INTERNATIONAL VIEWS ON NEW / EMERGING SPILL RESPONSE TECHNOLOGIES

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C-NLOPB Spill Prevention and Response Forum *'Working on the Water'*

January 14, 2021, 10:45 a.m. - 11:15 a.m.

SUMMARY

- Two novel *in situ* burn technologies
  - Remotely Operated Surface Vehicle (ROSV) built from a commercial jet ski
  - “Burning Tongue” allows ISB with standard boom

PRESENTATION OUTLINE

- Background on ISB
- Herder technology description
- Prior research & development on herders
- Recent developments on herders
- Development of a Remotely Operated Surface Vehicle
- Development of the “Burning Tongue” concept

BACKGROUND ON IN-SITU BURNING (IPIECA / IOGP, 2016)

BASIC REQUIREMENTS

- Oil layer thickness must be at least 2 to 3 mm (0.08–0.12 in) to sustain combustion
- Oil must have some volatiles and not contain too much water
- Winds can't be too high – "blows out the candle"

EFFICIENCY OF IN-SITU BURNING

- Efficiency of a burn depends on the oil thickness
  - "Chimney effect" (wind herding) thickens oil during burn
- Thick oil layers can burn at a rate of 2.5 mm/minute (1 inch in 10 minutes).
- Burn rate limits burn times to 10 – 20 minutes for **free-floating oil slicks** thereby mitigating the potential hazard of uncontained oil fires
- Combustion normally continues until the final thickness is approximately 1 mm, burn efficiencies for free-floating oil slicks in excess of 90% can be achieved

IPIECA / IOGP, 2016, Controlled In-situ Burning of Spilled Oil, International Association of Oil & Gas Producers, IOGP Report 523.

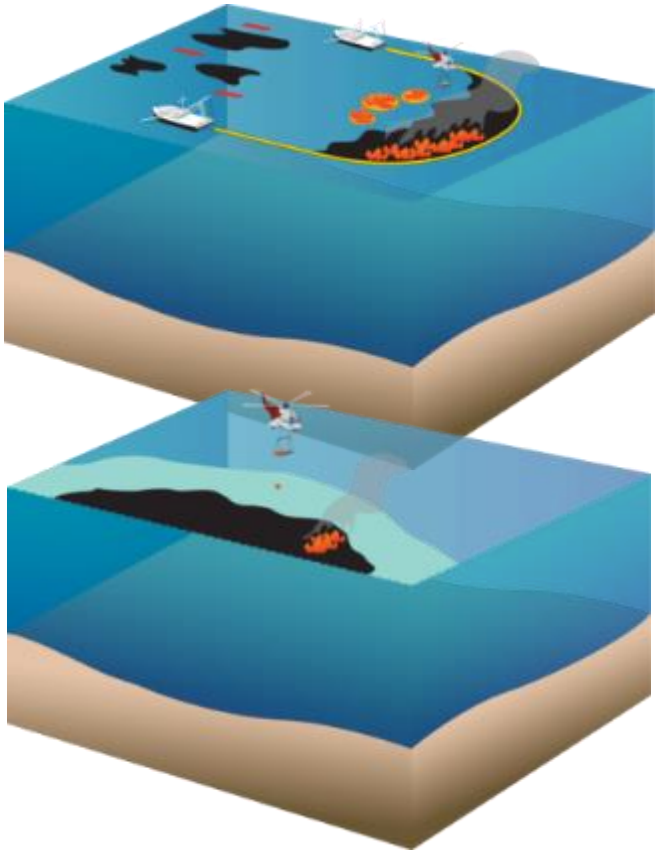
HERDER TECHNOLOGY DESCRIPTION

Herders use a ‘surfactant boom’ to thicken slicks—no boundary required (Garrett & Barger, 1972)

Herders typically require at least an order of magnitude less product than treating slicks with dispersants (Buist et al., 2014)

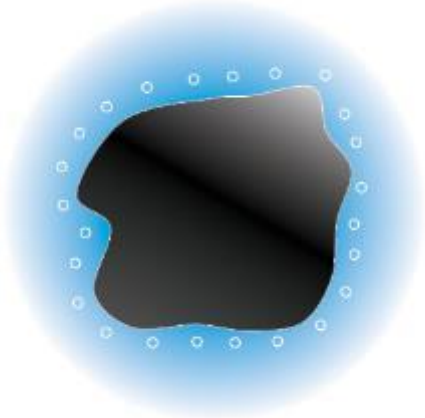
Herder technology originally developed for open water (Garrett & Barger, 1972); in 2000’s research focused on marine applications with ice; but more recent research has again concentrated on open water (Cooper et al., 2017; Buist et al., 2011)

The goal is to develop another tool that can be rapidly applied to make ISB a routinely used response option

