DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

National Institute for Occupational Safety and Health
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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 seventh 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 #7) provides background, describes methods, reports findings, and provide conclusions and, where appropriate, interim recommendations for our evaluation of beach cleaning workers. This evaluation took place in Alabama, Florida, Louisiana, and Mississippi in June and July 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
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1 Enclosure

cc:
Mr. David Dutton, BP
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Health Hazard Evaluation of Deepwater Horizon Response Workers
HETA 2010-0129

Interim Report #7
Evaluation of Shore Cleaning Workers; Alabama, Florida, Louisiana, and Mississippi, July, 2010

Introduction

In July 2010, NIOSH investigators made multiple 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 repair and decontamination and waste management. This report presents the findings for shore cleaning worksites.

Evaluation

NIOSH investigators were organized in two-person teams who were 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 sites. The NIOSH teams were based out of the command centers in Mobile, Alabama, and Houma, Louisiana. On-shore worksites 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.

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 a structured exposure assessment checklist was used. Of those 59 sites, 36 (61%) were shore cleaning sites, with six in Alabama, seven in Florida, five in Louisiana, and 18 in Mississippi (Table 1). 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 24 sites to have a level of “light” residue, six to have a level of “moderate” residue, and three to have a level of “heavy” residue. All sites with “heavy” residue and five of the six with “moderate” residue were in Mississippi.

Upon arrival at the shore cleaning sites, NIOSH investigators contacted the site safety officer to coordinate activities. When possible, the NIOSH investigators were introduced to the assembled workers at the 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 workers at all sites. The one-page health symptoms survey covered demographics, job duties, exposure to oil or other substances, symptoms experienced by the 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 4848 workers worked at the 36 shore cleaning sites around the time of the NIOSH evaluations; 1899 (39%) completed the health symptom survey. Table 2 presents a summary of participant demographic information. The results of the symptom survey 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.

The shore cleaning sites NIOSH investigators visited were sand beaches. During the evaluations, NIOSH investigators observed that beach cleaning tasks involved risk factors for musculoskeletal disorders (MSDs), including repetitive awkward postures of the back and upper extremities using moderate force. At these sites workers used shovels, rakes, and improvised hand tools to manually remove tar balls from the sand. An evaluation was conducted at one worksite to provide more detailed information about some of the tools being used (Appendix).

Results

Environmental Conditions, Work Tasks, and Site Descriptions

NIOSH investigators measured temperature at 29 worksites and relative humidity at 26 worksites (Table 3). The mean temperature was 88 degrees Fahrenheit (°F) (range: 82 – 95 °F) and the mean relative humidity was 69 percent (range: 52 – 88 percent); the heat index based on mean values was 101°F (range: 87 – 134 °F).

The most common operation observed involved workers walking the beach using tools to collect solid or semi-solid oil residue ("tar balls") and placing the residue in large trash bags. Generally the workers placed two or three shovels of material into a bag; filled bags weighed about 10 to 20 pounds. Some site safety managers reported having a 20-pound weight limit for the trash bags. At some sites all-terrain vehicles and heavy equipment were used to transport the filled bags.

The most common work schedule was 12-hour shifts, 7 days a week. However, some crews involved in island beach cleaning often worked more than 14 hours per day; this occurred for various reasons including delays in transportation between the staging area (such as a port) and the cleaning site (such as an off-shore island). Some workers reported that they had not taken off any days for many days (up to 40). Some workers reported commuting long distances to get to their worksite (up to 90 minutes one way).

Sanitation facilities were readily available at most work sites, with some exceptions. Sanitation facilities were less readily available at designated National Seashores. The most common deficiency at those sites was lack of hand washing stations.

Exposure Characterization

As noted above, the amount of oil residue observed by NIOSH investigators varied among sites and from day-to-day at each site. Even at worksites where oil residue was judged to be "heavy," worker exposure to oil residue typically was judged to be limited because of the nature of the oil residue (oil-soaked sand

or solid to semi-solid tar-balls) and the use of personal protective equipment (PPE) (PPE use is described below). NIOSH investigators saw no evidence of exposure to dispersant at the shore cleaning sites.

