ECOGIG

Ecological Impacts of Oil and Gas Inputs to the Gulf

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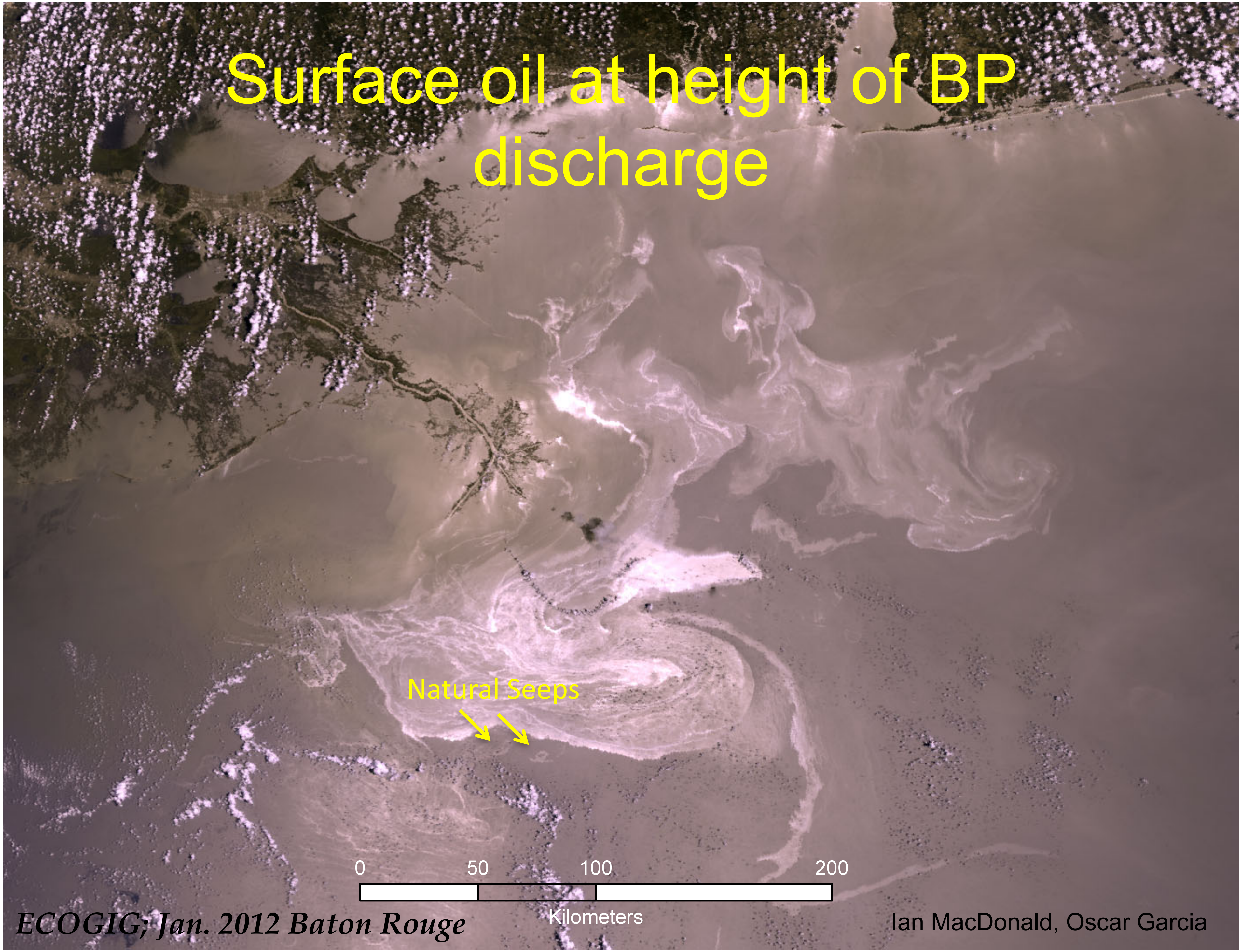
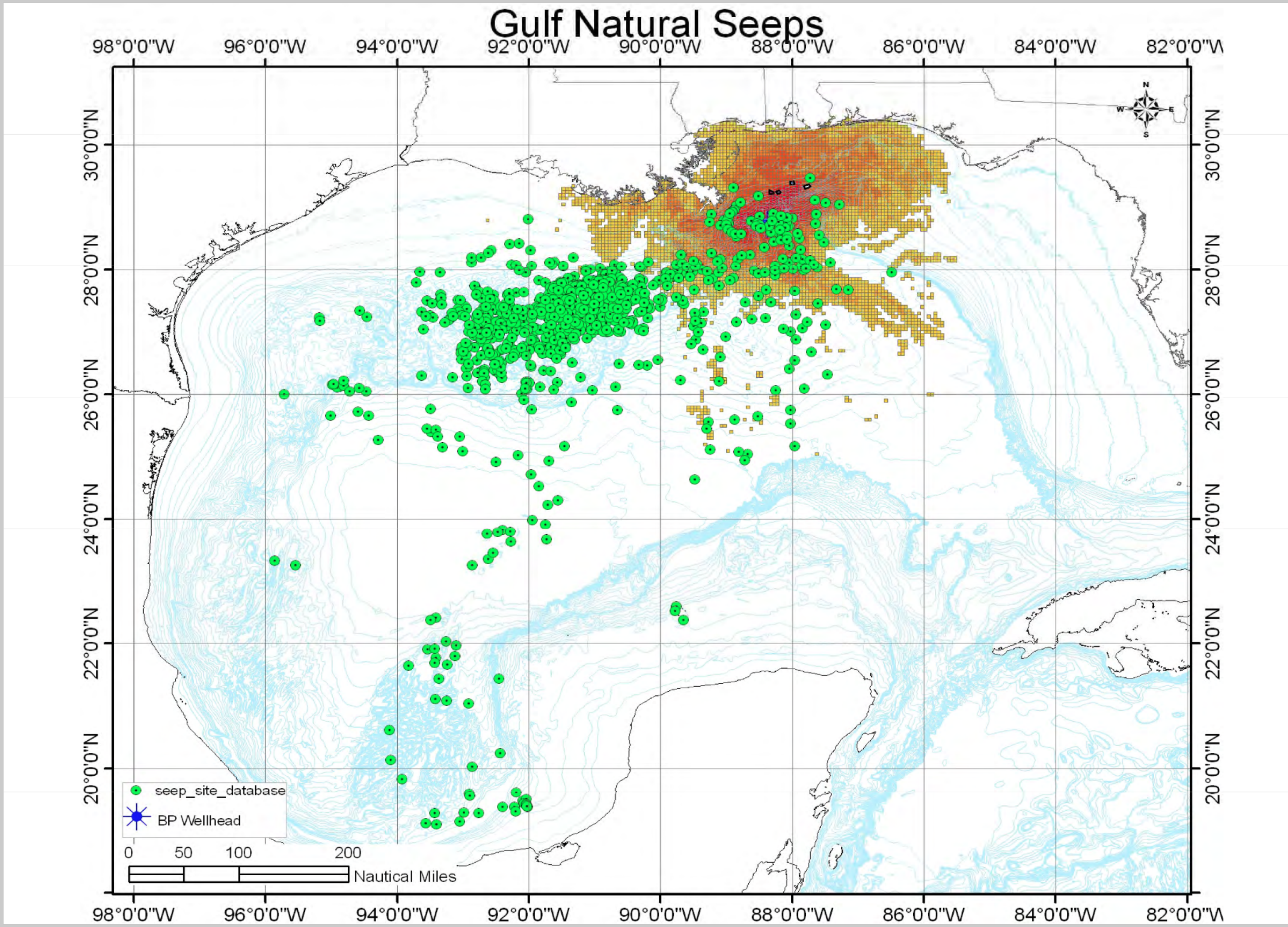
Uta Passow,
Marine Science Institute, UC Santa Barbara
and many more

