Overview of DFO-COOGER Chemical Oil Dispersant Research

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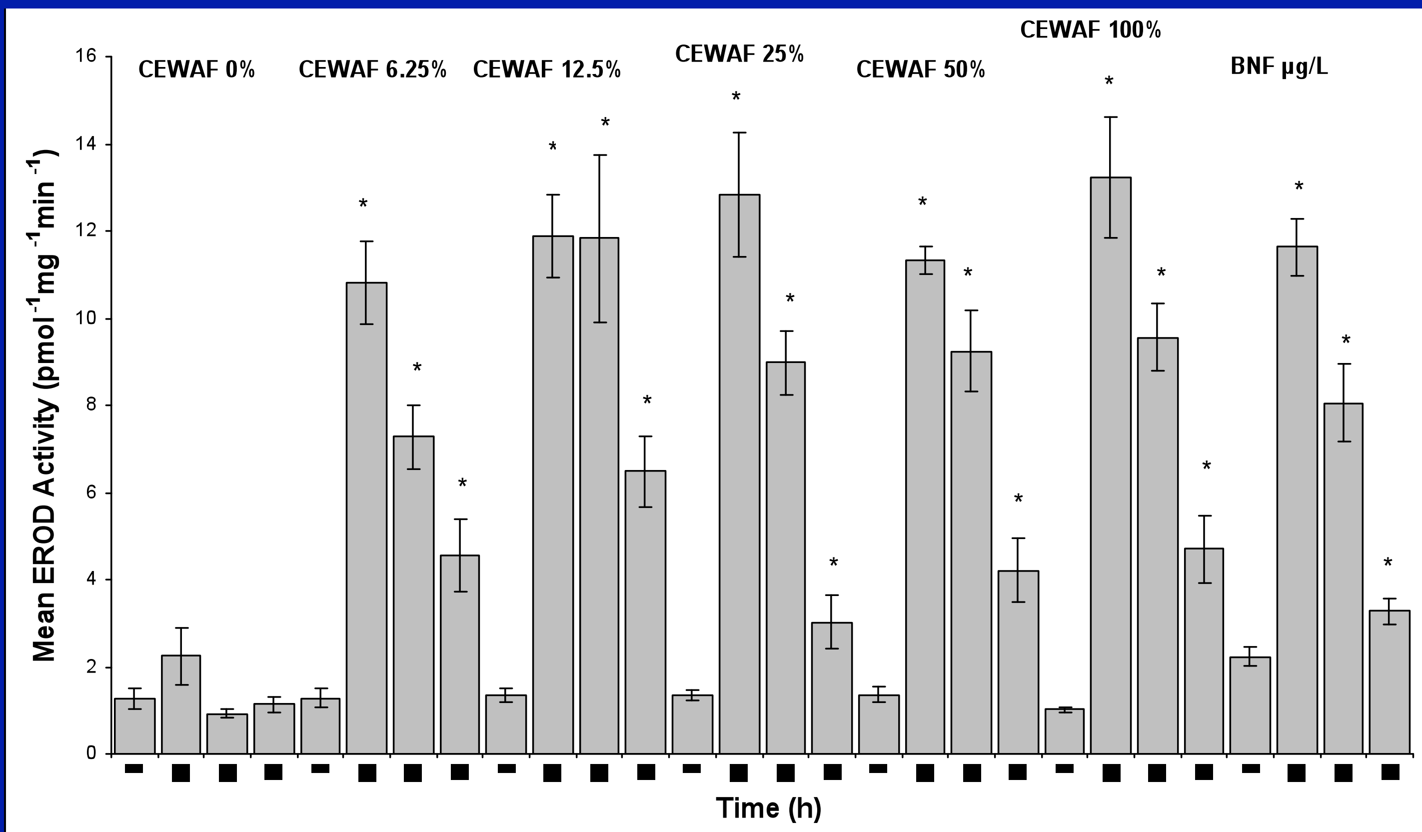
Biological effects of produced water, oil, oil dispersants and mixtures on early life stages of Atlantic cod (*Gadus morhua*)

