# TESTING SUBMERGED OIL RECOVERY SYSTEMS

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## ABSTRACT

For spills of submerged oil, current methods are inadequate to find and recover the oil with responders having to reinvent the techniques on each occasion. The Coast Guard R&D Center has embarked on a multi-year project to develop a complete approach for recovery of spills of submerged oils. Three companies spent one year in designing separate systems to identify and recover oil that is sitting on the bottom. This paper describes the designs of the three systems and initial results from prototype testing at the Ohmsett test facility in the United States.

## BACKGROUND

Even though heavy (sinking) oils have historically accounted for a small percentage of spills, environmental and economic consequences resulting from a spill can be high. Heavy oils can sink and destroy shellfish and other marine life populations in addition to causing closure of water intakes at industrial facilities and power plants. The underwater environment poses major problems, including: poor visibility, difficulty in tracking oil spill movement, colder temperatures, inadequate containment methods and technologies, and problems with the equipments' interaction with water. The National Academy of Science recognized these issues and developed a report that provided a baseline for responders (NRC 1999). Since that report some progress has been made to identify successes and performance gaps (CRRC 2007, Michel 2008, and Rymell 2009). In addition a guideline for assessment and removal techniques is being developed by the International Maritime Organization (Chapman 2011). The R&D Center developed specifications and awarded three contracts to design a complete detection and recovery system to Alion Science & Technology Corporation, Marine Pollution Control (MPC) and the Oil Stop Division of American Pollution Control (AMPOL) (Hansen et. al. 2011). In 2011, these three were awarded options to build prototypes for testing. It was recognized that not all of the specifications could be evaluated during a test in a tank but would be described in the design documentation. Trays were laid on the bottom of the Ohmsett test tank in New Jersey (USA) and filled with two types of sand from 2-10 centimeters in depth and three types of oil ranging in viscosities from about 15,000-180,000 centistokes (cSt) at thicknesses of 2-10 cm.

**REMOTELY OPERATED VEHICLES (ROV) SYSTEM**

Alion has developed a design concept built around Remotely Operated Vehicles (ROVs) called Sea Horse (SEagoing Adaptable Heavy Oil Recovery SystEm). In developing a system that fills the niche of a lightweight approach, the three major aspects considered crucial were: mobility, flexibility, and low cost. This system should provide the ability to deploy multiple small systems and to respond rapidly. Three sonars were evaluated as part of the detection component and the recovery system consisted of two Sea Lion II ROVs, a Lamor GTA 20 pump (capacity of 20 cubic meters/hour ($m^3$/hr)) and an aluminum framework. Buoyancy was added to maintain a level orientation for the system. The designed decanting system was not demonstrated.

For detection, three models of Sea View detection sonar system were evaluated; an MB1350-45, a MB2250-45 and a P900-130. The P900 was used to track the position of the ROV. These systems appeared to be able to detect oil but analysis is still being completed. The recovery system (See Figure 1) consists of the ROV-powered sled, the pump, the nozzle, and the hoses. The system weighed about 91 kilograms when assembled but any of the individual components could be handled by 1-2 people so it meets the lightweight criteria.