GULF OF MEXICO RESEARCH INITIATIVE
RESEARCH BOARD

Surface oil at height of BP discharge





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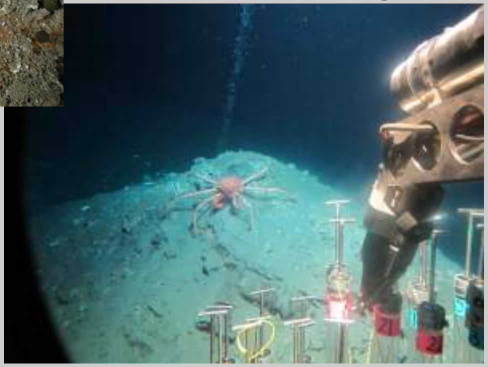
Gulf of Mexico: Natural Seepage

Natural seepage:

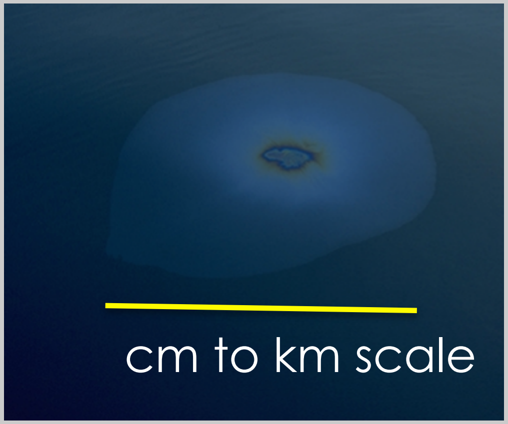
- diffuse, slow, variable in time/ space
- ~1000 natural seeps discharging 1000 to 2000 BOPD
- gas seepage more poorly constrained
- clear influence on the benthos
- **limited knowledge of the fate of oil and gas derived from natural seepage**

Oil seepage

Gas Seepage



Surface expression of oil seepage



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ECOGIG Objectives

- elucidate the effects of biological activity and physical processes versus dispersant application on oil transfer between surface waters, deep water, and sediments;

- quantify the impact of oil inputs on the pelagic community composition & activity and on carbon flow, and food web structure;

- define how weathered, sedimented oil influences benthic (microbial and invertebrate) and pelagic community composition and performance;

- track recovery and document the controls on recovery for benthic and pelagic systems impacted by the Macondo Blowout; and,

- develop tools and techniques to track and characterize hydrocarbons as they are biologically processed.

General Approach

in situ Monitoring:
pelagic & benthic environments

Habitat Description:
hydrography/biology/ geology/microbiology geochemistry

Modeling:
Water column/Sediments- coupled physical/biological/ biogeochemical

Process Studies:
in situ quantification of material transfer through dominant biological pools

Experimental Manipulations:
to assess regulatory mechanisms and feedbacks

Study Sites

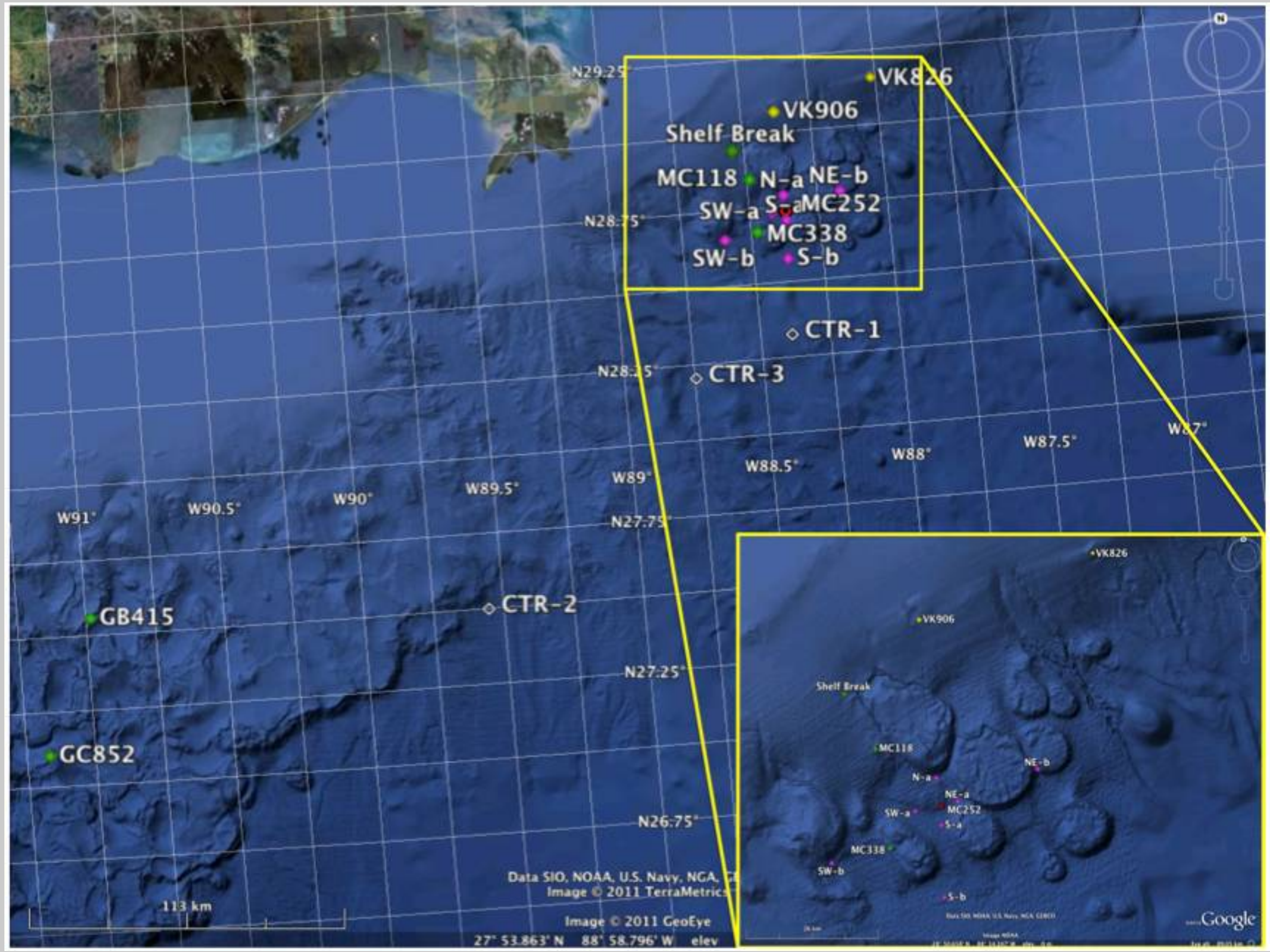
Main Sites (timeseries):

