# Not So Fast: Some Progress in Spill Response, but US Still Ill-Prepared for Arctic Offshore Development

*A Review of U.S. Department of the Interior, Minerals Management Service's (MMS) "Arctic Oil Spill Response Research and Development Program – A Decade of Achievement."*

WWF

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Cover Photo: Lamor

# INTRODUCTION

*Oil industry interest in Alaska's Arctic waters has increased dramatically in recent years. In 2006, seismic activity took place in the Chukchi Sea for the first time in over 15 years and led to a record-setting lease sale the following year. There are now nearly 700 active leases in Alaskan outer continental shelf (OCS) waters, and in both the Chukchi and Beaufort Seas multiyear exploration plans are scheduled to begin in 2010. At the same time, the arctic environment is facing increasing pressure as a result of climate change and retreating ice.*

*The risk of an oil spill is a clear and present concern, especially for people living on the North Slope who depend on a clean and healthy marine ecosystem for their subsistence livelihoods. It also poses a grave threat to endangered bowhead whales, the threatened polar bear, beluga whales, walrus, seals, the endangered Steller's and spectacled eiders and other waterfowl and birds inhabiting the area.*

*WWF recognizes that efforts are ongoing to test and improve spill response technologies for use in arctic conditions. However, despite reported technological advances, situations commonly exist when oil spill response technologies are not sufficient to clean up spilled oil. These "response gaps" exist in nearly all operating environments, but are perhaps most significant in the Arctic, where extreme cold, moving ice floes, high winds and low visibility can make spill response operations extremely difficult or totally ineffective.*

*In light of the severe limitations of current response technology, the expansion of offshore development is not a responsible course to protect arctic wildlife and the people who depend on those resources. In fact, WWF believes that no further oil leases or permits should be granted until the government, in cooperation with stakeholders, determines acceptable thresholds for response gaps and implements operational limits that acknowledge these thresholds. Prevention and planning measures must be implemented until spill prevention and cleanup technologies are field-proven and market ready. Areas that are too sensitive to be put at risk from an oil spill should not be leased. For areas where development may be appropriate, the federal government should require response gap analyses before additional leases are sold or permits are granted. This analysis should use historical and/or modeled environmental and climate conditions to quantify the percentage of time during which local conditions exceed the demonstrated limits of spill response systems. Then, through a process that involves local governments, stakeholders, and natural resource managers, the government should demonstrate clear and proven methods for closing the response gap before allowing exploration activities to occur.*

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# EXECUTIVE SUMMARY

In 2009, the U.S. Department of the Interior, Minerals Management Service (MMS) published a paper entitled, "Arctic Oil Spill Response Research and Development Program – A Decade of Achievement."[1] The Decade of Achievement paper summarizes 31 Technology Assessment and Research (TAR) reports completed by the agency's Arctic Oil Spill Response Research (OSRR) program during the period of 1997-2008, related to oil spill response in the arctic. This WWF report reviews the MMS Decade of Achievement Report, the Technology Assessment and Research (TAR) reports that are cited, the advances that have been made in the overall ability to cleanup oil in the Arctic Ocean. Finally, WWF highlights the biggest remaining challenges to oil spill clean-up.

The MMS "Decade of Achievement" paper cites the highest recoveries achieved under optimal lab and field conditions, a set of conditions almost never experienced in Alaska's Arctic. Yet, the Decade of Achievement paper does not present the serious technical limitations that are documented in the Technology Assessment and Research (TAR) reports.

In any spill response scenario, the weakest link in the response chain limits response capability. In the Arctic, weather, human factors, and the lack of ice class vessels in Alaska's Arctic are among the main factors that limit response effectiveness today. An effective response requires the ability to locate the spilled oil and continually track it; access to the spilled oil (technical capability to transport response workers and equipment to the spill site and support for the response operations); environmental and oil spill conditions safe enough for humans to operate response tools; and response tools that are effective for the type of oil spilled and the environmental conditions encountered. The inability to track and access the oil under typically severe arctic weather conditions are major weak links in the response chain.

After reviewing the MMS methods of testing oil spill response tools, as well as its report summarizing key lessons from its research, WWF concludes that despite progress, significant gaps remain in the availability of effective oil spill response tools for the Arctic. WWF reached six findings regarding oil spill response in arctic waters.

## FINDINGS

**1. The inability to detect oil spilled in and under ice in the most common arctic conditions remains a major technical challenge.** Ground penetrating radar (GPR) may be used to locate thick slicks of oil (1" or thicker) under ice or trapped in ice up to 3' thick (when detected by air) and up to 7' thick (when detected by a ground level unit). GPR cannot detect thin oil slicks or oil trapped under new ice, young ice, first year ice, rafted ice, rubbles or ridges, or ice thicker than 7'. GPR ground units are slow and labor intensive. Only one GPR unit is available for the entire Alaskan Arctic at this time.

> *"It is not easy to detect and map spilled oil among drifting broken ice…The detection and mapping of spilled oil encapsulated in and under ice is very difficult since the oil is hidden from view beneath a (generally) thick sheet of ice." (MMS Decade of Achievement paper, p.10)*

**2. Oil spill thickness mapping requires additional testing in arctic conditions.** While multispectral aerial imagery,[2] combined with infrared detection show some promise in mapping oil thickness, additional testing is required to tune these tools to arctic conditions and oils produced in the Arctic. The sensor has been tested in California, but no arctic field tests have been conducted. Additional work is needed to develop a commercially available multispectral tool for arctic use; this tool is not currently available in the Alaska Arctic at this time.

> *"A critical gap in spill response is the lack of capability to accurately measure and map the thickness of oil on water and to rapidly send this information to response personnel in the command post." (MMS Decade of Achievement paper, p.12)*

**3. Mechanical response equipment has very low effectiveness in waters with more than 30% ice coverage in the spill area.** While MMS has tested new, stronger ice booms and has tested a new type of skimming system (MORICE) to separate oil from ice, neither of these types of tools are commercially available at this time. Improved oleophilic[3] skimming systems, such as brush and grooved drum skimmers, have shown some minor improvement (a few %) increase in oil recovery, but the main challenge in the Arctic is the ability to access the spilled oil. Ice class tugs or barges are not available in Alaska at this time. Oil skimmers are not effective in ice conditions if they cannot reach the spilled oil. Oil recovery in 30%-70% surface ice coverage conditions remains a major challenge. Oil trapped under ice is nearly impossible to recover.

