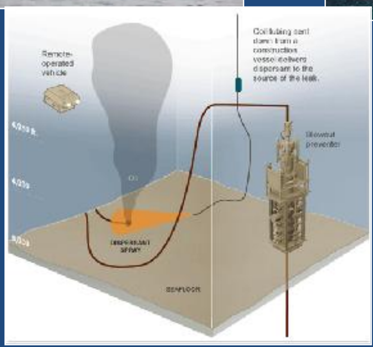
Deep Water Horizon:
Dispersant Use During the Response

Mr Robert G. Pond
US Coast Guard
Marine Environmental Response Policy

DWH: Dispersant Use – USCG Remarks

- Overview of the Response
  - Application method
  - By the numbers
- Effectiveness
- Decision Making Process
  - For the response
  - For daily application
- Monitoring
- Risk Communications
- Future

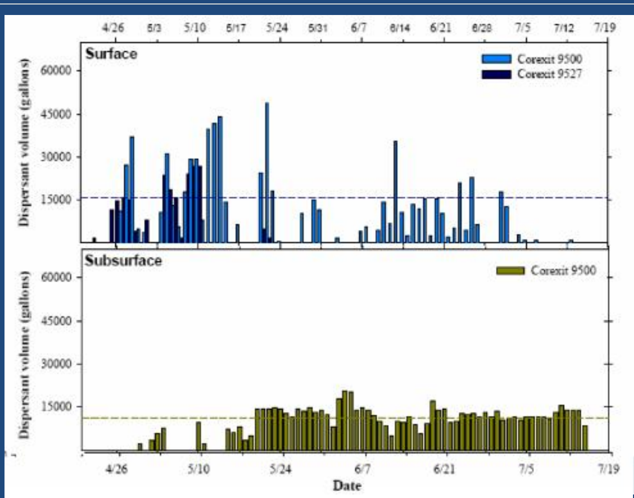
DWH: Dispersant Application Methods



Photos from Sintef, Oilspillcommission.gov and BP

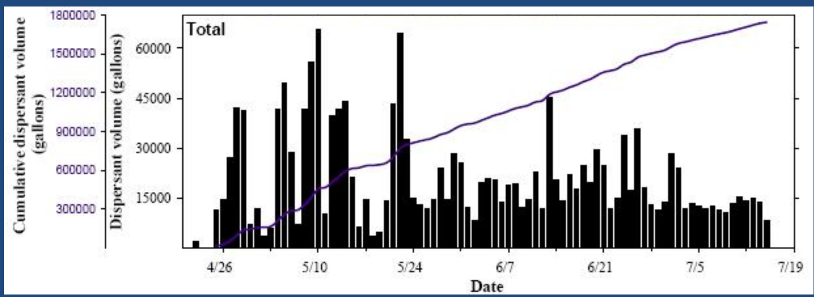
DWH: Dispersant Use – Statistics

Daily surface and subsurface dispersant application during DWH. Dashed lines represent the avg surface (blue) & subsurface (dark yellow) applications.



Source: The Future of dispersant Use in Oil Spill Response Initiative, March 22, 2012, Coastal Response Research Center, Research Planning Incorporated and National Oceanic and Atmospheric Administration

DWH: Dispersant Use – Statistics



Daily (bars) and cumulative (line) surface and subsurface dispersant application totals during DWH.

Source: The Future of dispersant Use in Oil Spill Response Initiative, March 22, 2012, Coastal Response Research Center, Research Planning Incorporated and National Oceanic and Atmospheric Administration

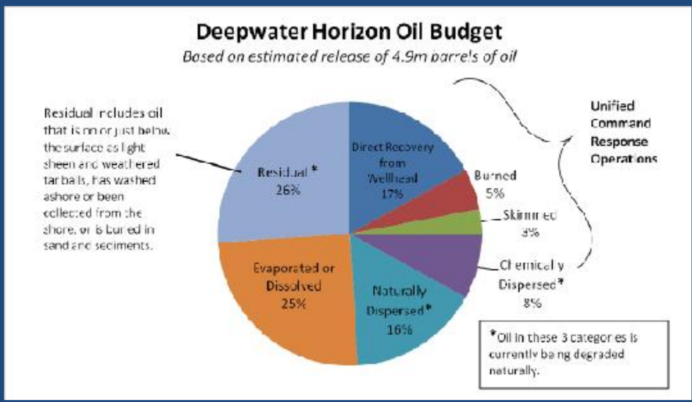
DWH: Dispersant Use – Efficacy

Aerial image before subsea dispersant application.

Aerial image eleven (11) hours after subsea dispersant application.

Source: Both images from Ocean Imaging

DWH: Dispersant Use – Efficacy



Source: BP Deepwater Horizon Oil Budget: What Happened to the Oil

DWH: Dispersant Use – Decision Making

- Decision to use Dispersants at the surface made immediately and approved quickly with the RRT-6 Dispersant Pre-Authorization in place
  - Application began 22 April
- Dispersant Monitoring and Assessment Directive for Subsurface Dispersant Application – 10 May, 2010
  - Addendum 1 – 14 May, 2010
  - Addendum 2 – 20 May, 2010
  - Addendum 3 – 26 May, 2010
- Decision to continue using Dispersants made daily
  - Daily Over flights to assess surface oil size and location

DWH: Dispersant Use – Monitoring

- Surface: Special Monitoring of Applied Response Technologies (SMART) Protocol
  - Tier III
- Subsurface: Three Parts for testing, continued application monitoring, and Application Parameters
- Shut-down criteria were also developed
- Long Term Monitoring Plan

DWH: Dispersant Use – Risk Communications

- Public Understanding and Perception was a Challenge
- Risk Communications Plans developed for traditional Worst Case Discharges
  - 40,000 gallon spill

DWH: Dispersant Use – Future

- Long-term monitoring continues
- Dispersants remain a valuable response tool
  - The US is developing policy that:
    - Provides guidance to and assists the Federal On Scene Coordinator in the decision to use dispersants
    - Standardizes monitoring requirements when dispersants are used
- Both public and private sectors are conducting research to understand the efficacy and impacts of dispersants.

Questions?

Bob Pond

Robert.G.Pond@uscg.mil

202-372-2240

Dispersant Application During the Deepwater Horizon Spill Response

Arden Ahnell,
Director, Environmental Technology
Safety and Operational Risk
BP

BP's Commitment

The Deepwater Horizon incident was a tragic accident that took 11 lives and impacted thousands of people and the Gulf environment

Going forward, we are

- **Determined to accelerate and further develop the capabilities and practices** that enhance safety in our company and the deepwater industry
- **Committed to sharing our learnings globally** so an incident of this magnitude never happens again

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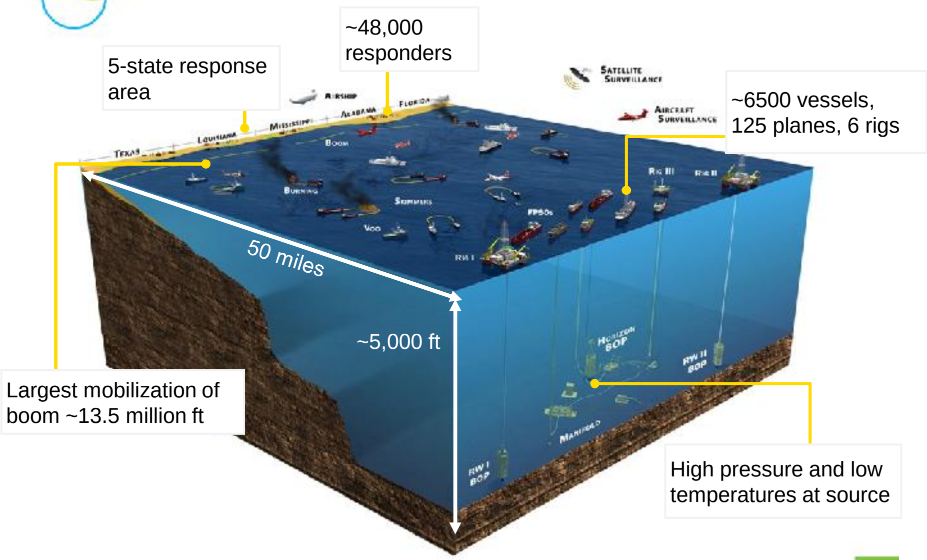
Unprecedented Scale of Response in Challenging Conditions



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Spill Response Options: The Toolbox

Mechanical Recovery:
Booms & Skimmers

Monitor &
Evaluate

Aerial
Dispersants

The goal is to design a response strategy based on *Net Environmental Benefit Analysis*

Controlled
In-Situ Burning

Subsea
Dispersants

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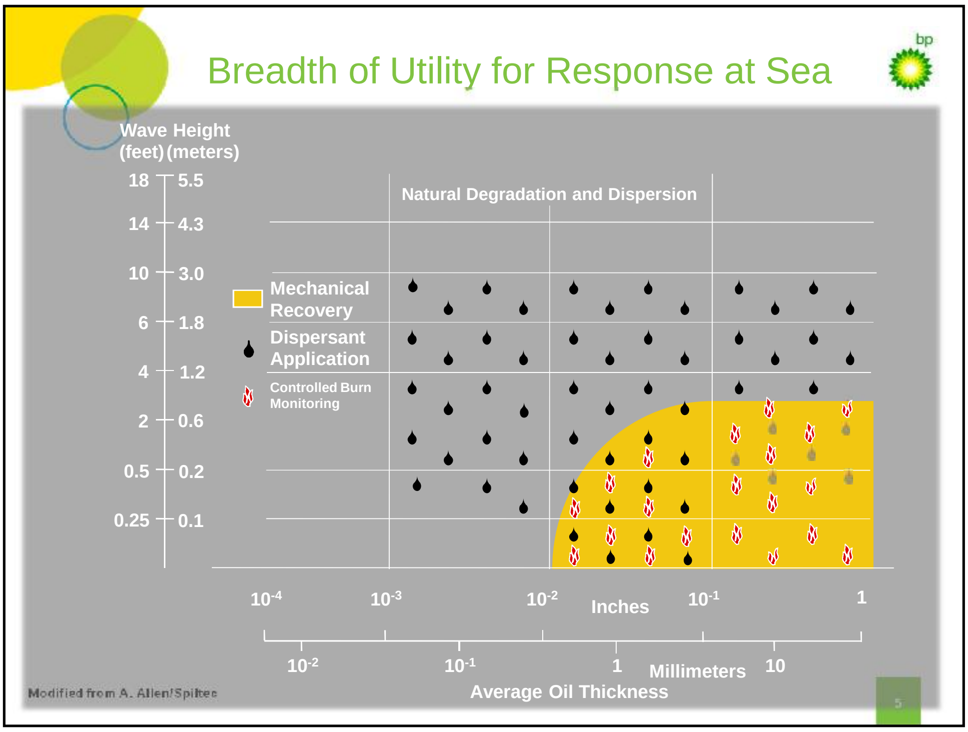
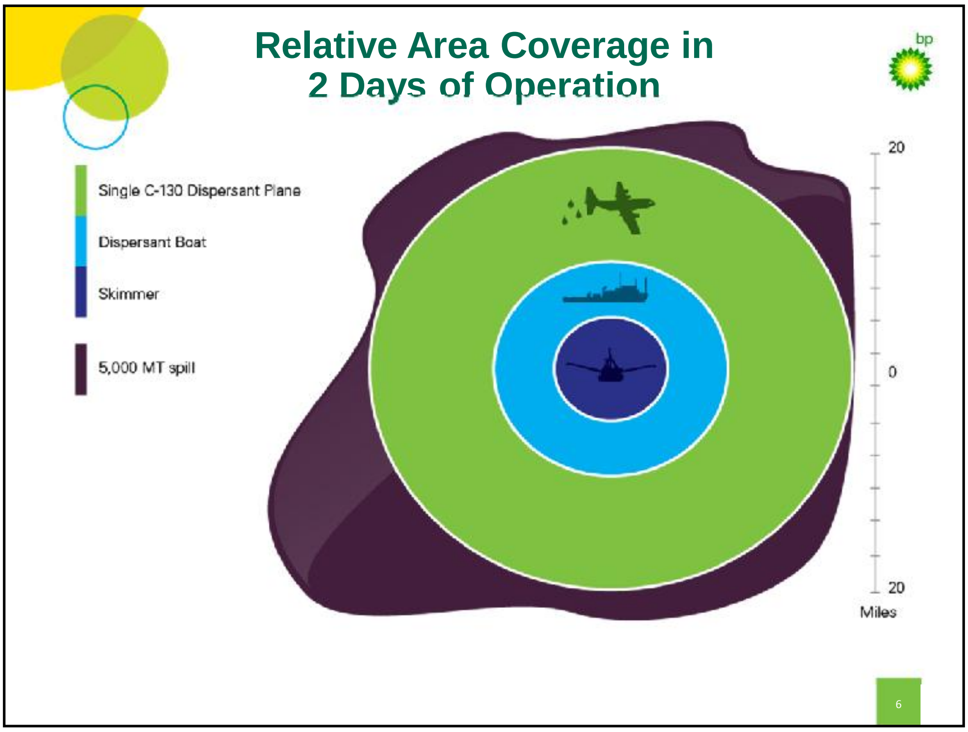
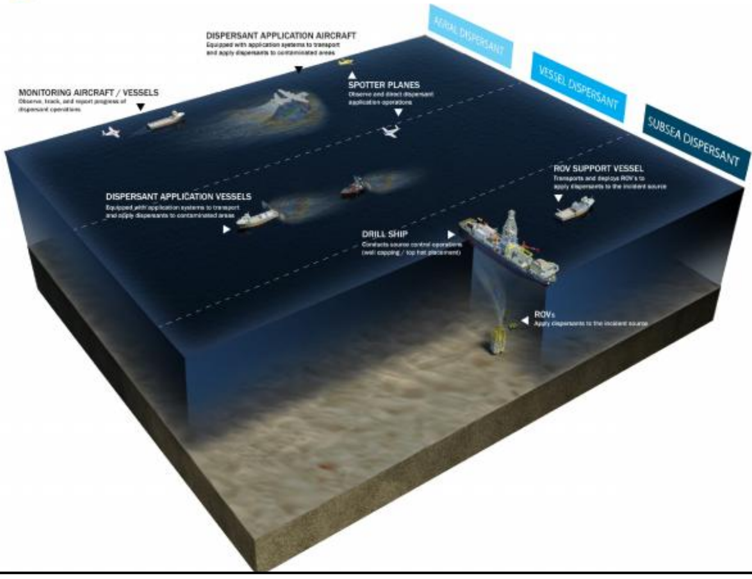


Breadth of Utility for Response at Sea
bp
Wave Height
(feet) (meters)
18 5.5
14 4.3
10 3.0
6 1.8
4 1.2
2 0.6
0.5 0.2
0.25 0.1
Natural Degradation and Dispersion
Mechanical Recovery
Dispersant Application
Controlled Burn Monitoring
10^{-4}
10^{-3}
10^{-2}
Inches
10^{-1}
1
10^{-2}
10^{-1}
1
Millimeters
10
Average Oil Thickness
Modified from A. Allen/Spiltec
5



Relative Area Coverage in
2 Days of Operation
bp
Single C-130 Dispersant Plane
Dispersant Boat
Skimmer
5,000 MT spill
20
0
20
Miles
6

Use of Dispersants in the Deepwater Horizon Incident



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Aerial Dispersant Objectives

- **Activate Assets**:
  - Ensure air spraying and support assets available for large, long term response
- **Document:**
  - Document Dispersant Application
    - Application will be reviewed by government and the public
    - Ensure all spray equipment tested and calibrated
    - Use standard application dosage for all aircraft and boats
    - Document where and when each spray sortie applied dispersant
- **Assess Impacts**:
  - Activate Science Team as part of Aerial Dispersant Group
    - Scientifically show dispersants effectiveness
    - Scientifically determine dispersants environmental impact
    - Assess alternate dispersant effectiveness in the field
- **Manage:** Establish Management and Support of Operations
- **Report:** Accurate and Reliable Source of Information on Dispersants

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DWH Aerial Dispersant Specifics

- ~ 973,000 gallons of dispersant applied
- 90 days of Continuous Operations
- 61 days of Spray Operations
- 20 aircraft (12 spray aircraft, 8 spotters)
- 412 Spray Sorties
- 816 Spotter Sorties
- 305 mi^2 sprayed over an operating area of 18,000 mi^2 (46,620 km^2)
- ~300 Aerial Dispersant Team members
- 1:20 ratio used for surface application

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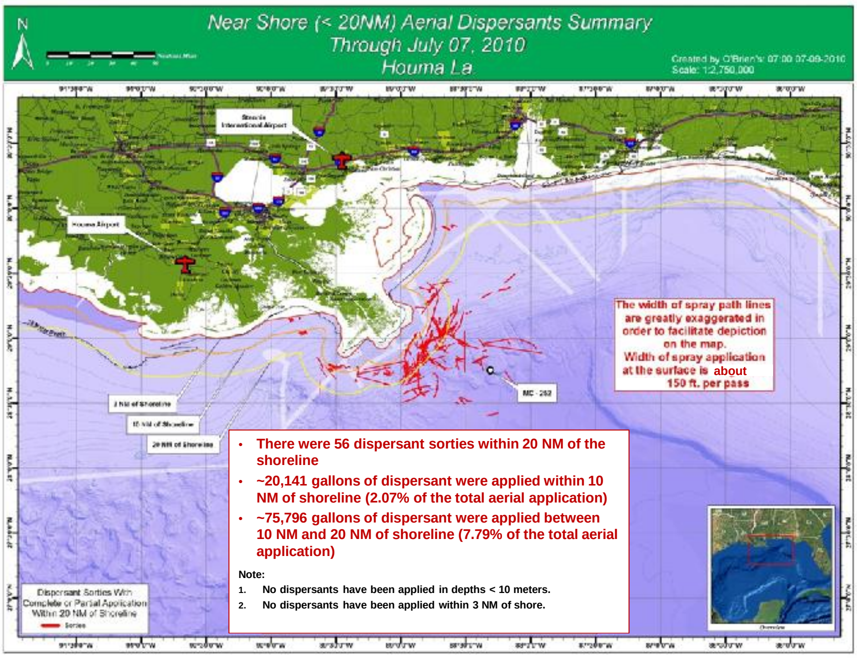

Special Monitoring of Applied Response Technologies (SMART)

> Developed by USCG, NOAA, EPA, CDC, MMS (2006)

> Key operational feedback on dispersant effectiveness

> Pre- and post-treatment observations

– Tier I: Visual observations

– Tier II: On-water monitoring for efficacy

– Tier III: Additional monitoring

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Surface Application Field Studies

> Dispersion of oil observable at 1 m below the slick

– Some natural dispersion occurring

– Dispersant application increased oil concentrations

> <u>Dispersed oil observed up to approx 10 m below a slick</u>

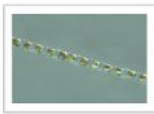
> Results of chemical analyses consistent with field fluorometry measurements

> No <u>acute </u>toxicity response observed <u>in mysids, brown shrimp or menidia</u>

Mysidopsis bahia

Farfantepanaeus duorarum

Menidia beryllina



Skeletonema costatum

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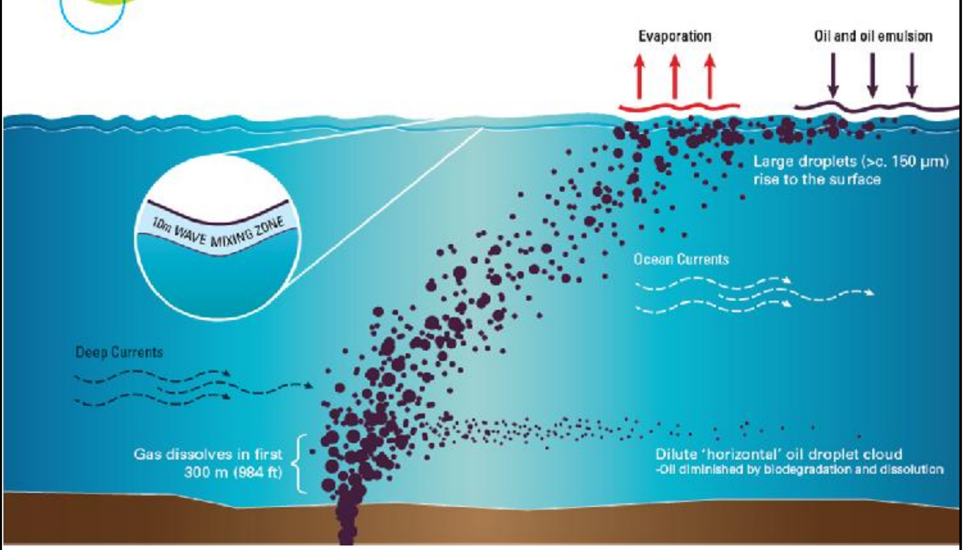
Oil in the Sea from a Deep Sea Release



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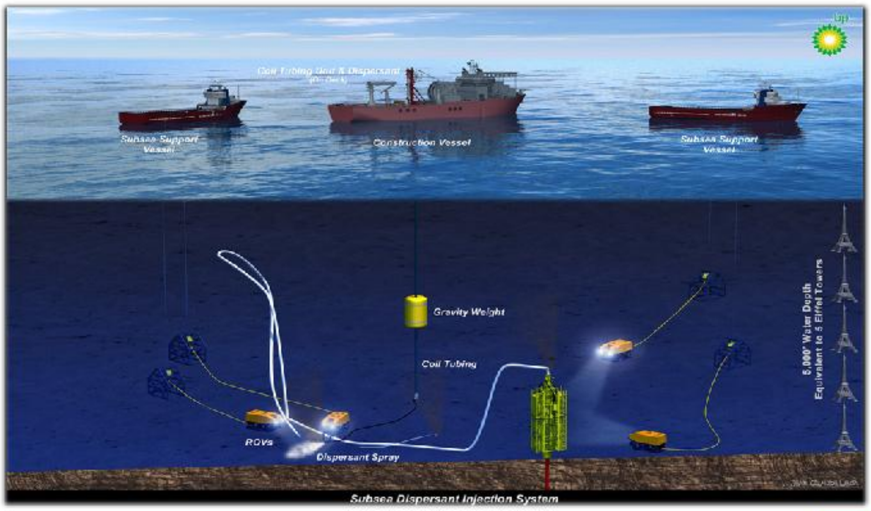
Subsea Injection System Model



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Subsea Dispersant Objectives

- **Activate Assets**:
  - Subsea dispersant injection had never been attempted.
- **Document:**
  - A plan for subsea injection
    - At the riser head (on the sea floor)
    - Depth of approximately 1.5 km
- **Goals:**
  - minimize oil droplets forming a surface slick.
  - minimize risks to shoreline/surface habitats.
  - minimize VOCs at the surface for containment work and relief well
- **Assess Impacts:**
  - Assess potential impacts of subsea dispersant use
- **Manage:** Establish Management and Support of Operations
- **Report:** Provise Accurate and Reliable Information on Dispersants

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DWH Dispersant Specifics

- ~ 747,000 gallons of dispersant applied
  - 10,000-15,000 gallons per day
- Application directed by FOSC and was Limited to < 15,000 gallons per day per the 26 May 2010 Addendum 3
- 62 days of Injection Operations
  - 15 May-15 July 2010
- Recognized Response As Historical Event
- Case Study for using dispersants in the US.

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Release Site May 9: Prior to Injection

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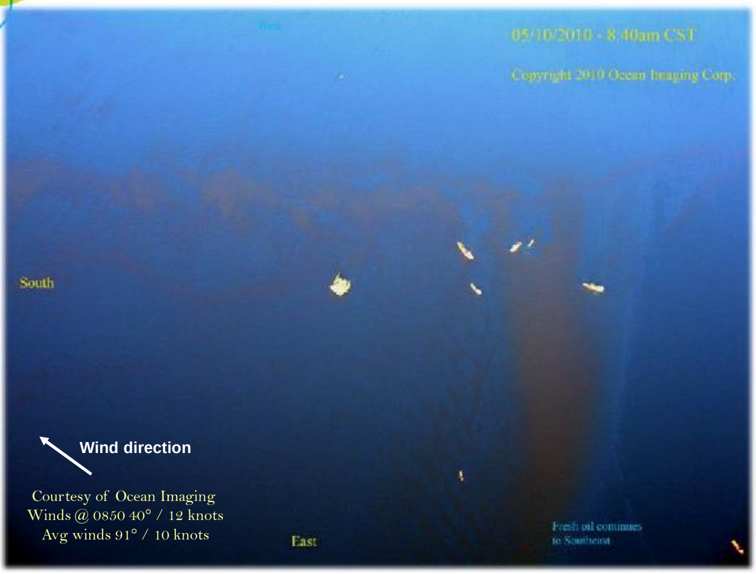
May 10: 3 hrs of Injection



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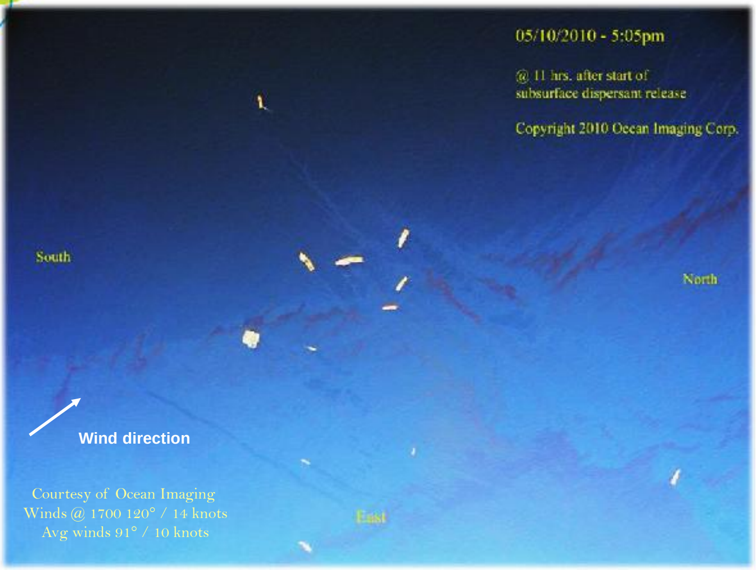
May 10: 11 hrs of Injection



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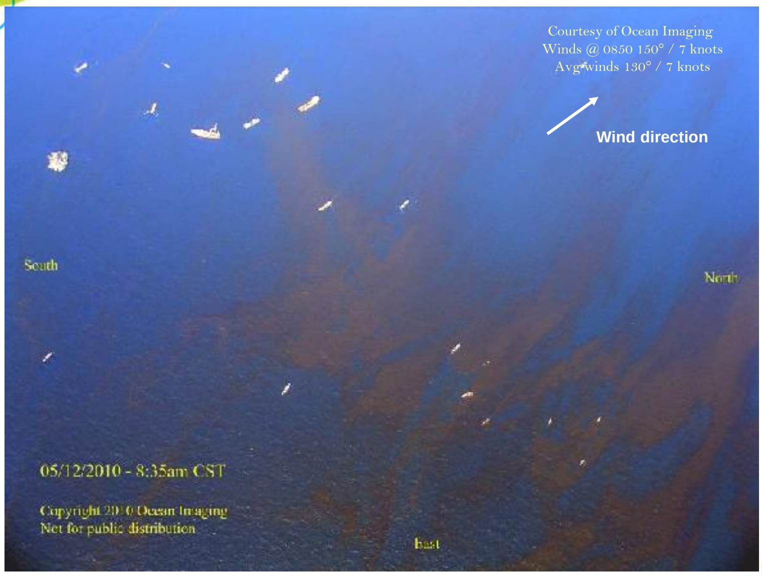
May 11: 5 hrs After Injection Ended

20

May 12 28 hrs After Injection Ended



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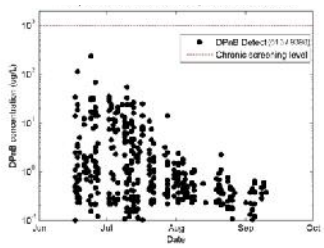
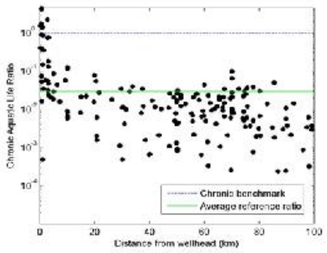
Offshore – Deepwater Monitoring

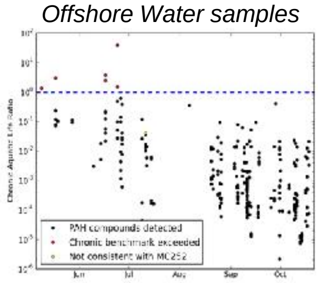
Dispersants in Water



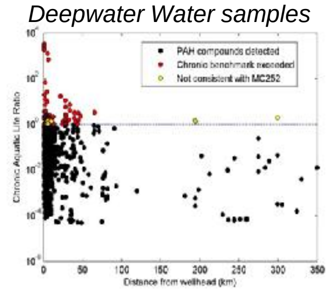
Deepwater Sediment samples



Offshore Water samples



Deepwater Water samples



> http://bp.concerts.com/gom/brooksmccallwatersamplingexpedition_080210.htm

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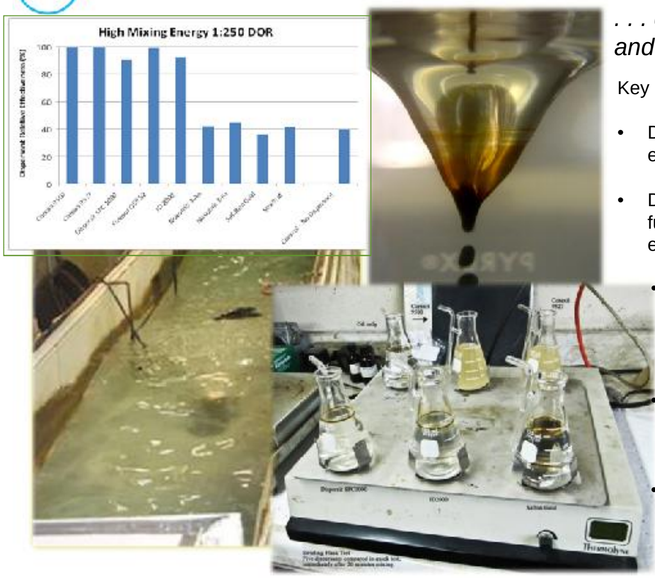
Dispersant Selection: Responding to the EPA Directive



. . . dispersant toxicity and efficacy

Key Points:

- Dispersant use involves ecological tradeoffs
- Dispersed oil toxicity is a function of dispersant effectiveness
  - Effective dispersant results in more bioavailability in the nearby water column
  - Dispersant efficacy is key to selection: use less product
  - Smaller droplets result in enhanced biodegradation

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Summary

- Dispersants are an important part of the oil spill response toolkit
- Under the appropriate circumstances, dispersant use can reduce safety risks and overall environmental impacts
- Dispersant selection and application based on science and government approval; pre-planning is very useful.
- Both industry and governments can do further research building on the experiences gained from the DWH response

The Value of Dispersants for Oil Spill Response

Dr. Thomas Coolbaugh
ExxonMobil Research & Engineering
Fairfax, Virginia

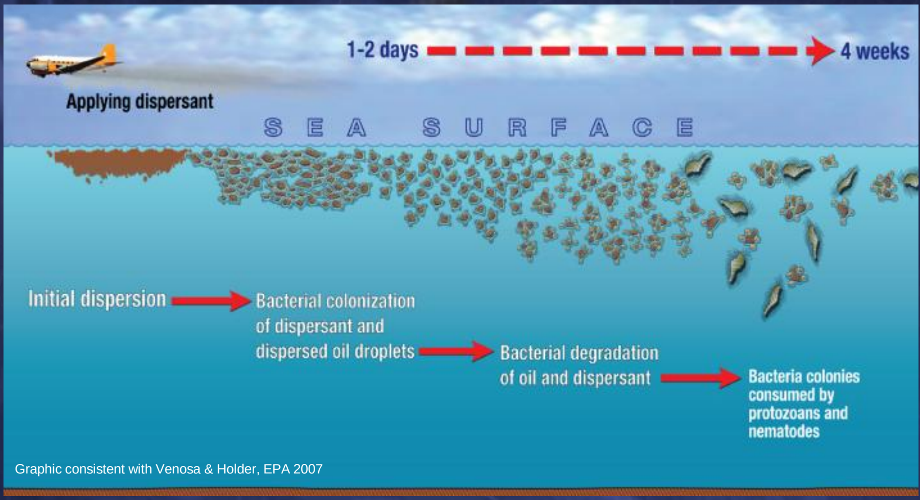
ExxonMobil

Introduction

Topics of Discussion

- Oil spill response options
- Background on dispersants
- Deepwater Horizon Incident
- Summary

Dispersants Enhance Removal of Oil from the Environment Through Biodegradation



Graphic consistent with Venosa & Holder, EPA 2007

Spill Response Options: *The Toolbox*

Mechanical Recovery: Booms & Skimmers

In-Situ Burning

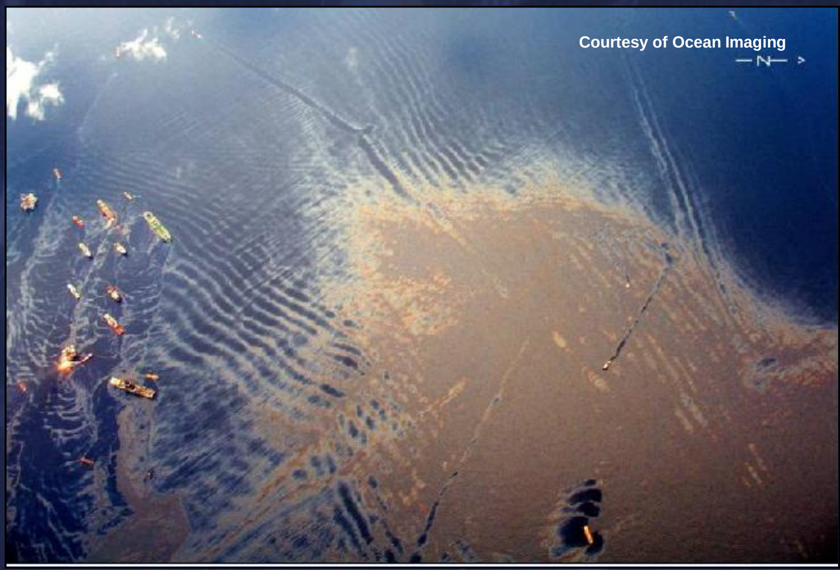
Monitor & Evaluate

Aerial Dispersants

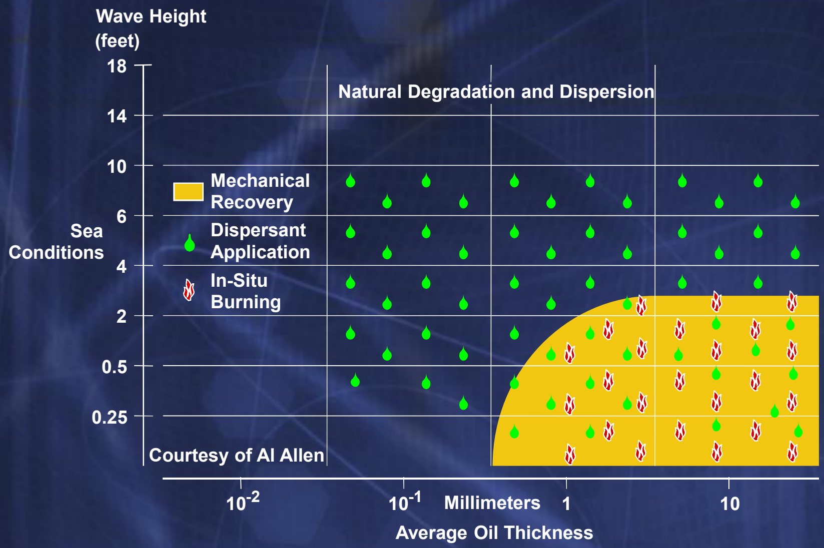
Subsea Dispersants

The goal is to design a response strategy based on *Net Environmental Benefit Analysis*

Encounter Rate is Key to Offshore Response

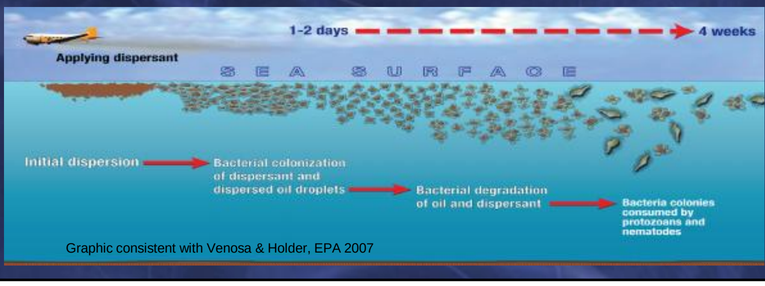


Spill Conditions Limit Response Options



Dispersants – What are they?