- **Oceanus 26**: BP impacted, no seep (2.5 miles SW DH, 1400 m,)
- **GC 600**: active natural seep (100 miles from DH)
- **AT357** old, active seep, corals & mussels (50 miles WSW of spill site, 1000 m)

Further sites

(500-2000m, baseline data (BOEMRE, NUIST)

- **Control sites** (no seepage or DH impact)
- **Natural seeps** impacted (MC118, MC338) or not (GC415, GC852)
- **Coral** (MC118, MC338, VK826, and VK906)
- 8 DH sites impacted to varying degrees



Satellite Remote Sensing of Natural Oil Seep & Episodic Plankton Blooms

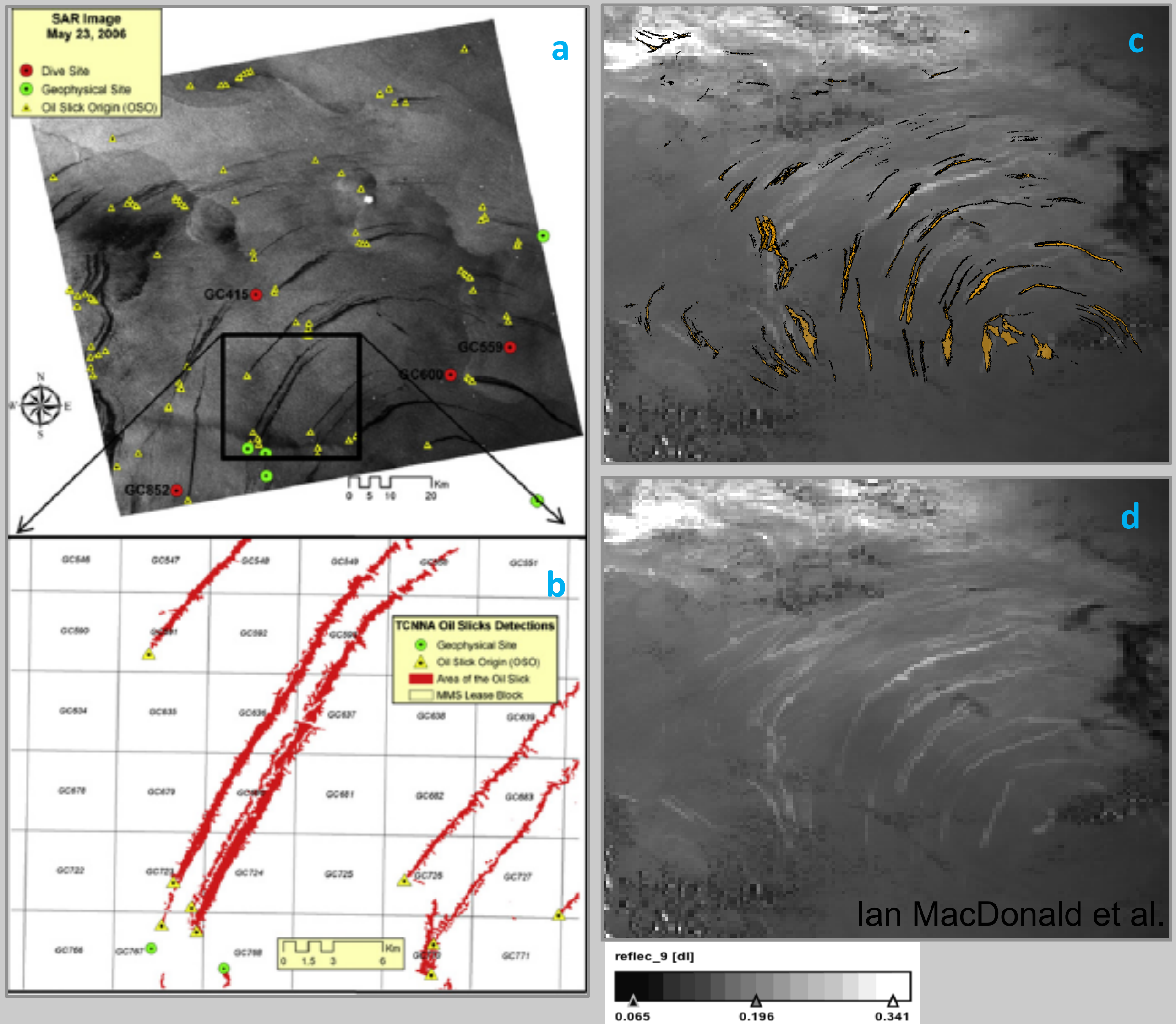
- **Monitor natural seeps** to determine the pathways and fate for oil released into the ocean
- Compare relative output magnitudes and temporal variability for the project study sites
- Provide an independent estimate for comparison to *in-situ* measurements
- Combine SAR and Ocean Color data to **investigate oil-phytoplankton interactions**

SAR-Synthetic Aperture Radar

Satellite Seep Detection

• Satellite SAR data distinct signatures for natural oil seeps.

• Repeat imaging provides the means for **estimating location** of geologic formations and comparing their output.



