Subsea Mechanical Dispersion – A New Response Technology..?

Presented by:
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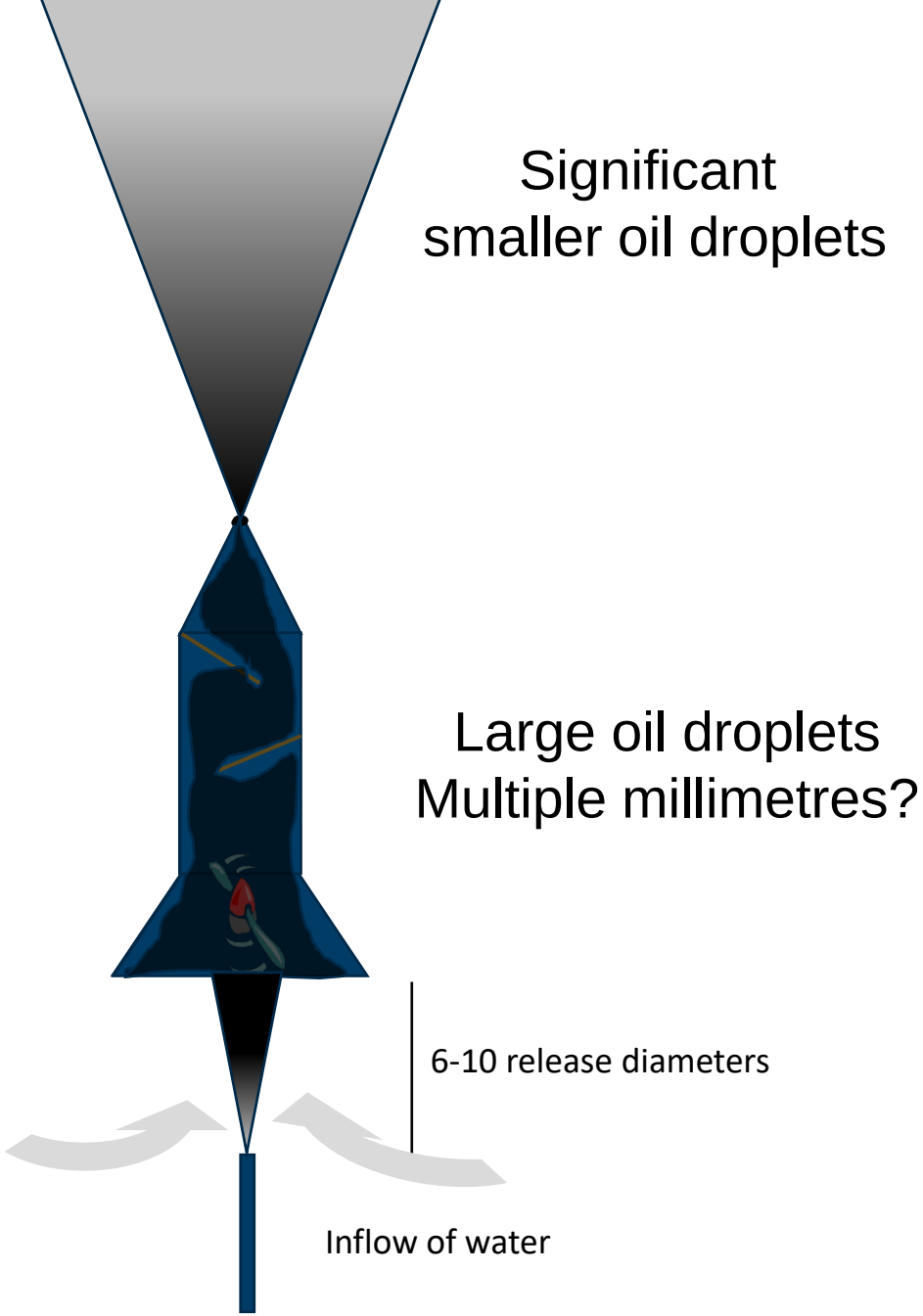
Basic concept Subsea MECHANICAL dispersion - SSMD

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

Several feasible concepts are tested at SINTEF in Norway



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SSMD R&D Program History

2012: R&D Project initiated by BP

2015: 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 Norway

Exponent

* in close cooperation with: OCEANEERING

SINTEF

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(BP initiated study and introduced concept to SINTEF)

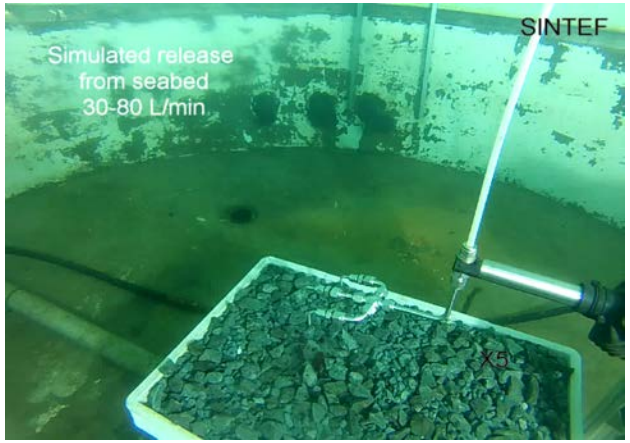
…. and personnel for our funding partners

Why Promote 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

Logistic challenges

Dispersant use challenging in for example Russia



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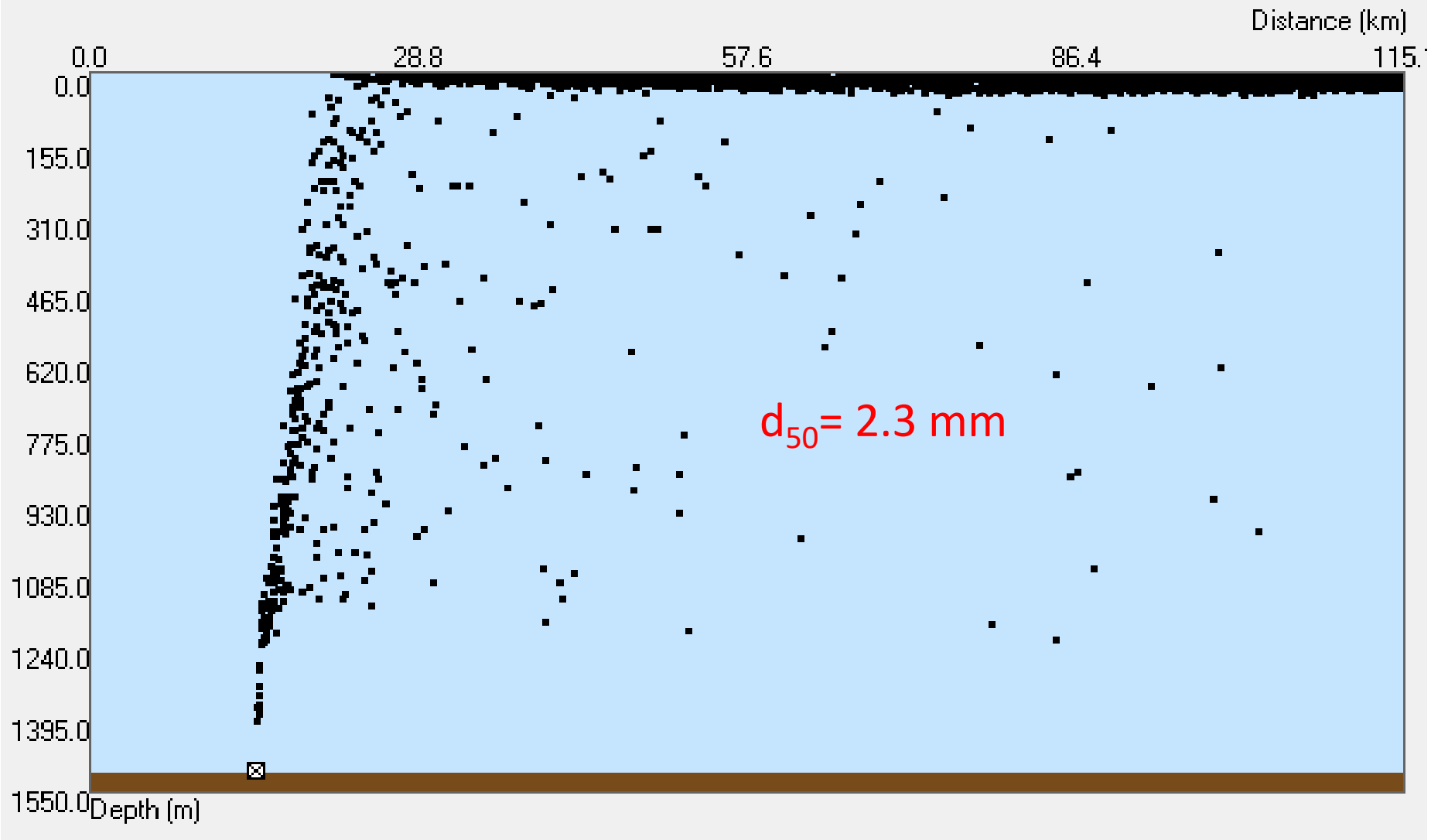
Low turbulence in release from seabed

