Oil in Water Fluorescence and Backscattering Relationships

Ian Walsh

Sea-Bird Scientific Ocean Research

Brian Robinson

Fisheries and Oceans Canada, Bedford Institute of Oceanography

John Koegler

Sea-Bird Scientific Ocean Research

Robyn Conmy

3USEPA/NRMRL/LRPCD

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Experimental Considerations

The particle size distribution impacts:

- Fluorescence
- Backscattering
- Forward Scattering

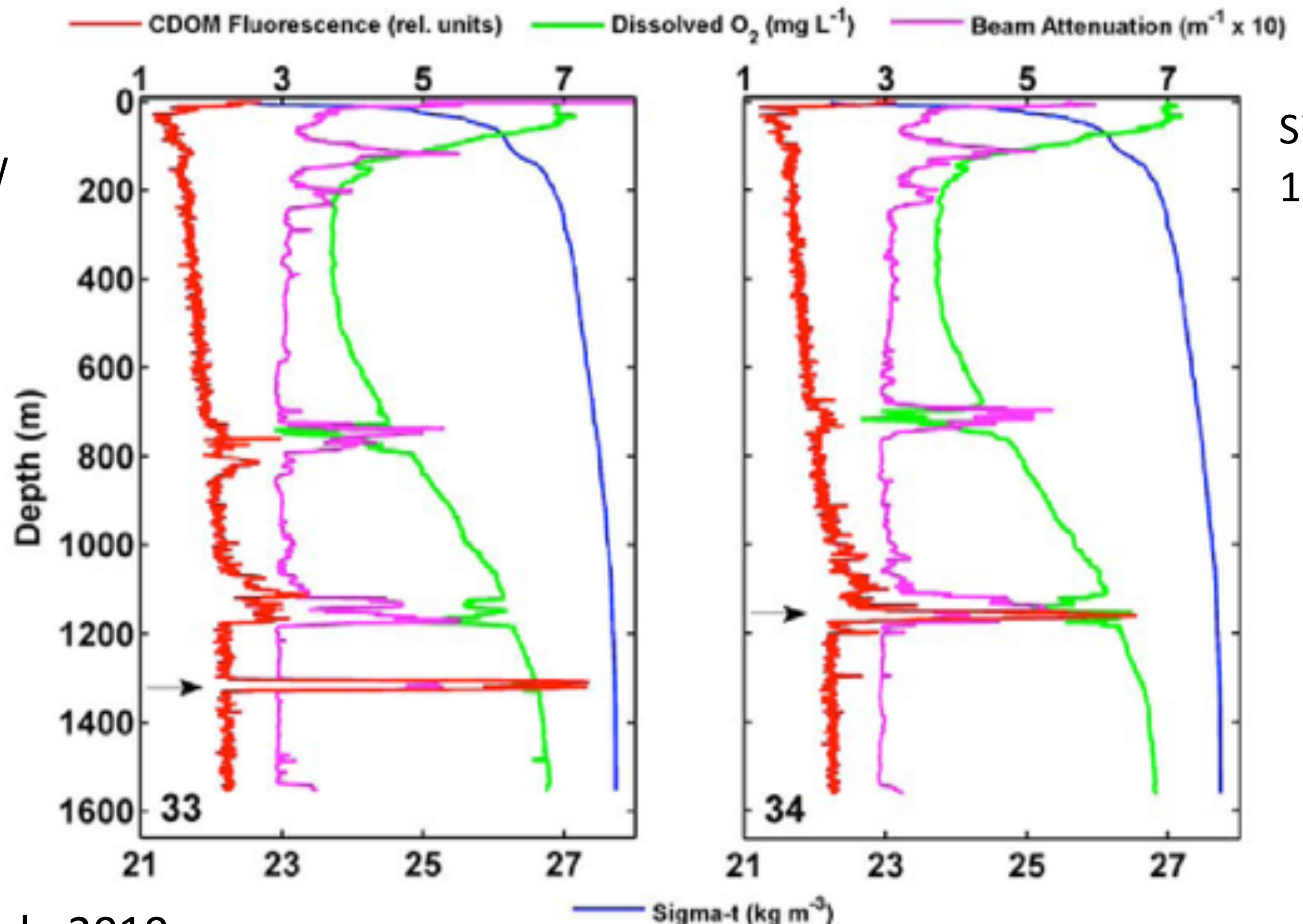
Backscattering and forward scattering demonstrate coherent responses

Fluorescence and backscattering signals can be used to:

- Measure dispersant effectiveness
- Quantify changes in the particle distribution

DWH Profiles - Pelican

Site 33
2.5 nm SW



Site 34
1.25 nm SW

Diercks et al., 2010

Situational Outline

- UV A fluorometers: relatively weak LEDs
  - Wide band filters on the detector (90 nm)
  - Higher gain (amplification) on the detector
  - Time average (not ECO)

  - Signal to noise is low relative to other sensors
  - Fluorometers worked ok for the DWH because the spill was so large