- Determine whether particular life stages of cod are more sensitive to oil or dispersed oil exposure
- Determine if there are sub-lethal indicators (biomarkers) of stress or exposure
- Assess the potential risk chemical dispersants to the various life stages using realistic exposure conditions

(Dr. Les Burridge, St. Andrews Biological Station, Fisheries and Oceans Canada)

Juvenile Atlantic Cod and MESA CEWAF

- All 24 h values >10 pmol/mg/min (greater than WAF)
- Maximum EROD for WAF and CEWAF was at 24 h
- CEWAF induced higher EROD responses than WAF



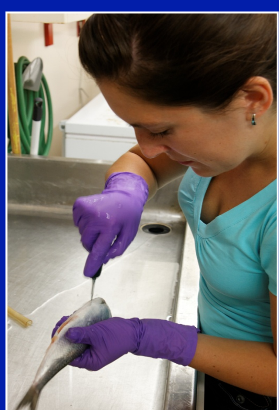
Atlantic Cod Response

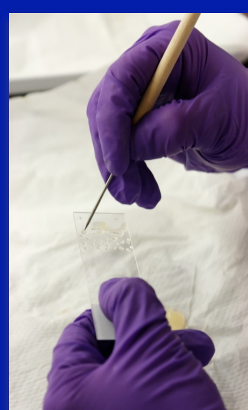
- All fish survived, there was no mortality to either WAF or CEWAF
- Maximum EROD induction occurred at 24 h
- EROD activity remained elevated over 48 h, but declined relative to the 24 h sample
- WAF significantly affected EROD activity only at the highest concentrations
- CEWAF induced higher levels of EROD activity at 24 h than WAF

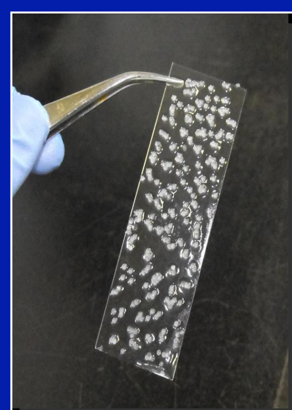
Toxicity of Chemically Dispersed Crude Oil to Herring Embryos

- **Does chemical dispersion of oil increase the concentration of hydrocarbons?**
- **Do Atlantic and Pacific herring respond similarly to oil exposure?**
- **Do herring embryos respond similarly to ANSC, MESA, and ALC oils?**
- **Does exposure time increase toxicity?**
- **Does oil dispersed in the wave tank result in the same toxicity as lab-prepared CEWAF?**

(Dr. Peter Hodson, Queen's University, Kingston, Ontario; Dr. Simon Courtenay, Gulf Fisheries Centre, Moncton, New Brunswick; Dr. Les Burridge, St. Andrew's Biological Station, St. Andrew's,New Brunswick)

