Resultater fra storskalatesting av Subsea Mekanisk Dispergering (SSMD)

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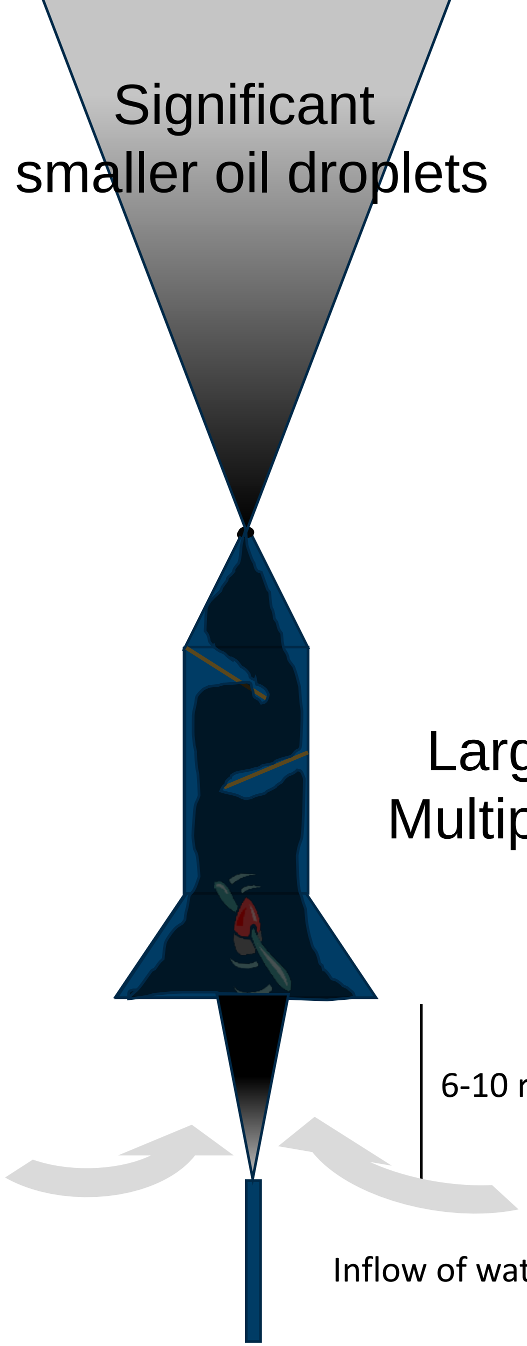
Basic concept
Subsea MECHANICAL dispersion - SSMD

Oil droplets from a subsea release are significantly reduced in size by mechanical forces.

Several feasible concepts are tested at SINTEF Ocean



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SSMD R&D Program History

2012: R&D Project initiated by BP

2017: Feasibility-I (Oil + Water jetting)

2018: Feasibility-II (Oil & Gas + HP)

2019: Large-scale testing at Ohmsett

2020: Final nozzle optimisation ➔ Full-scale design

Next…?
Design & construction of full-scale prototype and operational field testing…?

Funders

bp
equinor
TOTAL
AkerBP
Lundin Energy Norway

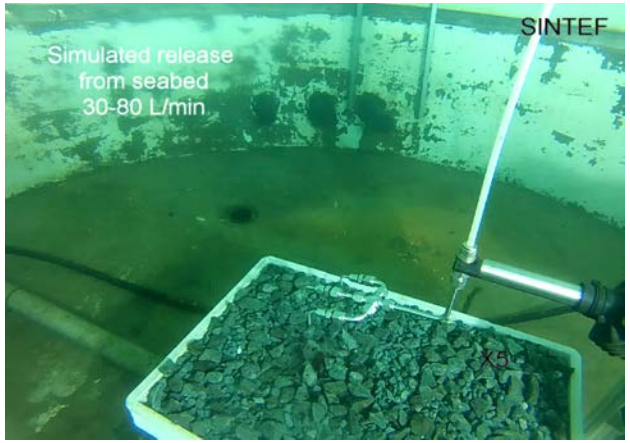
Exponent — Zachary Owens, Lindsey Gilman and Min Yun
OCEANEERING — Torleif Carlsen, Leiv-Ove Nordmark and Michal Koranek

Why pursue SSMD...?

1. Challenging logistics using chemicals
2. Subsea dispersant injection (SSDI) challenging due to local legislation
3. Too low turbulence for dispersant-oil mixing & droplet formation

Logistics

Dispersant use challenging in eg. Russia



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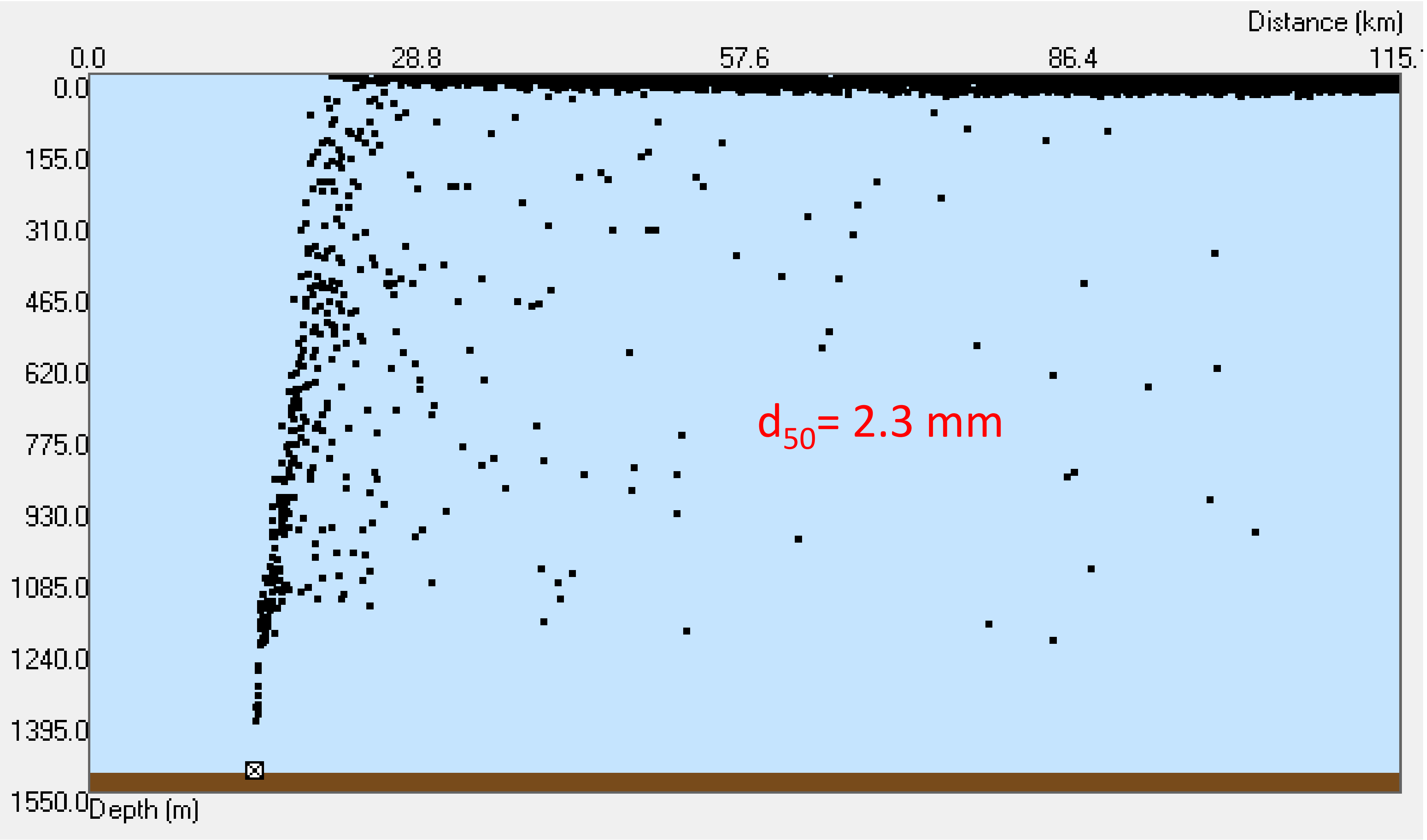
Low turbulence in release from seabed