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Remote sensing

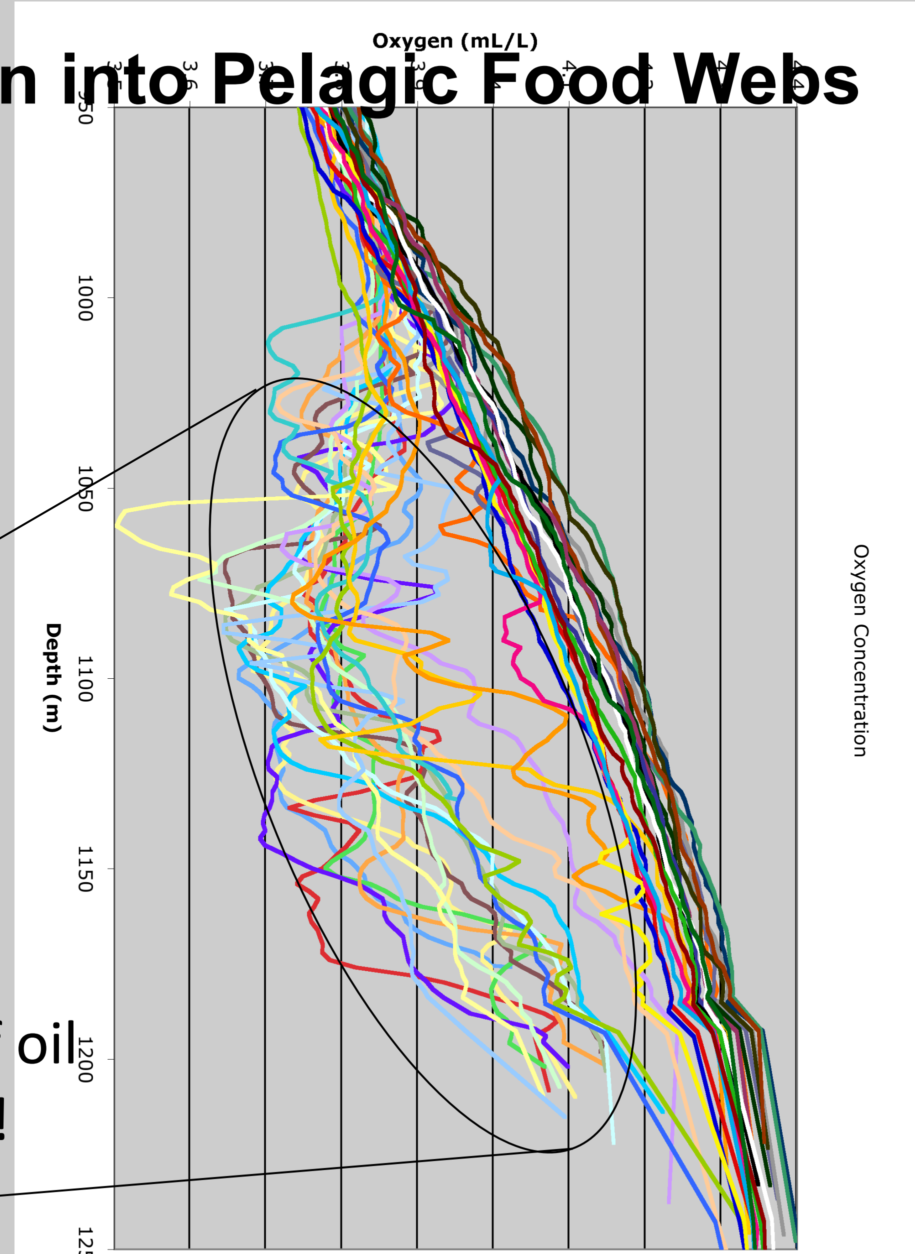
Transfer of Fossil Carbon into Pelagic Food Webs

Determine stable carbon and nitrogen isotopes in phytoplankton, zooplankton, traps, sediments

Biochemical measurements

Physiological impacts on phytoplankton

The ghosts of oil plumes past!!



Montoya et al.

Water column

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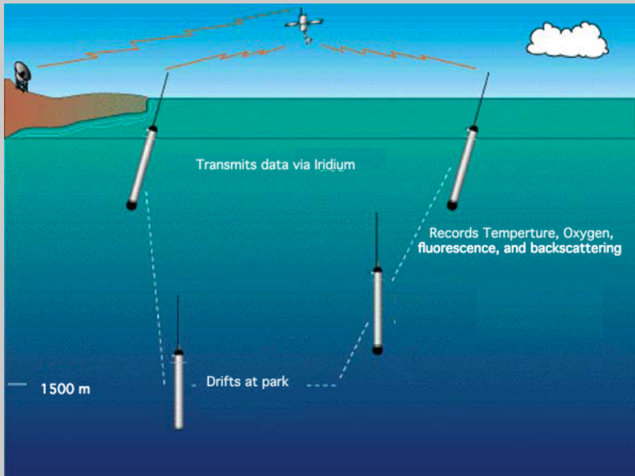
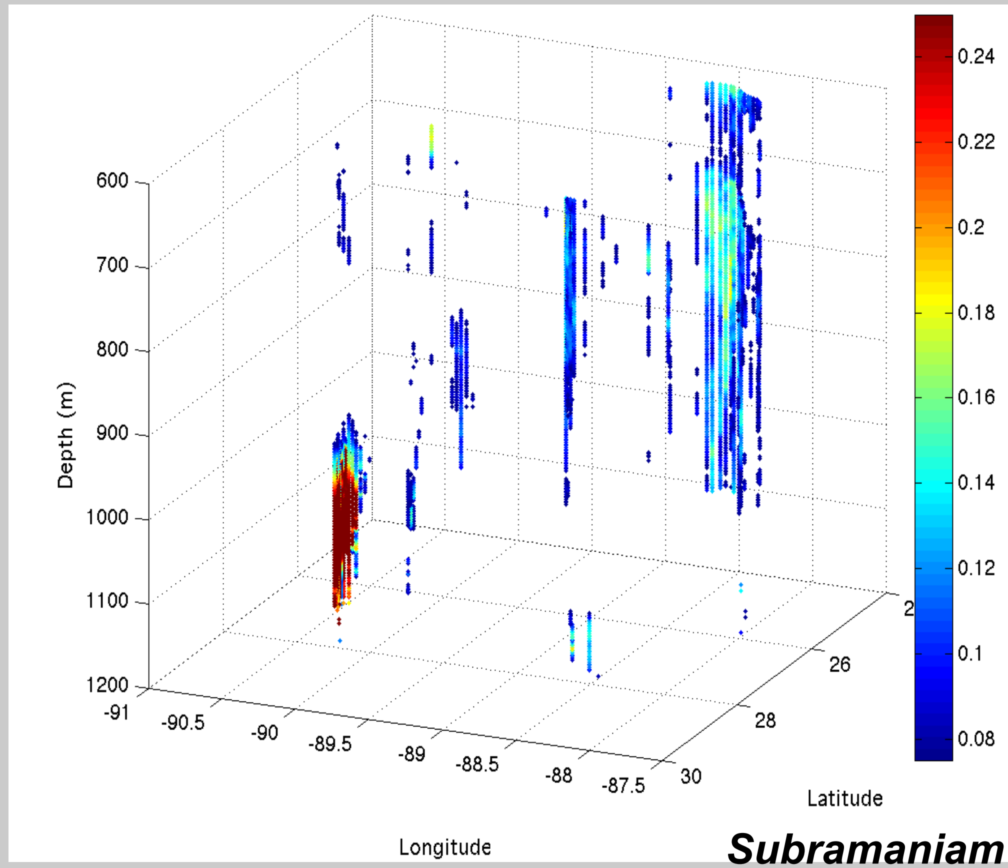
Free drifting APEX floats



DO anomalies



POGO data from GoM August 2010

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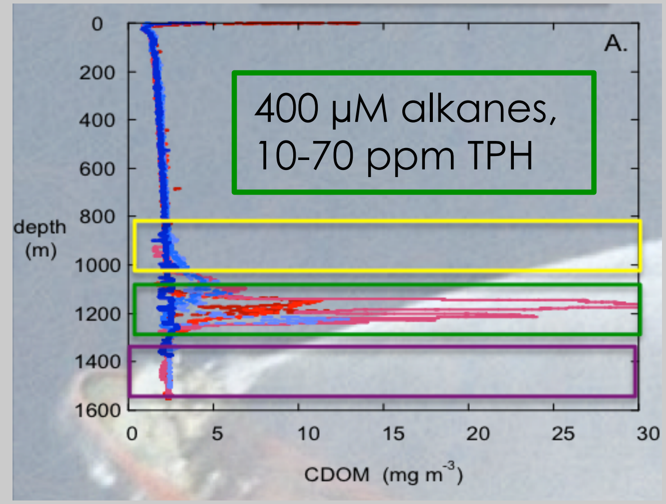
Water column