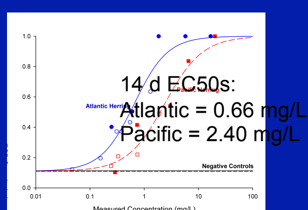


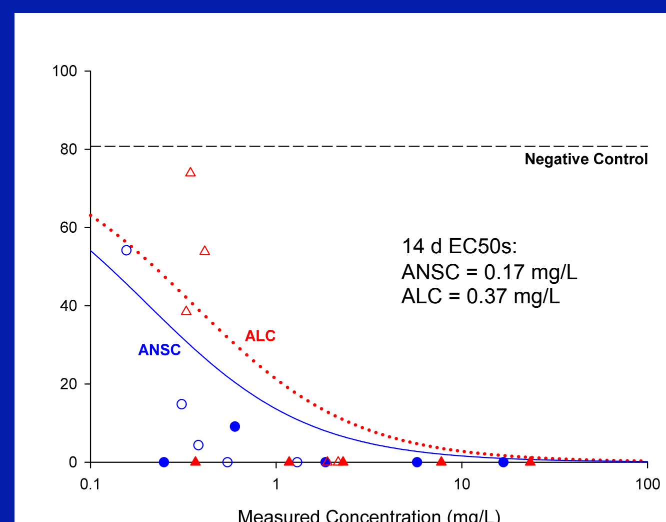




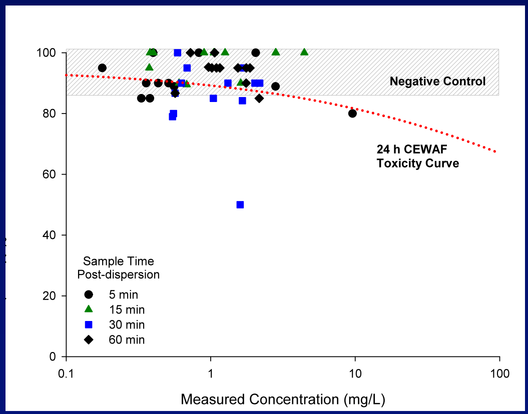
Toxicity of Chemically Dispersed Crude Oil to Herring Embryos

- **Chemical dispersion increases the concentration of fluorescent (PAHs) compounds within the water and toxicity increases with exposure time**
- **There is a significant difference between EC50s for %Normal and the BSD Severity Index in Pacific vs. Atlantic herring embryos**
- **ANSC appears 2x more toxic than ALC to Atlantic herring embryos**





Dispersed AL Prepared in Wave Tank



TOXIC ZONE

Hydrocarbon concentrations for AL were not high enough to cause toxicity in Atlantic herring embryos

Ecological Relevance

- These preliminary studies were conducted with oil exposure under static conditions

  Dose response curves can be established. What's their ecological relevance?

- Actual concentrations encountered in the field during response operations may be below toxicity threshold limits observed in the laboratory experiments
- ANS CEWAF EC_{50} values of <1mg/L were only evident with exposure times exceeding 24h
- Future multi-trophic level studies should be conducted in the wave tank operated in the continuous flow mode and monitoring programs during spill events to account for the influence of natural dilution processes

Natural Attenuation as an Oil Spill Response Strategy

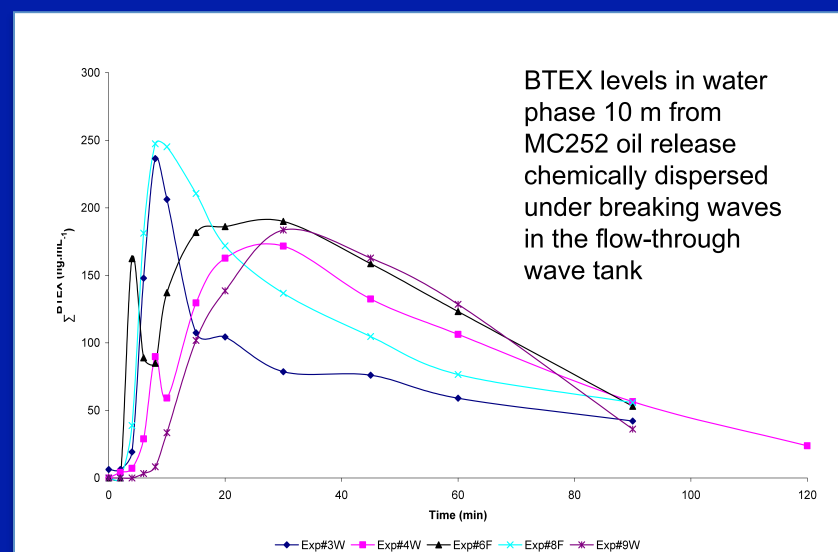
- Assess the microbial and genetic capacity of the marine ecosystem to clean itself from residual oil
- Identify measurable quantitative parameters to correlate levels of transcripts with available concentrations of hydrocarbons
- Develop baseline data and monitor the impacts of a spill on the microbial community structure and function and rate of biodegradation in the field
- Study the influence of dispersants and suspended particulate material.
- Identify and assess the natural attenuation capacity of pristine and contaminated marine systems (including the Arctic) in response to potential increases in petroleum hydrocarbon inputs

(Dr. Charles Greer, National Research Council, Canada;
Dr. Christine, Michel, DFO - Freshwater Institute)

