# ISB Research Updates – RRT5

- Lab Scale ISB Study for Enbridge Energy, LP. by SL Ross Environmental Research Ltd. Ottawa, ON
- Large Scale ISB of Persistent Crude and Heavy Oil in Freshwater w/ and w/out Marshland Vegetation – Joint Maritime Training Facility, Mobile, AL


# SL Ross Lab ISB Study - Objectives

- Determine the ignitability and burn effectiveness for representative light oils moved on Line 5
- Increase the understanding of the window of opportunity for in-situ burning based on oil weathering and ISB lab tests
- Characterize the physical and chemical composition of the burn residue

# SL Ross Lab ISB Study – What was tested?

- A range of three light oils moved on Line 5
  - U.S. Sweet – Clearbrook (UHC)
  - Light Sour Blend (LSB)
  - Synthetic Sweet Blend (SYN)

- Tests were completed for fresh and weathered oil
  - Ignition – 2 methods @ 3 weathering states
  - burn effectiveness – if ignited how much burned
  - residue – what's left

# SL Ross Lab Study – Weathering & Technique

| Weathered State | Time in Wind Tunnel |
|---|---|
| Fresh | 0 days, as received |
| WS-1 | 2 days |
| WS-2 | 2 weeks |
| WS-3 | 6 weeks |

| PROPERTY | FRESH LSB | LSB WS-1 | LSB WS-2 | LSB WS-3 |
|---|---|---|---|---|
| Density g/mL @0°C | 0.85006 | 0.92440 | 0.93642 | 0.94334 |
| Density g/mL @15°C | 0.83826 | 0.91203 | 0.92415 | 0.93111 |
| **Density g/mL @20°C** | **0.83452** | **0.90858** | **0.92036** | **0.92726** |
| Density g/mL @30°C | 0.82696 | 0.90129 | 0.91311 | 0.91991 |
| Viscosity cP @0°C, SR $100s^{-1}$ | 10 | 350 | 1544 | 3105 |
| Viscosity cP @15°C, SR $100s^{-1}$ | 8 | 95 | 282 | 526 |
| **Viscosity cP @20°C, SR $100s^{-1}$** | **6** | **61** | **175** | **312** |
| Viscosity cP @30°C, SR $100s^{-1}$ | 6 | 34 | 84 | 139 |

# SL Ross Lab ISB Study – Burn Equipment

- SL Ross wind/wave tank
  - Marine-grade aluminum, measuring 11 meters long by 1.2 meters wide by 1.2 meters deep
- Floating 40-cm diameter circular ring to contain the oil
- Trolling motor was used to create a current underneath the oil containment ring, to simulate the oil being towed in a fire boom
- Fresh water at ambient temperature of approximately 20°C
  - 20°C was determined to be the appropriate strategy as it simulates the most rapid weathering conditions
- Additional ignition testing was performed in a slightly smaller 30-cm burn ring at a starting temperature of approximately 2°C