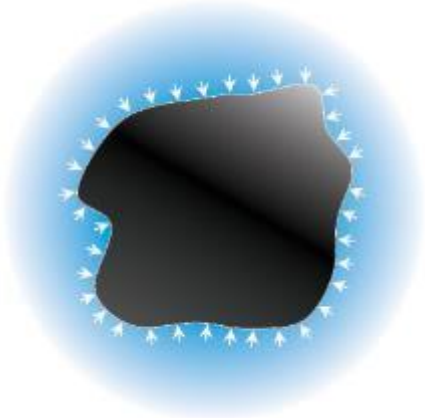


- Buist, I., & Nedwed, T., 2011. Using Herders for Rapid *In situ* Burning of Oil Spills on Open Water, International Oil Spill Conference Proceedings, Mar 2011, Vol. 2011, No. 1 pp. abs231.
- Buist, I., Nedwed, T., Tidwell, A., Lane, P., Newsom, P., & Flagg, K., 2014. Update on Developing and Commercializing Oil Herders for In-Situ Burning, International Oil Spill Conference Proceedings, May 2014, Vol. 2014, No. 1 pp. 1441-1456.
- Cooper, D., Buist, I., Potter, S., Daling, P., Singsaas, I., Lewis, A., 2017. Experiments at Sea with Herders and *In Situ* Burning, International Oil Spill Conference Proceedings, May 2017, Vol. 2017, No. 1 pp. 2184-2203.
- Garrett, W.D. and Barger, W.R., 1972. Control and Confinement of Oil Pollution on Water with Monomolecular Surface Films, Naval Research Laboratory, Washington, D.C., NRL Memorandum Report 2451.

TECHNOLOGY DESCRIPTION

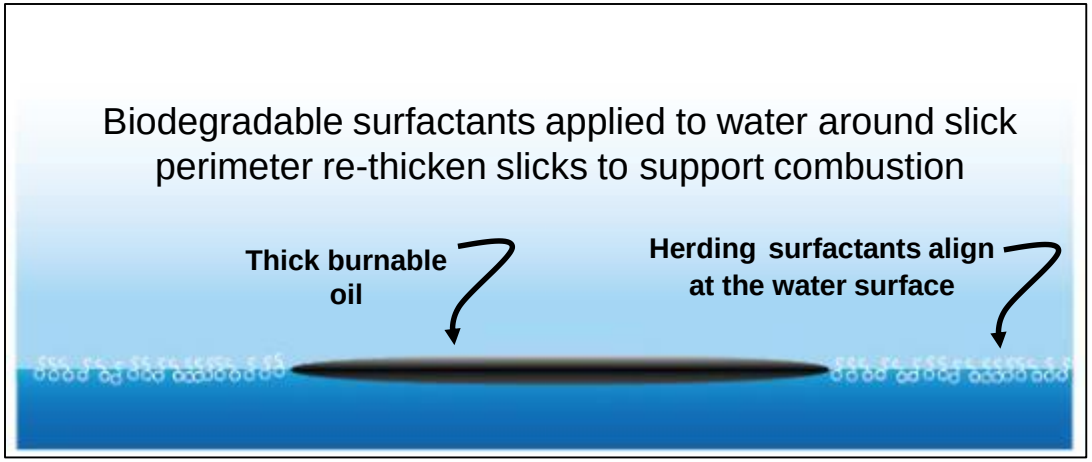


Herders sprayed on water around perimeter of slick via aircraft, boat, USV



Herders rapidly spread to form monolayer of surfactant on water surface

Herders change surface tension of water forcing slick into smaller area



PRIOR RESEARCH ON HERDERS

Over 15 years of research has proven that herders for ISB work
- Most development performed under temperate, open-water conditions

Herders have been formulated to be low toxicity and rapidly biodegradable, e.g., Thickslick™ 6535 herder

Herders may work in sea states greater than boom as the surfactants reduce wave cresting – Garrett & Barger (1972) kept a slick herded for 2.5 hours in 6 foot seas with numerous white caps

Two herders (ThickSlick™ 6535 and OP-40) are listed on the EPA NPL for potential use in US waters

Results of EPA Required Toxicity Testing for NCP Listing

Herder	Menidia beryllina (minnow) 96 hr LC_{50}	Mysidopsis bahia (shrimp) 48 hr LC_{50}
Thickslick™	138 ppm (practically non-toxic[a])	286 ppm (practically non-toxic[a])

[a]as defined by the US EPA aquatic toxicity ranking system (http://www.epa.gov/espp/litstatus/effects/redleg-frog/naled/appendix-i.pdf)

