May 24, 2019

Review of Key Oil Spill Response Tools: In Situ Burning

Tom Coolbaugh
Exxon Mobil Corporation
Spring, Texas

Key OSR Principles - General

- Prevention, including source control, is a basic design and operational goal for industry.
- Equipment + people + planning + training + drills/exercises + reviews = response capability.
- Operators should have effective and functional contingency plans, up to and including a credible worst case discharge.
- Plans must have detailed, actionable components that can be translated into a physical spill response capability.
- The Tiered Response Concept (i.e. cascading resources) remains the preferred approach for ensuring adequate resources are readily available.
- Industry continues to build capacity in all areas (planning, mechanical recovery, surveillance/monitoring/visualization, in-situ burning, dispersants, shoreline protection/recovery, comparative risk assessment, etc.).
- Spill Impact Mitigation Assessment (SIMA aka NEBA) should be used to evaluate all response options and select those providing the best outcome.

Optimum Response Strategy

- Use appropriate combination of response tools to minimize impacts
  - If possible, deploy mechanical in thick oil to maximize recovery
  - Consider dispersant use early in a response
  - Responder and public safety is critical
- Environmental protection priorities
  - Minimize wildlife exposure
  - Minimize habitat contamination
  - Minimize oil stranding on sensitive shorelines
- Human resource protection priorities
  - Tourist beaches
  - Marinas, commercial activities
  - Shoreline property values

Spill Response Options: The Toolbox

Monitor & Evaluate

Mechanical Recovery

In-Situ Burning

Dispersants

Aerial

Vessel

Subsea

The goal is to design a response strategy based on
Net Environmental Benefit Analysis (NEBA)/Spill Impact Mitigation Assessment (SIMA)

NEBA / SIMA

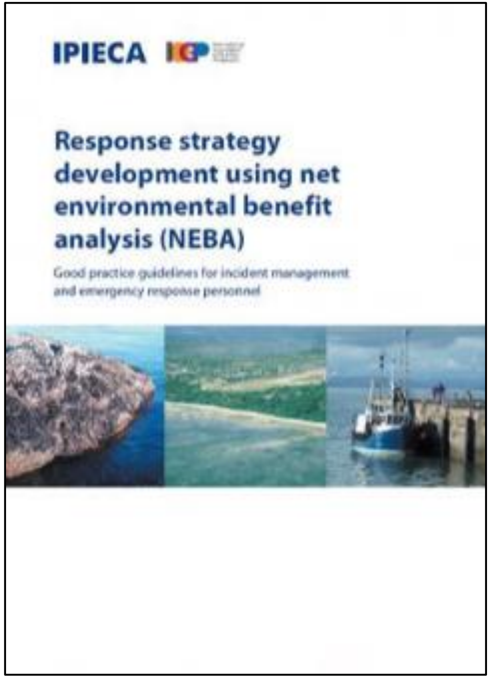
- A risk comparison process to improve decision-making
- A planning and response tool
  - Rank response options by least negative environmental consequences and effectiveness in treating/removing spilled oil
  - Speed the selection of response options for various locations, weather conditions and spill circumstances

- Can be an intensive and detailed process to arrive at a consensus with respect to the response decision
  - Have the necessary discussions in advance of a spill

- SIMA: Spill Impact Mitigation Assessment includes broader socioeconomic considerations.

NEBA/SIMA Resources

- Structured approach used by the response community and stakeholders during oil spill preparedness planning and response
- Compares the environmental benefits of potential response tools
- Supports development of a response strategy that will reduce the impact of an oil spill on the environment