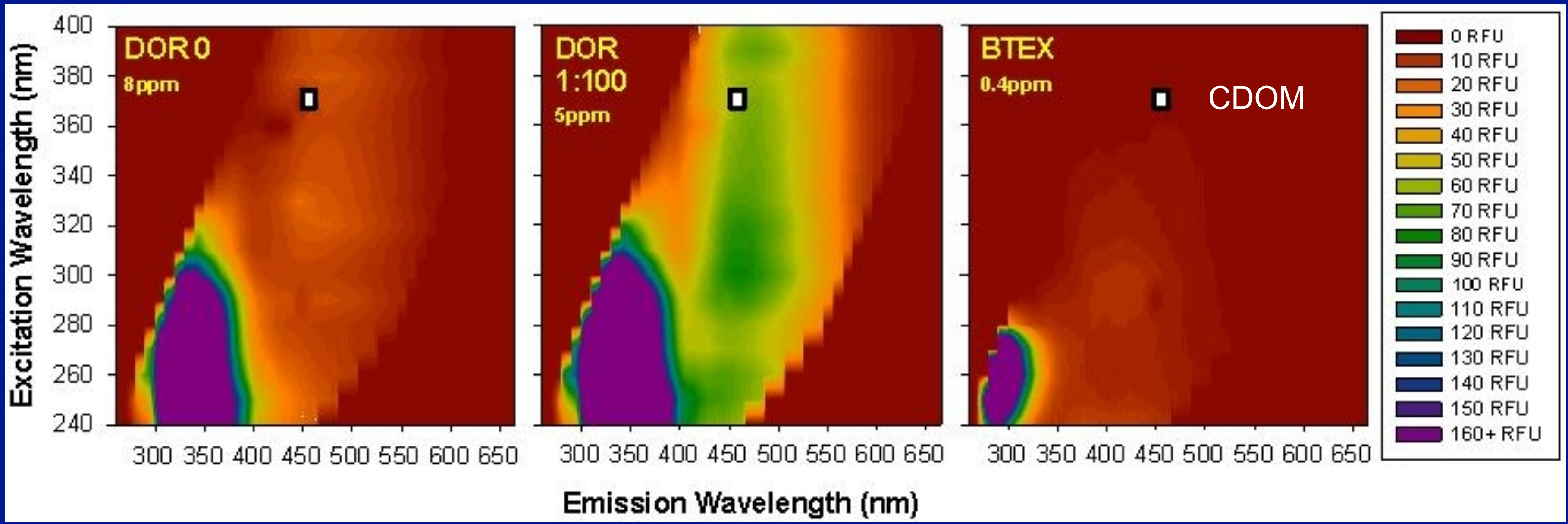
Improvements in Fluorescence Methodologies Track Dispersed Oil

- **Two studies funded by NOAA were conducted to compare existing in-situ fluorometers as well as other in situ sensors (LISST, SUNA) to monitor dispersed oil (both physical and chemically dispersed).**
- **Development and validation of a Fluorescence Intensity Ratio (FIR) method for determining oil dispersion efficiency at high and low oil concentrations**

(NOAA funded Research Team and DFO-COOGER)



3D Fluorescence Spectra: MC252 & BTEX

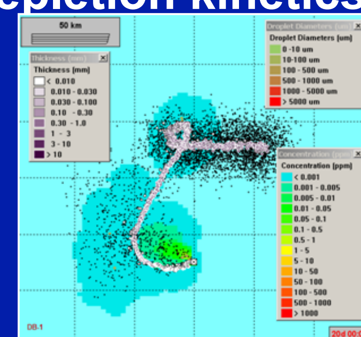


DFO/NOAA Fluorometry Workshop

- Chelsea Aquatrack
- Wetlabs Safire
- Wetlabs Eco
- Wetlabs EcoTriplet
- Turner C7
- Satlantic Suna