Results of Biodegradation Testing

Herder	% biodegradation Day 1	% biodegradation Day 20
Thickslick™	14.8	>99

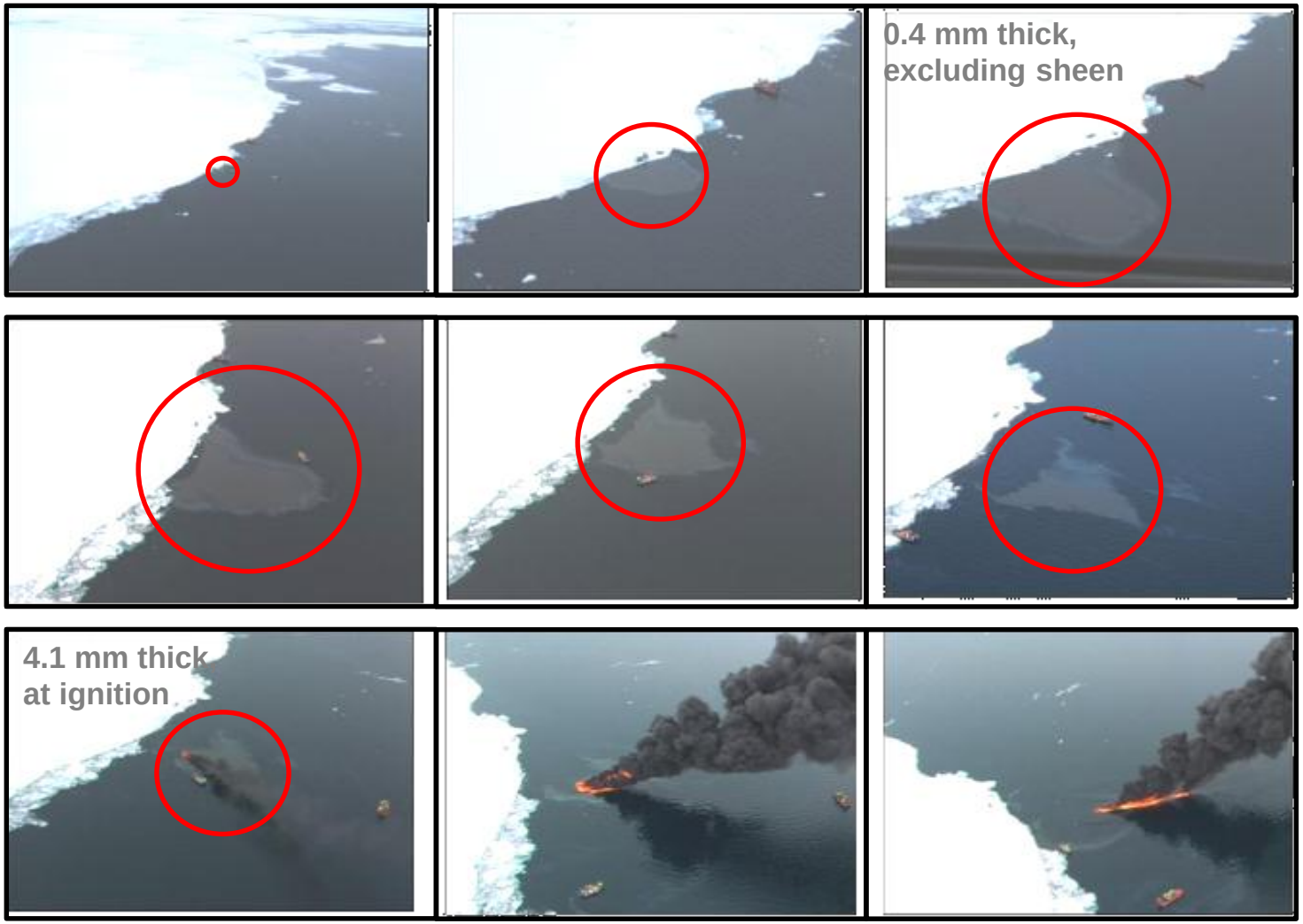
Garrett, W.D. and Barger, W.R., 1972. Control and Confinement of Oil Pollution on Water with Monomolecular Surface Films, Naval Research Laboratory, Washington, D.C., NRL Memorandum Report 2451.

PRIOR LABORATORY TESTING

Courtesy of Ian Buist / SL Ross

FIELD RESULTS IN ICE (Buist, 2010)

PERFORMED UNDER A PRIOR JOINT INDUSTRY PROJECT



Oil release & spread (15 minutes)

630 liters of fresh crude

Herder applied & contracts slick (9 minutes)

Ignition & ISB (9 minutes)

Courtesy of David Dickins

Buist, 2010. Report No. 6, Field Testing of the USN Oil Herding Agent on Heidrun Crude in Loose Drift Ice, Oil in Ice – JIP, SINTEF Materials and Chemistry, Marine Environmental Technology, 15.03.2010. Available on-line 8/29/2019 at https://www.sintef.no/globalassets/project/jip_oil_in_ice/dokumenter/publications/jip-rep-no-6-fex2008-herders-final.pdf

FIELD RESULTS IN ICE - VIDEO

Courtesy of David Dickins

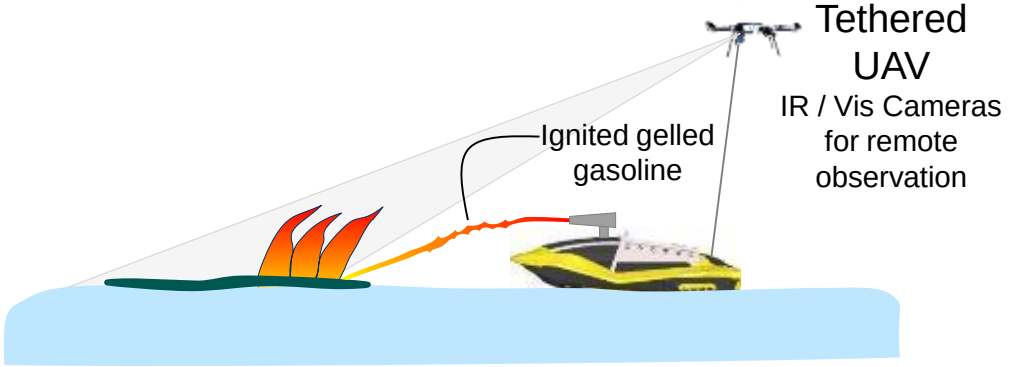
Remotely Operated Surface Vehicle (ROSV) for OSR

Consortia is developing a multifunctional ROSV for OSR

- Deployable from ship, helicopter, airplane
- Autonomous operation or remote (virtual reality) operator
  - GPS / long range radio / satellite communications
- Speeds up to 65 mph / 500 mile range / 12+ hrs operation
- Herder application / slick ignition
- 350 lbs payload capability
- Collision avoidance system
- Aerial remote sensing with tethered UAV (visible / IR / other sensor)
- 4 surface / 2 underwater / 1 360˚ VR cameras
- Underwater Lighting