# SL Ross Lab ISB Study – Burn Equipment

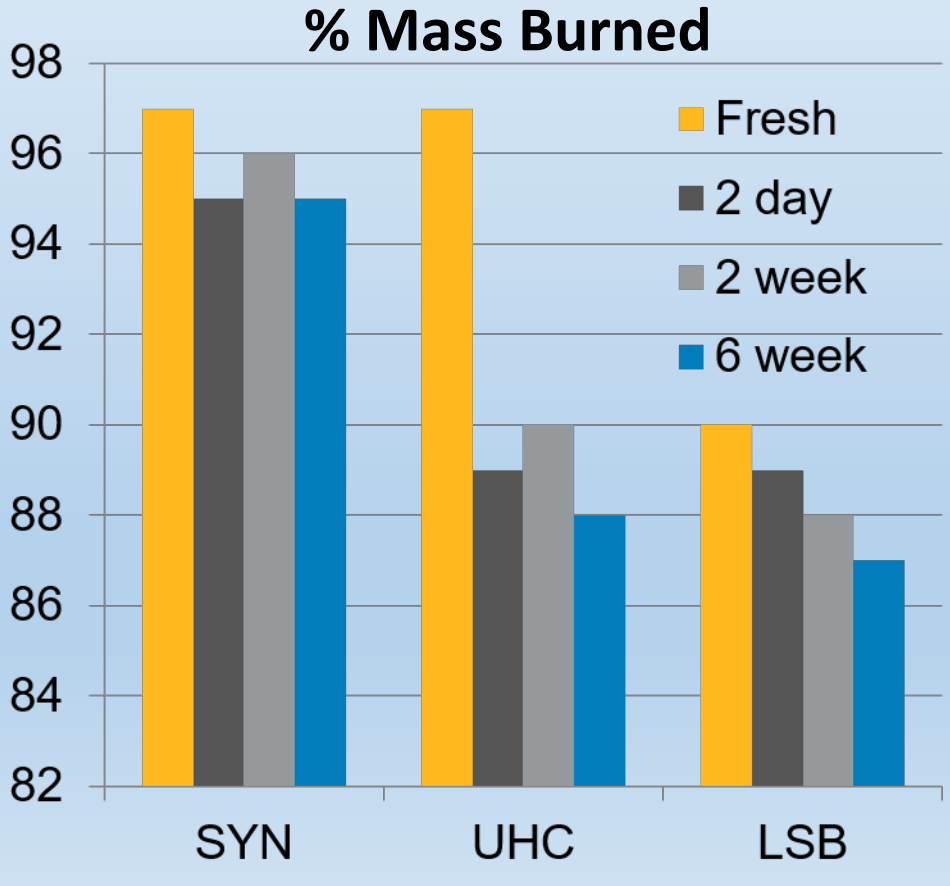
# SL Ross Lab ISB Study – Burn Protocol

- The burns were conducted targeting 4 litres of fresh or evaporated oil resulting in an initial slick thickness of 32 mm
- Theoretically burn down to between 1 and 1.5 mm
- Result in a maximum target burn efficiency of approximately 97%
- The burn time and burn efficiency were recorded as well as any observations
- The burns were video recorded
- Full procedure Page 7-8 of Final Report
- Full burn observations, parameters and timings Page 8-19 of Final Report

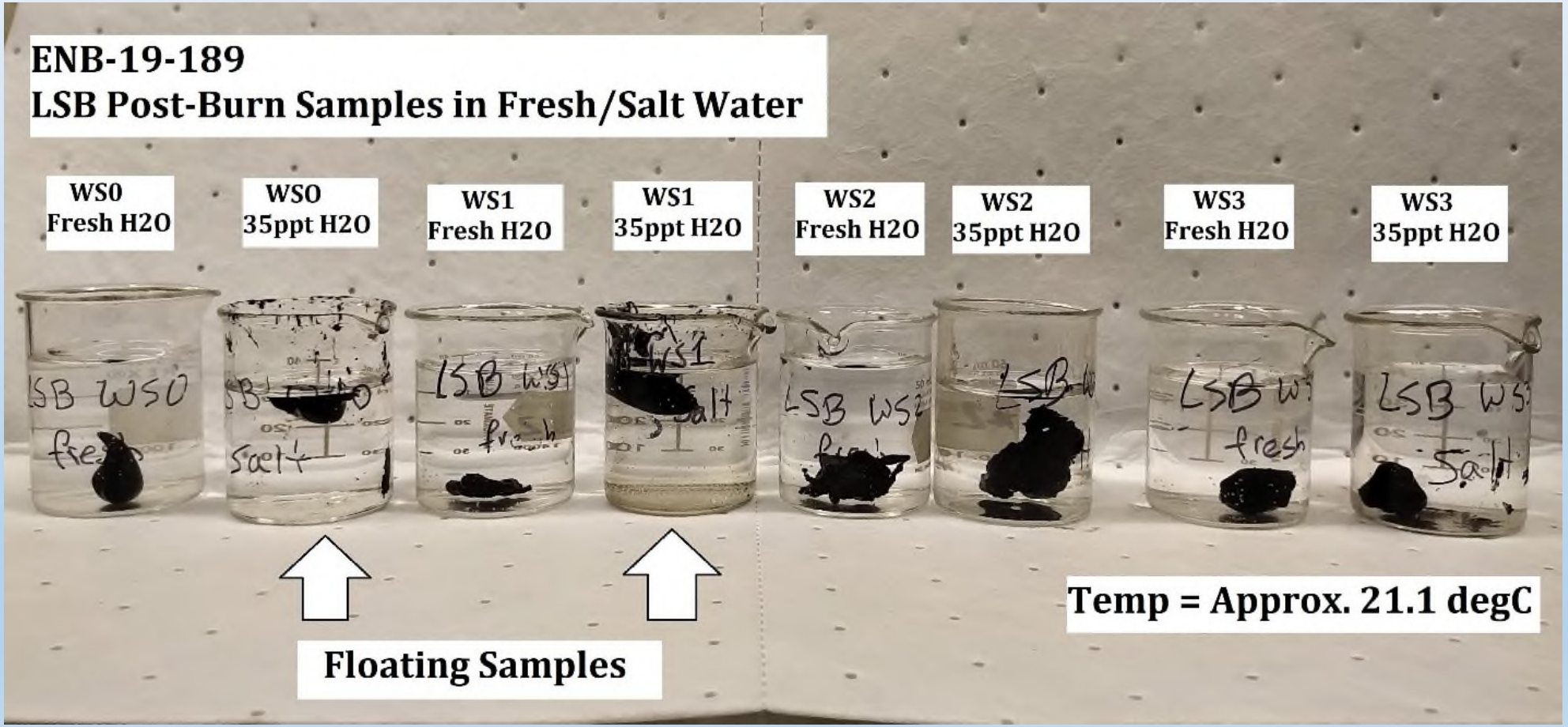
# SL Ross Lab ISB Study – Burn Test Results

