Oil plume simulations:
Tracking oil droplet size distribution and fluorescence within high release jets

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DWH spill highlighted knowledge gaps regarding subsurface oil dispersion. Needed was an evaluation of physical behavior of oil droplets.

- Evaluate Dispersion Effectiveness as a function of
  - Oil type
  - Dispersant type
  - DOR
  - Water temperature
- Track the oil movement in high pressure release jets
  - Fluorescence
  - Particle Size Analysis
  - Chemistry
- Integrate DE findings into oil behavior numerical models





DFO Bedford Institute of Oceanography Tank Facility

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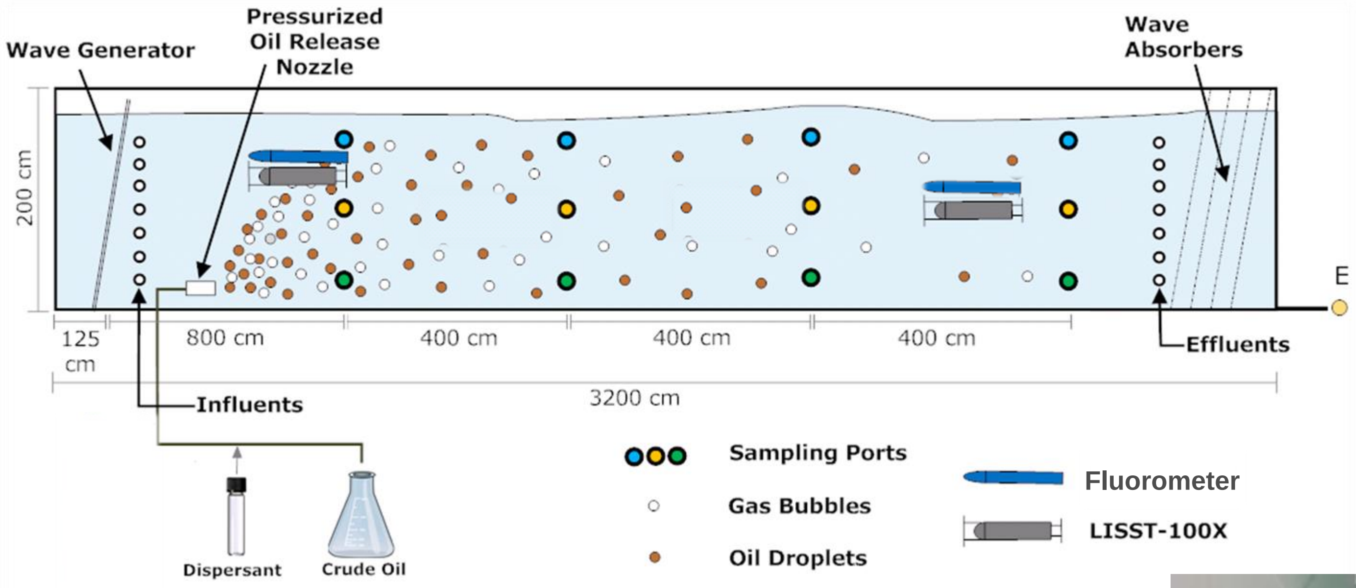
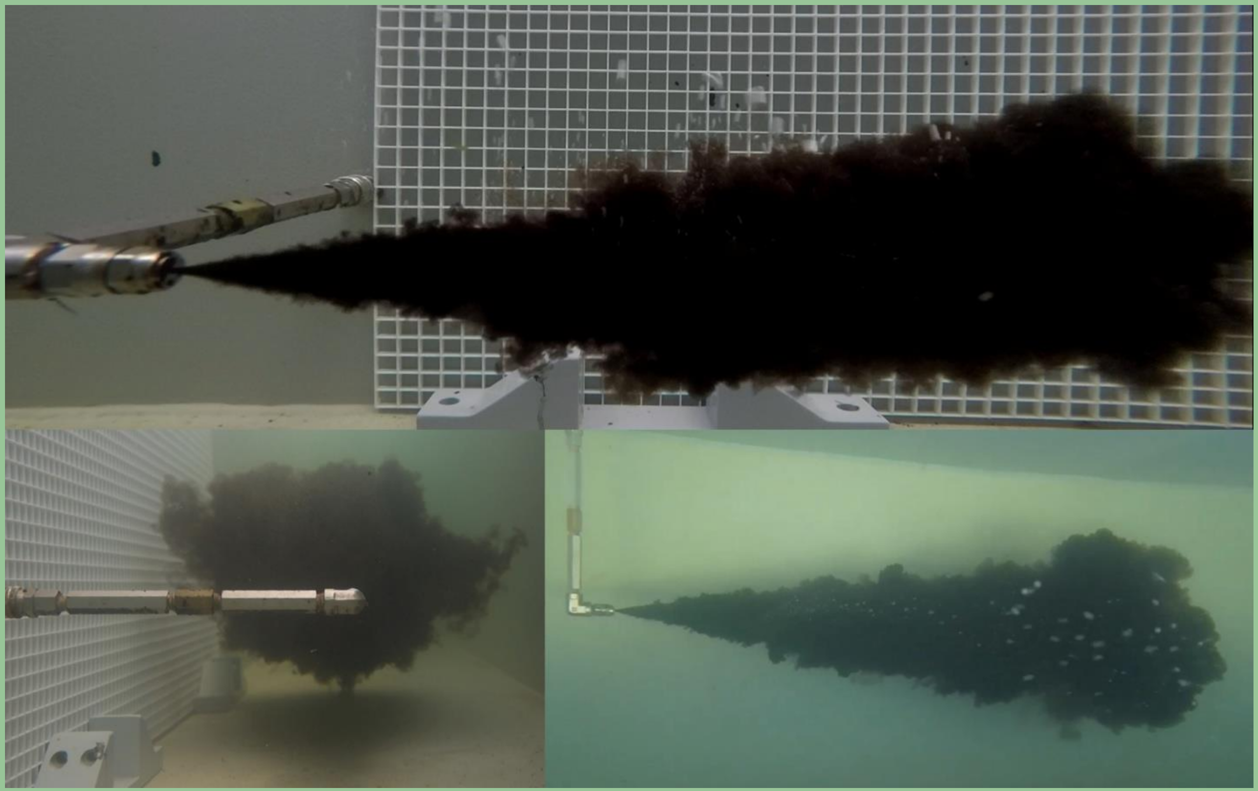


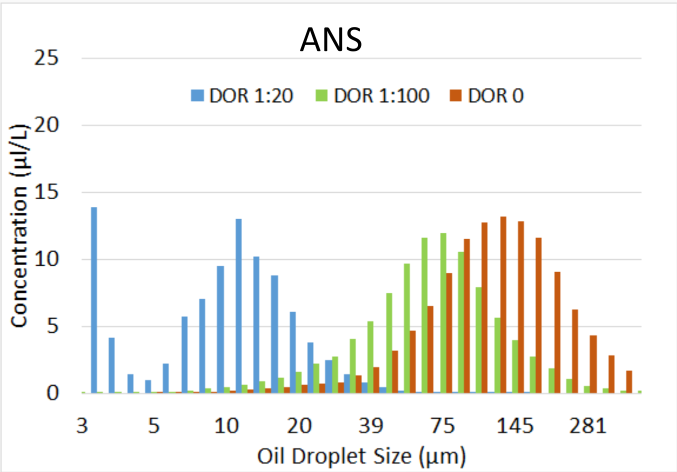
- Hot oil (80°C)
- Water T (4-18°C)
- Jet 40 psi release
- Current flow 1 cm/s
- Oil: SLC; ANS; IFO-120
- 2 Dispersant types
- DOR 0, 1:200, 1:100, 1:20

