5506
Polynuclear aromatic hydrocarbons	NMAM 5506
Temperature and heat index	Direct reading—QUESTemp° 36 Thermal Environment Monitor, Quest® Technologies, Oconomowoc, Wisconsin
Toluene	NMAM 1501†
Total Hydrocarbons	NMAM 1501†
Volatile organic compounds (Screening)	NMAM 2549
Xylene (Total)	NMAM 1501†

*National Institute for Occupational Safety and Health (NIOSH) Manual of Analytical Methods [NIOSH 2010]
†Analysis by an adaptation of the method

Table 2. Occupational exposure limits for substances evaluated during decontamination operations at Port Fourchon, Louisiana, on August 10, 2010

Chemical	NIOSH REL*	OSHA PEL†	ACGIH TLV‡	AIHA WEEL§
Benzene	0.1 ppm TWA¶ 1 ppm STEL**	1 ppm TWA 5 ppm STEL 0.5 ppm Action Level	0.5 ppm TWA 2.5 ppm STEL	N/A††
2-Butoxyethanol	5 ppm TWA	50 ppm TWA	20 ppm TWA	N/A
Carbon monoxide	35 ppm TWA 200 ppm Ceiling	50 ppm TWA	25 ppm TWA	N/A
Ethyl benzene	100 ppm TWA 125 ppm STEL	100 ppm TWA	100 ppm TWA‡‡ 125 ppm STEL	N/A
Limonene	N/A	N/A	N/A	30 ppm TWA
Napthalene	10 ppm TWA 15 ppm STEL	10 ppm TWA 15 ppm STEL	10 ppm TWA 15 ppm STEL	N/A
Polynuclear aromatic hydrocarbons	N/A§§	N/A§§	N/A§§	N/A
Toluene	100 ppm TWA 150 ppm STEL	200 ppm TWA 300 ppm Ceiling 500 ppm Peak (10 min max)	20 ppm TWA	N/A
Total hydrocarbons	350 mg/m^3 TWA 1800 mg/m^3 Ceiling (Petroleum distillates)	2000 mg/m^3 TWA (Petroleum distillates as naphtha)	200 mg/m^3 TWA (Kerosene as total hydrocarbon vapor)	N/A
Xylene	100 ppm TWA 150 ppm STEL	100 ppm TWA	100 ppm TWA 150 ppm STEL	N/A

*National Institute for Occupational Safety and Health (NIOSH) recommended exposure limit (REL) [NIOSH 2005]
†Occupational Safety and Health Administration (OSHA) permissible exposure limit (PEL) [29 CFR 1910]
‡American Conference of Governmental Industrial Hygienists® (ACGIH) threshold limit value® (TLV) [ACGIH 2010]
§American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Level (WEEL) [AIHA 2009]
¶TWA = time weighted average
**STEL = short term exposure limit
††N/A = not applicable
‡‡Proposed to be changed to 20 ppm TWA and STEL eliminated [ACGIH 2010]
§§With the exception of naphthalene, OELs are not available for the individual PAHs measured in this evaluation.

Table 3. Environmental conditions during decontamination operations at Port Fourchon, Louisiana, on August 10, 2010		
Site	**Temperature (°F)***	**Heat Index (°F)***
C-Port†		
Outdoors	85–95; 91	[Equipment malfunction]
Charlie Company‡		
Outdoors	85–97; 91	93–108; 100

*Reported as range; average
†Hours of monitoring approximately 8:10 a.m.–5:22 p.m.
‡Hours of monitoring approximately 8:31 a.m.–5:08 p.m.

Table 4. Personal breathing zone and area air concentrations for substances measured at C-Port boat/boom decontamination site on August 10, 2010				
Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker A				
Pressure Washer	Benzene	436	43.6	<0.001 ppm
Pressure Washer	Benzene soluble fraction	434	866	<0.08 mg/m^3
Pressure Washer	Ethyl benzene	436	43.6	<0.001 ppm
Pressure Washer	Limonene	436	43.6	0.020 ppm
Pressure Washer	Toluene	436	43.6	<0.001 ppm
Pressure Washer	Total hydrocarbons	436	43.6	0.21 mg/m^3
Pressure Washer	Total Particulates	434	866	(0.074 mg/m^3)
Pressure Washer	Xylenes	436	43.6	<0.002 ppm
Personal Breathing Zone Air Samples—Worker B				
Hose Holder	Acenaphthene	438	443	<0.0001 mg/m^3
Hose Holder	Acenapthylene	438	443	<0.00009 mg/m^3
Hose Holder	Anthracene	438	443	(0.00041 mg/m^3)
Hose Holder	Benzene	440	34.9	<0.002 ppm
Hose Holder	Benzo(a)anthracene	438	443	<0.0001 mg/m^3
Hose Holder	Benzo(a)pyrene	438	443	<0.0002 mg/m^3
Hose Holder	Benzo(b)fluoranthene	438	443	<0.0001 mg/m^3
Hose Holder	Benzo(e)pyrene	438	443	<0.0002 mg/m^3
Hose Holder	Benzo(g,h,i)perylene	438	443	<0.0001 mg/m^3
Hose Holder	Benzo(k)fluoranthene	438	443	<0.0002 mg/m^3
Hose Holder	Chrysene	438	443	0.0093 mg/m^3
Hose Holder	Dibenzo(a,h)anthracene	438	443	<0.0002 mg/m^3
Hose Holder	Ethyl benzene	440	34.9	<0.001 ppm
Hose Holder	Fluoranthene	438	443	<0.0001 mg/m^3
Hose Holder	Fluorene	438	443	<0.0002 mg/m^3
Hose Holder	Indeno(1,2,3-cd)pyrene	438	443	<0.0001 mg/m^3

Table 4. Personal breathing zone and area air concentrations for substances measured at C-Port boat/boom decontamination site on August 10, 2010 (continued)

Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples— Worker B (continued)				
Hose Holder	Limonene	440	34.9	0.062 ppm
Hose Holder	Naphthalene	438	443	0.000031 ppm
Hose Holder	Phenanthrene	438	443	0.00077 mg/m^3
Hose Holder	Pyrene	438	443	0.00052 mg/m^3
Hose Holder	Toluene	440	34.9	<0.002 ppm
Hose Holder	Total hydrocarbons	440	34.9	0.44 mg/m^3
Hose Holder	Total PAHs	438	443	0.0032 mg/m^3
Hose Holder	Xylenes	440	34.9	<0.003 ppm
Personal Breathing Zone Air Samples—Worker C				
Pressure Washer	Acenaphthene	256	258	(0.00022 mg/m^3)
Pressure Washer	Acenapthylene	256	258	<0.0002 mg/m^3
Pressure Washer	Anthracene	256	258	0.0015 mg/m^3
Pressure Washer	Benzo(a)anthracene	256	258	<0.0002 mg/m^3
Pressure Washer	Benzo(a)pyrene	256	258	<0.0004 mg/m^3
Pressure Washer	Benzo(b)fluoranthene	256	258	<0.0002 mg/m^3
Pressure Washer	Benzo(e)pyrene	256	258	<0.0003 mg/m^3
Pressure Washer	Benzo(g,h,i)perylene	256	258	<0.0002 mg/m^3
Pressure Washer	Benzo(k)fluoranthene	256	258	<0.0003 mg/m^3
Pressure Washer	Chrysene	256	258	0.010 mg/m^3
Pressure Washer	Dibenzo(a,h)anthracene	256	258	<0.0004 mg/m^3
Pressure Washer	Fluoranthene	256	258	<0.0002 mg/m^3
Pressure Washer	Fluorene	256	258	<0.0004 mg/m^3
Pressure Washer	Indeno(1,2,3-cd)pyrene	256	258	<0.0002 mg/m^3
Pressure Washer	Naphthalene	256	258	0.00011 ppm
Pressure Washer	Phenanthrene	256	258	0.0020 mg/m^3
Pressure Washer	Pyrene	256	258	0.00074 mg/m^3
Pressure Washer	Total PAHs	256	258	0.0054 mg/m^3