Subsurface release – With NO Treatment



Release conditions: D: 0.20 m, 6000 m^3/day, waxy crude, temp: 54°C and GOR: 500

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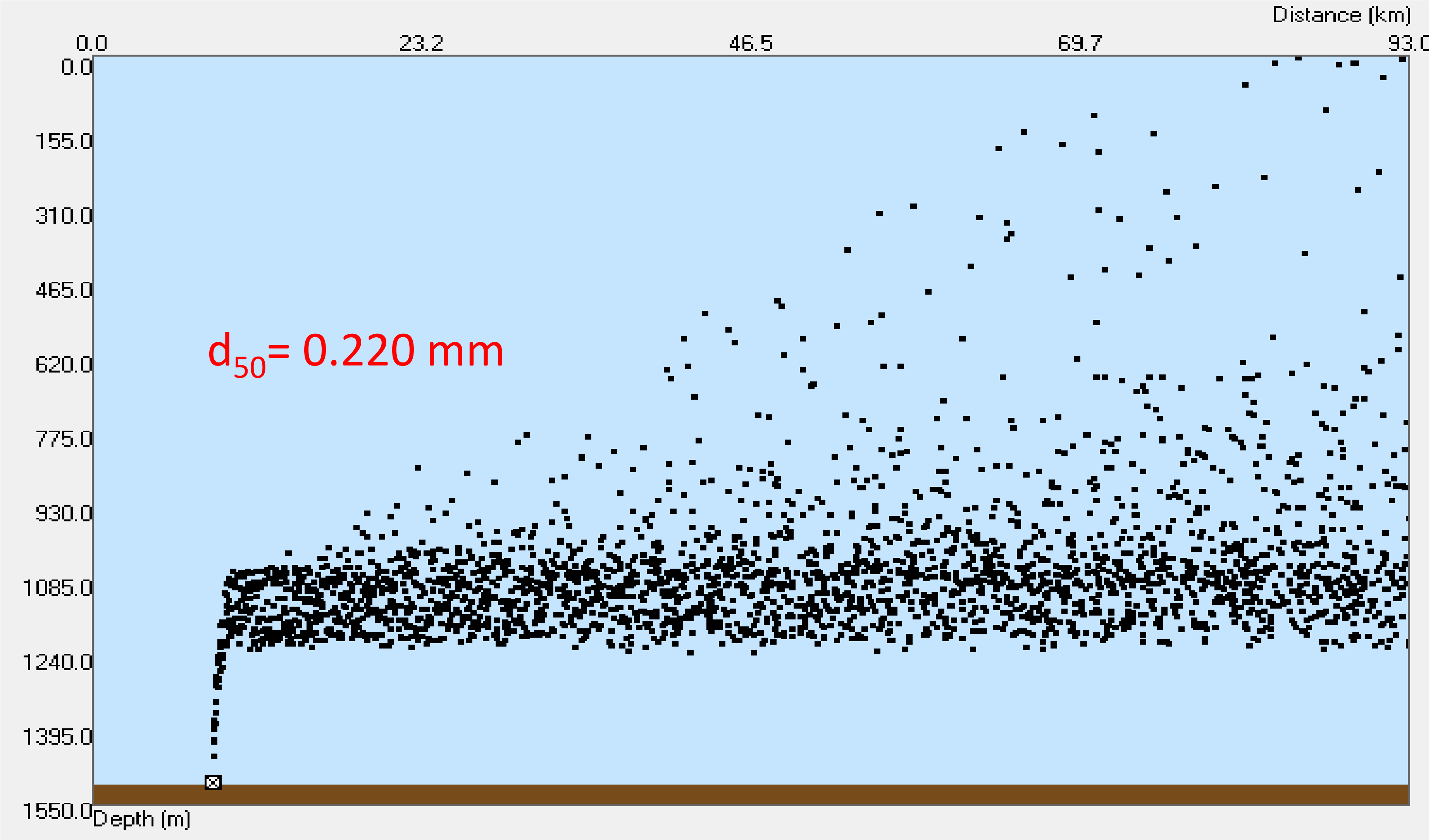
Subsurface release – With Treatment



NB: Surfacing of oil dependent on depth!

Release conditions: D: 0.20 m, 6000 m³/day, waxy crude, temp: 54°C and GOR: 500

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Phase-I: Mechanical shearing device

The mechanical shearing device used in the MiniTower (80 liters of natural sea water)