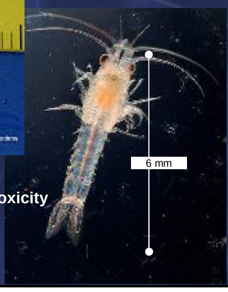
- Dispersants are solutions of surfactants dissolved in a solvent
- Surfactants reduce oil-water interfacial tension – allows slicks to disperse into very small droplets with minimal wave energy
- Dispersed oil rapidly dilutes to concentrations <10 ppm within minutes, <1 ppm within hours, ppb range within a day
- Each dispersed oil droplet is a concentrated food source that is rapidly colonized and degraded by marine bacteria
- Dilution allows biodegradation to occur without nutrient or oxygen limits



Graphic consistent with Venosa & Holder, EPA 2007

Environmental Impacts

- Toxicity of oil > toxicity of the dispersant
- Modern dispersants use ingredients found in household products



Organisms used in EPA's toxicity tests

Other Uses of Corexit 9500 Ingredients (from Nalco website)

Corexit 9500 Ingredients	Common Day-to-Day Use Examples
Span 80 (surfactant)	Skin cream, body shampoo, emulsifier in juice
Tween 80 (surfactant)	Baby bath, mouth wash, face lotion, emulsifier in food
Tween 85 (surfactant)	Body/Face lotion, tanning lotions
Aerosol OT (surfactant)	Wetting agent in cosmetic products, gelatin, beverages
Glycol butyl ether (solvent)	Household cleaning products
Light Hydrotreated Petroleum Distillates	Air freshener, cleaner

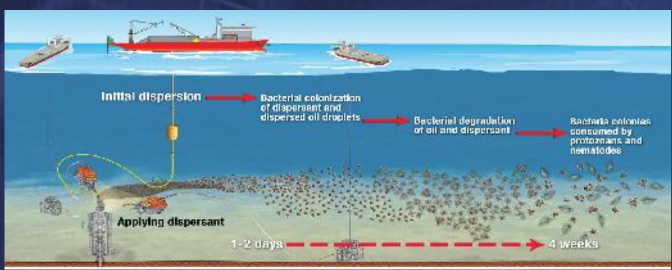
Relative Toxicity: Environment Canada Study

(96 HR Rainbow Trout LC_{50})

AGENT	TOXICITY (ppm)
Palmolive Dish Soap	13
Sunlight Dish Soap	13
Mr. Clean	30
Corexit 9527	108
BP 1100 WD	120
Corexit 9500 (27 times less toxic than dish soap)	350
BP 1100X	2472

Subsea Injection of Dispersants

- Preliminary observations of DWH experience
- Benefits of subsea injection
- Long-term fate and effects



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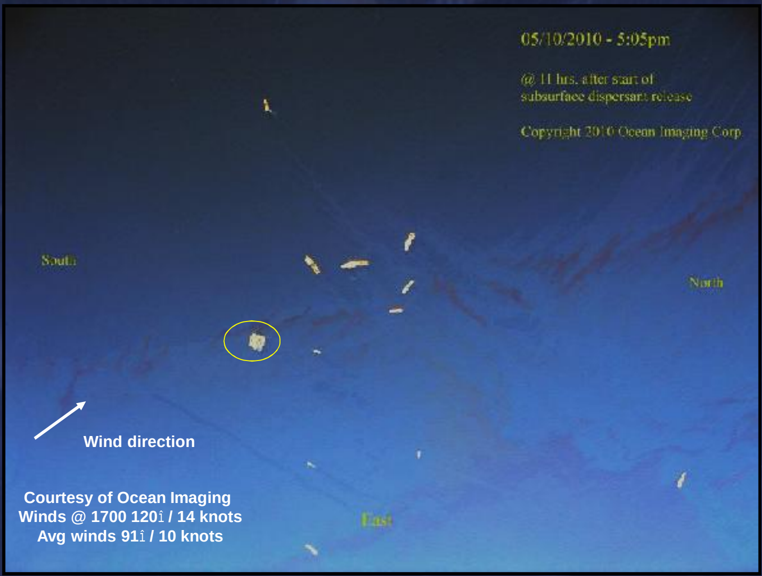
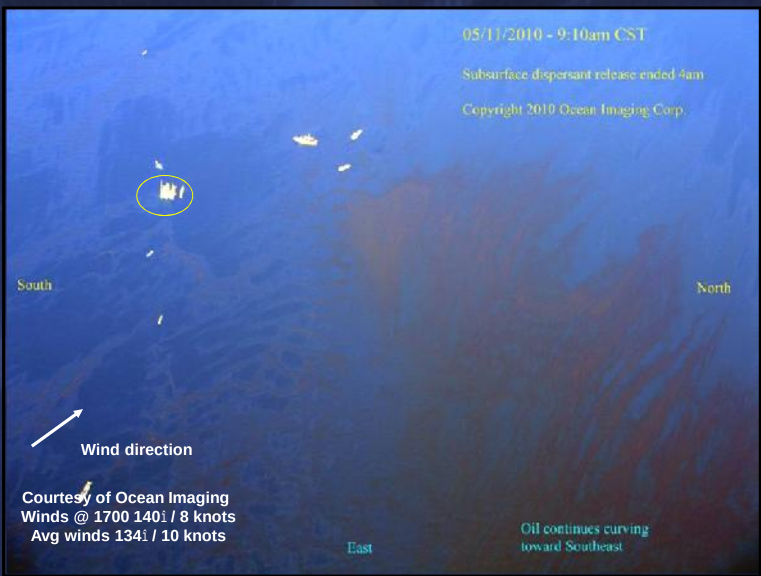
Release Site May 10: 3 hrs of Injection

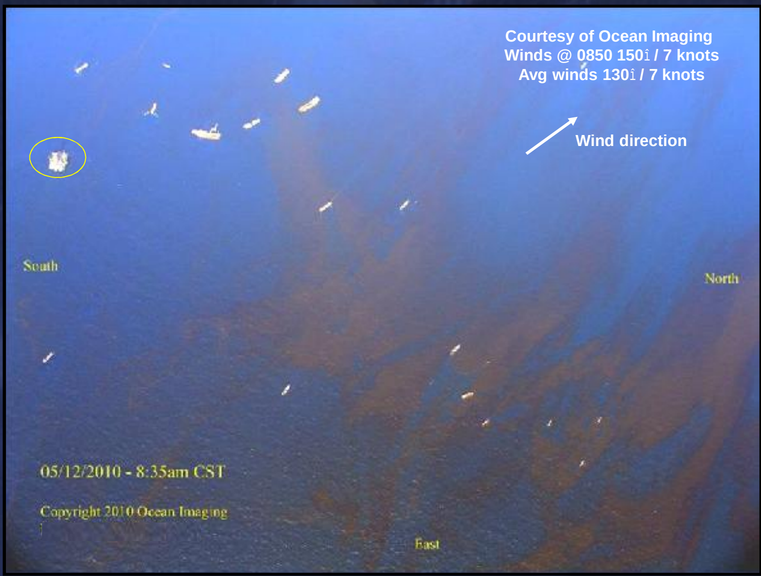
Release Site May 10: 11 hrs of Injection



Release Site May 11: 5 hrs after Injection Ended



Release Site May 12: 28 hrs After Injection Ended



Summary

- Along with prevention, robust oil spill response (OSR) is critical
- Highest priority in emergency response is human health and safety
- Basic strategy for addressing oil spilled from an offshore well
  - Respond as close to the source as possible
  - Utilize all appropriate tools to keep oil from reaching shorelines
- Dispersant use presents a beneficial tradeoff given the limitations of mechanical recovery and should be a primary response option
- Subsea injection is a step-change advance that may reduce spill impacts by an order of magnitude
- More research is needed to optimize subsea injection and better understand the long term effects of dispersed oil in deep waters

Thank you

EMSA Workshop addressing oil spill dispersant use following the Deepwater Horizon incident
26 November 2012

Deepwater Horizon Oil Spill (DWHOS): Current status regarding the DWH spill environmental impacts

Deborah French McCay
RPS ASA
South Kingstown, RI, USA
Debbie.FrenchMcCay@rpsgroup.com

Experience: Deborah French McCay

- Background
  - PhD Oceanography (Univ. of Rhode Island)
  - Modeling of oil spills since 1984
  - Developed modeling approach for evaluating exposure and injuries of oil spills for NRDAs in US
  - Applied to numerous spills to assist Government with assessments
- Role for DWHOS
  - Co-Lead of Offshore and Shelf Water Column, Fish & Invertebrate Technical Working Group (TWG) representing NOAA
  - Lead for exposure and injury quantification using modeling

EMSA Workshop addressing oil spill dispersant use following the Deepwater Horizon incident
26 November 2012

Deepwater Horizon Oil Spill (DWHOS): Sampling Techniques and Modelling Used to Support and Direct the Sampling Efforts

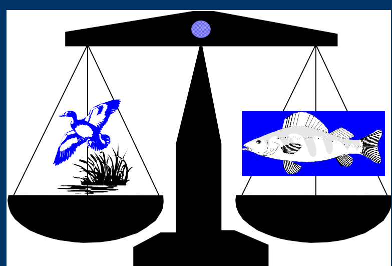
Deborah French McCay
RPS ASA
South Kingstown, RI, USA
Debbie.FrenchMcCay@rpsgroup.com

Potential Impacts and Tradeoffs of Effective Dispersant Use on Oil Spills

Application of dispersants

- Reduces impact from surface floating oil
  - on birds and other wildlife
  - on shorelines

- However, dispersant use is a trade-off with increased risks to fish and invertebrates in the water column.



Deepwater Horizon Oil Spill

- Largest oil spill in US history
  - Preliminary estimates made by Response
    - 4.1 million bbl (652 million litres; 172 million gallons) over 84 days
    - Roughly 10-30% was dispersed (65-195 million L)
- Tradeoff:
  - If it were not dispersed, more oil exposure:
    - Water surface
    - Shorelines
    - Birds, mammals and sea turtles
  - However, with dispersants, more water was affected
    - Deepwater at ~1000-1400m
    - Surface water where dispersants sprayed

Monitoring Subsurface Oil: Objectives

- Evaluate effectiveness of the subsurface dispersant applications
  - Oil droplet sizes
  - Chemistry
- Track oil transport and fate of the oil hydrocarbons and dispersants
- Measure concentrations of
  - Oil droplets
  - Dissolved components
  - Dispersant components
- Evaluate potential exposure of biota and toxicity
  - Water column organisms
  - Impacts

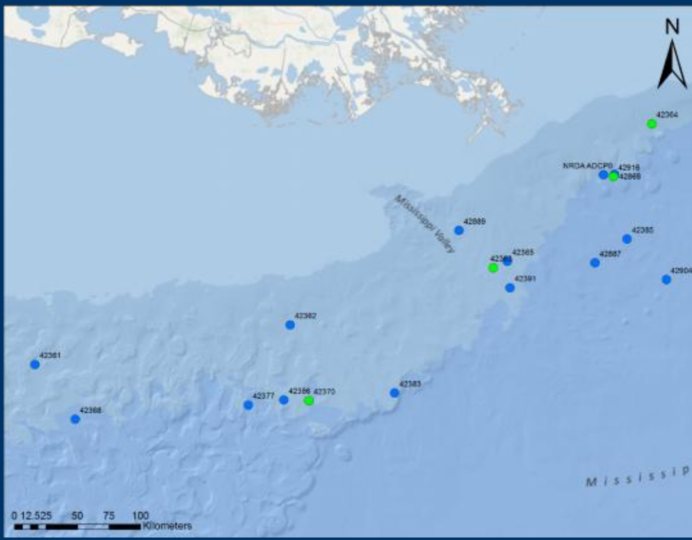
Field Sampling Strategy for Subsurface Oil: Sampling Locations (x, y)

- Determined by use of transport modeling (SIMAP)
  - Currents = f(depth, time)
    - Detailed 4-d model for deepwater was not available in real time with sufficient accuracy for directing adaptive sampling
    - Used measured currents by the ADCPs at the wellhead and nearby offshore areas (available on NOAA website)
  - Vertical rise rate of oil droplets – currents vary by depth in the water column
    - Rise rate = f(droplet size) – larger rise faster
- Determine direction from wellhead where
  - Various droplet sizes should occur
  - Dissolved aromatic hydrocarbons should be highest
  - Dispersant components may occur

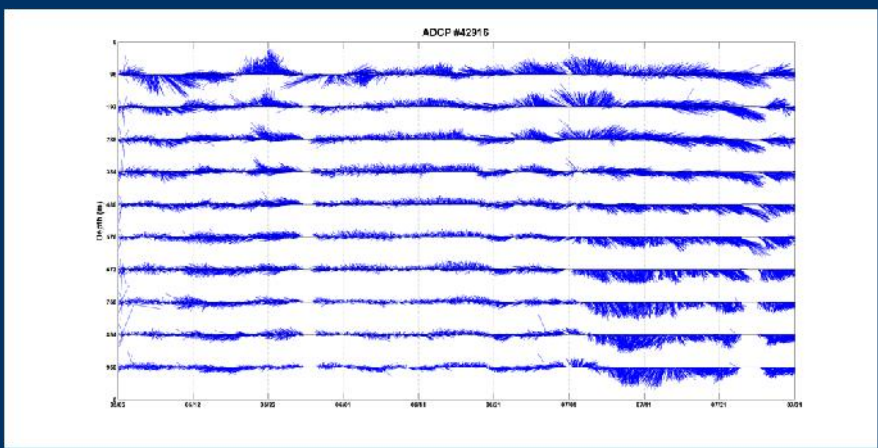
Real Time Hydrodynamic Models

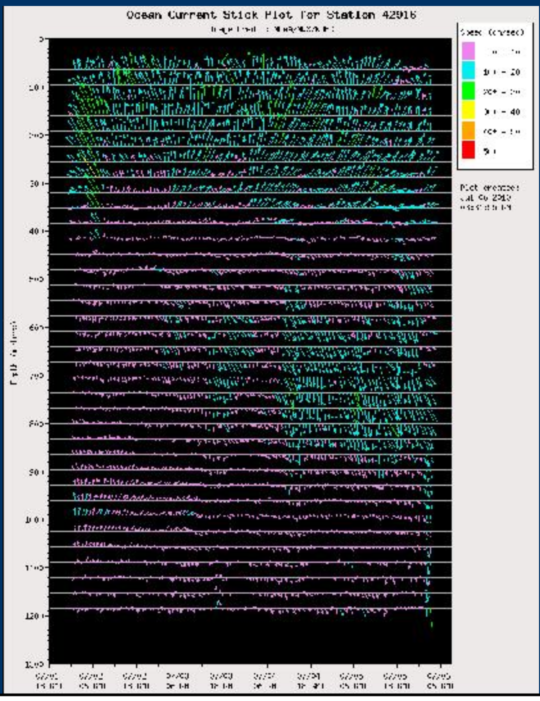
- 3-d and time varying models covering the offshore waters of the northeastern Gulf of Mexico
- Available operational forecast models (e.g.)
  - NGOM – NOAA's implementation of POM
  - NRL GLOBAL HYbrid Coordinate Ocean Model (HYCOM) (Navy)
  - Various models run by academics
- However
  - Some were not covering entire domain of spill
  - Some were not accessible in real time in a down-loadable and usable format
  - Available model outputs in real-time forecast mode were not accurate enough to capture details needed to track the subsurface oil plume

Available ADCPs (Current Meters) During April - July 2010



Example Vector Plot Time Series for ADCP at Wellhead





As seen in Real Time: Prior 5 days

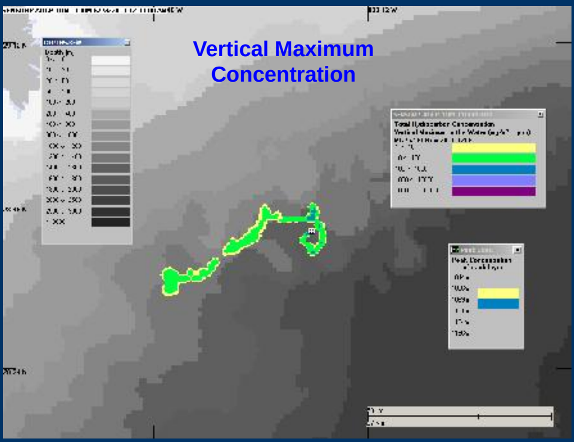
Variable over Depth

Significant changes on hourly-daily time scale

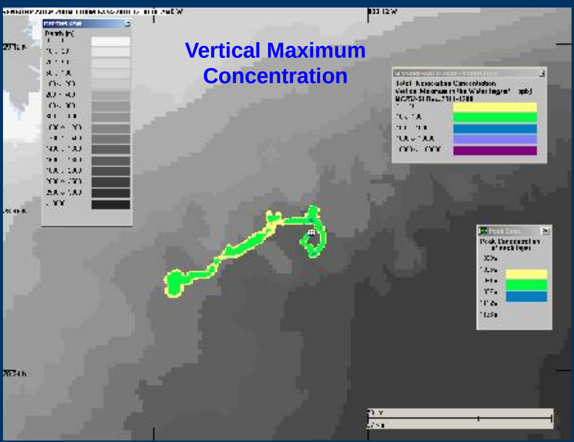
Tracking the Oil Transport – A Complex Problem

- **Currents**
  - **Temporal variability**
  - **Vertical shear**
  - **Weakly forced: Horizontally medium and small scale variability dominates**
- **Sensitivity to droplet size distribution**
- **Sampling logistics for data acquisition**

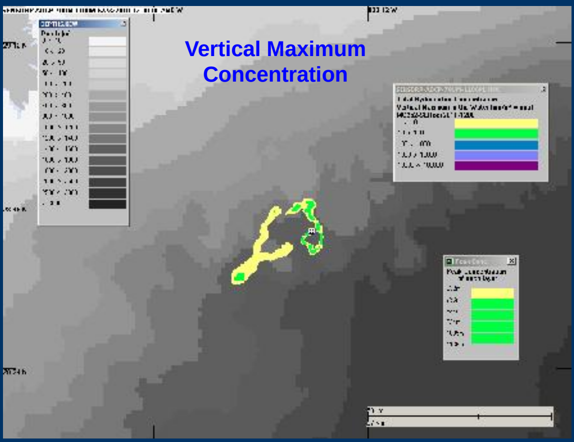
Example: Concentrations of total hydrocarbons if all released as 1 mm droplets from Jun 4 – Jun 23



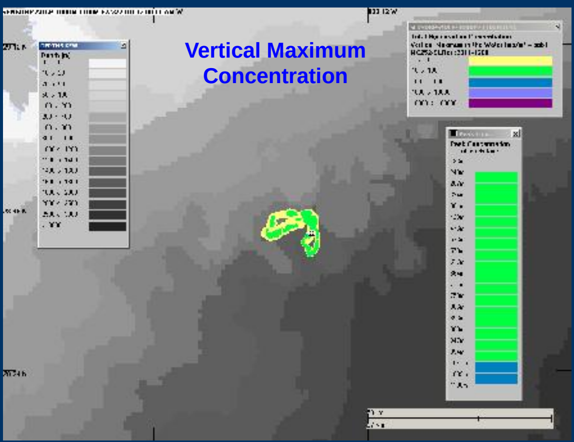
Example: Concentrations of total hydrocarbons if all released as 20 mm droplets from Jun 4 – Jun 23



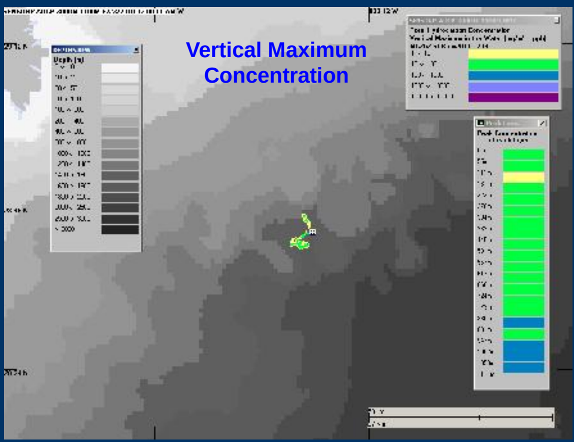
Example: Concentrations of total hydrocarbons if all released as 70 mm droplets from Jun 4 – Jun 23



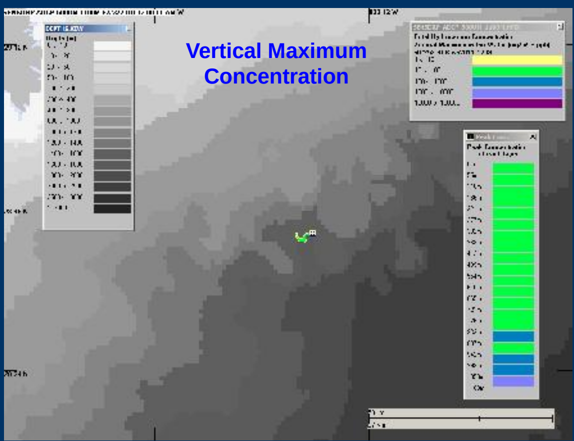
Example: Concentrations of total hydrocarbons if all released as 100 mm droplets from Jun 4 – Jun 23



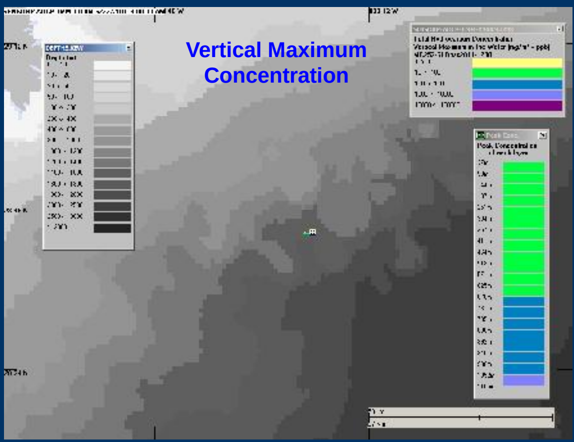
Example: Concentrations of total hydrocarbons if all released as 300 μm droplets from Jun 4 – Jun 23



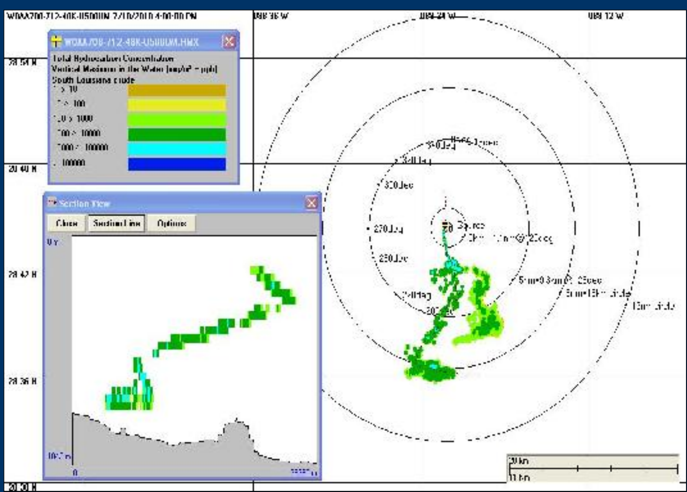
Example: Concentrations of total hydrocarbons if all released as 500 μm droplets from Jun 4 – Jun 23



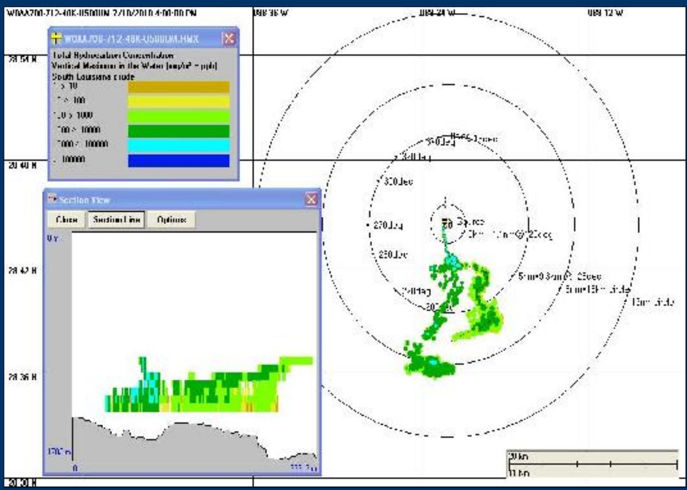
Example: Concentrations of total hydrocarbons if all released as 1 mm droplets from Jun 4 – Jun 23



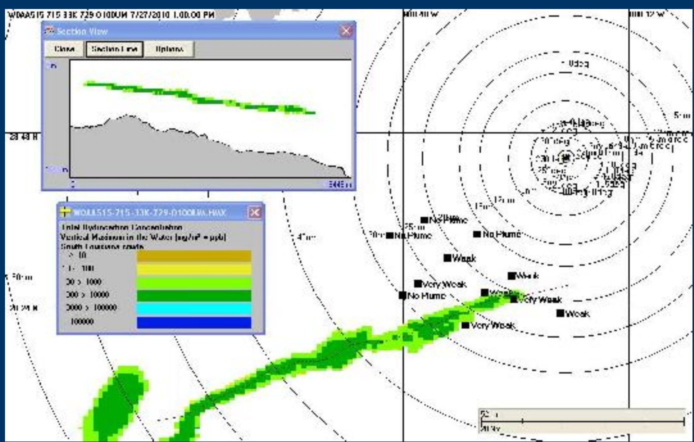
Where to Sample? Modeled Release July 8-10 (mixed droplet sizes): 2010 July 10 at 1600 CDT Using Real-Time Interpolated ADCP Data



Modeled Release July 8-10 (mixed droplet sizes): on Jul 10 at 1600 CDT



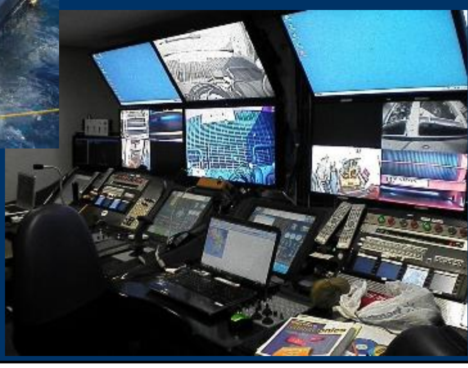
Modeled Release 15 May to 15 July: on Jul 27 at 1300 CDT – 100um Droplets



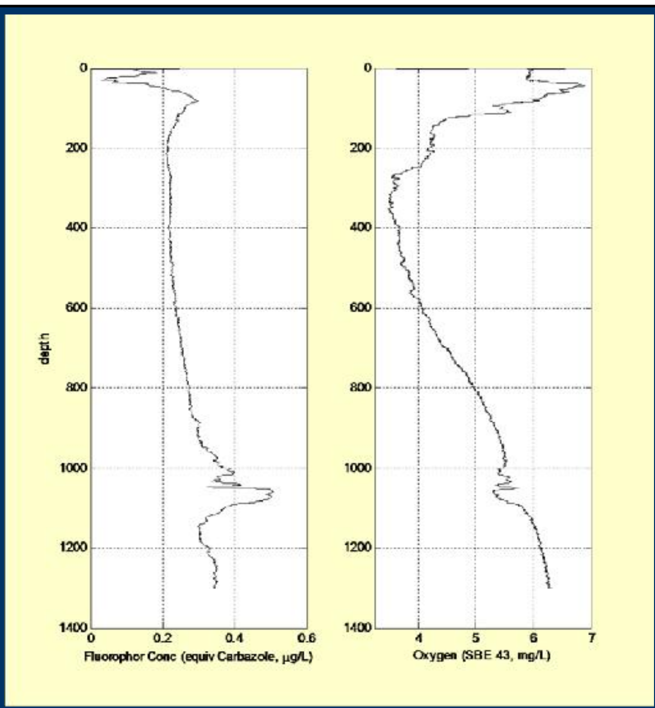
Field Sampling Strategy for Subsurface Oil: Vertical Sampling

- Real-time sensor measurements
  - – CTD (temperature, salinity vs depth)
  - – Fluorometers – indicators of oil
    - CDOM (for > 1ppm)
    - Turner Cyclops (for >100 ppb)
    - Aquatracka (for >0.1 ppb)
  - – Dissolved oxygen sag (indicating degradation)
  - – Optical
    - ROV high definition images
    - Image analysis systems (Holocam, VPR, SIPPER)
- Chemistry samples

ROVs Used to Sample to Allow Comprehensive and Focused Sampling



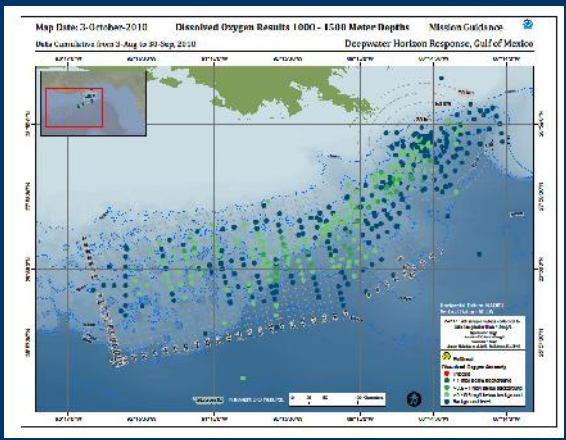
Examples of Vertical Casts



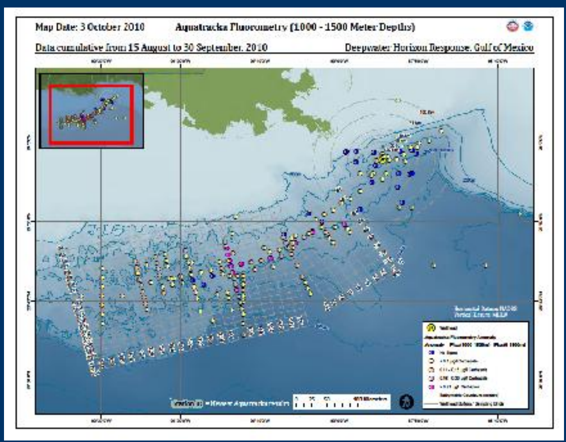
Field Sampling for Subsurface Oil: Measurements

- Filtered and whole water samples
  - Dissolved vs particulate oil as droplets
  - Chemistry:
    - Hydrocarbons (MAHs, PAHs, alkanes)
    - Dispersant components (tracers)
    - Nutrients, organic carbon, suspended particulate matter
- Images (photography, video, image analysis systems)
  - Oil droplet sizes and concentrations
  - Oil – Suspended particulate matter
  - Plankton
- Acoustics (particulate sizes and concentrations)

Observed (DO Sag)



Observed Aquatracka Fluorometry



EMSA Workshop addressing oil spill dispersant use following the Deepwater Horizon incident
26 November 2012

Deepwater Horizon Oil Spill (DWHOS): Current Status of the Analysis and On-going Assessment of the Dispersed Oil Monitoring and DWH Oil Spill Impacts

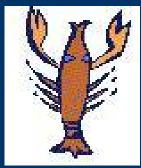
Deborah French McCay
RPS ASA
South Kingstown, RI, USA
Debbie.FrenchMcCay@rpsgroup.com

NRDA: Offshore and Shelf Water Column, Fish & Invertebrate Technical Working Group (TWG): Approach

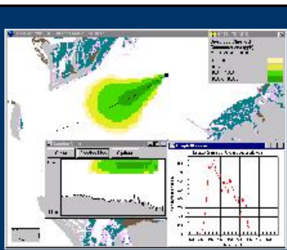
- Evaluate
  - Pathways and fate of oil
  - Exposure of fish and invertebrates in the water column
  - Injuries resulting from exposure
- Quantify exposure and injuries
  - Modeling combined with field data analysis
  - Use site- and event-specific data, as available and appropriate for model inputs and output comparisons

Field-Based Assessment

- *Comprehensive* field sampling of *all* injuries
  - Spills in general
    - either not feasible or
    - too costly to be justifiable
  - In DWH not feasible
- Difficult to quantify
  - Scale
    - Over large area and potentially depth range
    - Timing – Immediate (hour, days, weeks) to long term (months, years)
  - Ephemeral evidence
  - Natural variability
    - Baseline?
    - Signal detectable over the noise?



Modeling



- Provides scientifically-based estimates of exposure and injury, based on:
  - Previous research and scientific analysis
  - Field data:
    - Historical data in local and reference areas
    - Event- and site-specific data
- Advantages
  - Completes mass balance
  - Quantifies exposure and injuries
  - Differentiates background from spilled contamination
  - Objective measure that falls out of what is known and scientific understanding

Transport and Fate Modeling

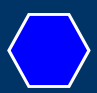
- Modeling is considering
  - Hydrodynamics (currents) – considering several
    - Operational models
    - Hindcasts of 2010
  - Winds – Observations and available models, e.g.:
    - NCEP 12-km NAM forecasting
    - 32-km NCEP NARR reanalysis
    - Navy NOGAP (1/2 degree) & 27-km COAMPS
    - Ocean Weather hindcast
  - Oil transport and fate modeling
    - Near-field: blowout (buoyant plume)
    - Far-field: SIMAP (3d transport and fate)

Oil Components – Varying Fate and Effects

C-C-C-C-C-C

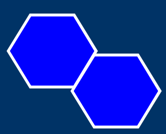
Aliphatics = Straight chain hydrocarbons (e.g., alkanes) –more volatile than soluble

p



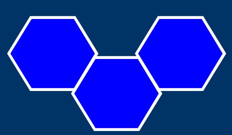
Monoaromatic Hydrocarbons (MAHs)

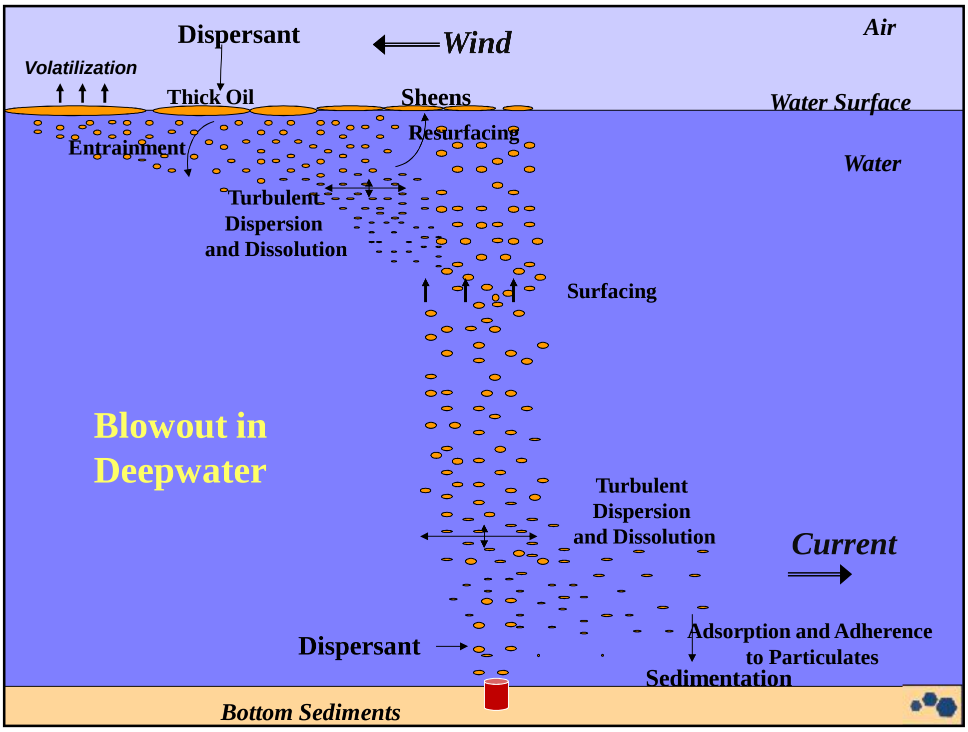
- Benzene, Toluene, Ethylbenzene and Xylenes = BTEX – highly soluble, highly volatile, moderately toxic
- Alkyl-substituted Benzenes – soluble, less volatile, more toxic

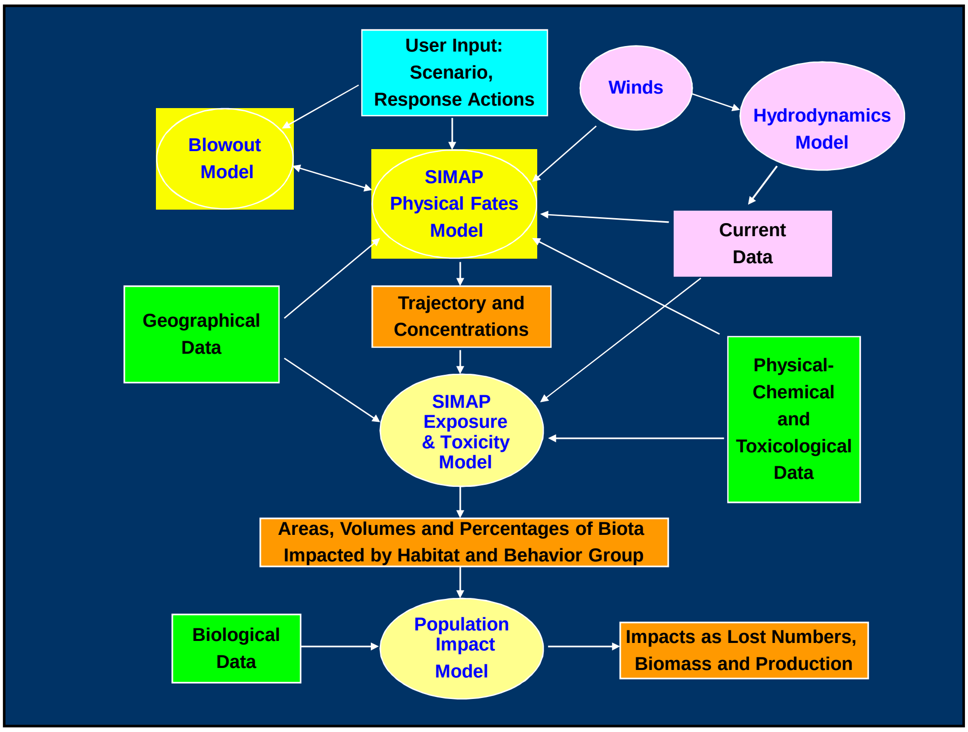


Polynuclear Aromatic Hydrocarbons (PAHs)

- Naphthalenes (2-ring PAHs)
  - soluble, less volatile, more toxic
  - with more alkyl chains, less soluble but more toxic
- 3 ring PAHs
  - Phenanthrenes
  - Fluorenes
  - Dibenzothiophenes
- 4-ring PAHs – parent compounds bioavailable
- larger PAHs insoluble




Dispersant
Wind
Air
Volatilization
Thick Oil
Sheens
Water Surface
Entrainment
Resurfacing
Water
Turbulent
Dispersion
and Dissolution
Surfacing
Blowout in
Deepwater
Turbulent
Dispersion
and Dissolution
Current
Adsorption and Adherence
to Particulates
Dispersant
Sedimentation
Bottom Sediments


