In-Situ Burn Operational Procedures Development Exercises

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Abstract

The following is a discussion of the conduct and results of three at-sea oil spill exercises developed and carried out by the US Coast Guard, Texas General Land Office, and National Response Corporation. Occurring during 1999 and 2000, the exercises test and evaluate several techniques for carrying out in-situ burning operations at sea. Actual response vessels, water-cooled fire boom, helicopters, and helitorch were used and appropriate data was recorded; several tons of oranges were used as a surprisingly accurate simulation of an oil slick. The results of these exercises are being used to create planning and training tools to make in-situ burning a viable spill response tool.

1. Background

When a petroleum spill occurs in the marine environment, one of the response technologies usually considered for use by the Incident Commander and staff is the burning of the petroleum product in-place on the water surface—in-situ burning (ISB). Some of the Regional Response Teams (RRTs) in the US, which are multi-agency, contingency planning groups, have established zones where ISB is pre-approved as a means of removing oil from the water thereby averting potential oil spill impacts to coastal beaches, marshes, and in-land resources.

However, ISB is seldom used during actual responses today, particularly in the offshore environment. Many factors contribute to this situation. They include, but are not limited to the lack of:

- a detailed ISB Operational Plan for the specific RRT pre-approval zone.
- sufficient ISB resources, both equipment and trained personnel, that can be mobilized within the limited ISB window-of-opportunity.
- understanding of and confidence in the fire-based ISB technology including misconceptions relating to the costs and benefits.

Given this background, the US Coast Guard (USCG) was very interested in learning more about the factors that impact the actual use of ISB within one RRT pre-approved offshore zone. As a result, the USCG Research and Development Center (RDC) assembled an experienced, public and private sector team to evaluate the feasibility of conducting ISB operations within RRT VI. This ISB Project Team includes the following principal private industry and government organizations: Texas General Land Office (TGLO), National Response Corporation (NRC), and RDC. Also, a number of USCG commands participated and played crucial roles in planning and executing the exercises: District Eight, Office of Response; Marine

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Safety Office Houston; Marine Safety Unit Galveston; Gulf Strike Team; Training Center Yorktown; National Strike Force Coordination Center; Air Station Houston; and Group Galveston.

This ISB Project Team developed and implemented a multi-year plan involving three, increasingly complex ISB exercises. Each was conducted within the ISB RRT VI pre-approved zone located 6 to 9 km (3 to 5 NM) off the Galveston, Texas coast.

1.1 Project Goal

The primary project goal is to investigate the viability of ISB by striving to make it a true operational tool for offshore spill responses within one USCG-selected response area. Operational procedures, guidelines, manuals, decision tools, job aids and training material developed during this project are intended for use by planners and spill responders in all areas of the country. Provided that the pre-approval guidelines are followed, the pre-approved zone offshore from Galveston, Texas, allows the pre-designated Federal On-Scene Coordinator (FOSC) to authorize ISB operations without seeking approval from the RRT.

Since the completion of the offshore exercises at Galveston, operational procedures are being developed for use on actual spills. A local ISB infrastructure was developed through the local response community's participation in the exercises. Essential ISB equipment (e.g., helitorch and fire boom) has been pre-positioned in the area and is ready for use during an actual spill. This allows the refinement of the call-out procedures and systems through repeated use in actual situations.

The objectives were pursued through a series of three offshore exercises. ISB Exercise One (conducted 19-23 April, 1999) was designed to evaluate several ISB vessel/fire boom operational procedures. Exercise Two (conducted 1-5 November, 1999) incorporated the findings and recommendations from Exercise One into the design phase and expanded the operational tasks to include their coordination with a helitorch ignition system. ISB Exercise Three (conducted 11-15 September 2000) refined lessons learned from Exercise Two and was conducted as an actual incident rehearsal; on-scene task force coordinators had increased autonomy.

1.2 Exercise Objectives

The primary exercise objective was to investigate the safe, effective, and efficient implementation of ISB vessel, fire boom, and helitorch operational procedures. Through the design of the exercises, it was necessary to conduct specific maneuvers and measure particular activities.