Table 4. Personal breathing zone and area air concentrations for substances measured at C-Port boat/boom decontamination site on August 10, 2010 (continued)

Activity	Substance	Sampling Information		Sample Concentration*†
		Time (min)	Volume (Liters)	
Personal Breathing Zone Air Samples—Worker D				
Hose holder	Acenaphthene	410	410	(0.00017 mg/m^3)
Hose holder	Acenapthylene	410	410	<0.0001 mg/m^3
Hose holder	Anthracene	410	410	(0.00076 mg/m^3)
Hose holder	Benzo(a)anthracene	410	410	<0.0001 mg/m^3
Hose holder	Benzo(a)pyrene	410	410	<0.0002 mg/m^3
Hose holder	Benzo(b)fluoranthene	410	410	<0.0002 mg/m^3
Hose holder	Benzo(e)pyrene	410	410	<0.0002 mg/m^3
Hose holder	Benzo(g,h,i)perylene	410	410	<0.0001 mg/m^3
Hose holder	Benzo(k)fluoranthene	410	410	<0.0002 mg/m^3
Hose holder	2 Butoxyethanol	245	24.5	0.048 ppm
Hose holder	Chrysene	410	410	0.011 mg/m^3
Hose holder	Dibenzo(a,h)anthracene	410	410	<0.0002 mg/m^3
Hose holder	Dipropylene glycol butyl ether	245	24.5	<0.0007 ppm
Hose holder	Fluoranthene	410	410	<0.0002 mg/m^3
Hose holder	Fluorene	410	410	<0.0002 mg/m^3
Hose holder	Indeno(1,2,3-cd)pyrene	410	410	<0.0002 mg/m^3
Hose holder	Naphthalene	410	410	0.000056 ppm
Hose holder	Phenanthrene	410	410	0.0012 mg/m^3
Hose holder	Proylene glycol ethyl ether	245	24.5	<0.001 ppm
Hose holder	Pyrene	410	410	(0.00037 mg/m^3)
Hose holder	Total PAHs	410	410	0.0055 mg/m^3
Personal Breathing Zone Air Samples—Worker E				
Brusher	Benzene	404	40.1	<0.002 ppm
Brusher	Ethyl benzene	404	40.1	<0.001 ppm
Brusher	Limonene	404	40.1	(0.0072 ppm)
Brusher	Toluene	404	40.1	<0.001 ppm
Brusher	Total hydrocarbons	404	40.1	0.032 mg/m^3
Brusher	Xylenes	404	40.1	<0.002 ppm
Personal Breathing Zone Air Samples—Worker F				
Pressure washer	Benzene soluble fraction	423	842	<0.08 mg/m^3
Pressure washer	2 Butoxyethanol	216	21.5	0.16 ppm
Pressure washer	Dipropylene glycol butyl ether	216	21.5	<0.0007 ppm
Pressure washer	Proylene glycol ethyl ether	216	21.5	<0.001 ppm
Pressure washer	Total Particulates	423	842	(0.055 mg/m^3)

Table 4. Personal breathing zone and area air concentrations for substances measured at C-Port boat/boom decontamination site on August 10, 2010 (continued)				
Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker G				
Hose holder	Benzene soluble fraction	356	713	<0.1 mg/m^3
Hose holder	Total Particulates	356	713	0.14 mg/m^3
Personal Breathing Zone Air Samples—Worker H				
Hose holder	Acenaphthene	73	73.8	<0.0007 mg/m^3
Hose holder	Acenapthylene	73	73.8	<0.0005 mg/m^3
Hose holder	Anthracene	73	73.8	<0.001 mg/m^3
Hose holder	Benzo(a)anthracene	73	73.8	<0.0007 mg/m^3
Hose holder	Benzo(a)pyrene	73	73.8	<0.001 mg/m^3
Hose holder	Benzo(b)fluoranthene	73	73.8	<0.0008 mg/m^3
Hose holder	Benzo(e)pyrene	73	73.8	<0.001 mg/m^3
Hose holder	Benzo(g,h,i)perylene	73	73.8	<0.0007 mg/m^3
Hose holder	Benzo(k)fluoranthene	73	73.8	<0.001 mg/m^3
Hose holder	Chrysene	73	73.8	0.0035 mg/m^3
Hose holder	Dibenzo(a,h)anthracene	73	73.8	<0.001 mg/m^3
Hose holder	Fluoranthene	73	73.8	<0.0008 mg/m^3
Hose holder	Fluorene	73	73.8	<0.001 mg/m^3
Hose holder	Indeno(1,2,3-cd)pyrene	73	73.8	<0.0008 mg/m^3
Hose holder	Naphthalene	73	73.8	(0.000049 ppm)
Hose holder	Phenanthrene	73	73.8	0.0029 mg/m^3
Hose holder	Pyrene	73	73.8	<0.0007 mg/m^3
Hose holder	Total PAHs	73	73.8	0.0022 mg/m^3
Personal Breathing Zone Air Samples—Worker I				
Pressure Washer	Benzene soluble fraction	356	722	<0.1 mg/m^3
Pressure Washer	Total Particulates	356	722	0.10 mg/m^3
Personal Breathing Zone Air Samples—Worker J				
Spray cleaning	Benzene soluble fraction	227	458	<0.2 mg/m^3
Spray cleaning	Total Particulates	227	458	(0.072 mg/m^3)
Personal Breathing Zone Air Samples—Worker K				
Hose holder	Benzene	498	49.4	<0.001 ppm
Hose holder	2 Butoxyethanol	490	49.0	0.072 ppm
Hose holder	Dipropylene glycol butyl ether	490	49.0	<0.0007 ppm
Hose holder	Ethyl benzene	498	49.4	<0.0009 ppm
Hose holder	Limonene	498	49.4	0.066 ppm
Hose holder	Proylene glycol ethyl ether	490	49.0	<0.001 ppm
Hose holder	Toluene	498	49.4	<0.001 ppm
Hose holder	Total hydrocarbons	498	49.4	0.54 mg/m^3
Hose holder	Xylenes	498	49.4	<0.002 ppm