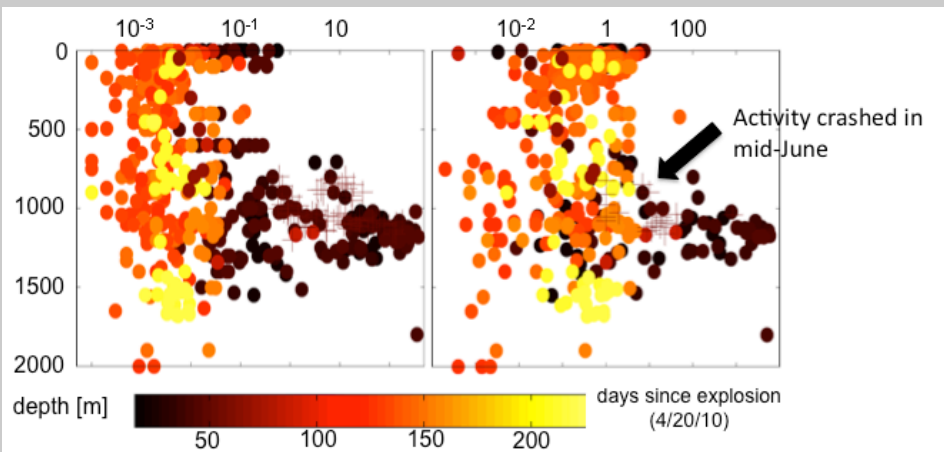
Microbial Response to DWH plume

deepwater gas/oil plumes



Asper, Diercks, Joye, Teske, Highsmith

CH_4 (µM) MOX (nM/d)



Joye et al.

dynamic- but ephemeral
microbial response to gas input

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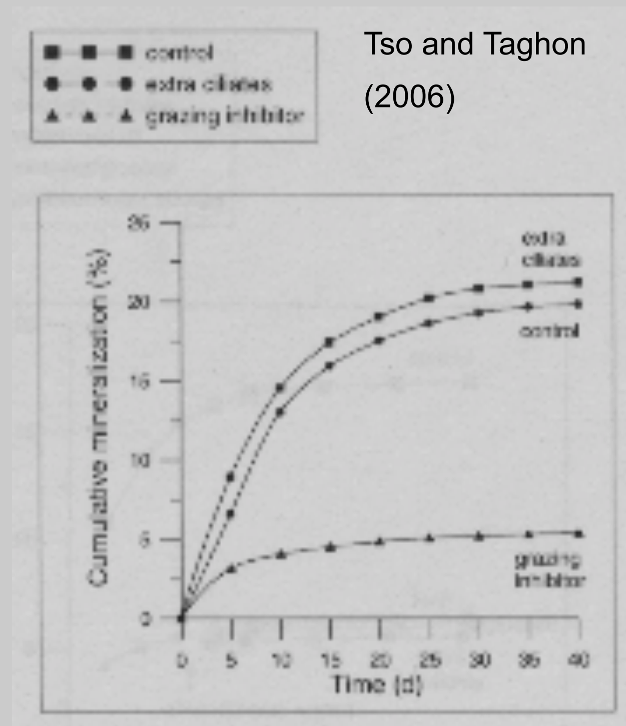
Water column/ sediments

Fate of Hydrocarbon-Degrading Bacteria: Microzooplankton

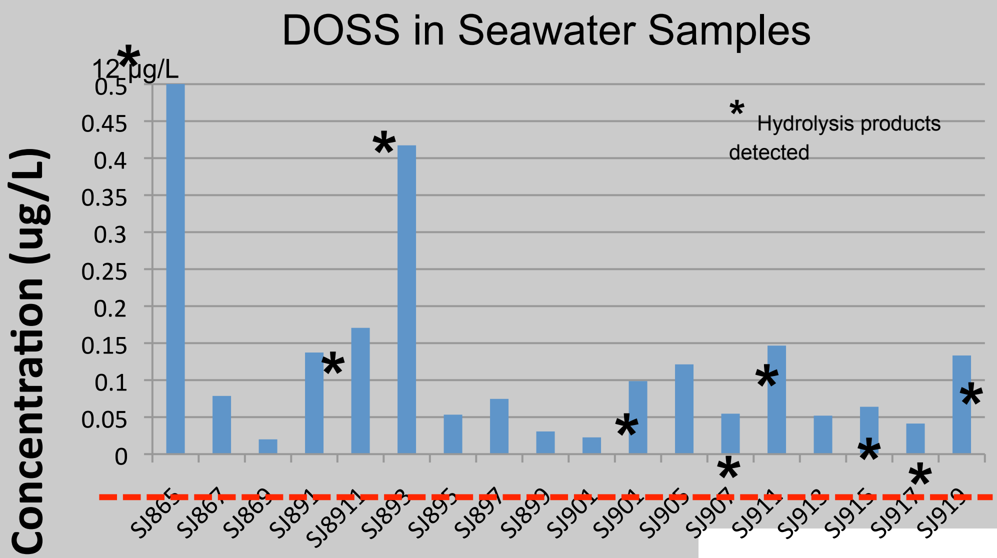
- Hypothesis 1 – bacterially mediated rate processes in the water column are **enhanced by microzooplankton predation**
- Hypothesis 2 – in areas without petroleum hydrocarbon contamination, bacterial O_2 drawdown and microzooplankton predation depend primarily on temperature
- Hypothesis 3 – in areas with petroleum hydrocarbon contamination, bacterial O_2 drawdown and microzooplankton predation depend on hydrocarbon concentration (probably together with temperature)



Tso and Taghon (2006)