- All samples were ignitable with a hand torch and sustained high efficiency burns
- Time to ignition increased with oil weathering state

| Time to Ignition | Fresh | 2 day | 2 week | 6 week |
|---|---|---|---|---|
| Light Sour Blend (LSB) | Immediate | 0:00:48 | 0:01:20 | 0:02:35 |
| Synthetic Sweet Blend (SYN) | Immediate | 0:03:23 | 0:03:29 | 0:03:32 |
| U.S. Sweet – Clearbrook (UHC) | Immediate | 0:02:00 | 0:02:19 | 0:02:56 |



# SL Ross Lab ISB Study – Burn Residue Physical Properties



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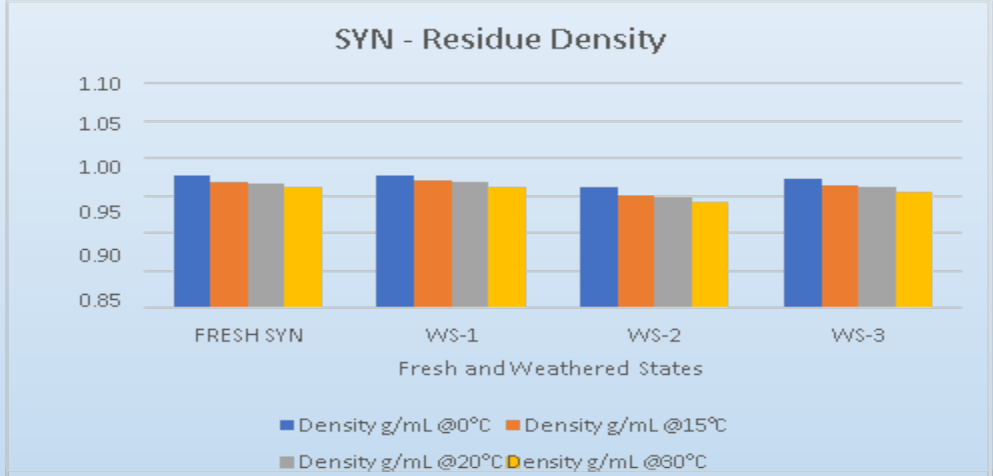
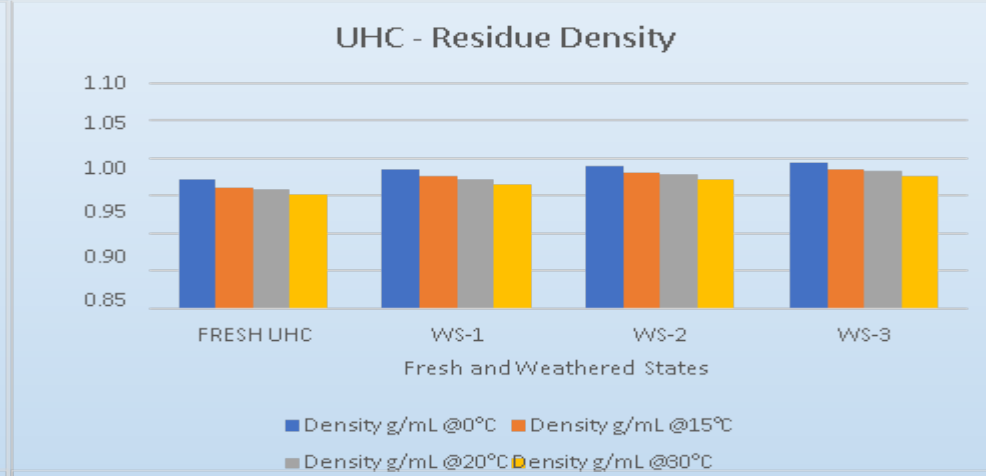
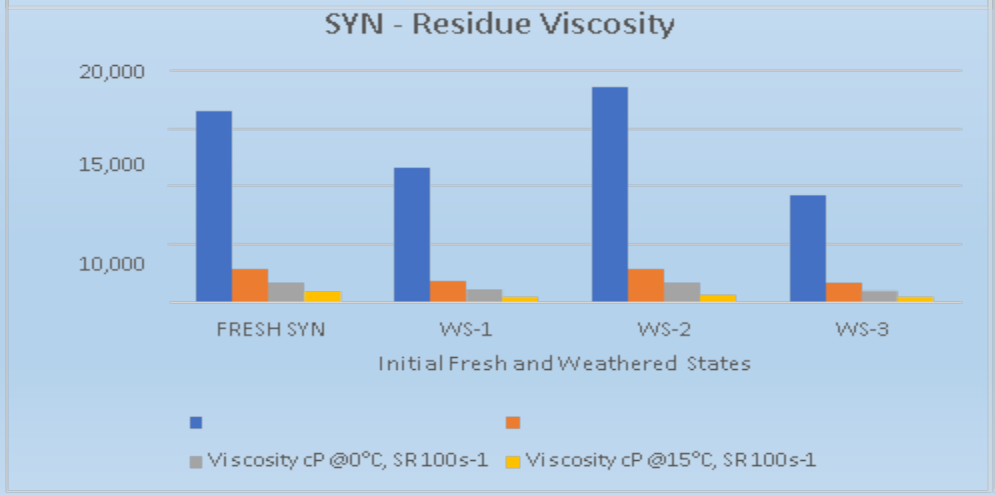
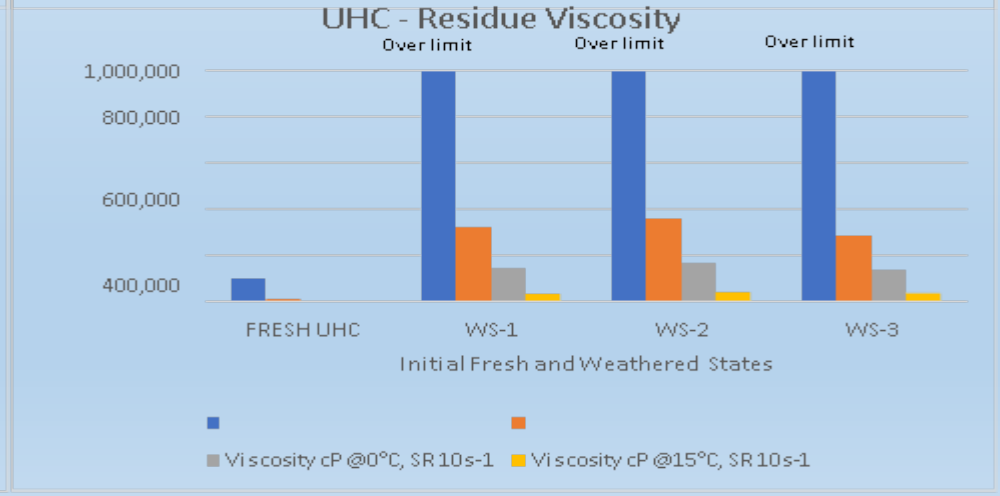