User Input:
Scenario,
Response Actions
Winds
Hydrodynamics
Model
Blowout
Model
SIMAP
Physical Fates
Model
Current
Data
Geographical
Data
Trajectory and
Concentrations
Physical-
Chemical
and
Toxicological
Data
SIMAP
Exposure
& Toxicity
Model
Areas, Volumes and Percentages of Biota
Impacted by Habitat and Behavior Group
Biological
Data
Population
Impact
Model
Impacts as Lost Numbers,
Biomass and Production

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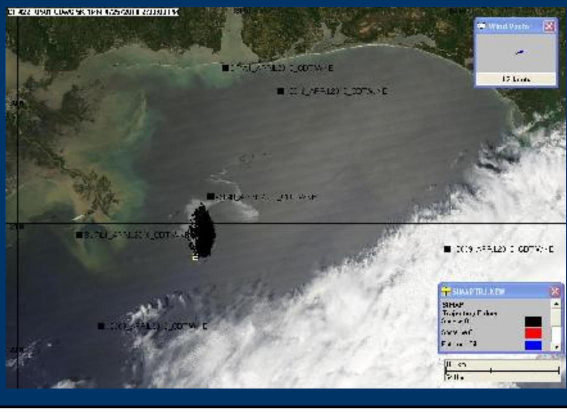
Oil Fates Modeling

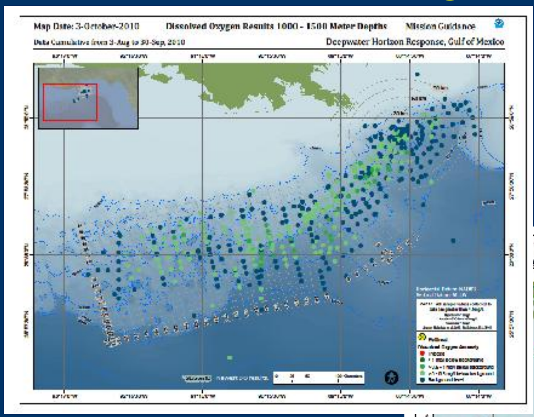
- Compare to
  - Observed oil movements
  - Shore oiling
  - Concentrations
    - Droplets in water column
    - Dissolved hydrocarbons
  - Instrument sensors
    - Fluorometers
    - Dissolved oxygen
  - Sedimented oil hydrocarbons

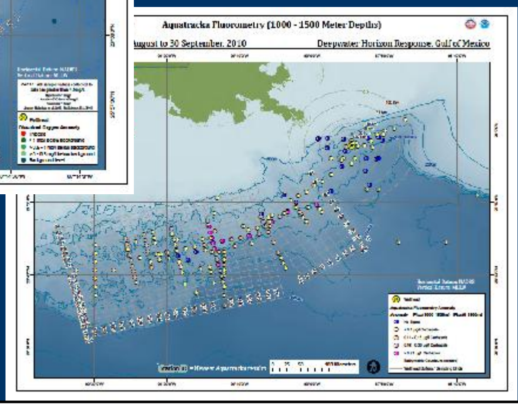


Water Column Data Related to Oil Fate

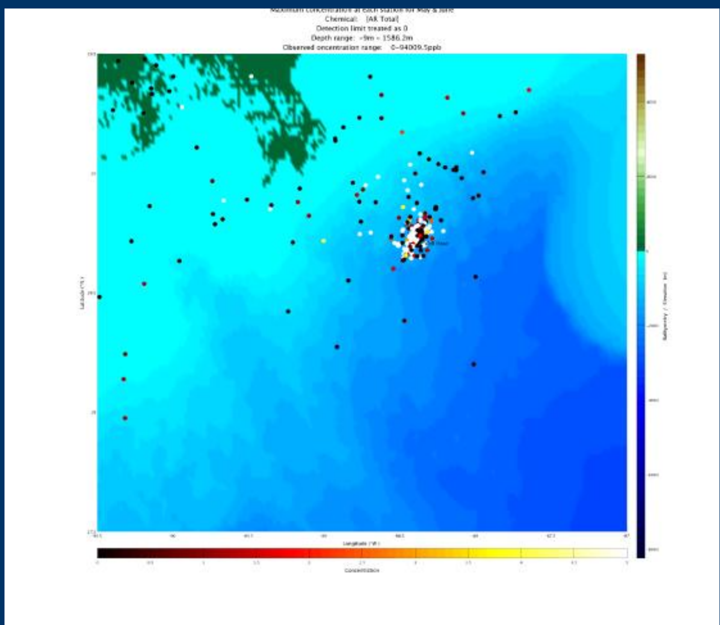
- Response and other data collections
  - Response monitoring and SMU
  - IOOS, Navy, BOEMRE
  - Academic cruises
- NRDA cruises to collect field data
  - 14 cooperative cruises in 2010 to sample water
    - CTD, DO and fluorescence
    - Chemistry [Hydrocarbons, nutrients, etc.]
    - Oil droplet sizes and densities, particulates
  - 2011:
    - Sediment sampling (5 cruises)
    - Seep evaluations – fall 2011
- Data analysis – on-going

Observed: DO Sag and Fluorometry

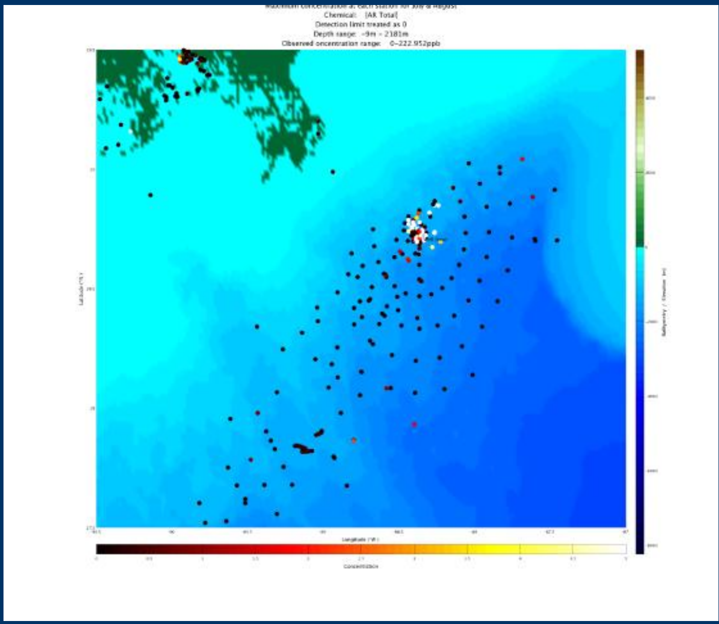




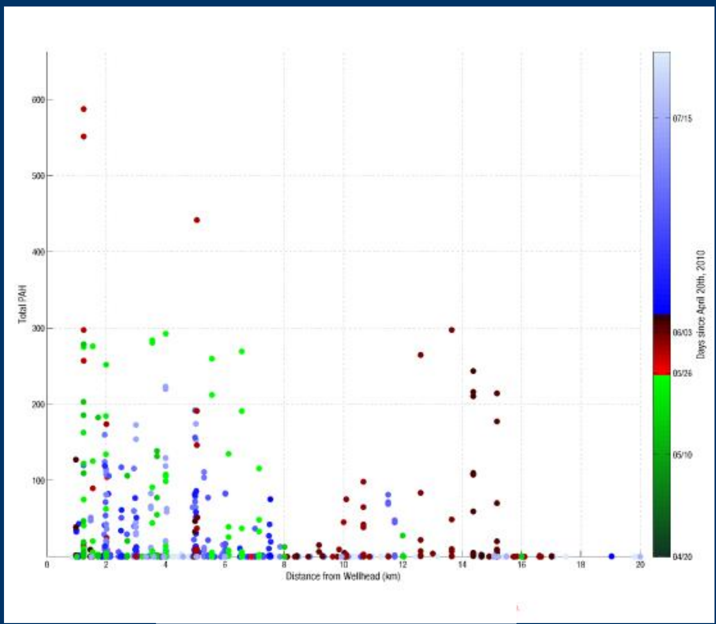
Total PAH Samples: May & June



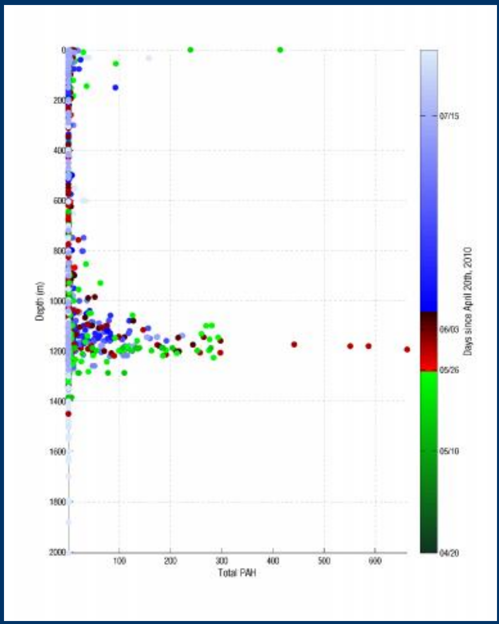
Total PAH Samples: July & August



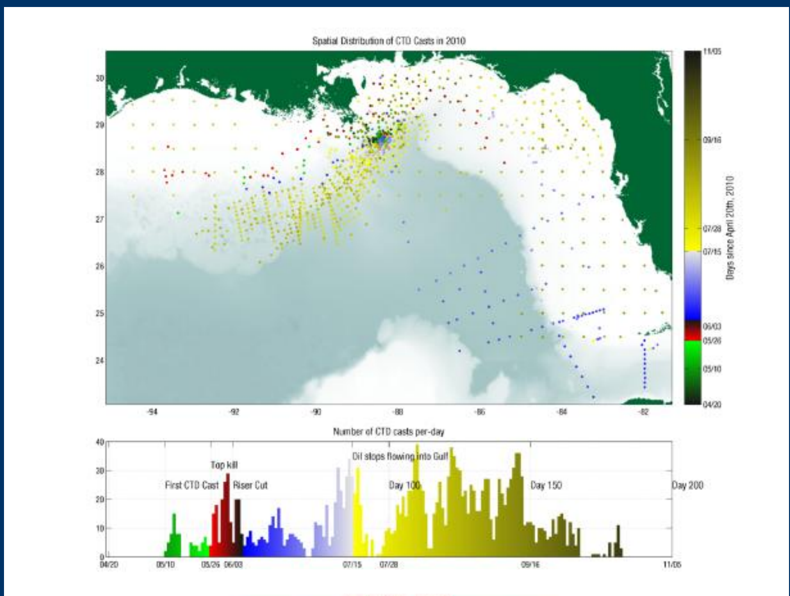
Total PAHs: Distance from Wellhead and by Date



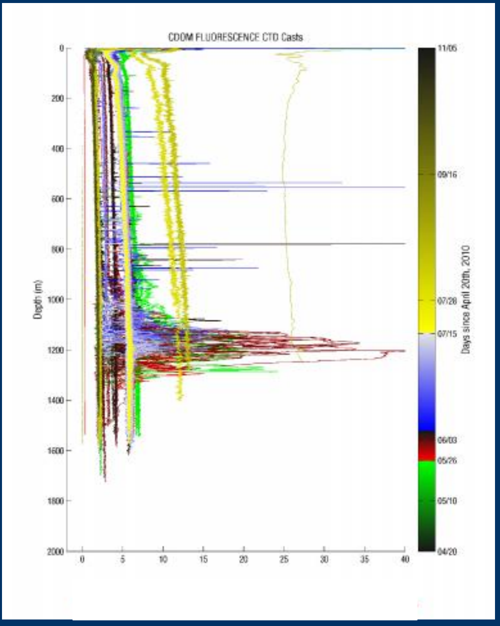
Total PAHs: by Depth and Date



CTD Casts in 2010



Fluorometry Data: by Depth and date



Un-verified Data Subject to Change

Zones of the Water Column

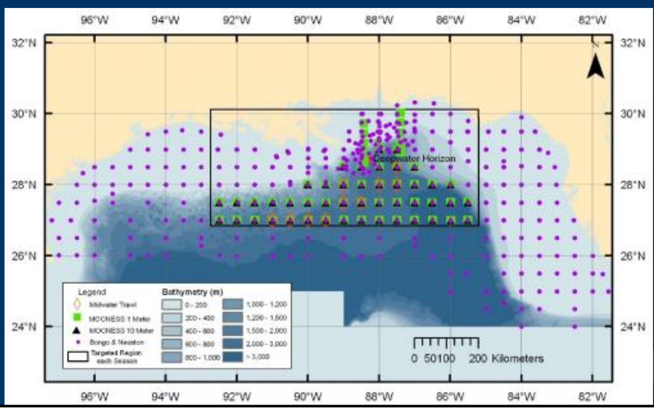
Fish and Plankton Activities

- Modeling and Data Analysis
  - Biological: Densities, life histories, behaviors
    - Existing information
      - NMFS SEAMAP Program
    - New data collections
  - Effects evaluations
- Cruises
  - Cooperative cruises each season
    - Plankton imaging systems
    - Bongo-neuston = Upper water column plankton
    - 1-m MOCNESS = deepwater plankton
    - 10-m MOCNESS = deepwater invertebrates & small fish
    - Midwater trawls = deepwater fish & large invertebrates
- Data analysis – on-going

Field Measurements for Biological Data Inputs

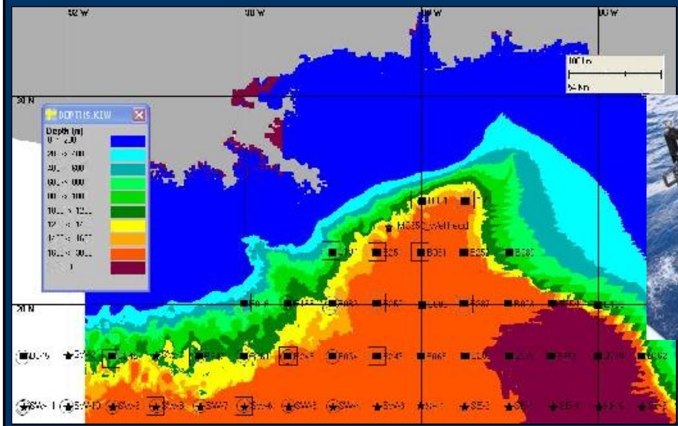
Plankton, Macroinvertebrates and Fish

- Neuston, Bongo, 1-m and 10-m MOCNESS, Mid-water Trawl nets
- Plankton Imaging
- Acoustics

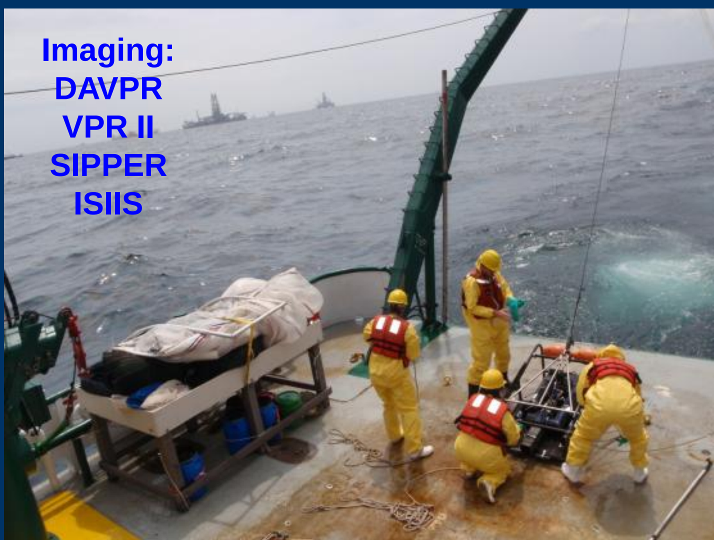


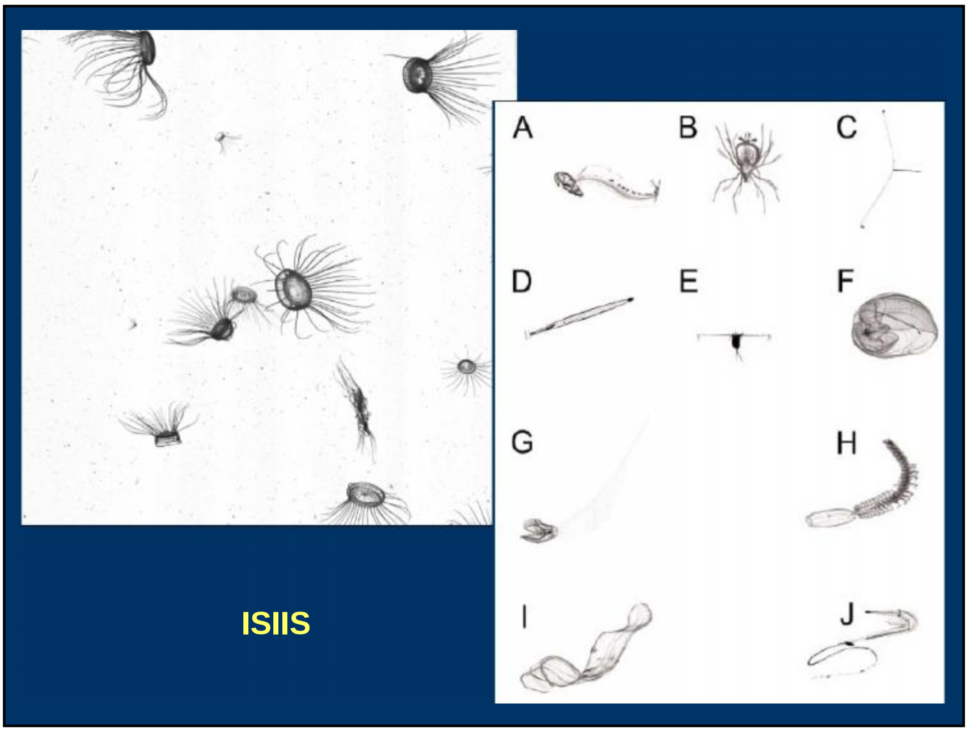
2011 Biological Sampling

- 1-meter MOCNESS Sampling
  - *Nick Skansi* – Jan7-Apr 1, deep MOCNESS tows @ 46 stations, acoustics with SIMRAD EK60, CTD, FlowCAM



Plankton Imaging Device Deployment

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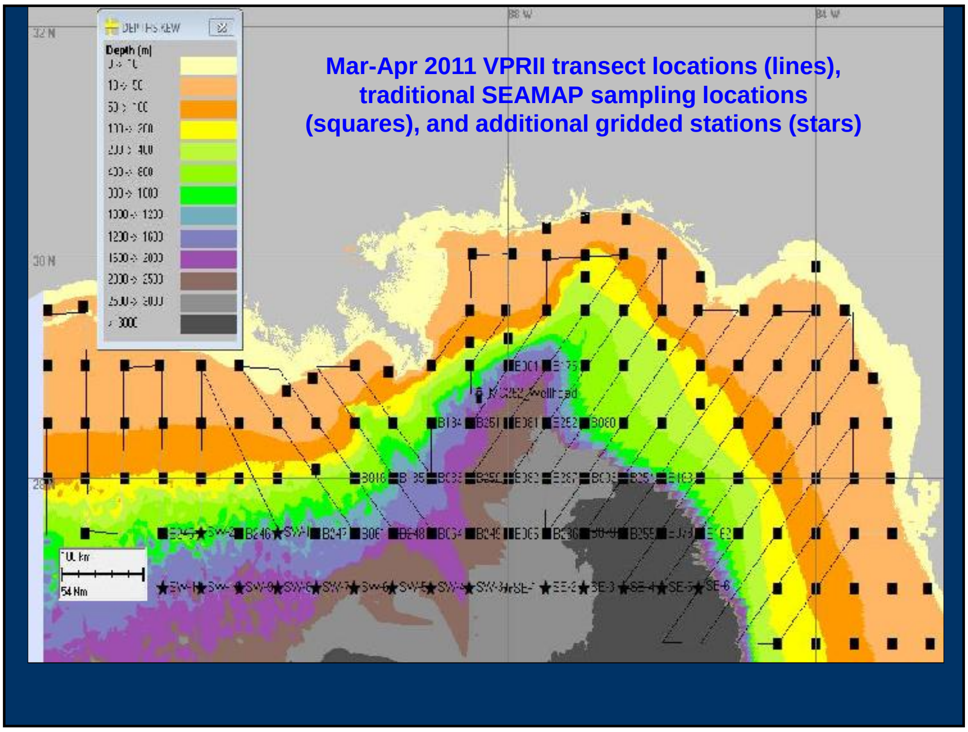
Mar-Apr 2011 VPRII transect locations (lines), traditional SEAMAP sampling locations (squares), and additional gridded stations (stars)
Depth (m)

Summary of 2011-2012 Activities

- Cruises
  - Fish and Plankton
  - Physical oceanography
  - Seeps
- Data analysis
  - Physical
  - Chemical
  - Biological
  - Mapping/GIS
- Modeling
  - SIMAP
  - Hydrodynamics
- All cooperative studies require work plans and SOWs

Ongoing Analyses

- Oil Fate Modeling & Comparison to Field Data
  - Environmental data :
    - Winds
    - Hydrodynamic modeling – evaluate several
  - Evaluate initial conditions
  - Chemistry data for calibration and verification
- Biological Distributions in Space and Time
  - Day and Night Sampling to >1500m – Vertical migration
  - Densities of biota in each depth zone
    - Ichthyoplankton
    - Zooplankton
    - Gelatinous invertebrates
    - Fish

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What could have happened if dispersants had not been used in the DWH incident?

Alun Lewis
Oil Spill Consultant

Caveats

- This presentation is based on only the publicly available information regarding dispersant use the *Deepwater Horizon* incident
  - Many facts are still not known with certainty, some will never be known and many inaccurate "facts" and opinions are widely available on the internet
- NRDA (Natural Resource Damage Assessment) studies are still in progress and are currently confidential
- At the time of preparation, some matters regarding the incident are still the subject of dispute and possible legal proceedings
- Nothing contained in this presentation constitutes anything other than the professional opinions of Alun Lewis

Information

- Facts
  - Known measured values of relevant parameter
- Interpretation
  - Parameter values inferred or calculated from some known facts (Includes modelling)
- Speculation
  - A range of values implied on basis of a previously held point of view
- Opinion
  - A single values determined according to a previously held point of view

Judging the degree of success of oil spill response

- Oil spill response actions should have reduced the damage that could have been caused by the oil
- How successful, or otherwise, was the response?
  - Cannot be judged in isolation, Compare:
    - What did happen (real events that occurred)
    - With what could have happened (events that did not happen)
    - Estimate the difference
- This is always difficult
  - And particularly difficult with the *Deepwater Horizon* incident

What did dispersant use achieve?

- The effectiveness of dispersant use cannot be directly measured at sea
  - Amount of oil on sea surface cannot be accurately determined
    - There is no remote sensing system capable of doing this
  - Amount of dispersed oil in water cannot be accurately determined
    - No matter how thorough the sampling regime
      - Insufficient resolution in space and time
      - Dropping below detection limit
      - Merging into background
- Estimates of dispersant effectiveness can be made, but are subject to a very high degree of uncertainty
  - Estimates require ‘inputs’ to generate ‘outputs’ and the accuracy (or lack of accuracy) of ‘outputs’ are related to accuracy of ‘inputs’

‘Inputs’ and ‘outputs’ for estimates

- Amount of oil released
  - Flow rate could not be measured
  - Various estimates were made during and after the release
- Amount of dispersant used
  - Known with a very high degree of certainty
- Amount of oil dispersed by added dispersant
  - Can be estimated, but only with an extremely high degree of uncertainty for the unusual circumstances of the incident

Slide 7

Oil flow rate estimates

Date	Estimates	US Govt. Flow Rate Technical Group estimates
April 22nd	8,000 bbls/day	
April 24th	1,000 bbls/day	
April 28th	5,000 bbls/day	
May 12th	Video released	
May 15th	EPA approve sub-sea use	
May 27th	10,000 to 50,000 bbls/day 36,090 bbls/day 25,000 to 50,000 bbls/day	12,000 to19,000 bbls/day
June 2nd		12,000 to 25,000 bbls/day
June 15th		35,000 to 60,000 bbls/day
July 15th	Oil flow stopped	
August 2nd		62,000 bbls/day (±10%) initially and declined to 53,000 bbls/day (±10%)

The National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling
"The Amount and Fate of Oil," Draft, Staff Working Paper No. 3

Slide 8

Amounts of dispersant used

Dispersant used	US gallons	Barrels	Cubic metres
Sprayed from aircraft	976,249	23,244	3,695.5
Sprayed from ships	96,264	2,292	364.4
Sub-sea	771,288	18,364	2,919.6
TOTALS	1,843,800	43,900	6,979.5

Amounts of oil and amounts of dispersant

- Sub-sea dispersant injection rates were based on a recommended dispersant application rate (DOR) of 1:20
  - Initially assumed oil flow rates of between 5,000 and 13,000 bbls/day
- On May 26th EPA restricted sub-sea dispersant use to 15,000 US gallons/day (357 barrels/day) of dispersant

Oil flow (bpd)	Dispersant (bpd)	DOR
1,000	357	1:3
5,000	357	1:14
16,000	357	1:45
30,000	357	1:84
48,000	357	1:135
62,000	357	1:174

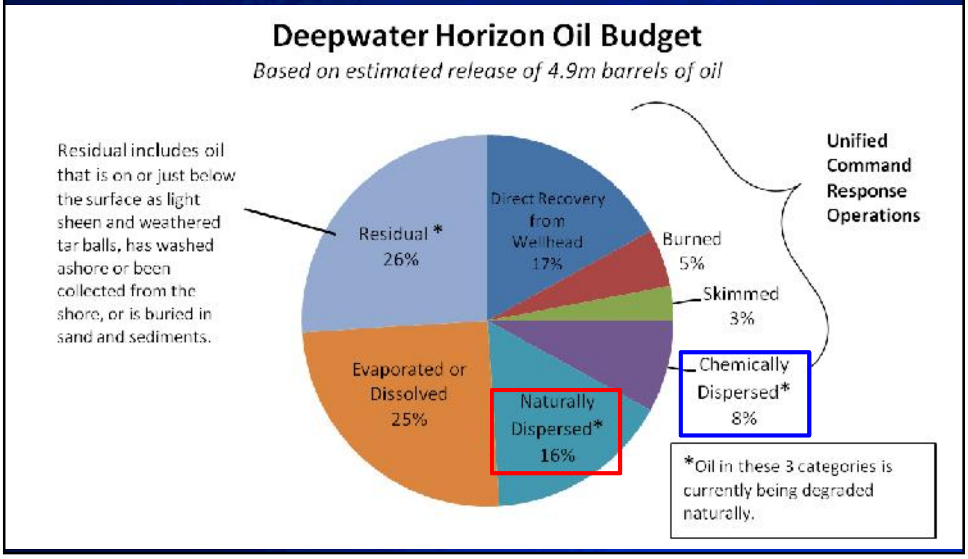
Results of subsequent investigations

- ‘Fresh’ MC252 crude oil is very easy to disperse
  - When ‘fresh’ can be totally dispersed by a dispersant treatment rate of a DOR of 1:200
  - When emulsified to the red-orange coloured emulsion on the sea surface requires a DOR of 1:25
- Intense turbulence at sub-sea oil and gas release
  - Caused some oil to be mechanically dispersed without dispersant
  - Should have caused high levels of dispersant effectiveness

Effectiveness of dispersant use

- How much oil was dispersed by the use of dispersant?
  - This is not known with any degree of certainty
- US Government published two “Oil Budgets”
  - August 4th 2010
    - Released in a blaze of publicity at the White House
  - November 23rd 2010
    - Revised version showing some uncertainty

August 4th Oil Budget



August 4th Oil Budget

- Did not present the uncertainty of estimates
  - Estimates to the nearest single percentage point seem suspiciously precise and certain
  - Was criticised by very many people for a very wide variety of reasons
- If 4.9 million barrels of oil were released
  - It was estimated that 800,000 barrels were mechanically dispersed
  - And estimated 400,000 barrels were dispersed by dispersant use

Oil Budget Calculator

Oil Budget Calculator
Deepwater Horizon
T E C H N I C A L D O C U M E N T AT I O N
November 2010
A Report by:
The Federal Interagency Solutions Group,
Oil Budget Calculator Science and Engineering Team

- 217 page report
- Many contributors
- Many criticisms have also been made of this report
- But it remains in the public domain

November Oil Budget estimates

- Presented three cases
  - “Worst”, “Expected” and “Best” cases
  - Oil classified as:
    - Direct recovery from well head
    - Naturally dispersed
    - Evaporated or dissolved
    - Burned
    - Skimmed
    - Chemically dispersed
    - Other oil
  - Estimates of dispersion were based on the views of a panel of experts, <u>not measurements</u>
  - Uncertainty acknowledged and “dealt with” by statistics

Many shortcomings

- The consequences of longer-term processes were not estimated
  - Biodegradation of dispersed oil not estimated
  - Sedimentation of oil, if any, not estimated
- Only the amount of oil recovered at the well head was actually measured
  - Everything else was estimated
    - With varying degrees of uncertainty

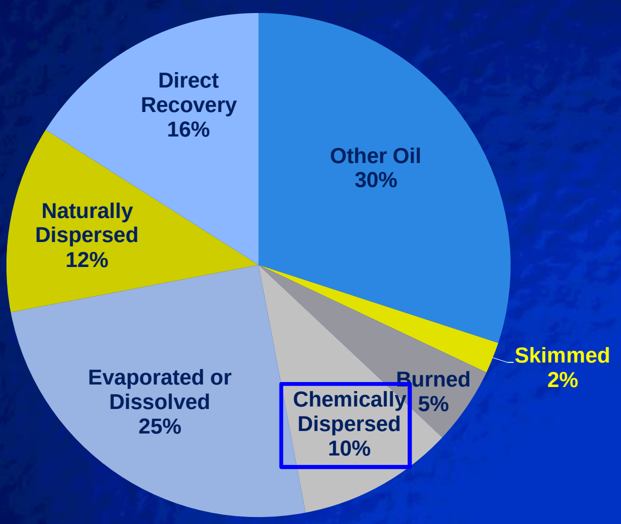
Slide 17

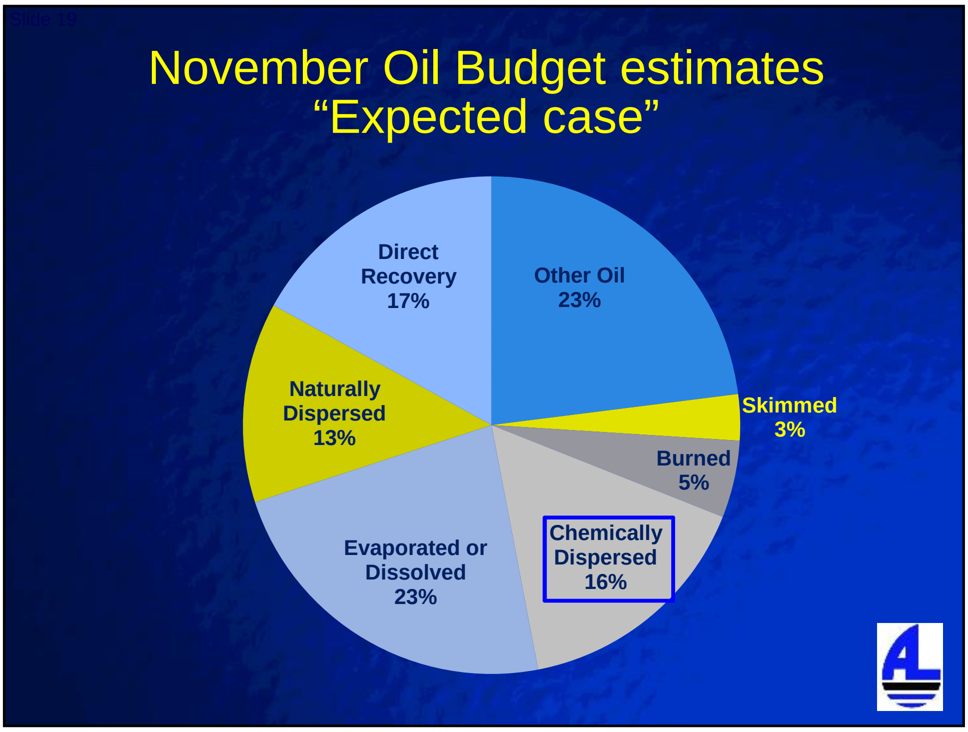
November Oil Budget estimates

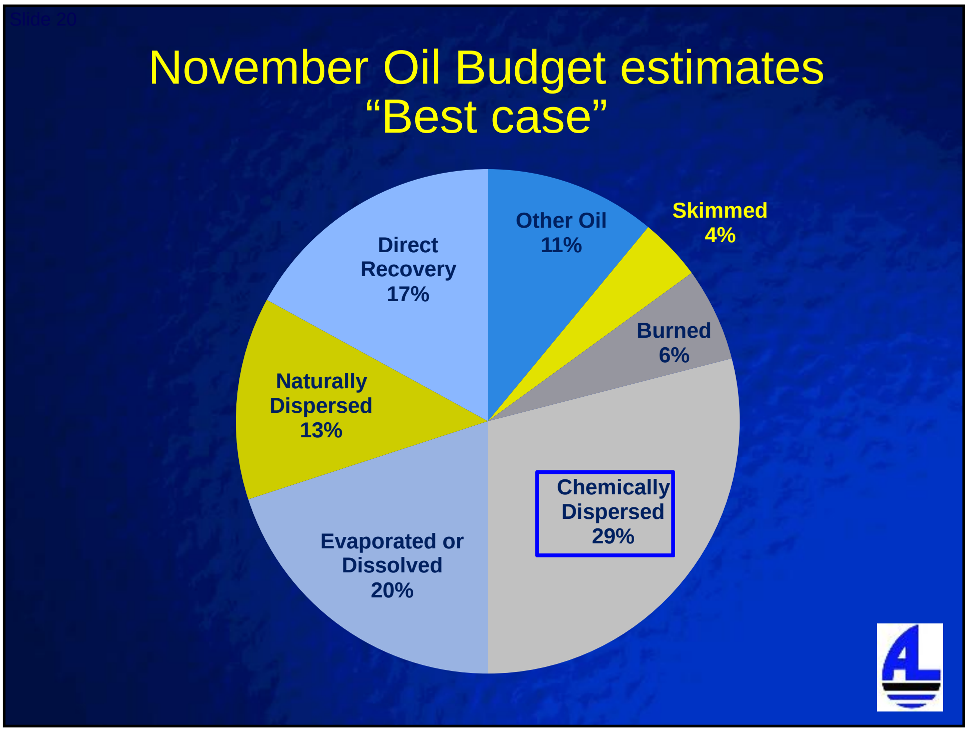
- “Worst”, “Expected” and “Best” cases
  - Each are as probable as each other
    - Nobody knows which most closely resembles what actually happened
- The most significant change between Auugust and November estimates was a doubling of the amount of oil classified as “chemically dispersed”
  – Revised from 8% to an estimated 16% with a possible range of between 10% and 29%

Slide 18

November Oil Budget estimates “Worst case”




November Oil Budget estimates
“Expected case”
Direct Recovery 17%
Other Oil 23%
Skimmed 3%
Burned 5%
Chemically Dispersed 16%
Evaporated or Dissolved 23%
Naturally Dispersed 13%


November Oil Budget estimates
“Best case”
Other Oil 11%
Skimmed 4%
Burned 6%
Chemically Dispersed 29%
Evaporated or Dissolved 20%
Naturally Dispersed 13%
Direct Recovery 17%

“Other oil”

- “Other oil” is that oil not accounted for in other ways and calculated by difference
  - Oil that was not:
    - Recovered at the wellhead
    - Naturally dispersed
    - Evaporated or dissolved
    - Chemically dispersed
    - Skimmed
    - Burned
  - Could have floated to the sea surface, but only a very small proportion was found to have come ashore
    - Although the amount of oil that did come ashore is not known

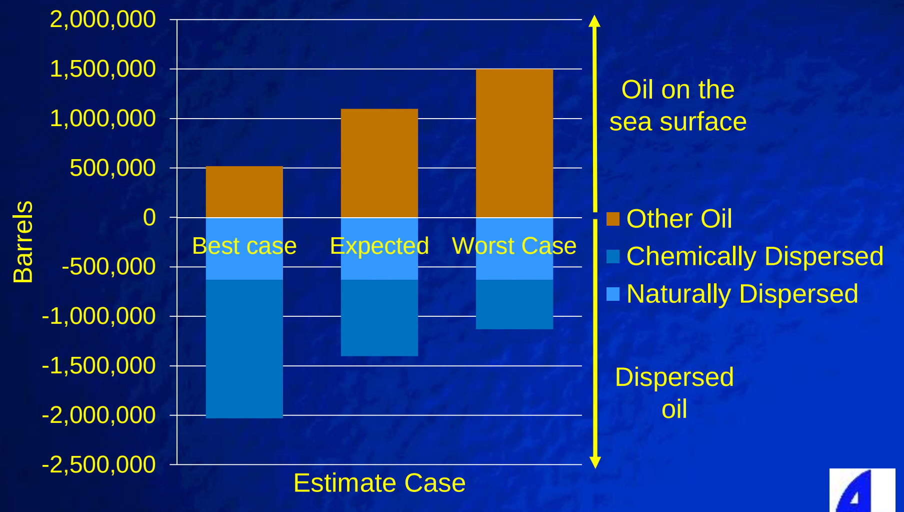
“Chemically dispersed” and “Other oil”

- As “chemically dispersed” oil goes up, “Other oil” goes down and everything else stays the same
- If “chemically dispersed” oil = 40%, “Other oil” = 0% and there would be no oil on the sea surface

	Worst Case %	Expected Case %	Best case %	Best possible case %
Chemically Dispersed	30	16	29	40
Other oil	10	23	11	0
Chem. Disp + Other	40	39	40	40
Everything else	60	61	60	60

Slide 23

Oil on the sea and dispersed oil



Slide 24

Oil Budget Estimates

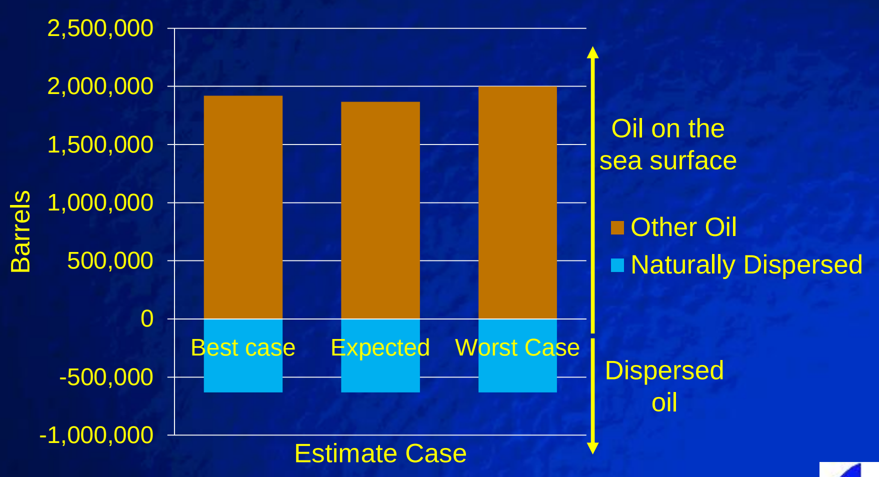
- The estimated total amount of oil on the sea surface was between 0.5 and 1.5 million barrels
- The estimated total amount of chemically dispersed oil was between 0.5 and 1.4 million barrels
- The estimated total amount of all dispersed oil was between 1.1 and 2 million barrels

	Best Case (bbls)	Expected (bbls)	Worst Case (bbls)
Other Oil	520,000	1,100,000	1,500,000
Naturally Dispersed	630,000	630,000	630,000
Chemically Dispersed	1,400,000	770,000	500,000

If dispersants had not been used

- There would be no "chemically dispersed" oil
- The oil would have risen to the sea surface and become "Other oil"

Oil on the sea and dispersed oil



Slide 27

If dispersants had not been used

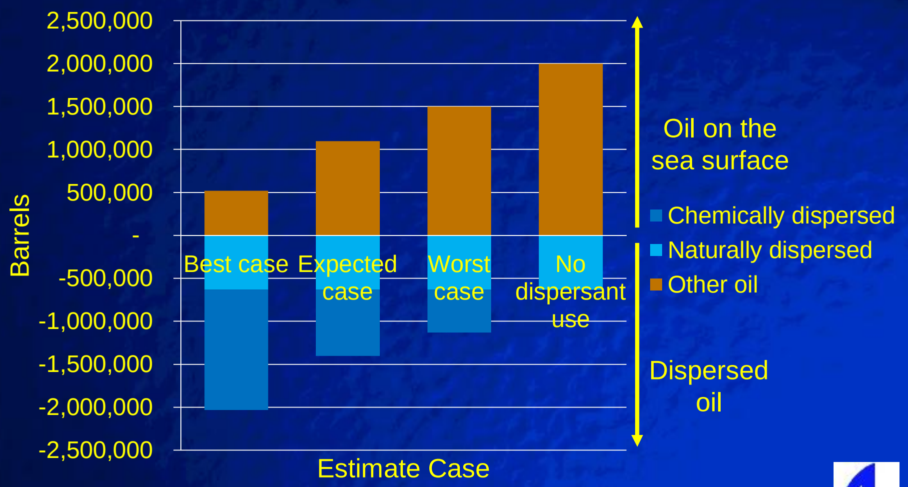
- The estimated total amount of oil on the sea surface is about 2 million barrels in all cases
- The estimated total amount of dispersed oil is 630,000 barrels in all cases

These estimates look very precise, but are they accurate?