Table 4. Personal breathing zone and area air concentrations for substances measured at C-Port boat/boom decontamination site on August 10, 2010 (continued)				
Activity/Site	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker L				
Pressure Washer	Benzene	506	50.2	<0.001 ppm
Pressure Washer	2 Butoxyethanol	505	51.8	0.068 ppm
Pressure Washer	Dipropylene glycol butyl ether	505	51.8	<0.0007 ppm
Pressure Washer	Ethyl benzene	506	50.2	(0.0019 ppm)
Pressure Washer	Limonene	506	50.2	0.024 ppm
Pressure Washer	Proylene glycol ethyl ether	505	51.8	<0.001 ppm
Pressure Washer	Toluene	506	50.2	<0.001 ppm
Pressure Washer	Total hydrocarbons	506	50.2	0.27 mg/m^3
Pressure Washer	Xylenes	506	50.2	<0.002 ppm
Area Air Samples				
Smoking Tent farthest from decontamination tent	Diesel exhaust	458	916	EC: 1.9 $\mu g/m^3$; OC: (26 $\mu g/m^3$)
Smoking Tent nearest decontamination tent	Diesel exhaust	593	1190	EC: 2.1 $\mu g/m^3$; OC: <20 $\mu g/m^3$
Smoking Tent near container	Diesel exhaust	570	1150	EC: 1.8 $\mu g/m^3$; OC: <20 $\mu g/m^3$
Generator NE nearest barge	Diesel exhaust	606	1220	EC: 0.90 $\mu g/m^3$; OC: <20 $\mu g/m^3$
Generator 0505-6W	Diesel exhaust	585	1180	EC: 1.6 $\mu g/m^3$; OC: <20 $\mu g/m^3$
Generator 0505-5	Diesel exhaust	588	1180	EC: 2.5 $\mu g/m^3$; OC: (24 $\mu g/m^3$)

*Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration.
†Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration).

Table 5. Personal breathing zone and area air concentrations for substances measured at Charlie Company boat/boom decontamination site on August 10, 2010

Activity	Substance	Sampling Information		Sample Concentration*†
		Time (min)	Volume (Liters)	
Personal Breathing Zone Air Samples—Worker M				
Decontamination‡	Acenaphthene	556	565	<0.00009 mg/m^3
Decontamination	Acenapthylene	556	565	<0.00007 mg/m^3
Decontamination	Anthracene	556	565	0.00094 mg/m^3
Decontamination	Benzo(a)anthracene	556	565	(0.00012 mg/m^3)
Decontamination	Benzo(a)pyrene	556	565	<0.0002 mg/m^3
Decontamination	Benzo(b)fluoranthene	556	565	(0.00017 mg/m^3)
Decontamination	Benzo(e)pyrene	556	565	<0.0001 mg/m^3
Decontamination	Benzo(g,h,i)perylene	556	565	(0.00027 mg/m^3)
Decontamination	Benzo(k)fluoranthene	556	565	<0.0001 mg/m^3
Decontamination	Chrysene	556	565	0.0037 mg/m^3
Decontamination	Dibenzo(a,h)anthracene	556	565	<0.0002 mg/m^3
Decontamination	Fluoranthene	556	565	<0.0001 mg/m^3
Decontamination	Fluorene	556	565	(0.00023 mg/m^3)
Decontamination	Indeno(1,2,3-cd)pyrene	556	565	<0.0001 mg/m^3
Decontamination	Naphthalene	556	565	0.000088 ppm
Decontamination	Phenanthrene	556	565	0.0013 mg/m^3
Decontamination	Pyrene	556	565	0.00057 mg/m^3
Decontamination	Total PAHs	556	565	0.0040 mg/m^3
Personal Breathing Zone Air Samples—Worker N				
Decontamination	Benzene soluble fraction	556	1110	<0.06 mg/m^3
Decontamination	Total Particulates	556	1110	0.11 mg/m^3
Personal Breathing Zone Air Samples—Worker O				
Decontamination	Benzene	558	55.9	<0.001 ppm
Decontamination	2 Butoxyethanol	558	56.3	0.11 ppm
Decontamination	Dipropylene glycol butyl ether	558	56.3	<0.0005 ppm
Decontamination	Ethyl benzene	558	55.9	<0.0008 ppm
Decontamination	Limonene	558	55.9	0.020 ppm
Decontamination	Proylene glycol ethyl ether	558	56.3	<0.0008 ppm
Decontamination	Toluene	558	55.9	<0.001 ppm
Decontamination	Total hydrocarbons	558	55.9	0.25 mg/m^3
Decontamination	Xylenes	558	55.9	<0.002 ppm

Table 5. Personal breathing zone and area air concentrations for substances measured at Charlie Company boat/boom decontamination site on August 10, 2010 (continued)				
Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker P				
Decontamination	Acenaphthene	540	538	<0.00009 mg/m^3
Decontamination	Acenapthylene	540	538	<0.00007 mg/m^3
Decontamination	Anthracene	540	538	0.0013 mg/m^3
Decontamination	Benzo(a)anthracene	540	538	<0.00009 mg/m^3
Decontamination	Benzo(a)pyrene	540	538	<0.0002 mg/m^3
Decontamination	Benzo(b)fluoranthene	540	538	<0.0001 mg/m^3
Decontamination	Benzo(e)pyrene	540	538	<0.0001 mg/m^3
Decontamination	Benzo(g,h,i)perylene	540	538	<0.00009 mg/m^3
Decontamination	Benzo(k)fluoranthene	540	538	<0.0001 mg/m^3
Decontamination	Chrysene	540	538	0.0093 mg/m^3
Decontamination	Dibenzo(a,h)anthracene	540	538	<0.0002 mg/m^3
Decontamination	Fluoranthene	540	538	<0.0001 mg/m^3
Decontamination	Fluorene	540	538	(0.00035 mg/m^3)
Decontamination	Indeno(1,2,3-cd)pyrene	540	538	<0.0001 mg/m^3
Decontamination	Naphthalene	540	538	0.000071 ppm
Decontamination	Phenanthrene	540	538	0.0012 mg/m^3
Decontamination	Pyrene	540	538	0.00056 mg/m^3
Decontamination	Total PAHs	540	538	0.0046 mg/m^3
Personal Breathing Zone Air Samples—Worker Q				
Decontamination	Benzene soluble fraction	539	1090	<0.06 mg/m^3
Decontamination	Total Particulates	539	1090	0.12 mg/m^3
Personal Breathing Zone Air Samples—Worker R				
Decontamination	Benzene	544	54.6	<0.001 ppm
Decontamination	2 Butoxyethanol	543	54.2	0.076 ppm
Decontamination	Dipropylene glycol butyl ether	543	54.2	<0.0005 ppm
Decontamination	Ethyl benzene	544	54.6	<0.0008 ppm
Decontamination	Limonene	544	54.6	0.019 ppm
Decontamination	Proylene glycol ethyl ether	543	54.2	<0.0009 ppm
Decontamination	Toluene	544	54.6	<0.001 ppm
Decontamination	Total hydrocarbons	544	54.6	0.30 mg/m^3
Decontamination	Xylenes	544	54.6	<0.002 ppm

