Monitoring Oil Spills Near an Ice Edge

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Abstract

The US Coast Guard Research & Development Center (RDC) has collaborated with multiple partner organizations to deploy equipment off the CGC Healy in August for the Arctic Shield 2014 Exercise. This paper will describe the technology demonstrations performed using an aerostat with cameras, small unmanned aerial vehicles (SUAS), an unmanned underwater vehicle (UUV) and a remotely operated vehicle (ROV) to track a simulated oil spill (oranges and a dye patch) near the ice edge. Environmental data collected from oil tracking buoys, an unmanned surface vehicle and a buoy to measure near-surface turbulence will be described. Information from all cameras and sensors were imported into National Oceanic and Atmospheric Administration's (NOAA) Environmental Response Management Application (ERMA®) stand-alone system on the CGC Healy to display near-real time events in a common operating picture.

Background

A large amount of work has been done to evaluate and develop methods and equipment to respond to oil spills in the Arctic and a comprehensive sample of efforts is not provided here. There have been oil-in-ice workshops, multiple general reviews, multiple manuals and specific analyses (Dickins, 2011, National Commission, 2010, AMOP, 2010, and SINTEF, 2010). There is also a large joint industry project tasked to identify and close the response gaps (Mullin, 2014). But there have been limited recent efforts to exercise the equipment and methods in an operational setting to determine specific deployment schemes in the ice, due to the lack of availability of ice-strengthened ships or icebreakers. BP Exploration and Alaska Clean Seas carried out a demonstration off of the North Slope of Alaska (Bronson et. al., 2002) that described the limit of less than 10 percent ice on the water for their mechanical recovery equipment to operate. RDC has conducted several demonstrations in the Great Lakes that attempts to address some of the issues (Hansen, 2013 and Hansen, et. al. 2014).

Demonstration Objectives

The objective of this Arctic Shield 2014 oil-in-ice demonstration was to conduct a field deployment using dye and oranges to simulate oil and test sensors to track the oil surrogates; including SUAS, surface (USV) and UUVs, aerostat mounted sensors and visual sightings. Specific objectives were:

1.) Collect data for trajectory oil spill modelers that track the position of the oranges and dye on an hourly basis.
2.) Identify technologies that can be used to track oil during a spill every 4-6 hours.
3.) Collect sufficient environmental data to support the above collection objectives.
4.) Evaluate each piece of equipment individually to assess its effectiveness in tracking the oil surrogates.
5.) Evaluate launch/recovery issues, data collection and data analysis processes/procedures.

6.) Develop tactics, techniques and procedures for each technology individually and simultaneously.
7.) Make recommendations for future Arctic tests or spill response.

The draft concept positioning is shown below in Figure 1. If the ice is stable enough, the CGC Healy could lay alongside the ice. If the ice is not stable, anchoring (if shallow enough) or positioning within sight of the oil surrogates would also be acceptable. A location was chosen that had a relatively well defined ice edge with open water and waves. The chosen location was well away from the edge of the Marginal Ice Zone (MIZ) to reduce swell and wave effects that would prevent small boat operations, due to safety concerns during launch/retrieval and operations. The test was scheduled for approximately 48 hours in duration, so short-term deployments of technologies were expected.

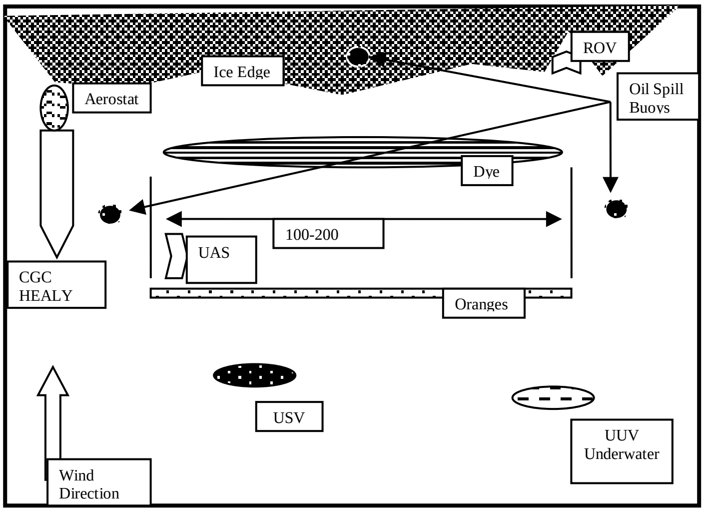

Figure 1. Planned layout of oil –in-ice exercise.