NIOSH investigators judged heat to be the primary exposure of concern. Site supervisory staff measured heat and humidity in a variety of ways at the work sites. Sometimes safety technicians had portable measurement devices and sometimes information was drawn from a commercial or government weather information web site or was transmitted to on-site safety supervisors from another location. Safety staff monitored the heat index and adjusted work/rest regimens according to guidelines provided by BP ("Comprehensive Heat Stress Management Plan, June 19, 2010"). Safety leaders had color-coded cards for calculating the heat index. Recommended work/rest regimens were based on the heat index. The guidelines called for work/rest regimens varying from "no limit" to 10 minutes of work followed by 50 minutes of rest (the most limiting regimen). NIOSH investigators observed variability in application of the heat stress guidelines. Some contractors appeared to do the minimum to follow the guidelines, while others followed a work/rest regimen more conservative than called for by the guidelines. Implementation appeared to vary by the nature of the worksites. At some National Seashore areas, work practices were dictated by limited access (possibly requiring long walks) and limited facilities (e.g., wash stations). Overall, despite the variability observed, NIOSH investigators found that heat stress was well managed. When safety technicians had to make qualitative judgments to interpret the heat stress guidelines, they generally erred on the side of worker protection.

Although PPE use varied by site, most workers wore safety glasses, hats to protect from sun exposure, gloves, and rubber steel-toed boots. Protective suits (such as Tyvek® suits) were used at some sites. NIOSH investigators observed that the range of required protection tended to be relaxed as the local heat index increased. The most comprehensive PPE program observed included steel-toed rubber boots covered by yellow rubber over boots (sealed with duct tape), shirts and long pants, yellow high-visibility safety vests, double gloves, head cover, safety glasses, and Tyvek® suits. At many shore areas, the area directly next to the water was considered to be a zone in which PPE was required. In general, NIOSH investigators observed workers adhering to good hazmat procedures for separating "hot" zones from rest areas. The observed procedures for donning and doffing PPE were effective at all work sites visited. At many beaches with minimal oil residue, NIOSH investigators observed bathers and swimmers adjacent to workers wearing protective ensembles.

Creams or sprays to provide protection from the sun were not always available; additionally, NIOSH investigators observed that hypoallergenic sun protection products (physical block type) were not available for persons with skin allergies or sensitive skin. Some work groups carried sun screen on their buses and others had tables at the worksites with sun screen spray readily available along with water and other supplies. NIOSH investigators were informed of several worksites that did not have ready access to shaded break areas. Most sites had access to medical tents located on the shore, and medics commonly patrolled the beaches.

Aside from heat, other weather hazards were well-managed and controlled. When lightning was electronically detected or observed, work teams were immediately evacuated from beaches. In situations where lightning was considered a hazard, workers waited in vehicles (buses or vans) at least 30 minutes after the last lightning was observed.

Ergonomic Evaluation
Tools used for beach cleaning varied considerably over the sites visited by NIOSH investigators. Tools included a variety of store-bought and homemade devices. Items such as shovels, rakes, and brooms were commonplace. Other non-traditional tools observed included swimming pool skimmer nets, aquarium nets, kitty litter sifters, and box sifters made from lumber and galvanized screening. Some workers cleverly designed homemade a tool to collect the most tar balls without too much sand. Findings from an evaluation of a few of the tools is presented in the Appendix.