	Best case (bbls)	Expected (bbls)	Worst Case (bbls)
Other Oil	1,920,000	1,870,000	2,000,000
Naturally Dispersed	630,000	630,000	630,000

Slide 28

Comparison



Slide 29

The fate of the oil that reached the sea surface

- Approximately 2 million barrels of oil would have reached the sea surface
  - A lot of the potentially volatile components (BTEX etc.) would have already dissolved into the sea and there would be reduced evaporative loss from the residue on the sea surface
  - Approximately 1.3 million barrels would remain and would have emulsified after about 1 week in a calm sea to form water-in-oil emulsions containing 75% volume water
  - Approximately 5 to 6 million barrels of w/o emulsion would have been formed

Slide 30

Emulsified oil on sea surface

- No dispersant use would have resulted in a total of 5 to 6 million barrels of w/o emulsion on the sea surface

- Dispersant use reduced the amount of emulsified oil that would have been on the sea surface
  - Best Case
    - 520,000 bbls of oil, approximately 1.3 million bbls of emulsion
  - Expected Case
    - 1.1 million bbls of oil, approximately 2.9 million bbls of emulsion
  - Worst Case
    - 1.5 million barrels of oil, approximately 3.9 million barrels of emulsion

Slide 31

Dispersed oil in the water column

- No dispersant use would have resulted in a total of 0.6 million barrels of dispersed oil in the water column
- Dispersant use increased the total amount of dispersed oil in the water column
  - Best Case
    - 2 million barrels of dispersed oil
  - Expected Case
    - 1.4 million barrels of dispersed oil
  - Worst Case
    - 1.1 million barrels of dispersed oil

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Conclusions

- If no dispersant had been used at the DWH incident (but all other estimates and response actions were the same) it can be estimated that:
  - 2 million barrels of oil would have reached the sea surface and this would have formed 5 to 6 million barrels of emulsified oil
  - 630,000 barrels of oil would have been dispersed (naturally)
- The emulsified oil on the sea surface would have been persistent and some would have drifted ashore
- The dispersed oil would have been rapidly biodegraded to a very substantial degree in the waters of the Gulf of Mexico

Conclusions

- 7,000 m^3 of dispersant was used at the DWH incident
  - This reduced the amount of emulsified oil on the sea surface by multiples of
    - 4 ("Best Case")
    - 2 ("Expected Case")
    - 1.5 ("Worst Case")
  - This increased the amount of dispersed oil in the water column by multiples of
    - 3.3 ("Best Case")
    - 2 ("Expected Case")
    - 1.8 ("Worst Case")

Conclusions

- How much more damage could have been eventually caused by the 5 to 6 million barrels of emulsified oil on the sea surface?
  - Compared to the damage caused by the totals of 1.3 million, 2.9 million or 3.9 million barrels of emulsified oil that might have been there?
- How much less damage could have been eventually caused by the 0.6 million barrels of oil dispersed into the sea?
  - Compared to the damage caused by the totals of 2 million, 1.4 million or 1.1 million barrels of dispersed oil that might have been in the sea?

National Response Team Guidance for Subsea and Prolonged Dispersant Application

Mr. Robert G. Pond
US Coast Guard
Marine Environmental Response Policy

Pre-Deepwater Horizon

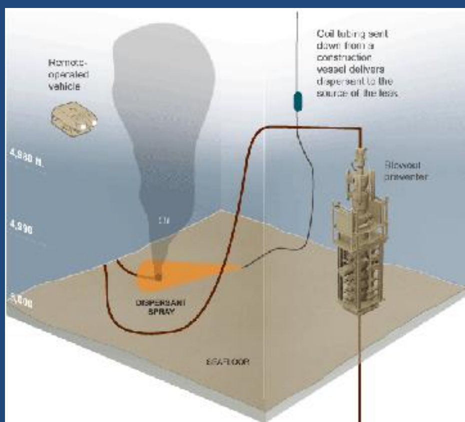
- National Oil and Hazardous Substances Pollution Contingency Plan (NCP)
- Preauthorization
- Special Monitoring of Applied Response Technologies (SMART) Protocol

Post Deepwater Horizon

- Existing guidance inadequate for;
  - Prolonged high volume discharges
  - Subsurface dispersant application
- Need to revise and update
  - NCP
  - Preauthorization
  - Monitoring protocol

Interim Guidance Development

- Prolonged application, monitoring and sampling at:
  - Subsurface
  - Surface



http://www.oilspillcommission.gov/media/response/response-actions-dispersants.html

Prolonged Dispersant Use Sampling & Monitoring

- Validate Oil dispersability:
  - tested in both laboratory and in-situ.
  - Flourometry for oil droplet size.
- Monitor Water column loading and assessment:
  - Flourometry for Dissolved Oxygen levels.
  - Oil and dispersed oil concentrations.

NRT Subsea Application Guidance

- Intended for use on oil discharges originating from oil exploration and/or production facilities (e.g., loss of well control).
- Generally applies to dispersant use in response to subsea discharges at depths greater than 300 meters and below the average pycnocline.

NRT Prolonged Surface Dispersant Guidance

- Guidance supplements SMART protocols where the duration of the dispersant application extends beyond the first 4 or 5 days of dispersant use.
- Anticipate to be used in conjunction with subsurface application for VOC control.
- And as a means of augmenting mechanical recovery.

Questions?

Thank You!

Robert.G.Pond@uscg.mil

202-372-2235

Global dispersant regulations

'Workshop addressing the Use of Oil Spill Dispersants following the *Deepwater Horizon* incident'

26-27 November 2012

European Maritime Safety Agency (EMSA), Lisbon

Alun Lewis
on behalf of IPIECA and OGP

The industry perspective

- National governments have the responsibility and right to develop laws and regulations as they see fit to protect their citizens and the ecosystems within their territories from the potential effects of oil pollution
- IPIECA and OGP represent the international oil industry that operates in many countries around the world
  - If national governments are the 'producers' of regulations about oil spill dispersants, oil companies are the 'consumers' or 'users' of these regulations
- Regulations about dispersants should ensure that they are an effective oil spill response method to be used in the right circumstances

Regulations about oil spill dispersants

- Why are there regulations about dispersants?

1. **History**
   - The *Torrey Canyon* incident in the UK in March 1967
   - Subsequent developments of true oil spill dispersants

2. **Existing national laws and regulations**
   - Many countries have existing laws and regulations designed to control the use of chemicals at sea

UK dispersant regulations in the 1970s

A. Dispersant approval regulations

Dispersants had to be approved before they could be used in UK waters and had to pass tests to ensure that:

- They were reasonably effective
- They were not too toxic

B. Dispersant use regulations

Dispersant use on spilled oil in deep water allowed, but dispersant use on spilled oil in ‘shallow water’ required special prior permission

- Shallow water defined as 20 metre depth on the chart or within 1 mile of such depths

UK Dispersant approval regulation tests

- Effectiveness test
  - "Harbour" test
    - Two boats in a harbour. Oil on water sprayed with dispersant from one boat and observers judged effectiveness by visual observation from second boat
  - Subsequently replaced by WSL rotating flask test

- Toxicity test
  - LC_{50} tests with brown shrimp
    - Lethal Concentration to 50% of test organism population
    - Compared toxicity of different dispersants

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Early dispersant regulations in other countries

- Dispersant approval regulations and tests
  - Effectiveness testing
    - Other countries developed their own effectiveness tests with different methods of mixing and different test oils
      - France developed the IFP dilution test method
      - USA developed EPA Test, replaced in 1993 by Swirling Flask Test, (and could be replaced by Baffled Swirling Flask Test)

  - Toxicity testing
    - Several countries developed their own LC_{50} toxicity tests with different test organisms
      - USA used brine shrimp (Artemia)

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Examples of legal basis of dispersant approval

- USA
  - The NCP Product Schedule resulted from a requirement of section 311(d)(2) of the Clean Water Act and was restated in section 4201(a)(G)of the Oil Pollution Act of 1990. This regulation requires the President to prepare *"a schedule of dispersants, other chemicals and other spill mitigating devices and substances, if any, that may be authorized for use on oil discharges..."*
- UK
  - The Marine and Coastal Access Act 2009 requires a licence to be issued for the deposit of any substance or article in the sea. Exemptions are contained in the Marine Licensing (Exempted Activities) Order 2011 for England and Wales.

    A licence is not required for the deposit of a substance for the purpose of treating oil on the surface of the sea, subject to the following conditions.
    - *The substance is approved by the licensing authority.*

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Dispersant regulations in other countries

- Dispersant use regulations

  Defined where and when dispersants could be used on basis of water depth and distance from shore
  - The "20 metre water depth / 1 nautical mile from shore" restriction originally used by the UK authorities has been adopted by many other countries (or in different Regions of the USA)
  - It has sometimes been used to prohibit dispersant use in shallow water
  - Although only a rough guide (or "rule of thumb") the 20 metre water depth rule has proved to be useful:
    - No significant effects on marine organisms in the water column (plankton, fish etc.) have been observed when dispersants have been used on spilled oil in relatively deep water

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Dispersant formulation developments

- "Low toxicity" dispersants were developed in 1970s
  - Odourless kerosene used as solvent and subsequently replaced by glycol ether solvents
- Much more effective dispersants were developed
  - Modern dispersants developed (for example Corexit 9527 in 1974)
  - Much more effective than earlier dispersants
    - Early dispersants used at **1 part** of dispersant to **2 to 3 parts** of spilled oil
    - Modern dispersants used at **1 part** of dispersant to **20 to 30 parts** of spilled oil

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Toxicity testing for dispersant approval

- It was found that the dispersed oil was more toxic than the "low toxicity" dispersants
  - If the dispersed oil could cause toxic effects to marine organisms, what was the point of testing the lower toxicity dispersant?
- Some, but not all, countries decided to carry out toxicity tests with dispersant plus oil
  - UK uses dispersant plus weathered Kuwait crude oil with shrimp as the test organism
  - USA uses dispersant plus No. 2 fuel oil with Menidia beryllina (silversides fish) and Mysidopsis bahia (mysid shrimp) as the test organisms

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Toxicity testing with or without oil?

- Using "dispersant plus oil" seems - at first sight - more sensible than using "dispersant alone" in toxicity test
  - The potential risk of toxic effects in real dispersant use on spilled oil at sea comes from the dispersed oil, not the dispersant
- However, the toxic effects that might be caused to marine organisms are due to their exposure (concentration and duration) to dispersed oil
  - Exposure to elevated concentrations of dispersed oil for a brief period of time, as happens when dispersants are used on spilled oil in relatively deep water, has been found to not cause significant effects (CROSERF studies)
  - The exposure conditions used in "dispersant plus oil" toxicity tests are more severe than found at sea

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"Dispersant plus oil" toxicity testing

- "Dispersant plus oil" toxicity tests **do not simulate** the real use of dispersants on spilled oil at sea
  - Exposure regimes are much more severe
- Different oils have different potential toxicities depending on their chemical composition
  - No. 2 Fuel Oil, as used in USA approval test, particularly toxic
- "Dispersant plus oil" toxicity testing inevitably discriminates against highly effective dispersant and towards less effective dispersants

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‘International’ dispersants

- Despite the wide variety of effectiveness and toxicity tests used for dispersant approval there are some dispersants approved for use in several countries, for example:
  - Corexit 9500 (made in the USA)
    - can be used in France, UK (offshore) and USA and other countries
  - Dasic Slickgone NS (made in the UK)
    - can be used in France, Norway, UK and other countries
  - Finasol OSR 52 (made in France)
    - can be used in France, UK, USA and other countries
- There are other international dispersants

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‘National’ dispersants

- There are many more dispersants that are only approved for use in their ‘home’ countries
- There are several reasons for this:
  - The dispersant manufacturer has to pay for approval testing for a dispersant and this can be expensive and many dispersant manufacturers decide only to have approval in their own country
- Some countries prefer dispersants made in their own country
  - The 24 dispersants approved for use (although rarely used) in China are all manufactured in China

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A common standard for dispersant approval?

- Some countries accept dispersants that have already been approved in other countries for use in their own waters
  - Dispersants already approved for use in France are approved without further testing in several West African countries
  - Dispersants approved for use in 2 out of 3 of France, UK or USA are approved for use in the ROPME Sea Area (Arabian / Persian Gulf)
  - Several regional agreements accept the use of dispersants approved in only one of the regional 'partners'
- But there is no international common standard for dispersant approval

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Current status of dispersant regulations

- Many countries have developed dispersant regulations, but a lot of countries have yet to do so
- Of the countries that have developed regulations, most have:
  - Dispersant approval regulations
  - Dispersant use regulations
- The regulations differ in complexity
  - Norway has integrated these two elements into a more sophisticated planning procedure
  - French dispersant use regulations define where dispersants can be used on the basis of the amount of oil spilled

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Current status of dispersant regulations

- Although different in detail and complexity, the different national regulations that exist share the common purposes of:
  - Ensuring that the dispersants to be used are reasonably effective and of low toxicity
  - Ensuring that dispersants are used on spilled oil in a way that poses minimal risk to marine organisms
- However, on almost every occasion that dispersants have been used – or have been contemplated to be used - on a large scale, there have been concerns expressed by many people
  - Many people do not understand why dispersants are used and some suspect the motivation of dispersant use

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The usefulness of toxicity test data

- The most misunderstood aspect is the potential toxicity of dispersants and of dispersed oil
  - Toxicology is a complicated science and the results from toxicity testing are often misunderstood by non-experts
- The results from “dispersant plus oil” toxicity testing carried out for dispersant approval purposes are almost invariably misunderstood
  - By the general public, politicians and senior regulators
  - The hysteria generated about dispersants at the *Deepwater Horizon* incident demonstrated a lack of understanding of the fundamental issues surrounding dispersant use and the significance (or lack of significance) of the toxicity test results

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The “knowns” and “unknowns” of dispersant use

- Another significant effect of the *Deepwater Horizon* incident was the widely propagated perception that much is “unknown” about dispersant use
- This is not true:
  - A great deal is known about the use and consequences of dispersant use when used in the ‘conventional’ way; sprayed onto spilled oil on the sea surface
  - A huge number of studies have been conducted in the 45 years since the *Torrey Canyon*
- What is true, is that there are some “unknowns” about the large-scale and prolonged sub-sea use of dispersants

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Regulation of sub-sea dispersant use at the *Deepwater Horizon* incident

- Dispersant use on oil on the sea surface was pre-approved at the *Deepwater Horizon* incident
- Nobody had foreseen the sub-sea use of dispersants
  - There were no regulations for dispersant approval (which dispersants could be used) or where and when they should be used
- The very large volumes and prolonged use of dispersants caused concern at the US EPA (Environmental Protection Agency)
  - The EPA issued several Directives limiting the amount of dispersant to be used and how the dispersant could be used

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Surface and sub-sea dispersant use

- Dispersant use on spilled oil on the sea surface produces widely scattered small plumes of dispersed oil in the upper water column
  - Individual, small plumes of dispersed oil are produced as and when breaking waves pass through the dispersant-treated oil slick
  - These are rapidly diluted into the upper, well-mixed water column and subsequently biodegraded to a large extent
- Sub-sea dispersant use at an underwater oil release produces a point-source of a much higher concentration of dispersed oil in the deeper water
  - This will be rapidly diluted to lower dispersed oil in water concentration as the plumes rises and disperses horizontally

Regulation of sub-sea dispersant use

- It can be reasonably expected that many countries will regulate sub-sea dispersant use
  - The USA and UK already have indicated that sub-sea dispersant use will require prior permission from the relevant Government authorities
- The early indications are that the national authorities will require evidence of:
  - Effectiveness
  - Potential for toxic effects caused by the dispersant and/or the dispersed oil
- This will be technically challenging to achieve

Conclusions

1. National authorities have the right to introduce such laws and regulations as they see fit about dispersant use
   - Many have done so, but a lot of countries have not

2. The original intention was to ensure that the mistakes of the past (such as at the *Torrey Canyon*) were not made again
   - Any dispersant has to be approved for used in national waters
     - This requires testing to ensure that it is reasonably effective and not too toxic to be used
   - Dispersants should not be used on spilled oil without prior permission
     - The potential risk is that dispersed oil concentrations in the water column will persist for long enough to cause harm to marine organisms

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Conclusions (continued)

3. Subsequent developments of the testing requirements for dispersant approval attempted to provide more ‘realistic’ simulations of dispersant use on oil at sea

   - Different effectiveness tests were developed in different countries
     - Some may be more ‘realistic’ than others, but none can be said to be an accurate simulation of a particular sea condition

   - Different toxicity test protocols have been devised that use “dispersant plus oil” to try and simulate the potential risk posed by dispersed oil to marine organisms
     - However, in order to retain the original aim of discriminating between different dispersants for approval purposes, exposure conditions that are more severe than would be experienced at sea have been used

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Conclusions (continued)

- Some existing “dispersant plus oil” tests discriminate against highly effective dispersants by employing exposure regimes that would not be experienced at sea when dispersant are used on oil in relatively deep water

4. The significance of the toxicity test results obtained for dispersant approval purposes are widely misunderstood and misinterpreted as being indicative of real dispersant use
   - These misunderstandings are not limited to the general public and include politicians and regulators
   - This became a major problem at the *Deepwater Horizon* incident and the legacy of confusion remains

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Conclusions (continued)

5. Sub-sea use of dispersants at the *Deepwater Horizon* incident had not been foreseen
   - There were no existing regulations
   - The very large volumes of dispersant being used and the duration for which they were being used caused concern and the US EPA issued Directives limiting dispersant use

6. Sub-sea use of dispersants is different in some ways from the use of dispersants on spilled oil on the sea surface
   - National regulations about sub-sea dispersant use will be developed
   - These will need to consider effectiveness and potential toxicity

   Past experience of dispersant regulations needs to guide the future

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Dispersant Use and Regulation in the UK

- The UK Dispersant Regulators
- Bonn Agreement
- UK Dispersant regulations
- Devolved administrations
- Dispersant operations
- Future considerations – dispersants offshore

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UK Dispersant regulators

- Marine Management Organisation
- Department of Energy and Climate Change / Marine Scotland

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Bonn Agreement

- Bilateral arrangements:
  - NORBRITPLAN – in place
  - MANCHEPLAN – in place
- Quadripartite
  - UK, France, Belgium, Holland – under development

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UK Regulations – Product Approval

Marine and Coastal Access Act 2009.

Products and tests					
Type of test	**Dispersant (inshore and offshore)**	**Dispersant (offshore only)**	**Sorbent**	**Bioremediation product**	**Degreaser**
Efficacy					
WSL LR 448	Y	Y	N	N	N
Flask Test	N	N	N	Y	N
Microcosm Test	N	N	N	Y	N
Toxicity					
Rocky Shore Test	Y	N	Y	Y	Y
Sea Test	Y	Y	Y	Y	Y
Agitation toxicity test 1	N	N	N	Y	N
Agitation toxicity test 2	N	N	N	Y	N
Wildlife licence	N	N	N	Y (if contains bacteria)	N

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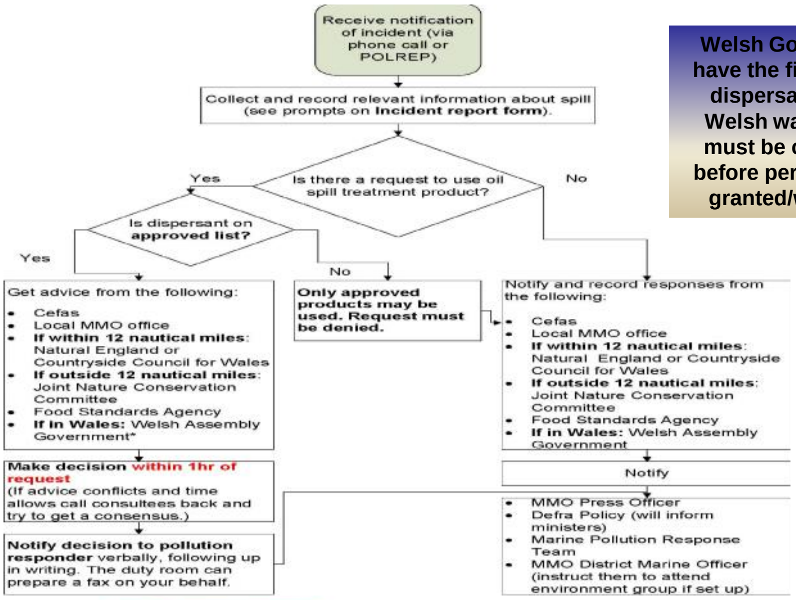

Welsh Government have the final say on dispersant use in Welsh waters, and must be contacted before permission is granted/withheld.

Factors informing response

- **Does oil/pollutant pose an environmental threat?**
- **Will shellfish or other fisheries be affected?**
- **Will Oil Spill Treatment Product (OSTP) protect environmental resources?**
- **Will OSTP use risk other damage?**
- **Is oil dispersible?**

Standing Approvals

MMO are not always required to authorise dispersant use

- Holders of approved Contingency Plans can apply for standing approval.
- Provides for oil spill treatment product use without the need to seek approval.
- However there are strictly defined conditions that Holders must adhere to, such as:
  - **Dispersant type & amount**
  - **Ebb tide**
  - **Geographic area**

- **Use of Dispersant must still be notified to MMO**

- Standing approvals are visible on MAGIC

Devolved Administrations

- England – MMO
- Scotland – DECC
- Welsh Government
- Northern Ireland

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Dispersant Operations

- Major spill reported
- Aircraft mobilised / Permissions required?
- Inform stakeholders with intentions
- Determine optimal dispersant
- Ongoing consultation with stakeholders

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Dispersant Operations

- Permission required if 20m depth or within 1 mile
- Dispersant must be on approved list
- Dispersant must be efficient
- Application must be closely monitored
- Keep stakeholders informed

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Environment Group

- Activated during incident
- SEGs are multi-agency bodies with responsibility for a particular area of coastline. Membership includes the Environment Agency, Natural England or Countryside Council for Wales, local authorities, ourselves and others.
- Provide environmental advice to SoSRep
- 14 SEGs around the England & Wales (+Scot & NI)
- Hold regular meetings in person so members know each other
- *MMO represented on EGs through coastal DI*
- Organisational hats come off

Future Considerations

Marine Management Organisation - Summary and response to the Review of the Oil Spill Treatment Product Approval Scheme April 2011

Review of all current arrangements

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Use of dispersants offshore and subsea

- UK Regulators meeting soon to discuss offshore and subsea dispersant use.
- OSRF working with Regulators to improve understanding of issues
- CEFAS paper submitted outlining need for greater understanding

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French policy on oil spill dispersants: Evolution of the geographical limits for the use of dispersants

Ct Bernard Cerutti – Bruno Lesven (Ceppol)
François Xavier Merlin - Stéphane Le Floch (Cedre)

Francois.merlin@cedre.fr *bruno.lesven@intradef.gouv.fr*

Geographical limits

- *Restriction of dispersants application in coastal area*
- *A safety precaution to avoid adverse effects from dispersants use:*
  - To avoid toxic high concentration of dispersed oil
  - To be far enough from sensititive resources

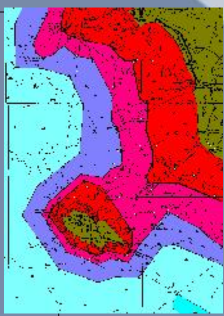
Geographical limits

- *Generally based on water depth and distance to the coast, and presence of sensitive items*
- *In force in many countries* (i.e. Europe)

Germany: depth <10m forbiden, and restriction for depth between 10 à 20 m
•Italy: need for autorisation when depth <30 m and distance to the shore <1 NM
•Malta: generally forbiden when distance is <3 NM and depth <60 m
•Norway : forbiden when depth <20 m and distance <200 m
•UK: need for autorisation when depth <20 m and distance <1 NM

Geographical limits in France

- *Based on*
  - Depth
  - Distance to the shore or sensitive items
  - Quantity of oil to be dispersed
- *Criteria : initial concentration* ***< 10 ppm***
  - According to acute toxicity data: LC_{50} 6h # 100ppm
- *3 limits: 10, 100, 1 000 t of oil to be dispersed*

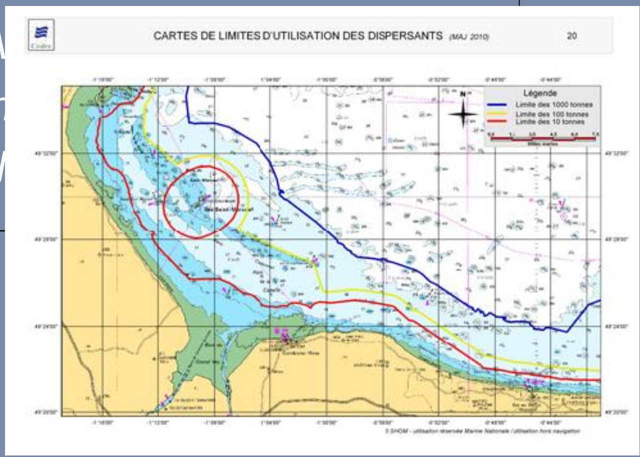


OIL	Water depth	Distance to the shore
(t)	(m)	(NM)
10	5	0.5
100	10	1
1 000	15	2.5

1993

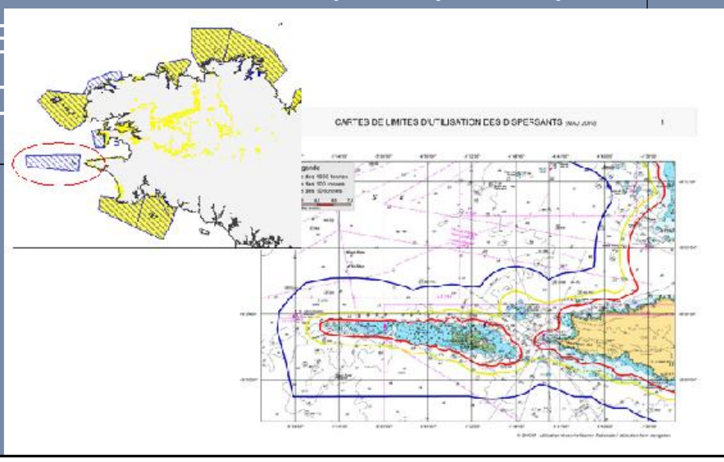
Evolutions of the geographical limits

- 15 m isobaths => 20 m isobaths
- NATURA
- Birds con
- Discobiol



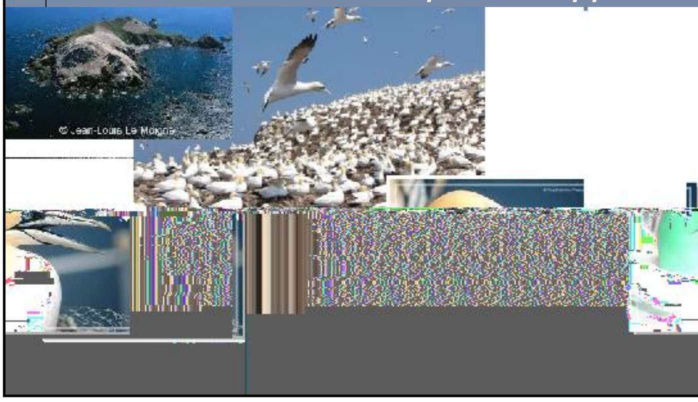
Evolutions of the geographical limits

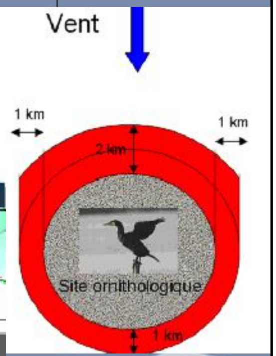
- 15 m isobaths => 20 m isobaths
- NATURA 2000 zones (still in process)
- E
- D



Evolutions of the geographical limits

- *15 m isobaths => 20 m isobaths*
- *NATURA 2000 zones (still in process)*
- *Birds concerns for dispersant application*





Evolutions of the geographical limits

- *15 m isobaths => 20 m isobaths*
- *NATURA 2000 zones (still in process)*
- *Birds concerns for dispersant application*
- *Discobiol issues*

Discobiol study

- *Objective: comparison of toxicity of oil when chemically and mechanically dispersed*
  - On fish and bivalves – juveniles or adults
  - With a reference oil (Crude Arabian Light slightly toped)
  - Acute and sublethal effects

Discobiol issues

- *Acute toxicity is not a pertinent criteria*
  - lethal concentration measured *(300 to 1300 ppm !!!)* >>>>> real observed concentrations in the field
  - *Sublethal effects are not permanent*
    - For quite severe exposures (30 – to 70 ppm for 48 h)
    - Assessment criteria: immunologic, stress, physiologic indicators
    - Most effects, when observed, disappear in few weeks

=> Possible damages from dispersed oil are less severe than feared

Discobiol issues

		Sea bass				Turbot			
	Experimental condition	DC1		DC2		DC1		DC2	
	Sample	T1	T2	T1	T2	T1	T2	T1	T2
Acid base equilibrium	pH								
	[HCO3-]								
	pO2	x		x					
	pCO2								
Hydromineral balance	[CL-]								
	[Na+]								
	osm								
Bioconcentration PAHs muscle			x	x	x	x		x	
Pyrene metabolite									
B(a)P type metabolite									
Growth	SGR								
Condition index	Fulton K factor								
	SSI								
	HSI								
Stress indicators	Glucose								
	Cortisol								
	Lactate								
Oxydative stress gills	SOD								
	Catalase								
	GPx								
	GSHt								
Oxydative stress liver	SOD								
	Catalase								
	GPx								
	GSHt	x		x		x		x	
Haematological parameters	Hematocrit	x	x	x	x	x	x	x	x
	Erythrocyte	x	x	x	x	x	x	x	x
	MGV	x	x	x	x	x	x	x	x
Leukocytic parameters	Cellular mortality								
	[leukocyte]								
	[lymphocyte]								
	[granulocyte]								
	[monocyte]								
Immunological parameters	Phagocytosis								
	Lysosyme								
	ACH50								

Discobiol possible consequences

- *Easing the limitation for the use of dispersant in coastal area*
- *Proposed modification of the geographical limits for dispersant application*
  - Keeping the limits
  - Increasing the quantity of oil which is acceptable to disperse : X 5 or X 2,5..

Atlantic

Limits for 50, 500 and 5 000 t of oil to be dispersed

Mediterranean Sea

Limits for 25, 250, 2 500 t of oil to be dispersed

Dispersant Use in Germany

D.-S. Wahrendorf [1], B. Böhme [2]
[1] Federal Institute of Hydrology
[2] Central Command for Maritime Emergencies

EMSA-Workshop, 26. - 27. November 2012

Topics

- Current national oil spill response strategy
- Experience with dispersants in Germany
- Prospective strategies and developments
- Update of the chemical response concept

Current oil spill response in Germany

In case of serious catastrophes and complex damage situations such as severe emergency or larger oil spills, the coordination and incident management is carried out by the Central Command for Maritime Emergencies (CCME).

Two response strategies in case of an oil spill:

Primary response: → mechanical oil recovery

Secondary response: → chemical response (e.g. dispersants)

Currently Germany does not have own stockpiles and must rely on the cooperations and agreements with its neighbour countries.

Secondary Response

Area of admission:

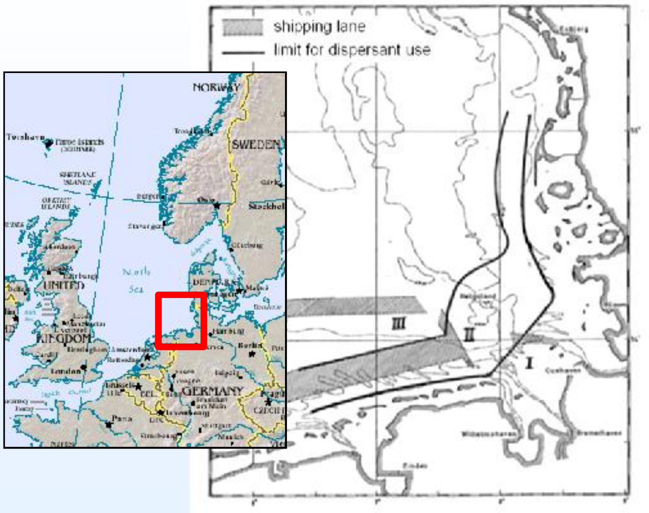
Accepted use of dispersants only in the North Sea,

areas of potential use are shown on the next slide.

Current requirements, e.g.:

- oil spill is out of reach for the mechanical response units
- limited capacity of the mechanical response
- weather and water conditions are not suitable for a mechanical response

German Bight with application zones



Zone III (approx. 12 sm)**:** application of dispersants possible

Zone II: limited use of dispersant possible

Zone I: application of dispersants not designated

Experience in Germany with chemical recovery methods

Fortunately:

- until today no extensive oil spills in Germany, so there was no need for the use and application of dispersants

Therefore:

- we only have limited practical experience in the use of dispersants

But:

- in dependence of the case/spill situation, the use of dispersants may provide an ecological benefit

Update and revision of the current national operation strategies

- Operational concept for the use of dispersants under revision.
- Evaluation and strategical planning, whether near shore waters can or should be integrated. And definition in which situations the use of dispersants can be appropriate here.
- Aims of the current revision process:
  - clearly defined rules for a decision
  - prior permission with the Federal States of Germany
  - shortening of the response time
  - simplifying the decision making process

Can we learn from current findings?

Task: Integrating current findings and experience in our revised national concept.

Current questions arise:
How to make a sound assessment for the use of dispersants in near shore waters?

What are the relevant questions and parameters for the decision making process for the usage of dispersants?

→ wahrendorf@bafg.de

Thank you for your attention.