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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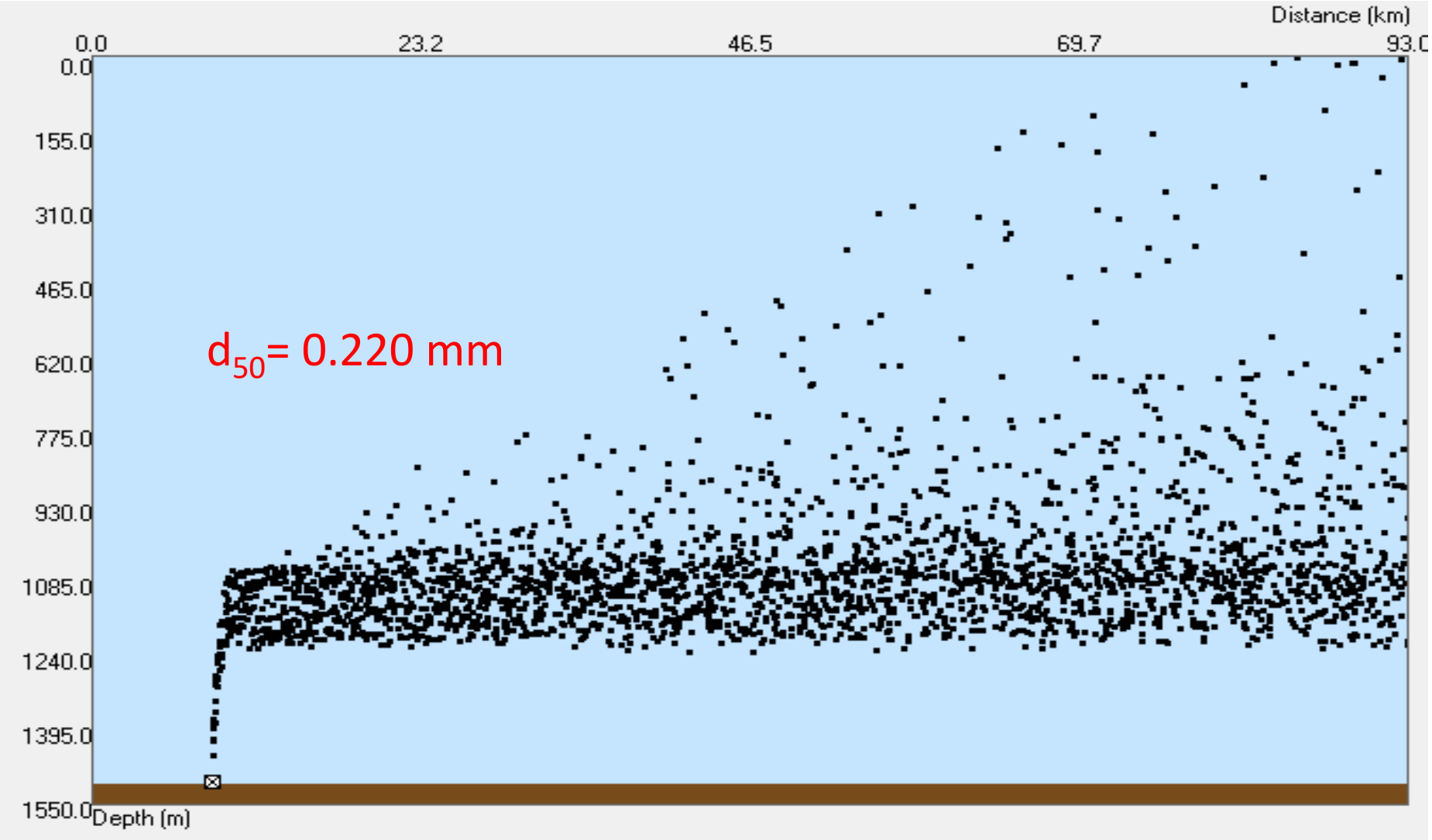
Subsurface release – With Treatment (SSDI or SSMD)



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

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Phase-I: Testing of Ultrasound unit

The ultrasound probe marinized and inserted into the SINTEF MiniTower

Phase-I: Mechanical shearing device

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

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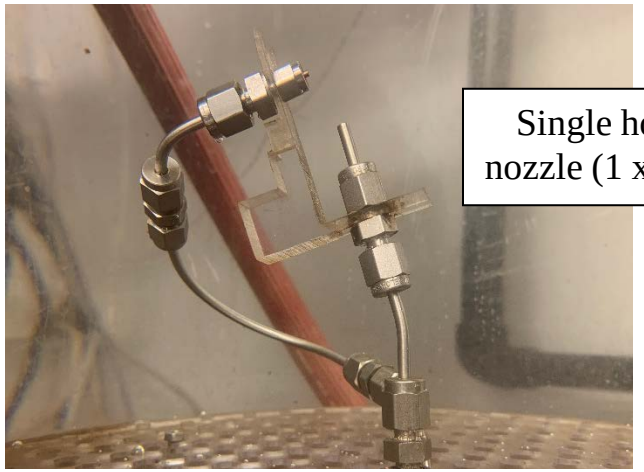
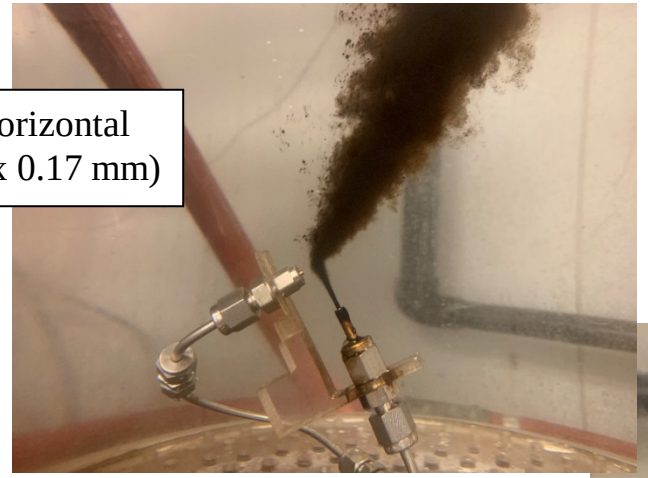
Phase-II: Water Jetting - Nozzle configuration