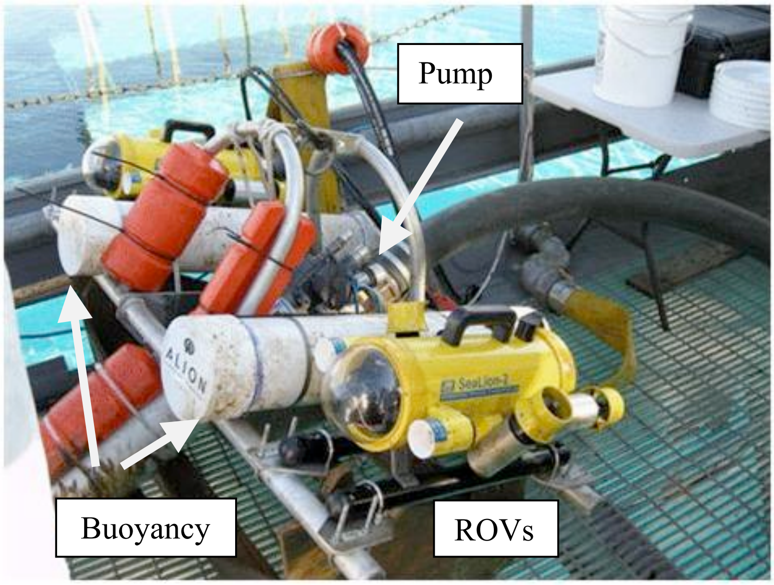



**Figure 1. Alion Sea Horse.**

**System Performance**

After some time in establishing neutral buoyancy, the recovery system was deployed into the oil. A major effort was to develop a dual ROV control system and this worked well. It appeared that the system is slightly underpowered to balance the weight of the hydraulic and recovery hoses and could only handle currents of less than 1.5 knots; this could be solved by replacing the Sea Lions with more powerful ROVs. The control of the system with its hydraulic and discharge hoses was difficult to maintain level to ensure that the suction nozzle was in the oil (Figure 2). Part of this was the lack of experience of the operator who had to periodically look over the side of the bridge to see where the vehicle was pointing. The pump moved the 15,000 and 60,000 cSt oils but some oil did not make it all of the way to the recovery tank and was caught in the recovery hose. Only a small amount was actually recovered. The pump was shown to easily handle these oils on the surface so possibly a smaller nozzle arrangement and smaller recovery hose along with the water injection may solve these problems.

**Figure 2: Sea Horse Nozzle**.

**SUBMERGED OIL RECOVERY USING A MANNED SUBMERSIBLE**

Marine Pollution Control has developed a system composed of a manned submersible teamed with a recovery capability and additional sensors including an oil-discriminating sonar and fluorescence polarization (FP) sensor. Since the Ohmsett tank was too shallow to deploy the submersible, a test rig (Figure 3a) was configured to represent the operational parts of the submarine including a heated nozzle, a robotic arm (Figure 3b), a sonar, two FP sensors and multiple video cameras and lights. A pump with a capacity of 500 $m^3$/hr mounted on a Vortex Enhancer to further control debris was hung from the main Ohmsett bridge. A full oil separation system was provided including two large tanks, a filter system, a heater to provide steam and pumps with adjustable inlets that could take water from the tank without taking oil from the surface or the bottom.

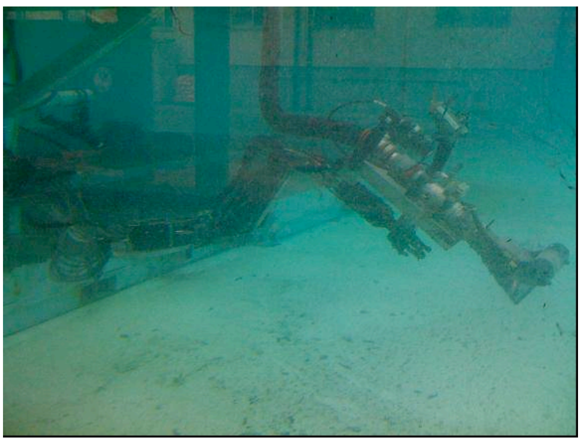


**Figure 3a. View of Rig on Surface**

**Figure 3b. Close-up of hydraulic arm and nozzle**

**System Performance**

To ensure that the rig would not be compromised, the system was evaluated by swinging the nozzle in an arc as the Ohmsett bridge slowly backed down. The result was circular paths in the oil and sand (Figure 4). The system easily picked up the oil and also a large amount of sand and water although these amounts were reduced as the nozzle opening and the power of the pump was reduced as the testing progressed. The efficiency of the system also improved as the testing went on as the operating procedures for communications to the pump operator and the bridge operator were refined. The steam to the nozzle interfered with the real-time sonar but the EIC FP sensor was successful in sensing oil in front of the nozzle as well as in the pump hose. The oil separator system worked well permitting water to be re-introduced into the Ohmsett tank after decanting and running through a sorbent filter system. The sonar results showed where oil had been removed but a rigorous analysis of each tray was not completed (Figure 5). More work is needed to optimize all of the parameters (pump rate, nozzle size, heat application, etc.) and this will probably be needed for each individual spill. This system provides the capability to change all of these variables as well as flexibility in the decanting process to ensure an efficient recovery.

