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2014 INTERNATIONAL OIL SPILL CONFERENCE

Responding to Oil Spills in Ice

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ABSTRACT 299935:

Responding to oil spills in ice is being addressed by many different organizations throughout the world, varying from oil producers to local responders. These efforts are needed to ensure spill response capabilities can be deployed in future spills in the Arctic. The US Coast Guard Research & Development Center (RDC) has sponsored a series of demonstrations in the Great Lakes to show existing stakeholders capabilities and identify potential gaps in response technologies and/or strategies to determine what area still need to be addressed within the United States. This was an attempt to take advantage of the existing Great Lakes ice conditions, vessels and logistics that are harder to access in Alaska. RDC has also participated in demonstrations in the Arctic off of Alaska in 2012 and 2013 to evaluate logistical and operational issues in that region. This paper will describe the demonstrations performed and the lessons learned with applications for any future Arctic spills and research still needed.

BACKGROUND:

A large amount of work has been done to evaluate and develop methods and equipment to respond to oil spills in the Arctic in order to prepare for additional traffic and exploration proposed to occur. A comprehensive list of efforts is not provided here but there have been oil-in-ice workshops, multiple general reviews, multiple manuals and specific analysis (Dickins. 2011, National Commission. 2010, AMOP. 2010, and SINTEF. 2011). There have been sensor tests performed at facilities using ice including the US Army Corps of Engineers Cold Regions Research and Engineering Laboratory (CRREL, http://www.crrel.usace.army.mil/innovations/oil_spill_research/detection.html) and at the National Oil Spill Response Research and Renewable Energy Test Facility, Ohmsett (MMS 2011). There is also a large joint industry project trying to identify and close the response gaps (Mullin 2014). But there have been limited efforts to exercise the equipment and methods in an operational setting to determine specific deployment schemes in broken ice. This is mostly due to the lack of availability of ice-strengthened ships or icebreakers both in Alaska and on the Great Lakes. One exception was carried out by BP Exploration and Alaska Clean Seas (Bronson et. al. 2002).

The US Coast Guard (USCG) Research and Development Center (RDC) started a project in 2009 to determine if operational demonstrations in the Great Lakes could be used to evaluate technologies. Most of the spills that the Coast Guard is expected to encounter in the Arctic in the near future will probably be in open water with the potential for the oil to drift towards the ice edge or the ice to drift into the oil. This ice edge is usually composed of first year ice that is not too different than in the Great Lakes. The results would be used to prepare a comprehensive approach to response in ice for both the Great Lakes and the Arctic.

Two workshops were held; the first one in Anchorage, Alaska on April 23, 2010 and the second one in Cleveland, Ohio on August 25, 2010. These were used to determine how conditions in the Great Lakes compared to the Arctic; and if anything could be learned in the Great Lakes. Participants identified specific tests that could be performed in the Great Lakes and still be applicable to an Arctic environment (Softye 2010, Hansen and Lewandowski 2011). These recommendations included but were not limited to ice management, use of fire-resistant booms, and evaluating potential response vessels. Based on these recommendations, three demonstrations occurred during the winters in the Great Lakes between 2011 and 2013. These were designed to deploy equipment and determine requirements and tactics that could be employed when using these or other equipment in the future. This paper will describe these demonstrations, as well as demonstrations conducted north of the Arctic Circle in 2012 and 2013 that also were used to evaluate equipment capabilities and tactics.

DEMONSTRATIONS IN GREAT LAKES:

Three field demonstrations were performed as part of the goal of collecting information on requirements for setup, equipment staging, operations, and offloading.