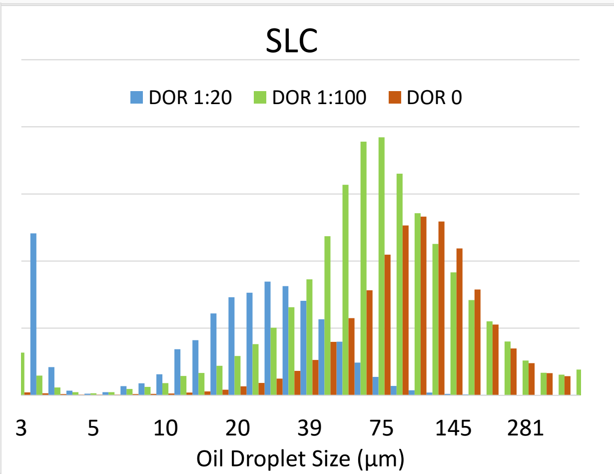


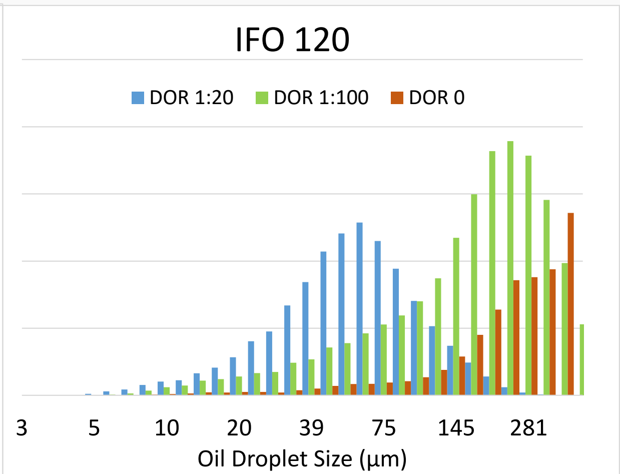
- TPH & BTEX
- Oil Droplet Size
- Fluorescence
- Air VOC

Chemical dispersants added to oil

- Decreased Volume Mean Diameter (VMD)
- Shifted Droplet Size Distribution (DSD)







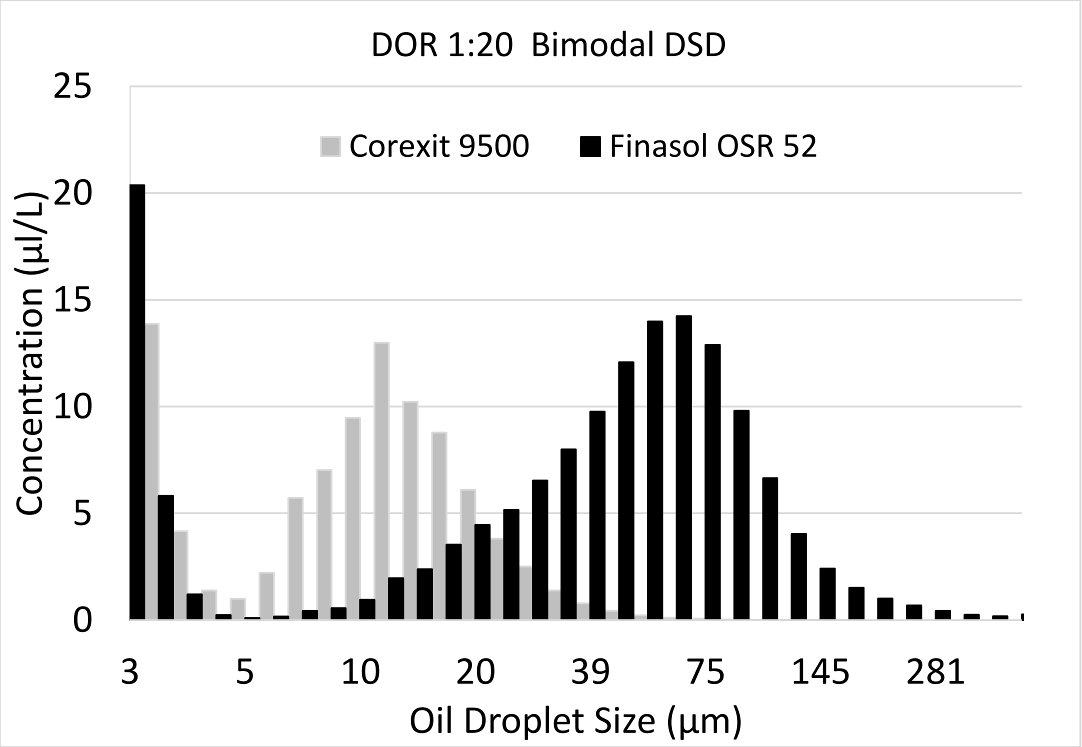
DOR 0 - VMD > 70µm; Unimodal DSD
DOR 1:20 - VMD < 70µm; Bimodal DSD

DOR 0 - VMD > 70µm; Unimodal DSD
DOR 1:20 - VMD < 70µm; Unimodal DSD

Chemical dispersants added to oil

- ➢ Decreased Volume Mean Diameter (VMD)
- ➢ Shifted Droplet Size Distribution (DSD)

For given DOR and oil type, Corexit 9500 produced smaller droplets compared to Finasol OSR 52

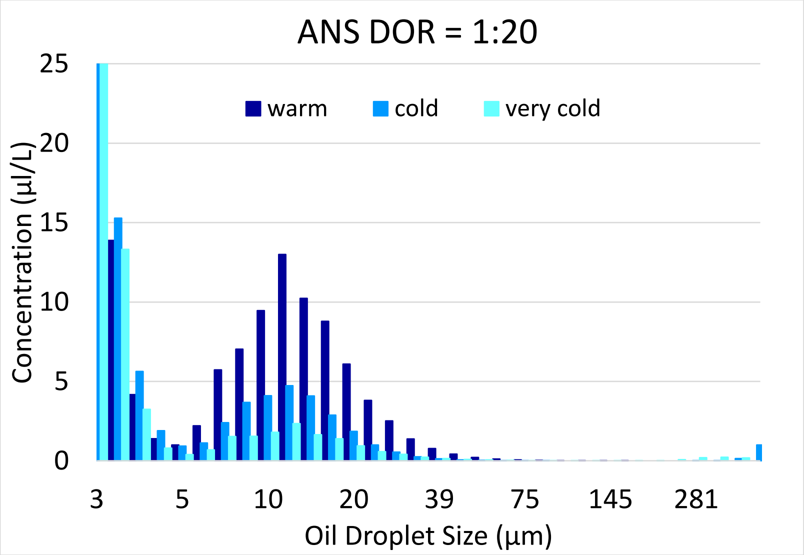


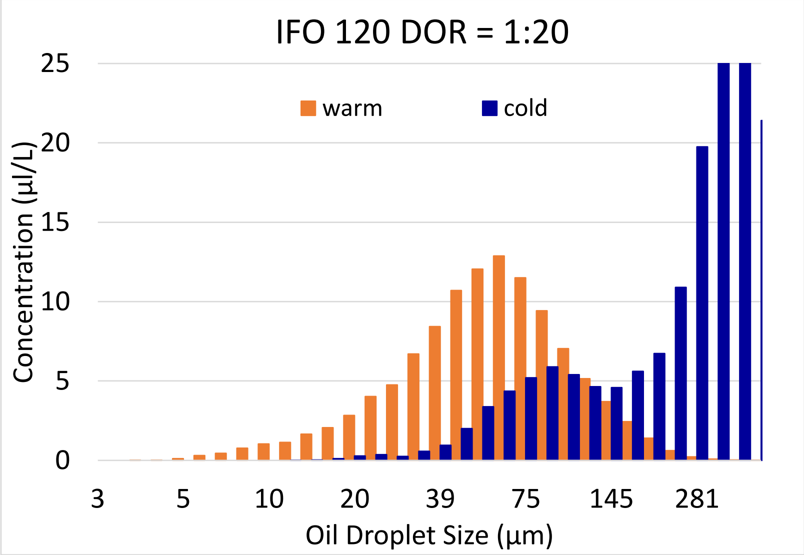
Temperature Effects on Dispersion

- ANS
  - Disperses well at warm and cold T (~ 5 °C)
  - Bimodal DSD
  - VMD not influenced by T (5-20 °C)