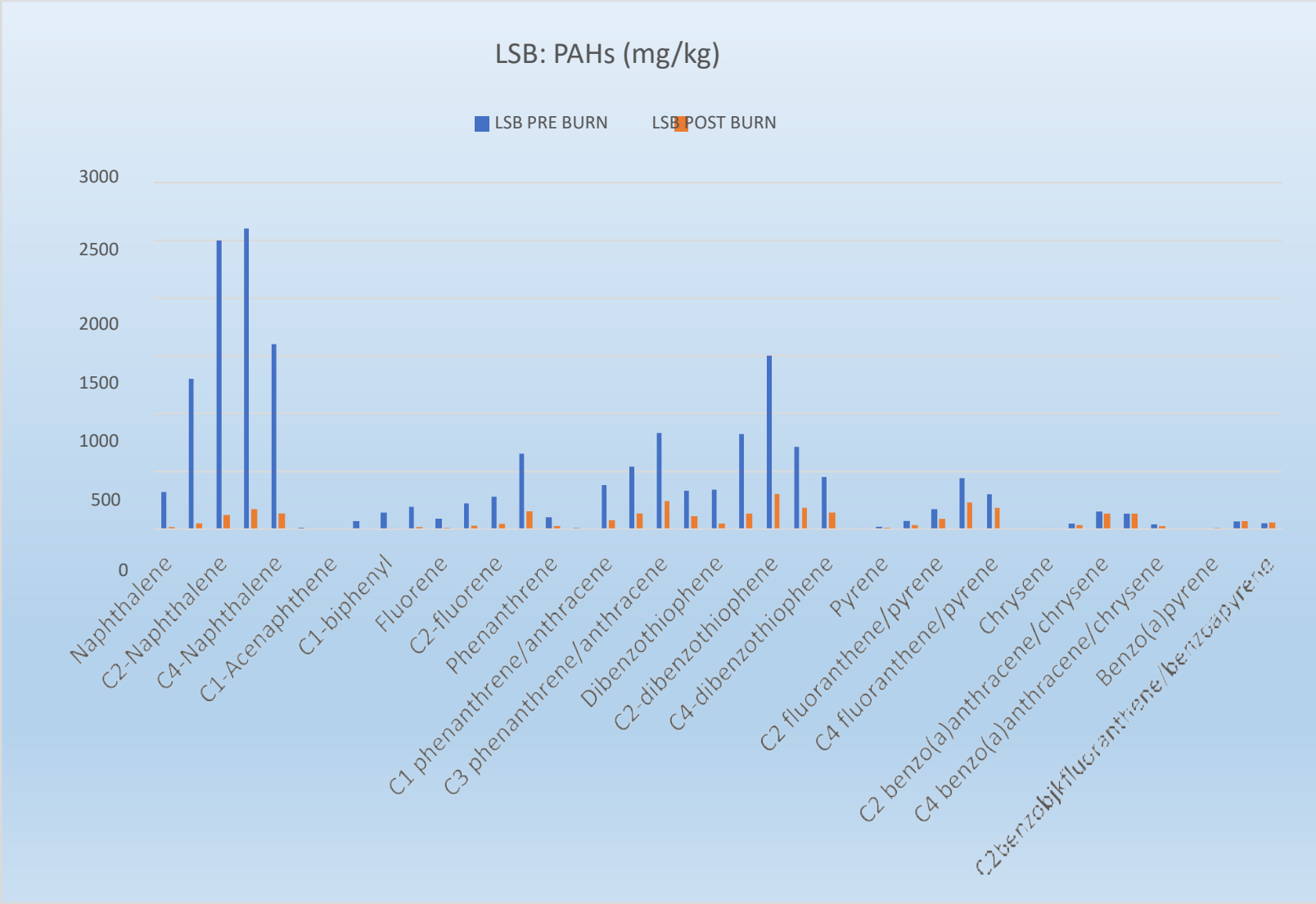



# SL Ross Lab ISB Study – Burn Residue Chemical Properties

- Appendix B – Chemical analysis of oils and residues
- PAHs and Alkyl PAHs
- Metals

# SL Ross Lab ISB Study – PAHs and Alkyl PAHs



# SL Ross Lab ISB Study – Dissolved Metals

- The results show that the concentration of the metals in post burn samples are greater than in the pre-burn sample.
- In some instances, the metals are only reported in the post burn samples, and none reported in the pre-burn sample. This is due to the concentration of the metals in the pre-burn sample being below the analytical detection limit.
- Common metals: Iron, Nickel, Sodium, Vanadium, Silicon, Calcium, Zinc, Sulphur, Magnesium, Potassium