CLIMATE AND POLLUTION AGENCY

KYSTVERKET

Regulations and requirements for dispersant use and product approval - Recent developments in Norway

EMSA Dispersants workshop Lisbon 26 – 27 Nov 2012

Kirsti Natvig (Climate and Pollution Agency) and **Hilde Dolva** (Norwegian Coastal Administration)

Dispersants follow-up in Norway, cooperation between Klif and NCA

Climate and Pollution Agency (Klif)

- Subordinate to Ministry of Environment
- Oil spill preparedness requirements and audits to municipalities and industry
- Dispersants regulations and guidelines

Norwegian Coastal Administration (NCA)

- Subordinate to Ministry of Fisheries and Coastal affairs
- Responsible for governmental preparedness against acute pollution

Future without pollution

CLIMATE AND POLLUTION AGENCY

Specific regulations related to the use of dispersants in Norway

Dispersant use is allowed if properly planned

Testing of effectiveness and toxicology is required according to specified methods

Documentation of net environmental benefit is required. New guidelines concerning basis for documentation are now being issued

New challenges past Macondo

No need for changes in the regulation is identified

Subsea dispersion effectiveness must be documented according to acknowledged methodology

Oil and gas activities on the NCS – Dispersion plans

- First oil discovery: 1969, first oil production: 1971
- Fields in production today:
  - 57 fields in the North Sea Approx 5
  - 12 fields in the Norwegian Sea Approx 8
  - 1 field in the Barents Sea + Goliat production drilling in 2012/2013
- Exploration activity:
  - 72 wells drilled in 2009, 46 in 2010, 54 in 2011
- Landbased activity
  - oil refineries
  - oil terminals/gas terminals
  - petroleum prosessing plants
- Past Macondo: All production fields will develop dispersion plans if relevant

Goliat field in the Barents Sea

New development of ship based spray booms in 2012

Future without pollution

CLIMATE AND POLLUTION AGENCY

A governmental plan for the use of chemical dispersants

1. NCA – the governmental preparedness against acute pollution
2. The oil industry in Norway – app. 650m^3 dispersant in stock (crude oil)
3. Ongoing project to evaluate use of dispersants in the governmental preparedness
   - define typical oil transported along the coast
   - type of dispersion
   - dispersion of HFO and window of opportunity
   - map showing where dispersion can/can not be used

Future without pollution

KYSTVERKET

Norwegian Coastal Administration (NCA)

EMSA Workshop Addressing the use of Oil Spill Dispersants following the Deepwater Horizon incident

Lisbona 26th - 27th November 2012

Session 3: Regulatory development following the DWH incident

Best Practices in Italy for the use of dispersants during an oil spill response

Luigi Alcaro

ISPRA

Italian approach in the use of Oil Spill Dispersants

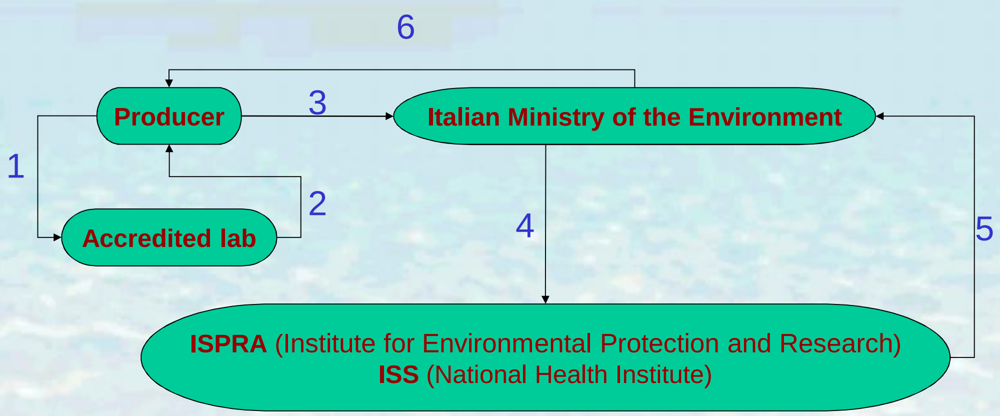
Because of the high sensitivity of Mediterranean ecosystems to oil pollution, Italy applies a three-step precautionary approach in combating oil spills:

1. Application of strict approval procedures of dispersants products (Italian Ministry of Environment Decree n. 116 25th February 2011);
2. Prioritary application of mechnical recovery strategies and use of sorbents when an oil spill occours;
3. Application, if strictly necessary, of dispersant products following a protocol of Best Practices.

Procedure for the approval of oil dispersants in Italy

Italian Ministry of Environment Decree n. 116

a. The Players

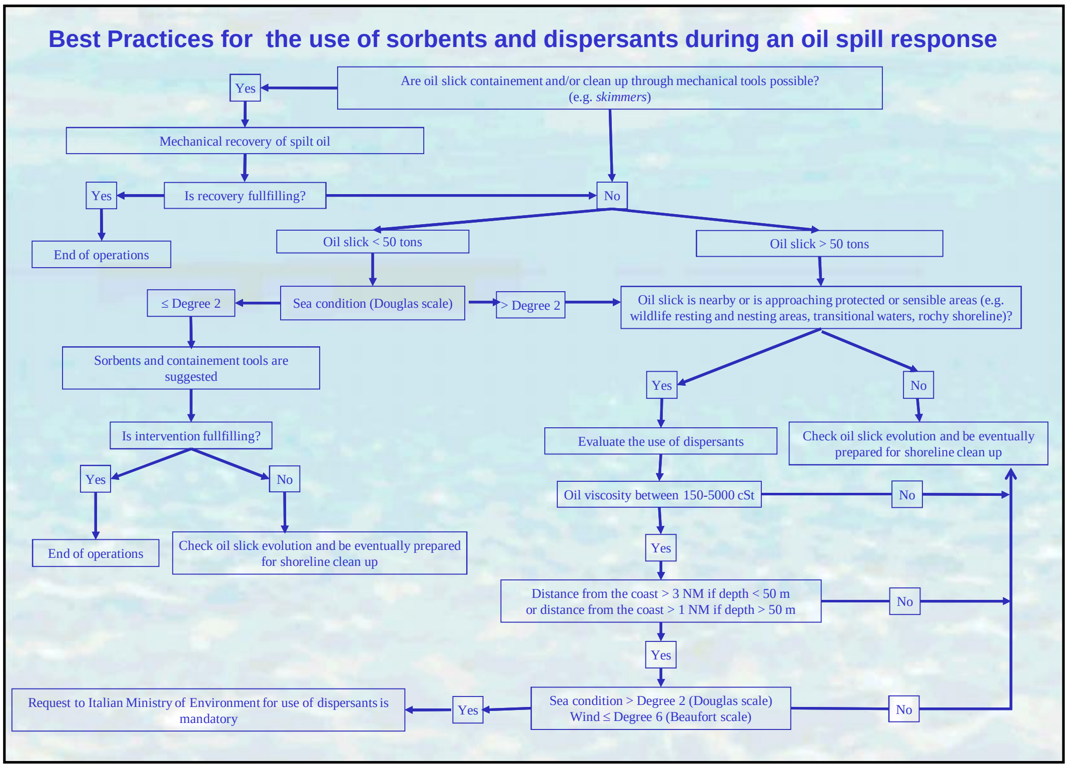


A Working Group was established in 2011 with the specific aim to develop "Best Practices for the use of sorbents and dispersants during an oil spill response"

The Working Group was coordinated by the Italian Ministry of Environment and had participants from ISPRA (Institute for Environmental Protection and Research), ISS (National Health Institute) and the Italian Coast Guard (Marine Environment Department).

Best Practices were developed taking into account:

- ✓ **quantity of oil spilt;**
- ✓ **characteristics of oil (viscosity);**
- ✓ **weather conditions (wind and sea state);**
- ✓ **depth of seafloor;**
- ✓ **distance from protected or sensible areas;**

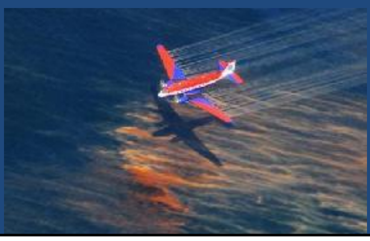

Best Practices for the use of sorbents and dispersants during an oil spill response
Are oil slick containement and/or clean up through mechanical tools possible? (e.g. *skimmers*)
Yes
Mechanical recovery of spilt oil
Is recovery fullfilling?
Yes
End of operations
No
Oil slick < 50 tons
Oil slick > 50 tons
Sea condition (Douglas scale)
≤ Degree 2
> Degree 2
Oil slick is nearby or is approaching protected or sensible areas (e.g. wildlife resting and nesting areas, transitional waters, rochy shoreline)?
Sorbents and containement tools are suggested
Yes
No
Is intervention fullfilling?
Evaluate the use of dispersants
Check oil slick evolution and be eventually prepared for shoreline clean up
Yes
No
Oil viscosity between 150-5000 cSt
No
End of operations
Check oil slick evolution and be eventually prepared for shoreline clean up
Yes
Distance from the coast > 3 NM if depth < 50 m or distance from the coast > 1 NM if depth > 50 m
No
Yes
Request to Italian Ministry of Environment for use of dispersants is mandatory
Yes
Sea condition > Degree 2 (Douglas scale) Wind ≤ Degree 6 (Beaufort scale)
No

Dispersant Research United States Efforts

Mr Robert G. Pond
US Coast Guard
Marine Environmental Response Policy

Historical Research

- Despite recent intense public scrutiny, dispersant research has been ongoing for the past 50 years.
- The Louisiana Universities Marine Consortium (LUMCON) developed a comprehensive dispersant research bibliography with approximately 2,000 citations including peer-reviewed research papers, government reports, conference proceedings and gray literature from 1960 through 2006 (http://www.lumcon.edu//library/dispersants/)



Government

- Information & priorities shared through 14 agencies via ICCOPR (www.iccopr.uscg.gov)
- Individual agencies sponsor research
- Current government projects:
  - Expanded toxicity studies
  - Blue Crab impacts
  - Validation of time windows needed for dispersant applications
  - Comparison of small-scale dispersant testing methods
  - Effectiveness of typical aircraft spray dosages on OCS Crude Oils

Government

- The National Oil Spill Response Research & Renewable Energy Test Facility tank is filled with 2.6 million gallons of saltwater.
- Allows testing of full-scale equipment with state-of-the-art data collection & video systems.

Industry

The American Petroleum Institute with its industry companies have developed a large-scale, multiple-year Subsea Dispersant Program to conduct controlled experiments about:

- Effectiveness of subsea injection over a range of conditions;
- Effects of dispersed oil on deepwater marine environments;
- Numerical modeling upgrade needs to better predict the fate of oil treated with dispersant and released from a deepwater well; and
- Monitoring tools that could be used to determine the effectiveness of subsea injection during an event.

Academia

- DWH spawned numerous university studies involving dispersants.
- Many regions of the country have developed cooperative research consortia to leverage funding & resource sharing.

Dr. Vijay John – Tulane University

Dr. Robert Lochhead – Southern Mississippi University

- Gulf of Mexico Research Initiative (GoMRI) is supplying $500 Million
- Dispersant research topics:
  - Weathering of dispersants
  - New dispersant development
  - Survival of Gulf nekton larvae

The Future

- On Water/In Situ dispersant testing?
- Improved understanding of
  - Effectiveness
  - Effects tradeoffs in water column, benthos, surface and shoreline when dispersants are used vs when they are not.
- Better dispersants, better application methodologies
- Greater responder, political and public understanding confidence in need and purpose.

• Questions?

Current status of industry led dispersant research activities

November, 2012
Thomas Coolbaugh, Ph. D.
Fairfax, Virginia

Joint Industry Research Projects

- American Petroleum Institute (API) Joint Industry Task Force "Subsea Dispersants – D3"
- International Oil and Gas Producers Association (OGP) Arctic Oil Spill Response Technology Joint Industry Programme
- NewFields Joint Industry Project on Toxicity and biodegradation rates of dispersed oil in Arctic marine environment

API Dispersants D-3 Program Overview

- Objective: Conduct research and development on subsea dispersant injection to provide optimal implementation methods
  - The program will include research on application methods, effectiveness, and potential environmental effects
  - Focus is ice-free open-water environments but there is applicability to shallower water and Arctic environments
- Key Team Members
  - American Petroleum Institute, Anadarko, BP, Chevron, ExxonMobil, Marine Well Containment Company, Nexen Petroleum, Shell, Statoil, Total, Wild Well Control
- Study Duration: 3 years - start 1 Oct 2011, possibly culminating in an open ocean field trial in 2014

3

API D-3 Program Rationale and Design

- Subsea injection helps maintain safe working environment for well containment personnel
- In many well control scenarios, subsea injection should provide a net environmental benefit considering its demonstrated effectiveness and the limitations of other offshore response options

- Five project teams: Effectiveness, Fate and Effects, Modeling, Monitoring, Communications
- Coordinating with other industry efforts, e.g., API Dispersant Communications D-1, OGP Oil Spill Response JIP

4

OGP Arctic Oil Spill Response Technology Joint Industry Program

- In January 2012, members of the international oil and gas industry launched a collaborative effort to enhance Arctic oil spill capabilities. This collaboration, called the Arctic Oil Spill Response Technology JIP, will expand industry knowledge of, and proficiencies in Arctic oil spill response.
- 9 participating companies:
  BP, Chevron, ConocoPhillips, Eni, ExxonMobil, North Caspian Operating Company, Shell, Statoil, Total

Photo: DF Dickins

OGP Arctic JIP: Objectives

- Create an international research program to further enhance knowledge and capabilities in the area of Arctic oil spill response (OSR)
- Raise awareness of existing industry OSR capabilities in the Arctic region

- Working together, the JIP companies are ensuring the most efficient use of resources, funding and expertise to improve technologies and methodologies for Arctic OSR
- Key research areas: Dispersants, Environmental Effects, Trajectory Modeling, Remote Sensing, Mechanical Recovery, In-Situ Burning and Field Research

OGP Arctic JIP: Dispersant Projects

- Fate of dispersed oil under dynamic drift and pack ice
  - Develop a numerical model to predict fate of dispersed oil plume that develops under ice, particularly the resurfacing potential
- Dispersant testing under realistic field conditions
  - Understand operational needs for dispersant and mineral fines application in Arctic conditions
  - Conduct large-scale basin tests and field verification on efficacy of dispersant and mineral fines in Arctic marine waters
- 2 project proposals in final negotiations

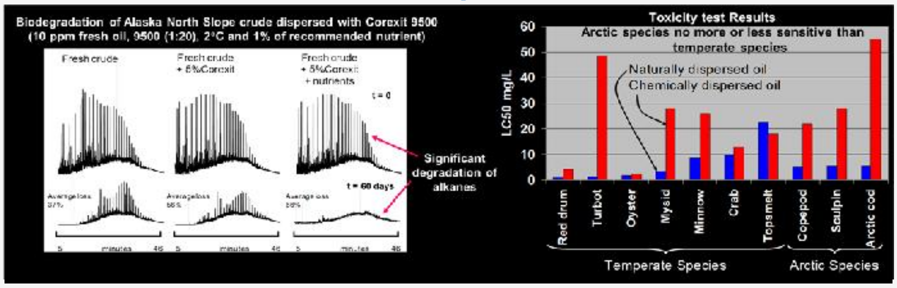
NewFields Joint Industry Program Research

Toxicology and Biodegradation of Crude and Dispersed Oil in the Arctic Marine Environment

Barrow Arctic Research Center
Barrow, Alaska

- Research Partners
  - NewFields, UAF, BASC, BARC, Alpha Analytical
- Technical Advisory Committee:
  - USCG, NOAA, USEPA, ADEC, NSB, CEDRE, UAF, COOGER, SINTEF, Akvaplan Niva
- Sponsoring Companies
  - Shell, ExxonMobil, Statoil, ConocoPhillips
- Identification of Research Needs
  - Literature review; International workshop; Develop scopes of work and test protocols
- Develop infrastructure to support research work in the Arctic
  - Personnel; Facilities ; Equipment; Testing procedures to accomplish tasks

Fate and Effects of Arctic Dispersed Oil



- Dispersed-oil biodegradation study using Arctic microbes and conditions
- Seawater samples collected from the Alaskan Beaufort Sea
- Tests performed between -1 and 2°C

- Dispersed-oil toxicity study using Arctic cod, sculpin, and copepod
- Alaska North Slope crude test oil
- Organisms collected from the Alaskan Beaufort Sea
- Tests performed between -1 and 2°C

- Workshop held with stakeholders in Anchorage, Alaska
- Papers on biodegradation and toxicology to be published

Other Industry Research

For example-

- Comparison of dispersant effectiveness tests
  - Different oils
  - Different bench tests
  - Correlate to large scale wave tank
- Development of higher activity dispersant
  - Examine wide range of crudes
  - Evaluate different dispersant to oil ratios, e.g., less than the typical 1:20
  - Cold water testing as well

Summary

- There continue to be significant advances in oil spill prevention and response technology
- These are international research programs to further enhance industry knowledge and capabilities
- To raise awareness of existing industry capabilities
- Working through joint industry projects ensures efficient use of resources, funding and expertise to improve technologies and methodologies for oil spill response

Thank you for listening.

SUB-SEA OIL SPILL DISPERSANT EFFECTIVENESS

Nicolas Passade-Boupat, Marianna Rondon-Gonzalez, Maurice Bourrel, *Total Petrochemicals*

Anne Courbot, Yannick Autret, *Total Exploration Production*

OBJECTIVE

- In case of an event, possible application of sub-sea dispersion
- Develop screening tools and methodologies :
  - To assess efficiency of the technique
  - To help selecting the most efficient among registered dispersants and optimizing its use
- Disperse Oil in Water :
  Analogies with chemical enhanced oil recovery (cEOR) techniques

Prevention	Remediation
• Method to select best dispersant during field development stage	• Way to optimize dispersion on-site with limited delay

OBJECTIVE – STABLE DISPERSION

Generate small oil droplets

No coalescence before being dispersed by dilution, and degraded

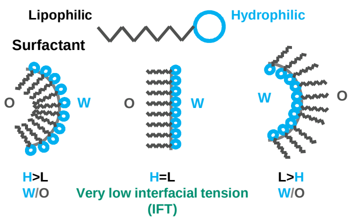
$$v = \frac{2r^2 g \Delta(\rho)}{9\eta}$$ Stokes speed

SCREENING OF DISPERSANTS

Dispersant for surface : Solvent + **Surfactants**

Surfactant : ↘ interfacial tension (IFT) to **disperse** oil droplets in water & to **stabilize** the droplets

Optimization & robustness of Oil / Surfactant / Water system (→ similar to cEOR)



LIPOPHILICITY ⇨ OIL TYPE
HYDROPHILICITY ⇨ ELECTROLYTES, pH, T

HYDRODYNAMIC FLOW CONDITIONS

Hydrodynamic : large drops or atomization

Controlled by Reynolds Number & Weber Number

(Reynolds = inertial/viscous /Weber= inertial / surface)

$$\mathrm{Re}_L = \frac{\rho U L}{\mu} = \frac{UL}{\nu} \qquad We = \frac{\rho \cdot v^2 L_c}{\sigma}$$

Atomization ↗ if throughput and shear ↗ or interfacial tension (IFT) ↘

If hydrodynamic helps, it is easier for the dispersant

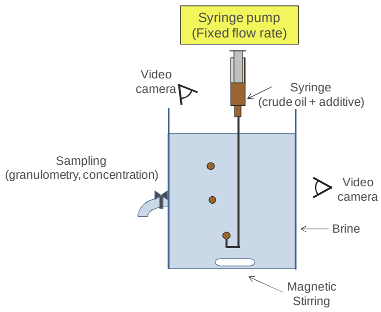
- Not ↘ IFT as much for same droplet size
- → Coalescence between droplets to consider

→ **Low throughput test more demanding for dispersant**

EOR : Possibility to optimize surfactant to field conditions

Sub Sea dispersion : Possibility to optimize dispersant choice and use

WORKFLOW

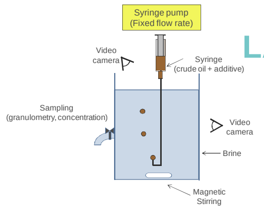


Lab scale dispersion test
Physicochemistry screening of the system
Inject for 1 min
Follow dispersion for 24h

Pilot scale dispersion test
H=2 m, ϕ= 0.5 m
Inject for 1 min
Follow dispersion vs H for 24h

Sampling : granulometry & oil dosage
Laser light transmission

WORKFLOW



LAB SCALE TEST

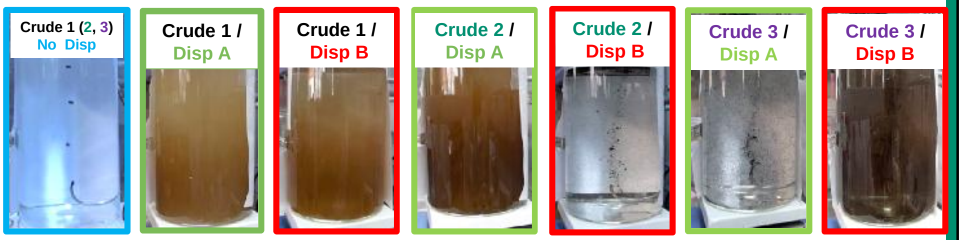
▸Lab scale test : to screen variables easily

- Low shear
- Variables
  - Oil type
  - Water chemistry (**Robustness**)
  - dispersant : type & concentration

Quantitative evaluation vs time :

- Transmitted light through laser
- Oil quantity
- Droplet size distribution

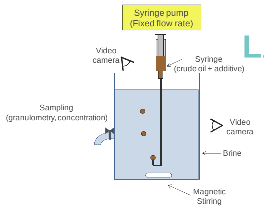
Sea Water/ Crude Oils / 2 % dispersant in the crude after 30s



Crude 1 d=0.87 h=24 cP **Crude 2 d=0.85 h=6.3 cP** **Crude 3 d=0.91 h=113 cP**

The most efficient dispersant is not always the same

WORKFLOW



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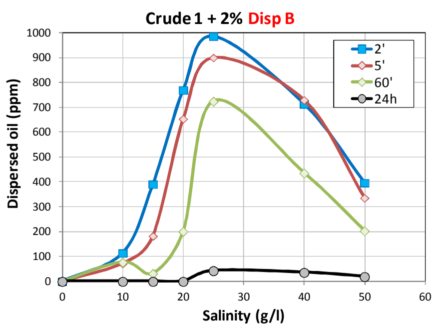
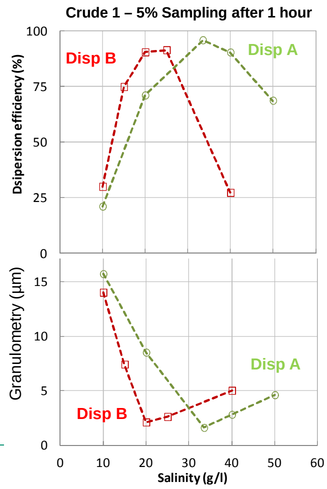




WORKFLOW

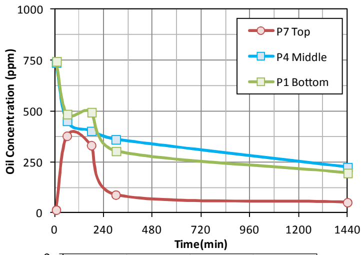
PILOT TEST

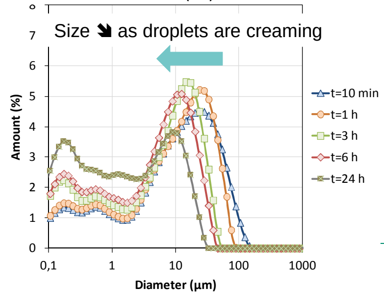
- Larger column : H=2m ; ϕ=0.5m
  - To be able to apply the dispersant in the water column
  - Confirm small scale tests
  - Study coalescence phenomena in the "plume"

After 1 hour

After 24 hours

Crude 1 / Sea Water / 2 % Disp A





CONCLUSIONS

- Stable oil droplet dispersions prevent resurfacing, and offer exposure to biodegradation
- Initial droplet size important for preventing creaming towards the surface (very dependent on process parameters)
- Paying attention to coalescence mechanisms in the "early" stage is key for keeping dispersion
- Importance of the oil / brine / dispersant adequation to optimize usage
- Lab test focused on low turbulence level to emphasize the dispersant contribution
- Try to understand "robustness" of dispersion vs. process parameters & oil variations
- Integrated in the follow up of the various JIP's on dispersants

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Subsurface releases of oil Oil droplet distributions and dispersant injection techniques

Presented by:

Per Johan Brandvik, Dr.scient.
Senior Scientist / Professor
(per.brandvik@sintef.no)

SINTEF Materials and Chemistry
Marine Environmental Technology department
Trondheim, Norway

A large team is involved in these studies

The team:

- **Øistein Johansen**, Dr.Eng., Modelling specialist
- **Per S. Daling**, MSc., Oil spill specialist
- **Umer Farooq**, PhD., Oil-surfactant interaction
- **Frode Leirvik**, Engineer, Tower basin operator
- **Marianne Unaas**, Engineer, Chemical analysis
- **Odveig Bakken**, Laboratory technician
- **Ivar Singsaas**, MSc, QA responsible
- **Per Johan Brandvik**, Scientific coordinator

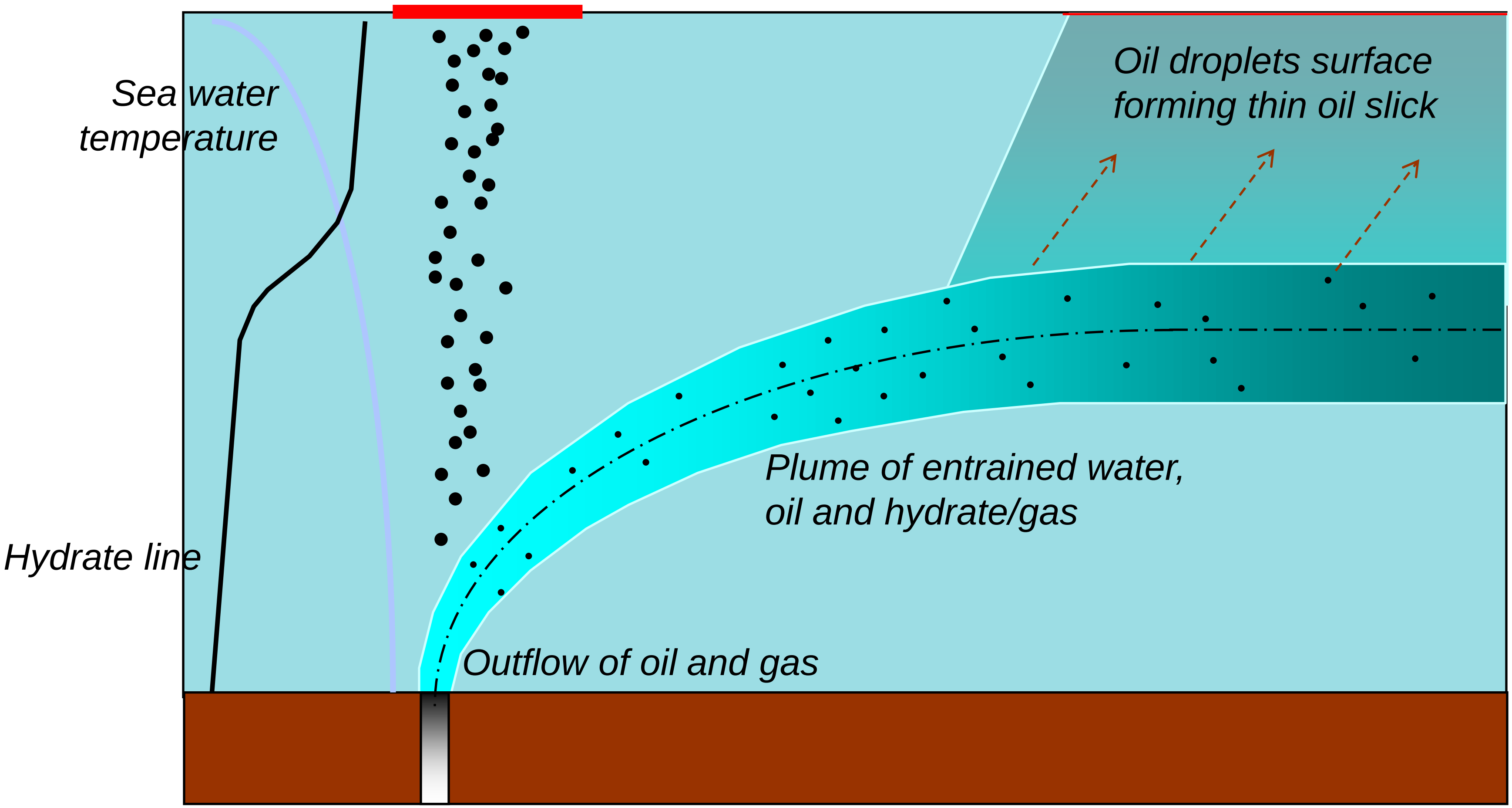
Presentation overview

1. **Basics for the SINTEF experimental facilities**
   - ✓ Tower basin (40 000 L)
   - ✓ Mini Tower (80 L)

2. **Experiments ➔ new dataset ➔ new algorithms to predict droplet formation**

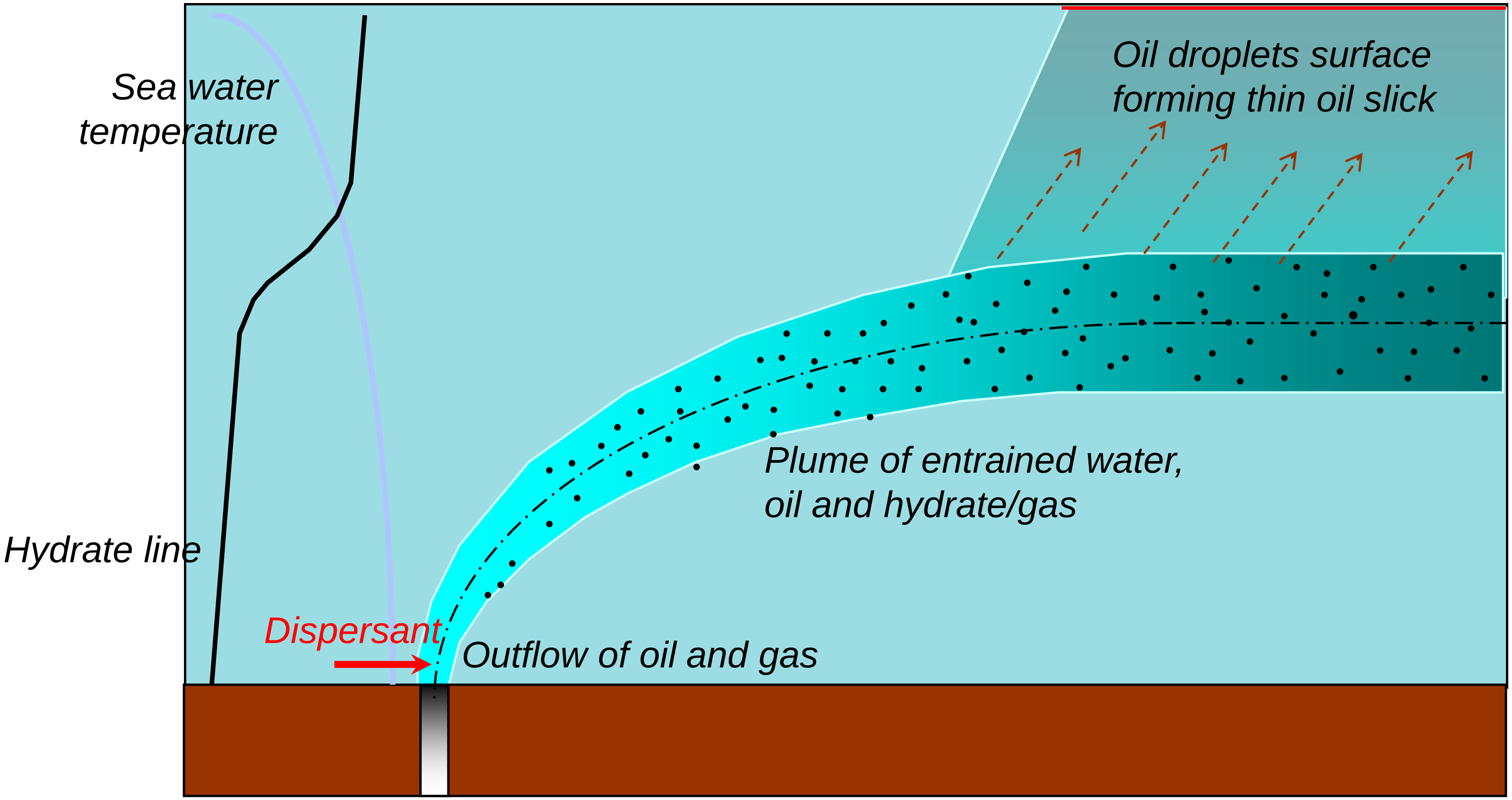
3. **Testing of different injection techniques**

Subsurface release – WITHOUT dispersant injection



An increased fraction of large oil droplets will give a more vertical stream of oil resulting in a thick surface oil slick directly above the release point

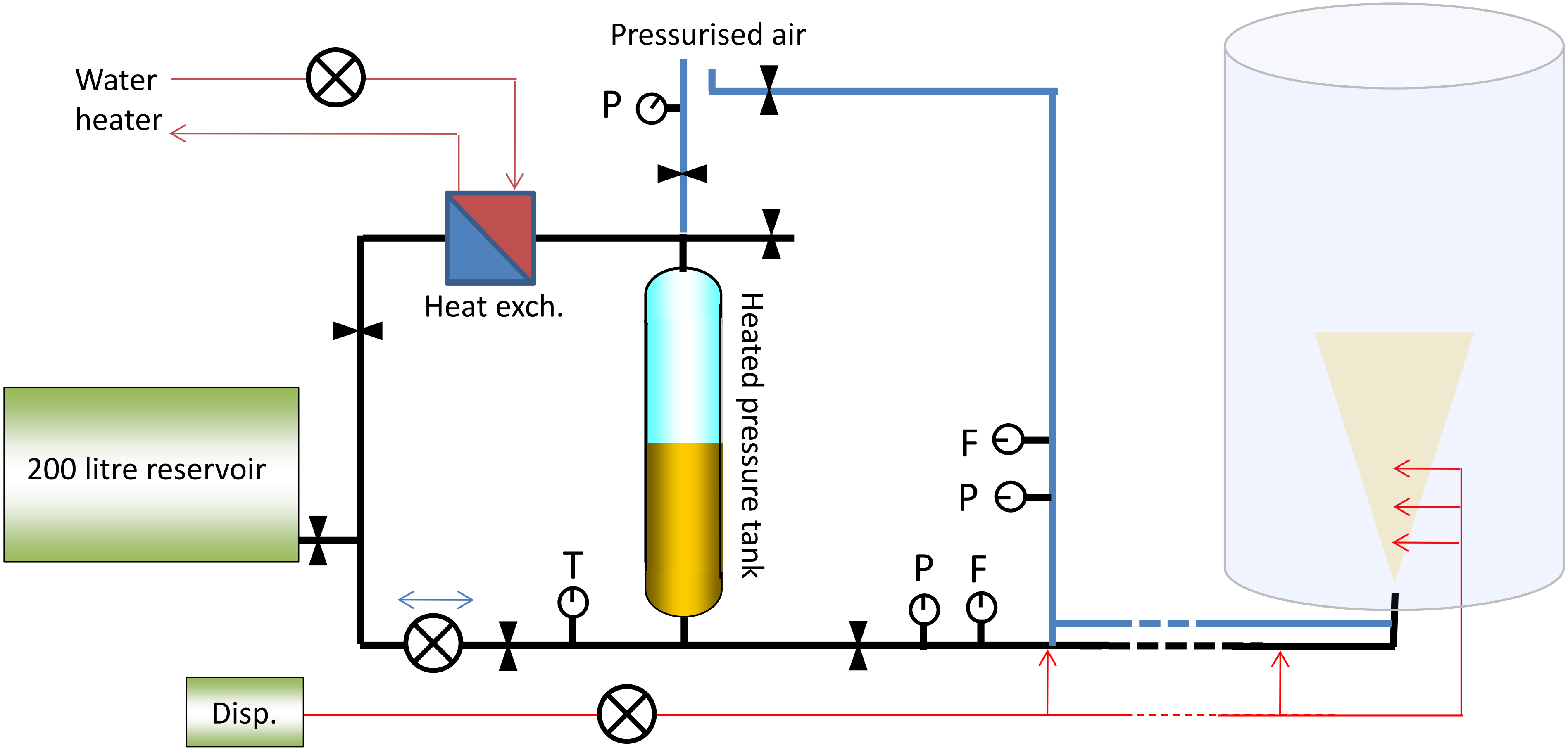
Subsurface release – WITH dispersant injection



Smaller droplets ➔ more oil will follow the plume of water beeing entrained due to cross currents and density layers. Resulting in a thin/wide surface slick and less oil on the surface

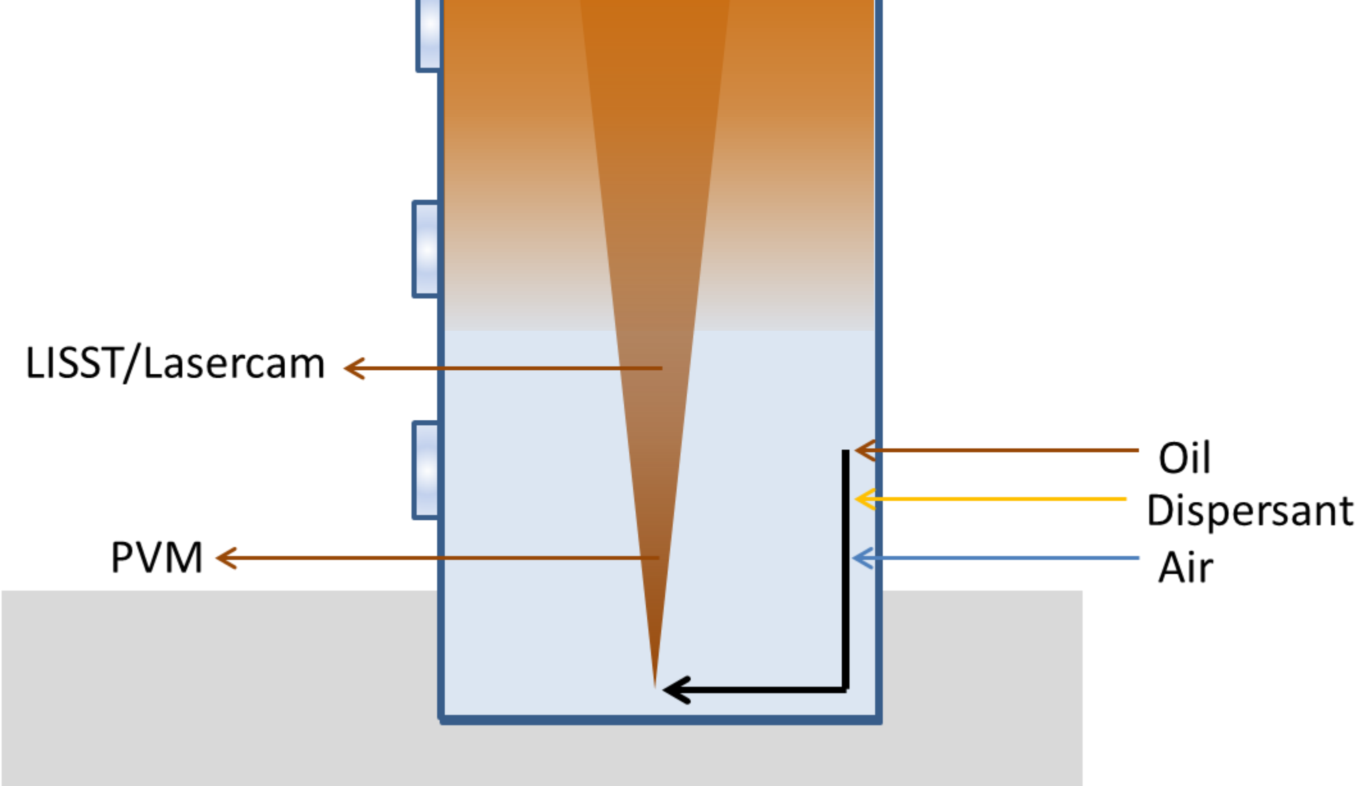
SINTEF Tower Basin

Overview of experimental set-up



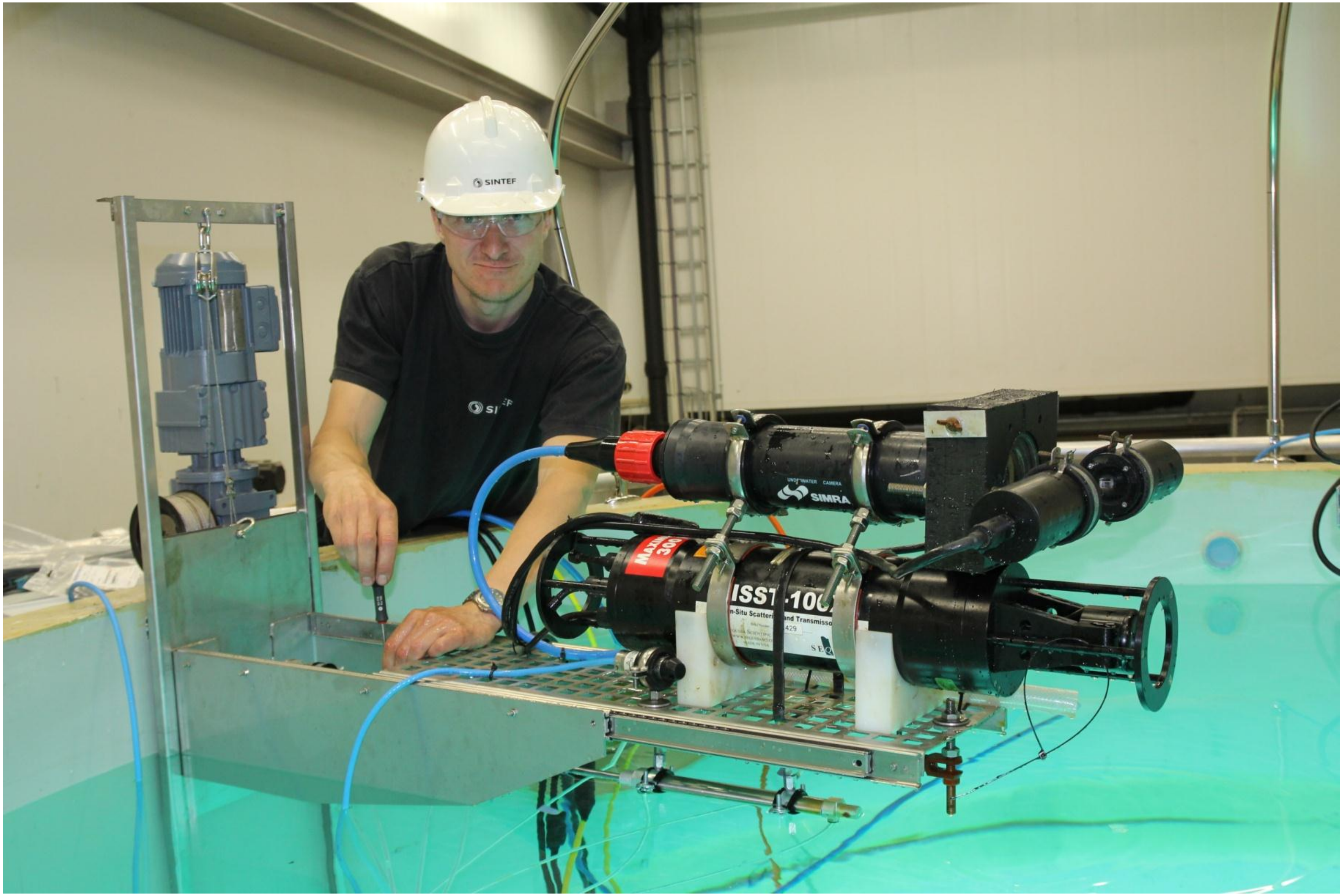
Principle overview of the set-up showing how oil, gas (air) and dispersant will be released during the experiments.