  - Lots of room for improvement, so we designed a new instrument

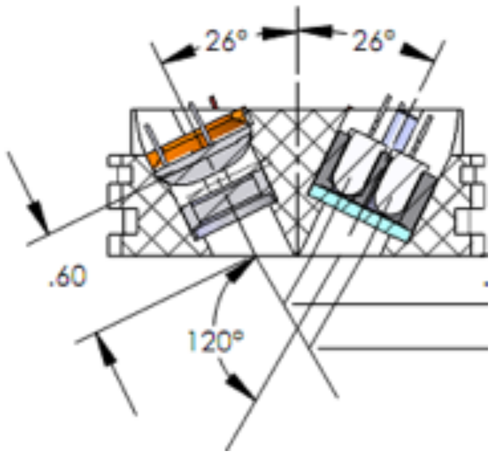
New Instrument – SeaOWL UV-A

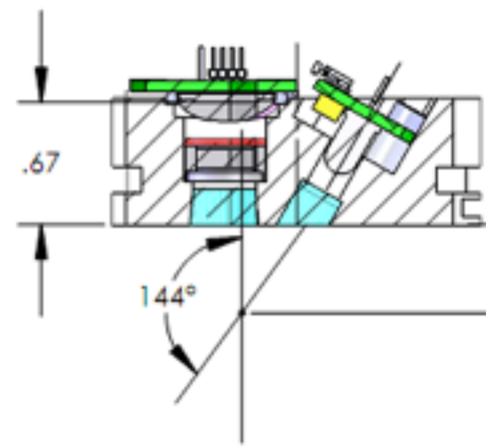
Higher Resolution : Better Signal to Noise
- Improved Electronics
- Design
  - Materials (FDOM)
  - Optics

Wider Range: One size fits all
- Retain high resolution
- Decrease chance of saturation

Multiple sensors in one instrument
- Co-locating oil discrimination factors
- Ease of use
- Economy

SeaOWL UV-A v ECO Optics





ECO
Sensing Volume:
Intersecting conical volumes
Energy return:
Approximately
1 cm^3 , 1 cm face

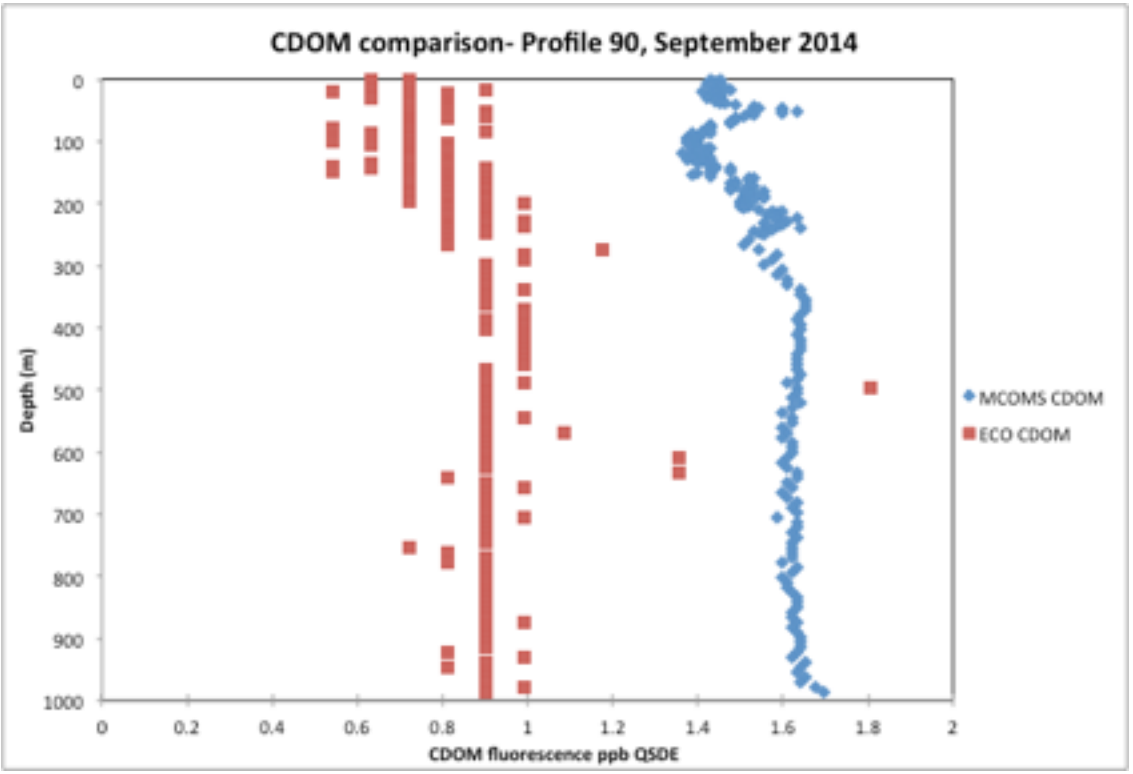
SeaOWL UV-A
Sensing Volume:
Illumination conical volume inside
wide angle detector volume:
Greater depth of field

Improvement in Sensitivity

SeaOWL FDOM has 4 – 7 x resolution of ECO CDOM

SeaOWL dynamic wide range technology makes saturation highly unlikely

Comparison Test on Navis Float in Labrador Sea demonstrated improved resolution



Detecting Oil: Fluorescence

Fluorescence:

The emission of light by a substance that has absorbed light or other electromagnetic radiation.

- Fluorometers excite at a specific wavelength
- Target emits light at a longer wavelength, lower energy, than the absorbed radiation
- Signal is a function of concentration
- Signal is Isotropic
- Signal is a function of the dispersion of the target in the volume

Detecting Oil Droplets

Backscattering:

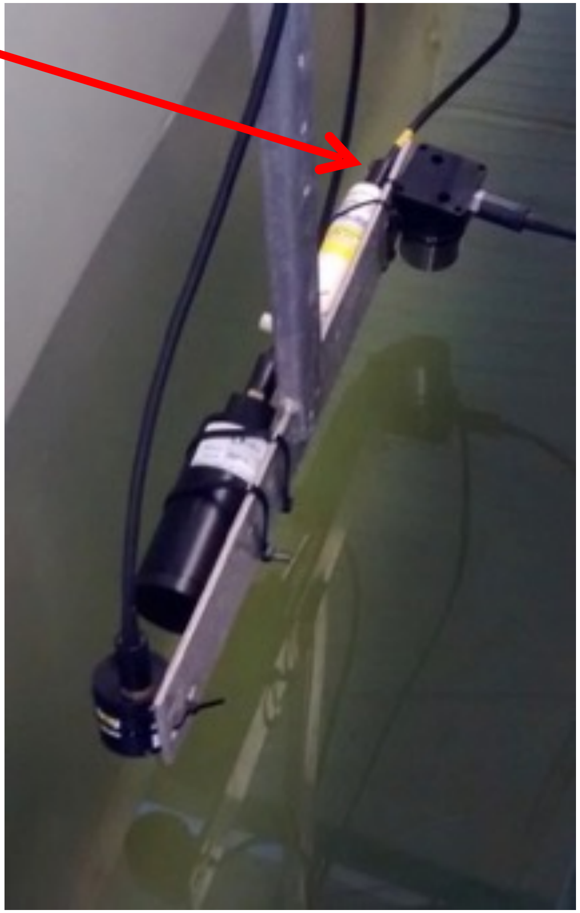
The portion of light scattered in the backward direction at a particular angle to the detector

- Backscattering sensors illuminate particles in the water at a specific wavelength
- Signal is a function of the angle
- Signal is a function of concentration (ESD) and particle size (PSD)

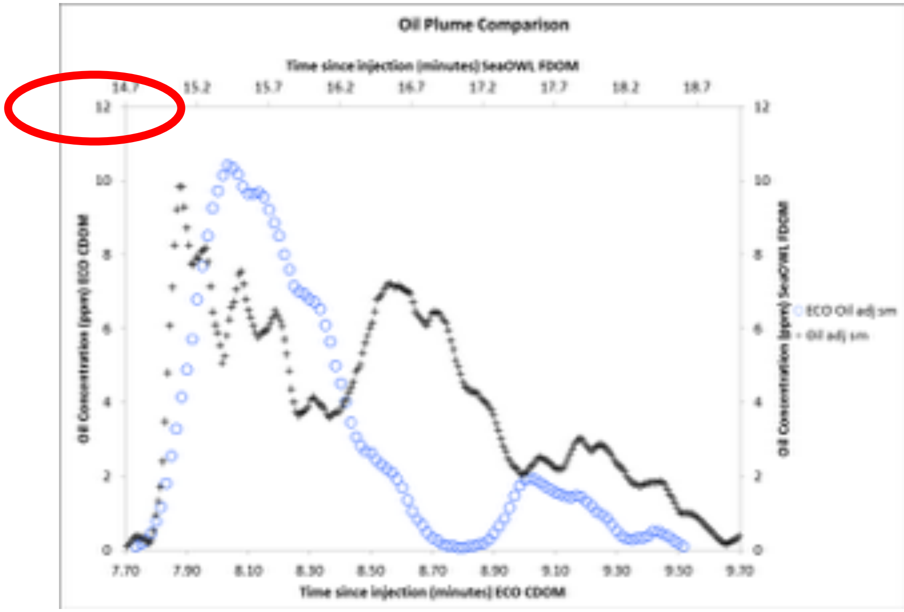
Testing at COOGER

7/17/15

SeaOWL UV-A



Advanced Oil Sensor Testing
SeaOWL UV-A v ECO



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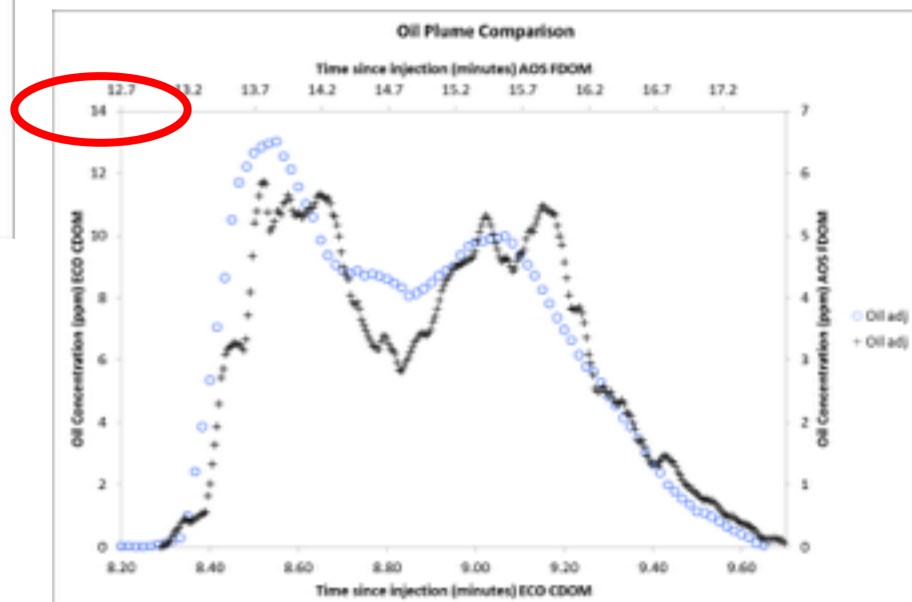

