Oil in the Arctic:

Improving Spill Response for Icy Climate

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Disaster Science: Marine Oil Spills

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Oil spills among the most visible and detrimental hazards to the marine environment. With an economy based heavily on the oil industry, it is very unlikely that the threat of a spill will ever disappear completely. In fact, the receding ice in the Arctic Circle has opened more waters to both drilling and shipping. Due to the unique conditions present in the arctic, current response measures may not have the same effectiveness as in other locations. It would be ideal if no oil was released into the environment due to human error, but since this is not likely in the foreseeable future, it is imperative to prepare a response system that can minimize the damage as much as possible. The current methods of response, specifically skimmers, booms, in-situ burning and dispersants, each have strengths in the arctic climate, but they must be modified in order to be prepared for future accidents. In this paper, I discuss the difficulties presented by the arctic, summarize what is known about response methods, and introduce research, both old and new, accompanied by my own suggestions.

The arctic has become vulnerable to the threat of oil spills from both drilling and shipping as the amount of ice present has receded over the years. In fact boat traffic has doubled, form 120 in 2008 to 250 in 2012 (Daniel, 2013). There are also numerous oil drilling and explorations planned for the near future. Seasonal changes occur in both ice coverage and thickness; an area may have a large sheet of ice, multiple smaller floes, or possibly no ice at all (Potter et al., 2012). Additionally, the amount of sunlight in the arctic depends on the time of year. The arctic is in constant darkness for part of the winder and in constant daylight during summer. According to Pew Charitable Trusts, October through January averages 5 hour of light per day while April through September receives over 20 hours each day on average (U.S., 2011). The same report gives an air temperature range of -49 degrees Fahrenheit to 20 degrees Fahrenheit throughout the year.

Because of the Arctic’s unique qualities, oil that is spilled there does not weather in the same ways observed in temperate climates. Although the percentage and type of ice present, as well as the oil type, can lead to different patterns, weathering is generally slower in the arctic. Evaporation is at best 30%, while a moderate climate will see upwards of 50% of the oil evaporate (Brandvik & Faksness, 2008). The same study also notes that emulsification is decreased in arctic conditions, mainly due to decreased wave action, leading to a smaller increase in oil volume and less water content. Viscosity reduced by the cold temperatures (Brandvik & Faksness, 2008) which is generally an obstacle for clean up, but it also means the oil does not spread as quickly and will form a thicker slick. Biodegradation occurs when bacteria and microbes consume the oil, decreasing its harmful effects. Bacteria that live in highly salty water are present in the arctic, and biodegradation has been shown to occur (Hanninen & Sassi, 2010), though slightly reduced due to the fact that the oil does not disperse and the encounter rate is lower. Additionally, some processes occur in the arctic that do not happen elsewhere. Oil can go under ice, and once there is often immune to standard weathering. However, it can become frozen into the ice in layers (Hanninen & Sassi, 2010). Both on water under ice, the icebergs act as natural booms, containing the oil relatively close to the spill site.

Given the characteristics of the arctic and oil that is spilled there, it follows that current response methods do no perform the same as they do in typical spill locations. The three most typical response options (booming and skimming, in-situ burning, and dispersants) are each affected in different ways, and certainly none are able to recover all of the oil if used as the sole response method. With current capabilities, mechanical clean-up is considered for spills on expanses of solid ice, but burning is generally preferred for areas with loose ice (Dickens 2004).

For physical recovery of oil, it must be gathered into a certain area so that a skimmer may encounter the floating slicks and remove them. The first challenge here is containing the oil with booms. It is difficult to anchor the boom in ice fields (Arctic 2009) and they can become ice coated which interferes drastically with their efficiency (Dickens, 2004). Assuming that the oil is contained, by either booms or the ice itself, the skimmers can begin to gather it. However, when there are ice pieces among the oil, the skimmers will pick up a mixture containing oil, water and ice (Arctic 2009). This means that the skimmer is able to hold less oil since some of its storage now is filled with ice. The more ice present, the less oil the skimmers can access and the encounter rate drops. If an area has too much ice coverage, a skimmer cannot be used at all because it cannot maneuver through the ice.

In-situ burning in the arctic is a good response option because it does not require an extensive amount of specialized equipment (Bellino et al., 2012) and can therefore be used in even remote areas in a relatively short amount of time. Because ice can naturally contain a spill, it will maintain the thickness required for burning for a good amount of time (Potter et al., 2012). Though burning can remove a good amount of oil, it does not leave the environment untouched either. The heat also decreases the amount of ice, though this is a minor consequence compared to contamination. Additionally, there is residue both at the burn site and in the air following the fire.

Dispersant use in the arctic is a complicated issue. The application of dispersants is controversial everywhere, and the arctic is no different. As a relatively new response measure, there is a lot of research being done on the positive and negative effects of dispersants and still many unknowns. However, it is established that dispersants can be applied by plane and therefore are capable of reaching a large area of oil. On the other hand, they are less effective in arctic waters once applied. Because the oil is more viscous in cold water, the dispersants do not mix as easily (Potter et al., 2012). Also reducing mixing, ice floes significantly wave action. It is necessary for the chemical dispersant to be actively combined with the oil for it to be affective. There is also a limitation if the oil is underneath the ice, because there is clearly no way for the dispersant to reach the oil from above.