Equipment

The Aerostat-IC system is a self-contained, compact aerostat platform and payload/sensor deployment unit which incorporates all the necessary components required to safely inflate, deploy and operate the lighter-than-air surveillance platform. This lighter-than-air platform is able to carry a diverse number of sensors or payloads of up to 40 pounds; ranging from cameras, communication relays, and atmospheric testing sensors amongst others to an altitude of up to 1000 feet. The Aerostat was deployed from the CGC Healy flight deck. The system utilizes a Launch and Retrieval System (LRS) which is comprised of small electrical winches located throughout the unit and controlled by a hand held controller. (Figure 2)

Figure 2. Aerostat and LRS .

The AeroVironment Puma All Environment (AE) is a small hand-launched UAS designed for maritime use. It has a wingspan of 7.6 feet and is 3.8 feet long. It weighs 13.5 pounds with a visual and infrared (IR) camera package. It is hand launched (Figure 3) and can be landed in the water; and was tested on this demonstration to be capable of landing on the flight deck or in a net near the bow of the CGC Healy.

Figure 3. Puma AE UAS.

The iSPHERE is an expendable buoy designed to track and monitor oil spills. It is 15.5 inches in diameter and weighs 24 pounds. It is constructed of high impact plastic (Figure 4). It provides global positioning system (GPS) and sea temperature data at 20 second intervals that is uploaded to a satellite every 30 minutes through an Iridium transceiver. The data collected were post-processed. These were provided by the Oil Spill Research Institute of Cordova, AK.

Figure 4. iSPHERE from MetOcean.

The Surface Wave Instrument Float with Tracking (SWIFT) Buoy (Figure 5) is designed and built by the Applied Physics Laboratory at the University of Washington. It is designed to measure turbulence near the ocean surface. The objective of this test was to study wave-ice interaction and associated mixing and dispersion.

Figure 5. Surface Wave Instrument Float with Tracking (SWIFT) Buoy.

Other types of technologies were deployed such as a Gavia UUV, a Wave Glider USV, ROVs and an ice radar navigation system. Limited useful data was recorded by the vehicles during this portion of the cruise, see further detail in the final report. (Hansen 2015). An ice navigation radar provided by Rutter of Canada enhanced the view of the ice fields during the demonstration and for use by the vessel in navigating. A separate report on the radar was issued (Balsley 2015) and is not discussed here.

Demonstration

The operational area for the demonstration was 600-1000 kilometers north of Barrow, Alaska. The use of NOAA's ERMA, a Geographic Information System, was used to provide a common operating picture to responders. It was deployed in stand-alone mode, as was done in 2013 (Hansen et. al 2014). During this demonstration, some limited data was passed back to Seattle to represent an incident command post as performed during an actual spill. For the first couple of days of the demonstration (August 16-17) the operations were near the southern Conductivity, Temperature and Depth (CTD) cast location where the shelf slope occurs as seen in Figure 6 from ERMA (NOAA 2013). The northern demonstration area was in deeper water near the northern CTD cast. The original intent was to stay in open water at the edge of the

MIZ. Wind data was collected on the CGC Healy, SWIFT buoy, and Wave Glider with the most complete set from the CGC Healy.