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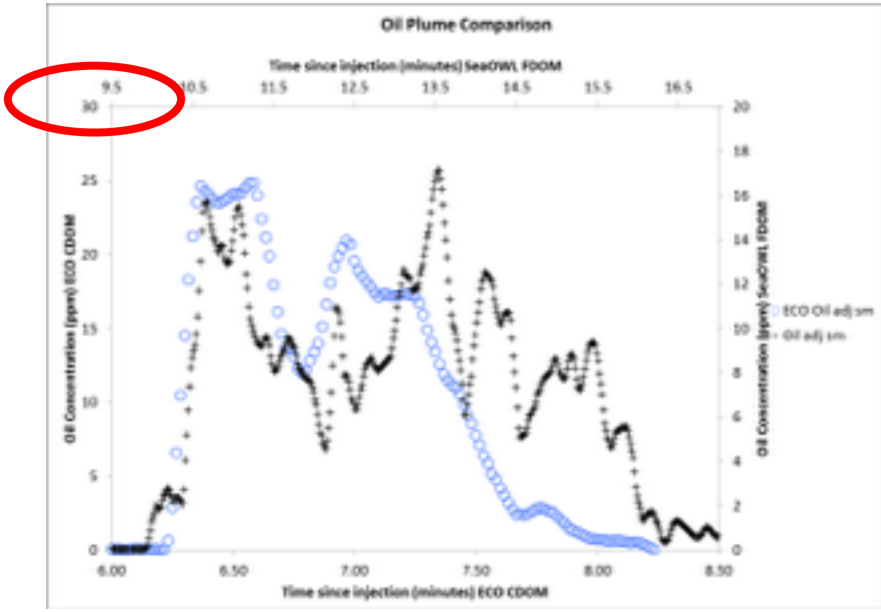
Advanced Oil Sensor Testing
SeaOWL UV-A v ECO



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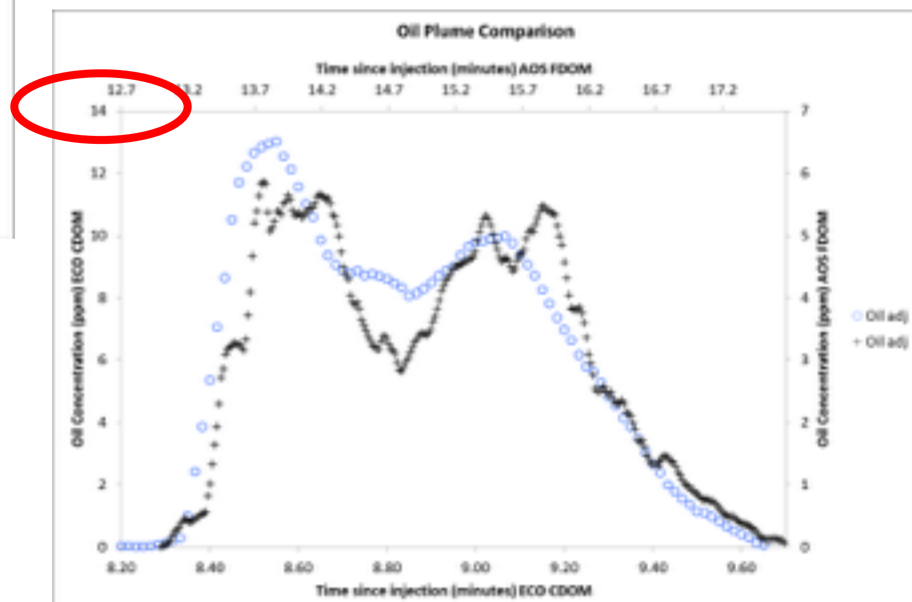


Advanced Oil Sensor Testing
SeaOWL UV-A v ECO

Increased Resolution

We estimate the relative increase in resolution between the ECO CDOM fluorometer calibrated for oil and the SeaOWL UV-A by comparing the calibrations of the instruments using quinine sulphate dehydrate.

Resolution for the ECO CDOM: 0.0306 QSDE/ count

Resolution for the SeaOWL UV-A: 0.0065 QSDE/ count

Applying the ECO CDOM crude oil calibration from Conmy et al., 2014 yields a scale factor in terms of oil concentration:

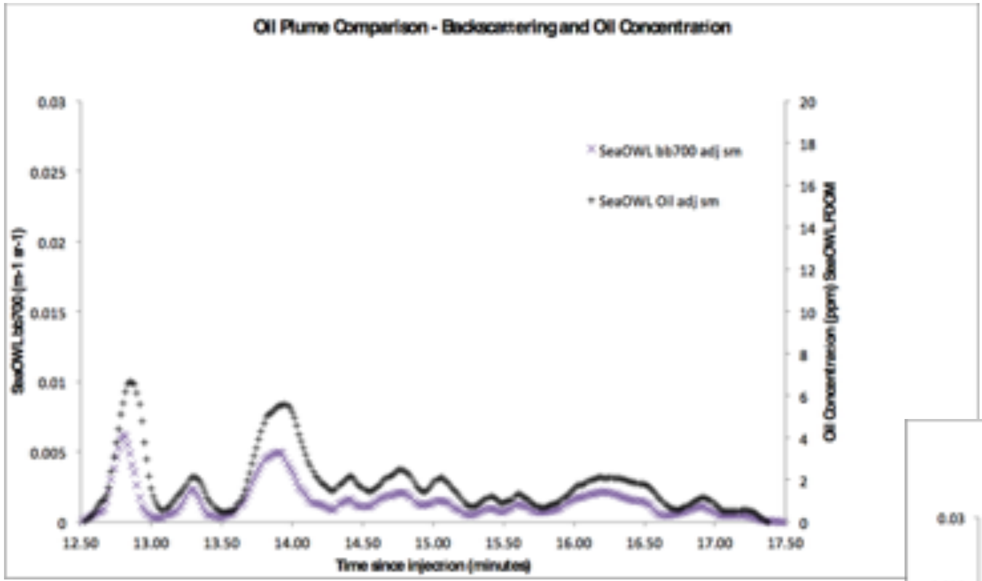
The estimated limit of detection (LOD) for the ECO CDOM fluorometer is < 300 ppb crude oil (Conmy et al., 2014), i.e. 30 counts.