Table 5. Personal breathing zone and area air concentrations for substances measured at Charlie Company boat/boom decontamination site on August 10, 2010 (continued)				
Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker S				
Decontamination	Acenaphthene	542	548	(0.00020 mg/m^3)
Decontamination	Acenapthylene	542	548	<0.00007 mg/m^3
Decontamination	Anthracene	542	548	0.0029 mg/m^3
Decontamination	Benzo(a)anthracene	542	548	<0.00009 mg/m^3
Decontamination	Benzo(a)pyrene	542	548	<0.0002 mg/m^3
Decontamination	Benzo(b)fluoranthene	542	548	(0.00014 mg/m^3)
Decontamination	Benzo(e)pyrene	542	548	<0.0001 mg/m^3
Decontamination	Benzo(g,h,i)perylene	542	548	<0.00009 mg/m^3
Decontamination	Benzo(k)fluoranthene	542	548	<0.0001 mg/m^3
Decontamination	Chrysene	542	548	0.0044 mg/m^3
Decontamination	Dibenzo(a,h)anthracene	542	548	<0.0002 mg/m^3
Decontamination	Fluoranthene	542	548	<0.0001 mg/m^3
Decontamination	Fluorene	542	548	(0.00027 mg/m^3)
Decontamination	Indeno(1,2,3-cd)pyrene	542	548	<0.0001 mg/m^3
Decontamination	Naphthalene	542	548	0.000084 ppm
Decontamination	Phenanthrene	542	548	0.0012 mg/m^3
Decontamination	Pyrene	542	548	0.00046 mg/m^3
Decontamination	Total PAHs	542	548	0.0035 mg/m^3
Personal Breathing Zone Air Samples—Worker T				
Decontamination	Benzene soluble fraction	540	1070	<0.07 mg/m^3
Decontamination	Total Particulates	540	1070	0.10 mg/m^3
Personal Breathing Zone Air Samples—Worker U				
Decontamination	Acenaphthene	541	542	(0.00028 mg/m^3)
Decontamination	Acenapthylene	541	542	<0.00007 mg/m^3
Decontamination	Anthracene	541	542	0.00096 mg/m^3
Decontamination	Benzo(a)anthracene	541	542	<0.00009 mg/m^3
Decontamination	Benzo(a)pyrene	541	542	<0.0002 mg/m^3
Decontamination	Benzo(b)fluoranthene	541	542	(0.00012 mg/m^3)
Decontamination	Benzo(e)pyrene	541	542	<0.0001 mg/m^3
Decontamination	Benzo(g,h,i)perylene	541	542	<0.00009 mg/m^3
Decontamination	Benzo(k)fluoranthene	541	542	<0.0001 mg/m^3
Decontamination	Chrysene	541	542	0.0014 mg/m^3
Decontamination	Dibenzo(a,h)anthracene	541	542	<0.0002 mg/m^3
Decontamination	Fluoranthene	541	542	<0.0001 mg/m^3
Decontamination	Fluorene	541	542	(0.00033 mg/m^3)
Decontamination	Indeno(1,2,3-cd)pyrene	541	542	<0.0001 mg/m^3
Decontamination	Naphthalene	541	542	0.00019 ppm
Decontamination	Phenanthrene	541	542	0.0011 mg/m^3
Decontamination	Pyrene	541	542	0.00037 mg/m^3
Decontamination	Total PAHs	541	542	0.0041 mg/m^3

Table 5. Personal breathing zone and area air concentrations for substances measured at Charlie Company boat/boom decontamination site on August 10, 2010 (continued)				
Activity	**Substance**	**Sampling Information**		**Sample Concentration*†**
		Time (min)	**Volume (Liters)**	
Personal Breathing Zone Air Samples—Worker V				
Decontamination	Acenaphthene	542	542	<0.00009 mg/m^3
Decontamination	Acenapthylene	542	542	<0.00007 mg/m^3
Decontamination	Anthracene	542	542	0.0012 mg/m^3
Decontamination	Benzo(a)anthracene	542	542	<0.00009 mg/m^3
Decontamination	Benzo(a)pyrene	542	542	<0.0002 mg/m^3
Decontamination	Benzo(b)fluoranthene	542	542	<0.0001 mg/m^3
Decontamination	Benzo(e)pyrene	542	542	<0.0001 mg/m^3
Decontamination	Benzo(g,h,i)perylene	542	542	<0.00009 mg/m^3
Decontamination	Benzo(k)fluoranthene	542	542	<0.0001 mg/m^3
Decontamination	Chrysene	542	542	0.0042mg/m^3
Decontamination	Dibenzo(a,h)anthracene	542	542	<0.0002 mg/m^3
Decontamination	Fluoranthene	542	542	<0.0001 mg/m^3
Decontamination	Fluorene	542	542	(0.00024 mg/m^3)
Decontamination	Indeno(1,2,3-cd)pyrene	542	542	<0.0001 mg/m^3
Decontamination	Naphthalene	542	542	0.000063 ppm
Decontamination	Phenanthrene	542	542	0.0012 mg/m^3
Decontamination	Pyrene	542	542	0.00057 mg/m^3
Decontamination	Total PAHs	542	542	0.0030 mg/m^3
Personal Breathing Zone Air Samples—Worker W				
Decontamination	Benzene soluble fraction	538	1020	<0.07 mg/m^3
Decontamination	Total Particulates	538	1020	0.091 mg/m^3
Personal Breathing Zone Air Samples—Worker X				
Decontamination	Benzene	533	53.8	<0.001 ppm
Decontamination	2 Butoxyethanol	545	54.1	(0.057 ppm)
Decontamination	Dipropylene glycol butyl ether	545	54.1	<0.0007 ppm
Decontamination	Ethyl benzene	533	53.8	<0.0009 ppm
Decontamination	Limonene	533	53.8	0.013 ppm
Decontamination	Proylene glycol ethyl ether	545	54.1	<0.001 ppm
Decontamination	Toluene	533	53.8	<0.001 ppm
Decontamination	Total hydrocarbons	533	53.8	0.33 mg/m^3
Decontamination	Xylenes	533	53.8	<0.002 ppm

*Concentrations reported as "<" were not detected; the given value is the minimum detectable concentration.
†Concentrations in parentheses were between the minimum detectable concentration and the minimum quantifiable concentration (parentheses are used to point out there is more uncertainty associated with these values than values above the minimum quantifiable concentration).
‡Decontamination workers at this site were not assigned one particular activity; they rotated job activities such as brushing, pressure washing, and spray cleaning throughout the day.