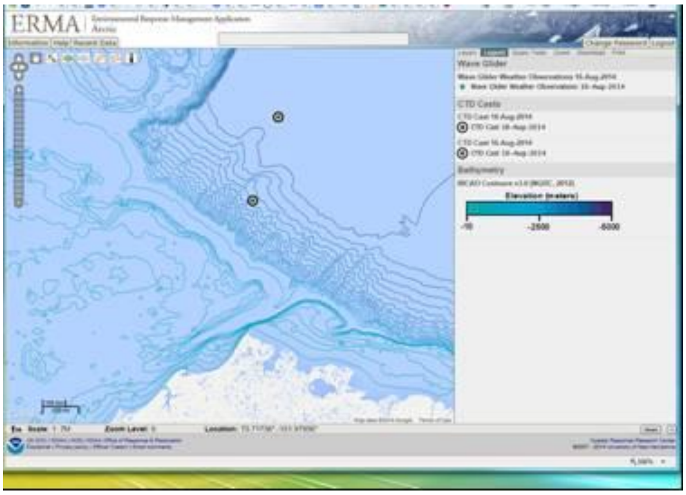

Figure 6. Location of CTD casts.

Drift Data

All of the data was gathered in order to determine how oil might move and drift in and around ice. A total of 4 iSPHEREs were deployed in the water and on ice floes on the 18th and recovered on the 19th local time. The drift is shown in Figure 7 with the initial position data to the top left of the picture and the recovery locations on the right-side bottom. All buoys and oranges drifted southeast, even though the winds were generally from the east and south; almost directly into the wind. All were caught up in ice after only a few hours and it appears that the ice movement restricted the drift. All of the buoys and many oranges were found next to each other when recovered. The movement was about 30 kilometers (about 18 miles) during the period. Looking briefly at wind for the previous several days, it appeared to be generally out of the North and Northwest. It is not clear whether the ice movement is influenced by the regular ocean currents or whether the ice movement was largely influenced by winds and the water moving south. Some current data collected by the Bureau of Ocean Energy Management (BOEM) indicates that “Atlantic Water” currents do move water towards the southeast in the region of the demonstration. (BOEM 2014) More research is needed that is outside the scope of this project. The key is that the local wind may not be driving the oil and ice movements.

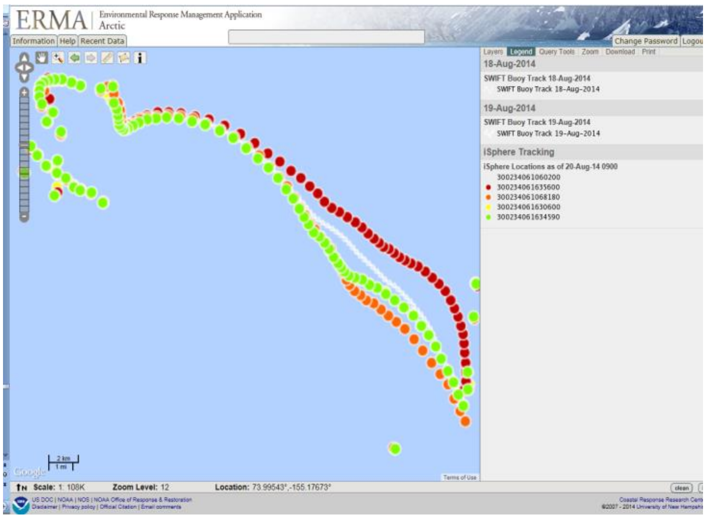

Figure 7. iSPHEREs and SWIFT buoy drift.

Dye Tracking

One of the other objectives of this demonstration was to determine a process to obtain data from unmanned vehicles and get it into a format that decision-makers could use. An image from the Aerostat of the dye patch taken on the second day of the exercise (Figure 8) was relayed to the ERMA system where operators; who then geo-referenced the image, enclosed the patch with a red line and then plotted it as seen in Figure 9 (green area). This method was approximated as the exact camera angles were not known. Assumptions were made for slant ranges and calculated using the known size of the Arctic Survey Boat (ASB) in the image. Almost simultaneously, PUMA collected images from locations shown in Figure 8 and samples are shown in Figure 9. The results are within about 2-3000 meters of each other, which may be useful for strategic decisions but not for any tactical decisions. Extra work would be needed to back-calculate the locations; but the geospacial data corresponding information is not available for the Puma AE images.