Reported Symptoms
Injuries and symptoms reported by shore cleaning workers in the symptoms survey are presented in Table 4. This table includes injuries and symptoms for workers at the shore cleaning sites and for the comparison group of workers recruited at the Venice, Louisiana site. The etiologies of the reported health symptoms are 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 was reported by 37% of the shore cleaning 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 7%. Both indicators of heat stress were more prevalent among the shore cleaning 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 shore cleaning workers when compared to the comparison group. Among the individual symptoms reported most frequently were headaches (reported by 28% of the shore cleaning workers); coughing (reported by 19%); and hand, shoulder, or back pain (reported by 17%). Eighteen percent of the shore cleaning workers reported one or more of five psychosocial symptoms (feeling worried or stressed, pressured, depressed or hopeless, short tempered, frequent changes in mood).

Discussion

Several potential occupational hazards were identified during the observational exposure assessments; however, the work sites visited generally had effective programs to manage these hazards. Nevertheless, for nearly all health outcomes, more injuries and symptoms were reported among shore cleaning workers than among the comparison worker group. This is not surprising given the strenuous work performed by shore cleaning workers 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.

Although this report focuses on issues related to shore cleaning workers, many potential occupational hazards faced by shore cleaning workers are similar to those faced by other Deepwater Horizon response workers. NIOSH investigators determined that heat stress was an important occupational health issue for most shore cleaning workers, but that 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 the rest/work regimens when they were in place. However, NIOSH investigators found that shaded rest areas were not readily available at several worksites. In addition, appropriate protective sunscreens were not always available.

NIOSH investigators noted that guidelines for PPE use may have led to PPE 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.

This evaluation found that 18% 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 shore cleaning 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 spill (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 shore 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 may have included working many days and long commuting distances.

The ergonomic hazards faced by shore cleaning workers were unique among Deepwater Horizon response workers because of the specific and unique work required for cleaning oil residue from sandy beaches. In general, NIOSH investigators found that workers were using tools that were never designed for this task. The shovels and rakes most commonly used were generally too heavy and required awkward and repetitive postures (especially when picking up the smaller tar balls and patties). The use of shovels also resulted in large quantities of sand being bagged along with the oil residue material, exposing workers to heavy lifting tasks. Also, workers had to frequently squat, bend, and kneel to pick up finer materials because the shovels and rakes were not designed for this task. In some areas workers had designed “homemade” tools. These tools, which were preferred by workers, were lighter and did a better job of sifting out sand.

These findings provide an overview of health and safety issues relevant to beach cleaning work during the Deepwater Horizon response. 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 health symptom survey were self-reported and not able to be verified by NIOSH investigators.

Recommendations

The following recommendations, focused on health and safety issues for repair/decontamination and waste management workers, reflect this and other evaluations by NIOSH of Deepwater Horizon response work. Elements of many of the programs and actions were in place at the worksites evaluated by NIOSH. These recommendations are relevant for ongoing work similar that that described in this report and may be applicable to workers involved in future incidents similar to the Deepwater Horizon oil release.