Interim Report #8B
Evaluation of Equipment and Boat Repair/Decontamination, and Waste Management Workers; Alabama, Florida, Louisiana, and Mississippi, July and August 2010

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Introduction

In July 2010 National Institute for Occupational Safety and Health (NIOSH) investigators made multiple site visits to on-shore worksites where Deepwater Horizon response activities were occurring. The worksites evaluated included (1) shore cleaning; (2) wildlife cleaning and rehabilitation; and (3) equipment and boat repair/decontamination and (4) waste management. This report presents the findings for repair/decontamination and waste management.

Evaluation

NIOSH investigators were organized in teams assigned to specific areas by a NIOSH coordinator. One investigator typically focused on observational exposure assessment and site characterization and the other focused on collecting health symptom data among the workers at the site. The NIOSH teams were based out of the command centers in Mobile, Alabama, and Houma, Louisiana. On-shore worksite were chosen for evaluation based on input from the command centers; among the factors considered in selection of sites were estimates of likely level of contamination, type of work activity, and number of workers. Efforts were made to evaluate worksites in each of the four affected States. Eleven equipment and boat repair/decontamination sites were visited including two in Florida (Greater Pensacola area and Oskaloosa County); three in Mississippi (Pascagoula – Jackson County, Hancock County, and Biloxi – Harrison County); four in Alabama (one on Dauphin Island, two in Theodore, and one in Gulf Shores – Orange Beach); and two in Louisiana (Grand Isle and Port Fourchon) (see Table 1)[1]. Six waste management operations were observed including three in Alabama (Theodore, Mobile, and Mt. Vernon) and three in Louisiana (Port Fourchon, Cocodrie, and Pointe Aux Chenes).

Upon arrival at each site, NIOSH investigators contacted the site safety officer to coordinate activities. When possible, the NIOSH investigators were introduced to the assembled workers at the site safety briefing. Self-administered health symptom surveys were distributed to workers at various times in the work shift (depending on multiple factors at each of the sites) and collected by NIOSH investigators. The surveys were offered to all workers in the groups directly contacted by the NIOSH investigator. However because of scheduling conflicts and other logistic issues, NIOSH investigators did not have access to all

[1] Two of the 17 sites described in the text are not included in Table 1

workers at all sites. The one-page health symptoms survey covered demographics, job duties, exposure to oil or other substances, symptoms experienced by workers, and other health-related topics. The purpose of the survey was to (1) assist NIOSH investigators in identifying health problems potentially requiring intervention, and (2) assist in generating hypotheses for future research. The survey was not specifically designed to allow for determinations of the cause(s) of reported health conditions.

NIOSH investigators estimated that 875 workers worked at 15 of the equipment and boat repair/decontamination and waste management sites (described in Table 1) around the time of the NIOSH evaluations; 499 (57%) workers at those site completed the health symptom survey. Table 2 presents a summary of participant demographic information. The results of the symptom surveys are presented in this report and compared to the findings of the same survey administered to workers at the Venice, Louisiana, Field Operations Branch and the Venice Commanders' Camp. The 103 workers in the comparison group reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals.

With the exception of measurement of temperature and relative humidity, exposure assessments were observational in nature. To maximize consistency and comparability of observations from site to site, teams made observations using a structured checklist. The checklist included assessment of chemical and physical exposures as well as of interventions for minimizing exposures; for example, gloves to minimize hand contact with oil or long sleeve shirts to reduce radiant heat exposure. The chemical agents of concern included oil, dispersants, and cleaning agents. The physical agents included heat and pest hazards. Pest hazards potentially included insects (mosquitoes, biting flies, and ticks), plants (poison ivy), and dangerous reptiles (poisonous snakes and alligators).

Indicators of chemical exposure used direct and in-direct measures. Direct measures include identification of worker contact with the chemical, e.g., job task description, chemical agent identity (oil, dispersant, and cleaning agent), form and concentration of chemical agent, and work practices. Indirect measures included documentation of the use of exposure control strategies such as protective gloves for handling oil-soaked materials. Indicators of exposure to physical hazards were largely determined by indirect measures. For heat exposure, measures of heat index can be helpful in indentifying the potential for exposure but an individual's use of sunscreen, body covering (long sleeve shirts, trousers, and hats), exposure times, rest breaks and periodicity, and water intake affect risk for heat stress. Heat index data were recorded when available.

Results

Sixty-seven on-shore worksites were evaluated by NIOSH investigators. At each site, they gave feedback to supervisors, site safety leaders, BP safety representatives, and workers, when warranted. At 59 of the 67 sites the structured checklist was used. Of those 59 sites, 15 (25%) were equipment and boat repair/decontamination or waste management sites. The exposure assessment checklist included a qualitative assessment by the NIOSH investigator about the level of oil residue at the site at the time of the survey. NIOSH investigators judged one to have no residue, four to have "light" residue, seven to have "moderate" residue, and one to "heavy" residue.

Process and Site Descriptions

Florida

Two operations were observed in Florida: a land-based equipment decontamination facility and a vessel decontamination facility (personally-owned vessels and Coast Guard vessels). In Escambia, Florida, a NIOSH team evaluated the Pensacola Equipment Decontamination facility where boats, all-terrain vehicles (ATV), loaders, tanks, booms, and skimmers were cleaned and decontaminated. In the land-based operation, a citrus-based cleaner and a detergent were applied to contaminated items with a garden sprayer. Items were also steam cleaned and wiped down with an absorbent cloth. Also in Escambia, the investigative team visited Pier B (the Coast Guard Vessel Decontamination facility). Here, workers used personal protective equipment (PPE) consisting of Tyvek® suits, nitrile gloves, rubber boots, and safety glasses. Workers frequently were required to wear personal flotation devices (PFDs). Workers set up rest areas and decontamination areas (boundaries were marked with spray paint). The decontamination areas were covered with a "carpet" of absorbent material, which periodically was removed, placed in plastic bags, duct taped, taken off ship, and placed into a dumpster. The deck of the vessel was then cleaned with Simple Green™ and wiped down with an absorbent cloth. The vessel rails and other components (e.g., cables) were wiped down with cloth rags soaked in Simple Green™. The deck was then recovered with plastic and the absorbent carpet material.

Alabama

Three types of operations were observed in Alabama: equipment (e.g., boats, boom, ATV) decontamination, waste management, and boom repair. At the Boggy Point site in Orange Beach, boat hulls were cleaned with a hot water mist from a handheld "mini turbo" sprayer and the residue was suctioned off. Suctioned liquid was moved to a holding tank and then to an approximately 21,000-gallon fractionating tank. Boats up to 37 feet in length were treated here. Also cleaned were booms, ATVs, and other items. Workers also used absorbent towels for hand wiping. At the Theodore Industrial Port, equipment and parts were unloaded from vessels, trailers, or trucks. Contaminated equipment was tagged to track origin and deployment location. This was the first of five planned decontamination facilities in the region to handle contaminated boom materials. The booms were brought in by boat and truck. Riggers hooked the tied up batches of boom to crane hooks. Crane operators then lifted the materials to an area next to the two bays set up for oil decontamination. Two other bays were used for non-oil contaminated materials. For example, booms in need of repair or covered with algae were washed here before being sent for repair. Simple Green™ and high pressure hot water were used to clean the booms. The booms were spread out on a 100-foot long deck over two layers of plywood suspended in water in a plastic and felt lined bath. The water in the bath was siphoned off, oil was removed, and the water was filtered and returned to the baths. Household bleach also was used. The decontamination area was staged so that when work was complete, PPE was doffed in an appropriate manner to facilitate cleaning and reduce cross-contamination.