> *"Field deployment tests of booms and skimmers in broken ice conditions in the Alaskan Beaufort Sea highlighted the severe limitations of conventional equipment in even trace concentrations of broken ice." (MMS Decade of Achievement paper, p.25)*

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[1] http://www.mms.gov/tarprojectcategories/arcticoilspillresponseresearch.htm

[2] Photographs taken from the air.

[3] Oleophilic means strong affinity to attract oil, leaving water in the sea.

**4. *In situ* Burning (ISB) is limited to thick, pooled oil.** Experts agree that in situ burning (ISB) is a viable response tool in some arctic conditions. However, the efficacy of this tool is dependent on a number of limiting factors. One of major response limitations for ISB is oil thickness. Oil must be at least 2 mm (0.08") of crude oil or 5 mm (0.2") of emulsified crude oil to sustain ignition. Emulsified oil (containing sea water) makes the oil very difficult to burn. Most oils spread rapidly on the sea, making the slick too thin for burning to be feasible within a very short time from point of release.[4] Oil spilled under the sea (occurring from a subsea blowout or pipe leak) quickly becomes emulsified and can spread into thin slicks when it reaches the sea surface. While MMS reports burn efficiencies between 55-98%[5] in cold water and broken ice conditions, this data is based on burns conducted in lab and field conditions where the oil was contained in a tank or by boom, thickened and available for burning. Catastrophic oil spills (e.g., well blowouts or subsea pipeline releases) will not provide optimal thick, non-emulsified oil for burning all across the spill area. When surface ice coverage conditions are between 30-70%, it may be possible to burn oil in thicker oil spill pockets but the efficiency and effectiveness is low. Above 70% ice, oil is trapped in ice floes and in situ burning at higher efficiencies may be possible only if ice class vessels and/or air support are available. There are no ice class vessels in the Beaufort Sea at this time.

> *"One fundamental problem with the application of in situ burning to oil well blowouts or subsea oil pipeline leaks is that the slicks are initially too thin, or they can thin quickly, preventing effective ignition and burning." (MMS Decade of Achievement paper, p.25)*

**5. Dispersants do not remove oil from the sea; rather they spread it through the water column.** Dispersants may be used as a last resort in deeper marine waters to prevent oil from reaching sensitive environments, but are of little value when the oil is spilled at the shoreline or in shallow waters. The use of chemical dispersants as a viable response tool for arctic waters in Alaska is still many years off. MMS correctly reports there is regional concern regarding dispersants. Opposition to using these chemicals has been based on the fact that dispersants do not remove oil from the environment and that toxicity impacts to marine life are not well understood. In field conditions, wind, wave, and other weather factors will limit the ability to apply dispersants to the oil slick. Furthermore, application of dispersants is frequently stymied by arctic conditions, preventing targeting application of the sprayed chemicals on the oil slick at the necessary optimal concentrations. Some wind and weather conditions (e.g. poor visibility) will preclude dispersant application from the air, and some conditions will make application very inefficient. Additionally, ice class vessels capable of storing and spraying large quanities of dispersants in Alaska's arctic waters do not exist at this time. Remote portions of Alaska's arctic waters lack port infrastructure and runways needed to support large-scale dispersant use.

**6. Chemical herding agents[6] may be helpful but are not currently available for use in Alaska.** Herding agents may be helpful in thickening oil when the ice coverage is too high to use containment boom for mechanical response and ISB techniques. To date, there are no commerically produced herding agents that have the approval of the Environmental Protection Agency (EPA) which are available for use in the Arctic. More arctic and toxicity testing is needed.  While research is promising, this tool is not currently available in Alaska.

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[4] Fingas, M. Weather Windows for Oil Spill Countermeasures. Report to Prince William Sound Regional Citizens' Advisory Council, 2004.

[5] MMS, Decade of Achievement paper, 2009, p.19.

[6] Herding agents are liquid chemicals sprayed onto spilled oil to thicken the oil.

# REVIEW OF MMS CONCLUSIONS

Having reviewed the MMS "Decade of Achievement" paper, WWF presents a critical analysis of the agency's descriptions of effectiveness and progress. Overall, WWF found that MMS's Decade of Achievement paper highlighted the highest recoveries achieved under optimal lab and field conditions, a set of circumstances almost never experienced in Alaska's Arctic, and did not consistently or accurately portray the limitations documented in MMS's TAR Reports on which the "Decade" paper was based. Weather, human factors, and the lack of ice class vessels in Alaska's Arctic are among the main factors that limit response effectiveness. In the following pages we provide additional context to the MMS report to allow for a more in-depth understand the technological advances and the remaining challenges in the Arctic.

## 1] Detection of Spilled Oil In and Under Ice

**MMS conclusion: Ground Penetrating Radar (GPR) has been developed into a useful operational tool to detect and map oil trapped in, under, on, or among ice.**

**Bottom line: Detection of thick, oil slicks (>1") under ice 1-7' thick has improved using GPR. However, spills spread rapidly and are usually thin (<0.008"). Slicks less than 1" thick still require responders to resort to the labor intensive, manual approach of drilling holes though ice to detect oil.**

*GPR Hand Held Unit, MMS TAR 569*

If oil cannot be detected; it cannot be recovered. Detection of a subsurface oil spill under ice remains a serious oil spill response limitation. A proven method involves drilling holes through the ice on a closely spaced grid pattern to expose oil trapped in or under the ice. However, this method is very labor intensive, inefficient, and requires ice thick enough to support personnel and equipment to drill the test holes. It does not provide a rapid initial determination of spill extent.

In 2004, MMS identified Ground Penetrating Radar (GPR) as a promising oil spill detection technology.[7] The GPR unit was tested in a laboratory tank in New Hampshire. Using sea ice and Louisiana crude oil, the test showed that GPR could detect spilled oil if it was at least 1" thick and under ice no thicker than 16" thick. Film thicknesses of 0.2mm (0.008") or less tend to dominate oil slicks.[8] This technology will not work for thin slicks under thick Arctic ice.