1.2.1 Response Time Analysis

Response time is critical in any spill response. The exercises were designed to provide empirical insight into the time required to assemble an ISB work group and to accomplish the work cycles associated with several ISB operational procedures for offshore spillet (i.e., smaller portion of a spill) preparation.

In planning the use of ISB, it is necessary to know how long it will take to accomplish certain steps. These can be summed to estimate the total time necessary to conduct ISB operations, and that time can be used in developing response plans and reviewing proposed plans. It can also be used during an actual response to make command decisions on how to proceed and to make the best use of the time remaining in the burn window-of-opportunity. Obtaining real time deployment data on three different exercises will help FOSCs and their Planning Section to better estimate resource arrival and on scene and anticipated burn times.

1.2.2 Operational Viability

The project helps determine operational viability of ISB procedures by providing:

- operational insight into the overall viability of selected ISB operational procedures for offshore spillet preparation.
- for evaluation of various techniques to determine what conditions or situations for which each may be appropriate.
- operational insight into the supervisor span-of-control limits associated with multiple task forces and multiple air support assets.
- operational insight into the use of National Interagency Incident Management System (NIIMS) Incident Command System (ICS) for offshore ISB spillet preparation operations.
- operational insight into the design of a recommended communications plan for offshore ISB spillet preparation operations.

2. ISB Maneuvers

2.1 Independent Task Force

In Independent Task Force Operations, each task force tows one fire boom and conducts burn operations independently (Fig. 1). Each fire boom must function as both an oil containment boom and a fire boom. It must be capable of being towed around the spill area to collect enough oil to burn and then approximately 2 km (1 NM) from the main spill to a Safe Burn Area where the oil will be ignited. The fire boom used for this task was 152 m (500 ft) long with a tow line length of 152 m (500 ft) and a gap opening of 45.7 m (150 ft). One disadvantage of Independent Task Force operations is using expensive fire boom as oil collection boom in an open ocean situation. Due to structural weakening or freeboard reduction, some fire booms may not tow well or collect oil after repeated burns.

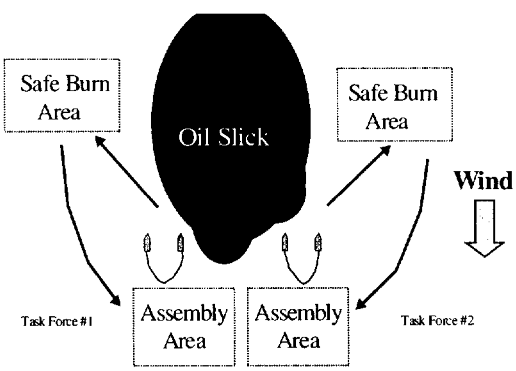

Figure 1 Independent Task Force Operations

2.2 Coordinated Task Force Operations

Coordinated Task Force Operation are intended to maximize the use of conventional ocean oil collection boom to collect oil and bring it to the fire boom. The coordinated Task Force (Fig. 2) has two or more conventional ocean containment booms that work separately to bring the oil to the fire boom. Oil collection will proceed faster because the collection booms can work independently to collect, transit, and transfer portions of the main oil spill to the fire boom. When the fire boom has sufficient oil, the oil can be ignited.

The Coordinated Task Force procedure maximizes the use of ocean oil collection boom, which is plentiful, relatively inexpensive, and appropriately designed for oil collection. Some fire booms are not well suited for extensive towing and collecting oil in an open ocean situation, and coordinated operations let the fire boom do what it does best—burn oil.

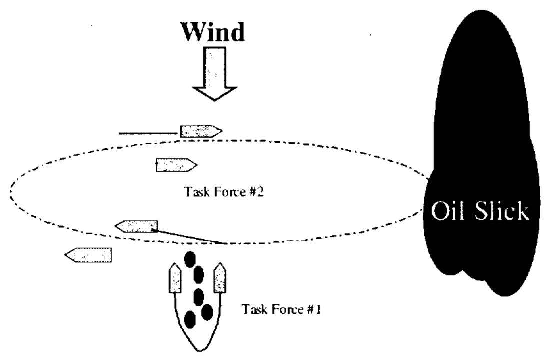

Figure 2 Coordinated Task Force Operations

During Coordinated Task Force Operations, Task Force #1 is the dedicated burning task force while Task Force #2 and Task Force #3 perform spillet collection and delivery operations (Fig. 2). With help from the spotter helicopter, Task Force #1 stays relatively stationary approximately 2 km (1 NM) from the slick during this operation. Task Forces #2 and #3 operate in a pattern, collecting oil spillets from the main body of the spill and transporting and delivering the spillets to Task Force #1 for burning. Each task force is under the direction of the Work Group Supervisor stationed on-scene.