NIOSH investigators also evaluated night shift operations at the Theodore Industrial Port and waste management operations at the Claudia Street Staging Area. Operations were designed to capture liquid waste from vessel tanks with a vacuum truck but were not yet operational at the time of the NIOSH evaluation, although some boxes of solid waste had been received. Oil-contaminated waste was separated from other waste (e.g., bottles, plastic, food, and other general beach debris), bagged, and sealed at a specific weight limit. However, the Alabama Department of Environmental Management had determined that solid waste was considered non-hazardous and was therefore mixed with community solid waste in a landfill. A record was maintained of the location of the landfill where the waste was deposited. NIOSH investigators also observed activities at the Chastang Landfill. It was reported that oil release solid waste, including items such as absorbent booms, bottles, plastic, and PPE booties and gloves, accounted for less than 1% of the waste entering the landfill.

Mississippi
Four types of operations were observed in Mississippi: boom decontamination, boom repair, off-shore vessel decontamination, and off-site road side cleaning. At the 8th Street decontamination site, investigators observed boom decontamination. Workers wore Tyvek® suits and sprayed booms using high pressure water with a citric acid mix. At this site, investigators also observed repair of booms that had been decontaminated. Booms were placed on raised tables for repair. At the Point Cadet decontamination site, investigators observed a night shift boom repair operation. The operation primarily involved patching holes in booms and replacing sections of steel cable. Tools included screw drivers, heat fans, cutting chains, bolt drivers, grinders, and ball peen hammers. In Hancock County, NIOSH investigators observed two-person crews using high pressure water spray to clean the containment walls at the side of a road. A crew was rotated off every 30 minutes.

Louisiana
Four types of operations were observed in Louisiana: boom repair, decontamination, and waste management; decontamination of beach cleaning workers; small vessel decontamination; and sand treatment. At the Grand Isle shipyard, NIOSH investigators observed the large boom decontamination station. The decontamination of hard booms dominated operations, however, some decontamination of small vessels (vessels fitting into a 30’x60’ containment area and weighing less than 50 tons) was observed. Absorbent booms and other contaminated items (such as PPE and discarded materials from vessels) were disposed in an industrial landfill. Decontamination was done with the use of pressure washers and a citrus-based degreaser. The pressure washers were mainly diesel-powered; however, some gasoline-powered units were observed. Some pressure washers were used in potentially occupied areas, possibly exposing workers to diesel exhaust. All waste water and material was contained and processed. Also in Grand Isle, investigators observed the decontamination of beach cleaning workers. Decontamination workers wore Tyvek® suits, rubber gloves, and boots. Shore cleaning workers were processed through two pools, the first for cleaning (using a chemical cleansing agent, RC-7) and the second for rinsing. At the same location, investigators observed the sand treatment system, which involved operators taking pre-cleaned sand and dumping the sand into a screening area; the sand was then processed by a hot water treatment system. Day and night shift operations occurred at the Port Fourchon decontamination station. NIOSH investigators observed the night shift when workers unloaded oil-soaked booms off barges. At these sites contaminated booms and sand were transferred from local trucks to long-haul trucks destined for a landfill north of Baton Rouge. Skim barges were also processed; the oil-contaminated water was pumped through hoses to tanker trucks for transport to another waste management location. At Pointe Aux Chenes, most employees operated on small vessels (shrimp boats and skiffs) placing booms around marsh areas. Hard booms required constant maintenance to ensure that they stayed in place. Absorbent booms needed to be periodically changed, so workers placed new booms and collected used booms. Used absorbent booms were bagged on the boats and transported to shore where they were unloading directly into waste roll-off boxes for eventual landfill disposal. Similar waste management operations were observed at the Cocodrie shoreline decontamination site.

Exposure Characterization

Decontamination activities provided potential for exposure to weathered oil and cleaning agents, many of which were citrus-based. Decontamination activities placed operators near contaminated items. The use of power washers posed unique exposure risks. Large diesel-powered pressure washing machines were located in areas where workers could be exposed to exhaust particulate and gases. A few small gasoline-powered pumps were used in some areas. Investigators suggested to the project manager and safety personnel exhaust gases from these machines be re-routed higher with stacks to avoid gases being released in occupied areas. NIOSH investigators advised that equipment manufacturers be consulted to ensure that modifications did not introduce other hazards. All pressure washers and gasoline-powered pumps were located outdoors. NIOSH investigators also suggested that pressure washers and gasoline-powered pumps be moved to unoccupied areas and areas downwind from occupied areas. The safety specialists and project managers were informed of potential carbon monoxide hazards associated with gasoline-powered equipment and also particulate and respiratory hazards associated with diesel exhaust.

Another concern raised by NIOSH investigators was the use of recycled and stored water for pressure washing. Skin contact and inhalation of aerosolized spray were of concern because of the potential for exposure to chemical and/or microbial contaminants in the recycled water. At some worksites supervisory staff was unfamiliar with proper procedures for storage and use of recycled water.

NIOSH investigators observed that many of the potential exposures noted above were mitigated through the use of PPE. In general, PPE was standardized across worker groups based on assigned tasks. Most decontamination workers wore combinations of Tyvek® suits, gloves, rubber boots, safety glasses (or face shields), hearing protection, and hard hats. When activities involved moving into water at shallow depths, hip waders were worn over the Tyvek® suits. Some workers wore respirators; however, the respiratory protection programs were not evaluated by NIOSH investigators.

Heat stress was the most significant hazard at the visited sites, and NIOSH investigators noted that decontamination workers were at increased risk due to layering of PPE. Temperature and relative humidity measurements were recorded by NIOSH investigators at a few worksites (Table 3). NIOSH investigators found that issues related to heat appeared well-managed and controlled. BP contractor site safety leads were vigilant about monitoring the temperature and relative humidity and enforcing rest/work regimens. Many managers used a more conservative standard than the heat index work/rest chart provided to all contractors (included within “Comprehensive Heat Stress Management Plan, June 19, 2010” which was used at all sites). Heat and humidity played important roles in limiting the amount of work performed. Methods of measuring heat and humidity varied; sometimes safety technicians had small portable measurement devices (not scientific instruments). NIOSH investigators noted that temperature measurements varied by several degrees at the same location, in large part because of the location of the measurement device. At some sites information was drawn from a commercial or government weather information web site or was “texted to” the safety leads regularly throughout the day. NIOSH investigators observed that when safety technicians had to make qualitative judgments to interpret the heat stress guidelines, they generally erred on the side of worker protection. Shaded rest areas were provided at each site. Some rest areas had only a few chairs so workers occasionally sat on plastic mats or stood during breaks. Other weather hazards were well-managed and controlled. If lightning was electronically detected or observed, all outside work stopped and workers took shelter until an “all-clear” signal was given.