Demonstration 1

The first demonstration in April, 2011 occurred off of a pier at Sector Sault Ste Marie as the vessel scheduled to participate in the demonstration was reassigned. The equipment evaluated included a grooved drum skimmer with a steam/hot water hook-up and a rope mop skimmer. Without ice in the water, it was not possible to fully evaluate their use; although the use of steam appeared to be a good idea. A short section (200 feet) of fire resistant boom (PyroBoom®) was towed by two small boats with outboard motors. They were not able to control that section of boom, indicating that larger vessels would be needed. A self-contained fire monitor was demonstrated as a means of guiding or directing oil into a boomed area. The participants were provided with initial exposure to the types of equipment and requirements for deployment in cold weather that many were not familiar with (Cooper and Dugery 2011). Among the recommendations by the participants and observers was to move forward with a more extensive demonstration.

Demonstration 2

The second demonstration occurred from January 23-26, 2012. One US Coast Guard buoytender (CGC Hollyhock WLB-214) and three ice capable commercial tugs were the vessels involved. The scenario used was a simulation of a leak from a pipeline that runs under the Straits of Mackinac about 2 miles west of the Mackinac Bridge. More details than can be covered by this paper can be found in Yankielun et. al. 2012.

A multi-drum grooved drum skimmer, with two drums mounted one in front of the other, and with a steam/hot water hook-up was deployed in and among broken rubble ice. (Figure 1) The skimmer did not have enough weight to displace the surrounding ice rubble in some locations; and have the drum surface sufficiently contact the water surface. This device appears to be a better candidate for use in open water including pools between the ice sheets. The PyroBoom® was deployed by two tugboats and the configuration was able to successfully capture and tow a quantity of ice broken from the ice pack by actions of one of the tugs (Figure 2). The assumption is that oil would be embedded in the ice and could be burned or skimmed by moving the oil away from the other ice and concentrating it. The ability of the tug to operate at a slow speed made it ideal for the process, as opposed to a vessel that must continually clutch its prop in and out to limit headway.

Figure 1. Heated Drum Skimmer **Figure 2. Fire Resistant Boom**

A self-contained fire monitor was again demonstrated as a means of guiding or directing an oil spill surrogate, consisting of peat moss and oranges. These were moved into a pocket formed by the hull of the CGC Hollyhock with bow ‘nosed into’ the ice sheet and adjacent sheet ice edge. While slow and somewhat tedious, this method appeared to work, but moving larger pieces of rubble ice with the water jet was difficult. Bow-mounting the water cannon may have made vessel handling and positioning easier. (Figure 3)

A rope-mop skimmer with multiple strings was briefly deployed. While it appeared to operate successfully, it should be deployed in more open water for maximum efficiency. High winds made it difficult to deploy the rope mop and have it fully engage with the water.

Figure 3. Fire Monitor Used for Herding **Figure 4. Aerial View of WLB Deck**

The Helix skimmer, provided by the CG National Strike Force, was deployed from the CGC Hollyhock, in both rubble and sheet ice conditions. Manipulation and positioning of this skimmer worked best when slung from the vessel’s bow mounted 750-pound crane block. It was noted that the Helix fittings, hoses and moving parts should be better ruggedized or armored to protect it from impact by rubble ice. A 50 barrel temporary storage tank was installed on deck (Figure 4) that confirmed the potential loading options first proposed for use during the Deepwater Horizon spill response (SFLC 2011). This tank configuration provides an alternative to a towed floating bladder that may be susceptible to ice damage.

A Remotely operated Vehicle (ROV, Deep Ocean HD2) with UV fluorometer was deployed during the second day of the exercise. It showed potential both as a means of locating oil concentrations under sheet ice by looking up with the visual camera or fluorometer and potentially as a means of positioning and manipulating oil recovery equipment beneath the ice. (Figure 5)

Figure 5. Remotely Operated Vehicle near ice

Many participants' past experiences involved deploying equipment from a beach or a pier and it was a new experience in deployment and support from vessels. Methods for equipment deployments used during these conditions are being compiled in a list of tactics (Yankielun et.al. 2012).

Demonstration 3

This third demonstration occurred the week of February 18, 2013 again off of St. Ignace, Michigan. The buoytender CGC Hollyhock returned, as did two commercial tugboats. In addition, a flat deck barge was also used. A partial Incident Command System (ICS) was set up at a local ice arena (Yankielun et. al. 2013).