  - TPC decreases (fewer droplets) with lower T

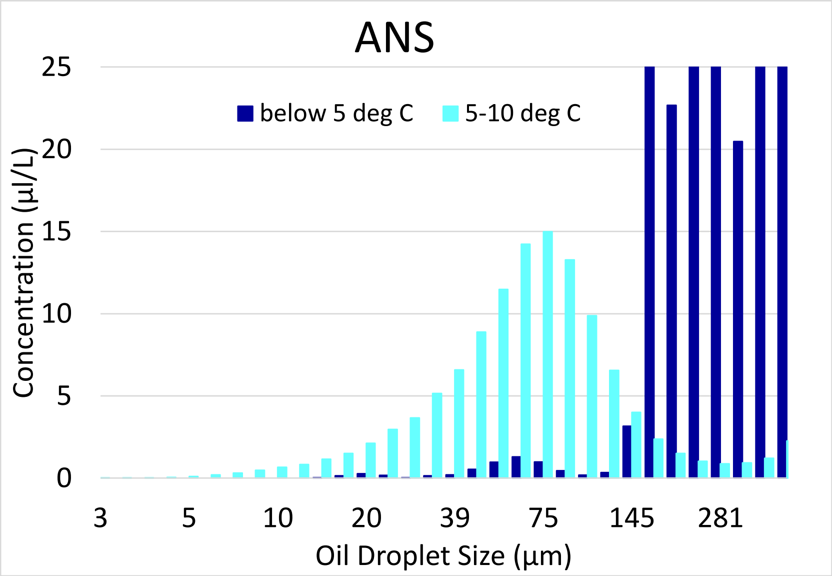
- IFO 120
  - Not well dispersed at cold T
  - Unimodal DSD

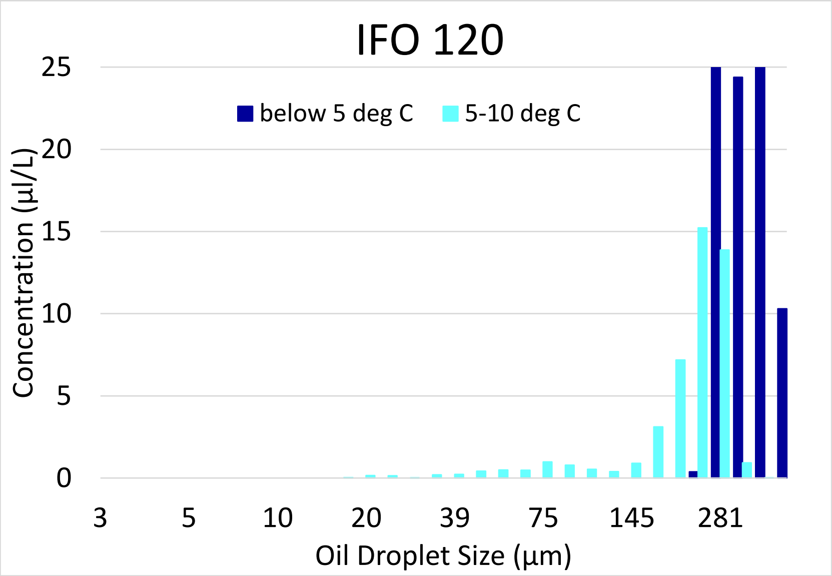




Temperature Effects on Dispersion

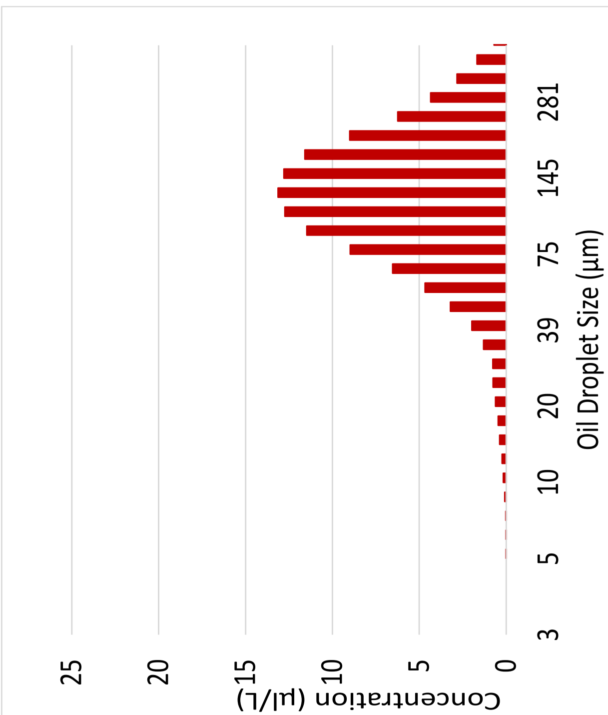
- Extreme cold T (<5 °C)
  - Particle size data appears problematic
  - Less dispersion; anomalous DSD
  - Additional testing of sensor's cold water T limits is recommended