Work organization was another concern noted by NIOSH investigators. Most workers were on 12-hour shifts, 7 days a week. Many workers reported that they had not taken any days off for many days (up to 40). Long work hours under the extreme heat conditions were also of concern. Night shift (6:00 p.m. – 6:00 a.m.) workers worked under less heat; however, NIOSH investigators observed that continuous night shift work or frequent rotation between night and day could contribute to fatigue. Many workers reported commuting long distances (up to 90 minutes one way).

To apply patches, boom repair workers used a solvent-based (solvents included tetrohydrofuran and acetone) chemical adhesive (identified as a skin absorption/penetration hazard on the Material Safety Data Sheet) nearly continuously during the work shift. Skin exposures were identified as a potential health hazard by NIOSH investigators. Workers were not provided, or wearing, chemically-resistant gloves. They were provided and worked with either leather gloves or latex gloves. Several workers wore only medical latex gloves while manually applying and handling the solvent-based adhesive. No respiratory protection was observed; the process occurred outdoors and fans were sometimes used. Some workers applied adhesive while holding the open container of the solvent-based adhesive either directly under, or in, their personal breathing zone.

Reported Symptoms

Results of the symptoms survey are presented in Table 4. This table includes injuries and symptoms for workers at the repair/decontamination and waste management sites and for the comparison group of workers recruited at the Venice, Louisiana site. The etiology of the reported health symptoms is likely multi-factorial and likely to include both occupational and non-occupational factors. A discussion of selected aspects of the data from the symptoms survey is presented here.

Questions potentially related to heat stress symptoms were included in the symptom survey. One or more of nine non-specific symptoms (see Table 4) that could be related to heat stress were reported by 38% of the repair/decontamination and waste management workers. Four or more of the symptoms, a constellation of symptoms considered in this evaluation as a more specific indicator of heat stress, were reported by 6%. Both indicators of heat stress were more prevalent among the on-shore workers than among the comparison group.

Many of the other health outcomes and symptoms included in the symptoms survey were also more prevalent among the repair/decontamination and waste management workers when compared to the comparison group. Among the individual symptoms reported most frequently were headaches (reported by 27%) coughing (reported by 16%); and hand, shoulder, or back pain (reported by 17%). Sixteen percent of the repair/decontamination and waste management workers reported one or more of five psychosocial symptoms (feeling worried or stressed, pressured, depressed or hopeless, short tempered, frequent changes in mood).

Discussion

The work sites described in this report had effective programs in place to reduce potential occupational hazards during repair/decontamination, and waste management operations. Nevertheless, for nearly all health outcomes, more injuries and symptoms were reported among these workers than among the comparison worker group. This is not surprising given the strenuous work being performed in hot outdoor conditions. Although a specific etiology for the various injuries and symptoms is not possible to determine from this evaluation, documentation of the self-reported symptoms among the workers in this evaluation may be useful for future clinical and/or epidemiologic evaluations.

Among the potential occupational hazards unique to repair/decontamination and waste management work was pressure washing. The use of pressure washers on contaminated materials, and recycling this water, could aerosolize contaminants (including oil, cleaning agents, and microbes) creating an inhalation hazard. Although a specific respiratory hazard was not identified in these evaluations, the potential for aerosol inhalation should be considered in future repair/decontamination and waste management operations. Additionally, state or federal regulations related to large scale pressure washing activities may apply in some areas.

Dermal contact with water and contaminants was limited during pressure washing activities by the use of barrier PPE such as Tyvek® suits, gloves, and eye protection or face shields. Nevertheless, incomplete protection of the skin from the contaminated water used in these activities likely was a cause for some of the skin symptoms reported in the symptom survey. Additionally, PPE by itself, along with exposure to heat, are other occupational factors potentially related to some of the skin symptoms reported by survey participants

Although this report focuses on issues related to repair/decontamination and waste management workers, many potential occupational hazards faced by these workers are similar to those faced by other Deepwater Horizon response workers. High temperatures at the worksites and physically demanding work often requiring use of PPE could contribute to the risk for heat-related and other health symptoms. NIOSH investigators determined that heat stress was an important occupational health issue for most repair/decontamination and waste management workers, but exposure to heat was well-managed and controlled by site supervisory personnel at most sites. BP and contractor site safety leads were vigilant about monitoring temperature and relative humidity and enforcing rest/work regimens when they were in place. However, NIOSH investigators found that shaded rest areas were not readily available at several worksites. Sun exposure was also a concern.

NIOSH investigators noted that guidelines for PPE use (and use of other protective equipment such as PFDs) may have led to equipment use above what was necessary for adequate protection at some worksites visited for this evaluation. Observation of PPE use in very hot and humid conditions made it clearly evident that PPE use can contribute to heat stress and skin irritation or rashes. Recommendations concerning PPE use, including some of the exceptions to the usual PPE recommendations, are provided below.

The ergonomic hazards faced by repair/decontamination and waste management workers were unique among Deepwater Horizon response workers because of the specific work performed at these sites. Work tasks such as handling and moving booms and other equipment to be cleaned and the actions associated with operating the pressure washers are likely to lead to awkward and heavy lifting tasks, potentially related to the reported musculoskeletal symptoms.

This evaluation found that nearly 20% of participants reported one or more of five psychosocial symptoms. All Deepwater Horizon response workers may have experienced psychosocial stressors in the course of their response work. Those doing repair/decontamination and waste management work may have been at risk of psychosocial stressors from specific aspects of their work or from other circumstances more generally related to the oil release (such as the impact on the fishing communities and the environment in general). Long work hours (many times in conditions of high heat index as noted above) can be an important concern for response workers. Efforts to minimize exposure to heat, such as working night shifts, can contribute to fatigue and psychosocial stress. Other contributing factors for fatigue many have included working many days as and long commuting distances.

These findings provide an overview of health and safety issues relevant for these Deepwater Horizon response workers. However, the following limitations are noted:

1. Exposure assessments were observational. Although a checklist was used, it lacked objective definitions for some items, such as levels of oil residue, so that inter-rater variability likely existed among NIOSH investigators. Moreover, scales used by NIOSH investigators may not have been comparable to those used by other agencies or organizations.
2. NIOSH investigators typically visited each worksite for one work shift. Work conditions changed over time, likely leading to changing exposure to occupational hazards.
3. The exposure and health data collected in the symptom survey were self-reported and not able to be verified by NIOSH investigators.