**Figure 4. Heated nozzles removing oil from tray**

**(bottom of tray exposed)**

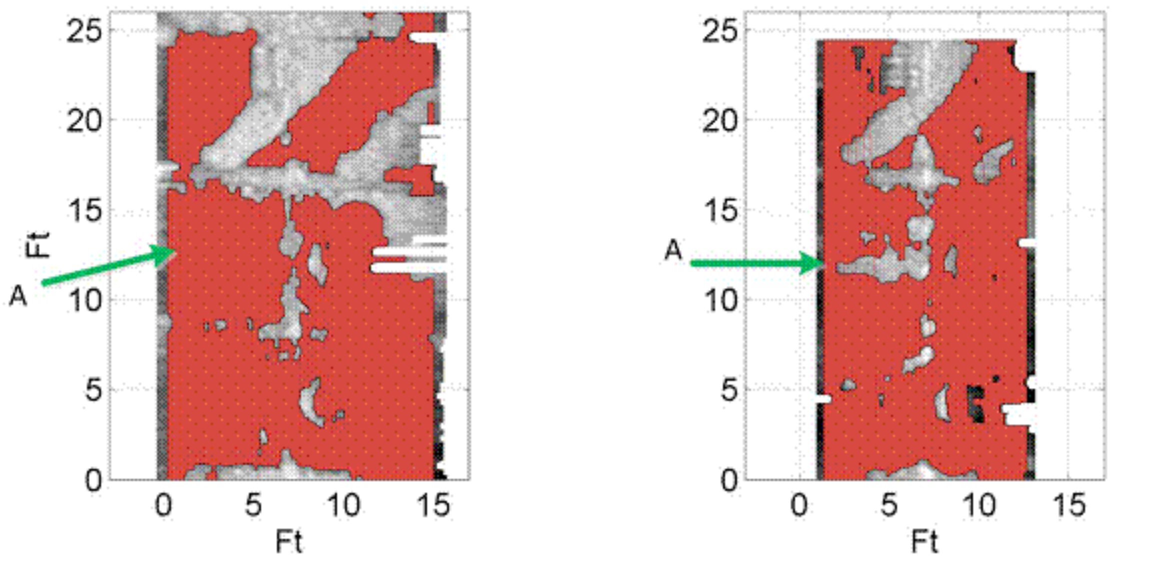



**Figure 5. Sonar results showing location A where oils has been removed from right side.**

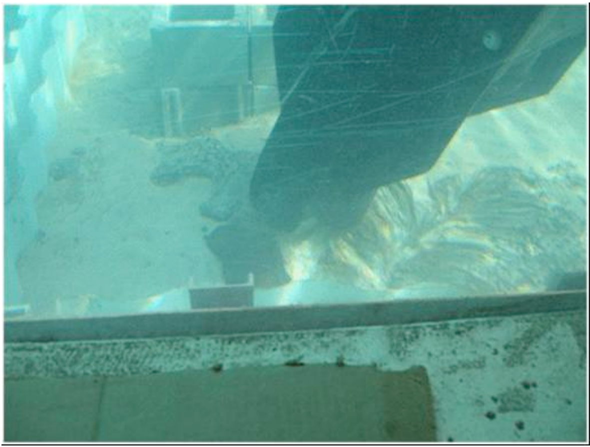
## SUBMERSIBLE DREDGE

The OSBORS (Oil Stop Bottom Oil Recovery System) utilizes the Sub-Dredge, a remote-controlled pumping vehicle designed by Tornado Motion Technologies (TMT), which has a pump with a 182 $m^3$/hr capacity. It relies on an external detection system for initial detection, but utilizes underwater cameras mounted on the pump for recovery. This system was also too big to place in the Ohmsett tank so the pump was mounted on an excavator and the mounted camera system used for control with a closed-circuit monitor installed in the excavator cab (Figure 6). In the excavator configuration, the system is proposed as a viable oil removal tool in water depths up to 15 meters. A pair of wheels designed to set the pump off the bottom were removed when it was determined that too much water was being recovered. A rotating rock shroud was also removed to permit the intake to be closer to the bottom. A full oil separation system was also deployed that also utilized a settling tank, mesh filter cloths and two surface skimmers.

**Figure 6. Pump mounted on excavator**

**System Performance**

Initially this system also recovered oil with a large amount of water but refinements and increased operator experience resulted in better output later in the testing period. A sweeping movement was also used and the results can be seen in Figure 7a. Turbidity measurements were made by using a zone-grab sampler to obtain oil from near the operations on the bottom and the results were consistently low. The oil separation system functioned well being similar to the MPC approach.



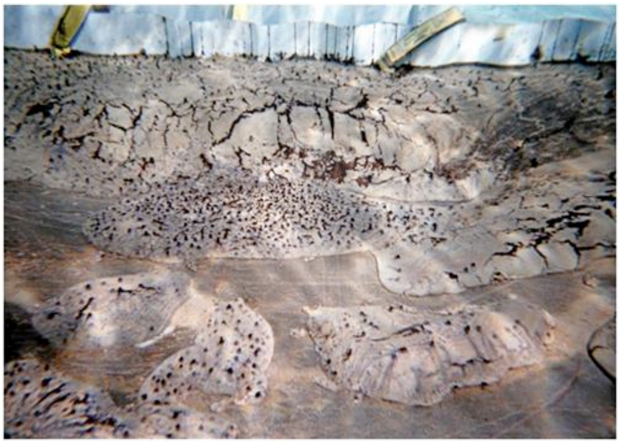


**Figure 7a. System deployed** **Figure 7b. Tray after OSBORS tests.**

**NEXT STEPS**

Field tests are tentatively scheduled for the summer of 2012 for the Alion and the Oil Stop systems to evaluate portions that were not evaluated in the tank. Tests of the manned submersible conducted previously by MPC were successful at recovering an oil surrogate (organic clay) from the bottom of a freshwater lake and river. (Usher 2008) (Figure 8)