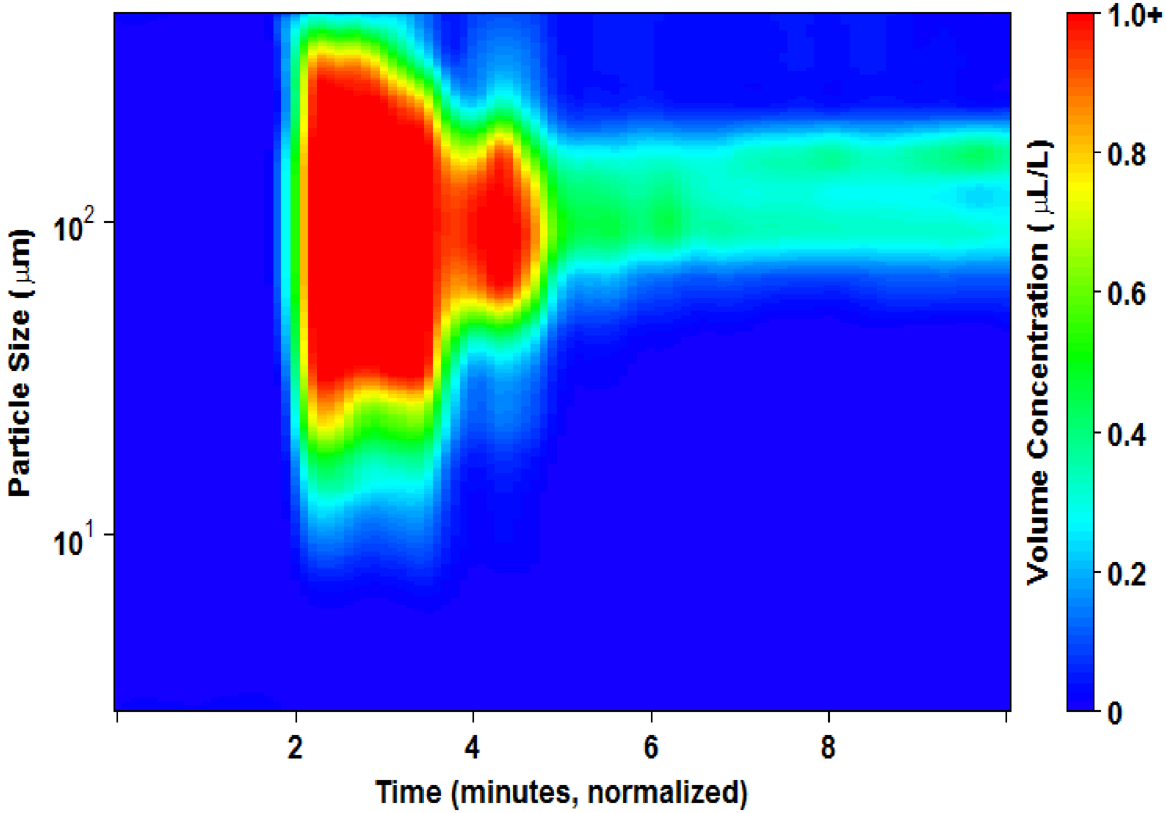




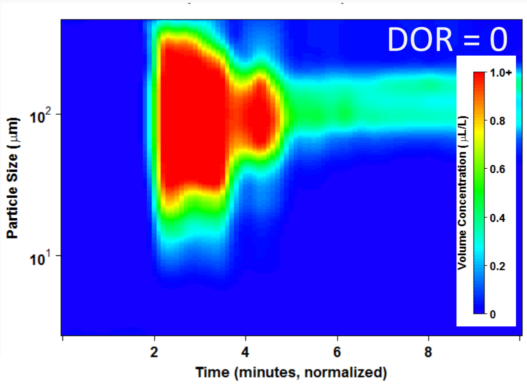
Oil Dispersion Time Series

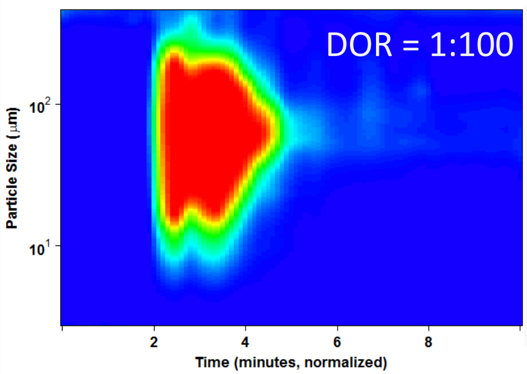
- DSD histograms are averages for each experiment
- Contours give DSD and TPC over time