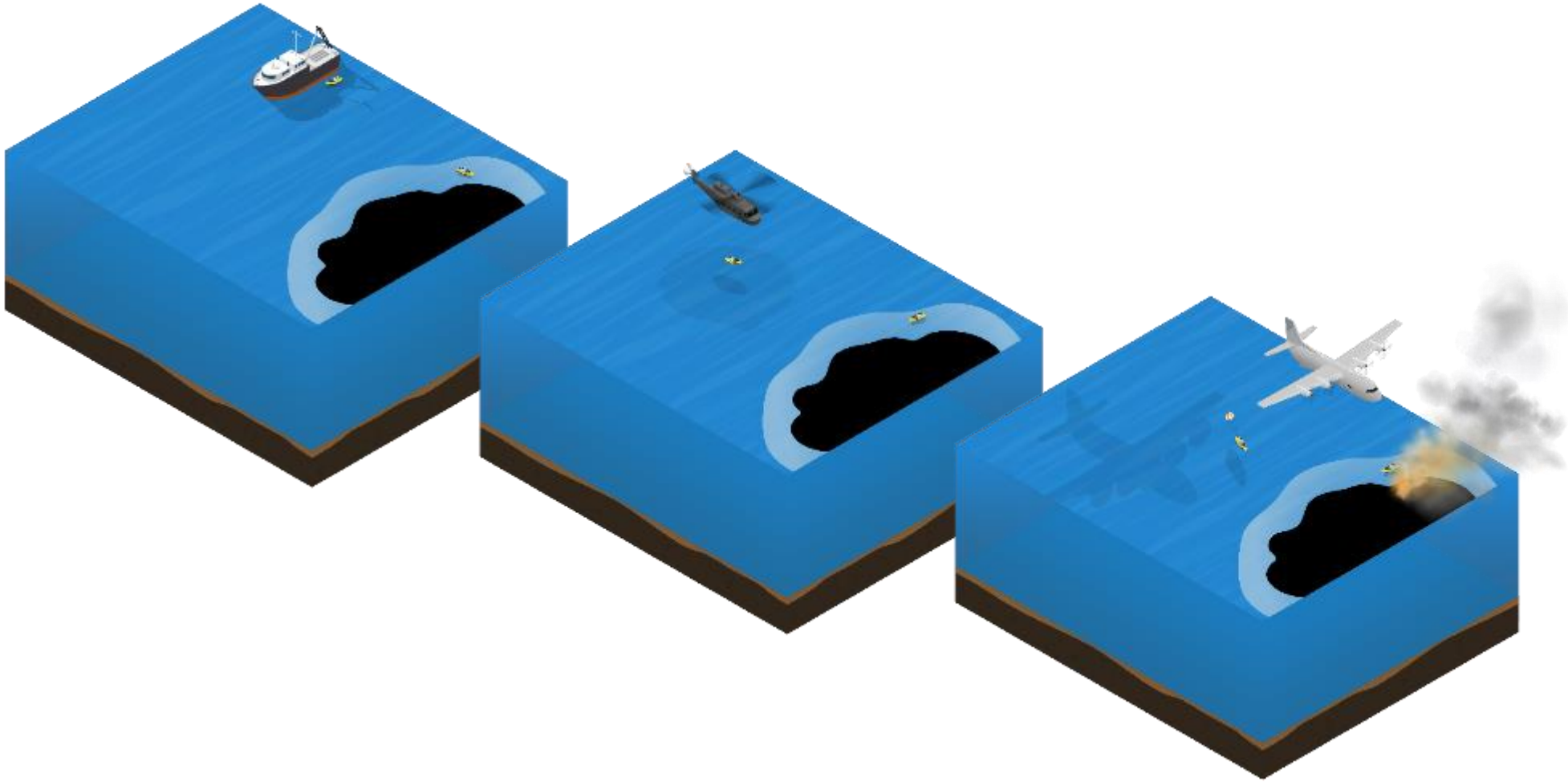
Potential additional capabilities

- VOC monitoring
- Oil slick thickness
- Oil slick sampling
- Fire control using jet pumps
- Pull boom



Remotely Operated Surface Vehicle (ROSV) for OSR

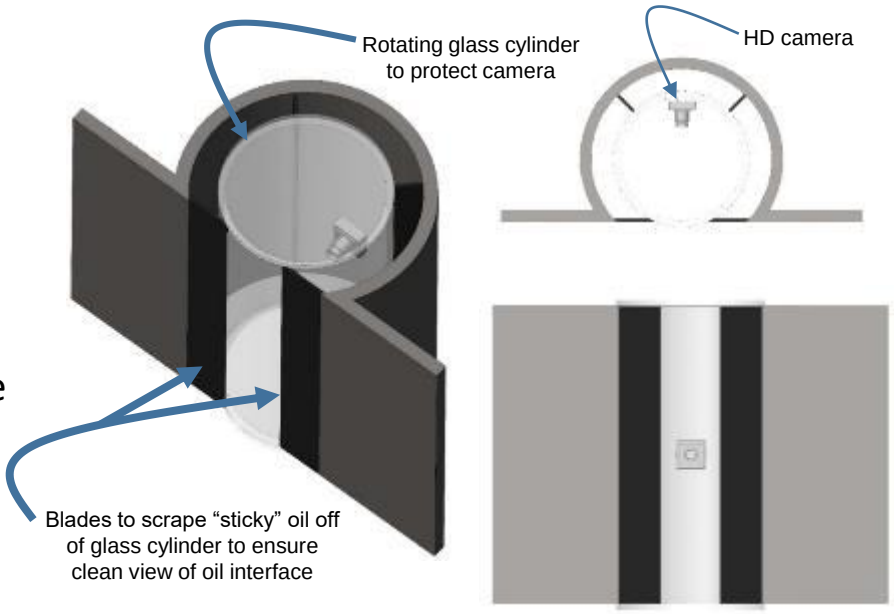
Deployable from ship, helicopter, airplane