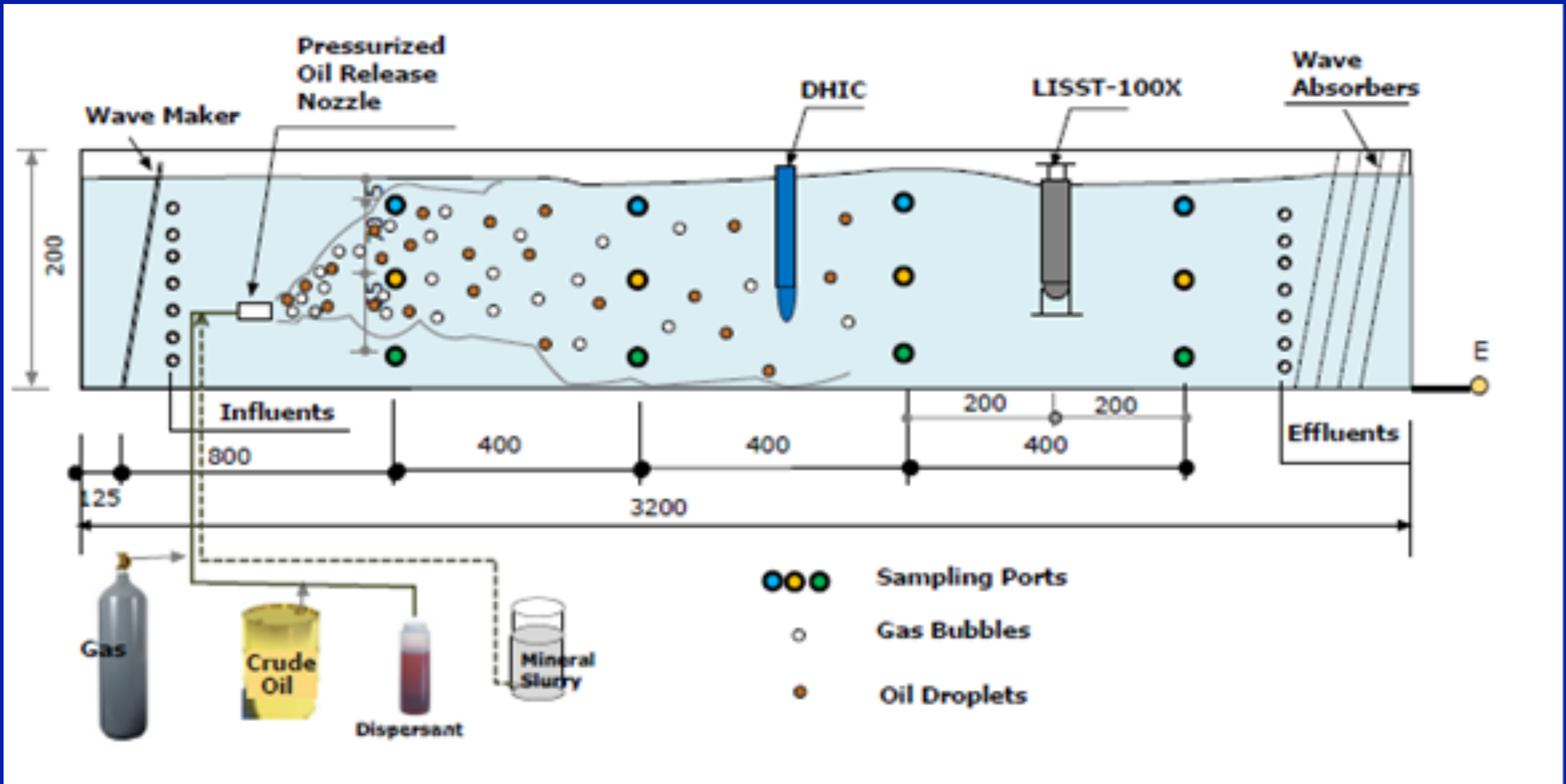
Subsurface Dispersant Injection as an Oil Spill Response Option

- **Develop countermeasure technologies for deepwater blowouts using chemical dispersants**
- **Characterize oil droplet size distribution as a function of depth, oil type, and dispersant-to-oil ratio**
- **Generate data for modeling fate and transport of oil, performing NEBA and NRDA analysis**
- **Provide data for development of numerical modeling tools that can be used for decision-making regarding use of dispersants in deepwater blowouts**
- **Track the fate and transport of dispersant and the depletion kinetics of dispersant from oil**