Given the low height-of-eye of the wheelhouse of some vessels, it may be very difficult for vessel operators to see oil escaping behind the boom or judge the thickness of the oil slick. The spotter helicopter can assist Task forces #2 and #3 and increase operational efficiency by reporting oil entraining from the boom and spotting the locations of the thickest oil.

2.2.1 Oil Spillet Transfer Techniques

In order to transfer the oil from the collection boom to the fire boom, two maneuvers were evaluated: towline release and J-release. Each technique requires the containment boom task force to position itself in front of the mouth of the fire boom. The oil is then released from the containment boom and allowed to drift back into the fire boom as the containment boom task force pulls slowly away.

2.2.1.1 Towline Release Method

In the Towline Release Method (Fig. 3), the towline of one vessel is released as the other vessel in the task force begins to pull ahead. As the boom straightens, the oil flows from the end of the boom and drifts back into the fire boom. When the boom is free of the spillet, both vessels can sprint back to the main slick, stop while one vessel retrieves the free end of the boom towline, and form a U-configuration to begin collecting more oil. Upon returning to the fire boom for oil transfer, the task force will have completed one work-cycle of the Towline Release Method.

The Towline Release Method eliminates close-in maneuvering between the vessels during the release maneuver and decreases transit time back to the main slick. A disadvantage of the Towline Release Method is that the towline must be pulled back aboard each time, which may become more difficult and dangerous as the line becomes oily or the seas build. Towline Release also increases the chance of fouling the vessels' screws with the towline.

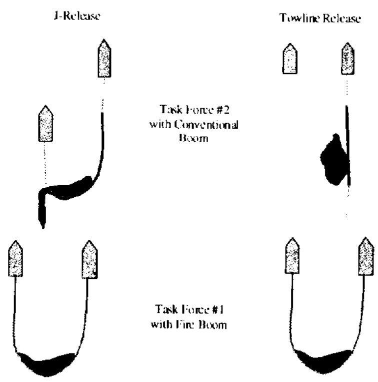

Figure 3 Two Spillet Transfer Methods

2.2.1.2 J-Release

During the J-Release Operation, the boom remains connected to both vessels in the containment boom task force. The spillet is transferred to the fire boom by having the lead vessel pull slightly ahead and towards the other vessel. This causes the boom to take on the shape of a "J" and the oil will eventually flow from the end of the boom (Fig. 3). Because the containment boom is still connected to both task force vessels, the task force must transit slower and closer together to reduce the water drag forces and prevent damage to the boom during their return to the main slick. This maneuver requires more slow-speed, close-in maneuvering by the vessels but does not require the release and retrieval of the boom towline. If the weather is rough, this could drastically increase crew and vessel safety.

2.3 Funnel Operations

The Funnel Configuration is comprised of two 305-m (1000-ft) legs of ocean boom connected by a 15.2-m (50-ft) bridle assembly at the apex (Fig. 4). Each leg of the system is towed by one of the task force vessels. Both vessels maintain approximately 229-m (750-ft) separation at the mouth of the system while maneuvering to acquire a target spillet as directed by the ISB Work Group Supervisor. The fire boom task force proceeds behind the open apex of the funnel and allows the oil collected by the funnel to flow into the fire boom.

The purpose of the Funnel Configuration is to substantially increase the encounter rate of the boom by increasing the mouth opening from approximately 45.7 m (150 ft) with the conventional boom. It also provides for the direct feed of the oil into the fire boom and eliminates the need to use the Towline Release and J-Release techniques. The vessels must come together to close the gap for high speed transit or high drag loads may damage the boom or apex bridle.