Novel camera system for determining slick thickness

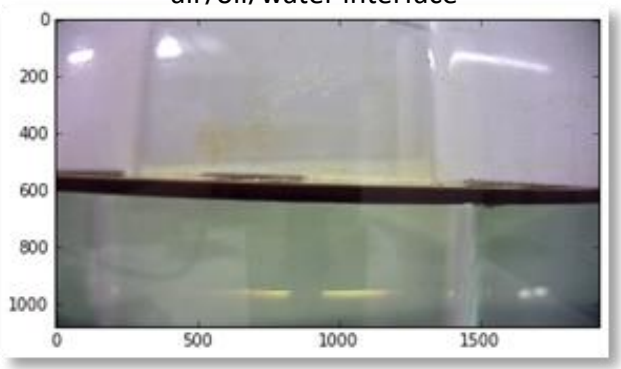
- Need: determine oil slick thickness in real time
  - Rule of thumb: 90% of the oil is in 10% of the slick
  - Satellite and aircraft remote sensing platforms provide estimates of oil thickness
    - Snap shots - oil is in constant motion
    - Remotely sensed oil thickness estimates can have limitations due to signal saturation
- Solution: develop RSV (remotely operated surface vessel)
  - High-definition camera to view the air/oil/water interface through a viewing window
  - Autonomous - GPS based autopilot – reprogrammable in real time
  - Automated oil thickness estimation
  - Streams latitude, longitude, and oil thickness in real time to a central command center for tactical OSR decision making

Camera system mounted in hull of USV to allow direct visualization of oil-water-air interface of oil slick to determine slick thickness



Camera system

HD camera at mean water line captures an image of the air/oil/water interface



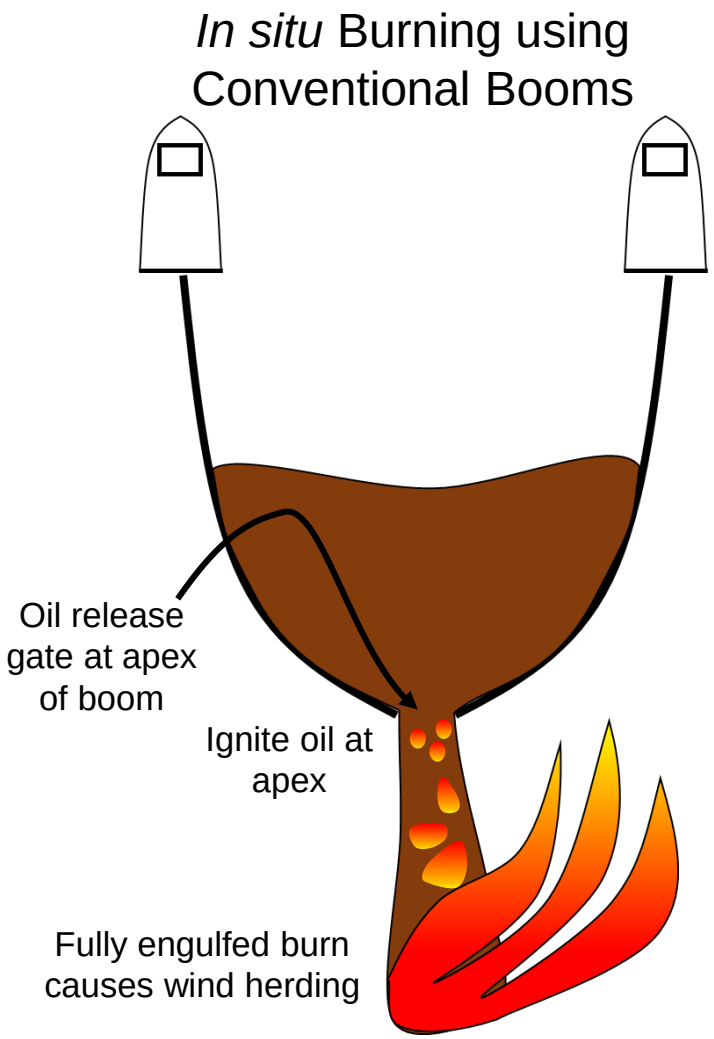
ROSV Photos / Video

ROSV Comms Trailer

Summary of ROSV Development

- Herders to enable *in situ* burning have undergone over 15 years of study
- Field / lab tests demonstrated they work in open temperate water; shown to work in the field in 2 m seas with numerous white caps
- ISB of oil slicks is fast (burn rates up to 2.5 mm slick thickness / minute) mitigating potential hazard of uncontained oil fire
- Herder / ISB typically requires very small quantities of a very low toxicity surfactant
- Herders commercially available and on the US EPA NCP Product Schedule
- ROSV herder delivery / ignition system in final development
  - Spring demonstration planned at 100 m x 100 m basin in Alaska
  - Field demonstration planned in 2021
- OSR organizations have stockpiles of herders & ignitors
- ROSV testing during MPRI field demonstration

Burning Tongue



Issue:

- Fire boom is a logistical challenge to deploy offshore because of its weight and complexity
- Heat from multiple burns destroys boom (5 – 8 burns possible)

Concept:

- Conduct ISB using conventional ocean boom – no fire boom.
- Corral & thicken oil slicks, open gate at the apex of the boom to produce finger of thick burnable oil
- Immediately ignite finger once the oil leaves the boom.
- Within a few 10s of seconds, the finger will fully engulf in flame
  - convective winds from the burn will cause additional thickening of the oil.
- Field tests in the 80's demonstrated concept as did burns during DWH
- Burning a thin, long finger more efficient than standard pool fire.