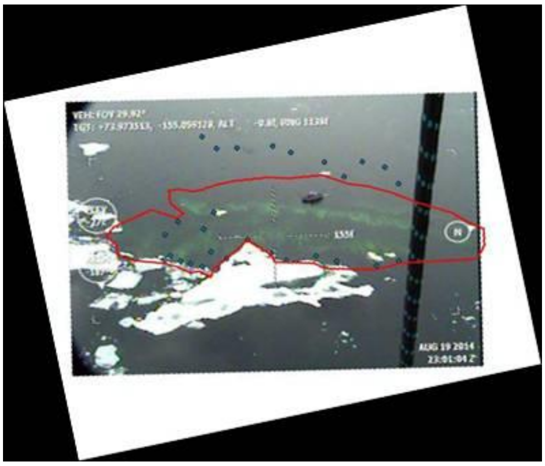

Figure 8. Aerostat Image taken August 19 at 2301.

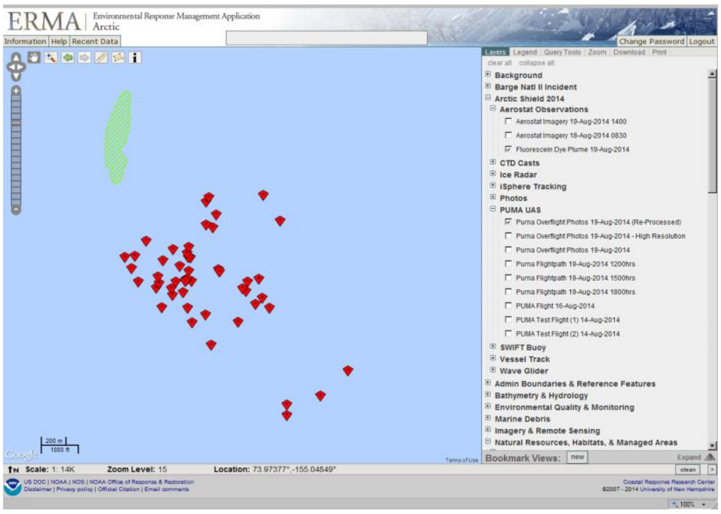

Figure 9. Dye patch and location of Puma AE images plotted in ERMA.