(Drs. Zhengkai Li and Haibo Niu, DFO COOGER)

Schematic diagram of the wave tank experimental system



DHIC: Digital Holographic Imagery Camera, to measure particles 20 – 2500 μm
LISST: Laser in situ Scattering and Transmissometry, to measure particles 2.5 – 500 μm

Subsurface dispersant injection

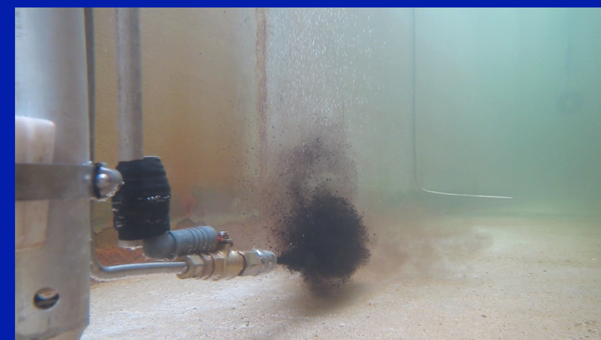
Oil + Dispersant

Small droplets form plume of dispersed oil

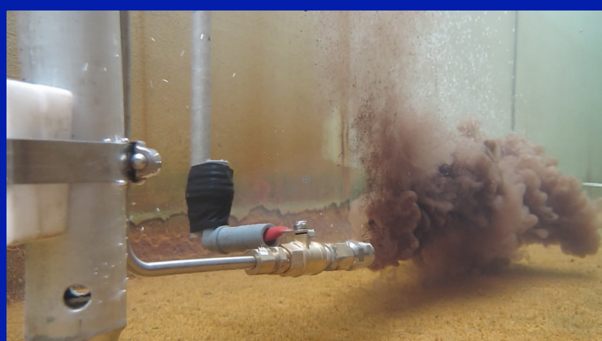
Oil Only

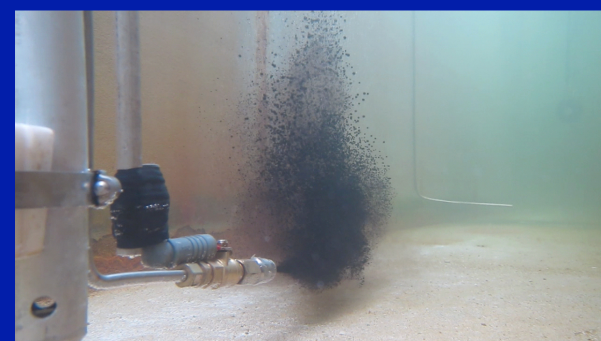
Large droplets quickly rise to the surface