1. Shore cleaning sites should follow appropriate heat stress management plans when the work occurs in hot conditions. The plan in place during this evaluation ("Comprehensive Heat Stress Management Plan, June 19, 2010") contains the elements of a complete plan.
    a. Local conditions or circumstances that interfere with implementation of appropriate management plans should be anticipated to the extent possible so that alternative plans can be made. In all cases response workers should have access to shaded break areas and readily available drinking water.
2. Officials responsible for worker health and safety should ensure that adequate sanitation facilities be available for all response workers.
3. The importance of the use of sun screen should be more consistently communicated and sun screen should be more readily available at shore cleaning worksites.
    a. Hypoallergenic physical sun block (titanium dioxide- or zinc oxide-based) should be made available for workers with a history of atopy or skin allergies.
4. In most situations with shore cleaning workers, PPE for protection from dermal exposure to weathered crude oil should be considered the primary concern. Further guidance concerning PPE for response workers is provided in the NIOSH OSHA guidance noted below.
    a. Selection and use of PPE should consider and address the potential to increase heat strain among workers.
5. Health and safety plans should include steps to reduce the risk of musculoskeletal disorders from work activities such as awkward lifting positions and heavy lifting tasks. Such steps generally would include providing adequate staffing for work tasks, using work rotation schedules, and providing appropriate equipment or tools for the required tasks. Because the nature of the work will likely differ during other responses, plans should account for the unique nature of each response.
    a. More efficient professionally-developed and manufactured tools, drawing from the "prototypes" observed in this evaluation, should be used for future shore cleaning in which solid or semi-solid material is being removed from sandy beaches.
    b. A combination of strategies should be used to control the weight of materials handled by shore cleaning workers, including: (i) having on-site lift scales (for example the type used to weigh bicycles) to check the weight of collected material; (ii) using standard sized refuse collection bags; and (iii) minimizing sand content of the collected material.
    c. Worksites where containers (such as bags) are routinely and repeatedly filled with material for disposal should develop procedures that minimize manual handling (for example, the number of times that bags are lifted or dragged).
    d. Additional information on methods to reduce ergonomic hazards can be found on the NIOSH website at http://www.cdc.gov/niosh/topics/ergonomics/.
6. 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 rest and recovery. The NIOSH OSHA interim guidelines noted below provide more details to help manage responder stress and fatigue during and after a response.
7. Workers should be encouraged to report health concerns and injuries to their supervisor or on-site safety representatives, and seek care through established on-site medical facilities or other healthcare providers as appropriate.
8. When response activities similar to the Deepwater Horizon response occur in the future, responsible parties should consider the need for pre-placement medical evaluations for workers participating in the response. The NIOSH OSHA interim guidance noted below provides further information on such evaluations.

A joint NIOSH/OSHA document ("Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers") provides guidance on protecting response workers. It includes more detailed information on the recommendations noted above. The document is available on the NIOSH website at http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/.

Table 1. Description of shore cleaning worksites evaluated with the observational 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)*		
			Light	Moderate	Heavy
Alabama	6	431	5	1	0
Florida	7	254	6	0	0
Louisiana	5	484	5	0	0
Mississippi	18	730	8	5	3
Total	36	1899	24	6	3

* The checklist included a qualitative assessment of the level of oil residue at the worksite: none (no sites in this category), light, moderate, and heavy; information was available for 33 of the 36 sites.

Table 2. Health symptom survey—demographics by group

	Shore Cleaning	**Unexposed***
Number of participants	1899	103
Age (median, range)	31 (18-71)	18–70
Race		
% White	639 (34%)	40%
% Hispanic	185 (10%)	29%
% Asian	10 (<1%)	9%
% Black	951 (50%)	19%
% Other	65 (3%)	3%
Male (number, % of total)	1522 (80%)	96%
Days worked oil spill (median, range)	28 (1-94)	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.

Table3 . Summary of temperature, relative humidity, and heat index at worksites

	Mean (range)*
Temperature (°F)	88 (82-95)
Relative Humidity (%)	69 (52-88)
Heat Index	101 (87-134)

*Based on values recorded by NIOSH investigators at the worksites during the workshifts, including temperature data for 29 sites and relative humidity data for 26 sites.

Table 4. Health symptom survey—reported injuries and symptoms by group

	Shore Cleaning Workers (n=1899)	**Unexposed*** (n=103)
	No. (%)	No. (%)
Injuries		
Scrapes or cuts	136 (7%)	11 (11%)
Burns by fire	6 (0.3%)	1 (1%)
Chemical burns	9 (0.5%)	0
Bad Sunburn	187 (10%)	8 (8%)
Constitutional & respiratory symptoms		
Headaches	535 (28%)	5 (14%)
Feeling faint, dizziness, fatigue or exhaustion, or weakness	409 (22%)	13 (13%)
Itchy eyes	190 (10%)	5 (5%)
Nose irritation, sinus problems, or sore throat	457 (24%)	16 (16%)
Metallic taste	31 (2%)	0
Coughing	362 (19%)	8 (8%)
Trouble breathing, short of breath, chest tightness, wheezing	166 (9%)	4 (4%)
Cardiovascular & gastrointestinal symptoms		
Fast heart beat	41 (2%)	1 (1%)
Chest pressure	31 (2%)	0
Nausea or vomiting	123 (7%)	3 (3%)
Stomach cramps or diarrhea	167 (9%)	7 (7%)
Skin & musculoskeletal symptoms		
Itchy skin, red skin, or rash	284 (15%)	8 (8%)
Hand, shoulder, or back pain	328 (17%)	6 (6%)
Psychosocial Symptoms		
Feeling worried or stressed, pressured, depressed or hopeless, short tempered, or frequent changes in mood	345 (18%)	7 (7%)
Heat stress symptoms†		
Any	710 (37%)	21 (20%)
4 or more symptoms	130 (7%)	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.