Predation can enhance bacterially mediated rate processes

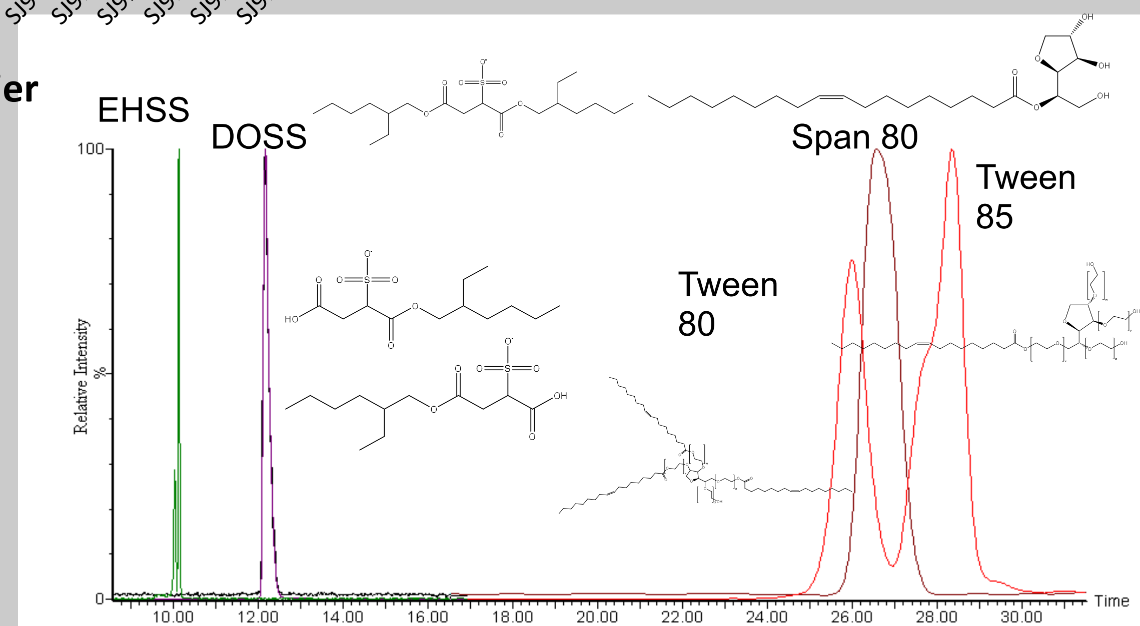
Dispersant and Oil characterization



Field et al.

Samples collected 2010 by M. Joye June 5-10 2010

Component Chromatography



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Analysis

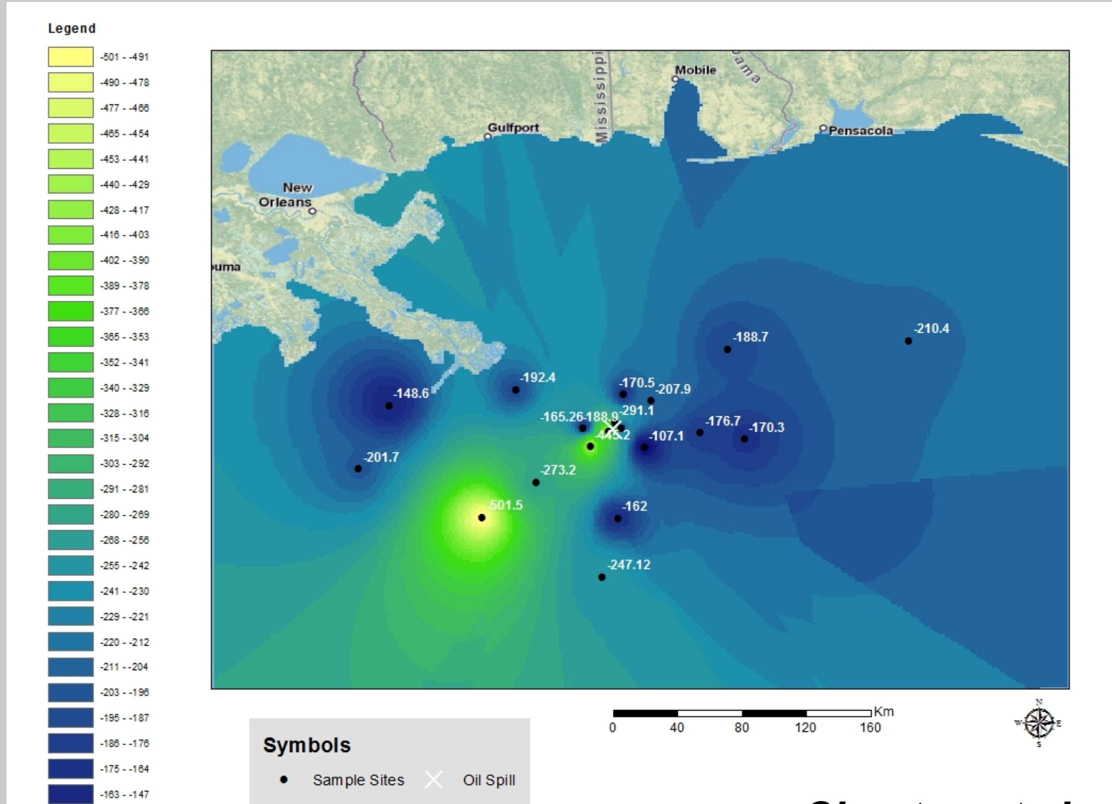
Pathways of Carbon Derived from Fossil Fuels

Radiocarbon

Stable Carbon, Nitrogen & Sulfur Isotopes

- Follow through food webs & onto sediments
- Importance of fossil carbon to seep megafauna.
- Ground truth of satellite observations of seeps.
- Quantitative determination of fossil carbon in DIC, on sediments, in organisms.
- Correlation with oil markers

Radiocarbon distribution



Chanton et al.

Radiocarbon distribution in surface sediments 0-1 cm: The brighter the color, the more fossil carbon

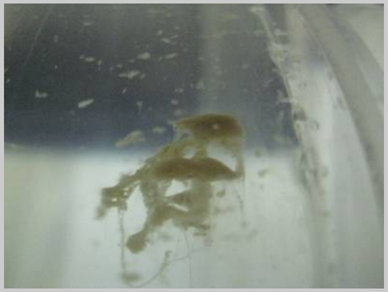
Experiments On The Formation And Fate Of Mucus & Oil Marine Snow

Oil promotes marine snow formation

• which **condition promote the formation** of snow

• What is the **role of the microbial community**

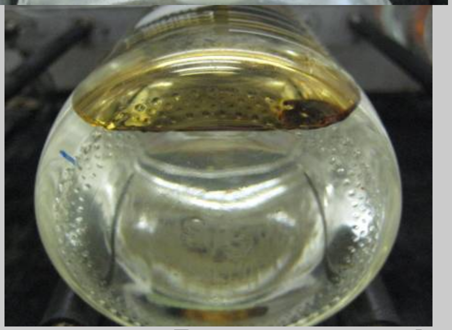
• Fate and degradation of oil rich snow.



GoM – Oil : Mucus Aggregates

Louisiana Ref. Oil: NO Aggregates

Pristine Macondo Oil: NO Aggregates



Passow et al.

Experimental/ Water column

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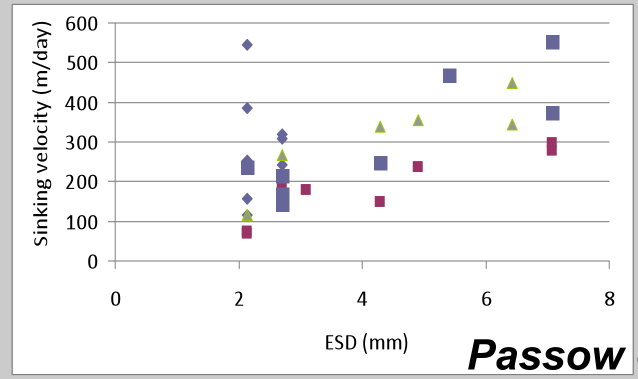
Sinking of oil rich marine snow

-rapid sedimentation via "oil snow"

-weathered oil on the seafloor (layers up to 12 cm thick; up to 2.5% PAH)

-oiled corals on the seafloor



***Passow* et al.**

Sinking velocity of *in situ* collected aged oil-snow

Oil rich marine snow sinks to the seafloor.

