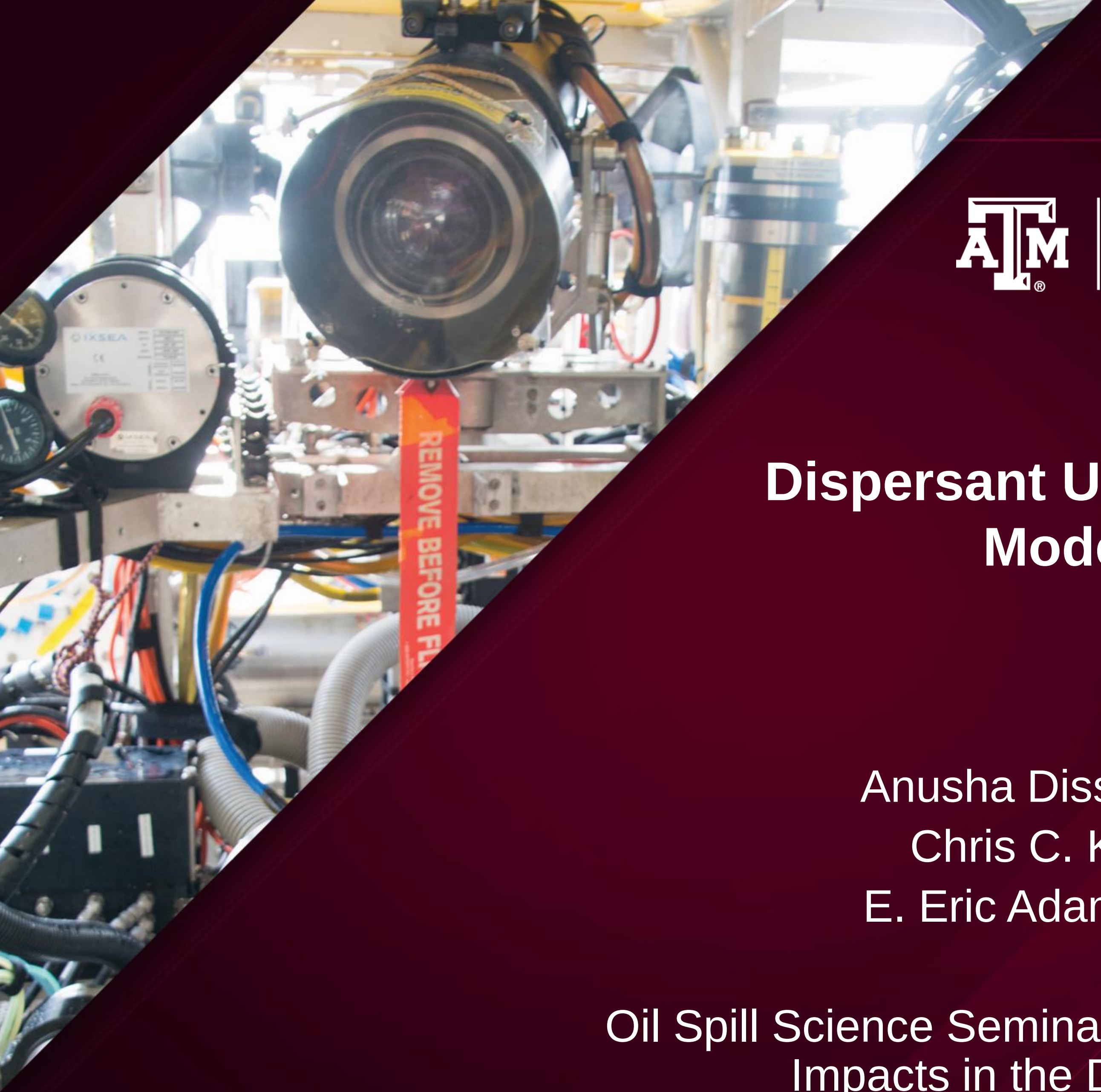

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Dispersant Use at Wellhead; Modeling Scenarios

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Anusha Dissanayake, Inok Jun,
Chris C. K. Lai, Binbin Wang,
E. Eric Adams, Michel Boufadel

Oil Spill Science Seminar: Exploring Oil Spill Impacts in the Deep Gulf of Mexico

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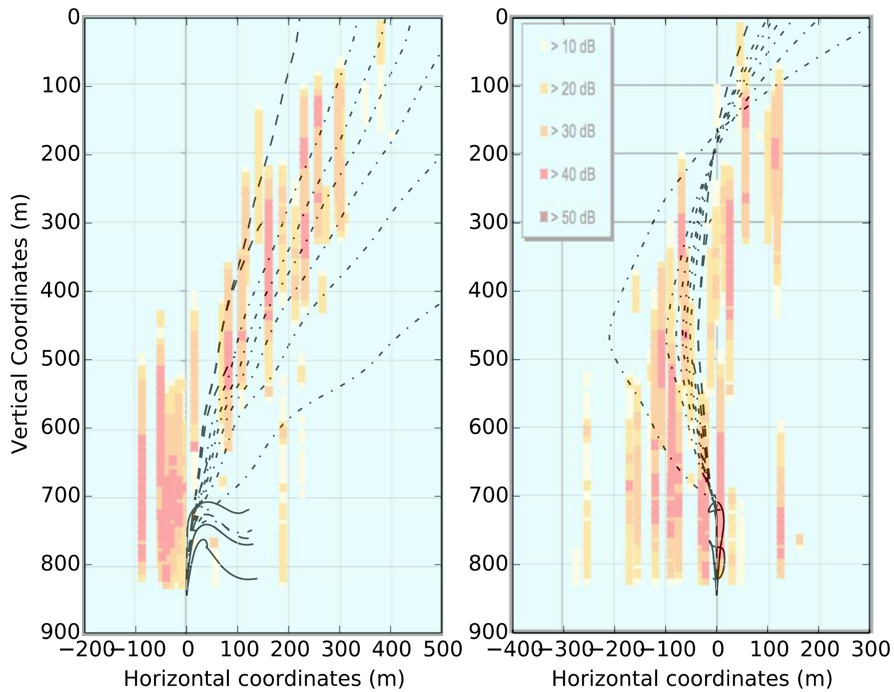
Acknowledgements

- BP/Gulf of Mexico Research Initiative
  - Gulf Integrated Spill Research Consortium (GISR)
  - Center for Integrated Modeling and Assessment of the Gulf Ecosystem (C-IMAGE, C-IMAGE II)
- NOAA Response and Restoration (NOAA R&R) with the Bureau of Safety and Environmental Enforcement (BSEE)
- U.S. National Science Foundation (CBET-1045831, CBET-1034112)
- Chevron-MIT Energy Institute University Partnership Program
- Chevron, U.S.A
- Shell International

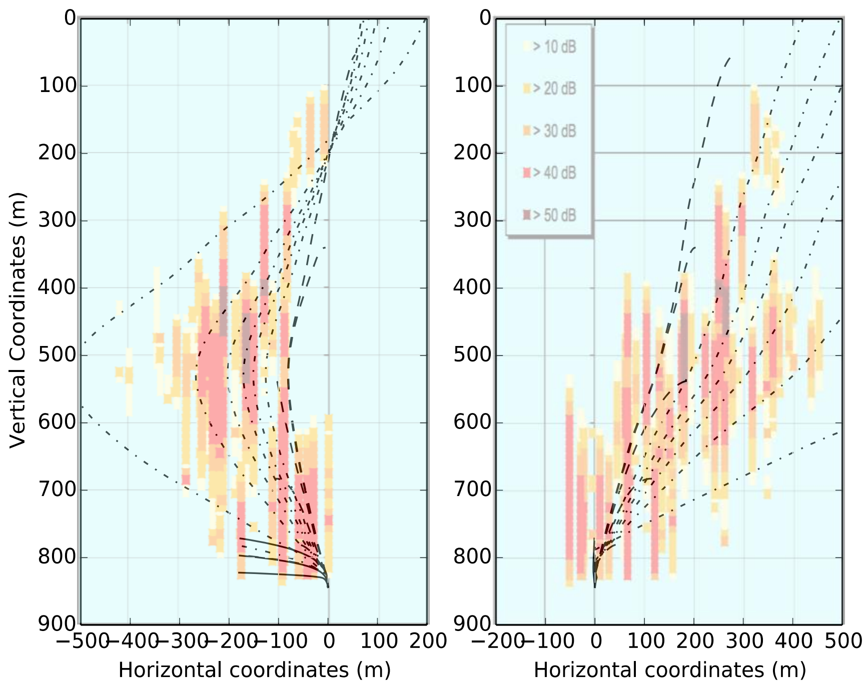
History

- DeepSpill project and field experiment of oil/gas plumes by SINTEF, Norway (Johansen et al., 2003)