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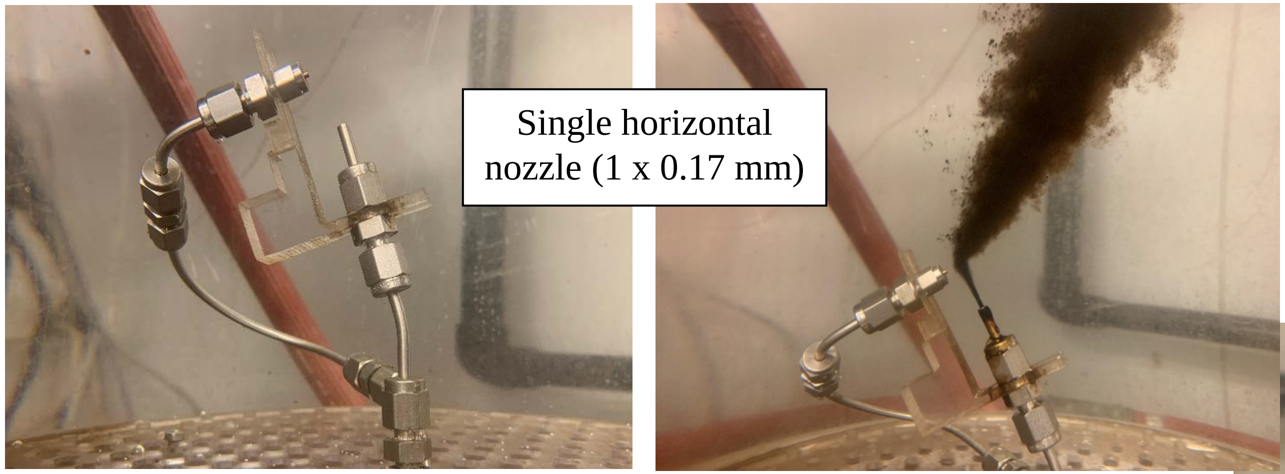
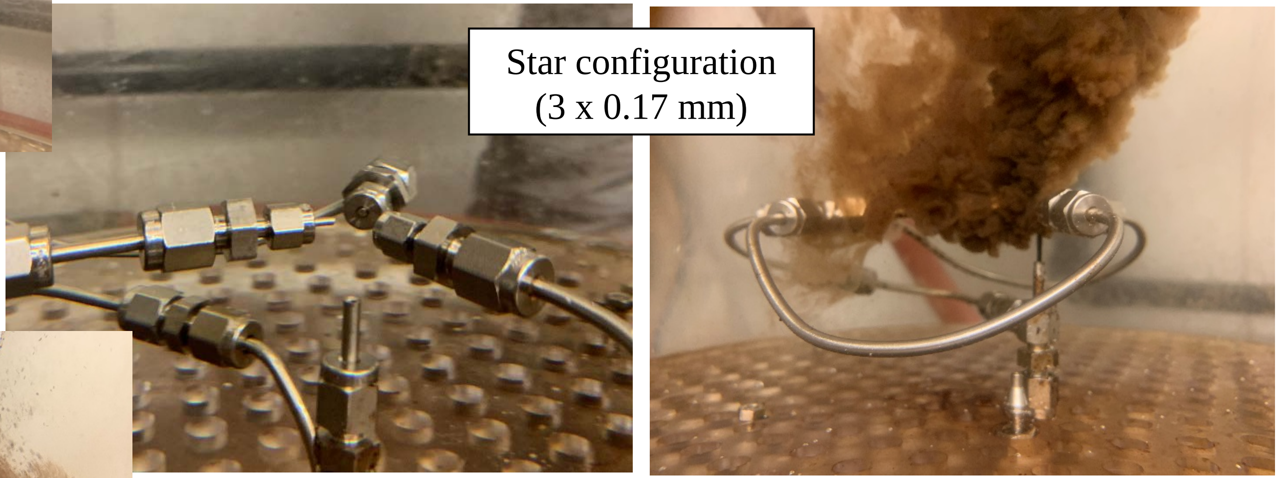
Water Jetting - Nozzle configuration

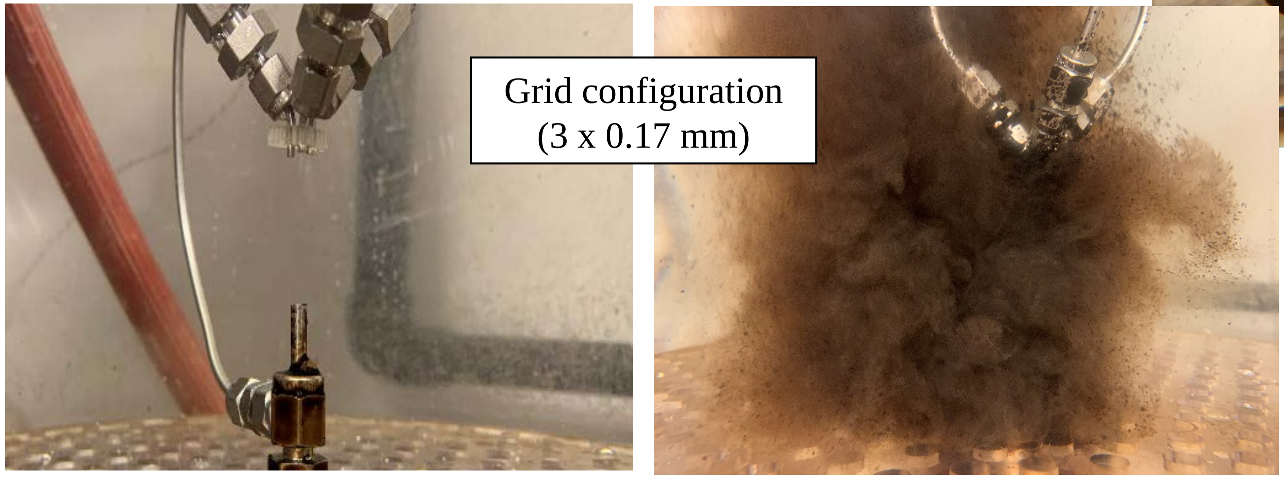
Three designs tested:
- Single (horizontal) nozzle
- Star configuration
- Grid Configuration



Single horizontal nozzle (1 x 0.17 mm)

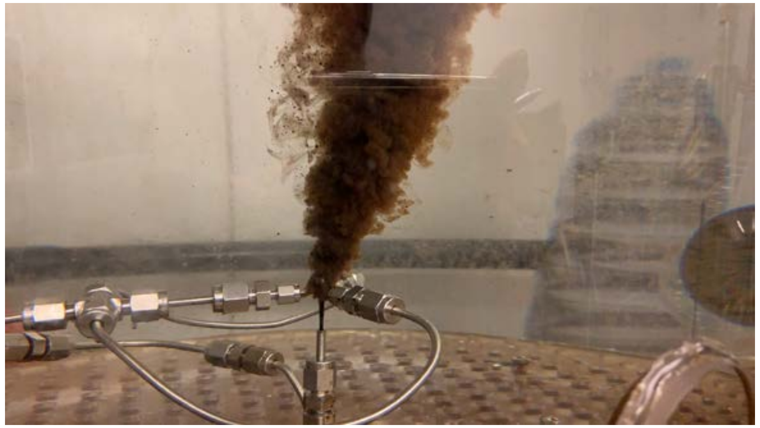


Star configuration (3 x 0.17 mm)



Grid configuration (3 x 0.17 mm)

Phase-III: Combined releases (oil & gas)