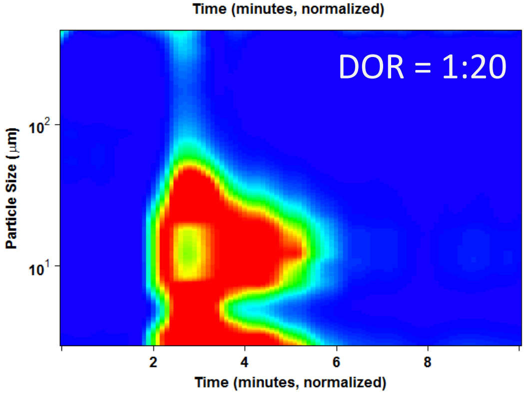


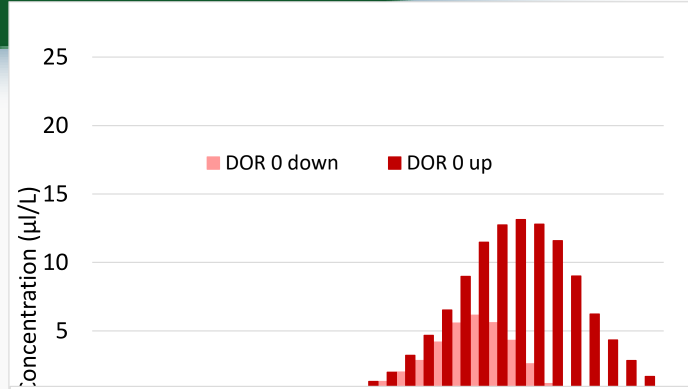


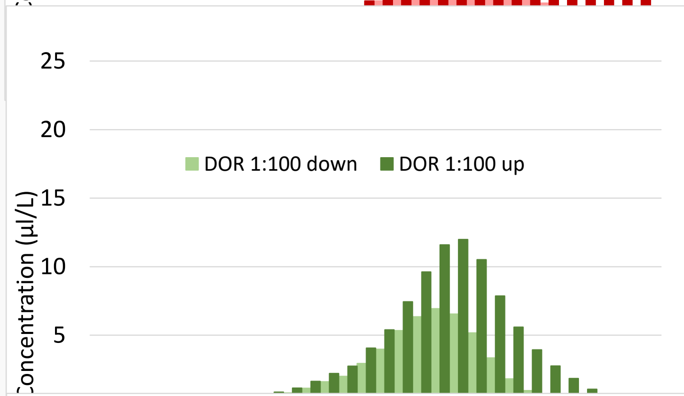
Upstream LISST

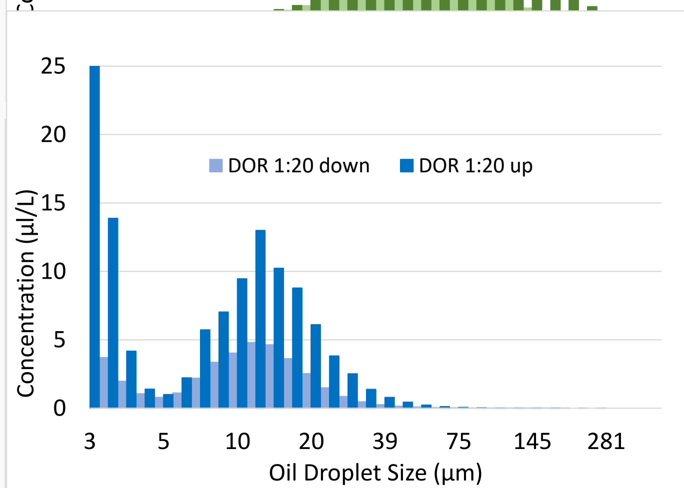




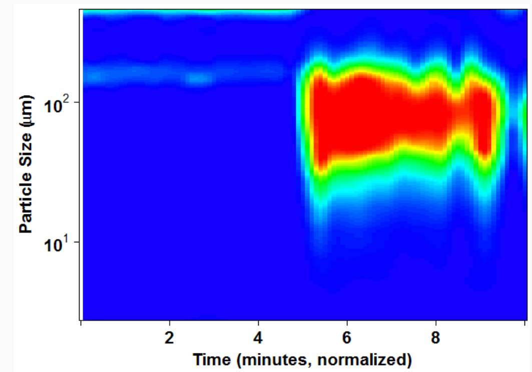


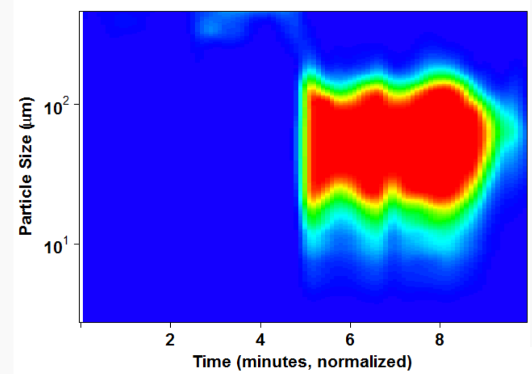


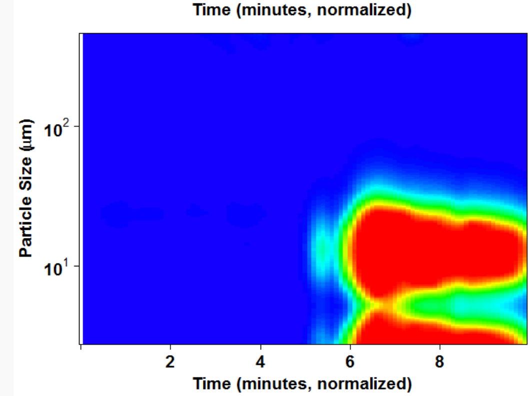




Downstream LISST



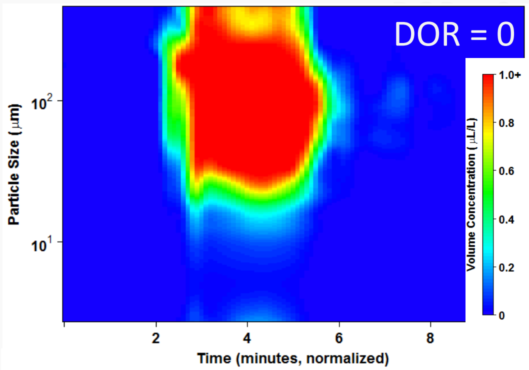


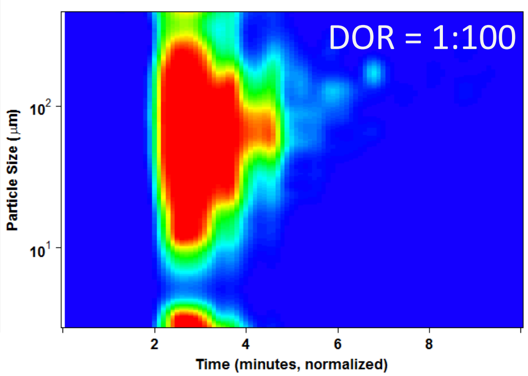


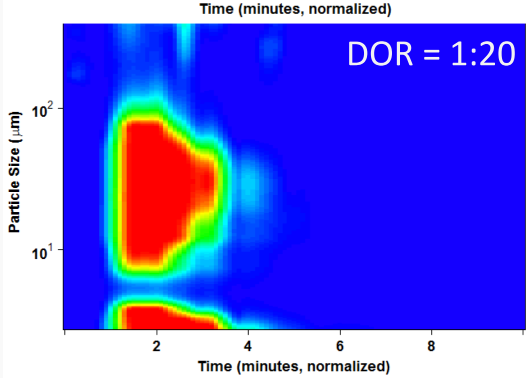
Upstream LISST

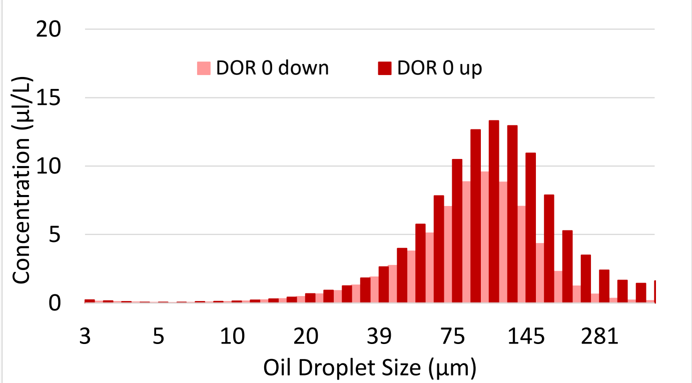
SLC

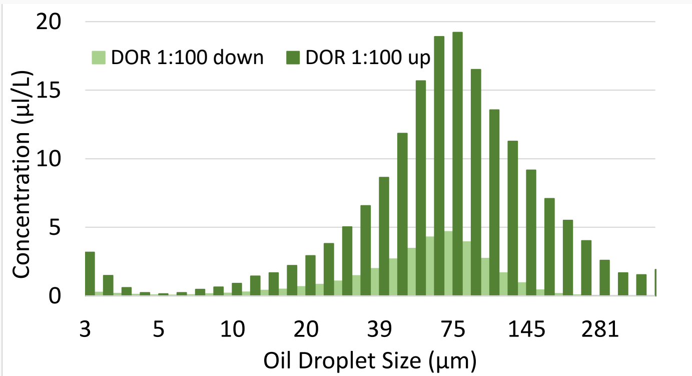
Downstream LISST

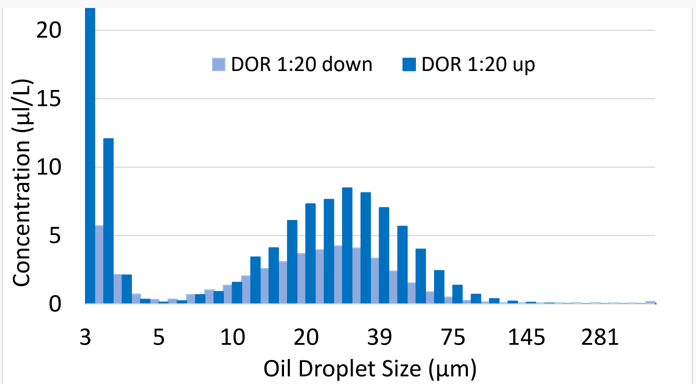