**GPR cannot detect thin oil slicks or oil trapped under new ice, young ice, first year ice, rafted ice, rubbles or ridges, or ice thicker than 7'.**

**Ability to detect thick oil slicks (>1") improved, under some limited circumstances.**

In 2006, field tests were conducted in Svalbard, Norway using Stratfjord crude oil.[9] GPR was tested by technicians using hand-held detection equipment walking along the ice surface and from helicopters (see photo on page 7). These tests showed GPR can detect oil slicks (1" and thicker) under or trapped within ice from 1' to 7' thick if deployed from a ground level, and up to 3' thick from an airborne platform.

MMS's conclusion that "GPR can now be considered as an operational tool in the Arctic to detect oil trapped on, within, and under ice," needs to be tempered by the fact that GPR detection capability is limited to thick oil slicks (at least 1" thick) in up to 3' of ice when detected from the air, and up to 7' of ice at a ground level. This tool will not detect thin oil slicks traveling under or trapped in pockets within the ice. Helicopters mounted with GPR- units must be flown at a very low altitude (15-30') above the ice surface. The 2006 field test report describes GPR limitations:

> *All of the experiments to date have been performed on first-year ice with relatively even top and bottom surfaces. Detection of oil under ice through multi-year ice or rafted[10]/ridged first-year ice might be difficult or impossible. While snow cover does not substantially affect radar penetration, the presence of voids and upturned blocks within rough ice is expected to present a major challenge.[11]*

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[7] Fingas, M. Weather Windows for Oil Spill Countermeasures. Report to Prince William Sound Regional Citizens' Advisory Council, 2004.

[8] MMS, Real-time Detection of Oil Slick Thickness Patterns with a Portable Multispectral Sensor, TAR Project 544, 2005.

[9] MMS, 2006 Svalbard Experimental Spill to Study Spill Detection and Oil Behavior in Ice, TAR Report 569, 2006.

[10] Rafted ice is ice layered cakes or sheets overlapping or piled on top of one another.

[11] MMS, 2006 Svalbard Experimental Spill to Study Spill Detection and Oil Behavior in Ice, TAR Report 569, 2006.

In 2008, MMS evaluated airborne radar system capabilities over select arctic spill scenarios, using a combination of lab data, field test data and modeling. This work concluded that airborne GPR units hold some promise, but there are still challenges in detecting oil particularly in thin, high salinity ice sheets and in warm, thick ice with high volumes of liquid brine. Higher performance is expected during the cold winter months of January and February, with declining performance in the fall (October and November) timeframe and moving into spring break-up (March to July). A GPR unit was purchased by Alaska Clean Seas (ACS) for Alaska's arctic "tool kit."

**ACS has purchased a GPR unit for further testing.**

*GPR Mounted Under Helicopter, MMS TAR 569*

## 2] Oil Spill Thickness Mapping

**MMS conclusion: An aerial sensor has been developed to measure and accurately map the thickness of oil on water and rapidly send this information to response personnel; including the ability to identify the thickest areas of the slick and operate effectively in bad weather or darkness.**

**Bottom line: Thickness measurement capability, for thin slicks, has improved using multispectral aerial imagery. More work and field testing is needed for Infrared (IR) tools to measure thick slicks and expand detection of both tools for a wider range of oil types and arctic weather conditions.**

Oil spilled into the marine environment spreads rapidly into thin layers. Film thicknesses of 0.2mm (0.008") or less tend to dominate oil slicks.[12] Mechanical response is inefficient in thin slicks. Emulsified crude oil thinner than 5mm (0.2") will not burn. Therefore it is critical that response personnel be able to rapidly identify and target thick accumulations of oil to optimize limited oil spill response resources. Visual estimation of oil film thickness distribution from aerial over flights is the most commonly used method. However, visual estimation is highly subjective in daylight hours and is not possible in darkness.[13]

In 2005, MMS identified multispectral aerial imagery as a possible tool to measure oil slick thicknesses.[14] Tests were conducted at the Ohmsett Lab in New Jersey and on natural oil seeps in the Santa Barbara Channel, California. The tool identifies oil slicks in the UV-Visible-Near IR spectral range. An oil spill thickness measurement is made by comparing measurements over the oil spill area and measurements over uncontaminated seawater. Data is collected in a Geographic Information System format that can be transmitted to ground crews by a satellite phone data link.

In the lab, tests were run using California and two types of Alaska crude (ANS[15] and Northstar[16] ). Field work examined California oil seeps, which contain oil that is significantly heavier than ANS crude oil. The multispectral aerial imagery tool measured oil thicknesses ranging from sheens to 0.4 mm (0.016") thick when ANS crude oil was tested in the lab, but was only effective up to 0.2mm thick in the field. At thicknesses above 0.2 mm, the oil spill film reflectance characteristic does not change significantly because sunlight does not penetrate through the oil film. Crude oil obtains its "full, true color" at a thickness of about 0.2mm; thicker films can no longer be accurately distinguished and classified with image bands in the UV-Visible-near IR range, using the multispectral sensor.[17]

**5mm thickness is needed to sustain an *in situ* burn of emulsified crude oil. Multispectral aerial imagery is not useful for this thickness range.**