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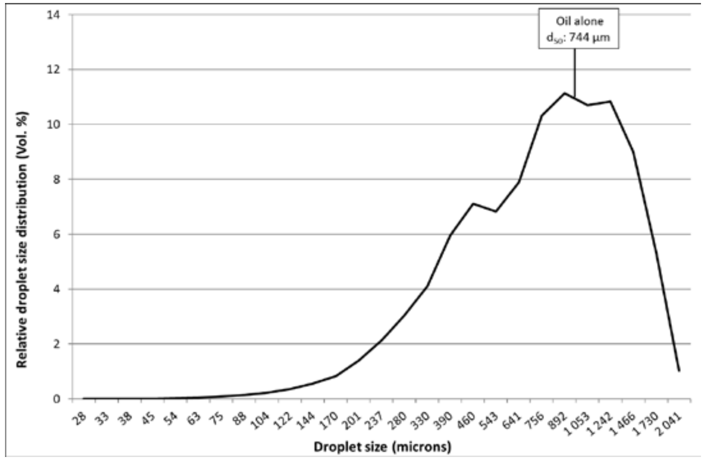
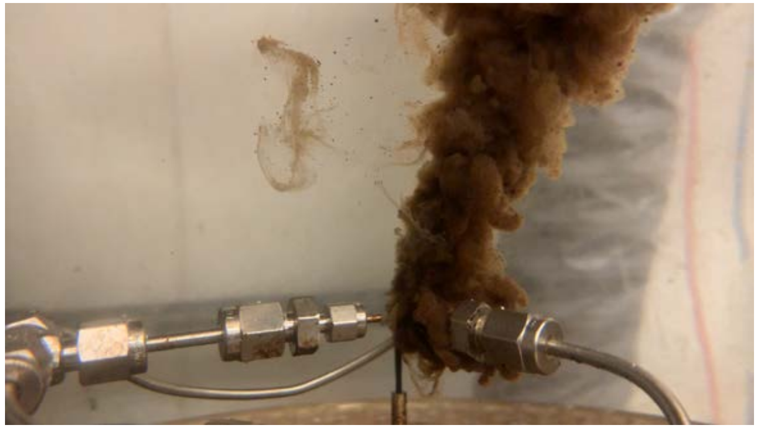
Large **untreated** oil droplets and gas bubbles





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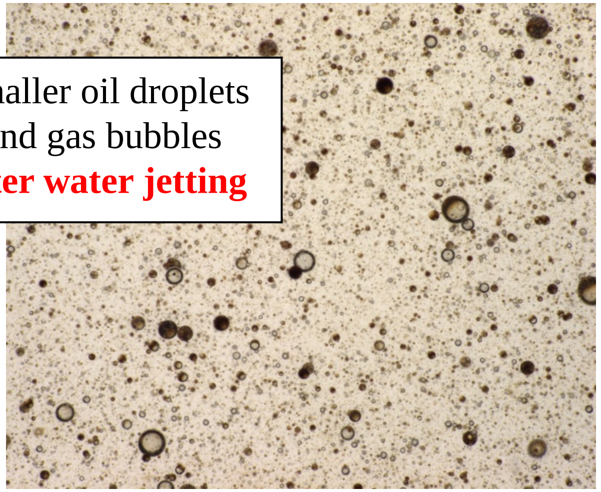
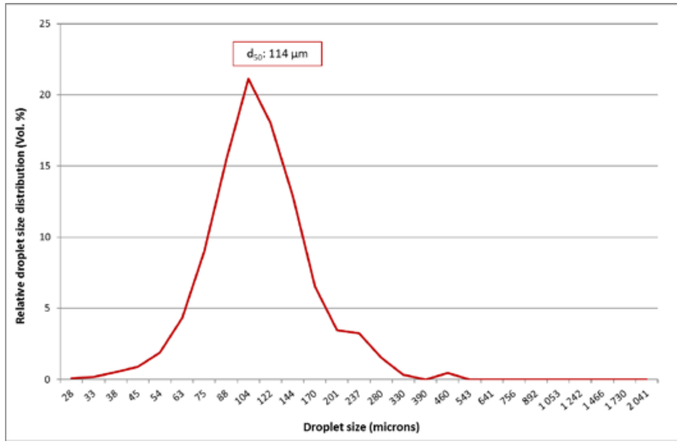
Smaller oil droplets and gas bubbles **after water jetting**





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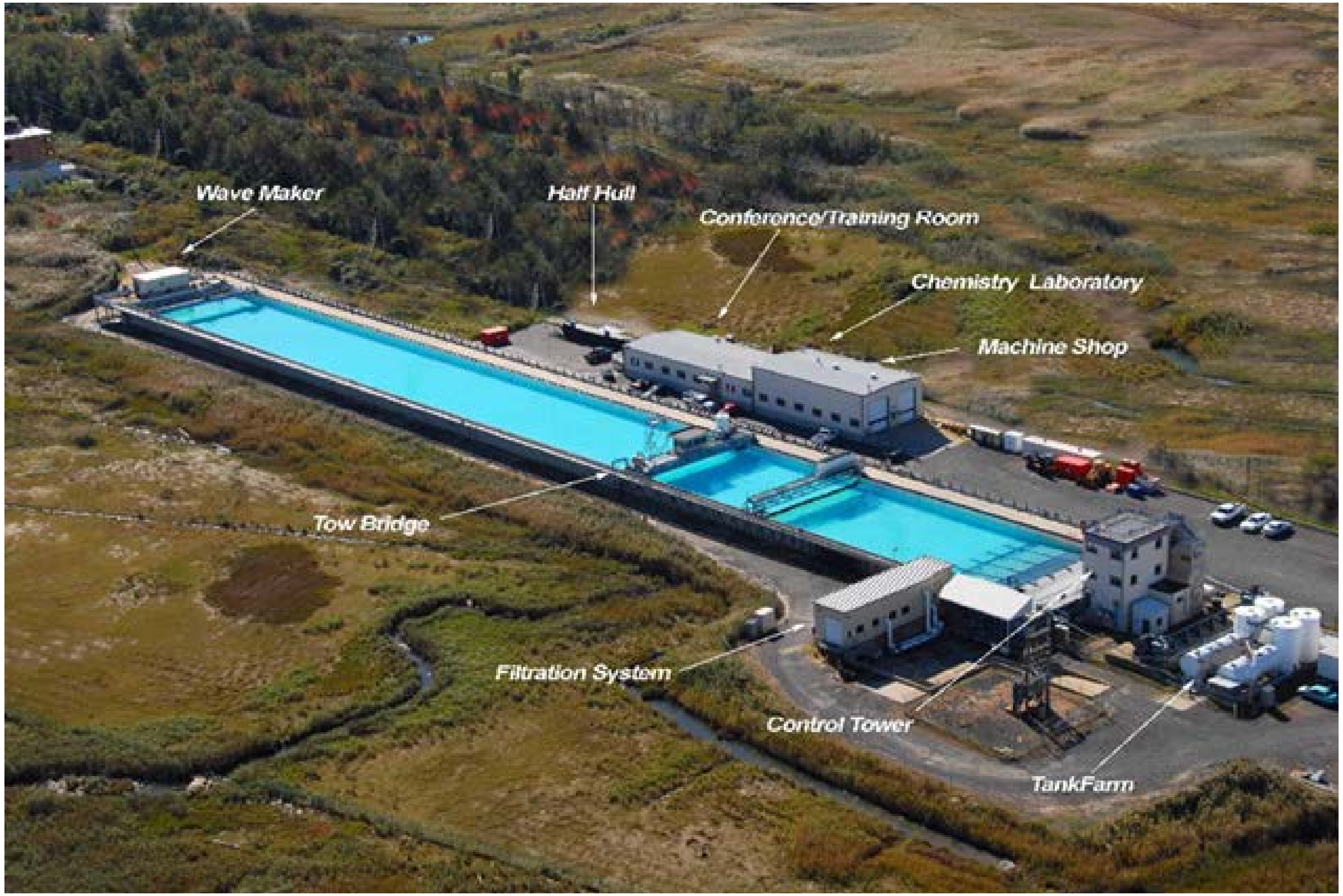
Phase-IV: Large-scale testing, Ohmsett, US