With an understanding of current recovery methods, it becomes clear that they are not adequate for an oil spill in the arctic. Research on the development of these methods is very common, but a few projects stand out as best meeting the needs. Devices to locate oil when tradition methods fail are making huge strides Also, mechanical skimmers are being changed and improved in a variety of ways to function better in icy conditions. Here, I give my thoughts on a few chosen methods, though it must be remembered that my opinions are not of expert pedigree, but merely ideas for moving forward.

When oil is spilled in most places, it is easy to tell. The boat crew can see the oil and give its location to responders and planes can be used once the oil has spread farther. If it happens at night, they must wait a few crucial hours in order to see it, but the oil will not be too far away. However, because of the lack of daylight during some seasons in the arctic and the added complication of ice, it is not always as easy. Oil can spill on the ice and snow, on the water, or underwater and become trapped by ice. Planes aren’t’ helpful if the oil is hidden under ice, or it is too difficult to distinguish between water, oil, and floes. The common detection method in the past was to drill holes to determine where the oil was (Arctic, 2009). Previous research has included everything from infrared to mass spectrometer vapor sensing to acoustic technologies (Dickens. 2004). Trained dogs have even been successfully used to sniff for oil (Potter et al., 2012), though this is logistically not the most efficient method for many reasons. Currently, ground penetrating radar from airplanes can accurately locate oil through up to three feet of ice if the oil layer is at least 2cm thick (Arctic, 2009). Since this seems to be an effective system, I would turn the focus to determining the thickness of the spilled oil since that is important when choosing a response method. There are already some ways to determine the thickness (Arctic, 2009), but it must be deployed quickly so that response can begin. The best way in my opinion is to combine this with the radar that detects the oil’s location. This doesn’t increase the manpower needed, and would be able to match a location and the thickness.

As for removal, one skimming device, called the JML under-ice scraper, is designed for areas with thick, solid ice floes. First proposed in 1999 by Jari M. Lahtinen (Hanninen & Sassi, 2010), the JML scraper is put under water to collect the oil form the water ice interface. It is more buoyant that water, so it rests against the ice surface and, in theory, can collect the oil in a mostly un-weathered state. After laboratory and location testing in the early 2000’s, the scrapper was determined to have a few flaws. IT was reported to be difficult to steer and work best with smooth, seamless ice, if the oil could even be found underneath the ice cover (Hanninen & Sassi, 2010). Given that this was over a decade ago, I believe the concept should be revisited with the technology we now have access to. With the improved oil sensing and tracking abilities, it seems there could be a way of having an automatically driven, or partially automatically, device. This would reduce the number of crew required and theoretically allow the scrapper to reach much further under ice sheets. The details would need to be studied in depth, but the potential here is great.

Another innovative form of skimming is the ice vibrating unit, designed for use in “rubble ice conditions” (Hanninen & Sassi, 2010). In development since the early 2000’s, this unit is essentially a filter system that is used in conjunction with typical skimming techniques. A grid is lowered into the water at an angle and vibrated so that the oil separates from the ice, floats up through the screen and into the mechanical retrieval system (Hanninen &Sassi, 2010). Currently, the unit is designed to be attached to the side of a vessel that is capable of moving through the ice. It is noted that small pieces of ice will pass through the grids, even after reducing the size of the openings in trials (Hanninen & Sassi, 2010). To me, the key to making this product an efficient recovery method is scale. Since you must encounter the oil in order to collect it, increasing either the size or the number of units per boat will increase recovery. Additionally, there needs to be a secondary barrier for the small pieces of ice that still enter the unit. I would suggest a barrier on the belt or brushes used in the skimming mechanism. This barrier would adjustable, based on the oil thickness, so that it does not contact the oil at all but could prevent the ice from being carried up. If the barrier was a V shape, ice would be pushed to the sides where it could be returned to the water. Some ice would still be collected, but it should be less, increasing the amount of oil that can be stored in the boat.

The final system is not specific to arctic conditions, but claims to work for any type, temperature, and viscosity of oil, as long as it is still floating. Developed in Finland, the OilWhale recovery system takes in large areas of water without causing turbulence in order to prevent emulsification of the oil (Hanninen & Sassi, 2010). The oil than must pass over a shallow barrier so that only the top layer, the floating oil can enter the second the chamber and be pumped into a separate recovery area (Meyer et al., 2011). The system was entered into a completion in 2011 called the Wendy Schmidt Oil Cleanup X Challenge, but placed near the bottom of the ten entrants by the competitions standards (Meyer et al., 2011). However, I think this concept has potential for the arctic because it could be modified to account for ice. The concept of minimizing further weathering is unique; while it might take longer to collect the oil, the recovered material would need less processing to be useable once more. But once the undisturbed section of water is contained, the oil could be separated by closing a two layer floor between the oil and water. The top layer of this door would be made of a screen similar to that used in the vibrating ice unit and would lift the ice and debris up and out of the oil. The oil would fall back through where it could be collected. This would work best for areas with larger ice chunks that could not pass through the screen. This method would likely be slower, but the key benefit would be the better condition of the recovered oil.

While the arctic presents many challenges for oil spill response, people remained determined to overcome them. Given the climate in the region and the ways oil is affected, current techniques simply aren’t performing well enough. At this time, burning is often the best option for protecting the environment, but it is not perfect. Dispersants are limited by the presence ice and traditional skimming cannot always reach the oil. Ideally, our society will be able to switch to a renewable energy source, but until that time, the Arctic’s waters are at risk for contamination. The ideas and developments made in response are moving in the right direction; they are working towards removing as much as possible from the water while keeping it in a condition that still has economic value. The arctic might be in the legal jurisdiction of only a few countries, but it belongs to all people and we must strive to maintain it.

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