**Range of Applicability for GPR Detection of Oil in Ice**

| Ice Age | Ice Thickness (cm) | Oil Pool Depth (cm) | Oil Under Ice or as a Trapped Layer | |
|---|---|---|---|---|
| | | | Airborne Radar | Surface Radar |
| **Early Winter Ice (October to December) - 30% of the ice season** | | | | |
| New or nilas | <10 | N/A | 🟥 | 🟥 |
| Young | 10 – 30 | 2 - 3 | 🟨 | 🟥 |
| Thin First-year | 30-70 | 3 - 7 | 🟧 | 🟦 |
| **Winter Ice (January to February) - 25% of the ice season** | | | | |
| Medium First-year | 70 – 120 | 7 - 12 | 🟦 | 🟦 |
| Thick First-year | 120 – 200 | 12 - 21 | | |
| **Late Winter Ice (March to April) - 25% of the ice season** | | | | |
| Thick First-year | 120 - 200 | 12-21 | 🟧 | 🟦 |
| **Spring and Summer Ice (May to June) - 20% of the ice season** | | | | |
| First-year ice | Highly variable | N/A | 🟥 | 🟥 |
| **Deformed Ice (any time of year)** | | | | |
| Rafted ice, rubble, ridges | 30 cm to 10 m+ | Highly variable cm to m | 🟥 | 🟥 |

| | |
|---|---|
| 🟥 | Detection considered highly unlikely due to warm, saline ice and lack of a defined oil layer. Ice too thin for surface operations. |
| 🟨 | Detection possible in the future with higher-powered systems. Results uncertain, due to poorly defined oil layer in thin ice. |
| 🟧 | Detection possible with existing systems but dependent on ice salinity and temperature. Consistent and reliable detection will require higher-powered radar systems or an improvement in signal to noise ratios. |
| 🟦 | Consistent and reliable detection expected, based on knowledge gained at CRREL (2004) and Svalbard (2006 and 2008). |

**Alaska oil films from sheens to 0.2mm could be measured using multispectral sensors.**

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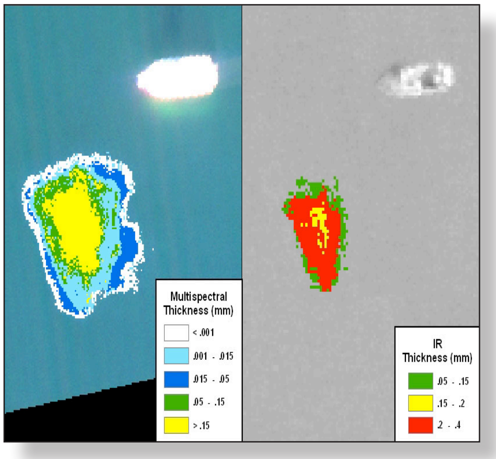
[12] MMS, Real-time Detection of Oil Slick Thickness Patterns with a Portable Multispectral Sensor, TAR Project 544, 2005.
[13] MMS, Real-time Detection of Oil Slick Thickness Patterns with a Portable Multispectral Sensor, TAR Project 544, 2005.
[14] MMS, Real-time Detection of Oil Slick Thickness Patterns with a Portable Multispectral Sensor, TAR Project 544, 2005.
[15] Alaska North Slope (ANS) crude oil is the combined oil type transported in the Trans-Alaska Pipeline.
[16] Northstar crude oil comes from BP's Northstar Offshore Production Facility in Alaska's Beaufort Sea.
[17] MMS, Development of a Portable Multispectral Aerial Sensor for Real-time Oil Spill Thickness Mapping in Coastal and Offshore Waters, TAR Report 594, 2009.

Investigators found there are four important variables affecting the accuracy of multispectral aerial images: (1) oil type; (2) water background color; (3) sun angle, sunlight and cloud conditions; and (4) need for site-specific field measurements to calibrate the tool. Field test accuracy was estimated at 63-80%.

In 2008, MMS explored the combined use of Infrared (IR) tools to measure thicker slicks based on heat radiance characteristics[18] and multispectral areal imagery (to detect thinner sheens). Investigators report that additional testing is needed in freezing temperatures, arctic conditions, and over waters with high sediment loads (which often occur during snowmelt) to adjustment tool algorithms for use at high latitudes and freezing conditions.[19]

**Multispectral aerial imagery quality was impacted by darkness and variable weather.**



*Multispectral Sensor image (left); Infared image (right) MMS TAR Project 594*

## 3] Mechanical Containment & Recovery in Ice Environments

**<u>MMS conclusion:</u> More than a decade of MMS research has focused on methods to improve the effectiveness of equipment and techniques for the mechanical recovery of oil spills in ice-infested waters. This research has substantially improved mechanical recovery of oil spills in Arctic environments.**

**<u>Bottom line:</u> Current arctic mechanical response technology will leave most oil in the sea. Skimmer and boom systems are only effective in sea ice conditions of less than 30% ice, with low recovery efficiency (1-20%). Independent skimming systems without boom can operate in ice conditions above 30%, but only at very low recovery rates. Oil spilled under ice is virtually impossible to recover. On ice that is thick enough to support response equipment, more than 70% of the spilled oil can be recovered. Mechanical cleanup on solid ice is not a new tactic or advance.**

MMS's statement that "substantial" improvements in mechanical recovery equipment have been made over the past decade is not consistent with the TAR reports cited or MMS's own conclusions found later in Decade of Achievement paper. MMS's headline overstates current mechanical response capability, but the body of the MMS Decade of Achievement paper more fairly assesses the primitive state of technology for Arctic operations. MMS concludes mechanical response in **<u>open water</u>** conditions may recover 5-30% of spilled oil.[20] Mechanical response in ice, and under ice, however, is substantially less effective, leaving most oil in the sea.

**Oil Spilled Under Ice:** There have been no major improvements in the ability to clean up oil spilled under ice. Response in this situation requires ice thick enough for personnel and equipment to stand on top of the ice, cut holes into the ice, and attempt to pump/skim oil out of drill holes. As explained above, it is very difficult to detect oil under ice. The inability to locate oil spilled under ice severely constrains the ability for response personnel to even determine where to drill oil recovery holes. The process is slow, tedious, labor-intensive, inefficient and produces low oil recovery rates.

**Recovery is slow, tedious, labor intensive, very inefficient and produces low oil recovery rates. No new MMS technology has been developed to recover oil under ice.**

**Oil Spilled in Ice:** Oil spilled where ice occurs in more than 30% of the spill area still remains a major response challenge for mechanical recovery. When there is greater than 30% ice coverage in the spill area, booms fail to contain oil, leaving skimmers to work inefficiently in open water leads areas between ice floes. Ice concentrations

*Rope Mop Skimmer in Ice, Nuka*

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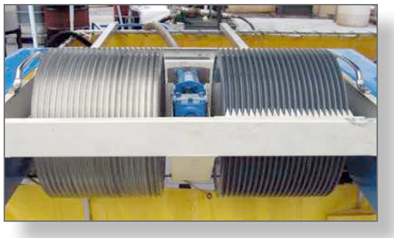
[18] The North Slope Oil Spill Response Organization (OSRO), Alaska Clean Seas (ACS) used Forward-Looking InfraRed (FLIR) to identify thicker areas of the oil slick that emit more thermal radiation, ACS Technical Manual.