Ohmsett test tank: Length 200 m, width 20 m, depth 2.4 m and 9 500 m^3 of salt water.

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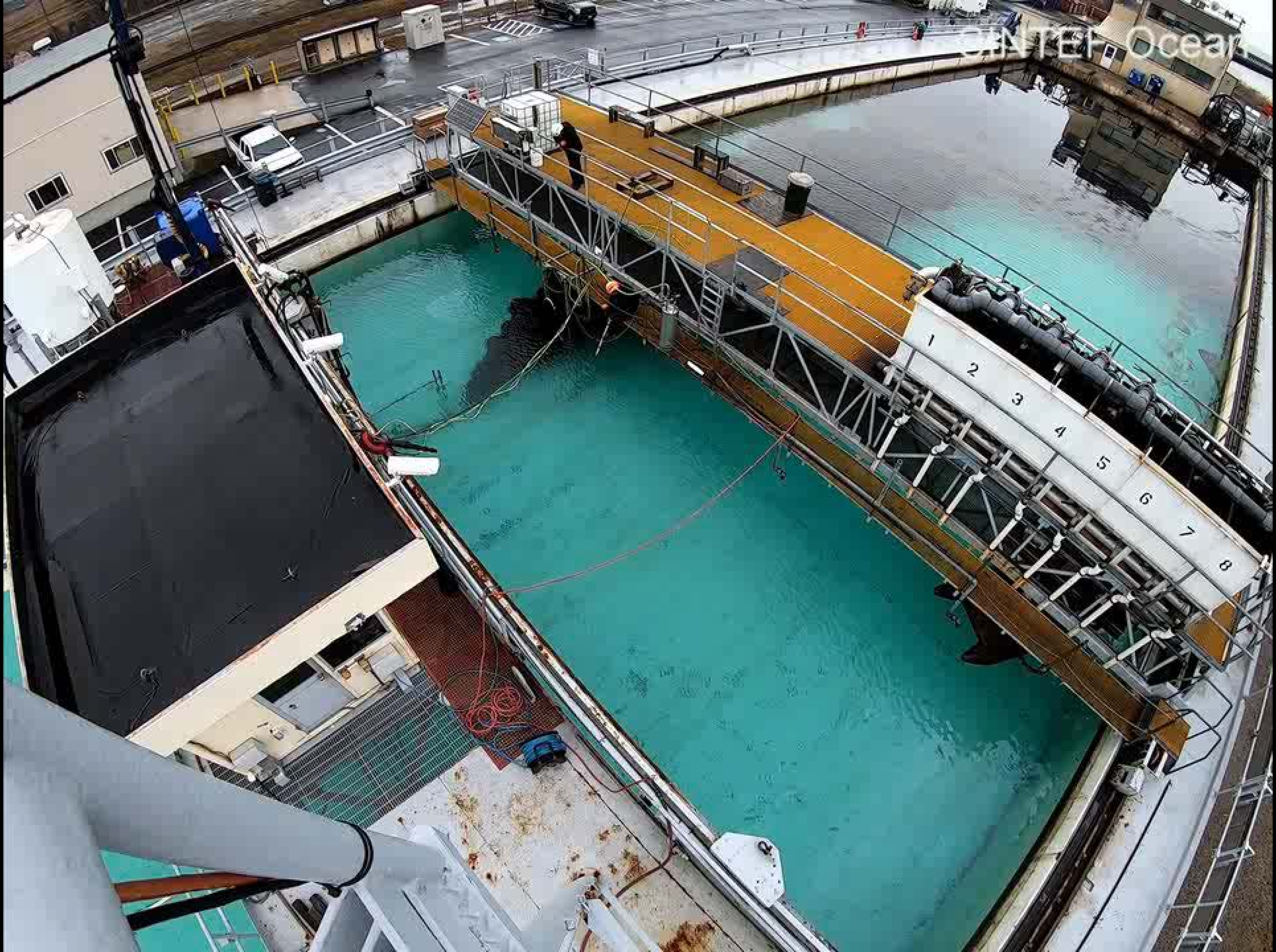

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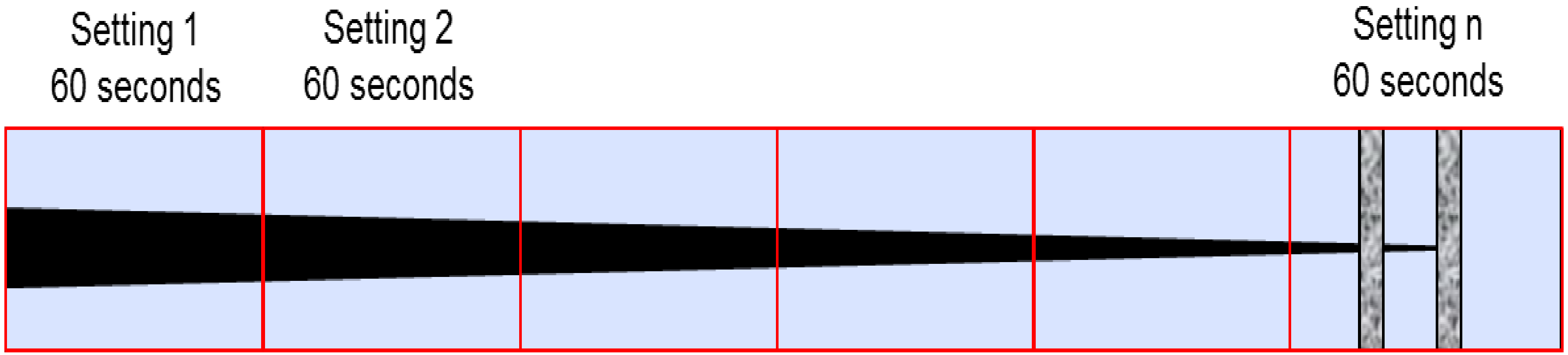
Ohmsett Experiments – Experimental Design



Ohmsett is 200 meter long (5-7 minutes of experimental time) for these towed experiments. Multiple experimental conditions (e.g. increased water velocity/rate) can be tested during one experiment.