Tower Basin - Experiment specifications



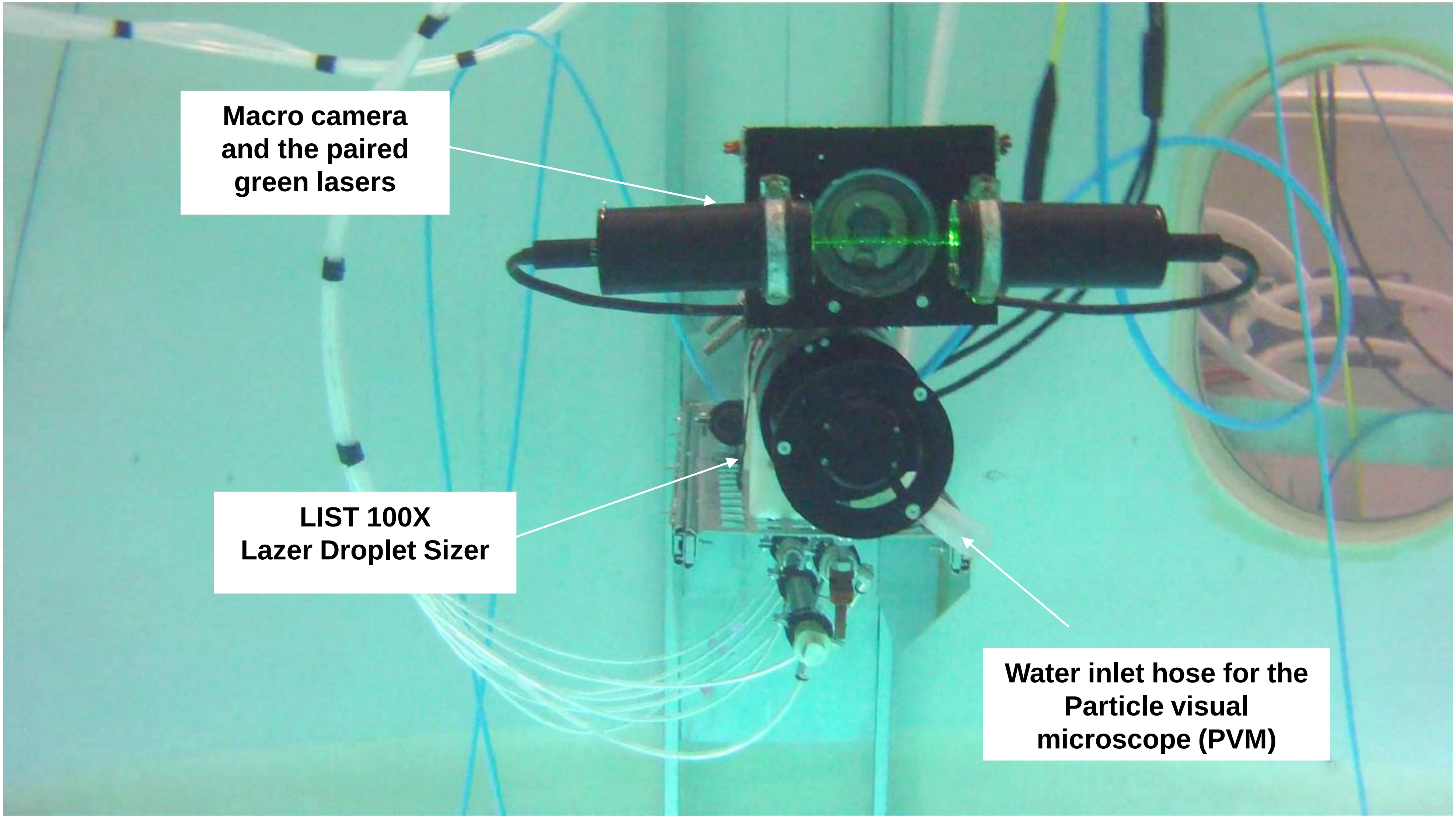
Limited test time 10-15 minutes

Tower Basin - Initial experiments

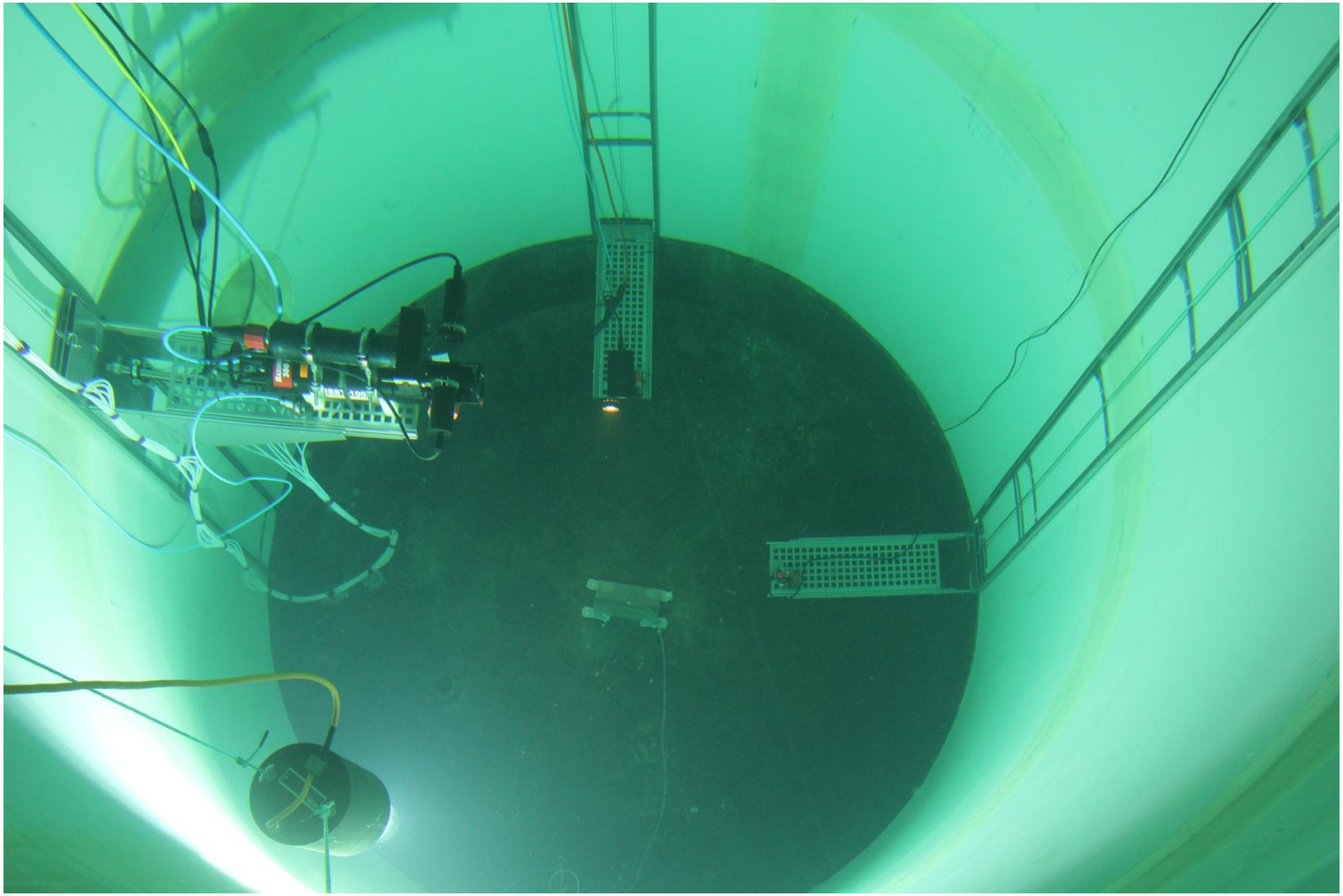


Adjusting camaras and sensors before the first experiment is initiated

Tower Basin - Droplet Size Monitoring



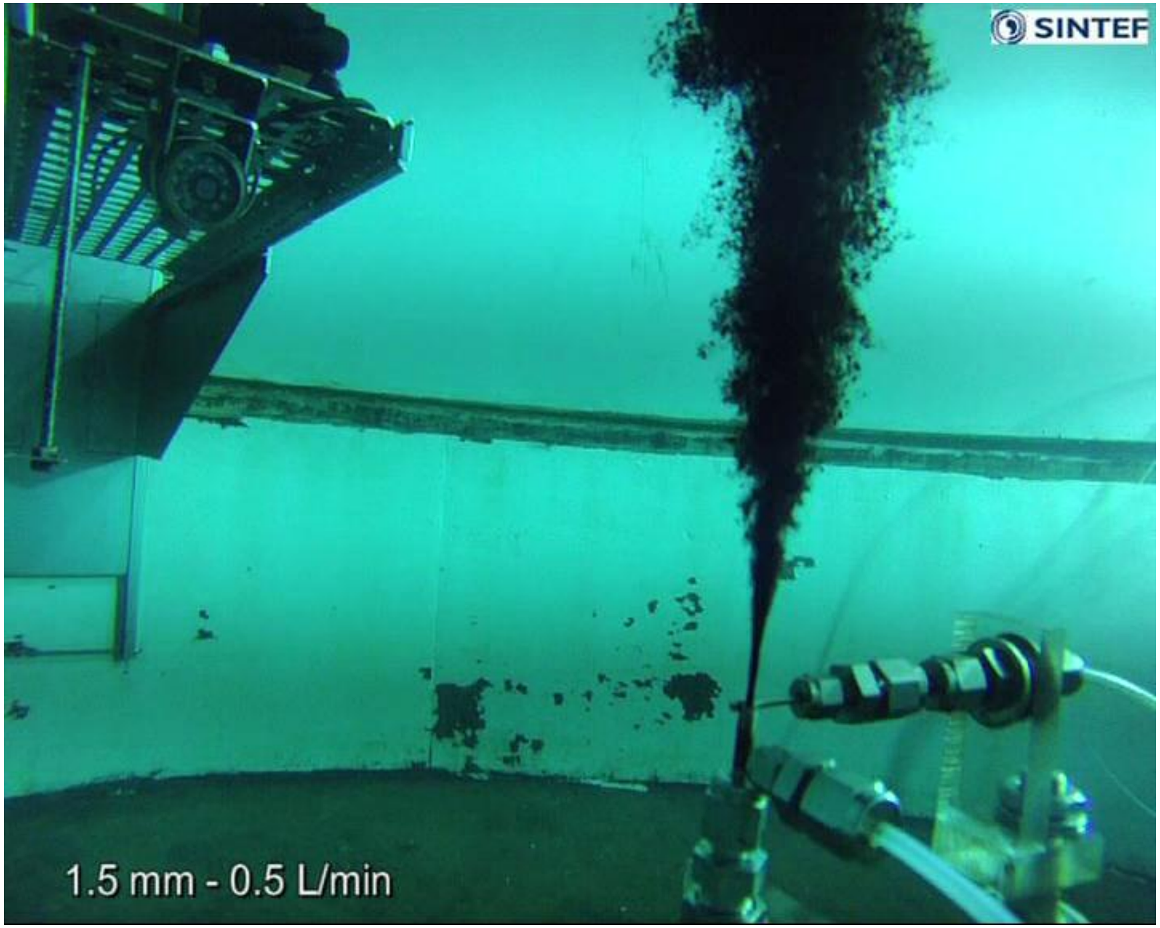
Tower Basin – prior experiment initiation



Click for video

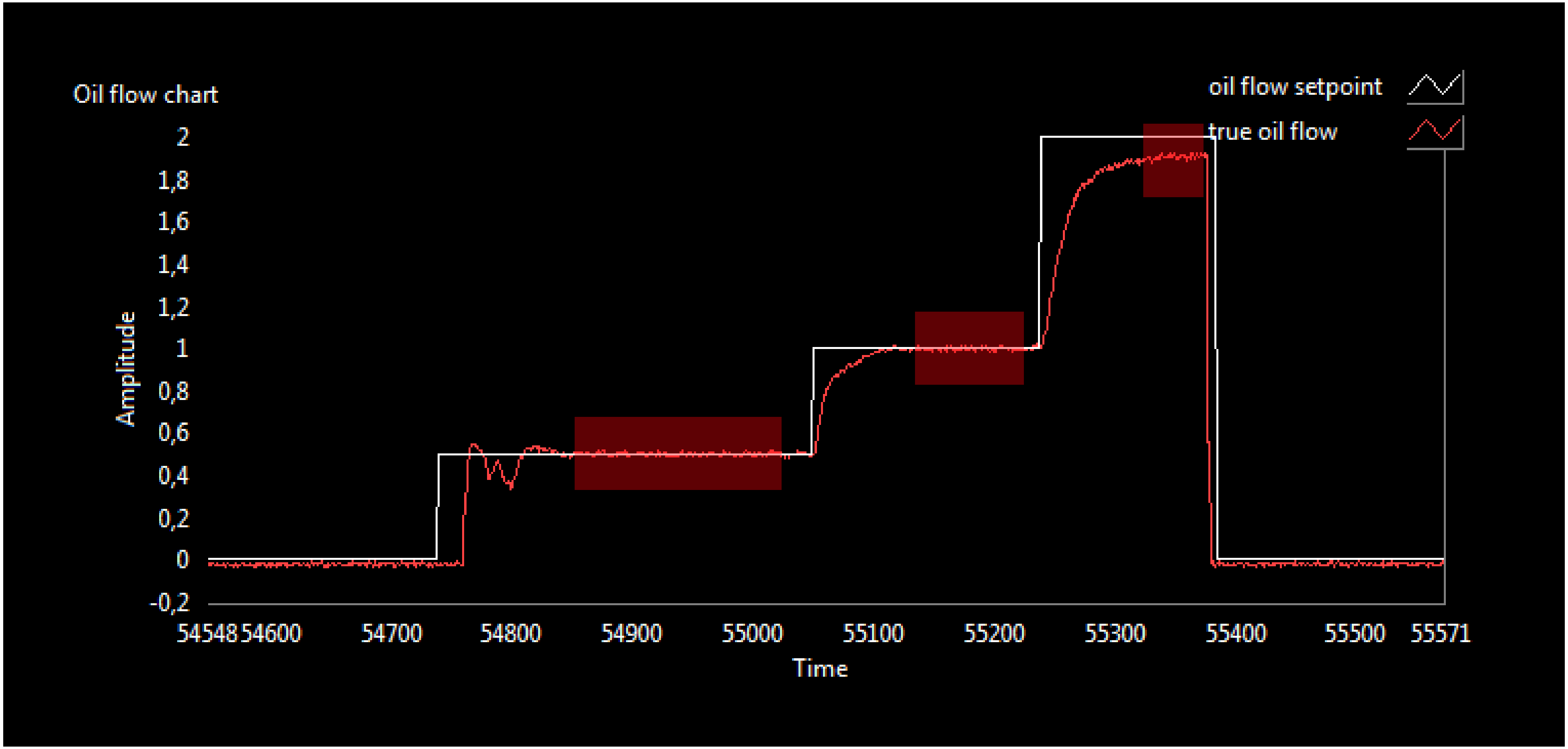
Droplet size monitoring equipment at 3 meters dept, cameras at bottom

Initial experiments
With different nozzles and flow rates



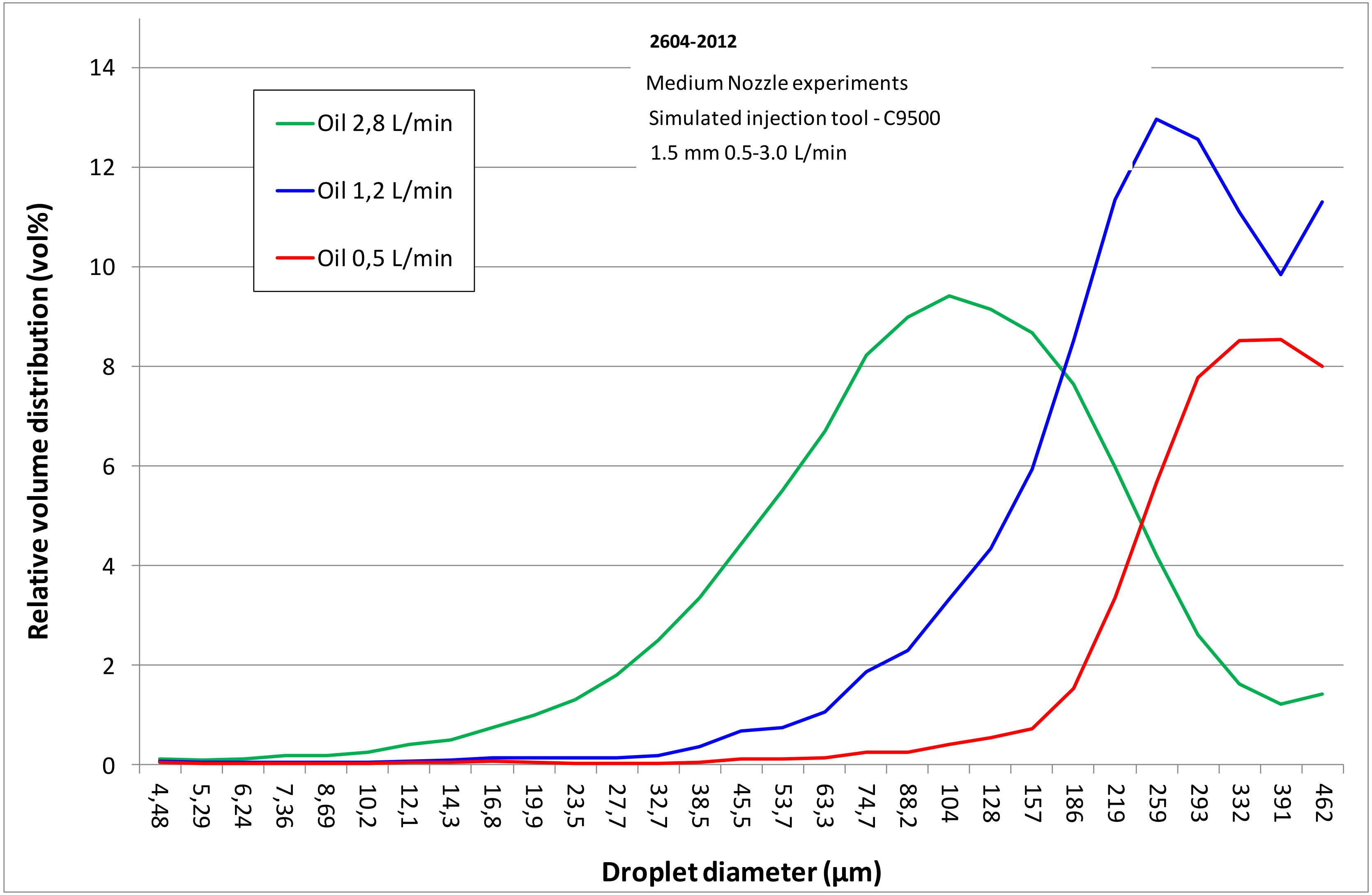
Release of Oseberg oil: Diameter 1.5 mm, rate: 1.5 L/min (0.5, 1.5 and 3 L/min)

Operational control – Flowrates versus time



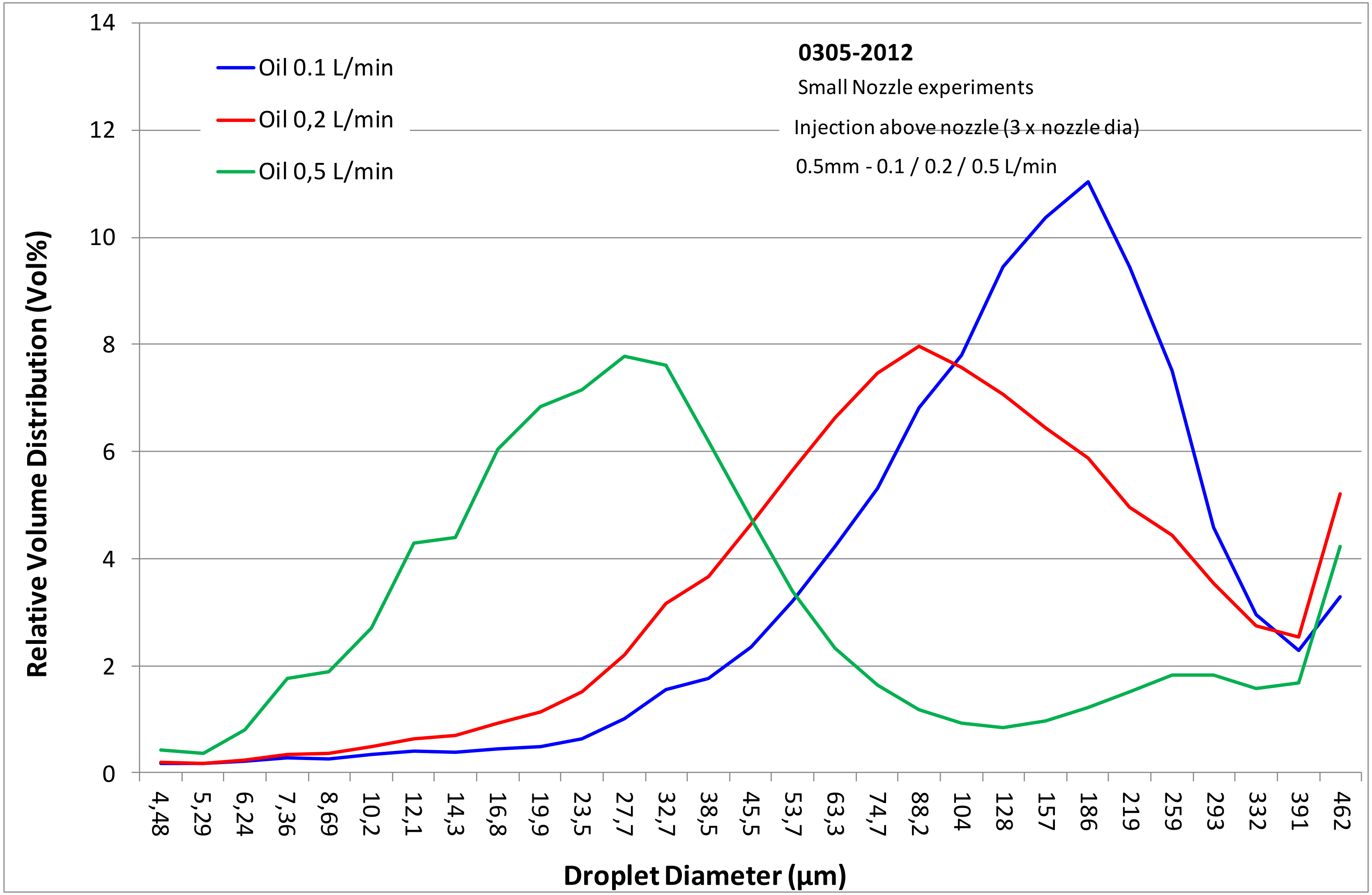
Controll and monitoring of oil flowrates for a typical experiment (one nozzle three flow rates)

Flow rate exp 1.5 mm Nozzle



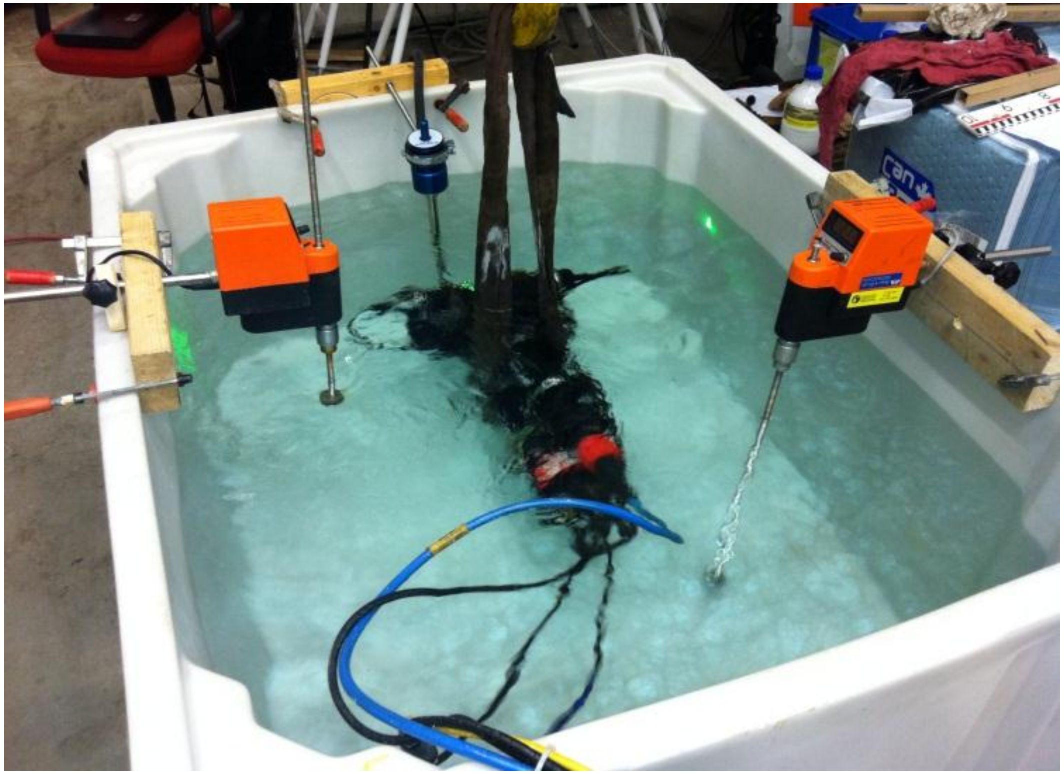
Oseberg experiments with different DORs (upstream injection)

Flow rate experiments 0.5 mm Nozzle



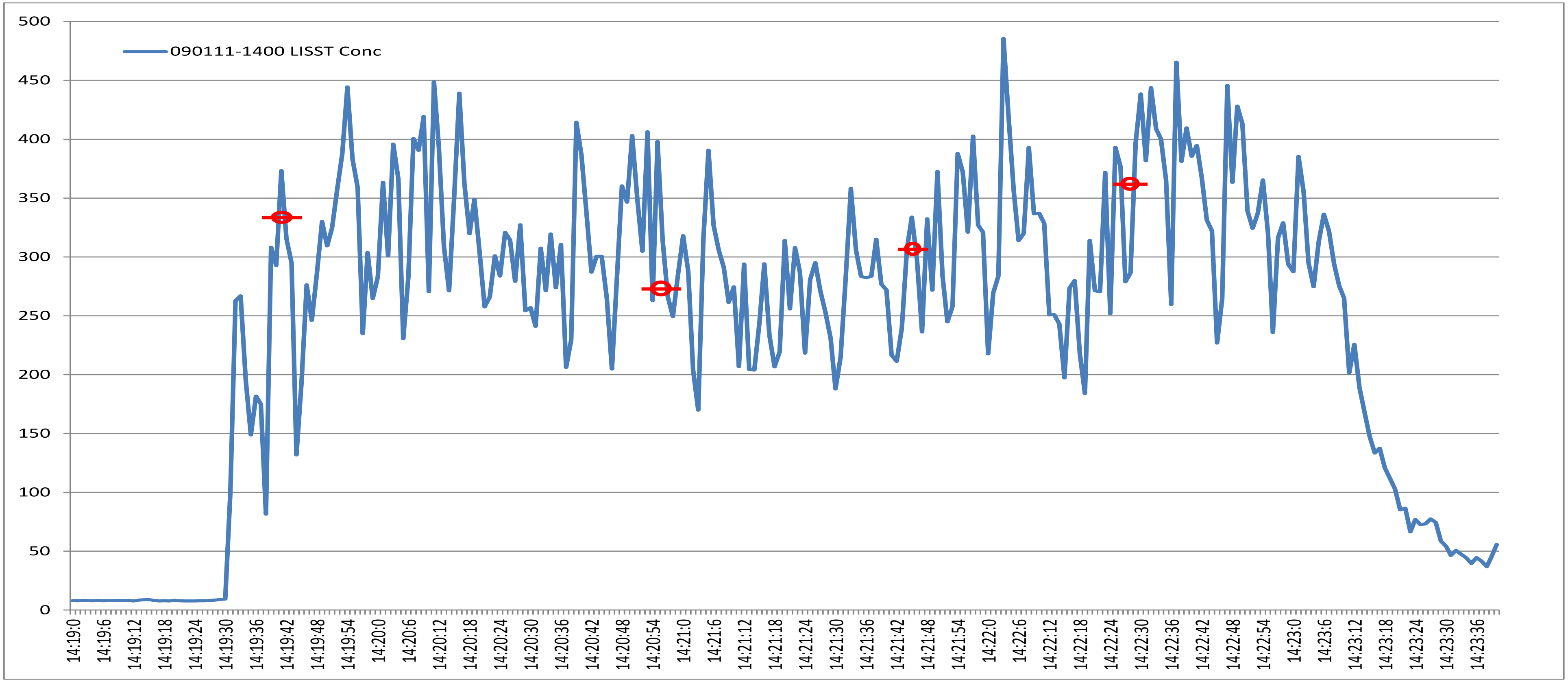
Oseberg experiments with different DORs (upstream injection)

Calibration of droplet size measurements



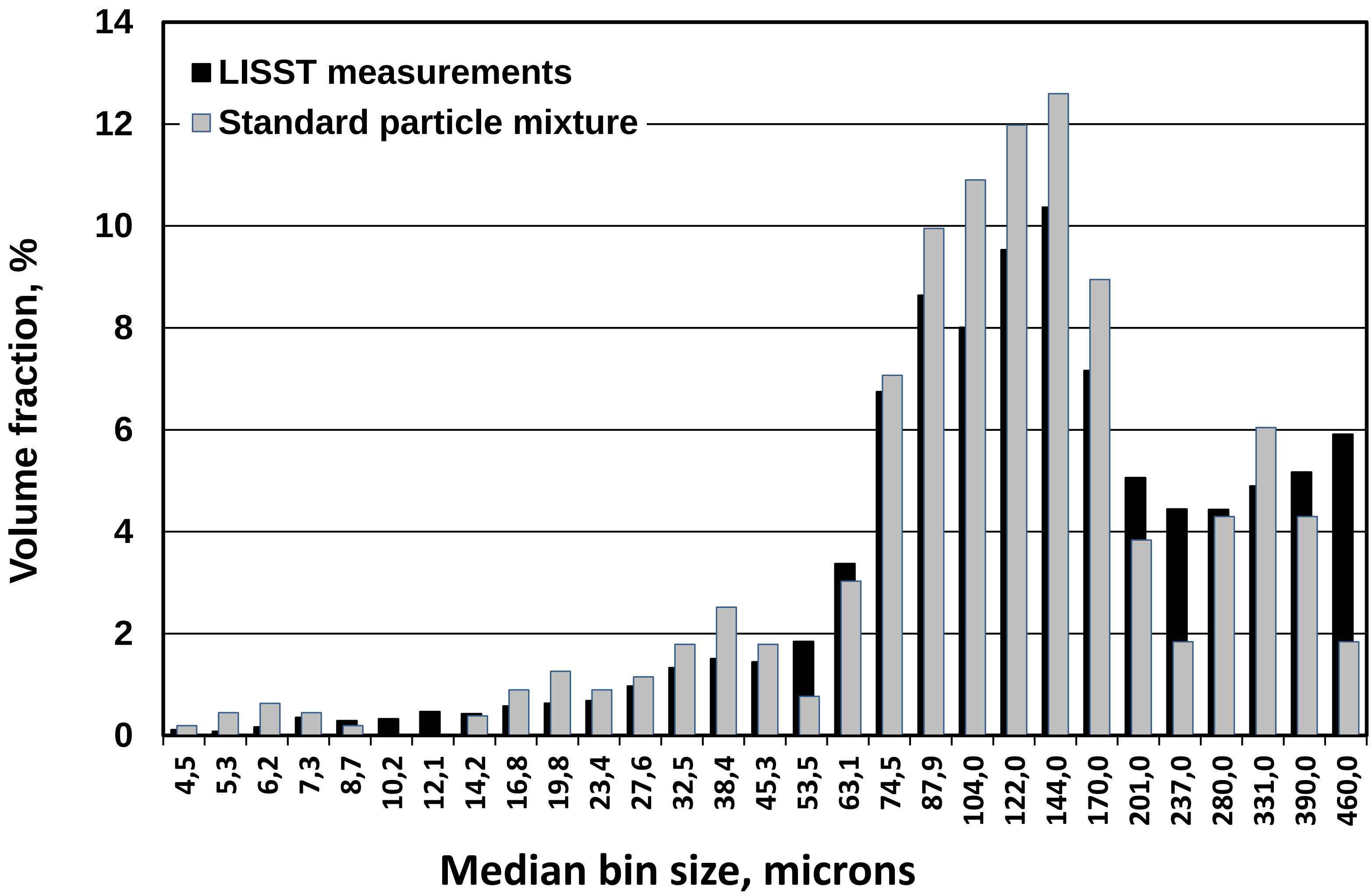
Verification of the LISST instrument in a 900 Litre container injecting batches of mono disperse particles.