Resolution for the ECO CDOM: 10 ppb crude oil/ count

Using the same count to LOD relationship, we estimate that the LOD for the SeaOWL is < 67 ppb crude oil.

Resolution for the SeaOWL UV-A: 2.2 ppb crude oil/ count

Advanced Oil Sensor Testing
SeaOWL UV-A v backscattering



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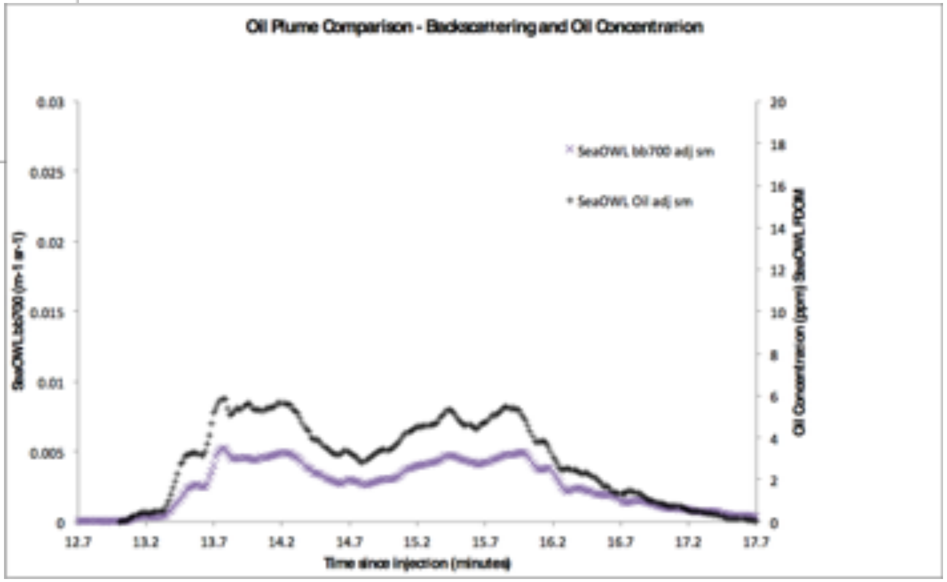

Advanced Oil Sensor Testing
SeaOWL UV-A v backscattering

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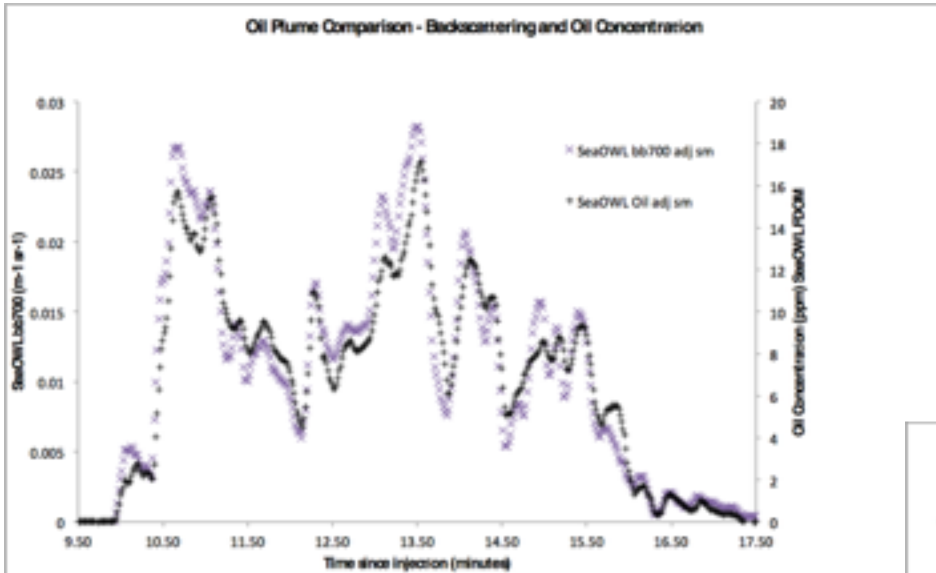

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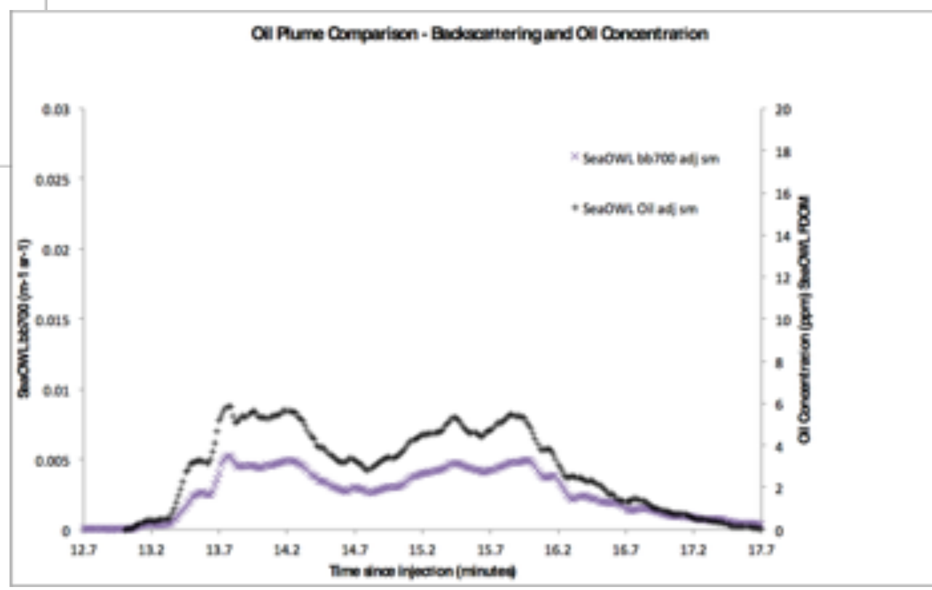