# SL Ross Lab ISB Study – Cool Temp Results

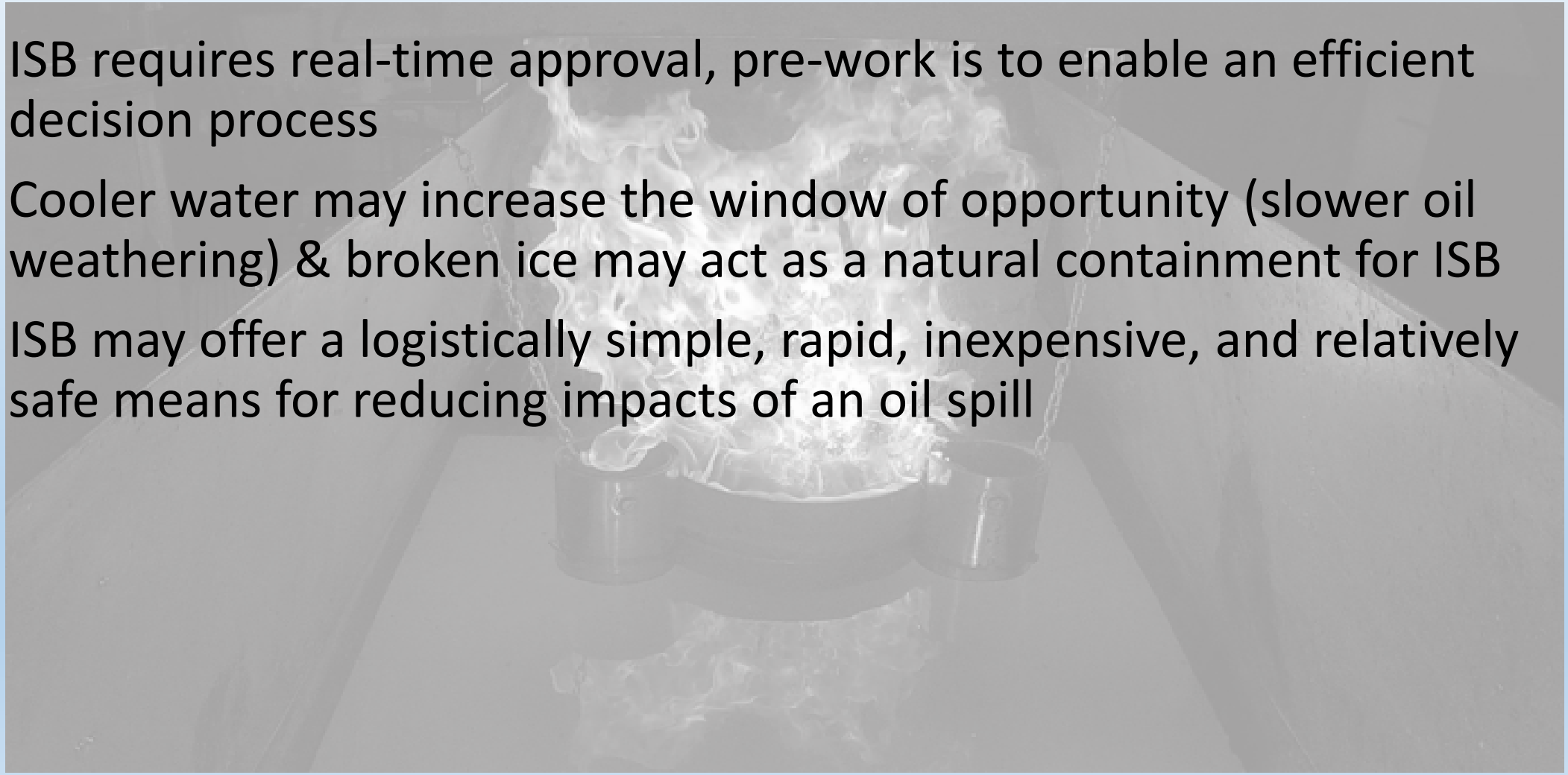
- To determine if water temperatures would adversely impact or prevent ignition. To produce the gelled fuel, 50 mL of gasoline was mixed with 0.4 grams of “Surefire” gelling agent.
- Add 700 mL of oil to be tested (record mass). This results in a starting layer of 10mm

| | LSB WS-1 | LSB WS-2 | LSB WS-3 | SYN WS-1 | SYN WS-2 | SYN WS-3 | UHC WS-1 | UHC WS-2 | UHC WS-3 |
|---|---|---|---|---|---|---|---|---|---|
| Ignition duration ( sec) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Full Ignition (sec) | 13 | 30 | 35 | 0 | 5 | 0 | 0 | 0 | 11 |
| Pass/Fail | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass | Pass |

# SL Ross Lab Scale ISB Study – Conclusions

- All the fresh and evaporated crude oil samples could be ignited and burned efficiently.
  - Oil weathering is not expected to be limiting factor in the ISB decision.
  - ISB decisions should be made quickly to maximize collection efficiencies.
- Increased oil weathering states decreased the ignitability of the oils, but did not significantly change the burn efficiencies.
  - Because all oils could be ignited with prolonged application of a propane torch flame, and weathered samples were also successfully ignited using a small quantity of gelled gasoline, commercially available igniters based upon gelled fuel such as gasoline or diesel should initiate a burn with any of these oils.
- This study aligns with the Regional Response Team 5 In-Situ Burning Annex
  - Under certain specific conditions, ISB may offer a logistically simple, rapid, inexpensive, and relatively safe means for reducing impacts of an oil spill.