1sec

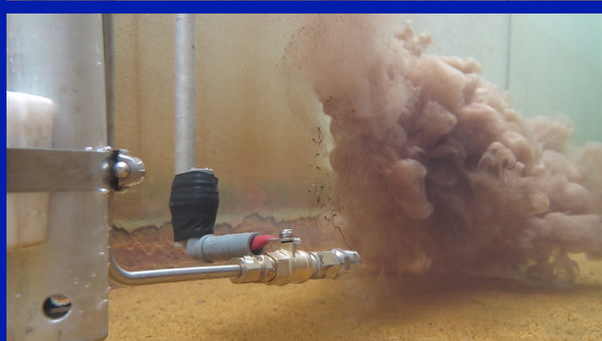


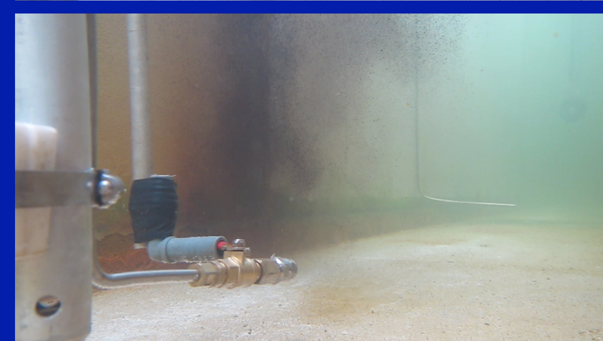
5sec





10sec



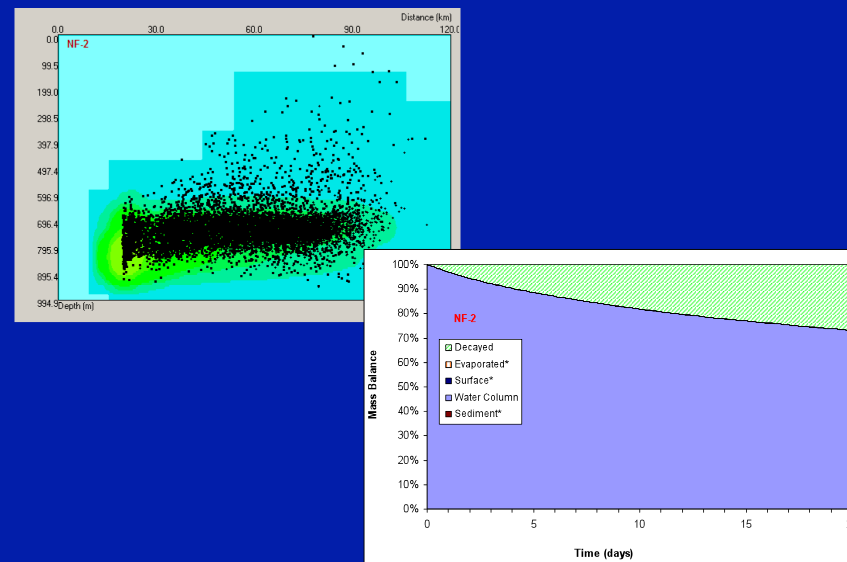


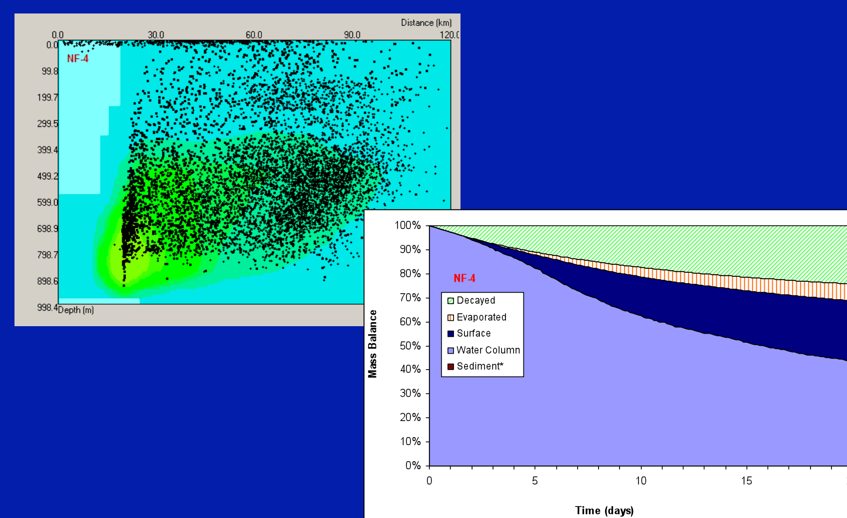
Numerical methods to estimate oil droplet size distribution

Objectives:

- Study the effects of dispersant on droplet size distribution
- Evaluate effects of high oil temperature, low water temperature, and the co-presence of natural gas on oil droplet size
- Integrate the new formulations of droplet size distribution with deepwater blowout models to examine the effects on oil fate and transport

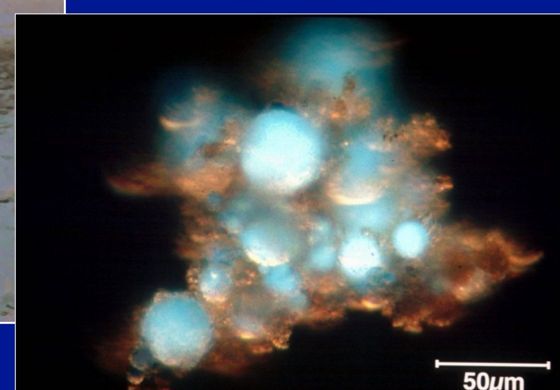
(Dr. Haibo Niu, DFO – COOGER)