Crude oil and gas release
Qoil = 1/60 m³/s
Qgas = 0.7 Nm³/s



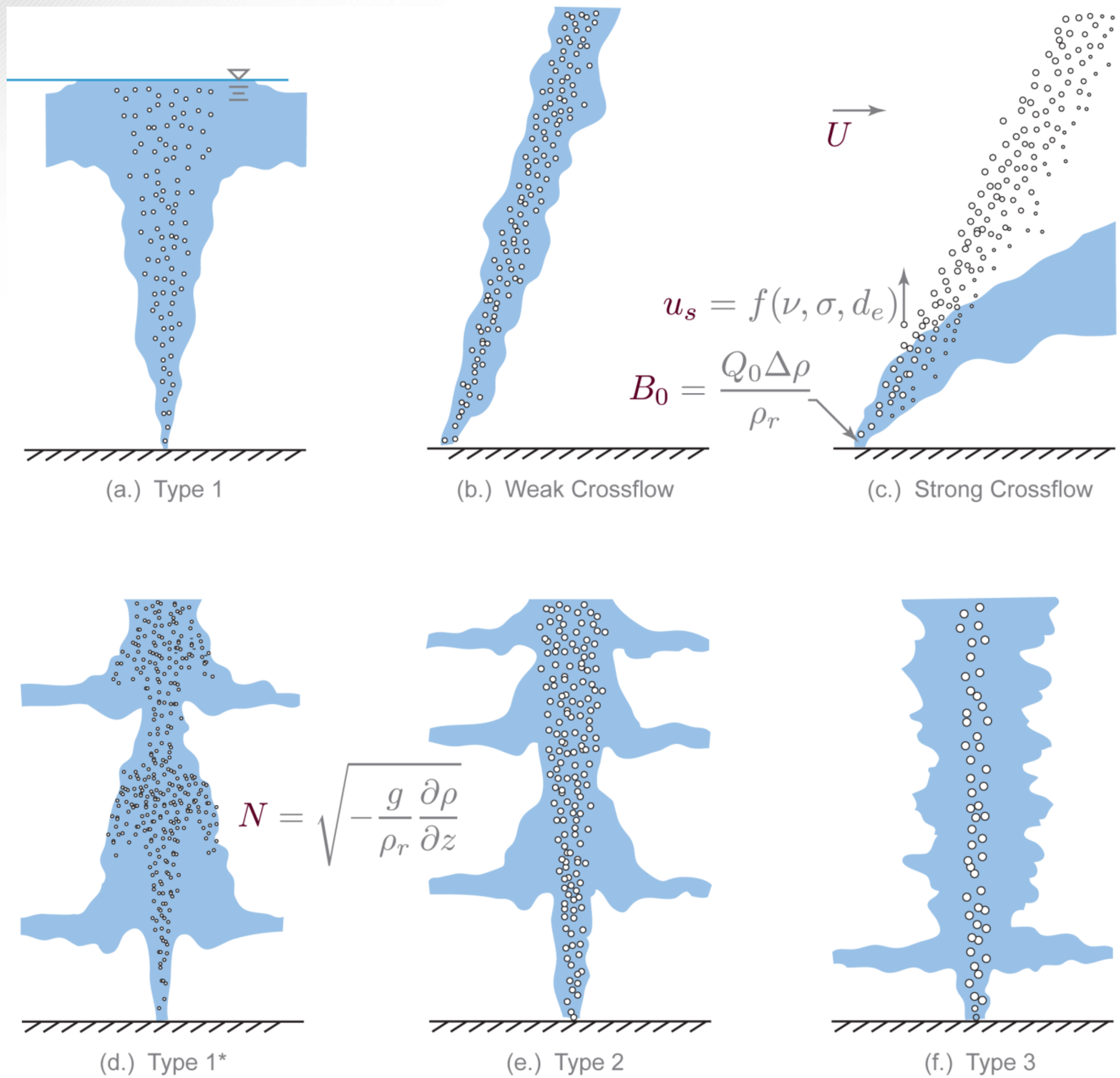
Diesel and gas release
Qoil = 1/60 m³/s
Qgas = 0.6 Nm³/s



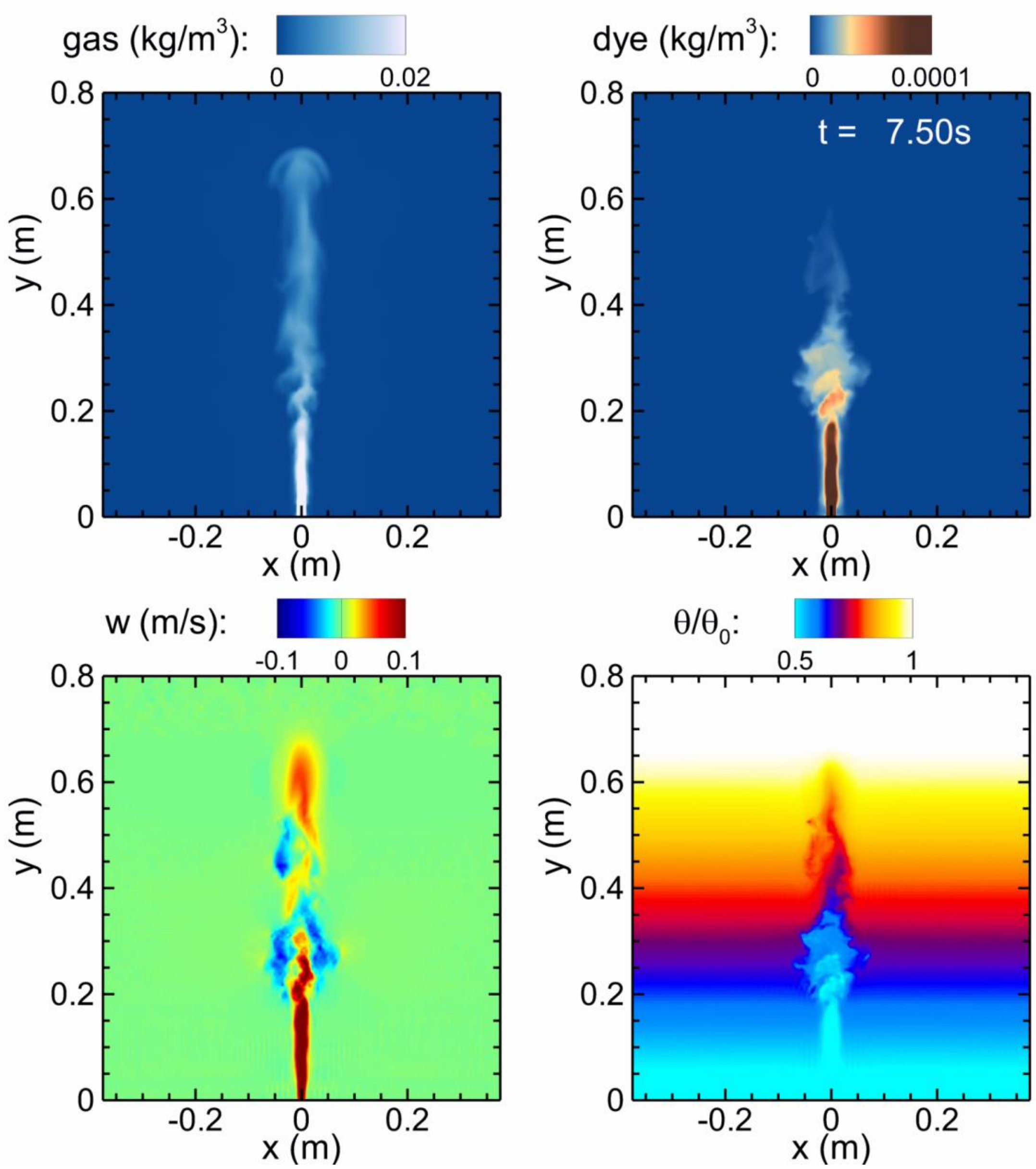
Plume Topology

Observed in Field and Lab Experiments

Predicted from Lab Experiments



LES Simulations of Stratified Bubble Plume



Configuration of LES

Domain size: **(0.76, 0.76, 0.9) m**
Grid number: **(150, 150, 257)**
Time step: **0.001 second**
Simulation duration: **140 seconds**

Physical parameters

Q_{air} = 0.09 L/s
ρ_{air} = 1.4 kg/m^3
N = 0.7 s^{-1}

Data sampling: every 0.25 seconds.
Movie: 20 frames/s, 400 frames.