[19] MMS, Development of a Portable Multispectral Aerial Sensor for Real-time Oil Spill Thickness Mapping in Coastal and Offshore Waters, TAR Report 594, 2009.

[20] MMS Decade of Achievement paper, 2009, p. 1411

Brush Drum Skimmer; Lamor



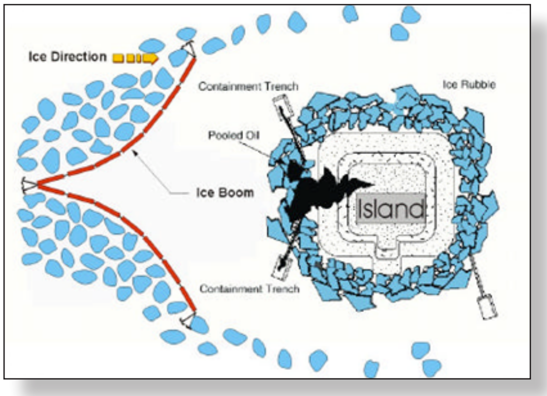
Groove Drum Skimmers; Arturo Keller

above 30% require ice class vessels, which are not currently available in the Alaska arctic response fleet. Oil cannot be recovered if a vessel cannot take the skimmer to the oil. Above 70% ice coverage, the ice acts as a natural boom to contain oil, but access to that oil requires ice breakers and recovery efficiency is extremely low. It is not until ice reaches 100% coverage that crews and equipment can be placed on the ice to start on-ice cleanup. On-ice cleanup may be effective if oil is spilled on the ice, but is very ineffective for recovery of oil trapped in ice or under ice.

**Recovery efforts with mechanical tools >30% ice is extremely low**

Sea ice may reduce the effectiveness of containment booms by interfering with the boom position, allowing oil to be entrained in the ice or travel under the boom, or causing the boom to tear or separate. Mechanical recovery relies on booms to concentrate and contain oil at a sufficient thickness to allow recovery by a skimmer; however, MMS reports that "conventional booms are of little or no use in large moving ice floes or in ice concentrations greater than 30%."[21] MMS describes new research on specially designed ice booms that may increase boom effectiveness in higher ice conditions (in waters with up to 50% ice coverage.[22])

The ice boom is designed to keep ice away from conventional oil recovery systems to allow them to operate more effectively. Yet the ice boom is still a lab prototype only – and is not commercially available. MMS researchers recommend more field testing and point out that an ice boom needs ice breakers for deployment (which are not currently in Alaska's arctic response fleet).



Ice Booming; MMS TAR 353

When ice conditions are above 30% ice, skimmers operate independently in open water leads between ice floes, a very inefficient method. Sea ice reduces a skimmer's efficiency to recover oil by lowering the encounter rate (rate at which skimmer comes into contact with pooled oil) and increasing the time to maneuver and reposition the skimmer for optimum recovery among ice floes.[23]

Some improvements were made in oleophilic[24] brush and drum skimmer technology, improving oil recovery in ice conditions by a few percent. MMS research shows that grooved drum skimmers may increase oil recovery by 20% over current skimming systems, **improving total overall recovery by only a few percent**, if the skimmer can even access the oil.[25]

**Oil recovery is not possible if the skimmer cannot reach the spilled oil.**

This slight increase in skimmer performance over an extremely low recovery rate still leaves more than 80% of the spilled oil in the sea even under the most optimal recovery conditions. In reality, the inability to track the oil, access it, and collect it while it is thick enough to be recovered by mechanical systems is more likely to leave 95%+ of the oil in the sea.

Individual skimming units deployed from ice class vessels can only access very small sections of the spill at a time. The three arctic skimmer types recommended by MMS (brush, rope mop, and groove drum) skimmers all encounter a very small area of the spill and are subject to ice clogging and freezing. Hoses used to transfer recovered oil/water liquid from the skimmers to a storage vessel are also prone to clogging and freezing.

The presence of dynamic, moving drift ice interferes with the ability to contain oil with sufficient thickness to recover it. Oil tends to disperse and mix into the ice, making it necessary to separate the oil from the ice in order to clean up the spill. While MMS has spent considerable funds and more than six years attempting to develop the MORICE[26] skimming systems to separate oil from ice pieces, the MORICE skimmer has not yet materialized into a commercially available skimmer.

The main problem is one of logistics. Responders must be able to get the skimmer to the spilled oil trapped amongst the ice. This requires ice class vessels to serve as transportation and deployment platforms for the skimmer, and to provide storage to collect the recovered oil. Ice class vessels do not currently exist in Alaska's arctic spill response inventory, severely limiting the ability to deploy brush skimmers in broken ice conditions. Only small aluminum class boats and airboats are available in Alaska's arctic "tool kit." As shown in the photo above, the operation of these vessels is limited to open water and mild ice conditions.

Beaufort Sea aluminum hull vessels for skimmer deployment; Harvey

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[21] MMS Decade of Achievement paper, 2009, p. 15

[22] MMS, Application of Ice Booms for Oil Spill Clean Up in Ice Infested Waters, TAR Report 353, 2001.

[23] Fingas, M., Weather Windows for Oil Spill Countermeasures, Report to Prince William Sound Regional Citizens' Advisory Council, 2004.

[24] Oleophilic means strong affinity to attract oil, leaving water in the sea.

[25] MMS, Optimization of Oleophilic Skimmer Recovery Surface; Field Testing at Ohmsett Facility, MMS TAR Report 528, 2006.

[26] MMS, Mechanical Oil Recovery in Ice Infested Waters, TAR Report 310, 2003.