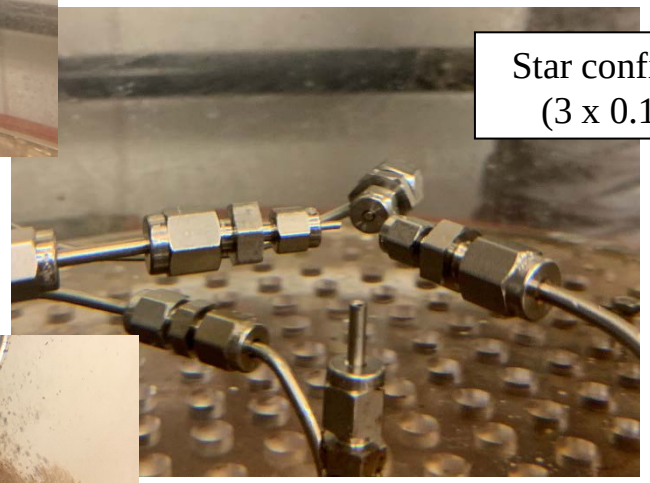


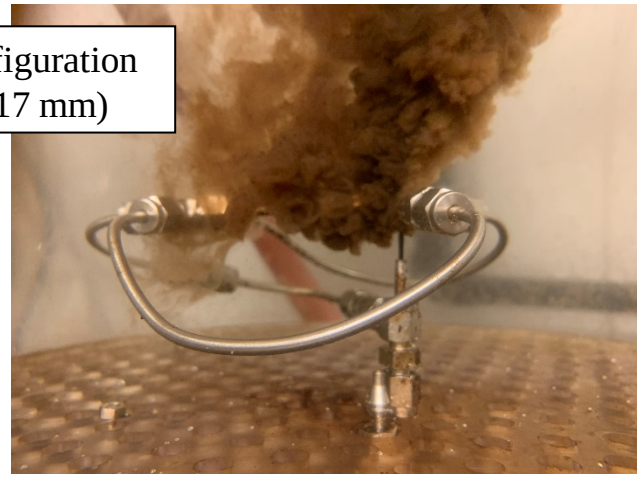


Single horizontal nozzle (1 x 0.17 mm)

Three designs tested:

- Single (horizontal) nozzle
- Star configuration
- Grid Configuration





Star configuration (3 x 0.17 mm)

Grid configuration (3 x 0.17 mm)

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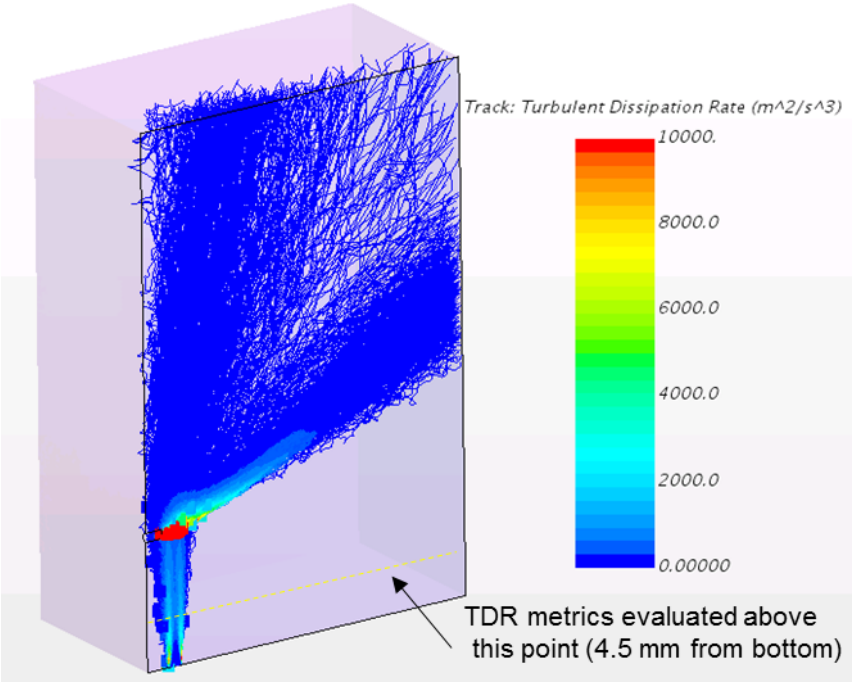
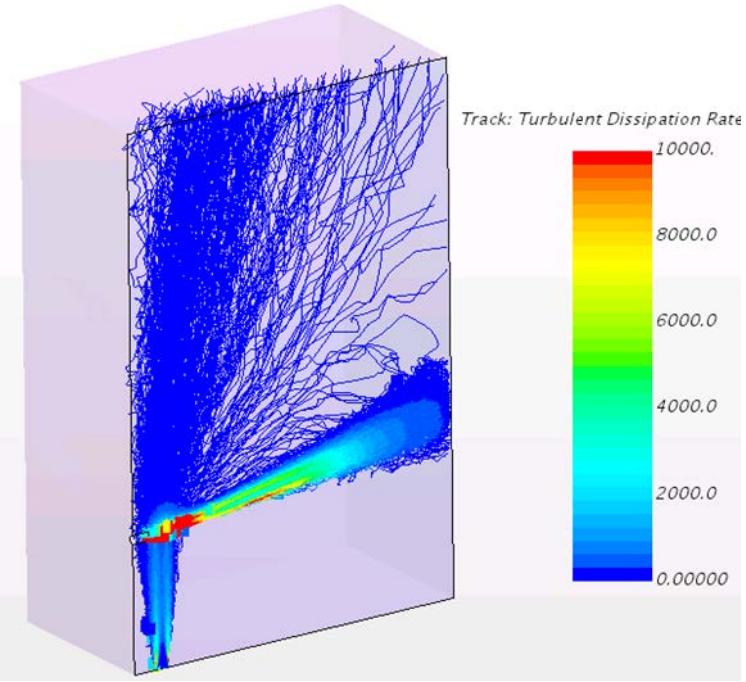
Phase-III: Optimize nozzle design (CFD)

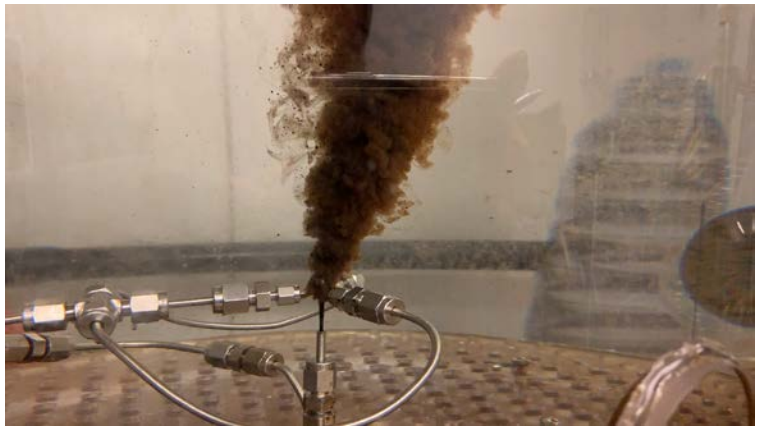




Using Turbulent Dissipation Rate metrics to quantify efficiency of different nozzle design