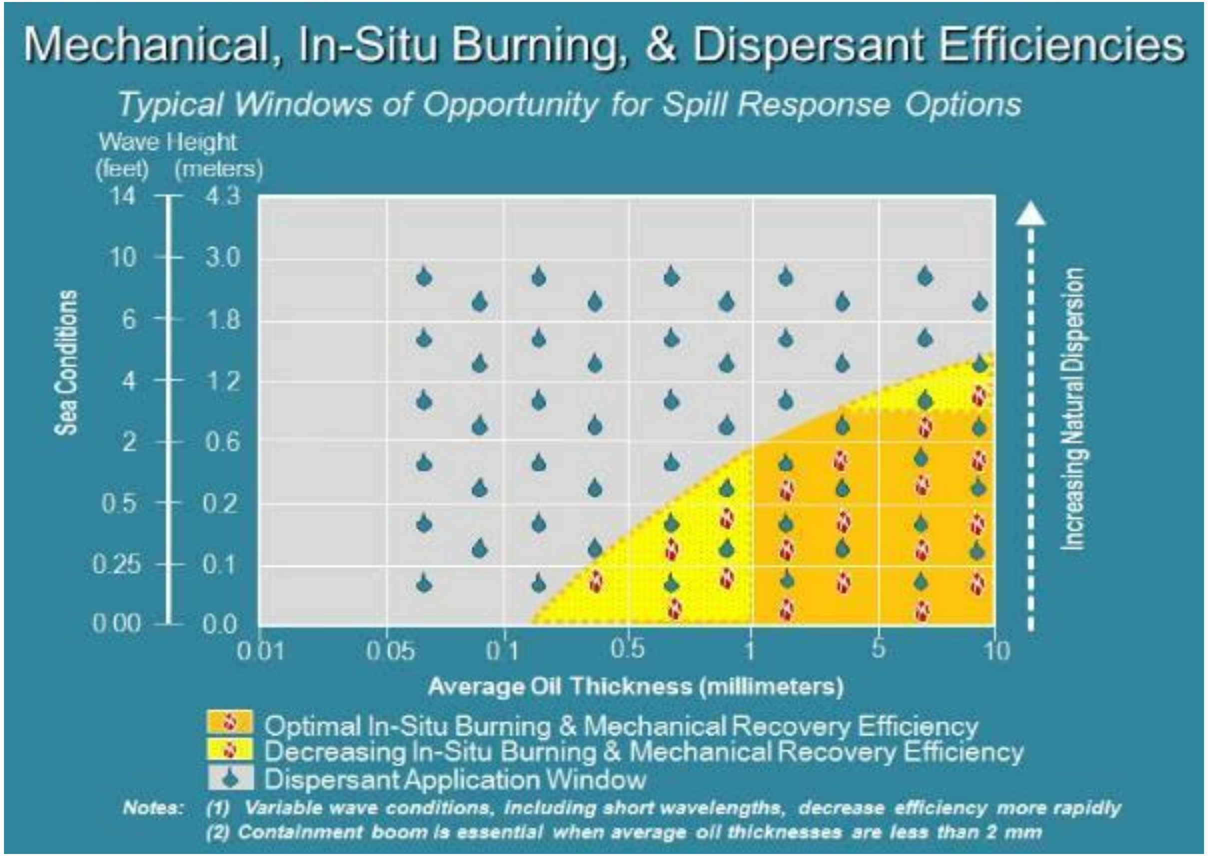
http://www.ipieca.org/resources/?themes=oil+spill

In-Situ Burning

- In-situ burning (burning oil in place) can quickly eliminate large quantities of spilled oil.
- There are some situations where controlled in-situ burning can be conducted safely and efficiently.
- There are situations where burning may provide the only means of quickly and safely eliminating large amounts of oil.
- Ensure regulatory requirements are met before, during and after the burn

The objective is to select the optimal equipment and application techniques that will result in the least overall environmental impact.

Spill Conditions May Limit On-Water Response Options



Possible Burning Scenarios

- On Water and Land
  - May immediately contain and burn
  - Can collect, relocate and burn elsewhere
  - May use for inland spills such as in marshes and in snow/ice conditions
  - Burn naturally contained spills

Figure 2. A marine ISB during the Deepwater Horizon response. (Source: NOAA Office of Response and Restoration)

NOAA gained a great deal of knowledge about in situ burn operations during the response to the 2010 Deepwater Horizon/BP oil spill. (U.S. Coast Guard)

Figure 1—Bayou Sorrel burn, 2013. Source: USCG.