**Ice class vessels do not currently exist in the Alaska arctic tool kit.**

While some companies have proposed to bring in ice breakers and ice reinforced barges to respond in the Outer Continental Shelf (OCS), access by ice class vessels is severely restricted by draft limitations in shallow waters along the Beaufort Sea coastline.

Even if ice class vessels were available in Alaska to get these new skimming systems into icy waters, MMS concludes that mechanical containment and recovery in light ice conditions (20-30%) may be possible, but would have reduced oil encounter rates; mechanical recovery over 40% ice may be possible at **very** low oil encounter rates.[27] Recovery is essentially futile in fall freeze-up conditions because skimmers and the fluid collection hoses become clogged with ice. Conventional marine operations in dynamic drift ice are vulnerable to rapid changes in weather and ice conditions. Significant down-time often occurs in conventional marine operations due to the movement of ice in response to wind conditions, with the sea state further impacting response efficiency.[28]

*Prudhoe Bay Spill, ADEC*

**Oil Spilled On Ice:** Oil spilled on solid ice that is thick enough to support response personnel provides the best scenario to recover oil. Oil recovery in excess of 70% has been reported using standard “yellow iron” equipment (e.g. bulldozers, excavators, trucks, hand tools). Recovery is labor-intensive and time consuming. Risky operations (e.g. exploratory drilling) in the near-shore Beaufort Sea have been limited to solid ice periods for this reason, to ensure that blowouts, if they do occur, result in spills on top of solid ice. This strategy works well for shallow waters where surface well blowouts might occur above the ice surface, but not for subsea well blowouts in deeper waters.

**Oil Well Blowout Response:** In reaching conclusions about methods to address well blowouts in its 2009 paper, MMS relies on data from its 1998 study[29] assessing spill response tactics and clean up capabilities for large blowouts in broken ice. MMS’s 1998 report estimates that 0.6-5.9% recovery is possible in fall freeze-up conditions and 4.4%-18% in spring break-up season, (assuming that some mechanical response could be achieved above 30% ice conditions). Yet, Beaufort Sea trials in 2000 demonstrated significant challenges for mechanical response in ice conditions above 10% ice coverage.[30] Based on the findings from this more recent field work, MMS’s 1998 recovery estimates – and thus the conclusion in the “Decade of Achievement” paper – should have been updated to reflect these challenges.

**Oil recovery on solid ice using “yellow-iron” construction equipment is an old tactic; no new MMS technology was developed in the past decade.**

Blowouts releasing oil on the water surface spray oil a long distance in thin slicks, which are very difficult to cleanup with mechanical response equipment. Blowouts at the seafloor release oil into the marine environment creating an emulsified crude oil mix that spreads and gets trapped under ice, making mechanical recovery ineffective. There are serious human safety issues that need to be considered when responding to a blowout. The inability to put personnel close to the thickened portion of the spill has a significant impact on recovery efficiency.

**Equipment Limits (The 30%-70% ice coverage “Response Gap” Rule):** Most containment booms can be used in light brash ice conditions and ice concentrations up to about 30%. Booms are ineffective in ice conditions above 30%. As ice concentrations increase, the potential for the sea ice itself to serve as natural oil containment increases. Ice concentrations of 70% or higher provide “an effective means of reducing oil spill spreading.”[31] Given these findings, ice conditions ranging from 30% to 70% coverage may present the biggest challenge to mechanical response: conventional booms are likely to be ineffective yet with this degree of ice coverage, natural ice conditions are also insufficient to afford containment of spills.[32,33] The gap in technology to adequately contain spilled oil in such conditions is commonly referred to as the 30-70% “Response Gap” Rule by oil response experts.

Results from MMS’s work support the 30%-70% “Response Gap” rule. In fact, MMS’s work showed that the gap may even be wider; in some cases containment of spilled oil may not be possible in waters with 10%-70% ice coverage. During a series of equipment trials in dynamic ice on the North Slope in 2000 by the State of Alaska and MMS, a barge-based mechanical recovery system was demonstrated to be somewhat effective in ice conditions up to 30%, coverage, but only when ice management systems were deployed to corral the oil such that the percentage of ice in the area where recovery was actually taking place was less than 10%. Sea ice caused considerable strain on containment booms, and boom failure was a problem.[34] The trials demonstrated that the maximum operating limit for the barge-based mechanical recovery system in ice-infested waters was ice coverage of 0-1% in fall ice conditions, 10% in spring ice conditions without ice management, and 30% in spring ice conditions with extensive ice management.[35]

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[27] MMS Decade of Achievement paper, 2009, p. 15

[28] Dickins, D., and Buist, I., Countermeasures for Ice-Covered Waters. Pure Applied Chemistry Vol. 71, No. 1. pp. 173-191, 1999.

[29] MMS, Evaluation of Cleanup Capabilities for Large Blowout Spills in the Alaskan Beaufort Sea during Periods of Broken Ice, TAR Report 297, 1998.

[30] Joint Agency Evaluation of the Spring and Fall North Slope Broken Ice Exercises, prepared by Nuka Research and Planning for Alaska Department of Environmental Conservation (ADEC) and approved by MMS, ADEC, ADNR, NSB, 2001.

[31] Dickins, D., and Buist, I., Countermeasures for Ice-Covered Waters. Pure Applied Chemistry Vol. 71, No. 1. pp. 173-191, 1999.

[32] Evers, Karl-Ulrich et al., Oil Spill Contingency Planning in the Arctic—Recommendations. Arctic Operational Platform (ARCOP), 2006.

[33] Glover, N. and Dickins, D., Oil Spill Response Preparedness in the Alaska Beaufort Sea. Reprint of material presented in 1996 Symposium on Oil Spill Prevention and Response and 1999 International Oil Spill Conference, 1999.

[34] Robertson, T. and DeCola, E., Joint Agency Evaluation of the Spring and Fall 2000 North Slope Broken Ice Exercises. Prepared for Alaska Department of Environmental Conservation, U.S. Department of the Interior Minerals Management Service, North Slope Borough, U.S. Coast Guard, and Alaska Department of Natural Resources. Anchorage, Alaska, 2001.