Using Computational Fluid Dynamics (CFD) modelling with tracer particle to describe additional turbulence caused by SSMD for the two selected lab experiments

Phase-III: Combined releases (oil & gas)



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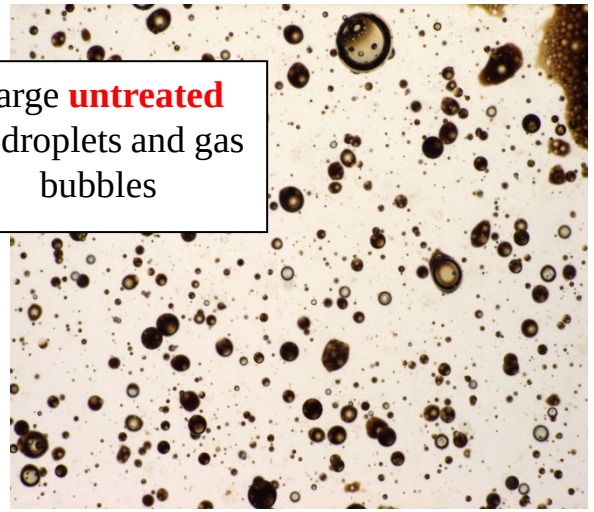
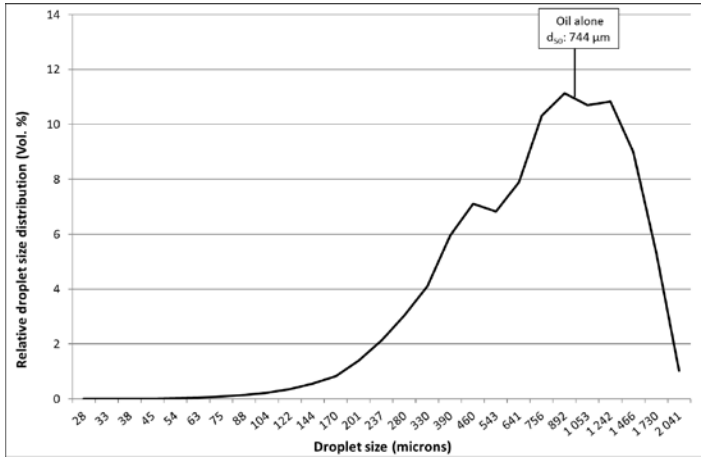
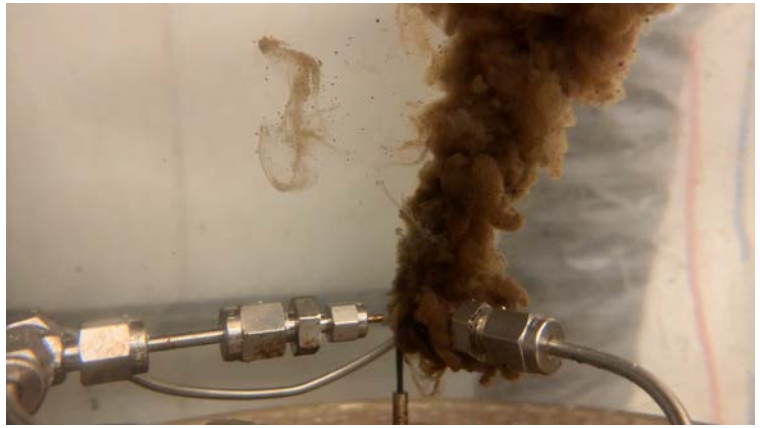


Large **untreated** oil droplets and gas bubbles





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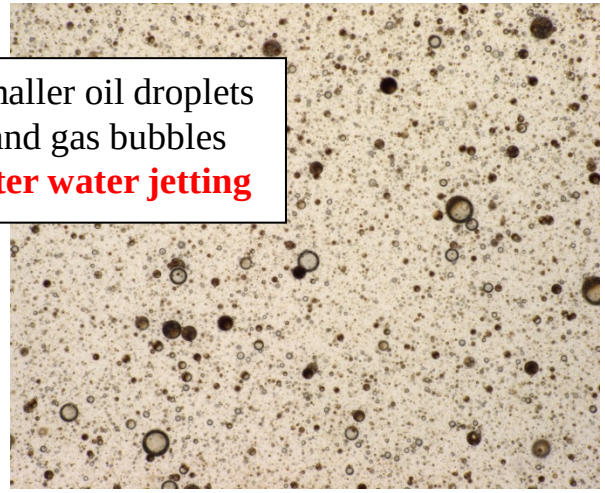
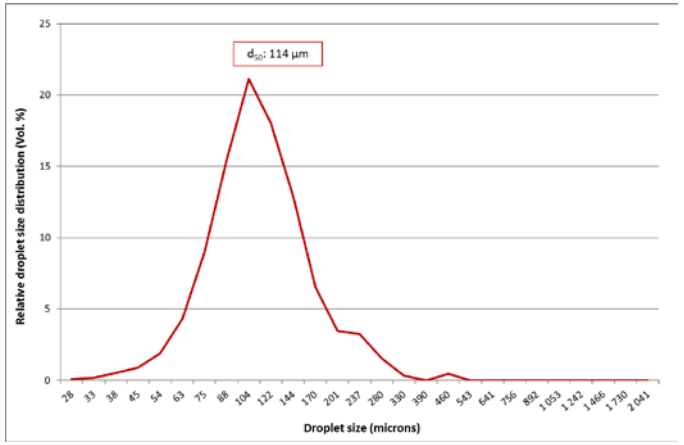