APPENDIX - Evaluation of Beach Cleaning Tools

Background

During the observational evaluation of shore cleaning workers NIOSH investigators observed that beach cleaning tasks involved risk factors for musculoskeletal disorders (MSDs) while using rakes, shovels, and improvised hand tools to manually remove tar from the shore. The main risk factors observed in the use of these tools included the following:

- repeated and sustained back flexion/twisting
- repeated and sustained squatting, ground-sitting, or kneeling
- repetitive upper extremity motions
- awkward wrist/forearm twisting
- moderate upper extremity forces to handle tools and mixtures of sand and tar balls
- moderate low back force to handle bags (10 - 20 lbs.) of sand and tar balls

The tools most commonly used on the mainland shores were conventional shovels and leaf rakes. Other tools such as strainers, sieves, and scoopers/sifters were also observed, especially on the barrier islands where workers were instructed to remove minimal amounts of sand during the cleaning process. The workers often developed alternative tool options after initially using the conventional tools with limited success. Short handled food preparation strainers were retro-fitted with long handles (i.e., sticks were duct-taped to the short tools) to reduce back flexion and increase comfort. Some workers sat on plastic sheets and used hand-held sifting boxes to reduce back flexion. Judging from the wide variability in tool usage observed during this evaluation, it appeared that little guidance had been provided to the workers and their employers about optimal tool choices to minimize physical stress and potential MSDs for the beach cleaning tasks.

Evaluation

To provide guidance, NIOSH field teams designed a small evaluation of several beach cleaning tool options. Four experienced workers who had been performing beach cleaning duties for several weeks in Mississippi were asked to use four alternate beach cleaning tools (a shovel, an improvised tool made of a manual sifter attached to a long handle, a manual fork, and a motorized sifter – see Appendix Table 1). The latter two tools are commercially-available farm tools designed for cleaning manure from horse stalls. Both the shovel and improvised manual sifter had been used at the work site, while the manual fork and motorized sifter were novel tools for this group and had not been recommended or selected by BP or the contractor on-site. After using each tool in a random order for approximately 5 minutes per tool, the volunteers were asked to complete a short survey in which they subjectively rated aspects of tool usability (weight, ease of use, comfort, durability, and productivity), their perceived level of exertion using the tool, relative likes/dislikes about the tool, and suggestions for improvement. A qualitative summary of the findings is presented here. The NIOSH evaluation did not include any evaluation of productivity, such as the amount of cleaning done by the workers in a given time.

Results and Discussion

The shovel received the poorest ratings for all usability aspects tested. The improvised manual sifter and the motorized sifter received the most favorable ratings.

Shovel
Most users disliked the shovel because it was heavy and made it difficult to remove tar balls off the beach without picking up excessive sand. The weight of the sand likely increased the force needed to handle the tool. NIOSH investigators observed that workers tended to twist the shovel awkwardly to pick up the tar ball with the left or right front corner of the shovel in an effort to minimize the amount of sand collected. This resulted in increased wrist and forearm twisting during the task.