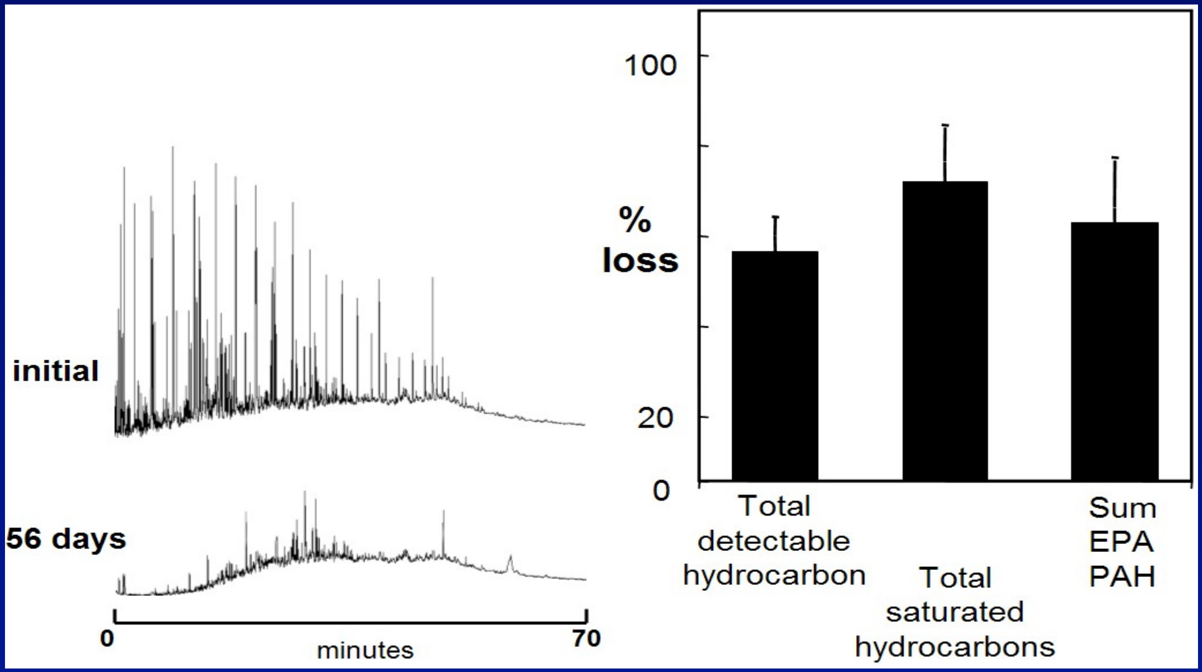
Enhanced Dispersion and Biodegradation of Oil in Ice

- Oil-mineral aggregate (OMA) formation is a valid oil spill countermeasure
- Has been tested in the field by DFO/COOGER



Low Temperature Biodegradation

- Water samples contained physically dispersed oil in the form of oil mineral aggregates (OMA)
- Samples were from a field trial to evaluate oil spill countermeasures in ice covered waters
- The oil had lost ~57% total detectable HC, ~65% of total saturated HC and >60% of USEPA priority PAHs



Oil spill countermeasure field trials in Arctic waters

- Most of what we know about oil spill behavior and response to spills in ice comes from laboratory, experimental test tank studies, and a few historical large-scale field experiments
- The operational effectiveness of numerous “new” oil spill clean-up technologies and response strategies is unknown
- Proof-of-concept and operational guidelines must be established before they are accepted by the oil spill response community
- The consensus of the scientific community is that field trials are essential
- Coordinate and conduct controlled oil spill field trials in Canadian North Atlantic and Arctic waters to develop and verify the effectiveness of new oil spill response strategies for the provision of scientific advice