[35] National Research Council (NRC), Board on Environmental Studies and Toxicology and Polar Research (BESTPR).Cumulative Environmental Effects of Oil and Gas Activities on Alaska’s North Slope. The National Academies Press. Washington, DC., 2003.

## 4] *In situ* Burning

**MMS conclusion:** ***In situ*** **burning is a viable countermeasure for offshore oil spills in arctic conditions.**

**Bottom line: ISB is effective if oil is thick, not emulsified, and accessible for burning. ISB is not effective for oil trapped under ice, thin slicks, emulsified oil, or for use in high winds. ISB converts aquatic pollution to air pollution, and leaves a thick residue which is difficult to recover.**

**Toxic air pollution is produced**

Experts agree that *in situ* burning (ISB) is a viable response tool in **some** arctic conditions. However, the efficacy of this tool is dependent on a number of limiting factors that are not mentioned in the MMS report. One of the major response limitations for ISB is oil thickness. Crude oil must be at least 2 mm (0.08") thick, and emulsified crude oil must be at least 5 mm (0.2") to sustain ignition. Emulsified oil (containing sea water) makes the oil very difficult to burn. Ignition success will also depend on the type of oil and the degree of weathering.

Most oils spread rapidly on the sea, making the slick too thin for burning to be feasible within a very short time from point of release.[36] Oil spilled under the sea (from a subsea blowout or pipe leak) quickly becomes emulsified and can spread into thin, emulsified slicks when it reaches the sea surface. While MMS reports burn efficiencies between 55-98%[37] in cold water and broken ice conditions, these burns were done in lab and field conditions where the oil was contained in a tank or by boom, thickened and available for burning. The photo to the right shows an example of MMS test burns in the lab. These conditions will not be common in an actual spill. Catastrophic oil spills (e.g. well blowouts or subsea pipeline releases) will not provide optimal thick, non-emulsified oil for burning across the spill area.

**MMS estimates very low ISB response efficiency to well blowout spills**
**3.4-6.4% fall freeze-up**
**0-14% spring break-up**

In such scenarios, fire-resistant booms are needed to concentrate oil so it can be burned, but fire booms are subject to the same wind, wave and ice limitations as convential mechanical response booms; thus, a fire boom's effectiveness is also limited to less than 30% ice. Between 30-70% ice it may be possible to burn oil in thicker oil spill pockets, but the efficiency and effectiveness is low. Above 70% ice, oil is trapped in ice floes and *in situ* burning at higher efficiencies may be possible if ice class vessels and/or air support are available. There are no ice class vessels in the Beaufort Sea at this time. Testing by Environment Canada has shown that ignition is not possible in winds above 40kts (46 mph). High winds are common in the arctic.

© MMS

The main disadvantages of ISB are its byproducts: toxic emissions, large plumes of black smoke and a burn residue that may temporarily float but eventually sink to the ocean floor. ISB converts aquatic pollution into air pollution, creating a major source of hazardous air pollution, including benzene, a known human carcinogen. ISB also creates large amounts of greenhouse gases. Since 1991, a team of researchers from Environment Canada, the US EPA, and the US Coast Guard conducted a series of over 45 burns to analyze the contents of emissions and residues resulting from ISB of crude oil and diesel. Research showed ISB produces: particulates, poly-cyclic aromatic hydrocarbons (PAH), volatile organic compounds (VOC), dioxins and dibensofurans, carbonyls, carbon dioxide, carbon monoxide, sulfur dioxide, and other gases, which all have human health and ecosystem impacts.[38] Floating ISB residues may be ingested by fish, birds, and marine mammals and can foul gills, feathers, fur, or baleen.[39] Sunken residues can threaten benthic communities, adversely impacting resources that would not otherwise be affected by an oil spill at the water surface.

As evidence of its conclusions about the viability of ISB, MMS reports that more than 96% of spilled was removed by ISB in a 2006 field test in Norway.[40] However, it is important to note that this experimental burn was conducted by spilling oil into a boomed containment area, and the oil was held in place under the ice by a circular plastic skirt inserted through the ice.[41] Such circumstances are more characteristic of an oil spill from a storage tank where containment is more feasible. In contrast, oil spilled from a blowout or subsea pipeline would be thin, widely dispersed, and more difficult to contain and ignite. In these conditions, *in situ* burning has not been shown to be successful at oil spill removal rates in the 90% range.

MMS does not advertise the low ISB efficiencies for a well blowout in its report headlines; this information is buried in the text of the MMS report. MMS still relies on a 1998 well blowout response study that estimates ISB efficiency in fall freeze-up conditions to be 3.4-6.4% (on water), and 0% (in slush ice). MMS research concludes "[f]or the freeze-up scenarios at low and medium ice concentration, *in situ* burning offers little advantage over [mechanical] containment and recovery techniques.

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[36] Fingas, M. Weather Windows for Oil Spill Countermeasures. Report to Prince William Sound Regional Citizens' Advisory Council, 2004.

[37] MMS, Decade of Achievement paper, 2009, p.19

[38] Fingas, M.F., Lambert, P., Li, K., Wang, Z., Ackerman, F., Whiticar, S., Goldthorp, M., Schutz, S., Morganti, M., Turpin, R., Nadeau, R., Campagna, P., and Hiltabrand, R., Studies of Emissions From Oil Fires. Proceedings of the 2001 International Oil Spill Conference. pp. 539-544, 2001.

[39] Shigenaka, G. and Barnea, N., Questions About In Situ Burning as an Open-Water Oil Spill Response Technique. National Oceanic and Atmospheric Administration. HAZMAT Report 93-3, 1993.

[40] http://www.mms.gov/tarprojects/569.htm

[41] Two spill containment skirts were installed as 11.2m diameter circles (area 100 m2) through 45 cm ice.

**Thin or emulsified oil slicks will not burn at 95%+ efficiency**

Because the slicks emanating from the blowout are below burnable concentrations, containment is required to concentrate and thicken oil before it is burned.”[42] *In situ* burning in spring break-up conditions was estimated at 0% to 14% (on water) and 15-33% (on ice). Only ISB removal efficiencies of 74-99% were estimated if operators were to ignite the well right at the wellhead, destroying the rig and any nearby facilities. The likelihood of this scenario, involving an operator setting facilities worth hundreds of millions of dollars on fire, is highly questionable.