**Figure 8. Submersible on surface during demonstration**

**SUMMARY**

Three unique systems have been designed and tested that meet most of the required specifications for detection and recovery of submerged oil. Funding only permitted about 4 days for the setup and testing of each and all could have used more time to refine their approaches. All improved their ability as the tests proceeded. Permitting the person viewing the video display at the recovery point (or positioning a pilot operator at that point in the case of the manned submersible) to control the pump will reduce any lag time when turning the pump on and off and should also reduce the amount of water and bottom material collected. All of the vendors indicated that larger and possibly multiple collection tanks would be needed for a large spill. The size of the filter system varied from below 10 to 200 microns and this will also probably need to be adjusted for each spill. The use of multiple steps for separating oil is needed, especially since any sand sticking to the oil may not separate during pumping operations. There was one question about the loose sand in the trays as compared to the harder-packed structure of the ocean bottom but it appears that since moving highly viscous oil sitting on the bottom requires high pump pressures, picking up the bottom material will most likely still be an issue. The components for any of the systems should be useful in combination if other scenarios are encountered. The development of these systems may not preclude the use of divers in some situations but may be substituted if the oil is deep (use manned submersible), in a surf zone (use crawler system) or if placing divers into the water is unsafe (use ROV). More guidance will be provided after the field tests in a final report later in 2012.

## NON-ATTRIBUTION POLICY

Opinions or assertions expressed in this paper are solely those of the author and do not necessarily represent the views of the U.S. Government. The use of manufacturer names and product names are included for descriptive purposes only and do not reflect endorsement by the author or the U. S. Coast Guard of any manufacturer or product.

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