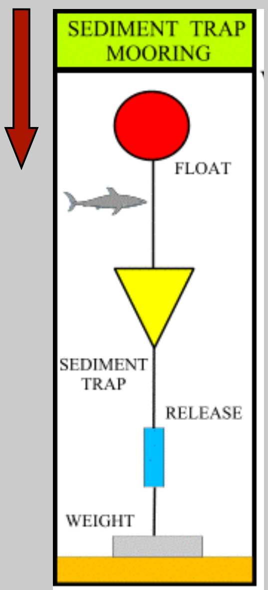
Sedimentation & Resuspension :

Time series sediment traps *monitor, collect and preserve* *particles* sinking into the trap over a time period of for example 1 year in 2-3 week intervals.

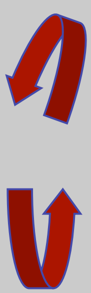
passow@lifesci.ucsb.edu

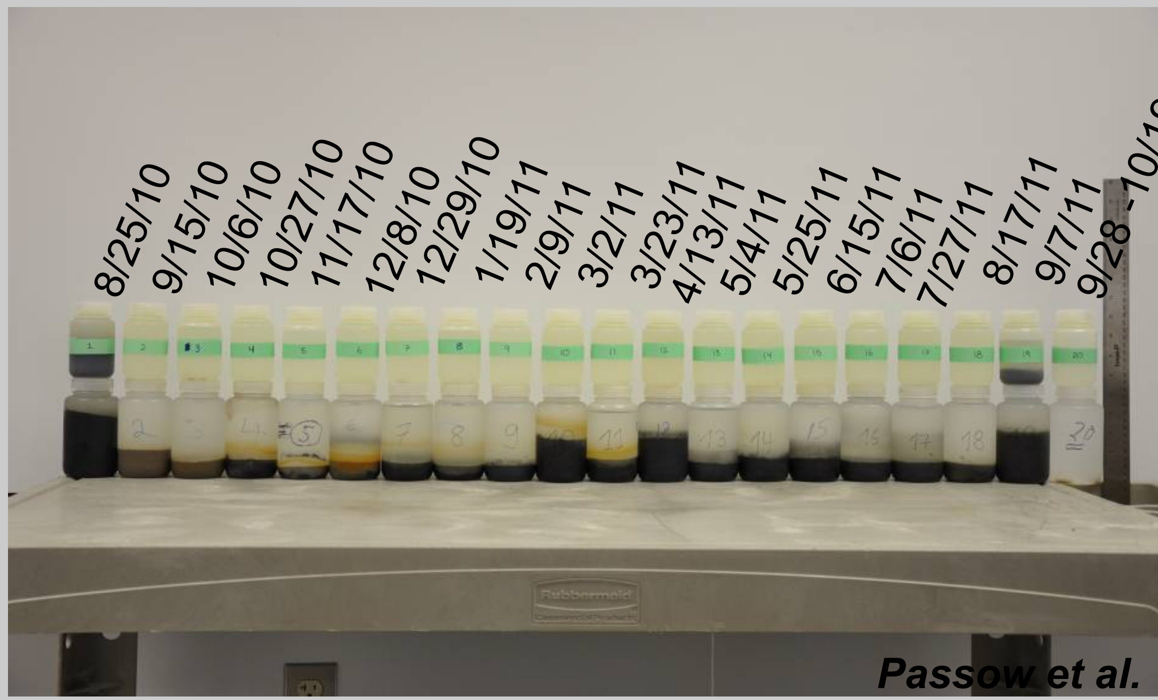
Sediment trap cups 8/2010-10/2011

Sinking



Resuspension

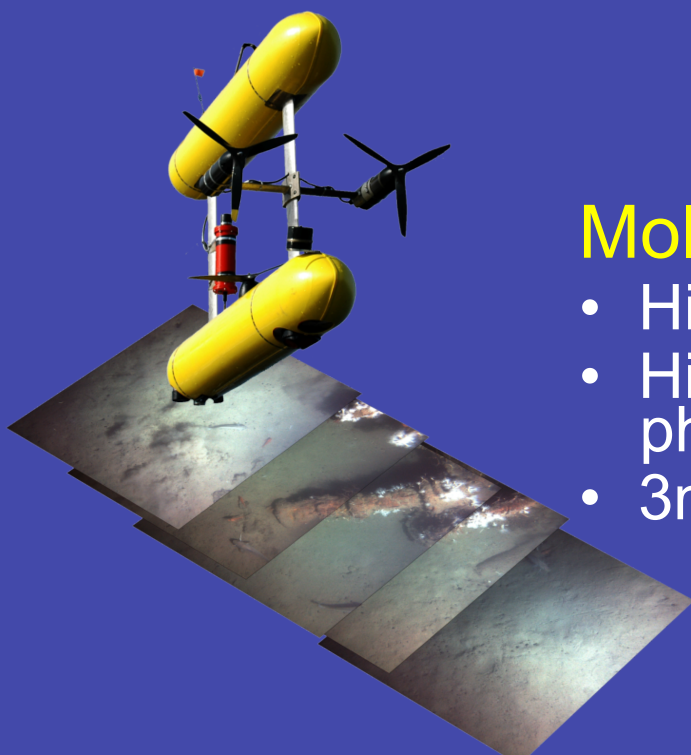




Autonomous Underwater Vehicles:

Eagle Ray

- 30 hr / 180 km endurance
- Sub-meter resolution maps
- 150 m MBES swath width
- 50 m above bottom @ 3.5 knots



Mola Mola

- High-resolution MBES maps
- High-resolution still cameras for photo mosaics
- 3m above bottom @ 0.2 knots

MBES = Mulit Beam Echo Sounder

Seafloor

Biogeochemical Processes

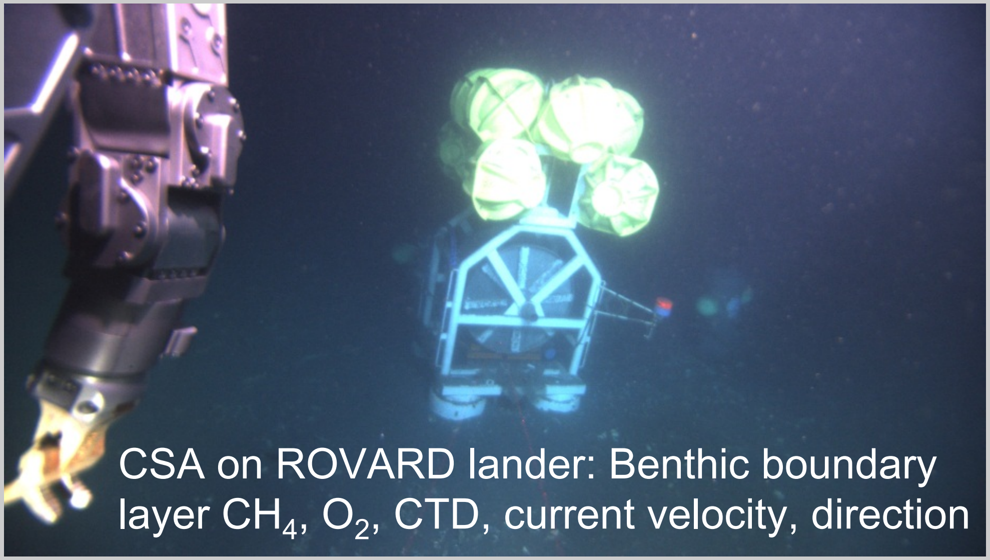
How do light hydrocarbon and oxygen concentration distributions and fluxes vary?