Figure 3. An inland burn of gas condensate oil in a salt marsh in Louisiana shows burning grass in the habitat and smoke propagating downwind. (Source: NOAA Office of Response and Restoration)

Consider Options for Each Scenario

- There may be situations where ISB is an appropriate component of a spill response plan

https://www.api.org/~/media/Files/EHS/Clean_Water/Oil_Spill_Prevention/NEBA/NEBA-Net-Environmental-Benefit-Analysis-July-2013.pdf

Advantages of In-Situ Burning

- Quick, highly-efficient removal of large volumes of oil from land, snow/ice, or water surface
- Reduced oiling of beaches, marinas, mangroves
- Oil removal when skimming and/or dispersion are not feasible
- Reduced storage and disposal needs
- Reduced exposure of workers to oil

Advantages	Disadvantages
• Can remove large amounts of oil	• Ignition of weathered or emulsified oil can be difficult
• Eliminates recovery and disposal chain	• Generates large amounts of smoke and soot and has inherent safety risks
• Once ignited, most oils will burn	• Some residues can sink
• Can be used in a variety of water environments	• Most fire booms are expensive and some are only effective for a few hours of burning

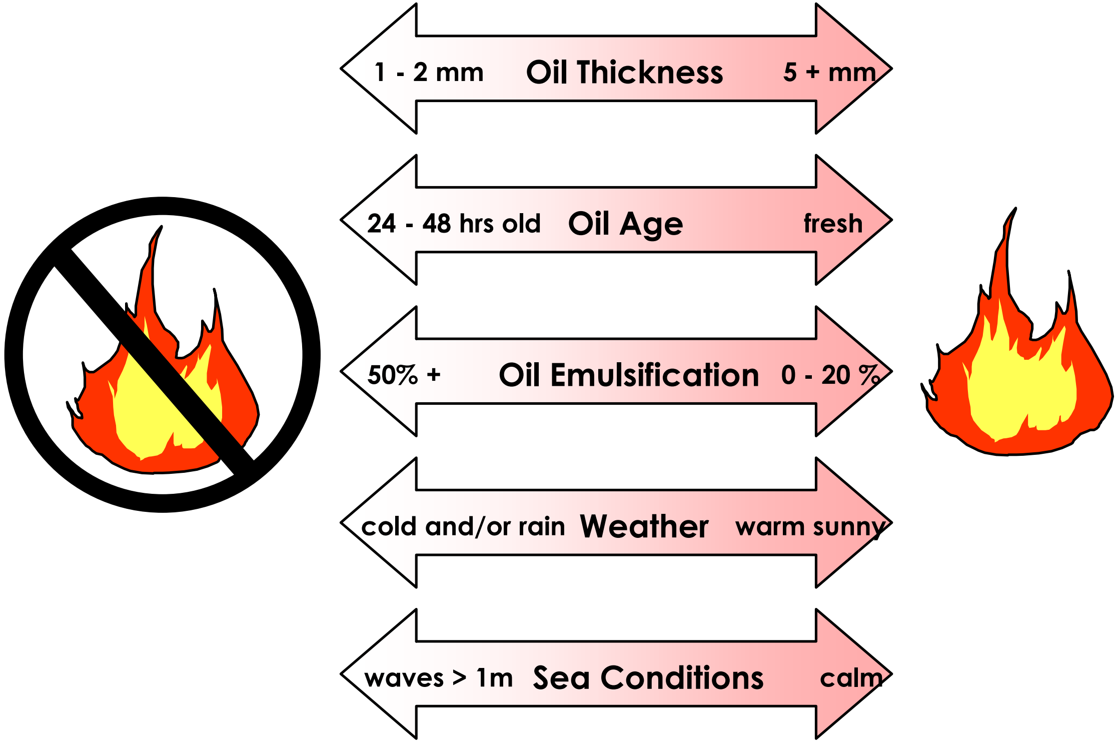
Basic Requirements of In-Situ Burning

- Oil layer thickness must be at least 2 to 3 mm (0.08–0.12 in) to sustain combustion.
- Oil must be relatively fresh and not contain too much water.
- A fire-resistant boom is generally used in open water to increase the thickness of the oil in place to maintain the burn by restricting spread.