Calibration of oil concentration measurements



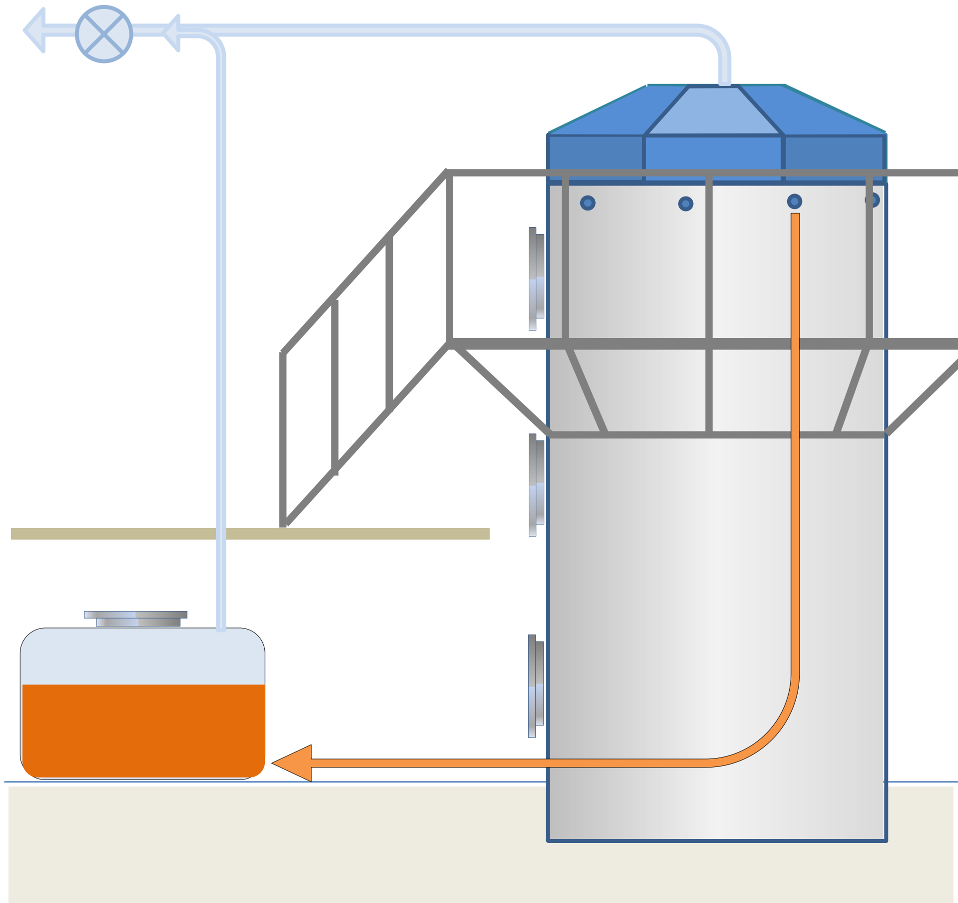
Verification of the LISST instrument in a 900 Litre container injecting batches of mono disperse particles.

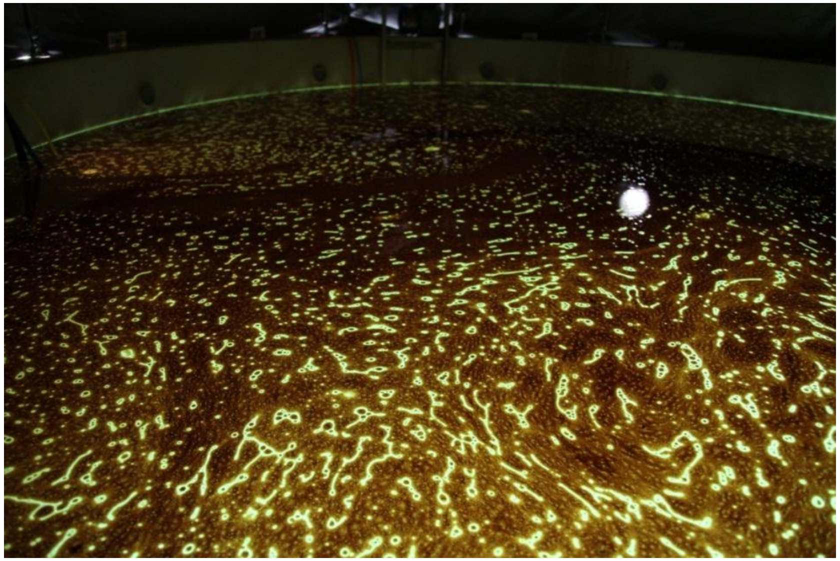
Calibration of droplet size measurements



Comparison of measured droplets with distribution of standard mixture

HSE consideration: Evaporation and Waste management





Surfacing fresh oil on top of the Tower basin. Light components are taken care of by the ventilating hood.

Surface oil is drained off and stored for later treatment.
Oily water treated by an oil-water separator (lower than 50 ppm) and disposed.

Three major subsurface blowout studies Focusing on: Droplet formation & dispersant injection

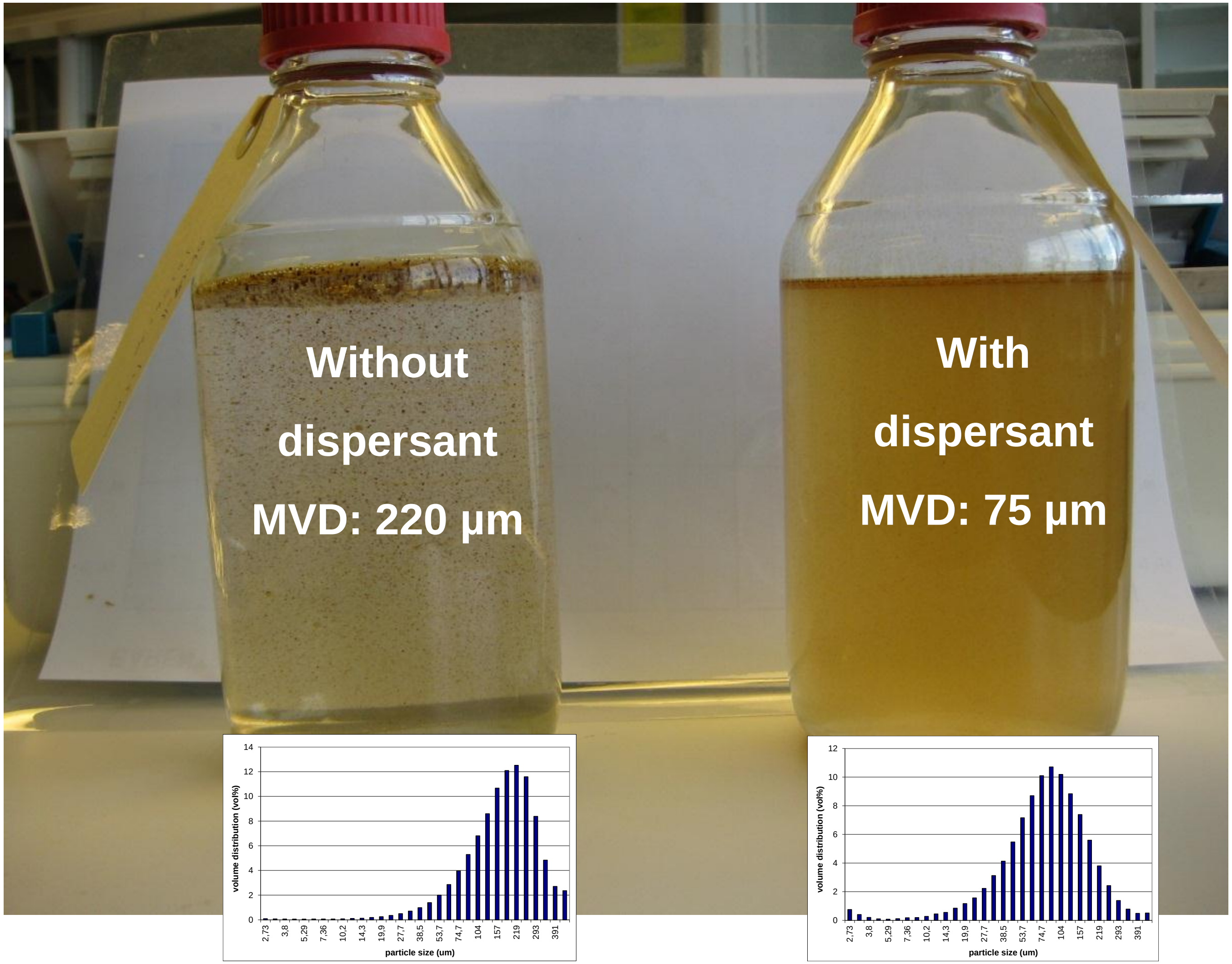
BP (March 2011 – March 2012)

- ✓ Brandvik et al, 2012 (submitted to MPB)
- ✓ Johansen et al, 2012 (submitted to MPB)

API Phase-I (March 2012 – November 2012)
API Phase-II (November 2012 – June 2013)

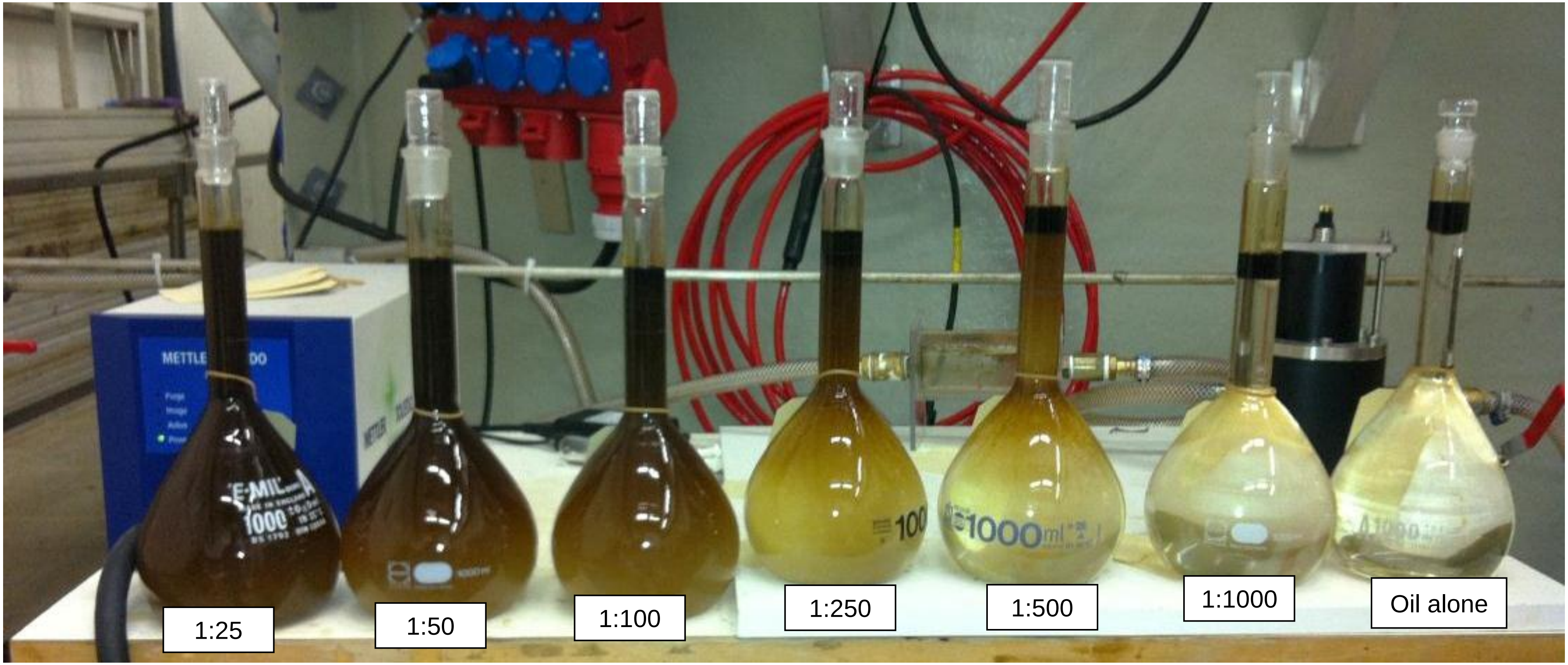
- ✓ Two technical reports
- ✓ Publications

Droplet size data from water sampling



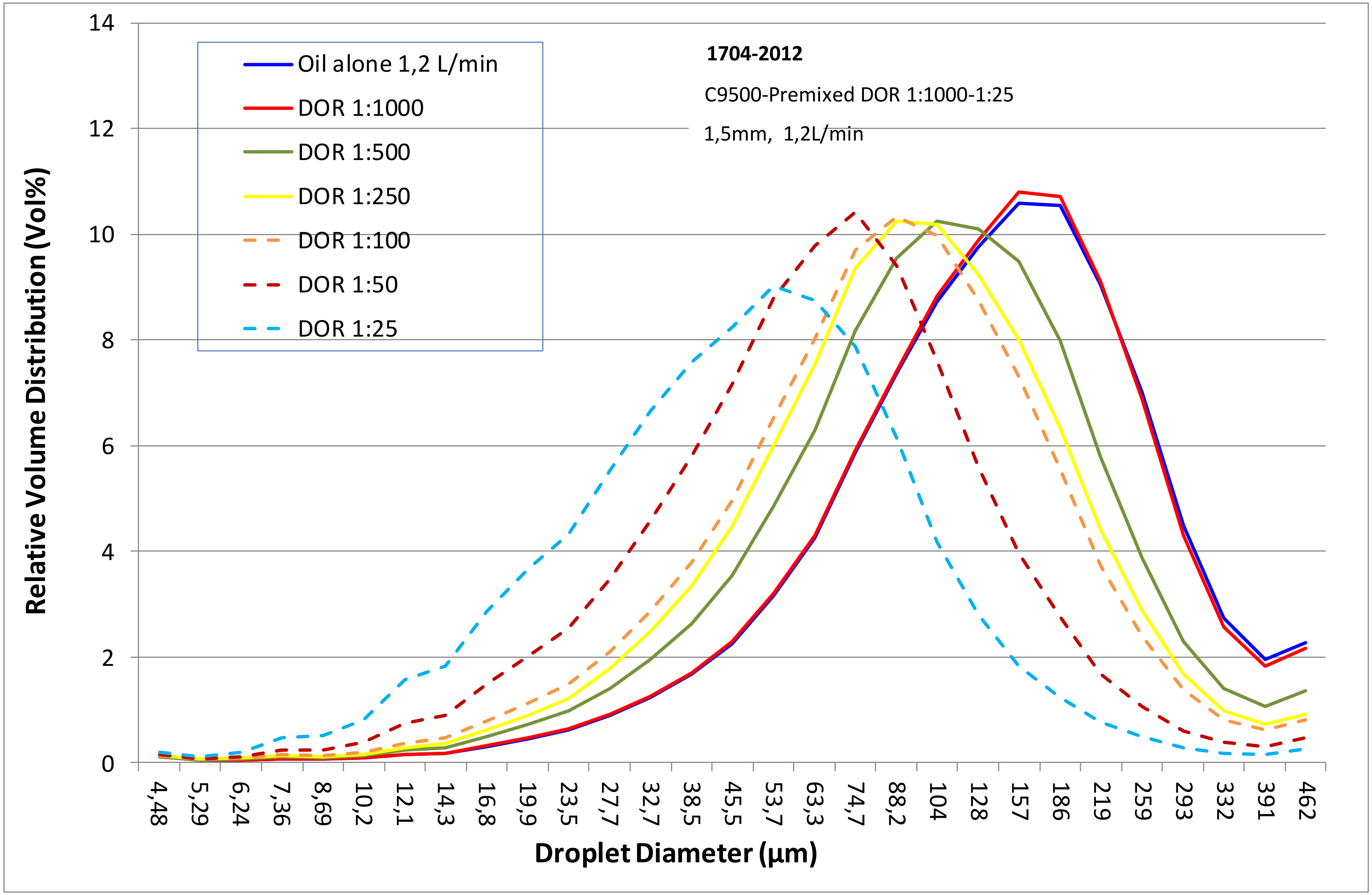
Water samples from Oseberg experiments **with** and **without** dispersant injection

DOR exp (Oseberg - 1.5 mm & 1.5 L/min)



Oseberg experiments with different Dispersant-to-Oil-ratios (DORs)
Upstream injection

DOR experiments (Oseberg-1.5 L/min)



Oseberg experiments with different DORs (upstream injection)

Estimation of droplet sizes based on release parameters, oil chemistry and use of dispersants

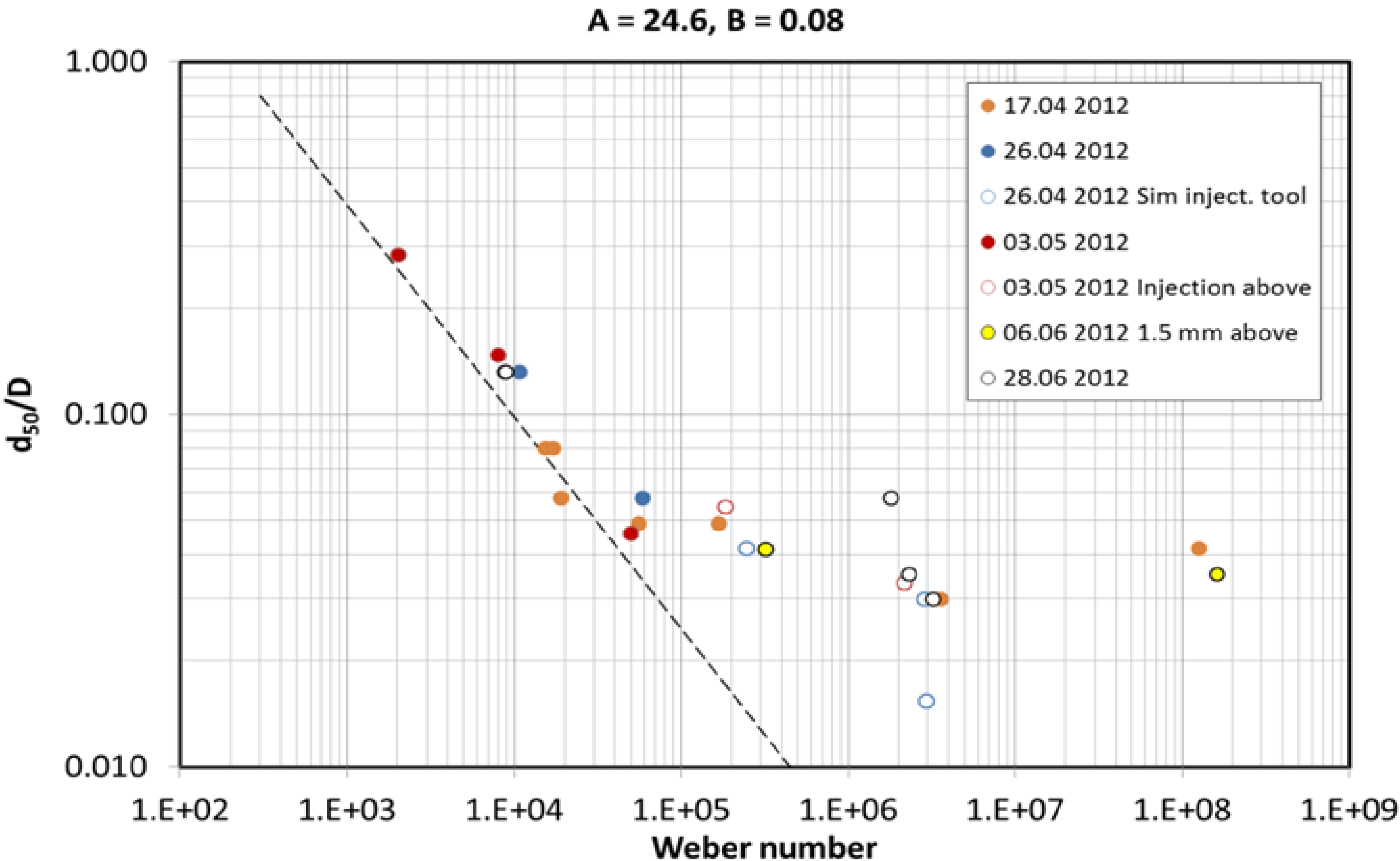
Current approach: Weber number estimation (Hinze 1955):

$$d_{50}/D = F\, We^{-3/5} = F\,(\rho\, U^2\, D/\sigma)^{-3/5}$$

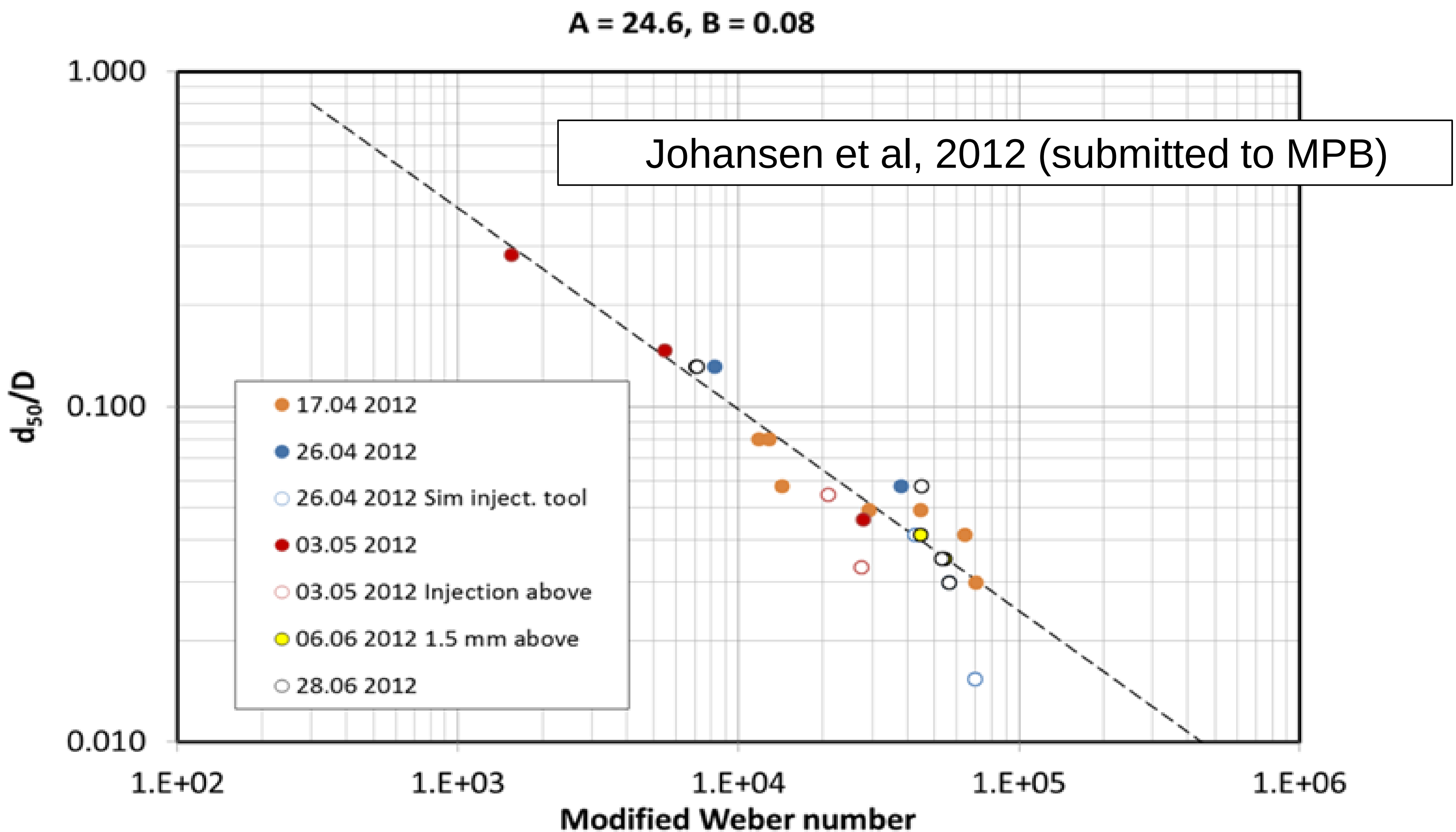
- d_{50} - parameter describing distribution
- *D - outlet diameter*
- *F - factor of proportionality*
- *ρ - density of the continuous phase (water)*
- *U - exit velocity*
- *σ - interfacial tension (oil-water)*

Based on our calibration dataset, we present a modified "Weber equation" ➔ better predictions of droplet sizes!

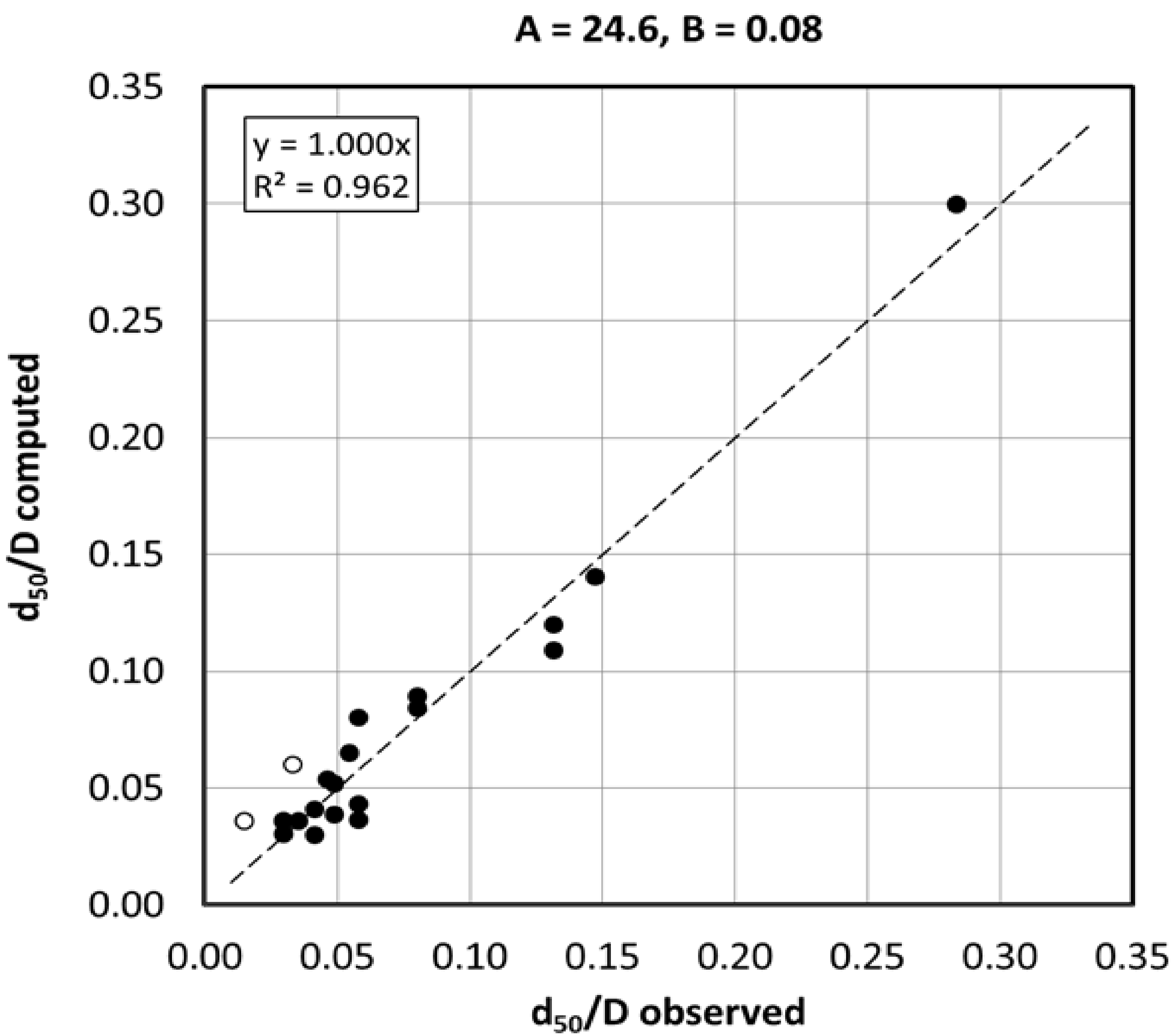
Weber number plot (Hinze, 1955)



Modified Weber number plot



Correlation plot



Improved estimation of droplet sizes based on release parameters

NB! *Verified by SINTEF subsurface field experiment from 2000 (844m)*

New approach:

$$d_{50}/D = F_c\, We^{*-3/5}$$

Use a fixed proportionality factor (F_c) and a modified Weber number (We*) with the following adjustments:

1. A void fraction correction will apply to combined oil and gas discharges
2. A buoyancy correction will mainly apply to large volume flows (Fr < 1)
3. A viscosity number correction will be important for dispersant applications

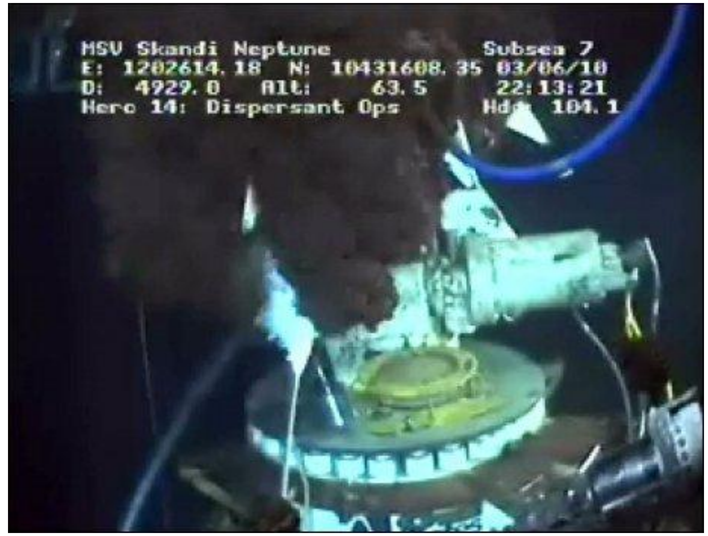
✓ Johansen et al, 2012 (submitted to MPB)

API JITS D3 Evaluation of subsea dispersant injection methods, equipment and effectiveness

Objectives:

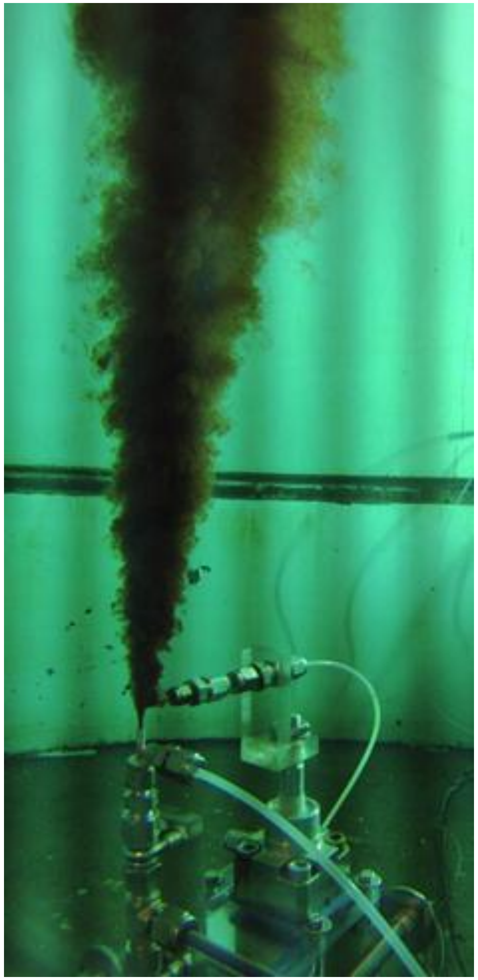
1. **How do dispersant injection method, dispersant to oil ratio (DOR) and dispersant type affect effectiveness (oil droplet size)?**
2. **How does the dispersant-oil mixing vary as a function of distance from the orifice for different injection methods and how does this affect effectiveness (oil droplet size)?**

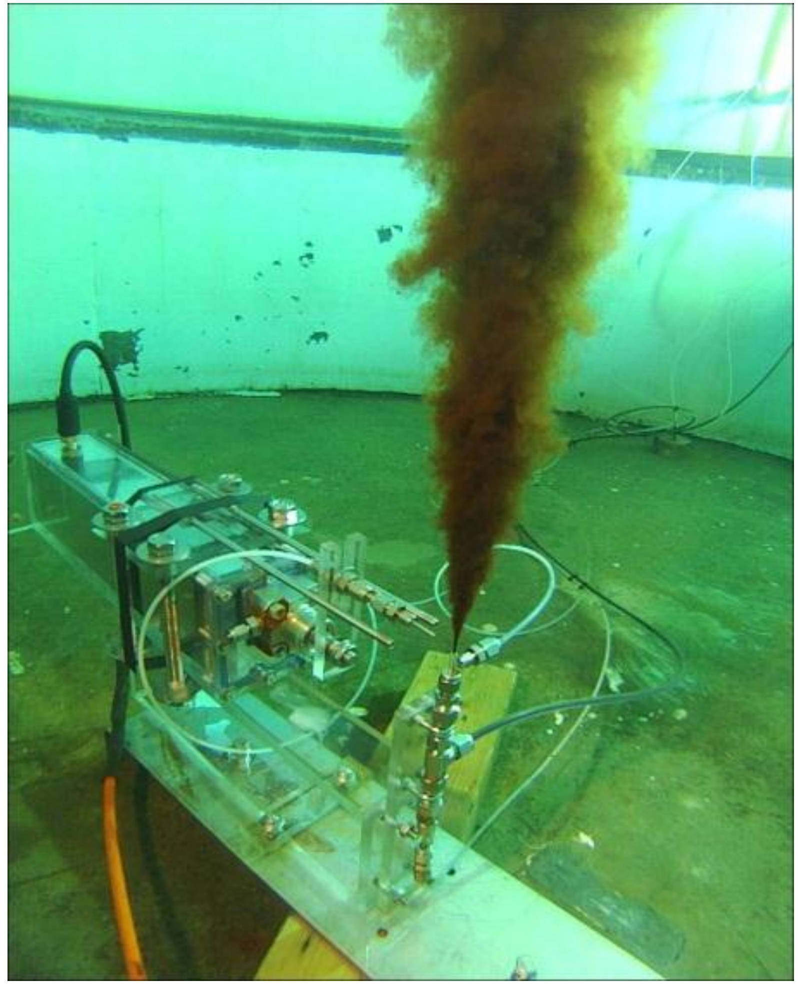
Underwater injection – Possible techniques