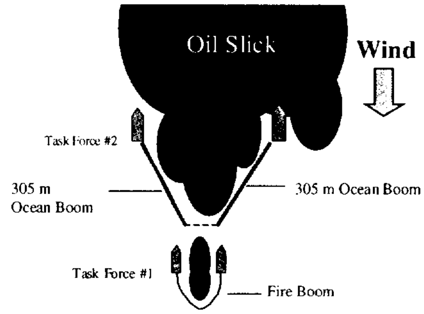

Figure 4 Funnel Configuration

Provided the fire boom has adequate towing characteristics to keep up with the funnel as it is maneuvered through oil, Funnel Operations have the potential to concentrate oil from a substantially greater swath width than using the U-configuration fire boom by itself. This may be very advantageous within selected spill scenarios, particularly when the oil is widely dispersed and low encounter rates are a problem. This technique is also suited for use with a continuous source release where it could remain almost stationary. Maneuvering with such a large boom requires prior practice by the tow vessel operators.

3. Individual Exercise Approach

3.1 Exercise Area Description.

The three ISB exercises were conducted within the geographic area where Region VI RRT has already given pre-approval to the local FOSC for use of ISB as warranted by the conditions of a specific incident response. The 11 km (6 NM) long x 5.6 km (3 NM) wide Exercise Box was located just seaward of the 5.6-km (3-NM) Pre-Approval Demarcation Line (Fig. 5).

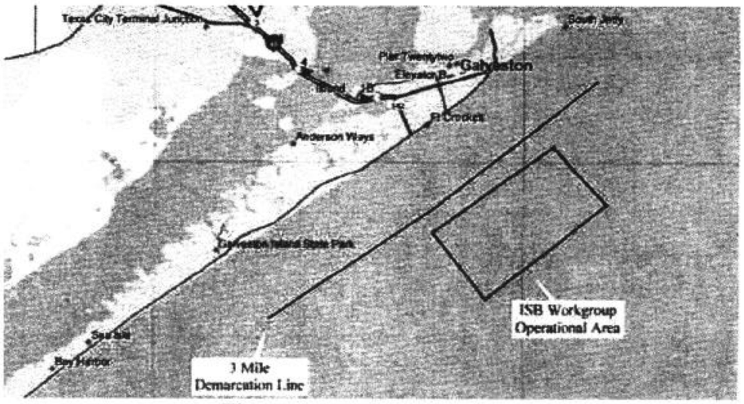

Figure 5 Exercise Area

3.2 Exercise Control Center

The Exercise Control Center (ECC) for all three ISB exercises was located on Galveston Island at the Hilton Hotel. The USCG Gulf Strike Team communications trailer was parked immediately outside the hotel and real-time video and radio antennae were installed on the roof of the hotel. The ECC itself was located inside the hotel's conference center and was staffed and organized similar to a Unified Command Post for a major spill response—with Command, Operations, Planning, Logistics, and Finance sections along with Safety and Information Officers. In addition, the ECC had appropriate data recording capabilities and there was a large-screen projection of at-sea operations using real-time video from a helicopter over the exercise area.

3.3 Exercise Resources

During ISB Exercise #3, which was the most comprehensive of the three exercises, the following resources were used to conduct at-sea operations:

- *Lead ISB Vessel*—One 33.5-m (110-ft), Oil Spill Response Vessel, the NRC Admiral, with 609.6 m (2000 ft) of ocean boom and its spill response crew complement.
- *Support ISB Vessels*—Five 33.5-m (110-ft), Seacor Marine, Off-Shore Supply Vessels with spill response crew complements.
- *Fire Boom*—152 m (500 ft) of Elastec/American Marine, water-cooled fire boom with support equipment and personnel aboard one Seacor vessel.
- *Spotter Helicopter*—One American Eurocopter AS350 with pilot, ISB spotter, and real-time video camera.
- *Relief Helicopter*—One USCG HH-65A Dolphin with normal crew, ISB spotter, and hand-held video camera.
- *Ignition Helicopter*—One Bell 206B Jet Ranger III with pilot and the IsoLair Helitorch described in Table 1 below.
- *Helitorch Ground Support*—One helibase located at USCG Group Galveston equipped with an IsoLair Batch Mixer and specially-trained, Petroleum Helicopters, Incorporated ground crew for refueling the helitorch.