Efficiency of In-Situ Burning

- The overall efficiency of a burn depends on the original oil thickness, and, in a continuously fed oil fire, the way in which burn areas are maintained throughout the burn process.
- Thick oil layers normally burn at a rate of 2.5 mm/minute (1 inch in 10 minutes).
- With combustion normally taking place until the final thickness is approximately 1 mm, burn efficiencies in excess of 90% can be achieved.

Factors Affecting Burning



On-Water ISB: Fire Boom Examples

Thermally Insulated

- Replaceable refractory blanket covers regular oil containment boom
- Tested to 2300°F (1300°C)

Elastec Hydro-Fire Boom

- Water cooled
- Survives multiple burns
- Used during the Macondo response

Types of Igniters

- Helitorch

- Flare

- Hand-held

- Used during Macondo response

Burning on Snow/Ice

- Burning may be the only viable option in snow and ice
  - Remote access
  - Sensitive habitats
  - Limited waste management capacity
  - May be performed at a later time

Burning oiled snow in volcano-shaped piles. Source: Alaska Clean Seas

Figure 3. ISB conducted in a freshwater marsh in snow. (Source: NOA

Photographs of the Brunswick Naval Air Station burn. Top: Burning of aviation fuel in open water areas. Bottom: Burning of oil in slots cut into the ice. Source: S. Lehmann, NOAA.

Environmental/Health Concerns

- Smoke inhalation is the primary concern
- Other considerations are the potential for
  - Fire/explosion affecting responders, others nearby
  - Ingestion of residues, burn products (contaminated food, water)
  - Skin contact with burn products

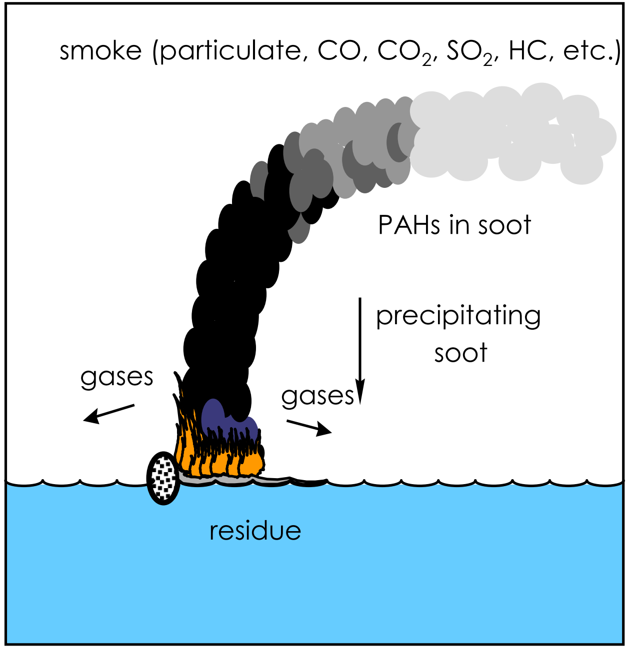


Fig. 1-Soot plumes from *in situ* burning

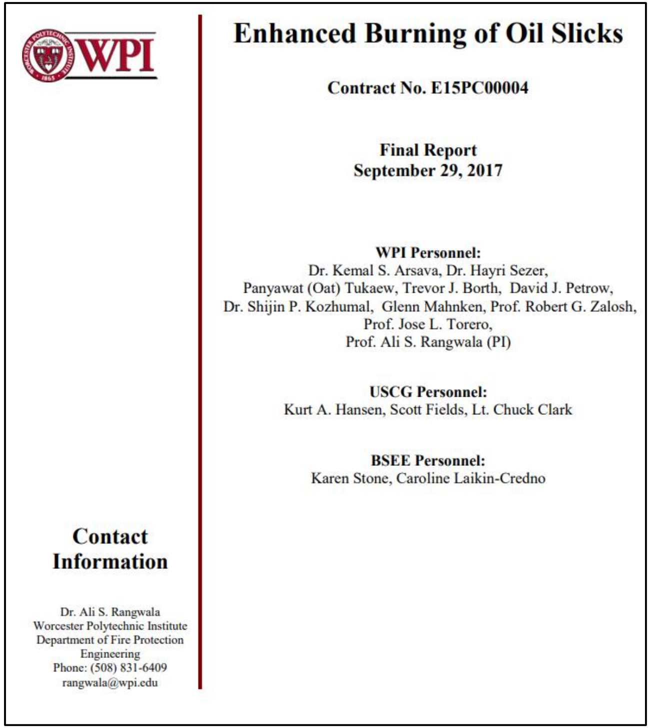
https://www.bsee.gov/sites/bsee.gov/files/osrr-oil-spill-response-research//1012aa.pdf