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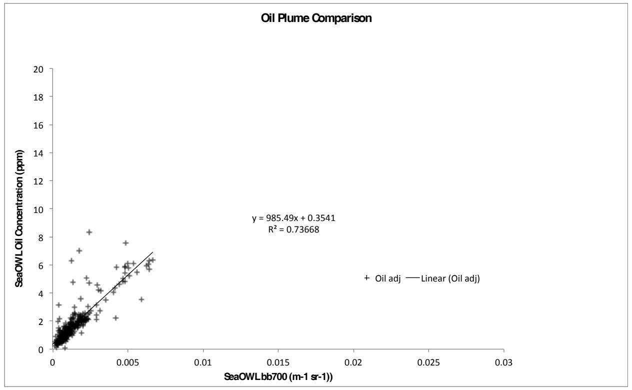

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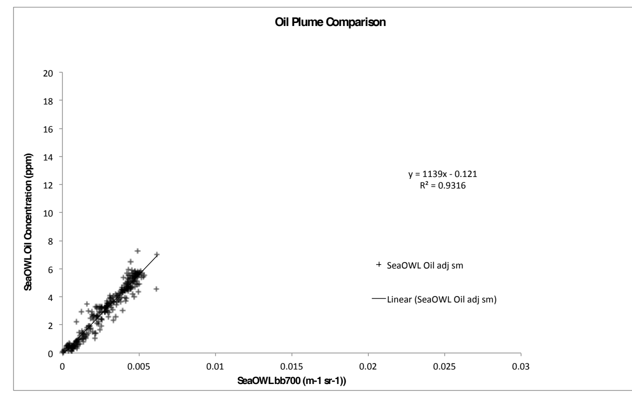

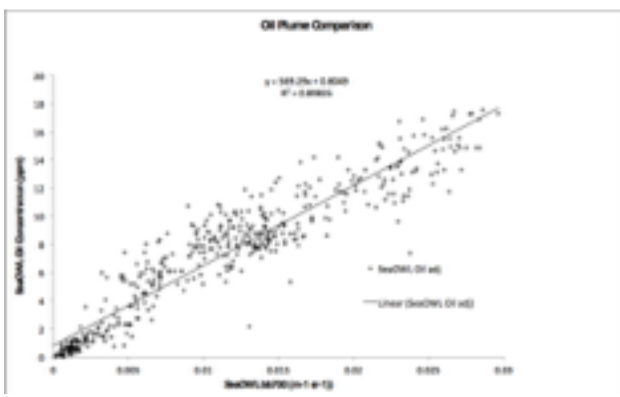

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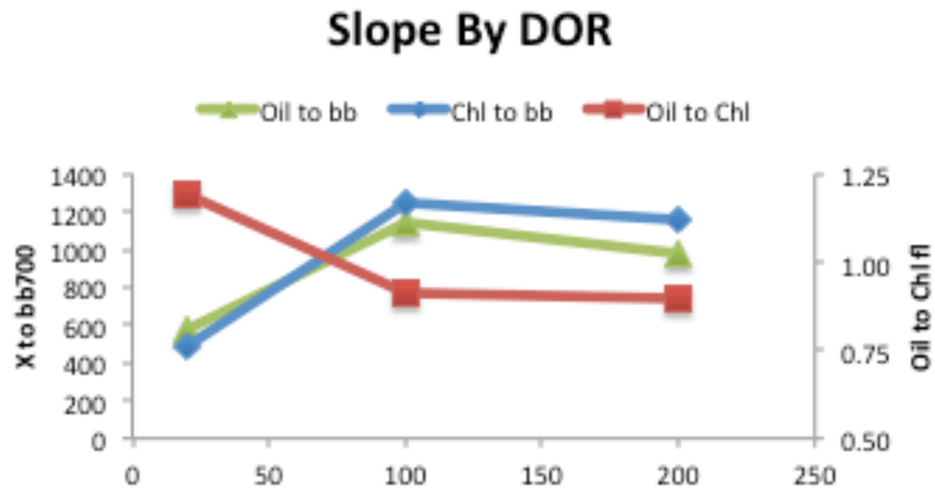
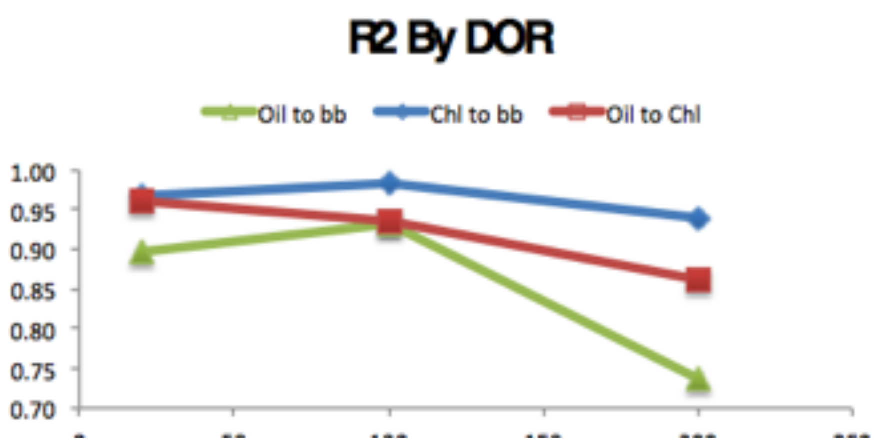
Response By DOR