Yang, et al. (2016) *JFM*.

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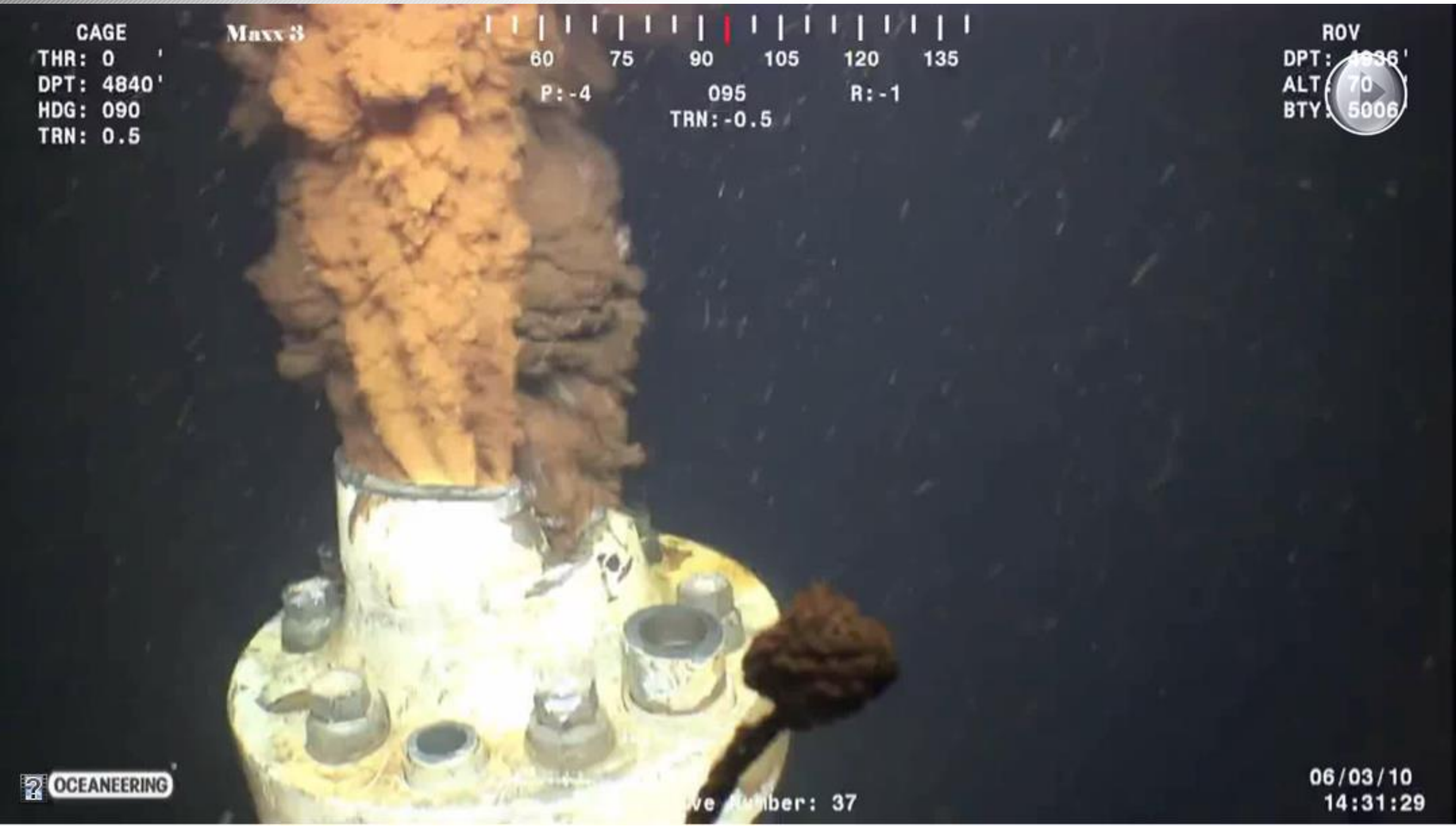
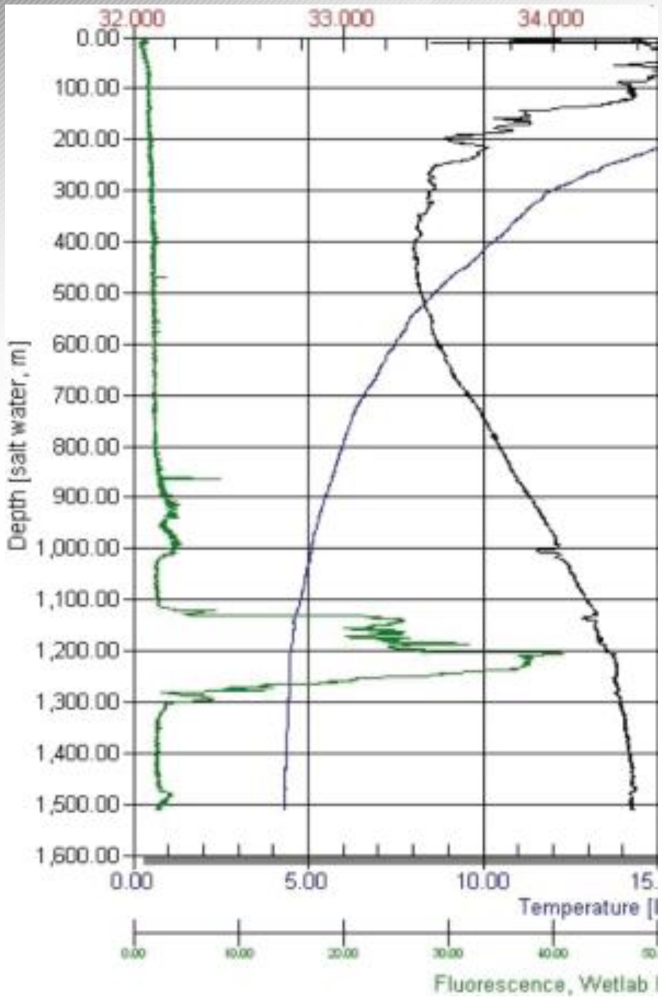
DWH Accident