Dispersant injection techniques

Injection directly into the plume above the release

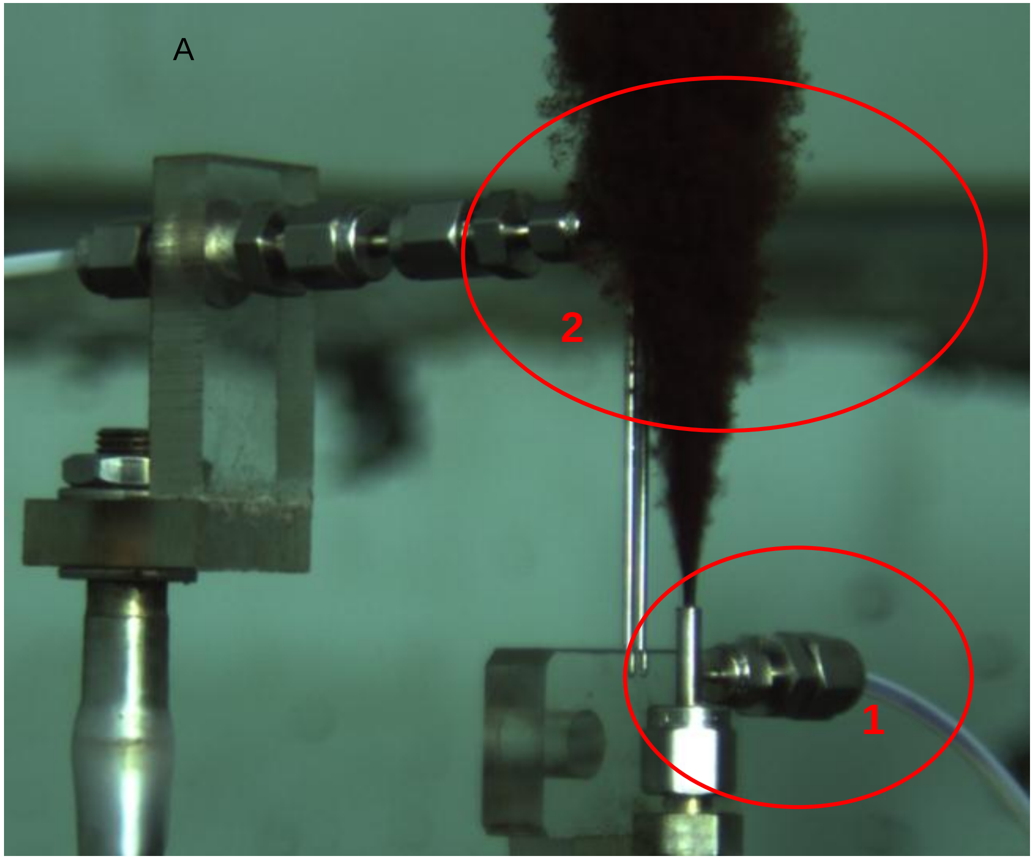


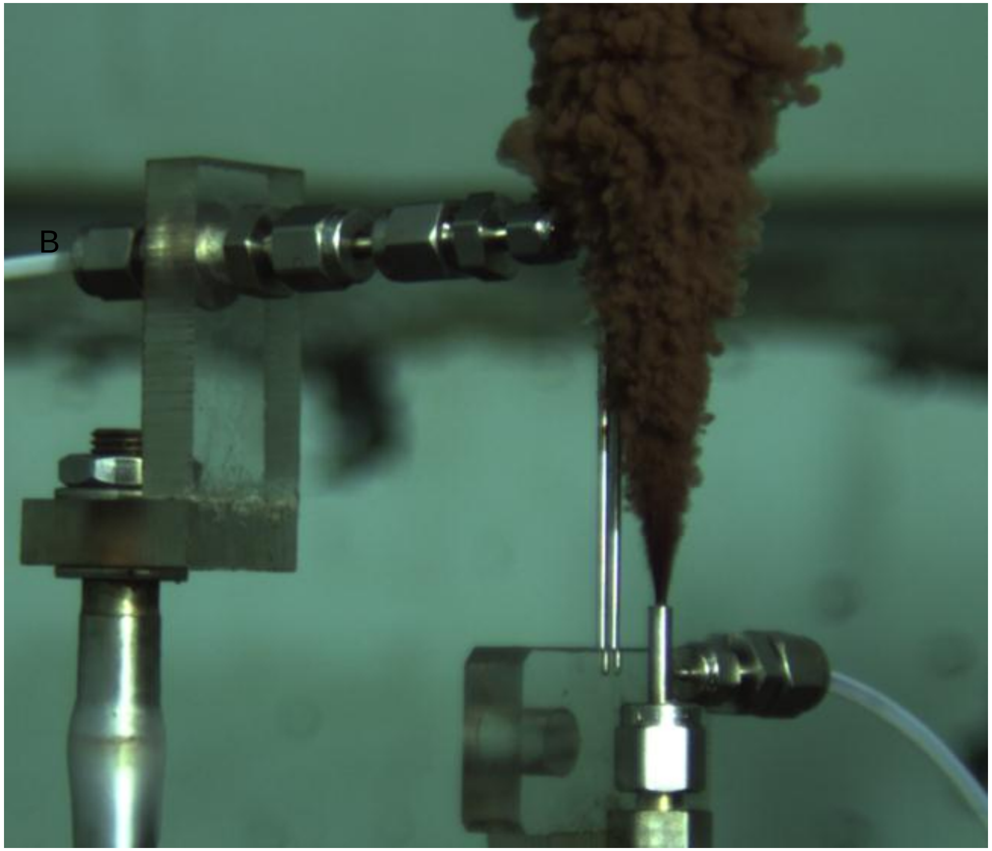


Injection from outside horizontally into the plume

Possible injection techniques - from initial testing with Oseberg Blend

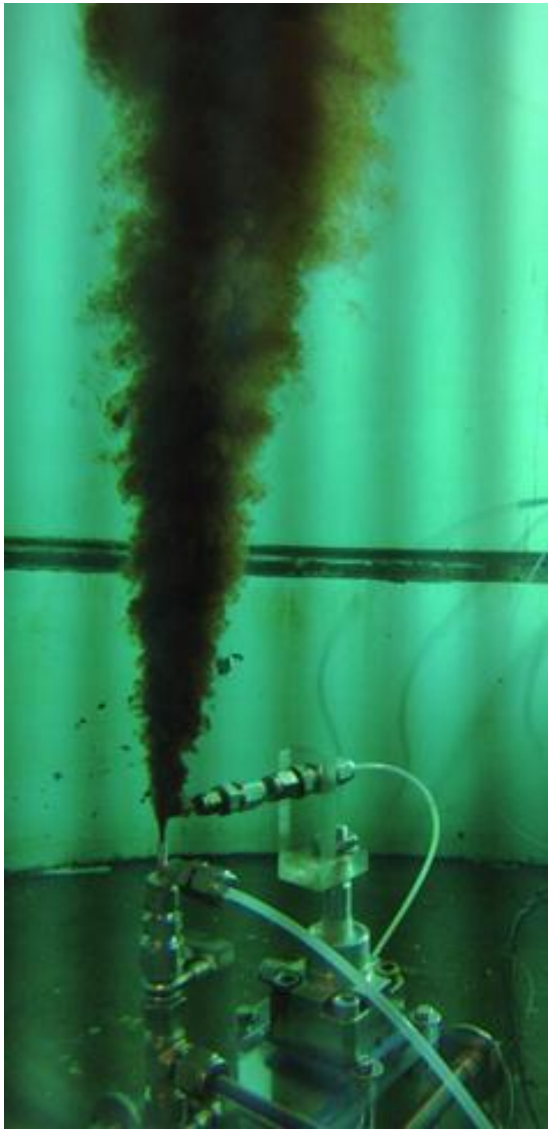
Evaluation of subsea dispersant injection
Dispersant injected ABOVE nozzle



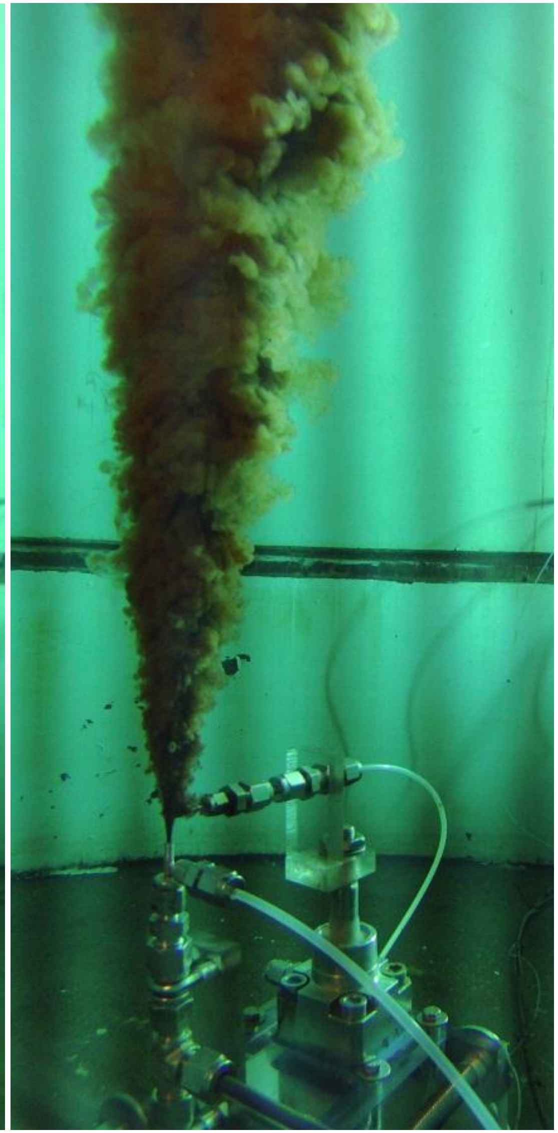


Release arrangement with options for injection of dispersant by the "Simulated insertion tool" (1) and "injection in the oil above the nozzle" (2).

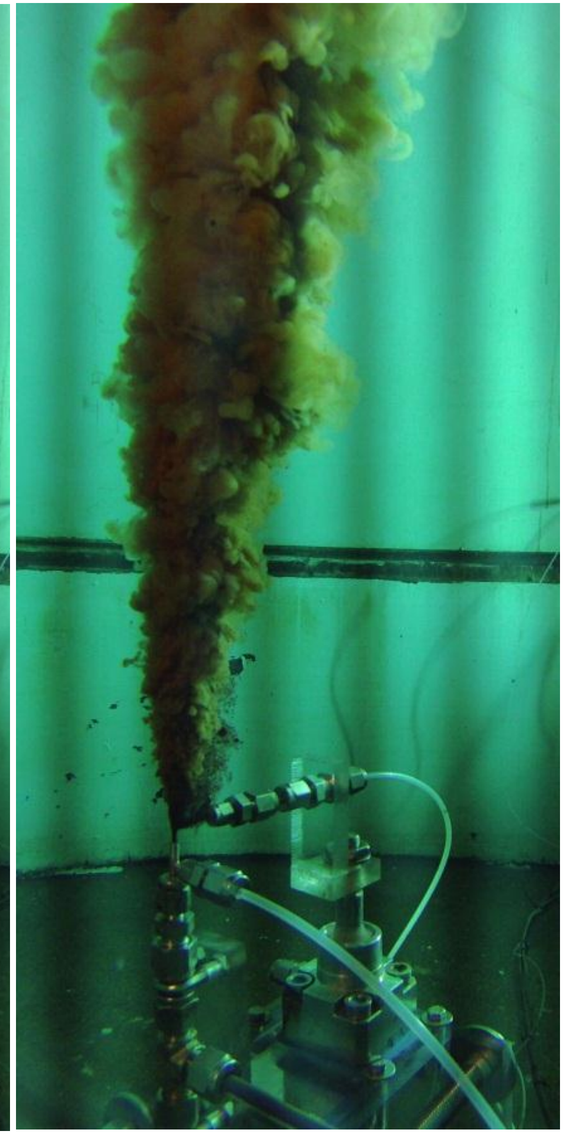
Injection into the oil ABOVE the nozzle



No dispersant

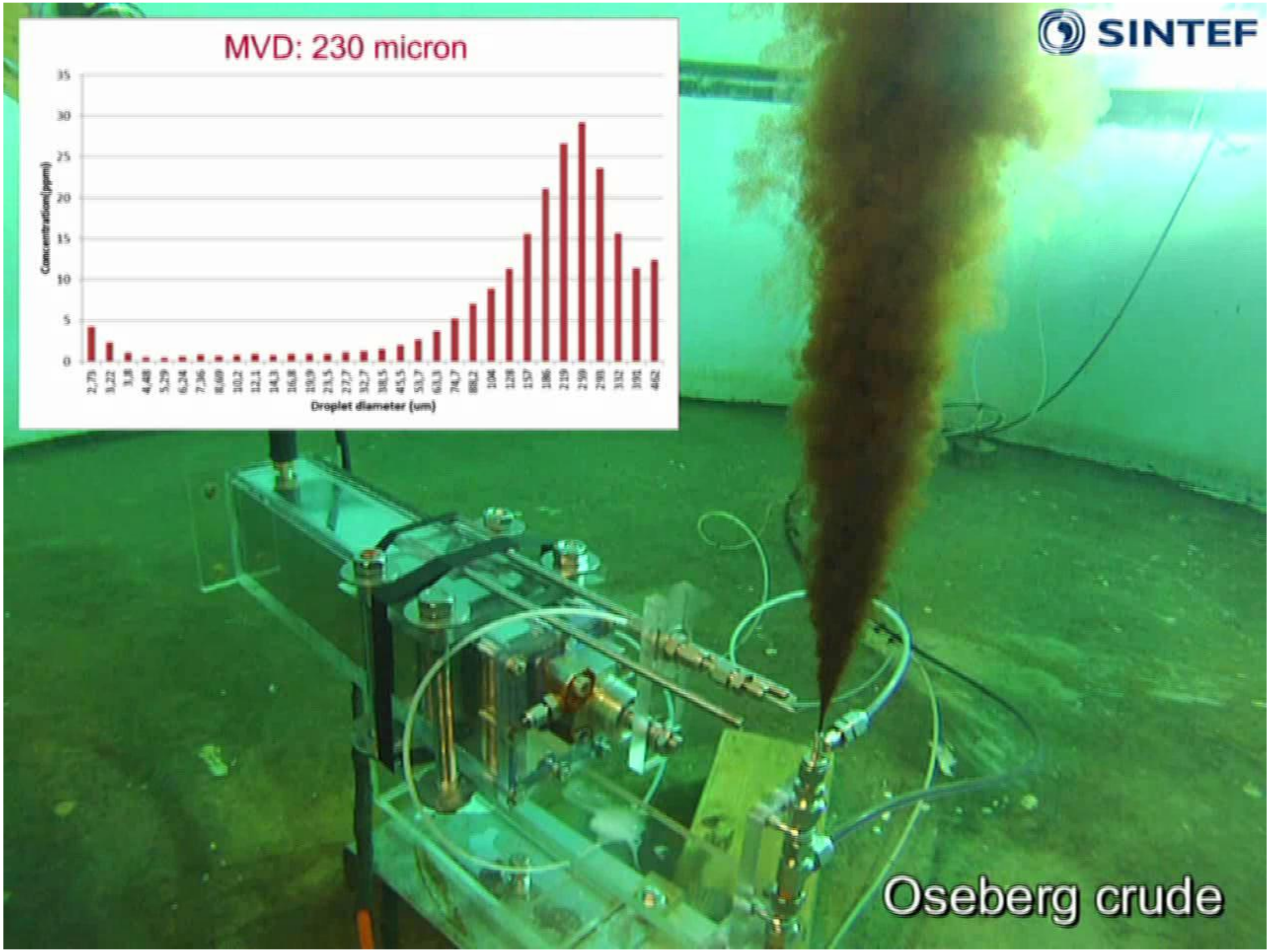


8 mm above



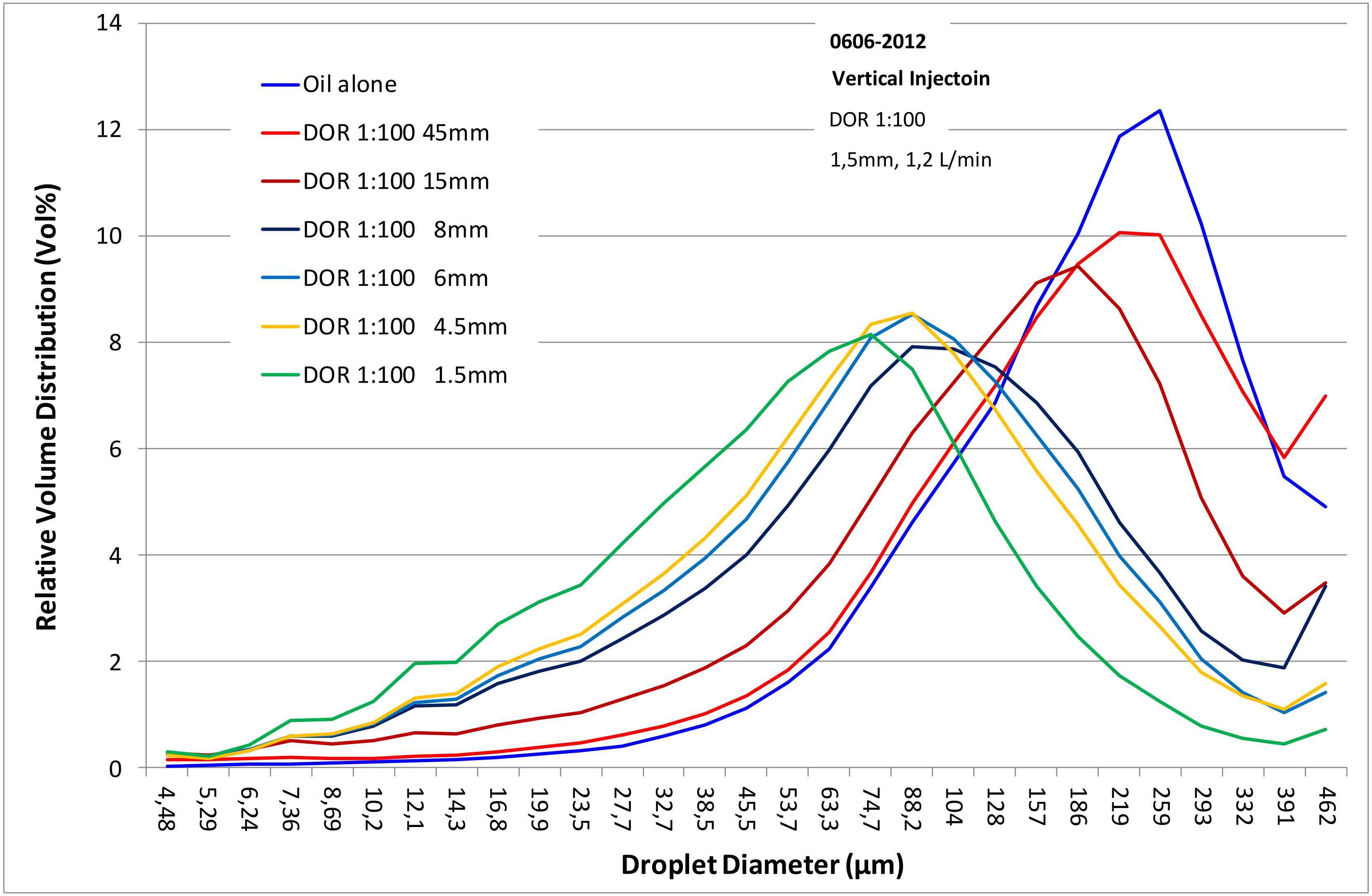
1.5 mm above

Dispersant Injection



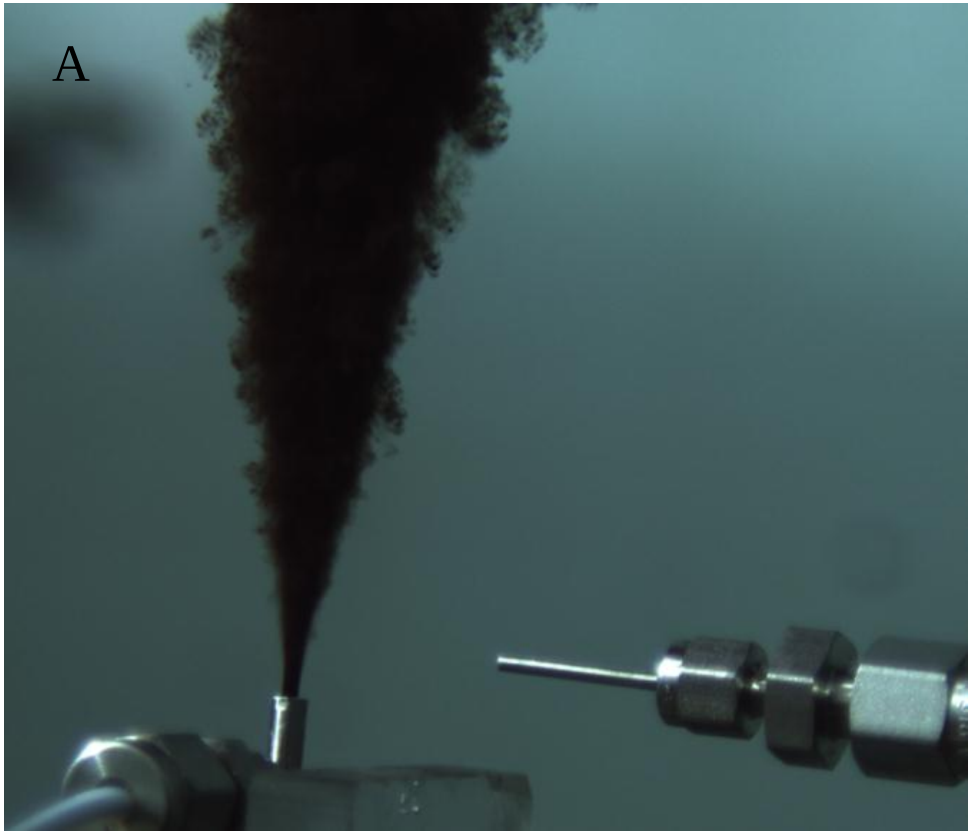
Release of Oseberg oil: Diameter 1.5 mm, rate: 1.5 L/min

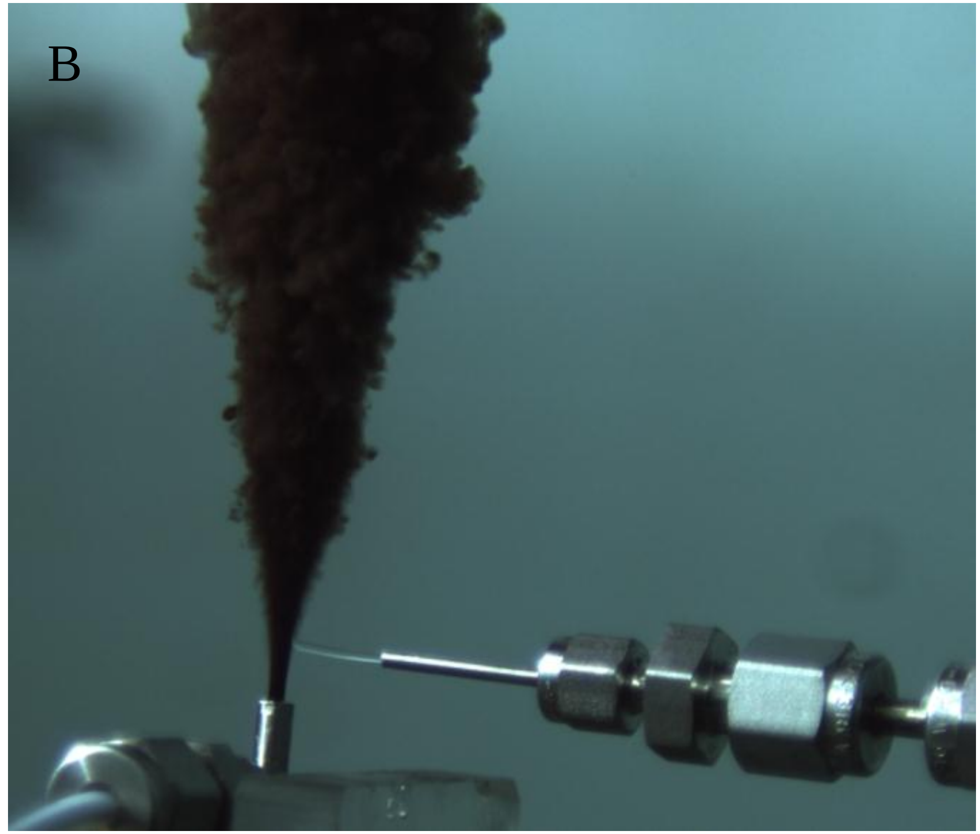
Injection above nozzle into rising plume



Release of Oseberg oil: Diameter 1.5 mm, rate: 1.2 L/min

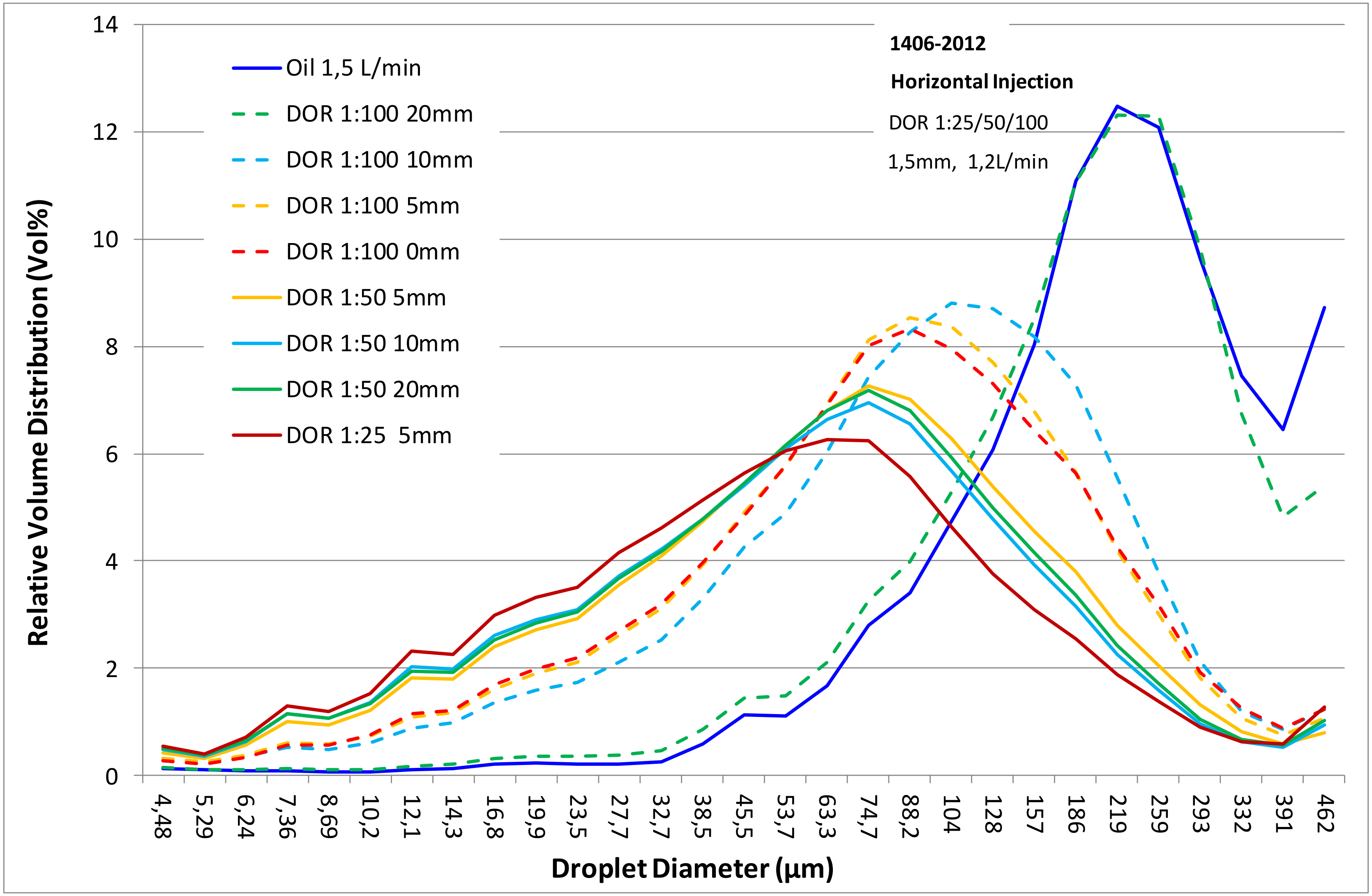
Evaluation of subsea dispersant injection
Dispersant injected HORIZONTALY





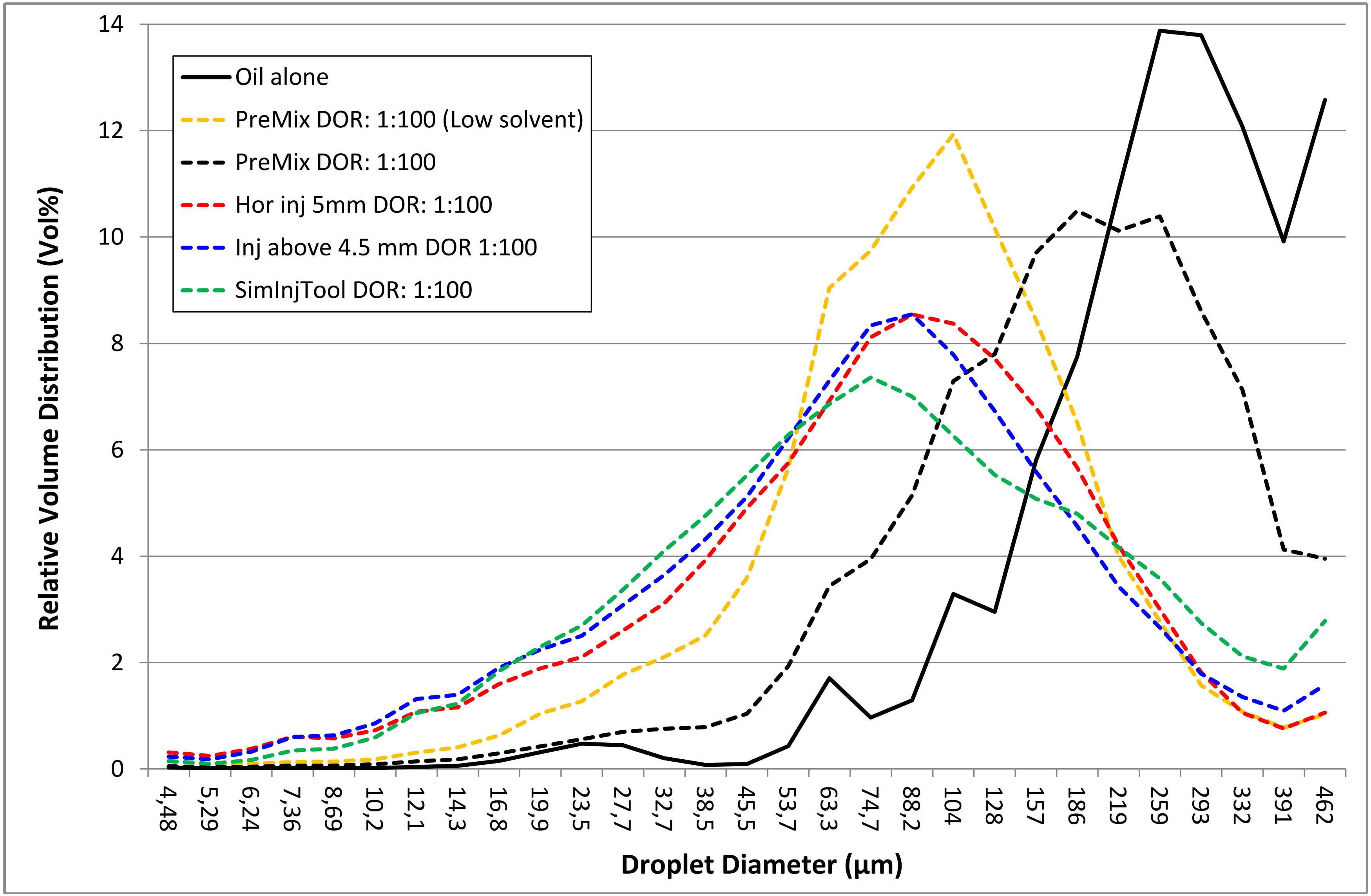
Release arrangement with dispersant injected horizontally into the oil.
A: Oil released alone B: Dispersant injected at DOR: 1:100.

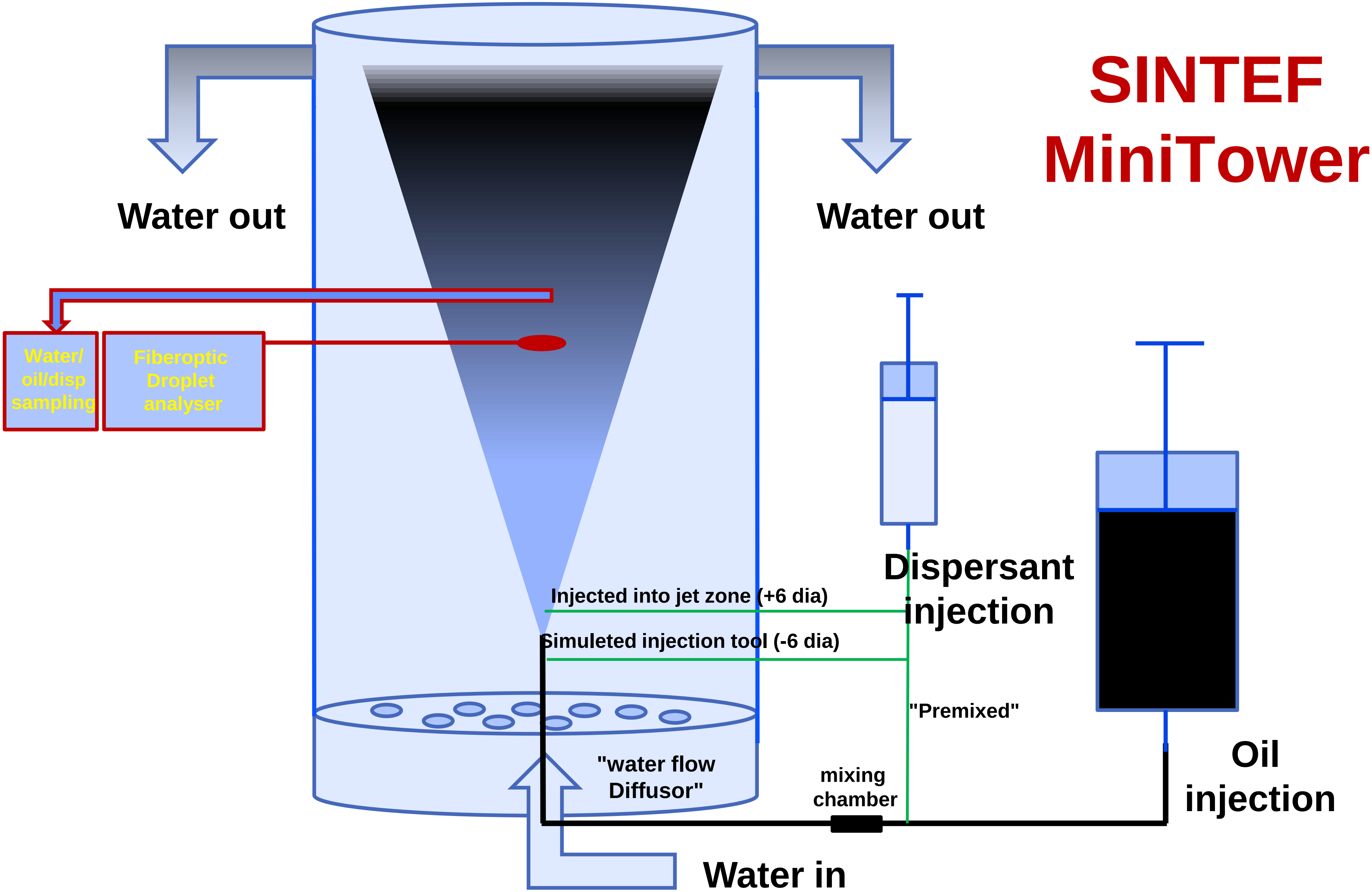
Horizontal injection into rising plume



Release of Oseberg oil: Diameter 1.5 mm, rate: 1.2 L/min

Comparison of injection techniques




SINTEF
MiniTower
Water out
Water out
Water/
oil/disp
sampling
Fiberoptic
Droplet
analyser
Dispersant
injection
Injected into jet zone (+6 dia)
Simuleted injection tool (-6 dia)
"Premixed"
Oil
injection
"water flow
Diffusor"
mixing
chamber
Water in

SINTEF MiniTower in use

0.5 mm nozzle – 0.1 L/min

0.5 mm nozzle – 0.1 L/min
+ C9500 (1:100)

Conclusions – Final remarks

- Improved predictions of droplet sizes from subsurface release are important:
  - Fate of oil; <u>Surface</u> or <u>entrained</u> in the water?
  - Where will the oil surface, thickness and lifetime?
  - Could we reduce personnel VOC exposure at the surface?
  - Rate of biodegradation and possible environmental effects (NEBA)

- What is the effect of injecting dispersants:
  - How much smaller will the droplets be?
  - How should the dispersant be injected?
  - How large quantities of dispersants do we need?

- Are these results valid at deep water pressure (100-300 bar)..?

- These and other important questions are now answered by on-going experimental studies at SINTEF.

Thank you for your attention!

Questions?

Contact:

Per Johan Brandvik

Senior scientist / professor

Per.brandvik@sintef.no

+47 90958576

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EUROPEAN MARITIME SAFETY AGENCY
QUALITY SHIPPING, SAFER SEAS, CLEANER OCEANS

Technical Correspondence Group Dispersants
(TCG-Dispersants)

LITERATURE REVIEW
RELATED TO DEEPWATER HORIZON

EMSA Workshop, Lisbon, 26-27 November 2012

François-Xavier MERLIN (Cedre)
(francois.merlin@cedre.fr)

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Technical Correspondence Group (TCG) Dispersants

- ❖ Established under the CTG MPPR framework.
- ❖ Platform for exchange of expertise & drafting of documents.
- ❖ MS Experts in dispersant testing & usage.

2

Objectives/Tasks:
1. Review dispersant studies related to the DWH spill, and define relevant output for Europe.
2. Discuss current dispersant testing procedures in the EU & draft recommendations for mutual acceptance of such procedures.

Final deliverables:
- ✓ Report(s) / Recommendations [non-binding for MS]

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1st Task - Literature review on DWH spill

TCG Dispersants Members & EMSA:

- Compiled a list of documents according to their relevance and their availability:
  – 49 documents listed
  – Technical reports, technical notes, studies, articles……
  – Available on web sites
- Created a reviewing format (reviewing sheet)
- Identified 8 areas of interest

3

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Literature review on DWH spill

8 areas of interest

1. Dispersant effectiveness and efficiency
2. Environmental impacts and assessment
3. Dispersant application and usage
4. Response technology
5. Regulatory principles & dispersant in NCP
6. Dispersant monitoring & methodology related to sampling
7. Human health & safety issues & sea food contamination
8. Public relations and communication

Reviewing work allocated between the voluntary members of the TCG Dispersants according to their area of interest

4

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Literature review on DWH spill
Preliminary main observations

1. Dispersant effectiveness and efficiency

- Large uncertainties in qualitative assessment
- Subsea efficiency estimated betwen 10 and 25 %
- Fresh oil require very low dosage of dispersant
- Need for optimising the sub-sea dispersant application

5

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Literature review on DWH spill
Preliminary main observations

2. Environmental impacts and assessment

- Limited extention of the dispersed plume (10 – 30 Km)
- No severe damage observed
- Toxic level reached only in the vicinity of the well
- Oil biodegradation seems rapid
- Questions remain on the long-term fate, impact and degradation of the oil

6

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Literature review on DWH spill
Preliminary main observations

3. Dispersant application and usage
4. Response technology
5. Regulatory principles & dispersant in NCP

- Objectives of dispersion were :
  - Safety of the rescue team (VOC reduction)
  - Shoreline protection
- Need to include subsea dispersion in NCP implementation
- Need to understand and clarify the risk and benefit of ultra deep subsea dispersion

7

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Literature review on DWH spill
Preliminary main observations

6. Dispersant monitoring and methodology related to sampling

- Depth of dispersed plume well forcast but uncertaincies for its localisation (ultra deep water circulation to be studied)
- Good detection with SFUV coupled with O2 measurement
- Need for defining monitoring strategies for ultra deep environment

8

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Literature review on DWH spill
Preliminary main observations

7. Human H&S issues and sea food contamination

- Observed stress in exposed people (protective equipment)
- Large fish ban (38% of US E.Z. – up to one year duration)

9

8. Public relations and communication

- Inappropriate or insuffisant communication led to fears and misunderstanding
- Examine ways of improvement & address communication in NCP

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Work of TCG Dispersants is ongoing

10

Thank you for your attention!