Increased dispersant:

Increases fluorescence and backscattering signals with a critical point < 100 DOR



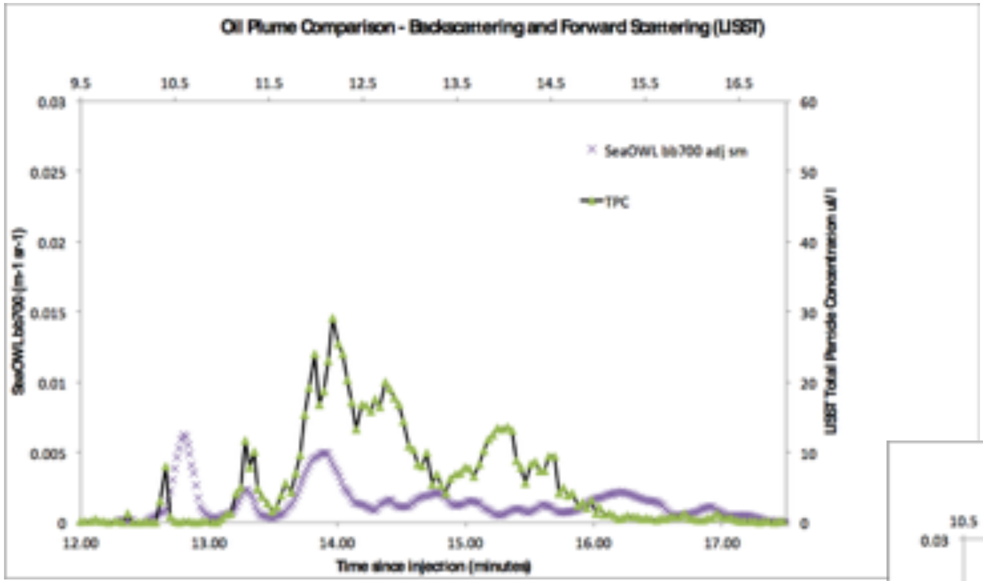


Increased dispersant:

Decreases variability in particle size distribution and dissolved to droplet ratio with a critical point < 200 DOR

Advanced Oil Sensor Testing
LISST TPV v backscattering

ANS DOR 1:200



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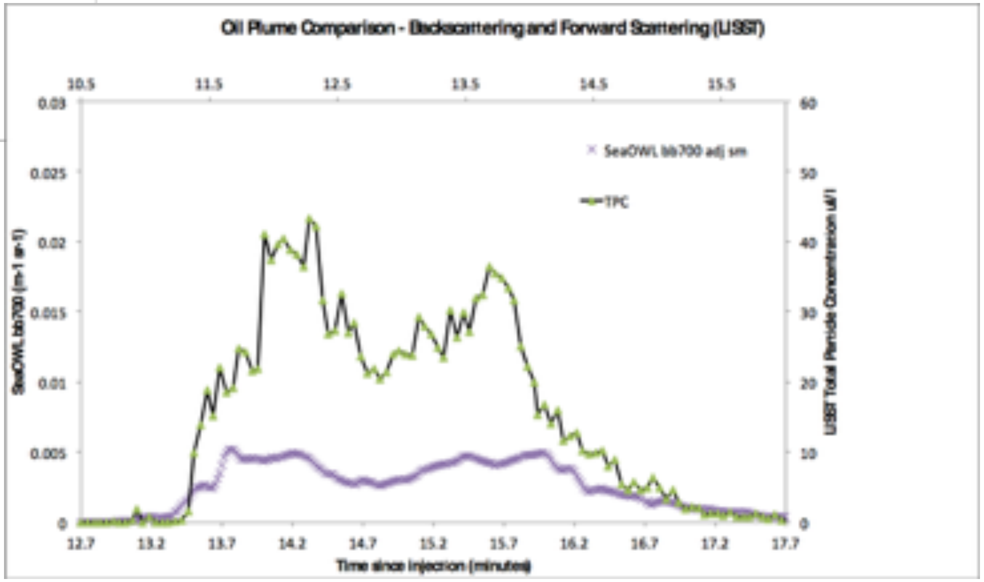

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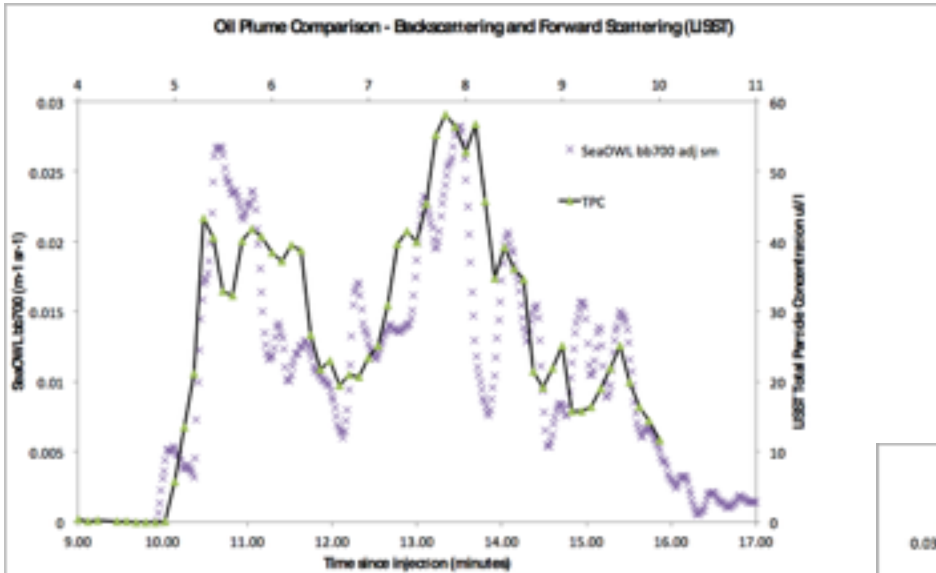