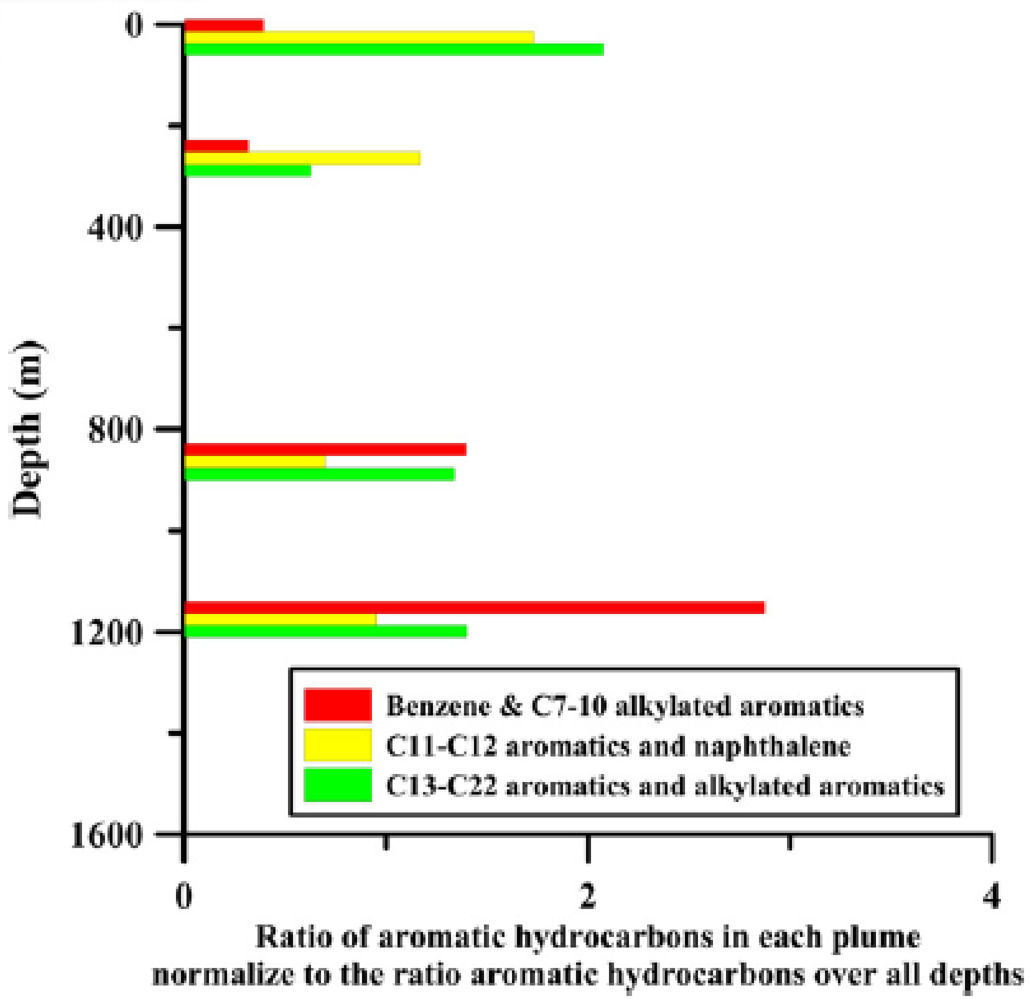


Video image capture from Maxx3 during DWH response activity

DWH Accident

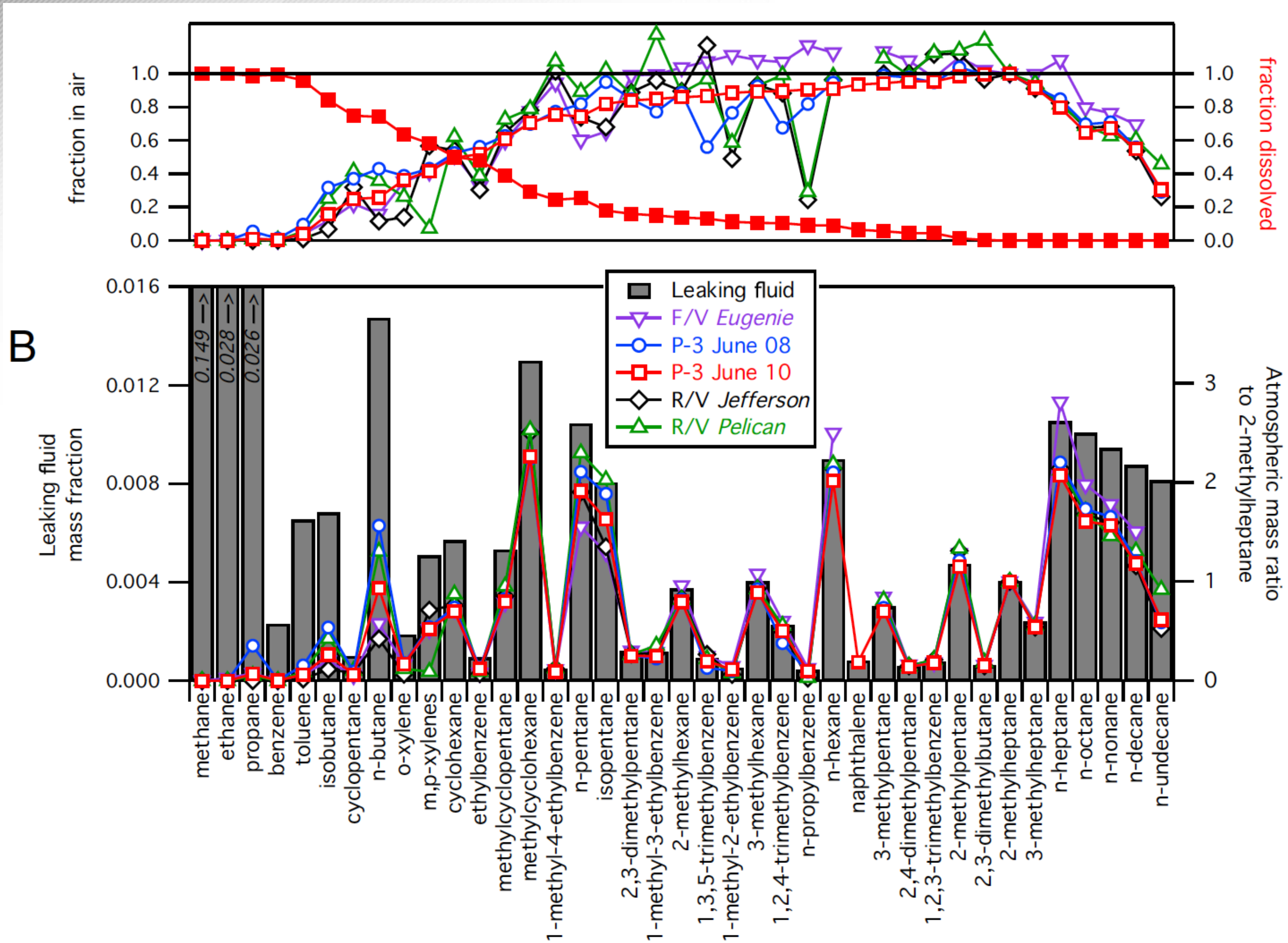


Station B54 on May 30, 2010
By R/V Brooks McCall



Spier et al. (2013) *Environ. Pollut.* 173.

DWH Accident



Ryerson, et al. (2011) *PNAS*

Model Inter-comparison

- Three test cases without dispersant

	Case*	GOR [scf/bbl]	Depth [m]	DOR [%]
1	Deep base case	2000	2000	0
3	Deep, low GOR	500	2000	0
5	Shallow	2000	200	0

*All cases at 20,000 bbl/day.

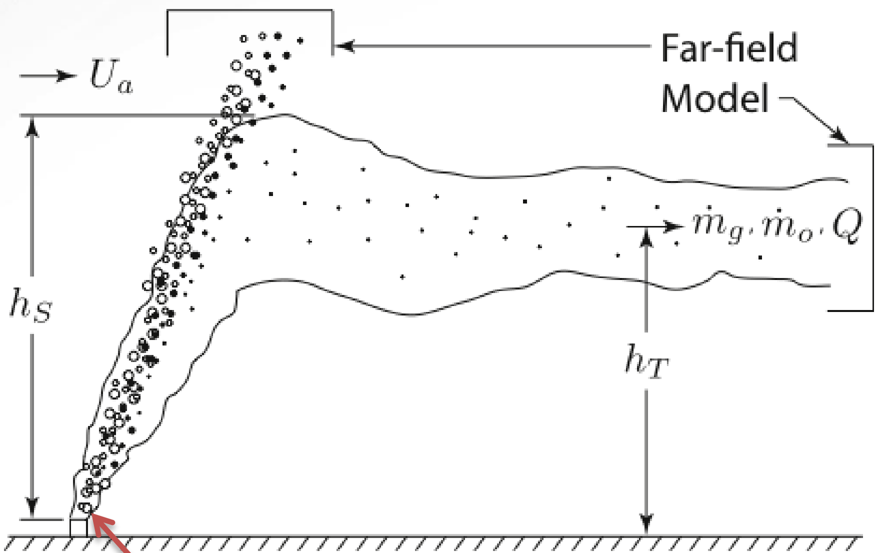
- Three test cases with dispersant

	Case*	GOR [scf/bbl]	Depth [m]	DOR [%]
2	Deep base case	2000	2000	2
4	Deep, low GOR	500	2000	2
6	Shallow	2000	200	2