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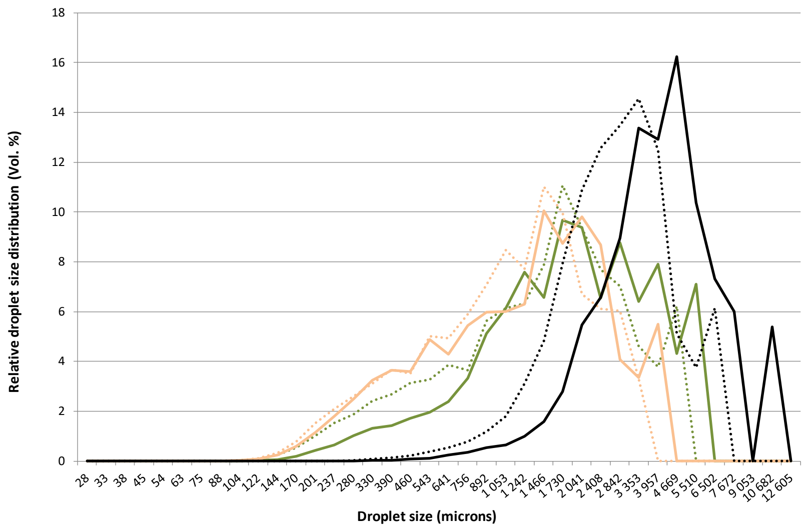
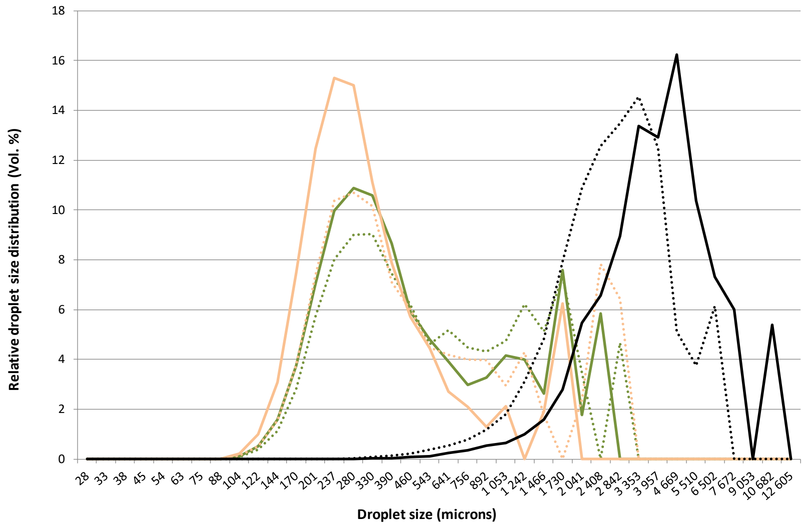
Single nozzle "the winner" vs. Star configuration

Star nozzle
(exp. 9)



Single nozzle
(exp. 10)



Tom will present the next slides!

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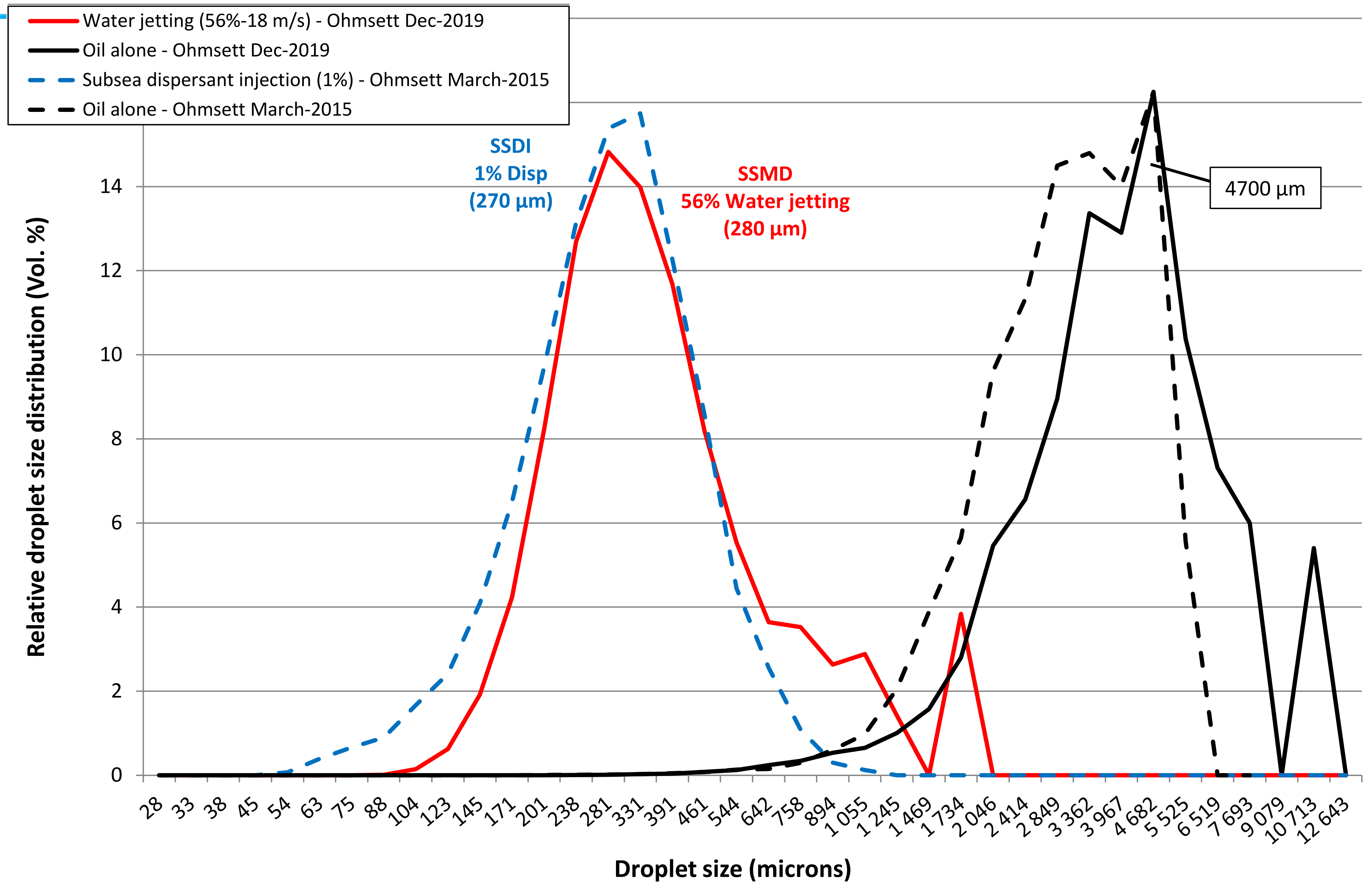
SSMD vs. SSDI effectiveness (32 mm nozzle)