Example of burn residue from an on-water burn. Source: S. Schraeder/USCG.

ISB: Reducing the Smoke

- Research is focused on increased burn efficiency
  - The operating principle is to transfer radiative and convective heat generated by the combustion back to the fuel to create a feedback loop that increases burning rate
  - The lighter color of the smoke indicates a reduction in concentration of carbon particles due to more

Figure iii: Picture of the smoke plume a) Baseline, b) Blanket+48 Coils (SH)



WPI

Enhanced Burning of Oil Slicks

Contract No. E15PC00004

Final Report
September 29, 2017

WPI Personnel:
Dr. Kemal S. Arsava, Dr. Hayri Sezer,
Panyawat (Oat) Tukaew, Trevor J. Borth, David J. Petrow,
Dr. Shijin P. Kozhumal, Glenn Mahnken, Prof. Robert G. Zalosh,
Prof. Jose L. Torero,
Prof. Ali S. Rangwala (PI)

USCG Personnel:
Kurt A. Hansen, Scott Fields, Lt. Chuck Clark

BSEE Personnel:
Karen Stone, Caroline Laikin-Credno

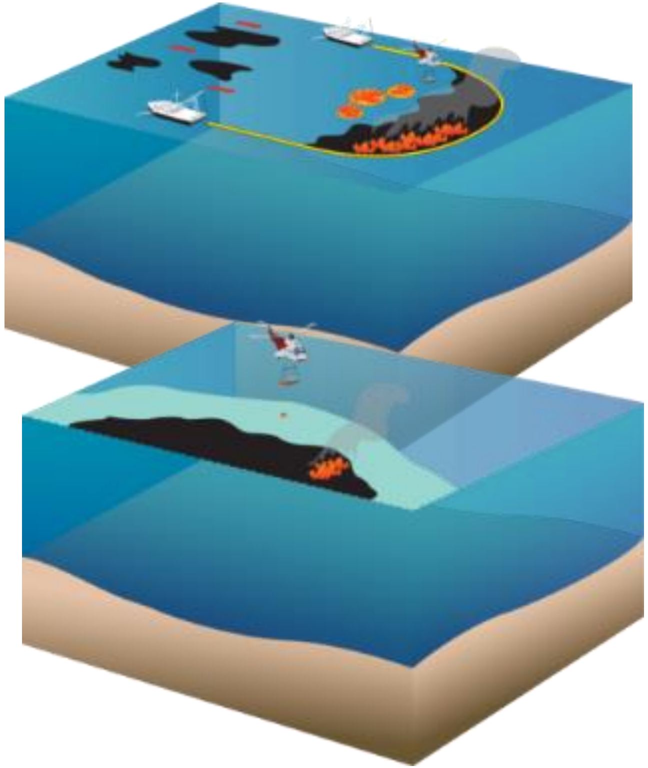
Contact Information

Dr. Ali S. Rangwala
Worcester Polytechnic Institute
Department of Fire Protection Engineering
Phone: (508) 831-6409
rangwala@wpi.edu

https://www.bsee.gov/sites/bsee.gov/files/research-reports//1068aa.pdf

Operability of In Situ Burn may be Enhanced by Herders

- Conventional process requires booms to keep oil thick
- Fire resistant booms are bulky and a challenge to transport
- Only operational use offshore during Deepwater Horizon
  - Over 400 successful burns
  - 11 million gallons estimated consumed
- The elimination of the mechanical containment step would be a step change
- Herders were originally developed for traditional mechanical containment and recovery efforts, but proved to be too fragile and shore-lived
- ISB could be quite different