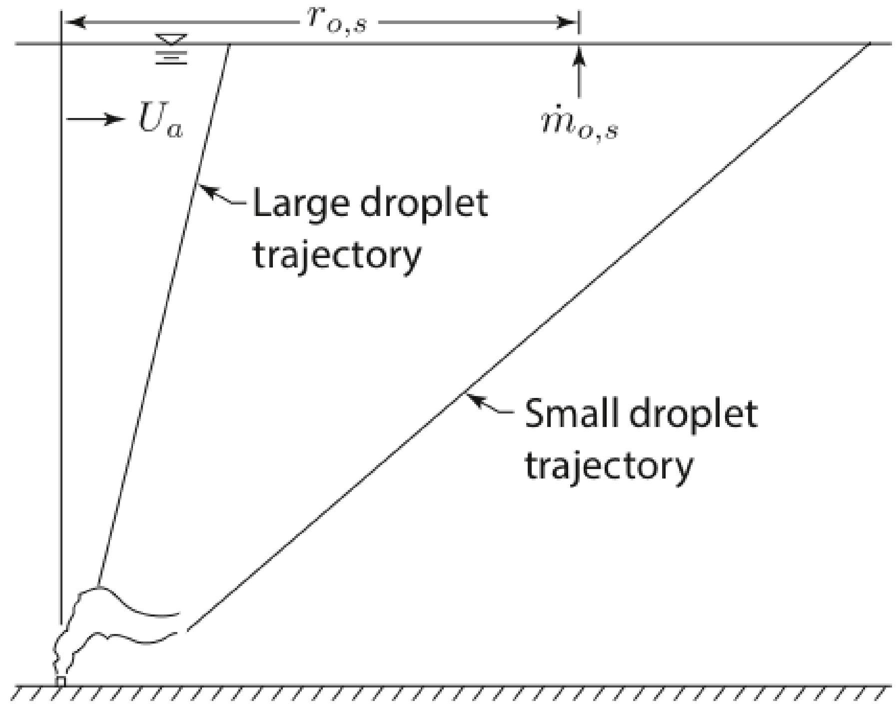
Socolofsky et al. (2015) *MPB.*

Model Inter-comparison Metrics

2.) Nearfield Plume Simulation



3.) Farfield Particle Tracking



1.) Droplet Size Distribution (DSD)

Socolofsky et al. (2015) *MPB.*

Droplet Size Distribution (DSD)

- Equilibrium break-up models

$$d_{50} = c\left(\frac{\sigma}{\rho}\right)^{3/5}\epsilon^{-2/5} \qquad \epsilon \propto \frac{U_C(z)^3}{b(z)} \propto \frac{U^3}{D}$$