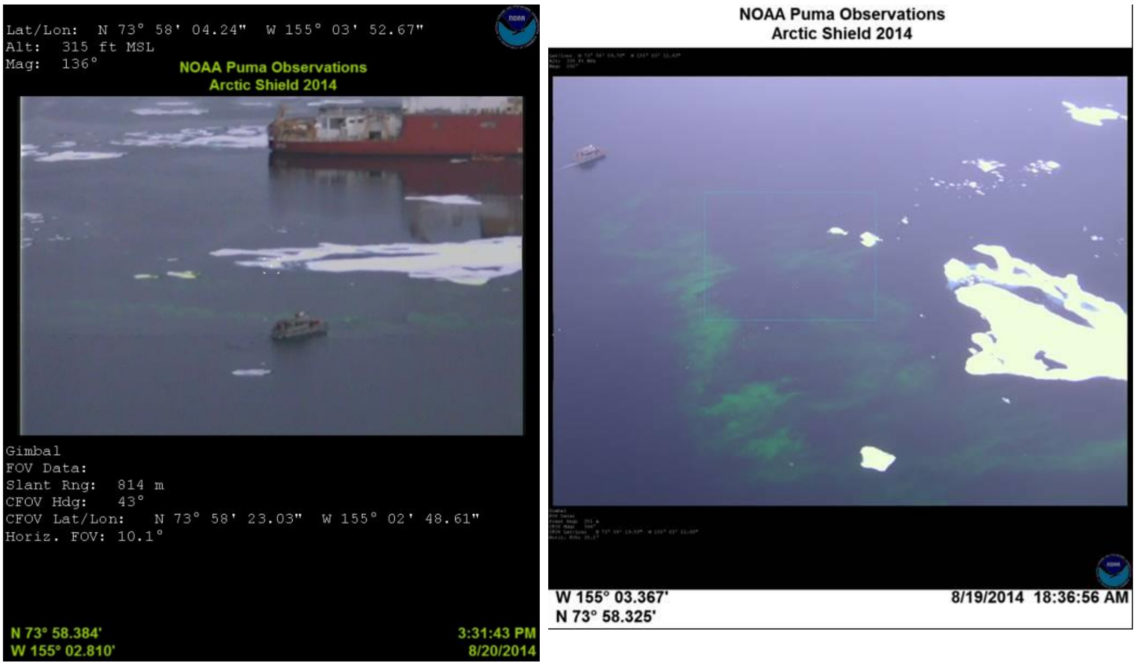

Figure 10. Dye patch from Puma AE.

Summary and Conclusions

Not all of the objectives were met for the oil-in-ice demonstration. The weather (fog and wind) prevented some systems from being deployed or identify the targets. The oranges and dye appeared to work as targets; but more oranges and a longer lasting dye would be more useful. As expected, weather will play a major role for any surveillance. High winds prevented operations when weather was clear. However, if the winds are low, the fog has a better chance of settling in. While the use of an aerostat and UAS should be safer, because a human pilot is not put at risk, they may not provide a full picture. Operating and sensor requirements, such as maximum wind speed and distance to targets, have to be known and specified for all deployed equipment.

The iSPHERE and SWIFT worked and collected good data. Both would be useful during an actual event, if there are difficulties in keeping the oil in sight. None of the deployed equipment (including the Wave Glider and Gavia) has been deployed in oiled conditions, so the influence of oil on their performance is unknown.

Although data was successfully passed to ERMA, rigorous data analysis is required to determine the degree of utility for each deployed sensor. Formats need to be developed so that the data is submitted in the same format; such as making a choice for positions for longitude and latitude positions either in decimal or degrees and minutes. General images of spilled oil may be visually interesting; but if no reference data (e.g. specific locations and aerial extent) is provided, it may be useless to a decision–maker. To facilitate efficient information management during an actual response, having a computer programmer available is mandatory to automate data processing methods more efficiently to support data collection during the next operational period.

Tracking oil in the Arctic will be difficult, as expected. But it may be even more difficult to do the research needed to determine how the oil will move. While many other investigators are recording general turbulence and mixing at the ice edge, it is dangerous to launch small boats in swells and choppy waves in order to place buoys and/or simulants into the water and recover them. Oranges may be thrown from a vessel deck into the water and survive, but their placement may not be in a good grouping. Dyes may be difficult to effectively release from the higher freeboards of a large vessel.

More robust surveillance systems will be needed; as well as dedicated platforms to support the surveillance mission. Smaller aerostats and SUAS could be deployed on skimming vessels, but harsh weather conditions will limit their usefulness. Deploying multiple systems on a single vessel, as done during this demonstration, is not recommended.

Next Steps

1. Assess UUV and USV operations in more congested ice fields to determine upper limits of capabilities under such conditions.
2. Assess the capability of smaller sized aerostat packages that can be deployed on smaller response vessels that will be located directly on scene of the simulated spill. Also assess different camera options and capabilities and different balloon configurations that could be used in higher wind conditions.
3. Check process with Alaska Clean Seas (ACS) and other NOAA organizations for the use of dye to develop more successful mixing strategies that could result in a longer-lasting dye patch. Identify better simulants for subsurface analysis. Follow up on the project by Bureau of Safety and Environmental Enforcement (BSEE) for oil surrogates.
4. Identify more robust systems that can be deployed in harsher weather. This includes all of the unmanned systems: aerial, surface and subsurface.
5. Conduct multi-vessel demonstrations combined with response to determine how much capability is needed for a successful outcome. These demonstrations should be conducted near the edge of the MIZ, where waves and swell are a major consideration. Consider the use of CGC Healy or other icebreakers as a “motel” ship to support extra crew on a separate response vessel, while also doing surveillance and conducting ice management operations around the other vessel.

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