Operability of In Situ Burn may be Enhanced by Herders

- Herders (surfactant-based) alter the surface tension of water and cause oil slicks to contract
- The reduction of surface area of the slick results in a thicker slick that may be ignitable without the use of mechanical containment (booms)

2014 INTERNATIONAL OIL SPILL CONFERENCE

Update on Developing and Commercializing Oil Herders for In-Situ Burning

Ian Buist
SL Ross Environmental Research, 200-1140 Morrison Drive, Ottawa, ON, Canada, K2H 8S9
Ian@slross.com

Dr. Tim Nedwed and Dr. Amy Tidwell
ExxonMobil Upstream Research Company, P.O. Box 2189, Houston, TX 77252-2189, USA

Peter Lane and Peter Newsom
Desmi-AFTI, PO Box 575, Orchard Park, New York 14127 USA

Ken Flagg
Oxnard, CA

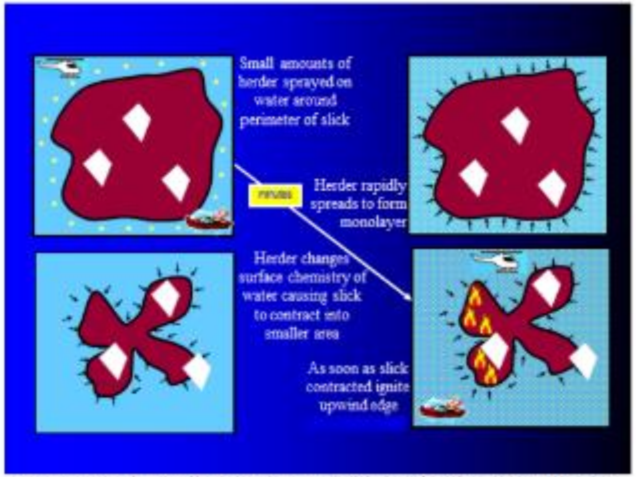


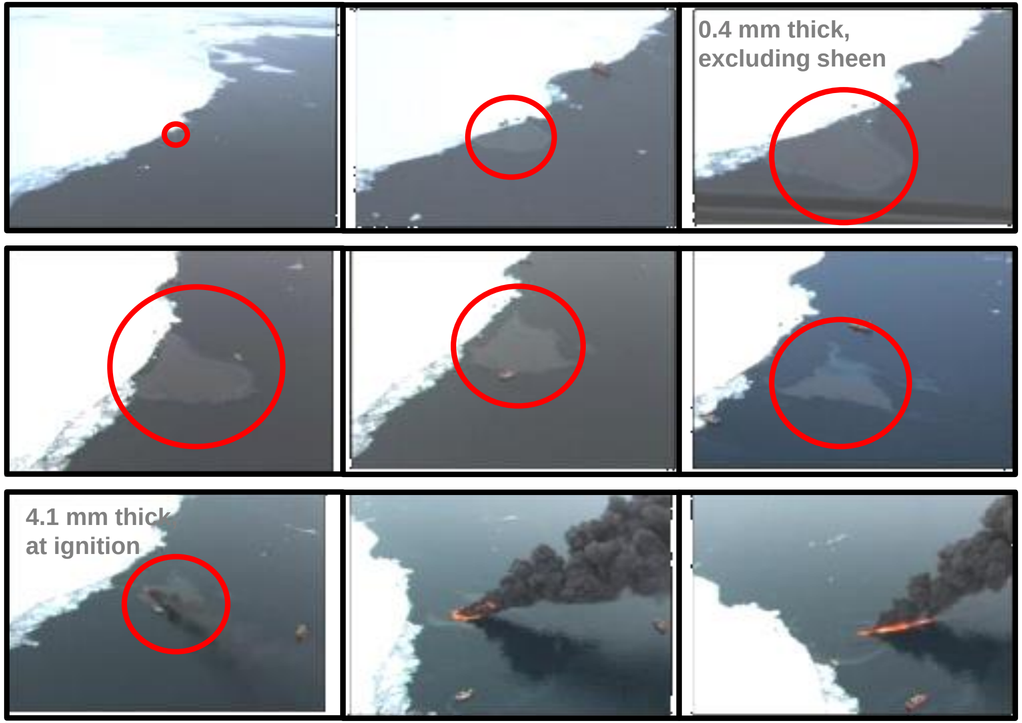
Figure 1. Concept for use of herders to contract oil slicks in drift ice for ignition and burning