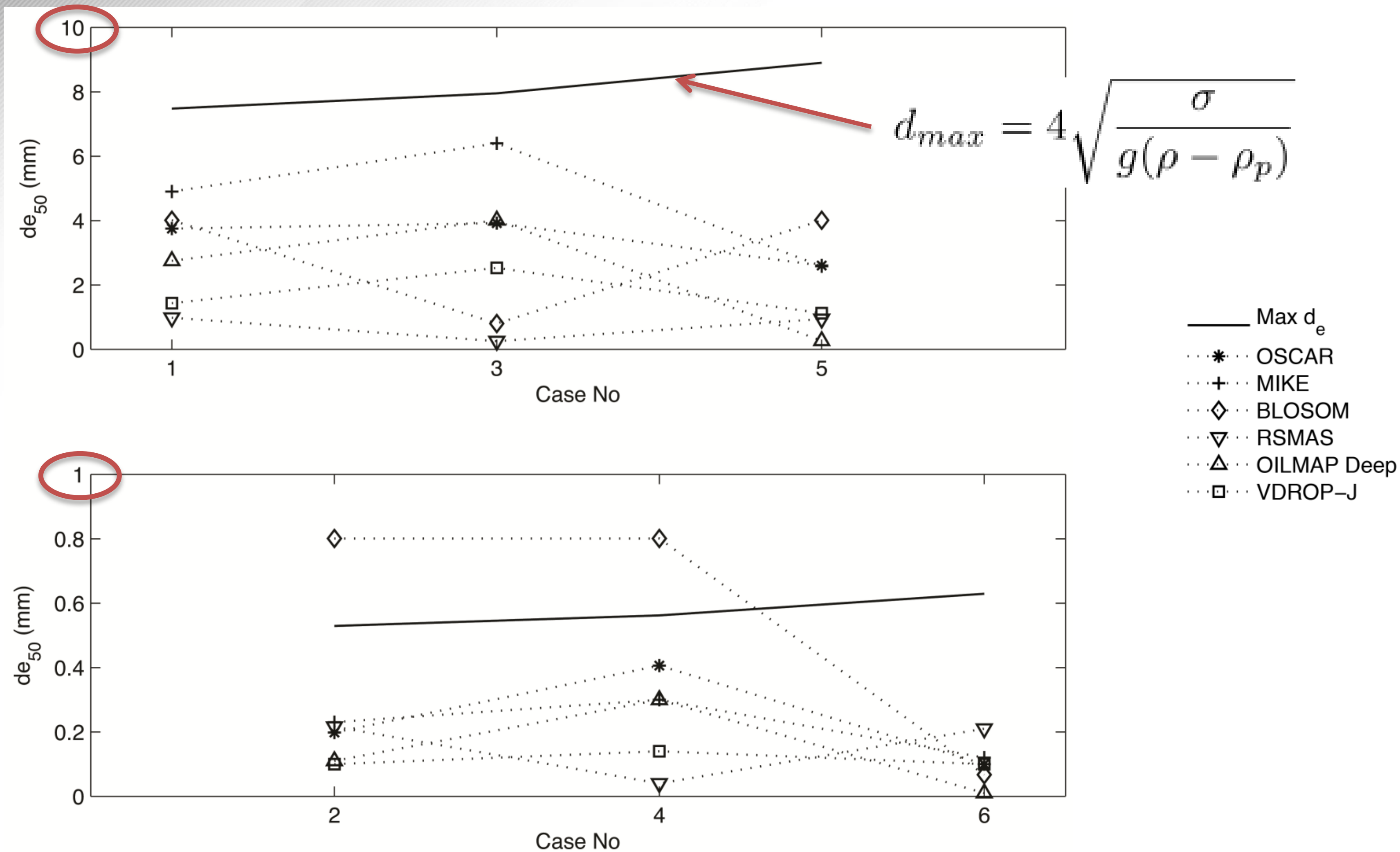
$$\frac{d_{50}}{D} \propto We^{-3/5}$$

- Resistance of viscosity at low surface-tension

$$Vi = \frac{\mu_p U}{\sigma} \qquad Re = \frac{\rho_p U D}{\mu_p}$$

Socolofsky et al. (2015) *MPB.*

Model Predictions for DSD

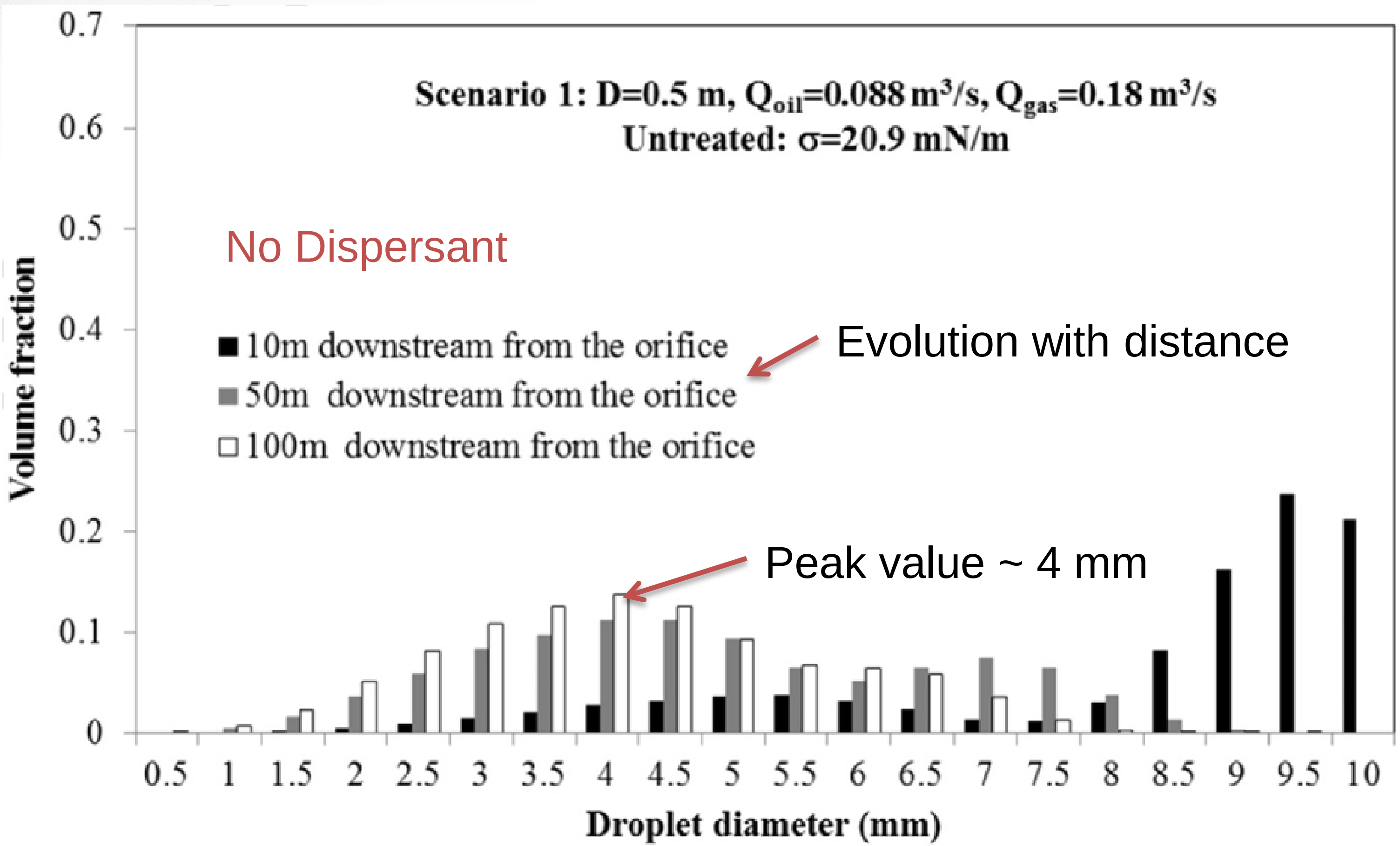


$$d_{max} = 4\sqrt{\frac{\sigma}{g(\rho - \rho_p)}}$$

Socolofsky et al. (2015) *MPB.*

Population Breakup Models

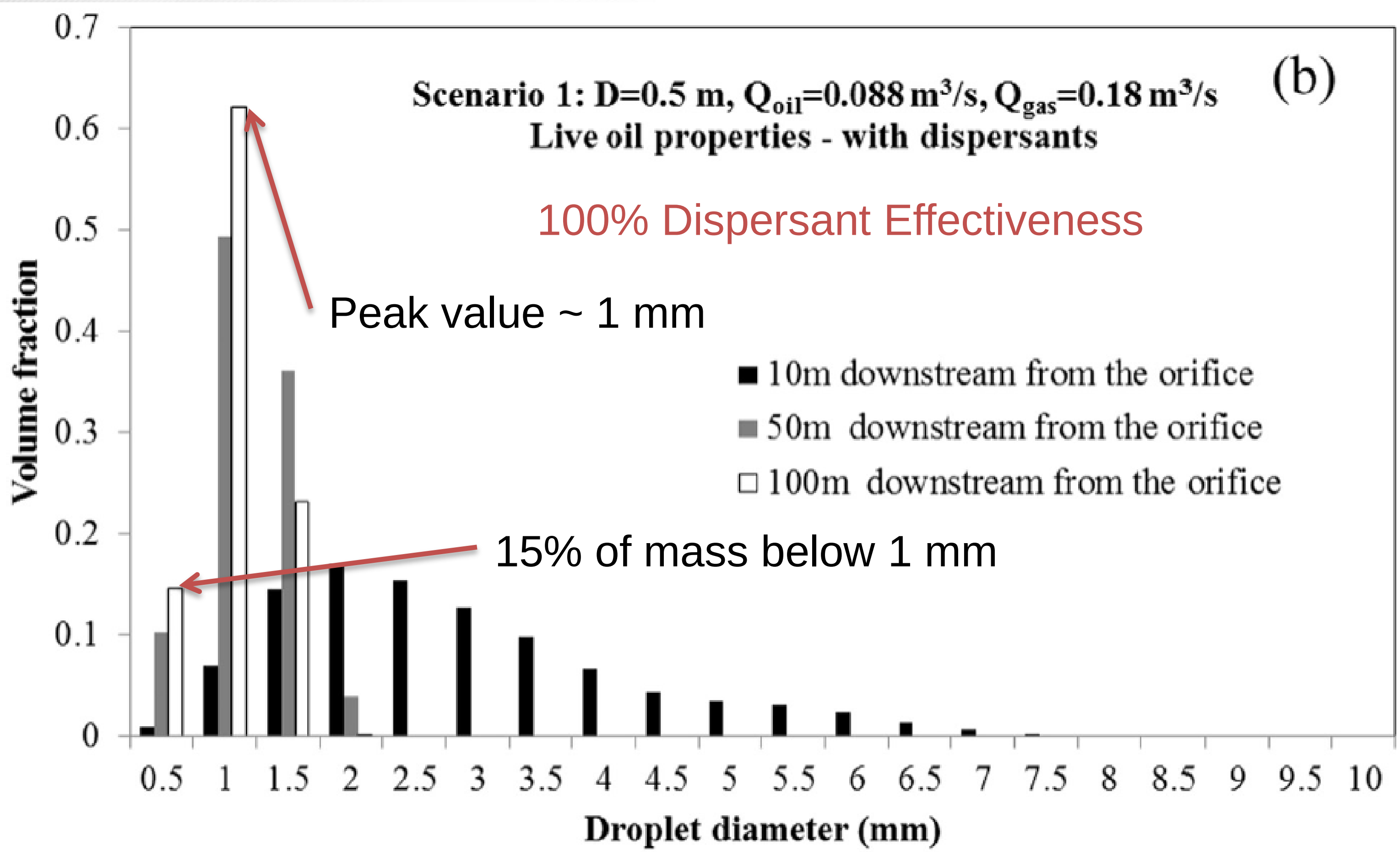
- Prediction of the DWH size distribution using VDROP-J