A practice American Fireboom MKII from Elastec American Marine (see Figure 6) was deployed from the barge by two tugboats; and was able to successfully capture and move a quantity of ice broken from the ice pack by actions of one of the tugs. This was much more fragile than the previous boom used in the second demonstration, having a "sacrificial" PVC cover and skirt that covered a high-temperature resistant core. Deploying or retrieving equipment over the ice is not recommended as this easily damages the outer covering. A Lamor Oil Recovery Bucket brush skimmer (see Figure 7) was mounted on the barge and deployed using a Fassi Model 130 crane. It was installed easily and quickly bought on line. Its location on the bow of the barge limited the tactics selected; as only oil that was near the bow of the barge could be recovered. Mounting the skimmer on the side of the barge would permit the side of the barge to be used to help contain the oil, a characteristic that the bow cannot provide.

Figure 6 American Fireboom MkII in Ice

Figure 7. Brush Skimmer on Barge

A self-contained fire monitor was again demonstrated as a means of guiding or directing an oil spill surrogate, consisting of peat moss and oranges, into a pocket formed by the hull of the barge. It was shown that herding to keep oil away from the ice, in order to use standard response equipment would require two vessels.

The Dual DOP Helix skimmer from the National Strike Force was again deployed from the CGC Hollyhock, both under rubble and sheet ice conditions. The system was reconfigured with a better method that kept the hoses off of the ice but the fittings were still exposed to damage (Figure 8).

Figure 8. Helix Skimmer

Figure 9. UUV

A developmental autonomous underwater vehicle (UUV) from the Woods Hole Oceanographic Institute (WHOI) was deployed (Figure 9). It had difficulties due to a frozen depth gauge, a buoyancy issue in fresh water and a small software problem on the first day; and an emergency recovery operation was necessary. All problems were corrected for a brief deployment on the second day that provided preliminary data for upward-looking sensors. This first deployment in fresh water for this system provided a useful first data point for the researchers developing the system for potential use in fresh versus salt water. The upward-looking capability would be useful for searching for oil under the ice where the ROV could not reach, although the data is not available in real time.

A Remotely Operated Vehicle (ROV, Deep Ocean Model HD2) with two sonars, one forward looking and one upward looking, was first deployed when the autonomous vehicle had problems. It successfully located the UUV and retrieved it, something that was not addressed in the planning of this demonstration. The visual camera provided a good view of the underside of the ice due to the cold clear water. When the upward-looking sonar was tried on the second day to look under the ice, the small ROV was not stable enough to collect good data. Either a larger ROV is needed or the sonar software would need to contain an automatic movement compensation algorithm to successfully map the under portion of the ice looking for oil.

A tethered Aerostat from Inland Gulf Marine with infrared and visual sensors was launched off the barge and images were sent to the CGC Hollyhock about 2 miles away (Figure 10) and to the Command post about 3-4 miles away. The company learned lessons about deploying in cold conditions; including needing more helium than anticipated, needing better protection gear for personnel and refining the use of the deployment and display equipment when heavy gloves are used.

Figure 10. Aerostat Sensor Output on CGC Hollyhock

An ice-navigation and oil detection radar processer from Rutter in Canada was connected to the output of the standard CG Bridgemaster radar. Physical characteristics of the ice that can be seen by the naked eye were more easily identified than the existing radar system (Figure 11). This capability would be the most useful in limited visibility and at night. It could easily identify open areas from further away that could contain oil, as well as assist in determining the best course for the recovery vessel to get to the opening without disturbing the surrounding ice.