# Previous Research Discussion



- ISB requires real-time approval, pre-work is to enable an efficient decision process
- Cooler water may increase the window of opportunity (slower oil weathering) & broken ice may act as a natural containment for ISB
- ISB may offer a logistically simple, rapid, inexpensive, and relatively safe means for reducing impacts of an oil spill

# Large Scale ISB JMTF - Objectives

- How do ISB residues interact with freshwater, having lower density than seawater?
- How does vegetation, such as that commonly found in marshlands, affect ISB?
- What is the ISB consumption rate and burn efficiency of heavier crude and bunker oils, and is this affected by wave action?
- What are the quantity, fate, physical and chemical properties of burn residual?
- What are the particulates and emissions concentrations in the smoke plume, and how do they move and/or dissipate in time and space?

# Large Scale ISB JMTF – What was tested?

- Persistent light to medium crude oil (37-41 API gravity)
- Heavy/”bunker oil” (RMG 380) (12.2 API gravity)
- Target burn length for each burn is about 20-30 minutes
- Expects each burn to consist of 155-170 gallons of oil

| Burn | Oil | Waves | Vegetation |
|---|---|---|---|
| 1 | Crude | -- | -- |
| 2 | Crude | Yes | -- |
| 3 | Crude | -- | Yes |
| 4 | RMG 380 | -- | -- |
| 5 | RMG 380 | Yes | -- |
| 6 | RMG 380 | -- | Yes |

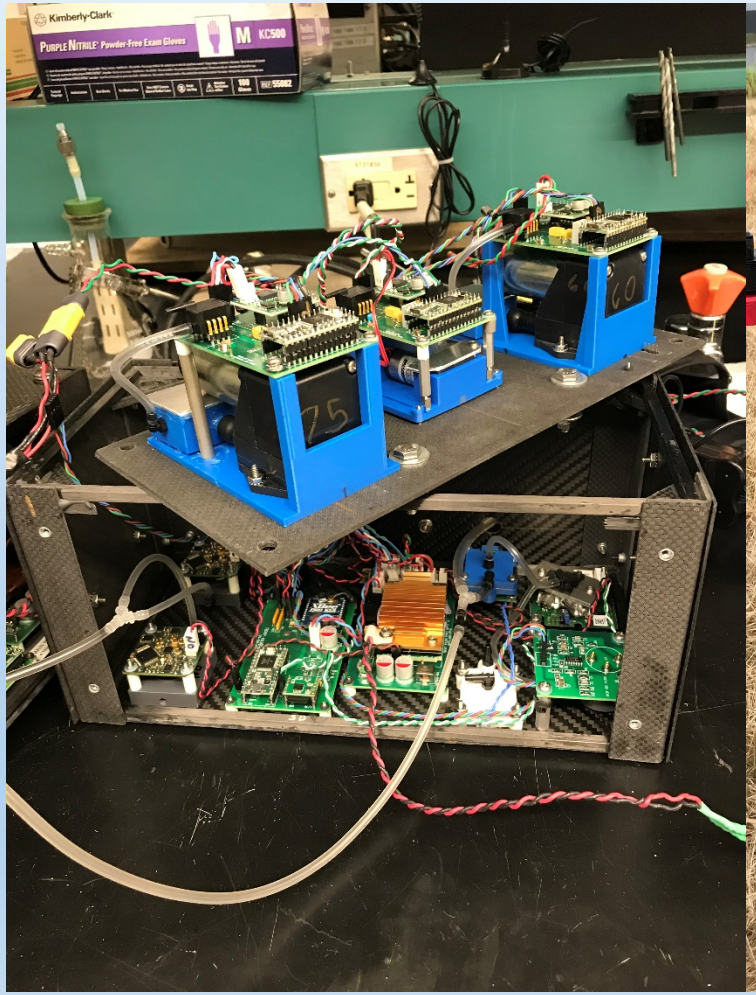
# Large Scale ISB JMTF – Procedures & Setup

- Heat flux measurements and thermocouples will target temperature measurement in the water, oil, fire and smoke plume so analysts may use burn temperature to assess burn efficiency.
- Prior to each burn, analysts will collect raw oil and water samples for analysis of baseline physical and chemical properties and pre-weigh any materials for burn residue collection.
- Once surface oil reaches the relative target oil thickness of 10 millimeters, flow will cease for five minutes prior to ignition.
- Propane torch for ignition.

# Large Scale ISB JMTF - Analysis

- Remote SR-UAS air sampling
- U.S. Environmental Protection Agency's Office of Research and Development (ORD) – Dr. Brian Gullett & Dr. Johanna Aurell
- Emissions sampled consisted of CO2, CO, PM2.5, VOCs, black carbon, brown carbon, elemental/ organic/ total carbon, and PAHs.
- Results are pending sample analyses.