Table 1 IsoLair Helicopter Flame Application System Description

Model #	Component	Specifications	
FIREFLY II Model 3800	Tank Assembly	Height–0.76 m (30 in)	Width–0.71 m (28 in)
		Length–1.52 m (60 in)	Access Cover–0.30 m (12 in) by 0.71 m (28 in)
	Voltage Required	24–28 VDC	
	Net Weight	45.4 kg (100 lbs)	
	Gross Weight	227 kg (500 lbs)	
	Capacity	208 L (55 gal (US))	

3.4 Exercise Organization

Each ISB exercise was designed and conducted using NIIMS ICS procedures. NIIMS ICS is the response management system that the USCG and most of the US spill response community use to organize and direct spill response activities. In addition, the use of NIIMS ICS simplified the planning and conduct of these exercises since most participants—USCG, State of Texas, NRC, and the various contractors—were familiar with the terminology, structure, and procedures. Unified Command was established; Planning, Operations, Logistics, and Finance Section Chiefs were assigned. Incident Action Plans (IAPs) were developed for each day of each ISB exercise that described how the various maneuvers (Section 2) were to be conducted. The Unified Command oversaw the exercise using live video and radio from the ECC. The Work Group Supervisor on one of the vessels controlled the movement of the various task forces as they carried out the maneuvers.

There are various ways to organize operational assets using NIIMS ICS management system. For over 95% of the oil spills (Tier I and II), only two functional groups are needed in the Operations Section: On-Water Fire Boom Deployment Group and Air Monitoring Group. Depending on the size of the area, each Group can consist of several Task Groups. This allows more flexibility in managing assets.

When the incident grows into a Tier III level oil spill where other spill removal technologies are used in combination with ISB, ISB operations may be organized as a branch. Careful planning, good communications, and strict safety procedures are paramount to success.

3.5 Exercise Target Logistics

In order to conduct the ISB maneuvers described within Section 2, realistic oil targets were required in order to simulate at-sea booming operations. Since the use of actual oil was restricted, oranges were used as target spillets during all exercises. During ISB Exercise #3, the most comprehensive exercise, 7260 kg (8 tons) of California oranges were employed. A local fishing vessel was contracted to discharge the oranges during the exercises and collect the oranges for disposal ashore upon exercise completion. Oranges are a realistic substitute for oil because they have about the same specific gravity as oil and seem to flow around and under booms as oil does. Oranges are easily visible in large numbers.

3.6 Exercise Schedule

Though it took months to plan for each ISB exercise, each only required one week for actual at-sea conduct. During each exercise week, Monday was set aside as the final preparation day for various equipment installations, check-outs, and briefings to train response personnel and go over pre-exercise objectives and procedures in detail. Tuesday and Wednesday were the primary at-sea operations days. Thursday was a contingency day in the event that weather or other problems prevented at-sea activities on Tuesday or Wednesday. Friday was identified as the exercise debriefing and de-mobilization day. Extensive de-briefing was conducted with exercise participants to give them the opportunity to capture lessons learned while the experience was still fresh. Figure 6 provides a summary of the typical exercise week.

Mon	Tue	Wed	Thur	Fri
Prep	**Day #1** **At-Sea Tasks**	**Day #2** **At-Sea Tasks**	**Contin-gency Day**	**Debrief Meeting**