Manual Fork
Users rated the manual fork slightly better than the shovel for most usability aspects. A concern raised about the manual fork was that smaller tar balls (especially those approximately 1-inch in diameter or less) tended to fall between the tines of the rake and back onto the beach. Users suggested the tool could be improved by moving the tines closer together, padding the handle, and providing a light-colored finish to reduce handle heat while in the sun. Participants reported that the manual fork would be the most appropriate tool for an initial team to sweep through an area to quickly remove larger tar balls.

Motorized Sifter
Users rated the motorized sifter and the improvised manual sifter the best among the four tools for most usability aspects. A main reported advantage was that the motorized sifter automatically sifted the sand through the screen on the bottom and quickly separated the sand from the tar balls. As a result, the process was more efficient and workers carried less sand to the waste bags and likely used less force in the process. A potential disadvantage reported for the motorized sifter was that the vibration could break pieces off the larger tar balls and cause some tar to fall back to the beach in smaller pieces. Users suggested that usability could be further improved by developing different sizes of the motorized sifters (i.e., specifically some smaller sizes) and limiting the level of vibration to avoid breaking apart the tar balls. Users further suggested a padded sleeve on the sifter handle to reduce vibration and a light-colored finish to reduce handle heat while in the sun.

Improvised Manual Sifter (long-handled)
As noted, participants rated the improvised manual sifter higher than the shovel and manual fork for most usability aspects. It is notable that the manual sifter was an improvised tool developed by the users and was the tool most frequently used at the worksite. For these reasons, there could have been some bias towards favoring this tool. Users indicated that they especially preferred the light weight of the tool and the ability to separate sand from the tarball. For improvements, users suggested finding commercially available long-handled sifters with slightly larger front sifter pan areas to increase efficiency. Users also suggested models with composite and/or padded handles with a light-colored finish to reduce handle heat while in the sun.

Conclusions

This evaluation of beach cleaning tools indicated that this sample of workers did not view the shovel as appropriate for the task of removing tar balls from sand on the beach. Workers indicated that they preferred a range of tool options and that some tools were more appropriate for certain tasks than others. Certain alternative tool options (including the long-handled manual sifter and motorized sifter) were reported as preferable among this small group of beach cleaning workers based on weight, ease of use, comfort, durability, productivity, and perceived exertion. These findings indicated that the tools could be improved to benefit usability and productivity during beach tarball cleaning. This evaluation was limited by very small sample size and lack of quantitative measurements. Further evaluation and

testing of these types of tools using a larger study group would provide more representative data for use in improving the design, manufacture, and selection of manual tools for shore oil release cleaning work.

Acknowledgements: The voluntary participation of the workers and supervisors of the BP Contractor at Ship Island, Mississippi, and of Gulf Crowder, at Gulf Shores, Alabama in this evaluation is gratefully acknowledged.

Appendix Table 1: Tool Comparisons				
Tool	**Shovel** 	**Manual Fork (Flex Fork™)** 	**Motorized Sifter (Shake 'n Fork™)** 	**Improvised Manual Sifter (long-handled)** 
Advantages	Removes larger sections of oil-contaminated sand and biomass debris; digs into sand for buried tar balls	Removes larger sections of oil-contaminated sand and biomass debris; digs into sand for buried tar balls	Automatically sifted the sand and quickly separated the sand from the tar balls; more efficient and less forceful process as workers were carrying less sand to the waste bags	Light weight; useful for sifting small portions of sand
Disadvantages	Heavy tool and workers tended to twist the shovel awkwardly to pick up the tar balls; tool tends to pick up excessive sand which increases force required and increases waste; sustained very fine muscle movements are required to pick up small tarballs.	Small (dime-size or less) tar balls tended to fall between the tines of the rake and back onto the beach	Vibration could break pieces off the larger tar balls and cause some tar to fall back to the beach in smaller pieces; potential hand-arm vibration concern if used at higher vibration settings for extended periods (could be controlled with addition of an adjustable trigger stop or motor limiter).	Small sifter area (~5-inch diameter) limits efficiency and productivity; tools had to be retrofitted with long handles in the field