Smaller oil droplets and gas bubbles **after water jetting**



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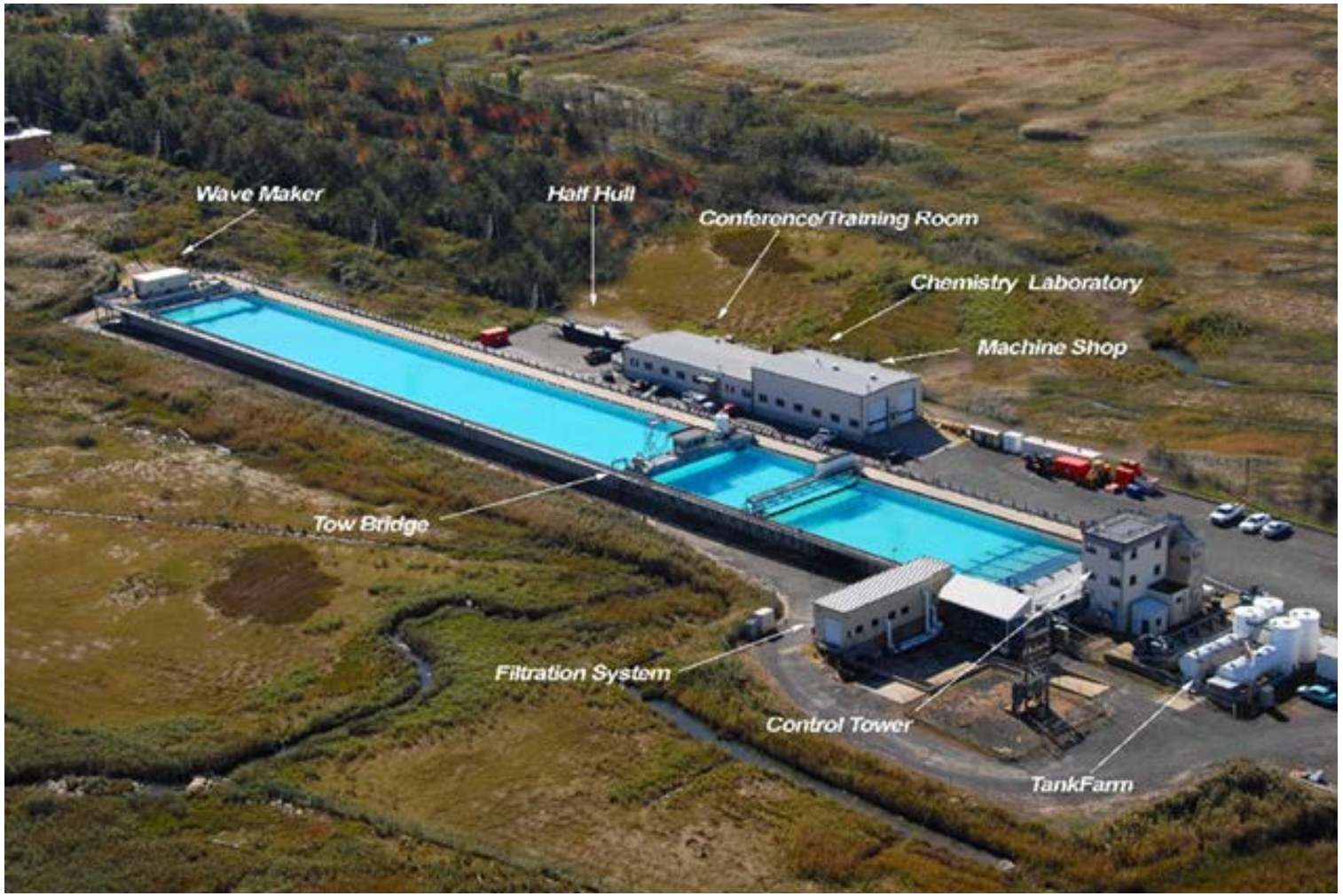
Phase-IV: Large-scale testing, Ohmsett, US



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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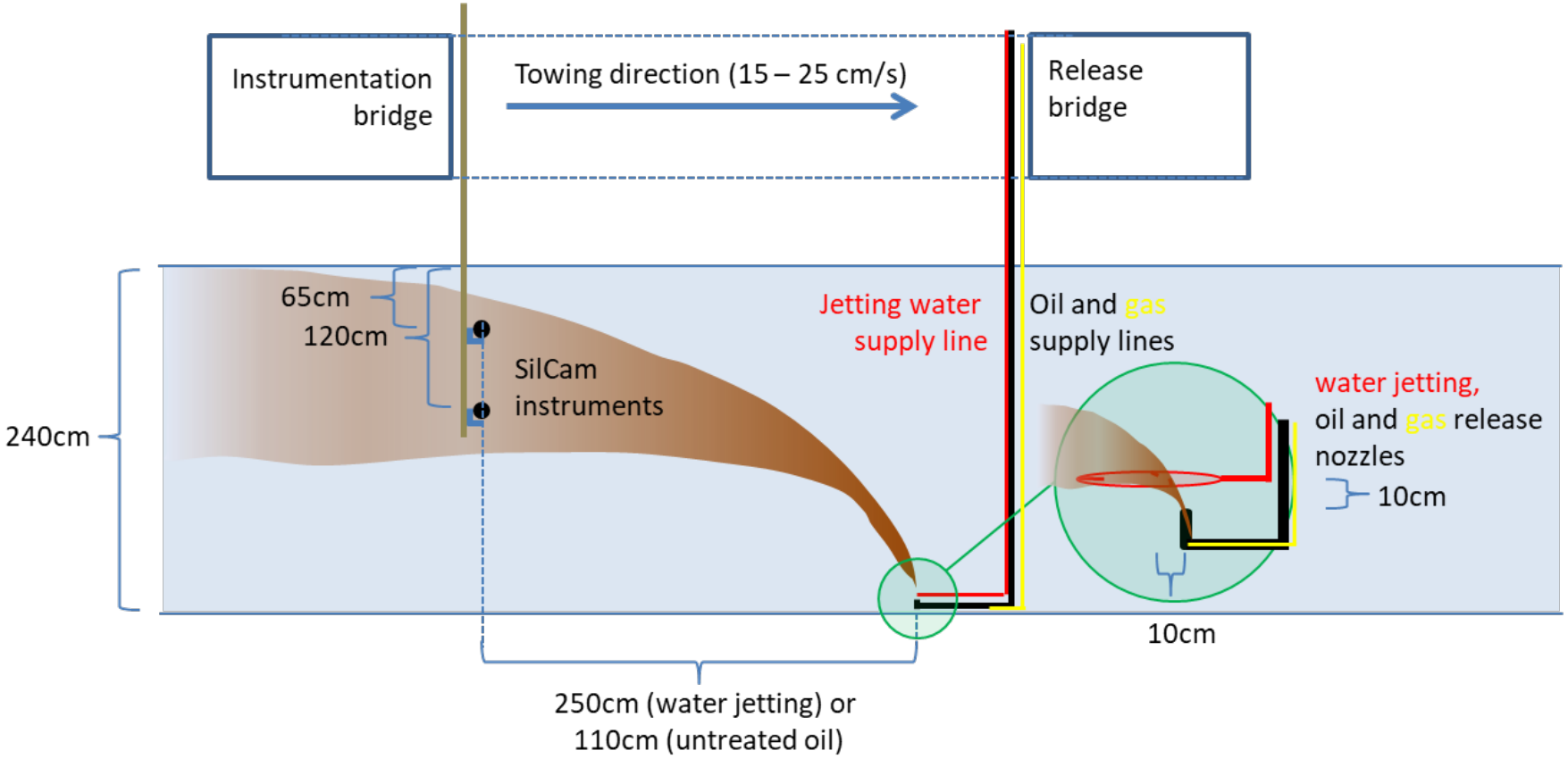
Ohmsett Experiments – Experimental Design