Figure 6 Typical Exercise Week

3.7 Data Recording Tools

- *Current Meters*—TGLO provided and operated current measuring equipment for each task force throughout the exercises. The equipment provided continuous, real-time, digital readouts of each vessel's speed through the water. Speed measurements were critical because oil loss by entrainment occurs at approximately 0.5 m/s (1 knot). If the task forces were allowed to perform their ISB maneuvers at greater than 0.5 m/s (1 knot), a false impression of overall ISB performance would have been obtained.
- *Real-Time Video*—Real-time video was displayed and recorded during the exercise via continuous feed from the helicopter to the ECC. The equipment used by the contractor (Griffin Communications, Inc.) was typical of gyro-stabilized, beta-format, video cameras commonly used by news media.
- *Back-up Video*—The HH-65A helicopter from Air Station Houston used a hand-held video camera to record exercise operations when the primary platform was at the helibase for fueling and pilot rest periods. In addition, assigned personnel aboard the ISB task force vessels recorded the field operations at the surface.
- *Geographic Plot*—In order to obtain a geographic plot record of each ISB Exercise, the USCG Training Center Yorktown set up and operated the Pollution Incident Simulation, Control, and Evaluation System (PISCES) throughout the course of exercise operations. Global Positioning System (GPS) transmitters were placed on the ISB vessels, and PISCES tracked the movement of these GPS transmitters and provided a summary plot of resource movement.
- *Manual Data Recorders*—Data collection personnel were stationed aboard the lead vessel of each task force. These personnel documented the timing and effectiveness of key elements within the various ISB procedures.

4. Conclusions

One of the key factors to the success of these tests is the team approach with government and maritime field and technical personnel. Research and development analysis coupled with hands-on operational resources evidenced the need to continue to improve existing oil spill response procedures and explore new procedures.

The tests demonstrated that ISB is a viable and efficient response tool provided it is used in the right situation. The greatest short fall in the series of tests was the inability to burn real oil on the water. Oranges proved a great simulation and offered responders a good visual target to collect, but oranges did not provide all the data we need; we need to know not only the time to capture and transfer oil, but also what percentage of oil can be removed. Our recommendation is for the US Federal Government to allow actual oil to be used for testing oil response equipment and procedures at sea.

The latest communications technology for responses—real time video—added great value to the exercises. Live video coverage helped the Command Post and Unified Command gain an appreciation for the activity at sea. Since a "picture is worth a thousand words," the Unified Command and other Command Post personnel did not need to call field personnel for updated information, which allowed briefs to be delivered with more timely and accurate information and without distracting the field assets.

The USCG now has additional oil spill response equipment capability in the Gulf-of-Mexico region. The USCG-owned helitorch, 152 m (500 ft) of water-cooled fire boom, and contracted air-support services are available to Federal and State On-Scene Coordinators at any time. We proved during the tests that ISB procedures could work well for offshore oil removal. However, the equipment may also be used for on-shore oil spill removal operations in locations such as marshlands where mechanical recovery will extend the damage to the effected areas as equipment and personnel travel to and from the clean up sites. Inland burns have been used in remote areas of the US inland rivers and Alaska with great success. Future tests and research should continue to refine current equipment and plans.

ISB is a great asset but is not always the best tool for every situation. Dispersants and mechanical recovery are also viable solutions. Many responders still evaluate each technology separately, and should consider combinations of two or more technologies. More field exercises are needed using ISB along with dispersants and skimming. For example, ISB can be used on the thicker area of a slick near the oil release source, dispersants can be sprayed over areas where the oil starts thinning, and skimming can be used in near-shore areas where current and waves are less intrusive. USCG Special Monitoring for Advanced Response Technology (SMART) teams, employed in Exercise Three, should be included in all future ISB exercises as a test of our full response capability.

4.1 Results

Operationally, the systems used in the exercise worked well. Booms and pumps for all systems used offshore were loaded in 0.5-1.5 hrs after the start of the exercise. It required approximately 1.5 hrs to transit the 26 km (14 NM) to the exercise area offshore.

4.1.1 Fire Boom

It took approximately 1.5 hours to deploy the Elastec/American Marine water-cooled fire boom from the start of deployment until the boom was ready for operations. This includes transferring the towline and pump hose from one vessel to the other and conducting the deck safety briefing for the day. The water-cooled fire boom performed similarly to traditional ocean boom as regards the containment of oranges. Recovery of the fire boom took approximately 1.25 hrs, which may be longer than normal because the fire boom team performed checks and repairs on the system during the recovery sequence; it seems probable that this type of detailed inspection would be normal after conducting burning operations.

4.1.2 Conventional Boom

The conventional containment booms required approximately 0.5 hrs to deploy each 152-m (500-ft) boom.