SSMD effectiveness comparable to SSDI effectiveness

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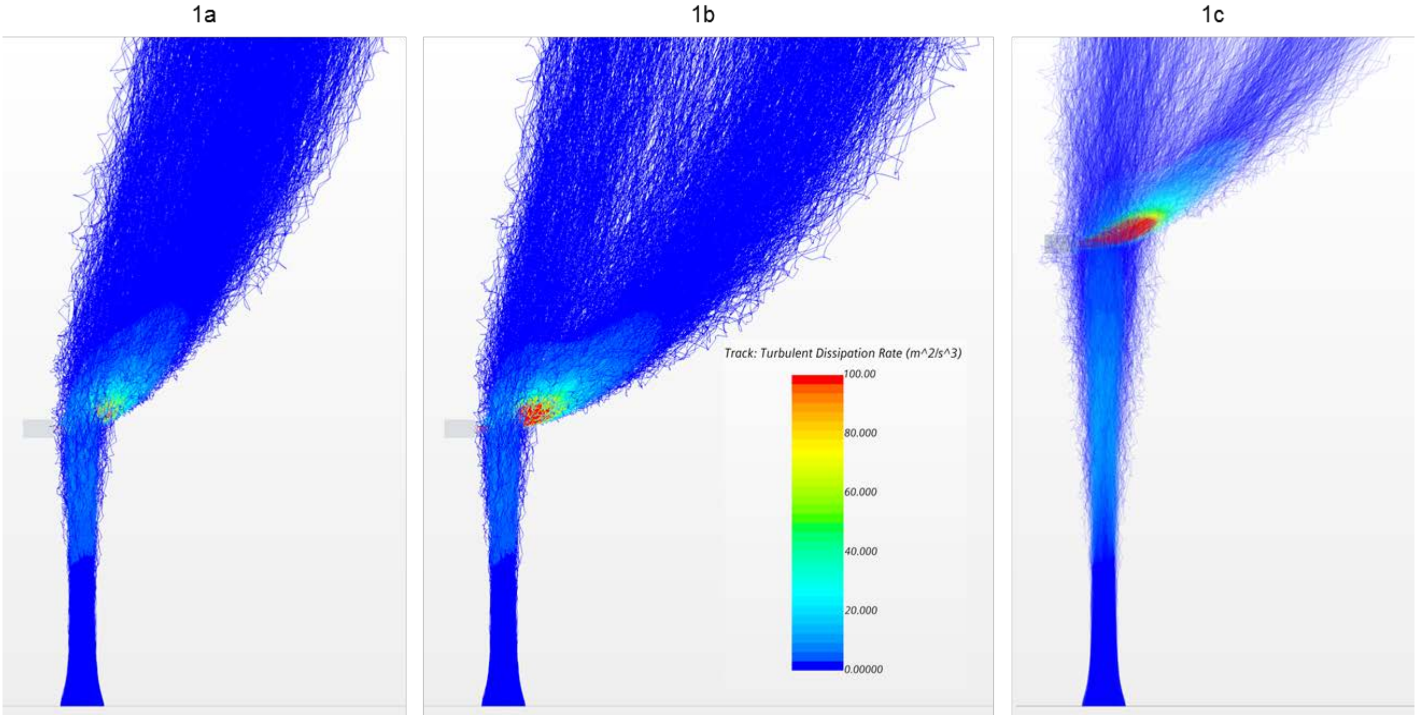
Full-Scale single nozzle - CFD Predictions

Case #	Nozzle Configuration	Oil Release Diameter (mm)	Oil Flow Rate (m^3/day)	Methane Flow Rate (m^3/day) @ release depth of 350 m	Water Nozzle Equivalent Diameter (mm)	Water Total Flow Rate (m^3/day)	Water Jet Exit Velocity (m/s)	Water Jet Distance above Oil Release (Oil Release Diameters)	Water Jet Lateral Offset from Edge of Oil Release (mm)	Water/Oil Flow Ratio
1a	Cylindrical	500	11,500	11,500	56	4,600	21.7	6	75	0.4
1b	Cylindrical	500	11,500	11,500	56	5,750	27.0	6	75	0.5
1c	Cylindrical	500	11,500	11,500	56	5,750	27.0	10	75	0.5



Release diameter: 0.50 m
Release rate: 11 500 m^3/day
Gas to oil ratio: 50%

Single water treatment nozzle: 56 mm
Water velocities: 22 – 27 m/s
Water consumption: 40-50%

Turbulent Dissipation Rate (TDR) metrics indicate high SSMD effectiveness in full-scale scenarios

A single-nozzle approach will be efficient for a full-scale scenario.

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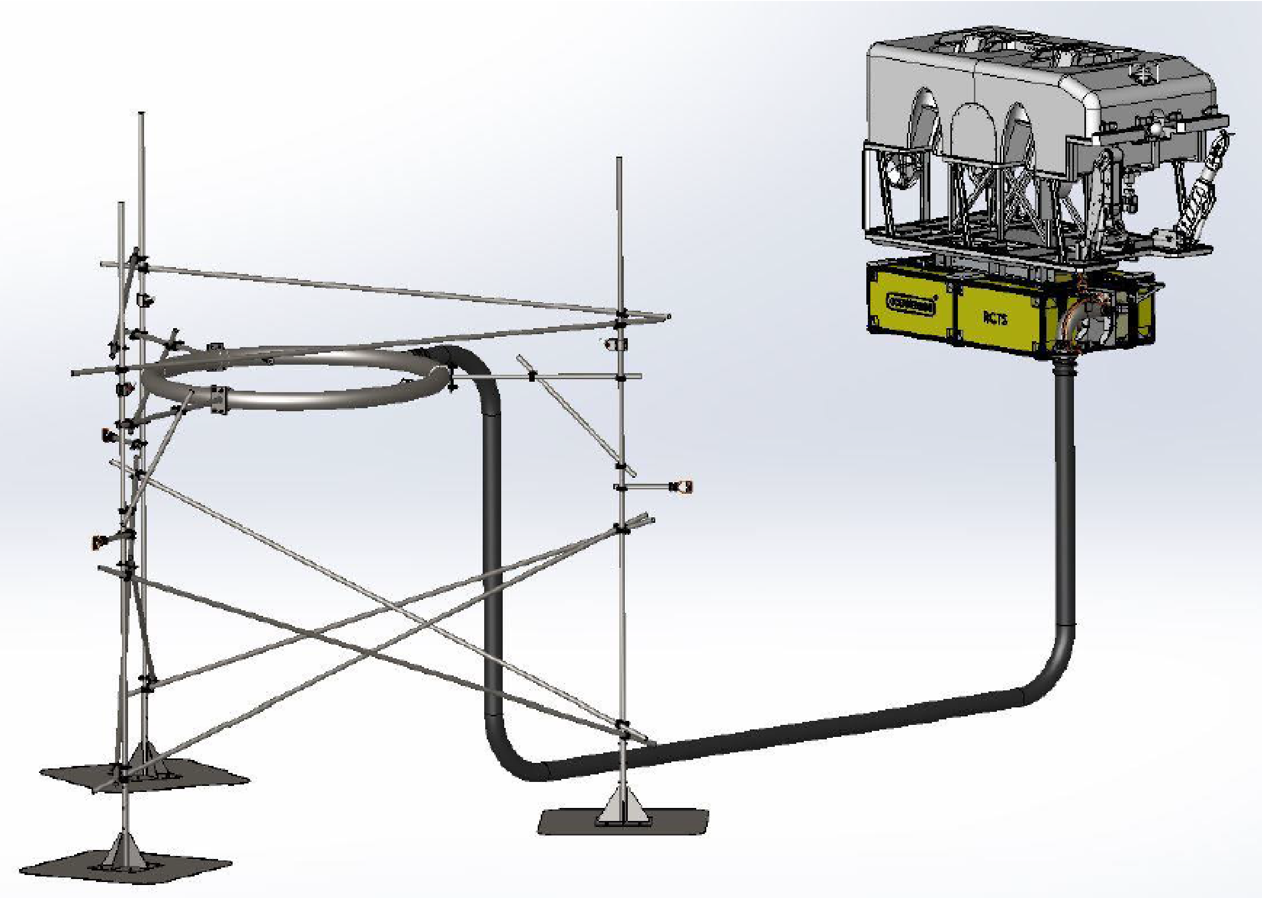
Phase-III: Design & cost study (full-scale)