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

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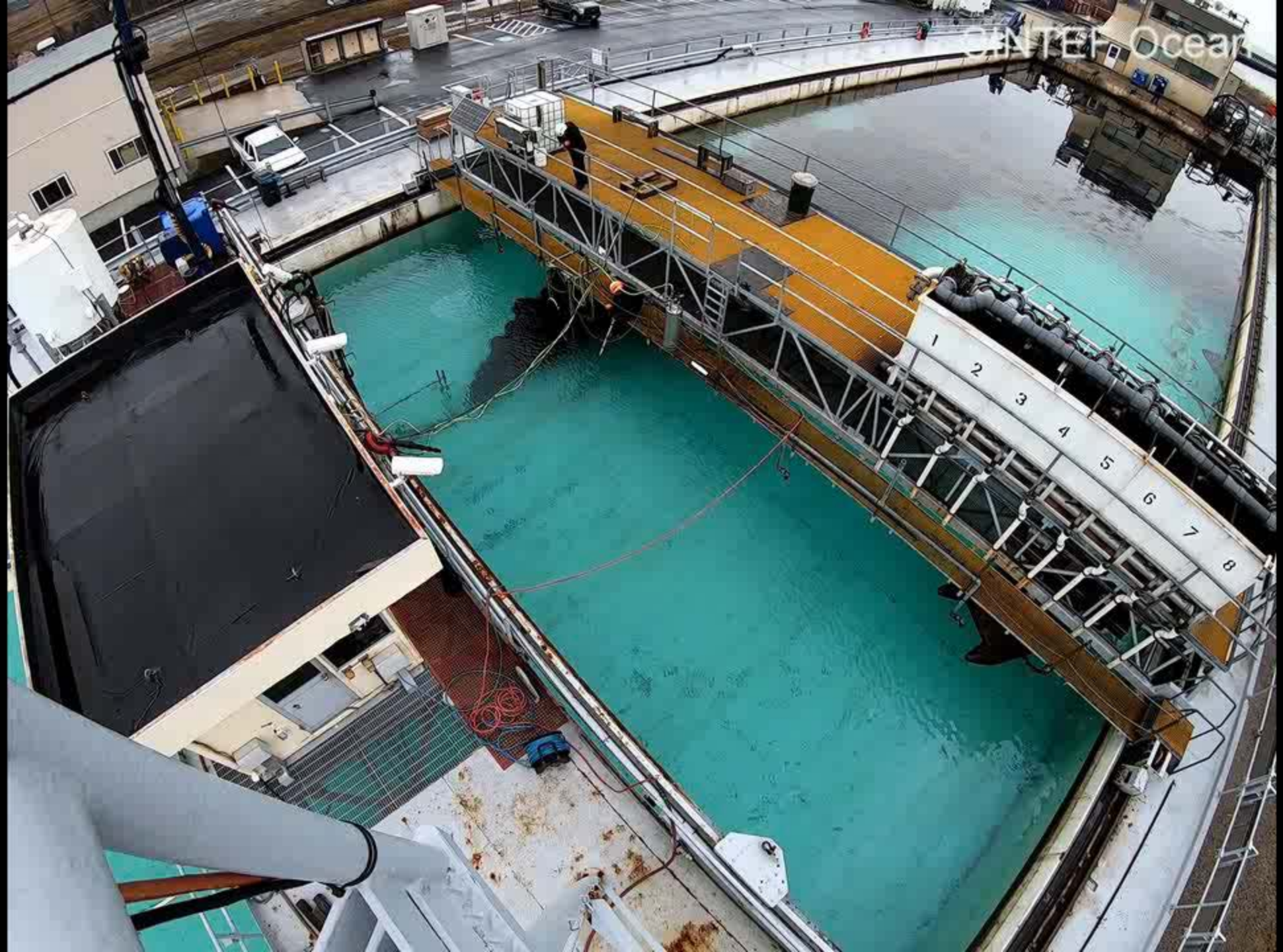
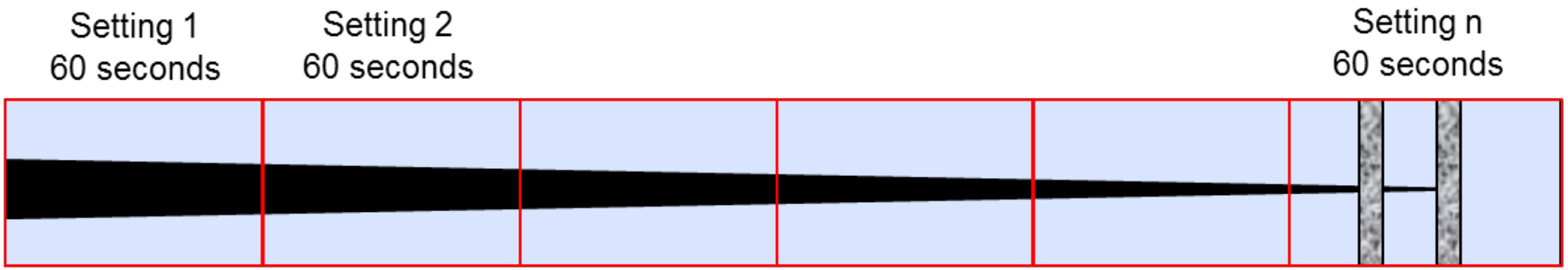


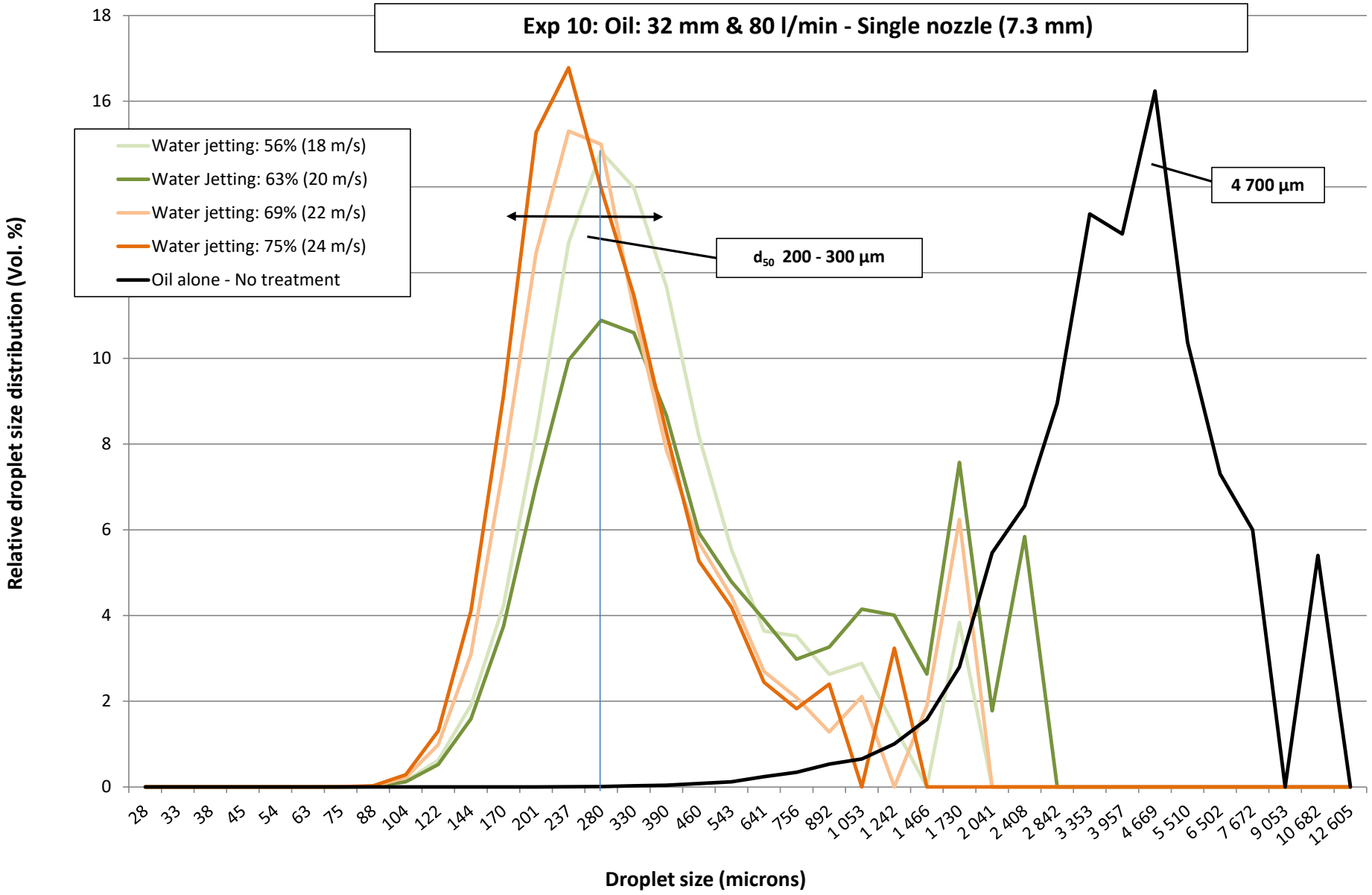
Click for video

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.