Figure 4. Testing of silicone-based herding agents at CRREL (far left shows oil release, centre shows oil spread at equilibrium, right shows contraction to new equilibrium after herder addition to water).

Laboratory Demonstration of Herding: 1 Minute Elapsed Time

Field Demonstration of Herding & ISB

- Images from 2008 Sintef OSR in Ice Field Test



Oil release & spread (15 minutes)

630 liters of fresh crude

Herder applied & contracts slick (9 minutes)

Ignition & ISB (9 minutes)

Courtesy of Ian Buist/SL Ross

Field Demonstration Herding & ISB: Offshore Norway 2016

- Field test conducted June 14, 2016
- First known study to successfully burn free-floating marine oil slicks in open water
- Herded slick burned for total of ~30 min.
- Control slick (no herder) burned for ~12 min.

Slick after Herder application / before burn

Control slick with no herder application 50 minutes after release

Slick burning

Prototype Herder Delivery / Ignition System

- Field testing in 2015 indicated that a combined herder delivery / ignition system needed
- System was developed and tested in Alaska in 2016/2017
- Demonstrated

Abstract 2017-060 2017 INTERNATIONAL OIL SPILL CONFERENCE

Aerial Application of Herding Agents can Enhance In-Situ Burning in Partial Ice Cover

Stephen Potter, Ian Buist, David Cooper
SL Ross Environmental Research, 200-1140 Morrison Drive,
Ottawa, ON, Canada, K2H 8S9
Steve@slross.com

Srijan Aggarwal, William Schnabel, Jessica Garron, Robin Bullock and Robert Perkins
University of Alaska Fairbanks, College of Engineering and Mines
Fairbanks, AK

Peter Lane
DESMI Inc.
Orchard Park, NY

Figure 5. Heli-torch operation over basin during Test 5.

Figure 7. Successful burn of free-floating ANS slick herded with TS 6535 in Test 5.

Key Herder / In Situ Burn R&D Findings Summary

- Herders to enable in situ burning have undergone over 10 years of study
- Field tests in 2008 & 2016 demonstrated they work in open water
- Field test in 2015 demonstrated helicopter-based herder delivery and subsequent slick ignition
- Herding typically requires very small quantities of a very low toxicity surfactant
- Herders commercially available and on the US EPA NCP Product Schedule
- OSROs including herders, boat-based delivery capability, and ignition devices in inventory
- Multi-platform herder delivery / ignition automated vessel system in final development (i.e., remote control jet ski-based platform)
  - Platform could be delivered by C-130 aircraft, i.e., at the speed of an aircraft
- Herder technology ready for first use
- Brochure to educate stakeholders / decision makers on herders planned

References

- A number of references have been developed since 2010, including:
    - Research summaries
    - Guidance documents
    - Fact Sheets
    - Conference proceedings
- Several are given below

http://www.oilspillprevention.org/oil-spill-cleanup/oil-spill-cleanup-toolkit/in-situ-burning

http://www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/in-situ-burning/api-technical-report-1256-in-situ-burnin.pdf

https://www.ioscproceedings.com/doi/pdf/10.7901/2169-3358-2014.1.1441

https://www.ioscproceedings.com/doi/pdf/10.7901/2169-3358-2017.1.2955

https://www.ioscproceedings.com/doi/abs/10.7901/2169-3358-2014-1-299723.1

Thanks for listening.

Any Questions?