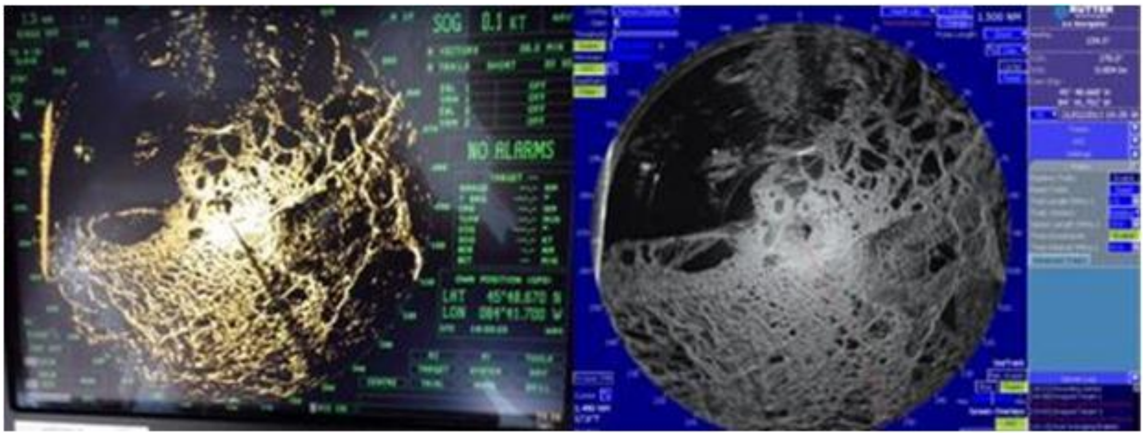

Figure 11. Standard Radar Display (left) and enhanced ice display (right)

Conclusions from Great Lakes Demonstrations

Many lessons learned and recommendations reflected the lack of experience in the Great Lakes for operating in cold climates on open water, due to the limited number of spills that occur. A list of potential tactics was compiled that include the equipment and vessel characteristics. There are limited platforms in this region that can support operations in ice conditions and most are Coast Guard assets (Hansen 2013, Yankielun et. al. 2013).

ARCTIC SHIELD:

As part of both Coast Guard’s Seventeenth District’s exercises, Arctic Shield 2012 and 2013, RDC was involved with the deployment of oil spill equipment off of the North Slope of Alaska.

Arctic Shield 2012

The US Navy Supervisor of Salvage (SUPSALV) was the primary player assisting the CG for this demonstration. SUPSALV rented a barge and tugboat from Prudhoe Bay. Response equipment that the Navy maintains in Anchorage was used. Four containers were trucked to Prudhoe Bay, mounted on the barge and then the barge was towed to Barrow, AK. At that location, the barge was moored alongside the CGC Sycamore (WLB-209) (Figure 13). On the first day, the standard CG Spilled Oil Recovery System (SORS, Figure 14), that each WLB has stored on board was deployed. The barge was successfully used as a temporary storage and assembly location for the components and would be useful during a spill response. There are no deepwater ports with piers available that the WLB can use to get the skimmer system out of the storage hold, the necessary equipment removed from storage containers, and the equipment assembled and deployed.

The Navy system that combined the Current Buster ® from Norway with the Boom Vane

® was successfully deployed the next day (Figures 15 and 16). The Boom Vane® replaces the Outrigger arm in the SORS system that is used to control the outboard end of the boom by providing a force out away from the vessel. The Boom Vane® can be controlled using a separate line and the boom opening can be closed by bringing it close to the vessel when ice is encountered to minimize damage to the boom and skimmer. It is easily reopened by releasing the line. The system was deployed while the vessel was at anchor with 1.6 knots of current passing under the bow. The ship did get underway briefly at about 4 knots with the Current Buster system. It displayed more flexibility that the SORS during recovery operations, but the Current Buster was more difficult to launch and retrieve (GPC 2012).

On the third day, the Coast Guard packed away most of the equipment and the CGC Sycamore moved out to an ice floe among some variable sized drifting ice about 8 -10 miles offshore. The Polar Bear skimmer was put over the side and provided experience for the buoytender crew in executing this type of deployment (Figure 17). It demonstrated that the Coast Guard could get equipment into the water, if a spill occurred; although potentially needing help from the Department of Defense or other organizations with additional barges or vessels.