# Large Scale ISB JMTF - Analysis




# Large Scale ISB JMTF - Analysis

- Residue Analysis
- Research analysts will calculate the burn efficiency as the ratio of the mass of oil burned to the initial oil mass introduced to the burn area.
- RDC chemist and/or designated sampler will collect water and oil residue samples for each burn
- The US EPA toxicology lab will analyze samples for total petroleum hydrocarbons (TPH), alkanes and polycyclic aromatic hydrocarbons (PAHs).

# Large Scale ISB JMTF

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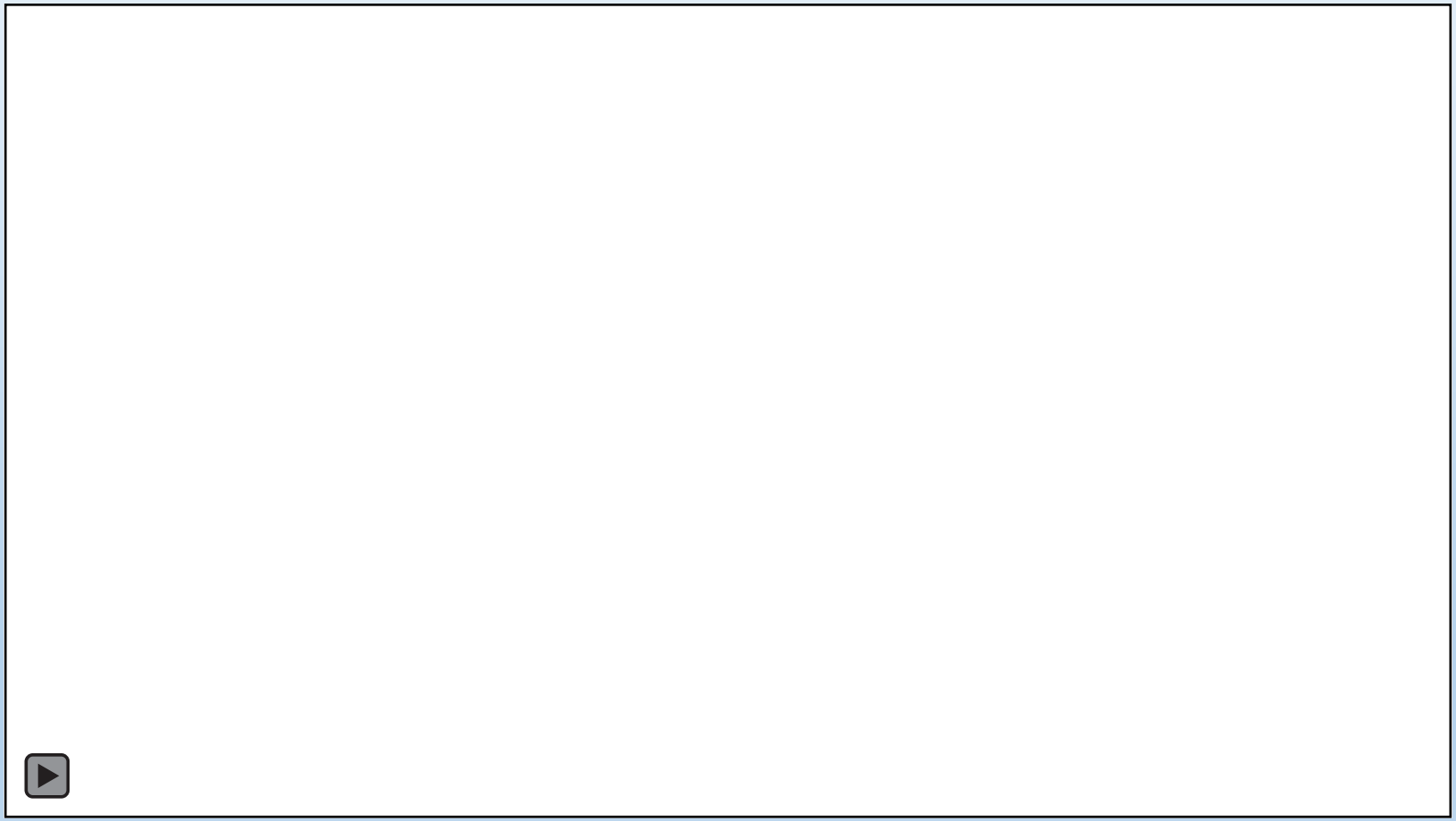

# Large Scale ISB JMTF