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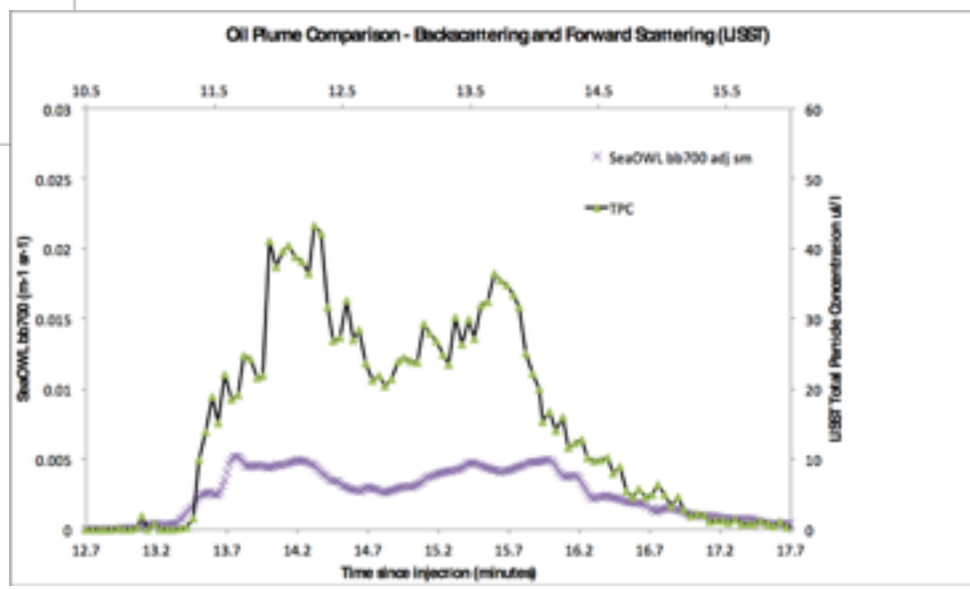

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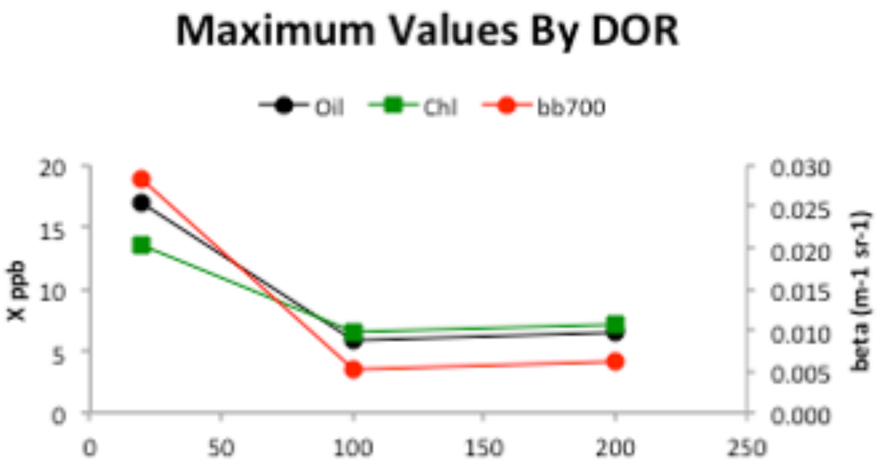
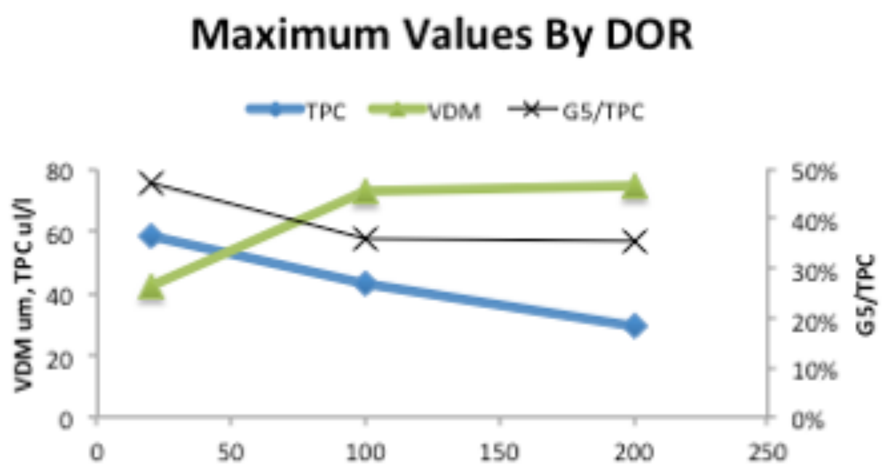
Response By DOR



Increased dispersant:

Increases apparent concentration with a critical point < 100 DOR



Increased dispersant:

Increases apparent concentration
Decreases volume median diameter
with critical point < 100 DOR

Conclusions

The dispersant ratio modifies the particle size distribution, which impacts:

- Fluorescence
- Backscattering
- Forward Scattering

Backscattering and forward scattering demonstrate coherent responses, but with different critical points

If mass concentration is constrained, fluorescence and backscattering signals can demonstrate dispersant effectiveness