Effectiveness – Single Nozzle configuration (Exp 10)



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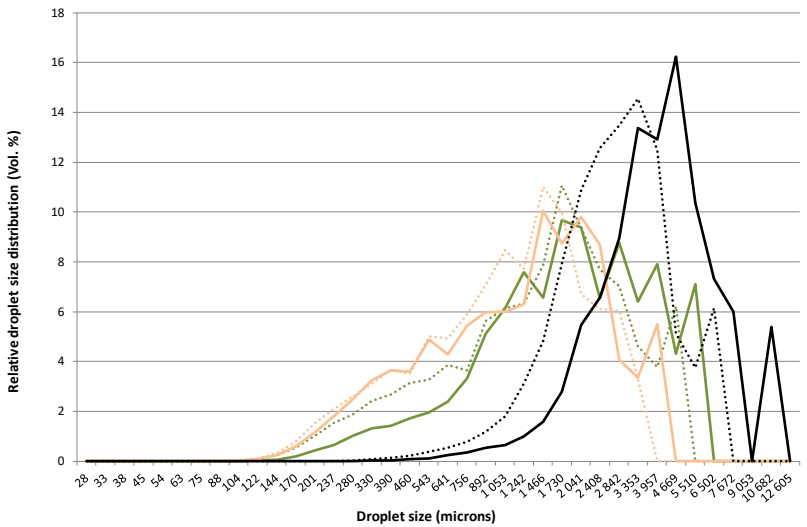
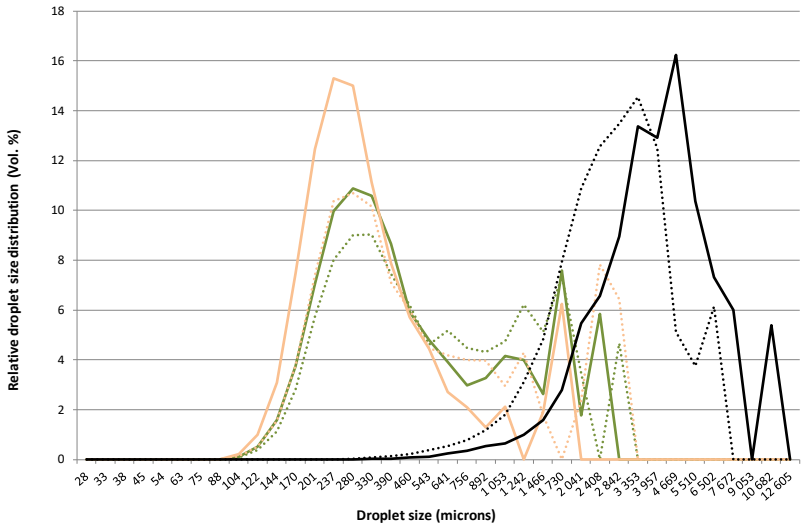
Single nozzle "the winner" vs. Star configuration

Star nozzle
(exp. 9)



Single nozzle
(exp. 10)



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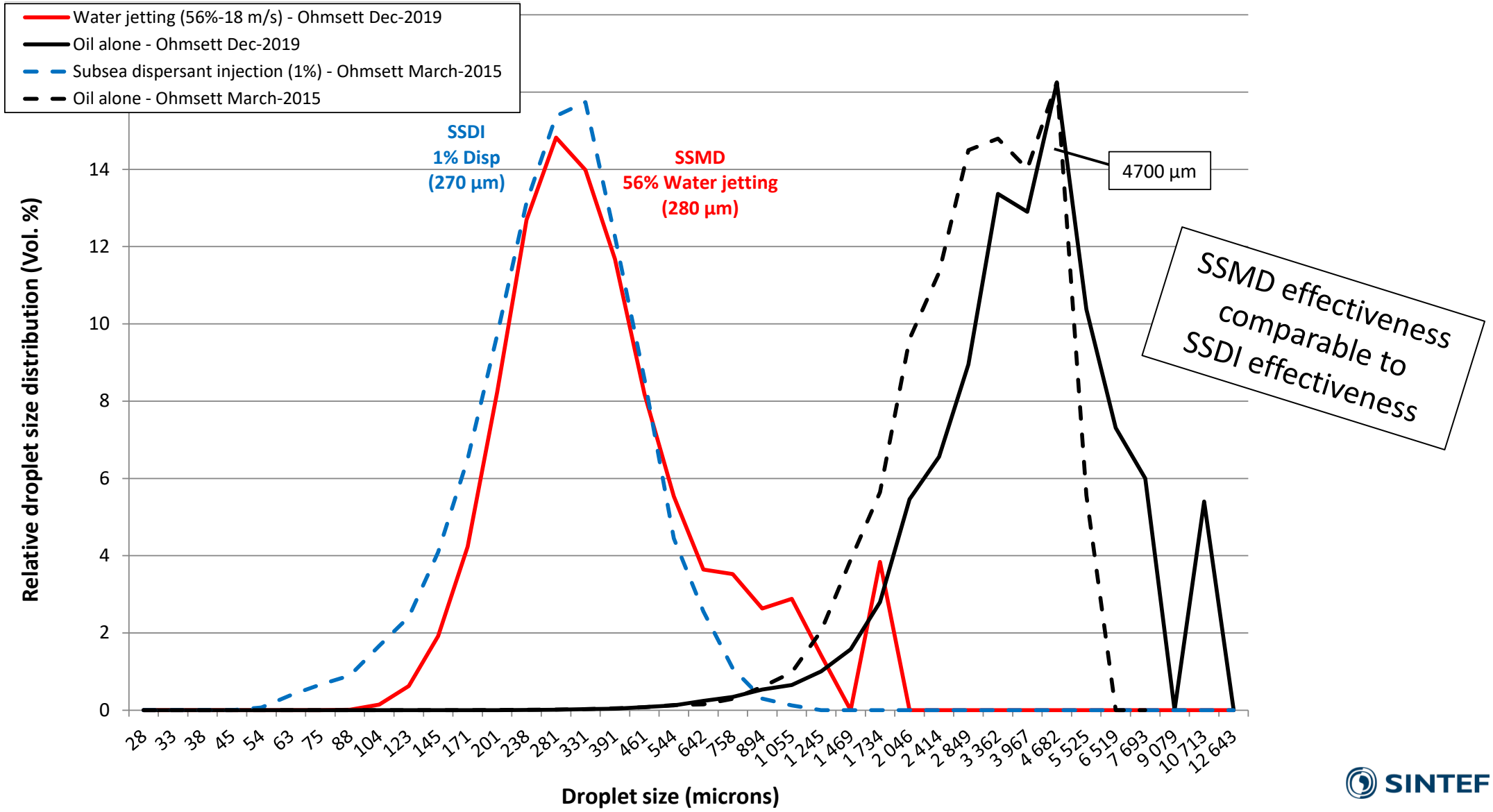
SSMD vs. SSDI effectiveness (32 mm nozzle)