If oil is released under ice, mechanical equipment (ice augers and ice breaking equipment) will be needed to provide access. If the oil is exposed, thick and not emulsified, it is possible to burn at relatively high efficiencies. But the inability to track and safely access the oil before it spreads too thin or becomes emulsified is the limiting factor. In actual spills, recovery efficiencies in the 90%+ range are unlikely to ever be achieved, except in small, limited, localized pockets.

MMS reports that ISB is a technically sound approach for removing oil that rises though brine channels[43] and melt pools in the ice during spring thaw. However, for wildlife such a practice presents potentially lethal impacts; melt pools are used as breathing holes for wildlife and provide an important ecosystem for other marine life. Leads, polynyas, and ice edges tend to be focal points of biological activity, as well as targets for pooled spilled oil.[44]

**Aquatic pollution is converted to air pollution**

## 5] Chemical Dispersants

**MMS conclusion: Dispersants are effective in near-freezing water temperatures, but this is highly dependent on the crude oil properties. Dispersants can be effective in broken ice if there is some mixing energy present. Dispersants provide an invaluable third response option when strong winds and sea conditions make mechanical cleanup and in situ burn techniques unsafe and/ or ineffective.**

**Bottom line: Dispersants do not remove oil from the sea and the risks of toxic contamination are not well understood.**

Dispersants are chemicals sprayed onto the oil spill surface to promote the formation of small oil droplets that disperse through the top layers of the water column. Dispersants do not remove oil from the sea; they merely spread it through the water column. These chemicals may be used as a last resort in deeper marine waters to prevent oil from reaching a sensitive shoreline or sensitive shallow waters, but are of little value when the oil is spilled at the shoreline or in shallow waters.

MMS reports that chemical dispersants in the United States are on the verge of achieving a similar acceptance status to that of mechanical containment and recovery countermeasures, yet there is no data in the MMS report to support this claim. The use of chemical dispersants as viable tools for arctic waters in Alaska is still many years off. MMS correctly reports there is regional concerns about the use of dispersants because of low expectations for effectiveness in arctic conditions. But more importantly, regional opposition has been based on the fact that dispersants do not remove oil from the environment and that toxicity impacts to marine life are not well understood.

Labratory testing in 2003-2005 showed that some Alaska crude oils will disperse in cold water conditions. COREXIT 9500 and 9527 dispersant chemicals were used. In these tests,[45] dispersants were sprayed directly on the oil and the oil was contained to a tank. High concentrations of dispersants were efficiently applied across the oil slick. In field conditions, wind, wave, and other weather limits will impact the ability to apply dispersants to the oil slick. Dispersants sprayed from the air will not all land on the oil slick, at optimal concentrations. Some wind and weather conditions (e.g. poor visibility) will preclude dispersant application from the air, and some conditions will make application very inefficient. Dispersant delivery system nozzles are also prone to freezing, impeding or ceasing dispersant application.[46]

**Dispersants do not remove oil from the sea.**

*Less Efficient Dispersant Application in Field; MMS*

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[42] MMS, Evaluation of Cleanup Capabilities for Large Blowout Spills in the Alaskan Beaufort Sea during Periods of Broken Ice, TAR Report 297, 1998.
[43] Brine channels are formed in the ice where more saline water, with a lower freezing point, remains in liquid form allowing fluids to flow through the ice.
[44] Stirling, I., The Importance of Polynyas, Ice edges, and leads to marine mammals and birds. Journal of Marine Systems, 1997.
[45] MMS TAR Reports 450, 476, 572, and 568.

MMS reports improved dispersant effectiveness when application is followed by the addition of mixing energy, such as the propeller mixing energy supplied by ice breaking vessels ("prop-wash"). However, ice class vessels capable of storing and spraying large quanities of dispersants in Alaska's arctic waters do not exist at this time. Application of dispersants with the help of vessels is currently limited to open water using small aluminum hulled vessels. Remote portions of Alaska's arctic waters lack port infrastructure and runways to support large-scale dispersant use.

*Dispersant Application by Vessel, MMS*

## 6] Chemical Herding Agents

**<u>MMS conclusion:</u> MMS is evaluating the possibility of using chemical herding agents to extend the window of opportunity for oil spill response countermeasures in arctic environments.**

**<u>Bottom line:</u> Chemical herding agents show some promise. More arctic and toxicity testing is needed before use.**

Herding agents are liquid chemicals sprayed on spilled oil to thicken the oil. As explained above, mechanical response and ISB are both rendered ineffective on thin slicks. Above 30% ice, fire and convention booming systems can not be used to concentrate and thicken oil to allow mechanical and in situ burning recovery. Herding agents may be helpful in thickening oil in the 30-70% ice response gap range.

MMS's work on chemical herding agents shows some promise.[47] If herding agent formulations are non-toxic, they may serve a valuable role in thickening oil so that mechanical response and ISB techniques can be effective.

Research has been underway since 2004, and continues. To date, there are no commerically produced, EPA approved herding agents available for use in the arctic. So while research is promising, this tool is not currently available for use in Alaska waters.

**Research is promising; but herding agents are not approved for Arctic use.**

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[46] Leslie Pearson, former Alaska Department of Environmental Conservation State On Scene Commander, experience using dispersants in Cook Inlet, Alaska, personal communication.

[47] MMS TAR Reports 554, and 617.

# CONCLUSION

In any spill response scenario, the weakest link in the response chain limits response capability. Despite some technological advances, most oil spilled in the Arctic would not be able to be cleaned up. Weather, human factors, and the lack of ice class vessels in Alaska's Arctic are among the main factors that limit response effectiveness. WWF calls for a response gap analysis in the Alaskan Arctic that would fully disclose and quantify the percentage of time during which local conditions exceed the demonstrated limits of spill response systems. No further oil leases or permits should be granted until the government, in cooperation with stakeholders, determines acceptable thresholds for response gaps and implements operational limits that acknowledge these thresholds.

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