Figure 13. Aerial View of CGC Sycamore And Barge

Figure 14. CG Spilled Oil Recovery System (SORS)

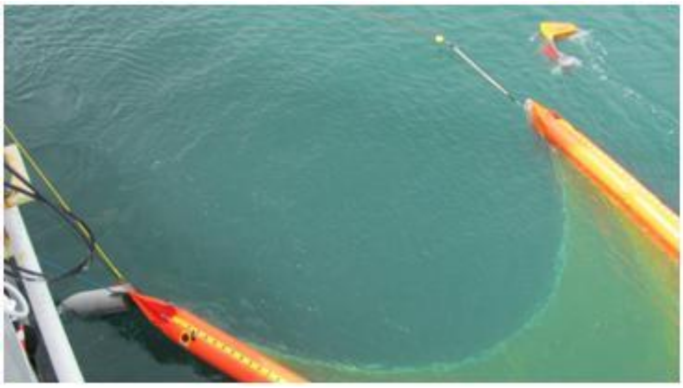

Figure 15 . Boom Vane attached to Current Buster opening

Figure 16. Current Buster

Figure 17. Polar Bear Skimmer Deployed

The main objective of this demonstration was attained by demonstrating the difficulty in getting equipment to Alaska and supporting it. The costs and time needed to perform this demonstration reinforces the main issues of remoteness and lack of support infrastructure on the North Slope of Alaska; including lack of deepwater ports, lodging for response personnel and limited warehouses/storage facilities and disposal facilities. All personnel supporting the deployment stayed onshore in housing in Barrow; and were taken by small boat out the vessels each morning.

RDC also had an opportunity to evaluate two amphibious Arctic craft as they moved over the land, ice and water (Story et. al. 2012). While these systems demonstrated some desirable attributes, (one system shown in Figure 18), the Coast Guard is continuing to assess options to modify existing vessels for use along an ice edge or during conditions of low ice coverage.

Figure 18 . ARCTOS Craft on the ice.

Arctic Shield 2013

RDC was provided some ship time aboard the CGC Healy (WAGB-20) under the Arctic Shield 2013 exercise during September 2013. In a joint interagency effort, several small unmanned aerial vehicles (sUAS, Figure 19), a small ROV (Figure 20), the same UUV deployed in the Great Lakes (Figure 21), the Helix skimmer with an improved hose recovery system (Figure 22) and the Environmental Response Management Application (ERMA) in a stand-alone mode were deployed.

Figure 19 PUMA sUAS

Figure 20 USCG Video Ray

Figure 21 UUV Being Deployed

Figure 22 Helix Skimmer launched by starboard crane.

There were 16 sorties with a total flight time of 14 hours for the PUMA sUAS. Their performance was limited during times of low ceilings, icing and high winds; but the sensors provided information about ice conditions out to several miles. The ROV was able to collect data on other system's performance by taking underwater pictures and video, able to easily survey under the ice within the tether length of the ship and provided an emergency inspection capability when a transponder was fouled in the ship's propeller. This ROV was too small to mount additional sensors besides the camera. The UUV was able to collect information under the ice with varying ice conditions during 10 deployments for a total of about 10 hours. A concept of operations is needed to determine how the collected data from the UUV can be used when offloaded at the end of a mission. The configuration of the Helix skimmer had been modified by removing the collapsible hose and replacing it with a solid stainless steel recovery hose; and that appeared to work well during the 4 deployments. The fragile flotation and potential exposure of the hydraulic fitting to ice damage is still an issue that needs to be addressed (RDC and CGC Healy 2013).

As an example of using ERMA, the path of the icebreaker Healy, a PUMA's flight path, and a specific photograph taken by the Puma along with a specific location can be displayed (Figure 23) to provide an operational picture. Considerations for getting the data from the various inputs (e.g. sUAS, ROV, UUV etc.) into a geographic information format (GIS) should occur before a spill, when possible. Otherwise during a spill response, a major effort may be needed to convert the large amount of collected data in a timely manner for use by responders.