4.1.3 Funnel Configuration

The Funnel System, consisting of two 305-m (1000-ft) sections of boom and a 15.2-m (50-ft) chain bridle at the apex, took approximately 2.5 hrs to deploy. This time may longer than normal since the deploying vessel had to retrieve, re-inflate, and re-deploy a segment of boom. The Funnel Configuration was effective for containing and delivering an increased swath width of oranges into the trailing fire boom in the U-configuration, but maneuvering a boom system that large is difficult and requires prior training and helicopter spotter assistance.

The principal difficulties encountered center around the communications and coordination needed to direct the task forces from one location or position to another. Each task force has two vessels towing opposite legs of a containment boom system, thus requiring the vessels to function as a single unit. In order for this type of operation to be effective, there needs to be a clear distinction between the dominant or primary vessel, and the subordinate or secondary vessel in the system. Operations training for the task force vessel operators conducted prior to the initiation of operations will clarify the operational procedures and dictate the lead vessel. Recovery of the funnel system took approximately 1.0 hrs from initiation until the system was retrieved on deck.

4.1.4 Spillet Transfer

The J-release work cycle (i.e., from J-release, transiting to the slick, containing more oil, towing the spillet back to the fire boom, and executing the J-release) took approximately 1.5 hrs to complete whereas the towline release method required 1.0 hrs. The coordinated maneuvering and slower repositioning transit time required during the J-release significantly added to the work cycle time. The towline release method work cycle (i.e., from towline release, transiting to the slick, containing more oil, towing the spillet back to the fire boom, and executing the towline release) took approximately 1.0 hrs to complete. This method of operations also provided for a smoother and more efficient sprint back to retrieve another spillet.

4.1.5 Helitorch Operations

In the Galveston area, it required 2.0-3.0 hrs to establish a helibase at USCG Group Galveston to support helitorch operations. This estimate is based upon the time to assemble a local qualified ground crew, obtain USCG Group Galveston approval, retrieve the helitorch from the USCG District Response Assist Team (DRAT) warehouse several miles away, procure fuel (e.g., gasoline or jet fuel), set-up the batch mixer and helibase, and mix the SureFire Powder™ with the fuel. Upon notification from the EEC, the helicopter can be airborne with the helitorch in 2 mins. Transit time from the base to the exercise was approximately 10 minutes. The helitorch helicopter arrived in the area of the ISB exercise operations and remained at the edge of the ISB operation until directed by the ISB Work Group Supervisor to release the gelled fuel. Under exercise conditions, a 15.2-m (50-ft) distance between the water surface and the helitorch appeared to provide the best continuous burning, floating gelled fuel mass for oil ignition. Below this altitude, the helicopter rotor wash would extinguish the gelled fuel and above this altitude the gelled fuel appeared to extinguish soon after impacting the water surface. Re-loading of the helitorch requires 2-3 minutes if the ground crew mixes the gel before the helicopter arrives at the helibase.

4.2 Recommendation

The times required to perform these many operation improved during the exercises. This clearly illustrates the benefit of and need for training prior to spill response so responders are familiar and experienced with equipment and evolutions. In these exercises, as in an actual spill response, responders got better and were more effective as they worked together and became a team.

5. Acknowledgements

The ISB Operational Procedures Project described within this paper was a considerable undertaking. Its success and safety record within the demanding, offshore environment were the result of many organizations and individuals working together in a positive, constructive manner. The three principle organizations—RDC, TGLO, and NRC—were united under a Cooperative Research and Development Agreement (CRADA). Each of these principle organizations provided *substantial* contributions and support for the project. Other organizations that provided support were Clean Channel Association, Elastec/American Marine, Marine Spill Response Corporation, USCG Headquarters (G-MOR), USCG District Eight, USCG Marine Safety Office Houston/Galveston, USCG Marine Safety Unit Galveston, USCG Group Galveston, USCG Gulf Strike Team, USCG Air Station Houston, and USCG Training Center Yorktown. The authors would like to thank all these organizations, along with the many contractors, who participated in the project. Without their dedication and professionalism, this project could not have attained such success.

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