Status

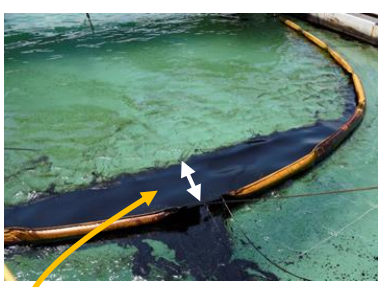
- Tested the concept at Ohmsett in June 2019

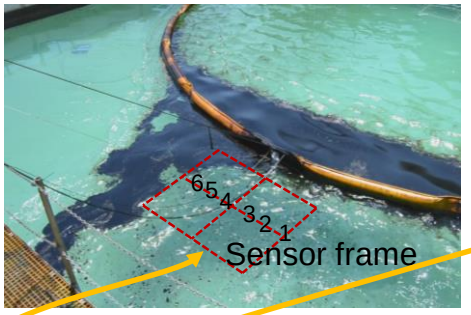
Next steps

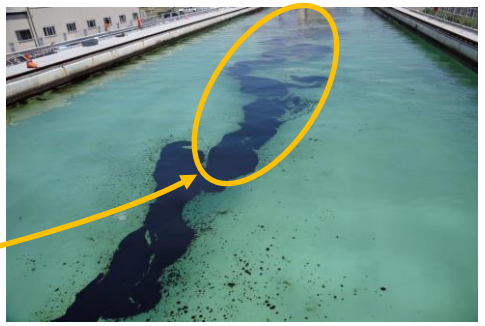
- Build / test a full-scale system
- Test during MPRI field demonstration

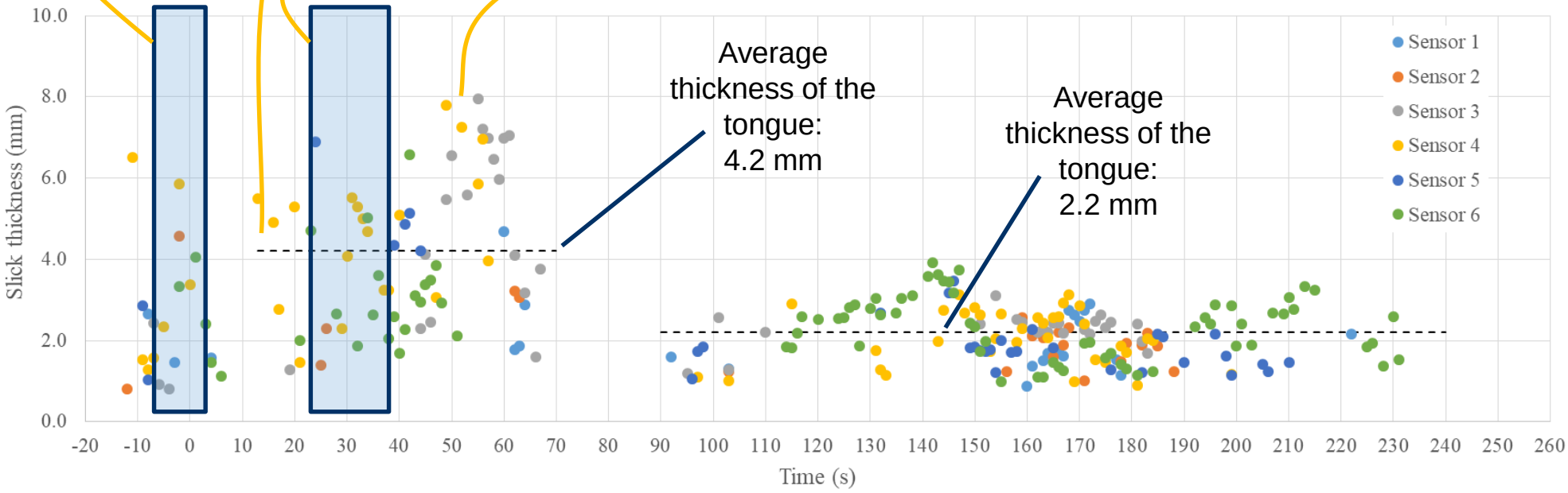
Prototype BT gate tests

Burning Tongue – weathered oil (1-4 days)