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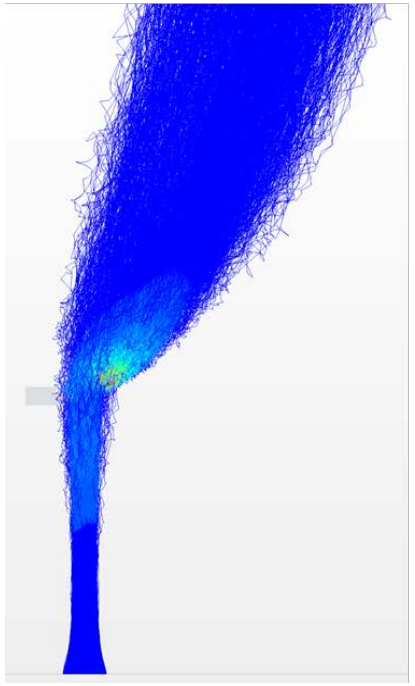
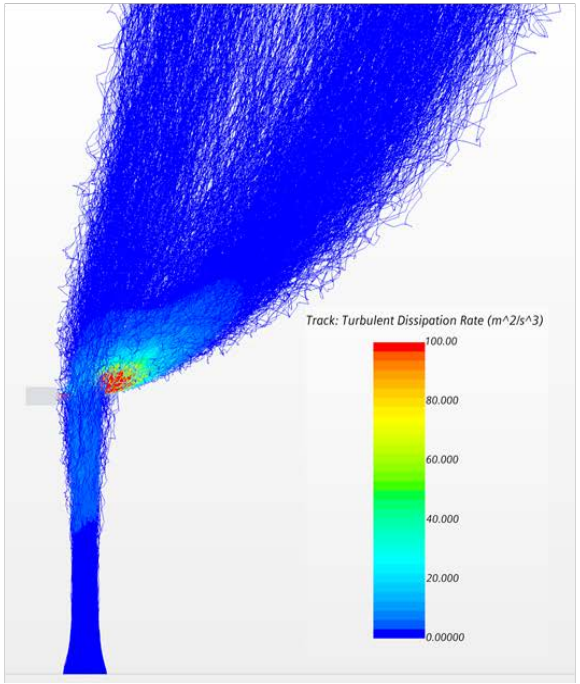
Full-Scale performance - CFD Predictions

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

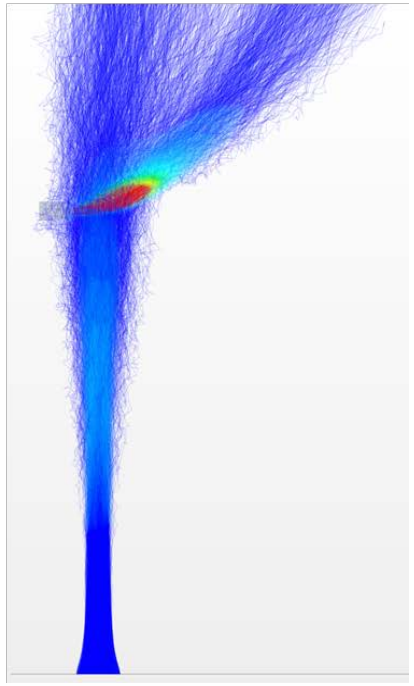
1a



1b



1c



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 also be efficient for a full-scale scenario.

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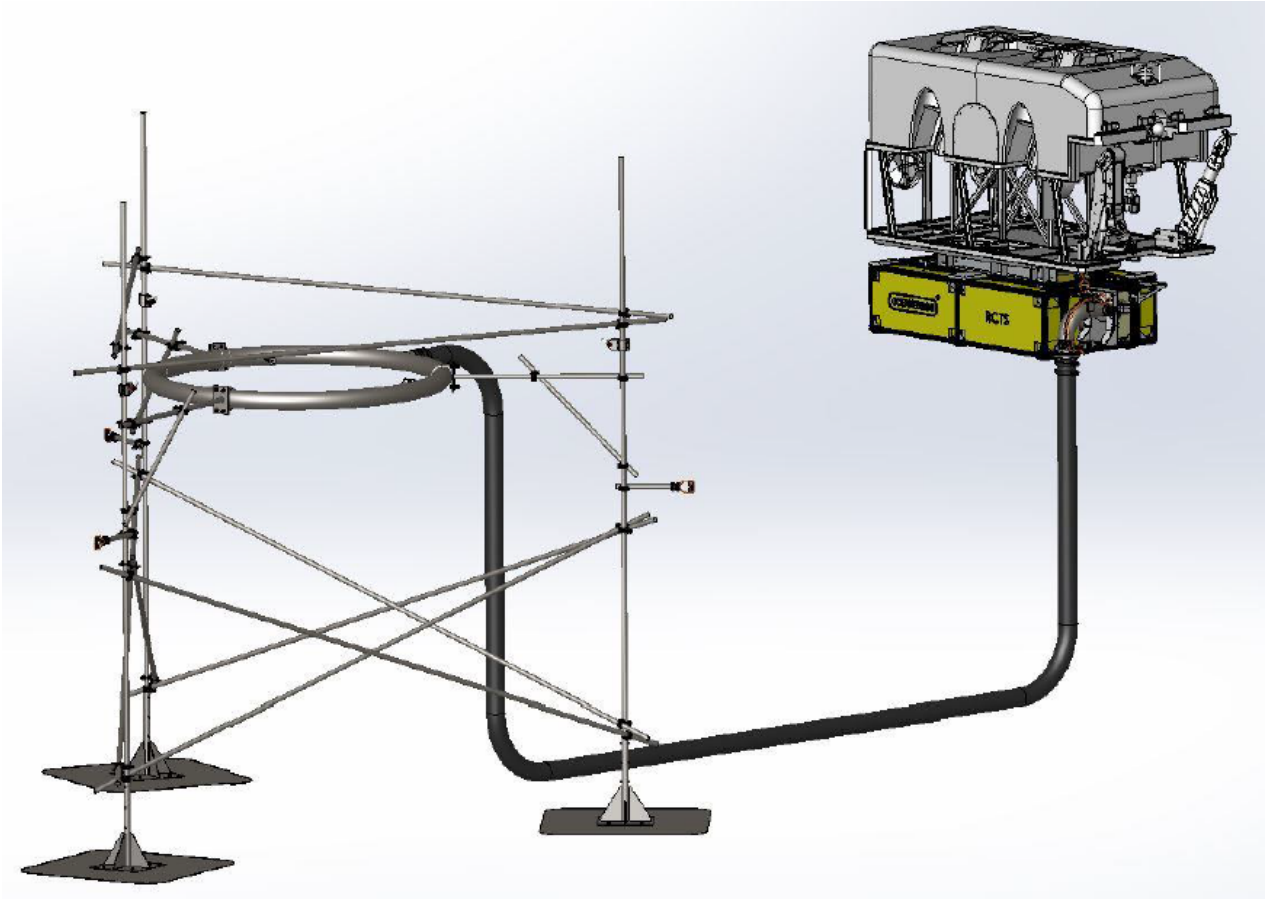
Phase-III: Design & cost study (full-scale)



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 config. optimized by CFD modelling and large-scale testing.
- Full-size concept based on submersible pumps and ROVs.
- Large-scale testing (Ohmsett) show comparable results to SSDI.

Further work – Operative verification?

- Full-scale field testing with vessel, ROVs, subsea pumps, and nozzle frame.
- What TRL is needed for operative implementation.?

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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