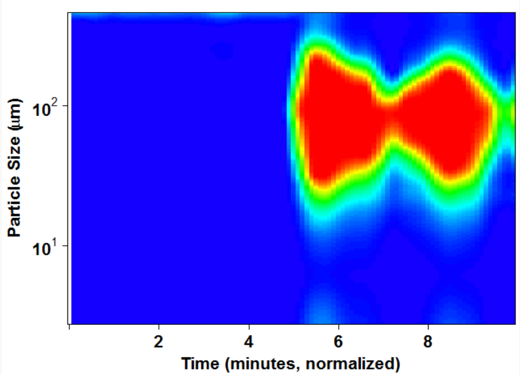


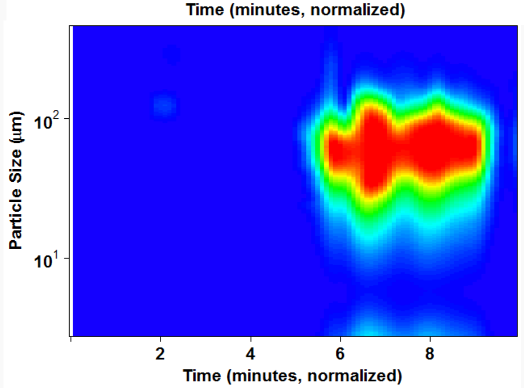


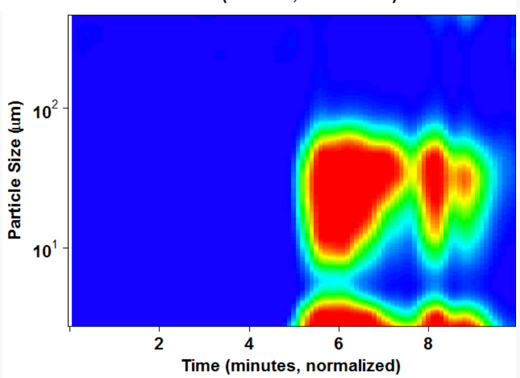








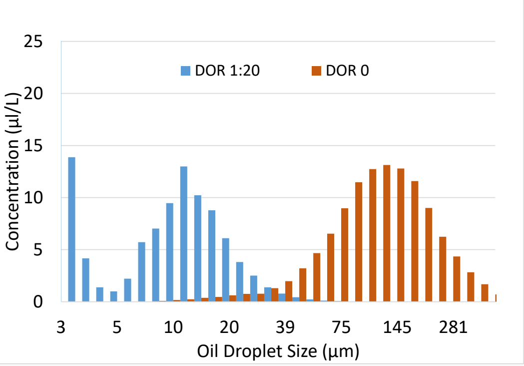




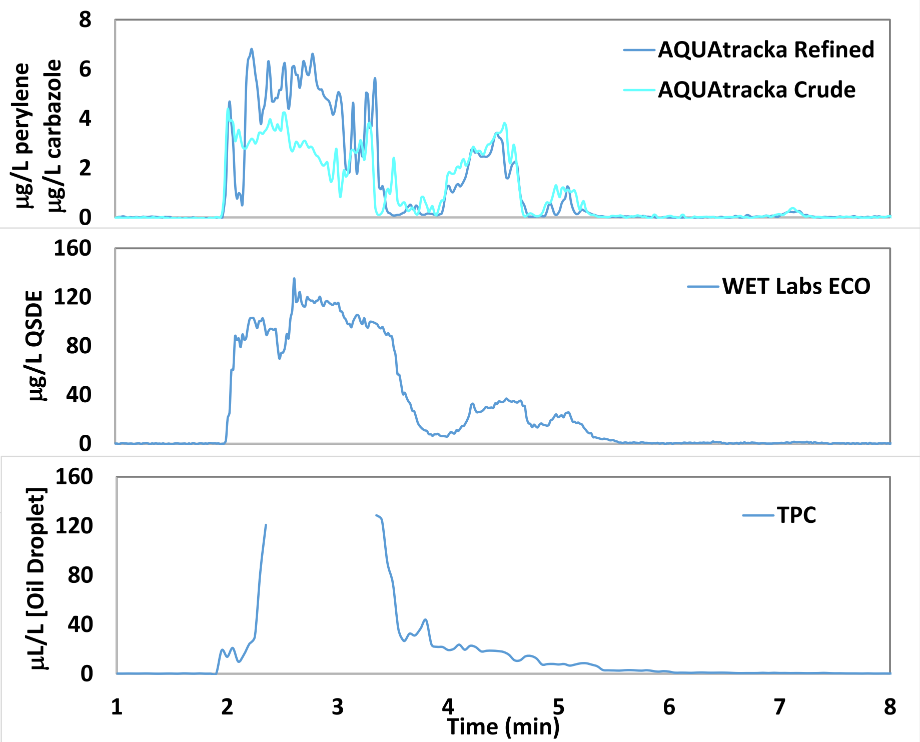
Oil Dispersion Time Series

- Fluorescence data support particle size results

ANS



DOR = 1:20



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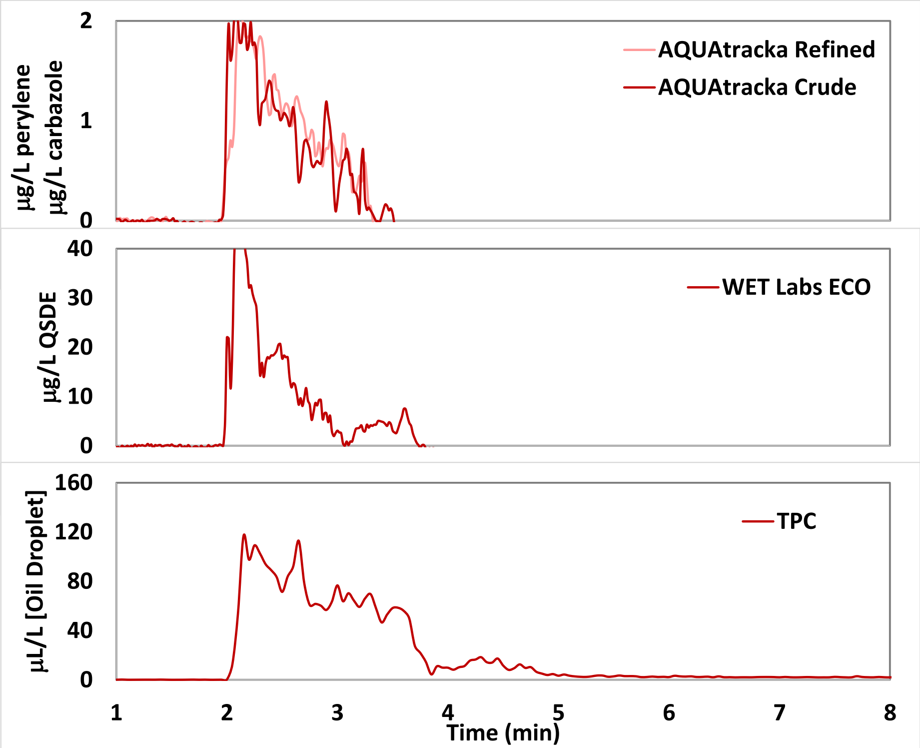
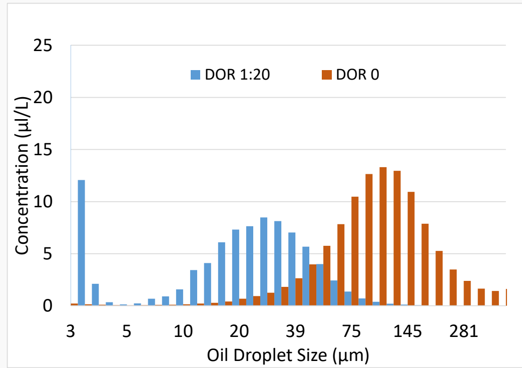


Oil Dispersion Time Series

- Fluorescence data support particle size results

SLC



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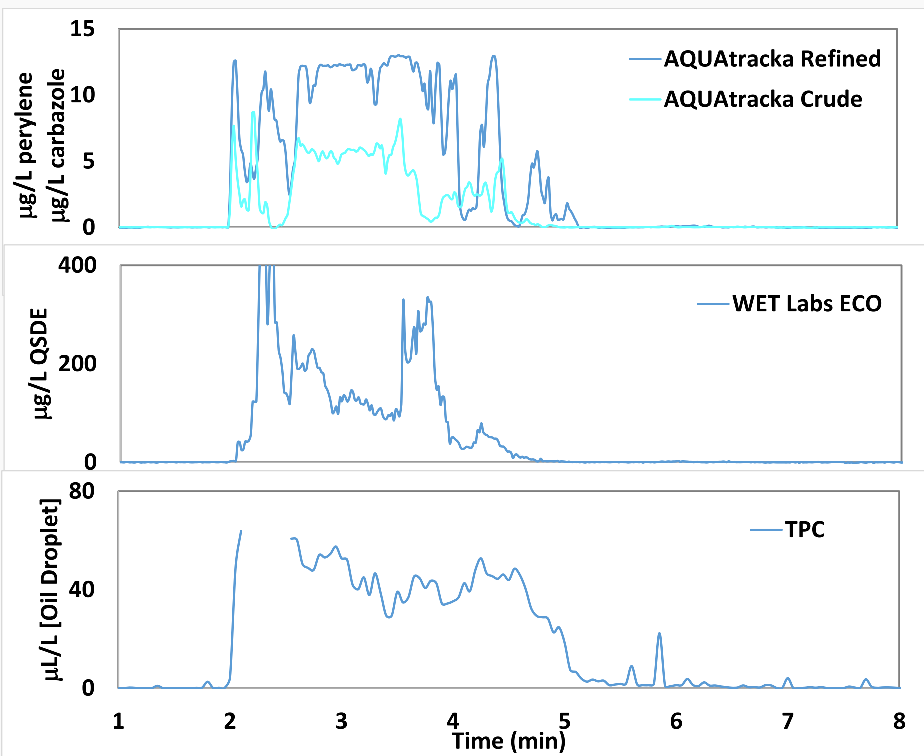