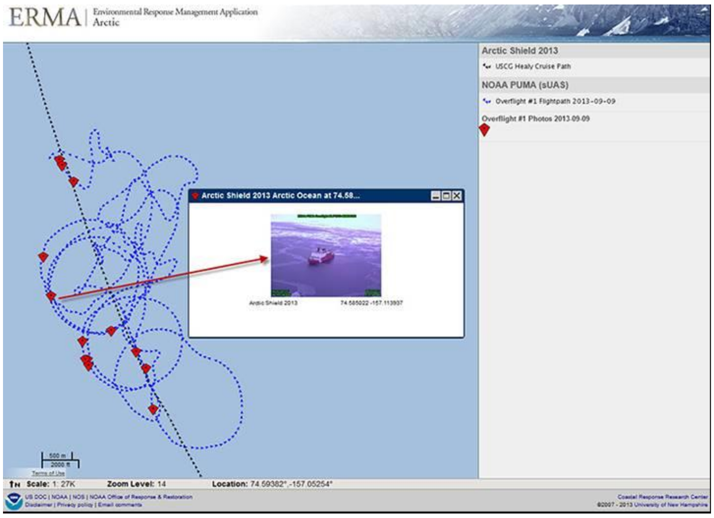

Figure 23. A view from Arctic ERMA (NOAA 2013)

CONCLUSIONS:

Many lessons were learned during the three demonstrations in the Great Lakes, as well as during the Arctic Shield exercise demonstrations. Some are unique to the specific equipment and location, but the results have built a knowledge base for any future spills in ice conditions. Among these, but not limited to:

- Different recovery systems and tactics are necessary for different ice and weather conditions.
- Icebreakers may be necessary to assist other vessels to make way through ice and to the oil.
- Environmentally sound equipment de-icing methods are necessary.
- Frequent crew rotations for work on deck are necessary in cold weather.
- Shipping and loading equipment in cold climates is performed more easily if everything is containerized.
- Ice radar can enhance performance during navigation and to identify ice types.
- Low temperatures and turbulence can have a high impact on operations for the Aerostat, so a dedicated platform is preferred. If not available, a platform with maneuverability is needed.
- Booms and any lines attached to equipment should never be deployed over ice.
- Additional exercises under extreme cold and harsh weather (e.g. higher waves and wind) conditions will further improve and build upon lessons learned; operational and tactical protocols; and equipment deployment, application, and design.
- The Helix skimmer needs to be ruggedized to protect cables, hoses and fittings from ice.
- Barge use and tending procedures need to be developed:
    - Use of barge in ice
    - Emergency response
- Need to document tactics and guidance for FOSC during ice conditions.

At this time, there are few vessels that are built to handle ice; so responders need to understand what equipment and vessels are available so that they can adapt. In some cases, the ice-strengthened vessels can perform surveillance missions and be available to ensure the safety of all response vessels.

RECOMMENDATIONS:

The deployed equipment exhibited varying utility for spill clean-up under various ice conditions, with performance for each dependent on ice, wind and weather conditions. Some of the tactics attempted in these demonstrations need to be refined and adapted to existing equipment and vessels. Consideration should be given when reviewing contingency plans and consider incentives to get the specialized equipment in place. Issues that still need to be evaluated:

- Temporary storage of oil on board vessels
- Ice Management Techniques for skimmers
- Decontamination for vessels and personnel in cold weather.
- Personnel Protection Equipment (PPE) for cold weather adapted for easy decontamination
- Develop a concept of operations for UAS, UUV and ROV efforts
- Continued collaborative field exercises in the Great Lakes and Alaskan Arctic under more severe weather and ice conditions, with use of an environmentally benign oil simulants, are recommended.

NEXT STEPS:

Tactics developed need to be exercised under harsh conditions to ensure they are complete and so that personnel can obtain experience, as well. Plans are being made for demonstrations of other technologies in 2014 in the Arctic; and to test any new developments for temporary storage, ice management and cold weather decontamination in 2015 in the Great Lakes.