Zhao et al. (2015) *MPB.*

Population Breakup Models

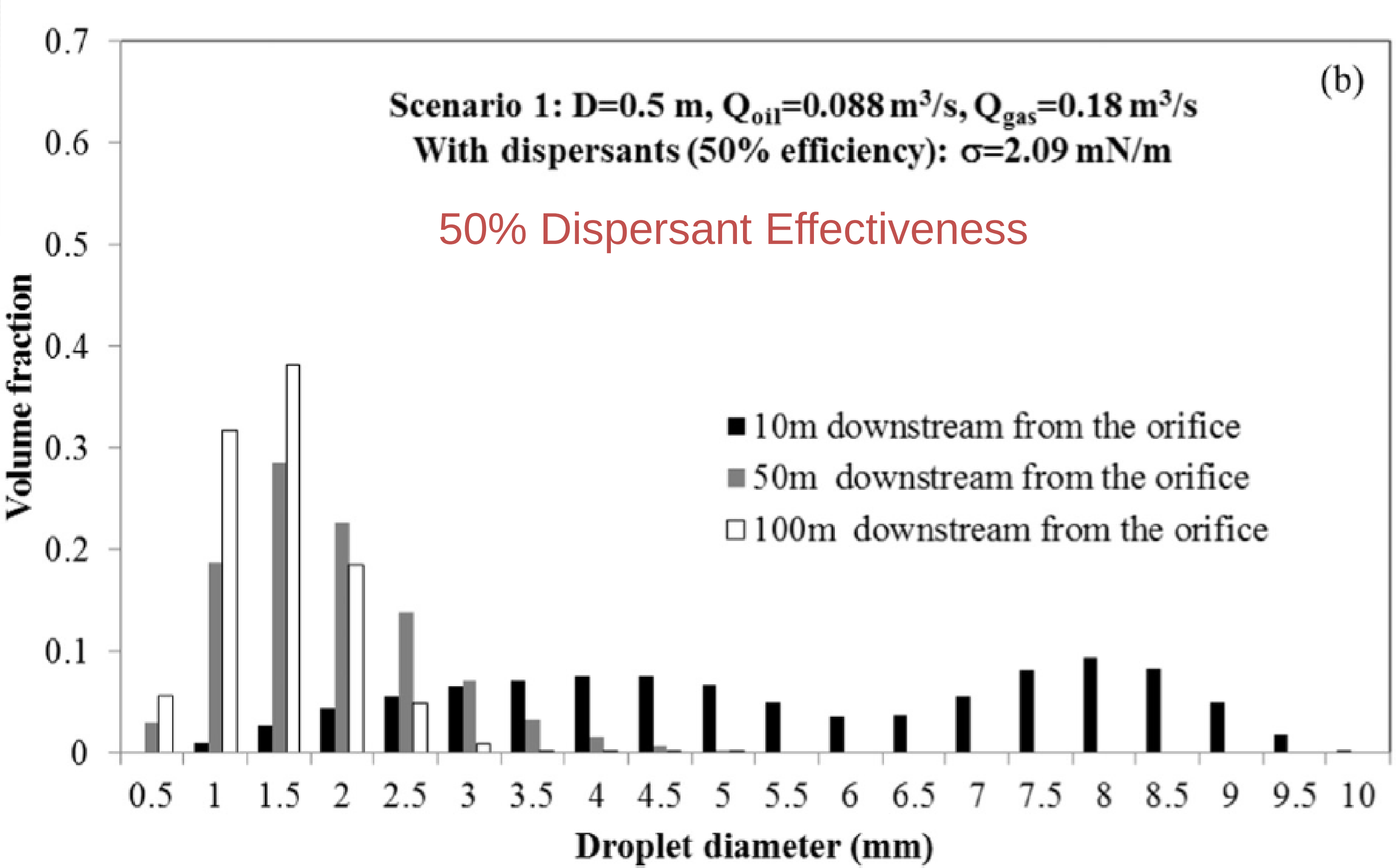
- Effect of dispersants



Zhao et al. (2015) *MPB.*

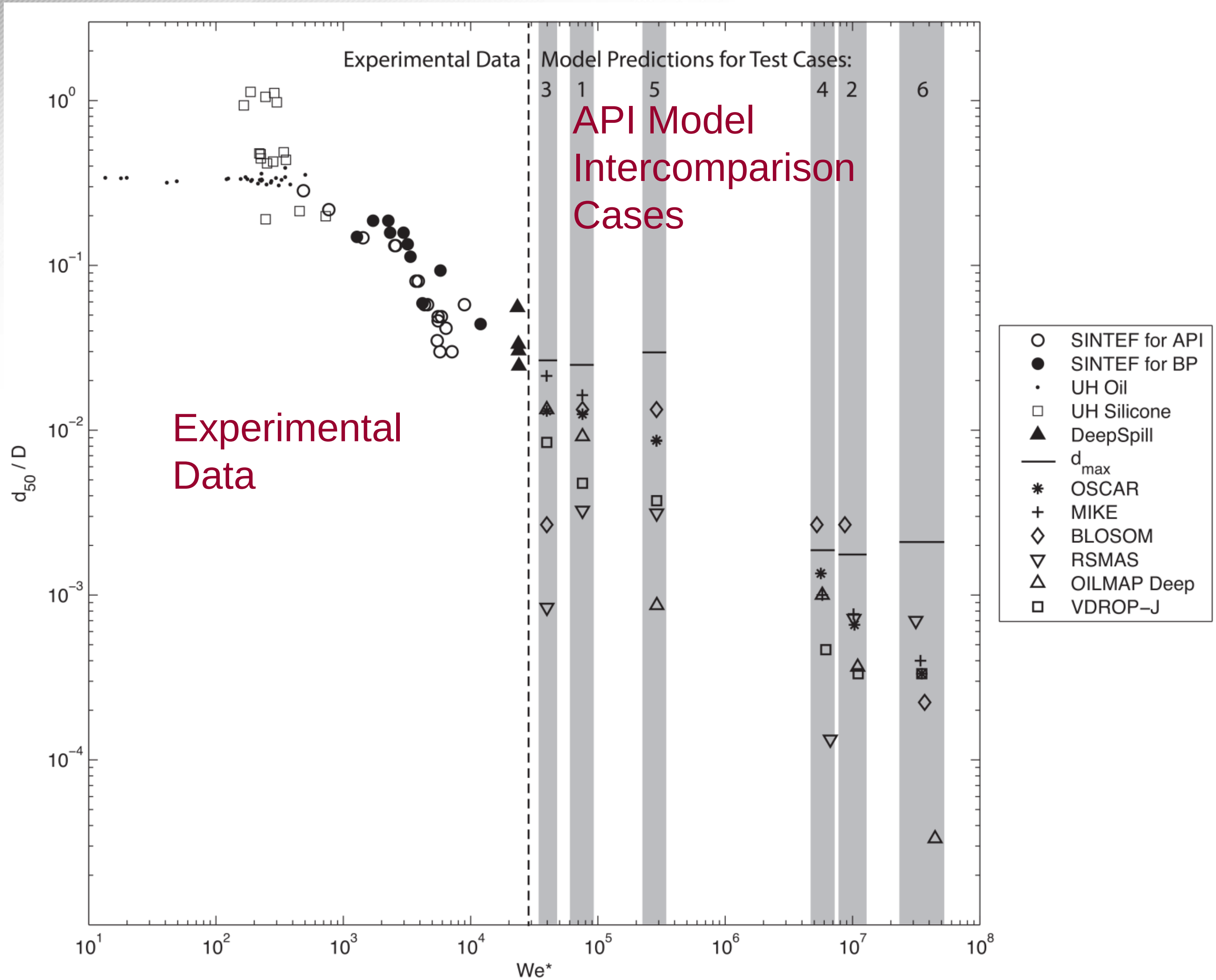
Population Break-up Models

- Effect of dispersants



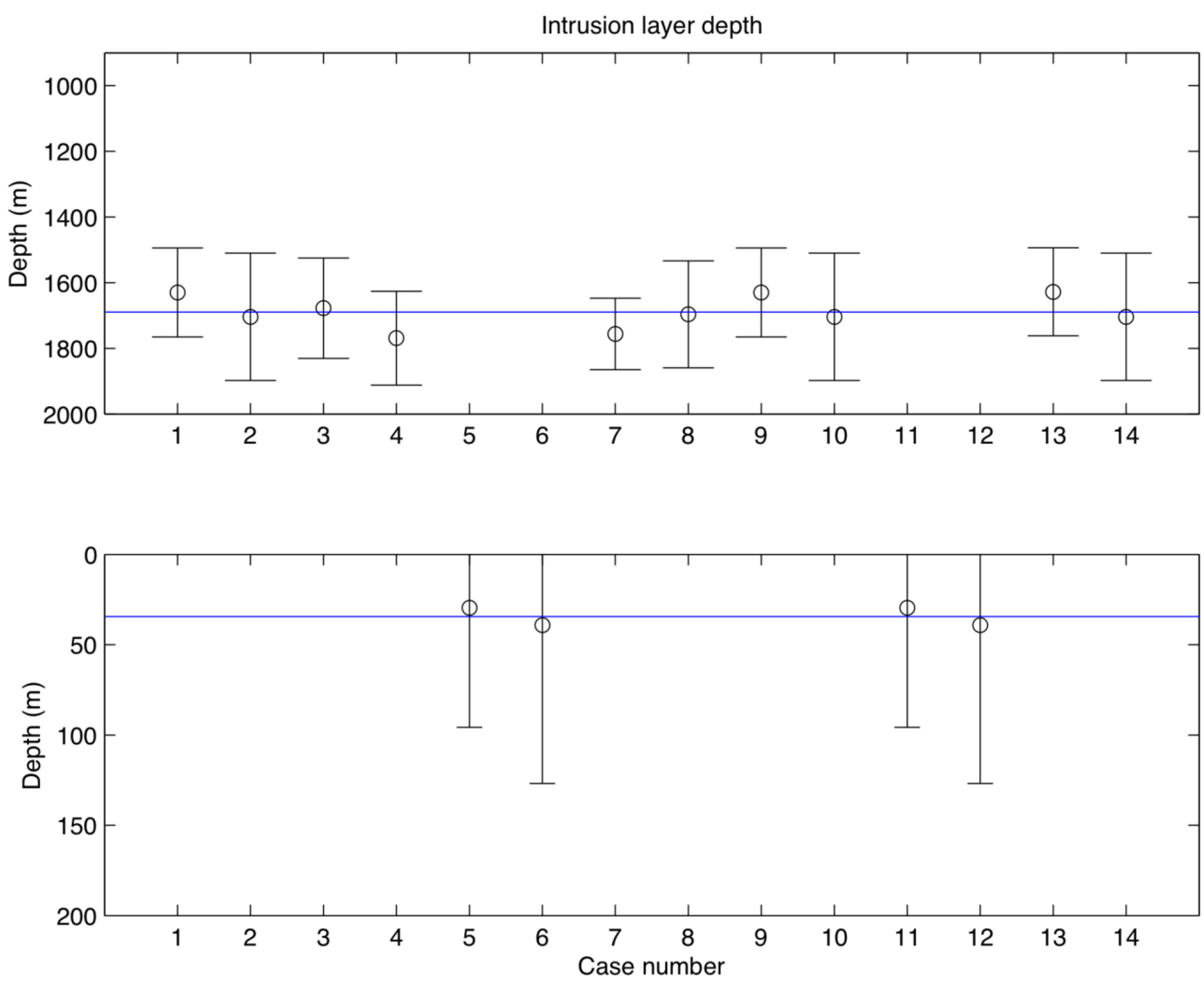
Zhao et al. (2015) *MPB.*

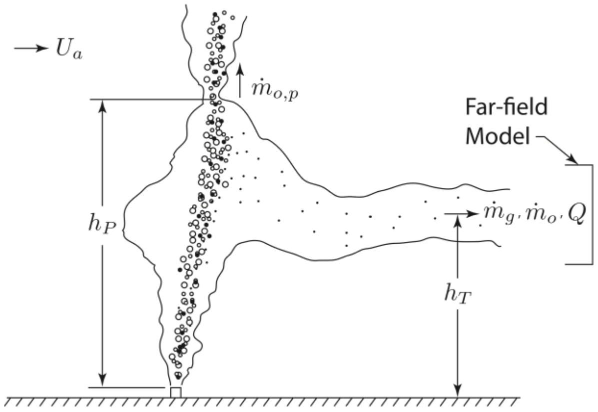
Comparison to Available Data



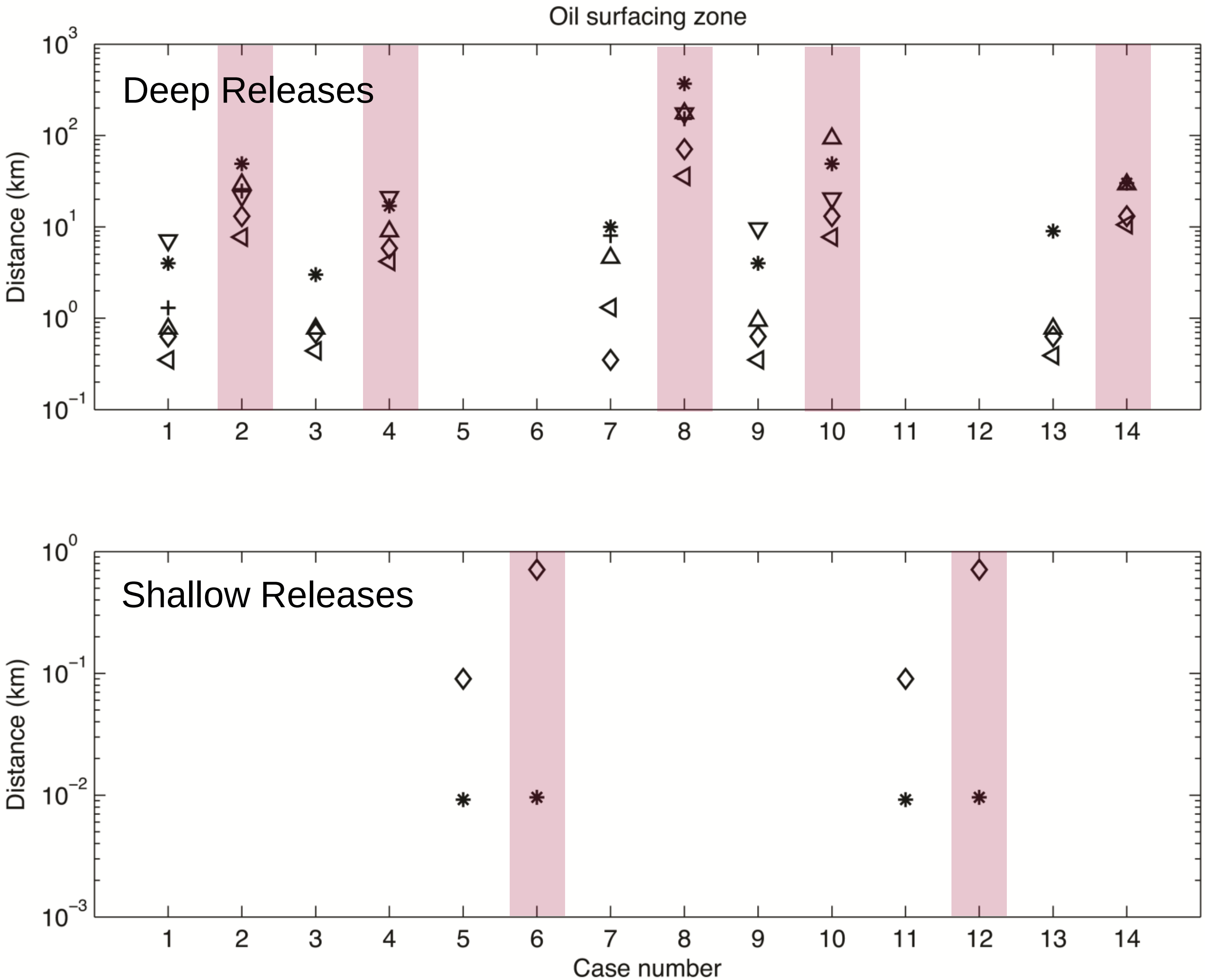
Socolofsky et al. (2015) *MPB.*

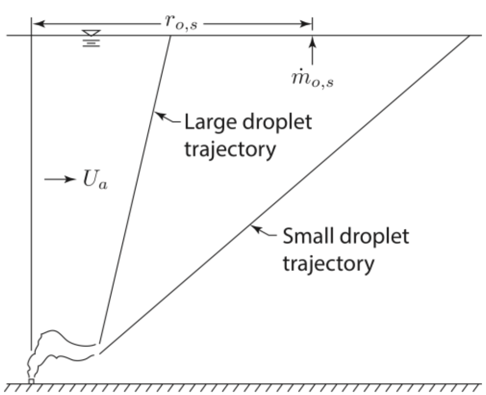
Trap Height Predictions





Surfacing Predictions





Conclusions

- DSD models must extrapolate from available data to match field conditions.
- Experiments demonstrate that subsea dispersant addition reduces the oil droplet size.
- Dispersant addition is modeled by an assumed reduction in the interfacial tension
- Available DSD models generally agree within an order of magnitude
- Water column models (near- and farfield) agree that dispersant can move surfacing zone up to two orders of magnitude downstream of the no-dispersant location

Future Needs

- Experimental data for DSD at larger scale
- Expand the observational database of near-field dynamics to constrain model assumptions (e.g., laboratory or LES simulation)
- Experimental data on effectiveness of mixing dispersants into oil at a blowout

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