Full-scale equipment operated by a ROV designed by Oceaneering.

Conclusions - SSMD

- Water jetting significantly reduce oil droplet size (10-fold with 50% water jetting).
- Nozzle configuration optimized by CFD modelling.
- Full-size concept based on submersible pumps and ROVs.
- Large-scale testing (Ohmsett) show comparable results to SSDI.

Way forward - SSMD

Technical – Operative verification

- Final design of concept; ROV, subsea pump and vessel requirement
- Design and detailed engineering of optimized nozzle design and nozzle frame
- Production and acceptance testing
  - Finalize acceptance criteria (secure required TRL for implementation)
- Field testing

Way forward - SSMD

Planning of next project phase

- Feedback from regulators
- Discussing several ways of organizing next step
  - Engage more partners for collaboration and cost sharing
  - Demo 2000 application?
  - How to develop technology through our global response providers

SSMD a new tool in the Oil Spill Contingency Toolbox…?

In-situ Burning

Dispersant application on surface oil slicks

Mechanical Surface Dispersion

Mechanical recovery

Bioremediation

Subsea Mechanical Dispersion - SSMD

Subsea Dispersant Injection - SSDI

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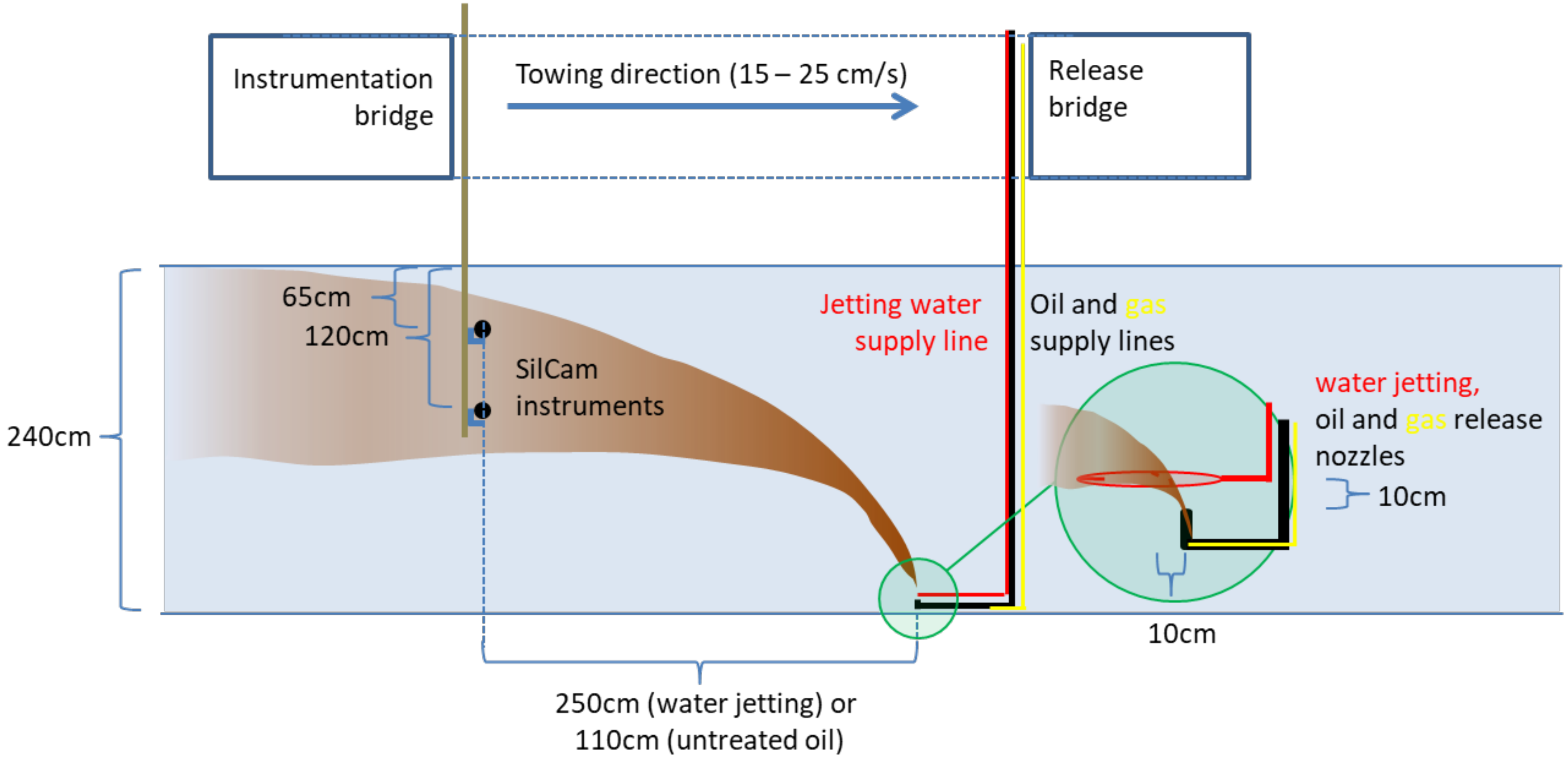
Ohmsett Experiments – Experimental Design



Arrangement for the combined releases of oil & gas and the water jetting

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