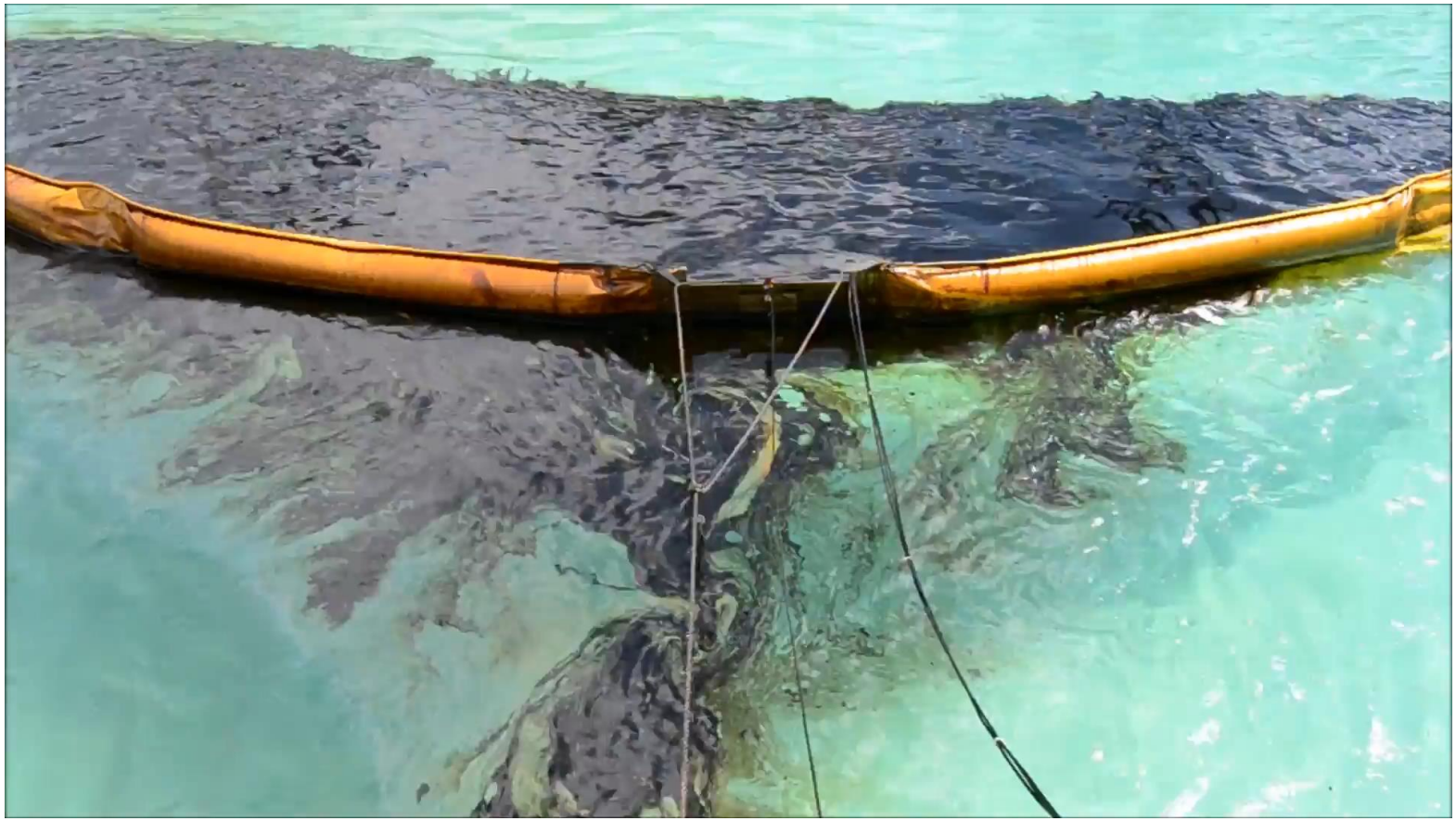




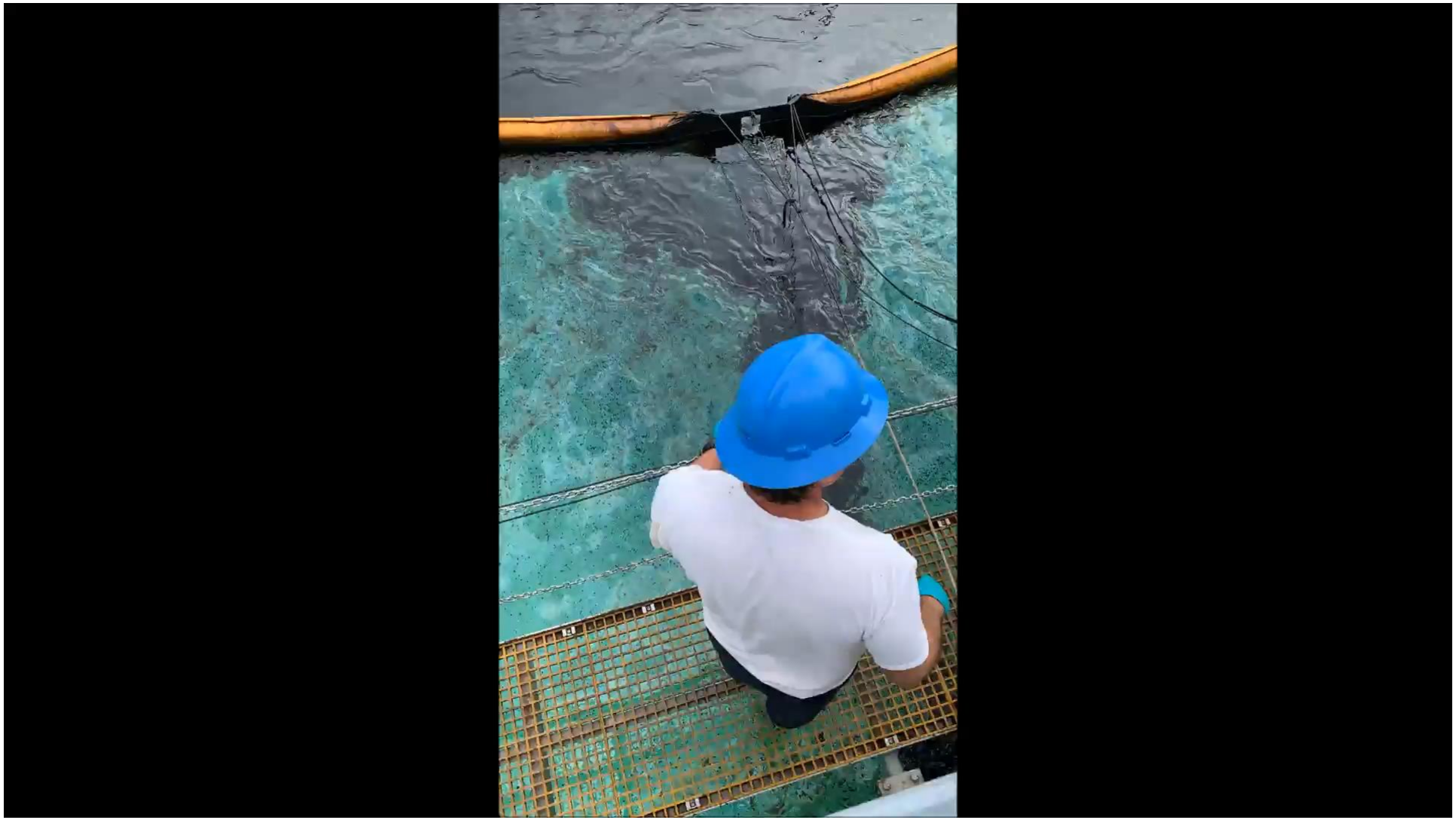




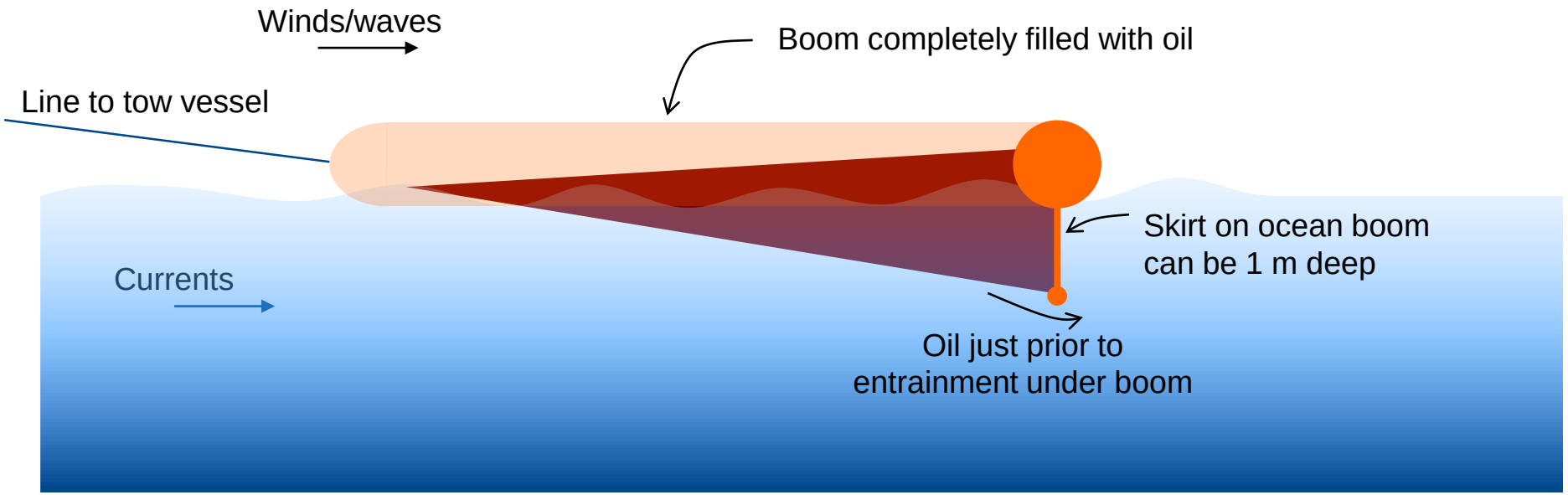
Video of prototype BT gate tests



Video showing convergence zone behind boom



How thick can oil get at the apex of a boom?



Summary on Burning Tongue

- Conventional booms can be used for ISB to eliminate need for heavy, fire-resistant boom
- Free-floating oil can burn; “chimney effect” thickens free-floating oil during burn (Guenette & Sveum, 1995; Ross, 1986)
- OHMSETT testing found the “convergence zone” behind boom significantly enhanced oil thickening; slicks remained 3 – 5 mm thick for over 3 minutes

U.S. Coast Guard, May 19, 2010

- Guenette, C C, and Sveum, P. *In-situ burning of uncontained crude oil and emulsions.* Norway: N. 1995. Available from SINTEF, N-7034 Trondheim, Norway.
- Ross SL. Environmental Research Ltd and Energetex Engineering, In-Situ Burning of Uncontained Oil Slicks, EE-60. Ottawa, ON: Environment Canada; 1986.

QUESTIONS?