Recommendations

NIOSH and the Occupational Safety and Health Administration (OSHA) have released an interim document ("Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers") providing guidance on protecting response workers, including information on heat stress and fatigue prevention, use of appropriate PPE for response activities, and many other topics. Those responsible for oil spill response work activities and workers should consult this document for recommendations to help minimize occupational health problems at their sites. The document, available on the NIOSH website, http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/, provides details related to the recommendations noted below:

1. Repair/decontamination and waste management workers should follow appropriate heat stress management plans when the work occurs in hot conditions. As a part of the plan, close supervisory observation of workers with potential for heat-related illness should be continued, with formal work/rest cycles used as appropriate. The plan in place during this evaluation ("Comprehensive Heat Stress Management Plan, June 19, 2010") contains the elements of a complete plan.
    a. Determinations concerning the need for PPE (including PFDs) during response work in a hot environment should be made should balance the risks of exposure to hazardous agents with the risk for heat stress posed by PPE.

2. Repair/decontamination and waste management workers have potential for health risks from dermal and inhalation exposures to oil, cleaning agents, water or water solutions contaminated with microbes, oil or cleaning agents, and equipment used in their work. Controls to minimize skin, mucus membrane, and inhalation exposures should be implemented. Such controls should include a combination of engineering, administrative, and work practice controls (for example, proper maintaining stored and recycled water, minimizing generation of water spray and aerosols) and PPE. Considerations for PPE should include eye protection [safety glasses, safety goggles, or face shields depending on the splash potential], hand and body covering (gloves and body covering of appropriate material), and respiratory protection.
    a. Use of recycled and stored water or water-based solutions for pressure washing is a potential skin and respiratory health hazard due to chemical and/or microbial contamination in the water. All sites where pressure-washing or other aerosol-generating activities are occurring should evaluate the need for workplace controls including PPE.
    b. Worksite supervisors should be aware of potential carbon monoxide hazards caused by use of diesel and gasoline-powered engines. Power equipment should be used only in well-ventilated areas away from air intakes. NIOSH recommendations concerning carbon monoxide can be found at http://www.cdc.gov/niosh/topics/co/.

3. Facilities where repair/decontamination and waste management occur should be aware of the need to reduce the potential for musculoskeletal disorders. Such steps generally would include providing adequate staffing for work tasks, using work rotation schedules, and providing appropriate equipment and tools. Additional information on methods to reduce ergonomic hazards can be found on the NIOSH website (http://www.cdc.gov/niosh/topics/ergonomics/).
    a. Slippery walking or standing surfaces should be minimized by appropriate maintenance/cleaning procedures. Where slippery conditions may exist appropriate non-slip footwear should be made available to workers.

4. Supervisors of disaster response workers should have management plans in place to minimize fatigue risks, recognize hazards associated with altered work schedules, and provide regular opportunities for worker rest and recovery. The NIOSH OSHA interim guidelines noted above provide details about managing stress and fatigue during and after a response.

5. During the course of response work, workers should be encouraged to report health concerns or injuries to their supervisor or on-scene safety representatives, and seek care through established on-site medical facilities or other healthcare providers as appropriate.

6. State or federal regulations relevant to pressure washing should be understood and followed, where applicable. In the Southeast U.S., the U.S. Environmental Protection Agency Region 4 Water Protection Division may be a source of important information related to this topic (http://www.epa.gov/region4/water/).

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Table 1. Description of repair/decontamination and waste management worksites evaluated with the observations checklist						
State	**Number of Sites Evaluated with Checklist**	**Number of Workers at Sites Completing Symptom Survey**	**Assessment of Level of Oil Residue (Number of sites at each level)***			
			None	**Light**	**Moderate**	**Heavy**
Alabama	7	230	0	2	5	0
Florida	2	23	0	0	1	1
Louisiana	3	212	0	1	0	0
Mississippi	3	34	1	1	1	0
Total	15	499	1	4	7	1

*The checklist included a qualitative assessment of the level of contamination of the worksite: none, light, moderate, and heavy; information concerning contamination was available for 13 of the 15 sites.

Table 2. Health symptom survey—demographics by group		
	Repair/Decontamination and Waste Management	**Unexposed***
Number of participants	499	103
Age (median, range)	33 (18–66)	18–70
Race		
% White	213 (43%)	40%
% Hispanic	94 (19%)	29%
% Asian	1 (<1%)	9%
% Black	160 (32%)	19%
% Other	20 (4%)	3%
Male (number, % of total)	468 (94%)	96%
Days worked oil spill (median, range)	30 (1–90)	0–45

*Participants were recruited from the Venice Field Operations Branch and the Venice Commanders' Camp. Those who reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals were included in this group; median age not available.

Table 3. Summary of temperature, relative humidity, and heat index at worksites	
	Mean (range)*
Temperature (°F)	90 (85–96)
Relative Humidity (%)	58 (57–59)
Heat Index	100 (89–115)

*Based on values recorded by NIOSH investigators at four worksites during the workshifts.

Table 4. Health symptom survey—reported injuries and symptoms by group		
	Repair/ Decontamination & Waste Management Workers (n=499)	**Unexposed* (n=103)**
	No. (%)	No. (%)
Injuries		
Scrapes or cuts	55 (11%)	11 (11%)
Burns by fire	2 (0.4%)	1 (1%)
Chemical burns	4 (0.8%)	0
Bad Sunburn	40 (8%)	8 (8%)
Constitutional & respiratory symptoms		
Headaches	134 (27%)	5 (14%)
Feeling faint, dizziness, fatigue or exhaustion, or weakness	113 (23%)	13 (13%)
Itchy eyes	50 (10%)	5 (5%)
Nose irritation, sinus problems, or sore throat	110 (22%)	16 (16%)
Metallic taste	14 (3%)	0
Coughing	81 (16%)	8 (8%)
Trouble breathing, short of breath, chest tightness, wheezing	42 (8%)	4 (4%)
Cardiovascular & gastrointestinal symptoms		
Fast heart beat	17 (3%)	1 (1%)
Chest pressure	10 (2%)	0
Nausea or vomiting	30 (6%)	3 (3%)
Stomach cramps or diarrhea	59 (12%)	7 (7%)
Skin & musculoskeletal symptoms		
Itchy skin, red skin, or rash	84 (17%)	8 (8%)
Hand, shoulder, or back pain	84 (17%)	6 (6%)
Psychosocial symptoms		
Feeling worried or stressed, pressured, depressed or hopeless, short tempered, or frequent changes in mood	80 (16%)	7 (7%)
Heat stress symptoms†		
Any	188 (38%)	21 (20%)
4 or more symptoms	31 (6%)	3 (3%)

*Participants were recruited from the Venice Field Operations Branch and the Venice Commanders' Camp. Those who reported that they had not worked on boats and had no exposures to oil, dispersant, cleaner, or other chemicals were included in this group.
†Headache, dizziness, feeling faint, fatigue or exhaustion, weakness, fast heart beat, nausea, red skin, or hot and dry skin.

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