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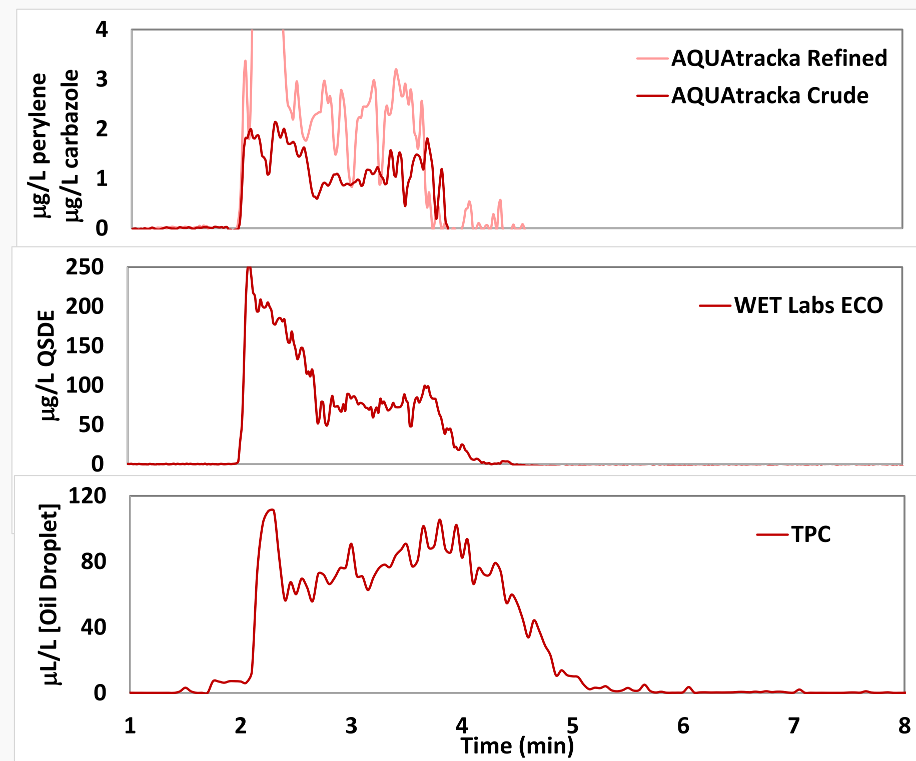
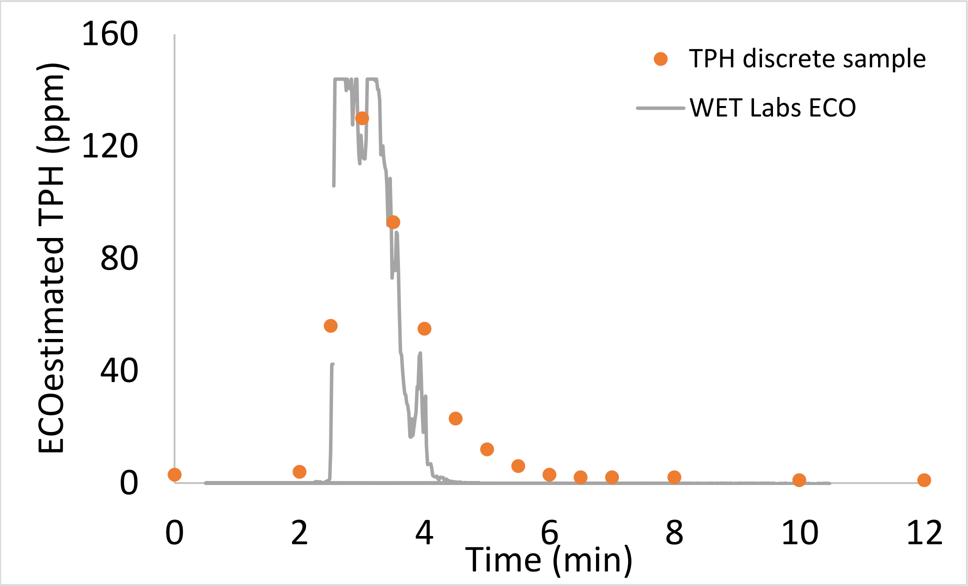
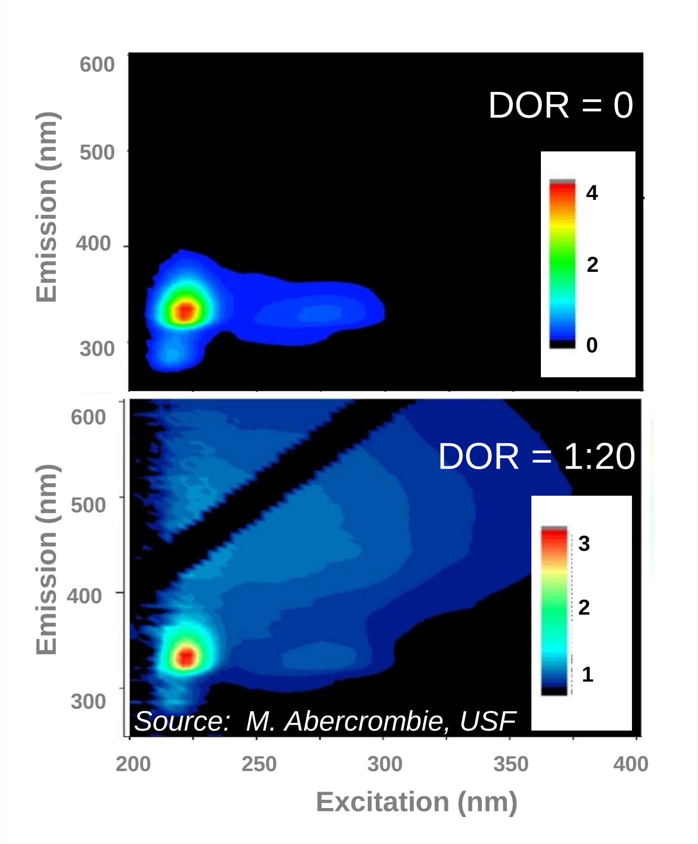