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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REFERENCES:

AMOP. 2010. “Special Session: Joint Industry Program (JIP) on Oil Spill Response for Arctic and Ice-Covered Waters,” Proceedings of the Thirty-third Arctic and Marine Oilspill Program (AMOP) Technical Seminar on Environmental Contamination and Response, pages 679-840.

Bronson, M., E Thompson, F. McAdams and J, McHale. 2002. “Ice Effects on a Barge-bases oil Spill Response System in the Alaskan Beaufort Sea,” Proceedings of the twenty-fifth Arctic and Marine Oilspill Program (AMOP) Technical Seminar, June 11-13, 2002, Calgary, Alberta, Canada, pages 1253-1267.

Cooper David and Daniel Dugery. 2011. “Oil-in-Ice Response Exercise Final Report”, USCG Acquisition Directorate, Research and Development Center, July 2011.

Dickins, D. 2011. “Behavior of Oil Spills in Ice and Implications for Spill Response, Arctic Technology Conference 2011, Houston, TX, February 7-9, 2011.

GPC (2012). “Final Report Operation Arctic Shield Barrow/Prudhoe Bay, Alaska, July 25-August 8, 2012,” Prepared for Naval Sea Systems Command (NAVSEA), October 9, 2012.

Hansen. 2013. “Results for Oil-in-Ice response Demonstration in the Great Lakes,” Proceedings of the Thirty-sixth technical Seminar on Environmental Contaminatio9n and Response” June 4-6, 2013, Halifax, Nova Scotia.

Hansen, Kurt and Marion Lewandowski. 2011. “Using Exercises to Advance Approaches to Response for Oil in Ice Environments”, Arctic Technology Conference 2011, Houston, TX, February 7-9, 2011.

Minerals Management Service. MMS 2011. “Arctic Oil Spill Response Research and Development Program, A Decade of Achievement”, 2010.

Mullin, Joseph V. 2014. “Advancing Oil Spill Response in the Arctic”, Arctic Technology Conference, Houston, TX, 10-12 February, 2014.

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 2010. “The Challenges of Oil Spill Response in the Arctic”, http://www.oilspillcommission.gov/document/challenges-oil-spill-response-arctic.

NOAA Office of Response and Restoration. 2013. “Above, under and Through the Ice: Demonstrating Technologies for oil Spill Response in the Arctic”, http://response.restoration.noaa.gov/about/media/above-under-and-through-ice-demonstrating-technologies-oil-spill-response-arctic.html

Research and Development Center (RDC) and CGC Healy. 2013. “Arctic Shield, 9/07-20/2013, Joint Demonstration After Action Report, October, 2013.

SINTEF. 2011. "Joint Industry Project (JIP) Oil in Ice", http://www.sintef.no/Projectweb/JIP-Oil-In-Ice/Publications/.

Softye, Richard, George Comfort. 2010. "Oil-in-Ice Workshop for the Great Lakes", BMT Designers and Planners for USCG R&D Center, October 2010.

Story, Jason, Scot Trip and Brent Fike. 2012. "Arctic Craft Demonstration Report", Report USCG-D-2-12, November 2012, Department of Homeland Security, US Coast Guard Research & Development Center.

US Coast Guard Surface Fleet Logistic Center (SFLC) (2011), Architecture Section, "Cold Water Oil Recovery - Final Report", US Coast Guard Internal Report.

Yankielun, Norbert E. and Daniel J. Dugery, Randy D. Sundberg, Kevin Wilson. 2012. "Great Lakes Demonstration 2 Final Report", Report CG-D-08-12, June 2012, US Department of Homeland Security, US Coast Guard Research & Development Center.

Yankielun, Norbert E., Richard Barone, Edward Cables, Christopher Locklear, Kevin Wilson. 2013. "Great Lakes Oil-In-Ice Demonstration 3 Final Report", Report CG-D-08-13, June 2013. Department of Homeland Security, US Coast Guard Research & Development Center.