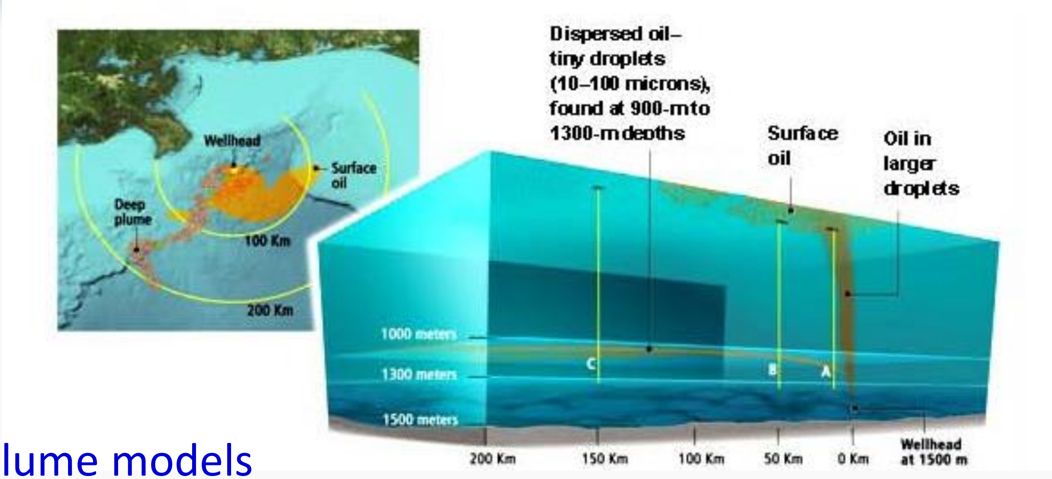
Oil Dispersion Time Series

- ➢In situ fluorescence serves as a good proxy for oil concentration
- ➢Well correlated with particle size analysis and concentration





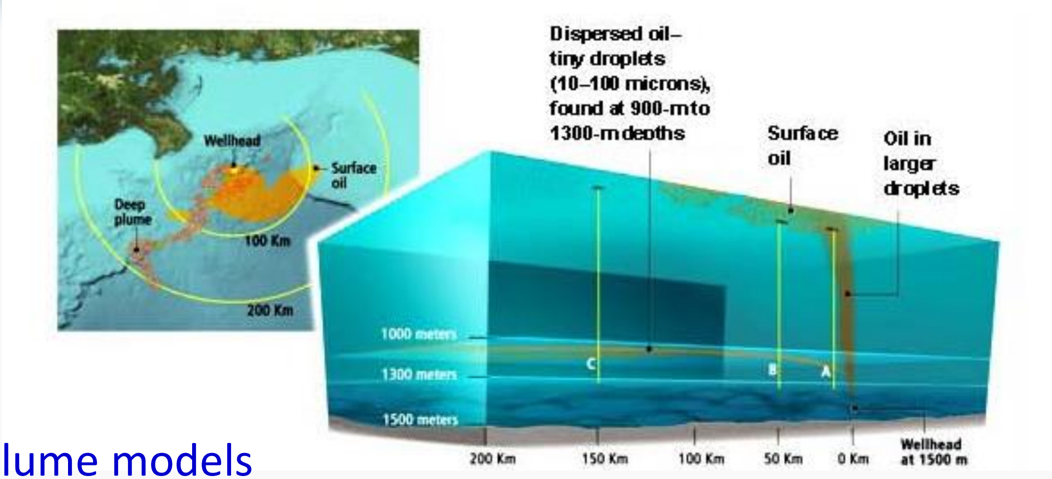
Knowledge of DSD is essential for predicting oil transport, degradation and fate



Integration of DSD into numerical jet / plume models

VDROP-J and JETLAG (*Michel Boufadel*)

- Experimental data to calibrate models of jet hydrodynamics, DSD and droplet movement
- Models predicted the stream-wise velocity and holdup along the plume centerline
- Agreement between models; implies VDROP-J is capable of predicting avg. DSD in plume
- w/o dispersant, VDROP-J predicted empirical DSD
- w/ dispersant, VDROP-J captured overall trend of DSD. Challenged in capturing peak concentration at 5 um (likely due to tip-streaming; no module yet for this component)

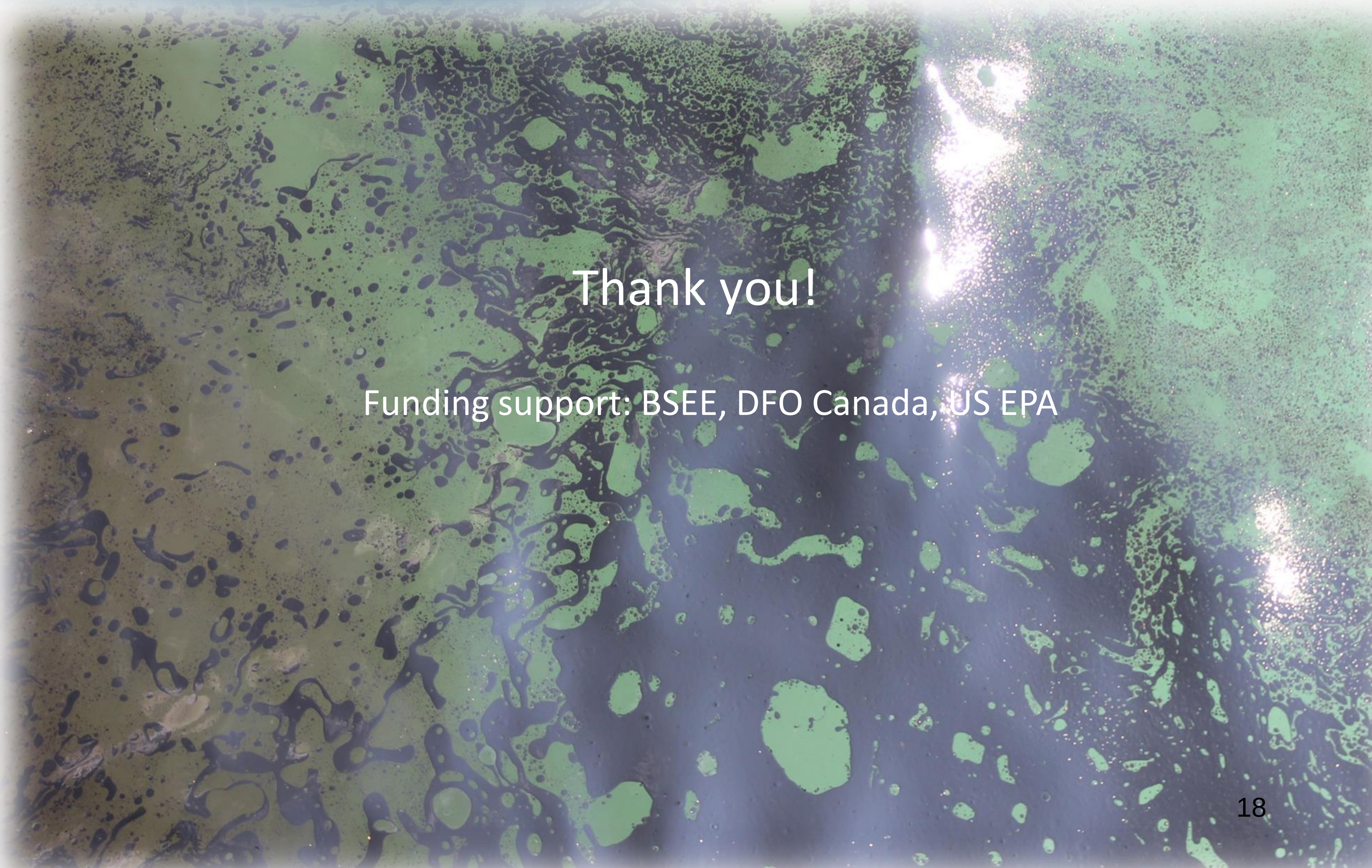


Knowledge of DSD is essential for predicting oil transport, degradation and fate

Integration of DSD into numerical jet / plume models

Modified Weber Number Approach (*Haibo Niu*)

- Approach for predicting DSD developed by SINTEF
- Previously validated by solely light crude oil
- Empirical DSD used to calculate median and relative diameters and correlate with modified Weber number, Reynolds number, and oil concentration
- A two-step Rosin-Rammler approach was found to better predict the droplet size distribution of ANS and IFO 120



Thank you!

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