How does the microbial community respond to such perturbations?

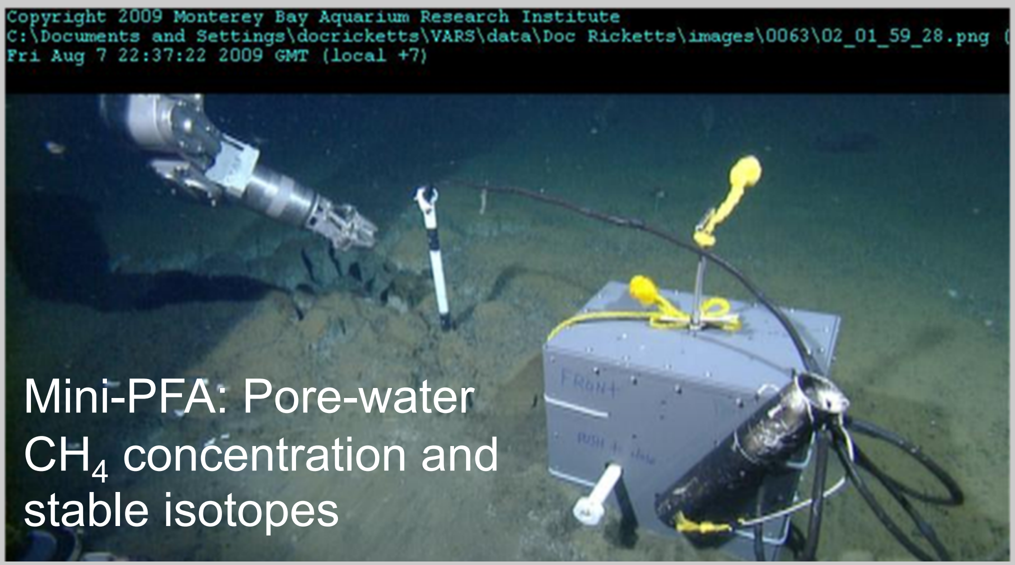
H: ***Microbes at natural oil seeps respond most efficiently to new oil and gas loading events***

H: ***Temporal variability in methane and oxygen concentrations near the seafloor result largely from large-scale perturbations such as tectonic activity***

Instrumentation for *in situ*, time-series measurements of biogeochemical processes at the seafloor



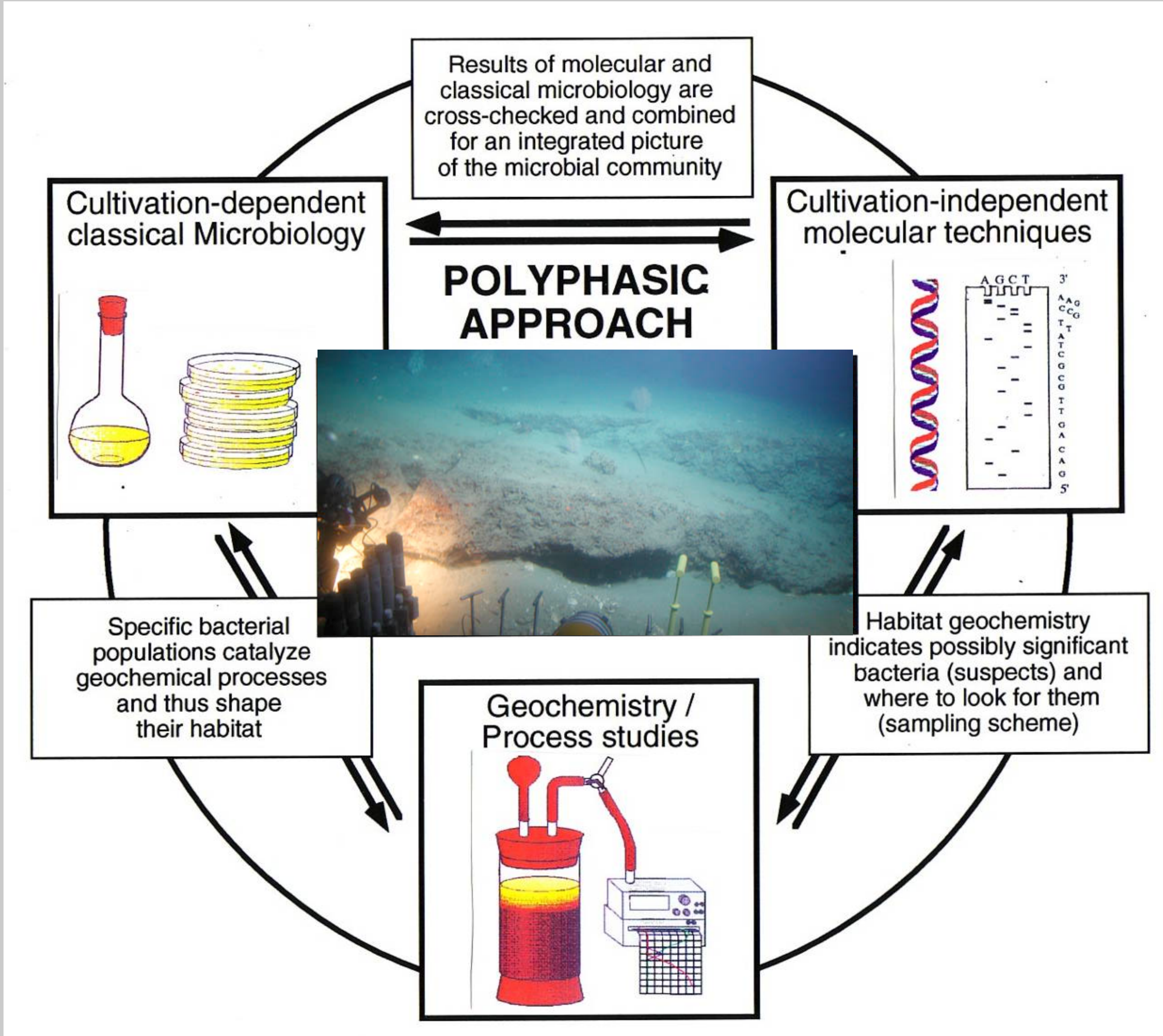
CSA on ROVARD lander: Benthic boundary layer CH_4, O_2, CTD, current velocity, direction



Mini-PFA: Pore-water CH_4 concentration and stable isotopes

MIMOSA: microbial community responses to *in situ* conditions and active seafloor oil additions

Sediment Geochemistry and Microbiology

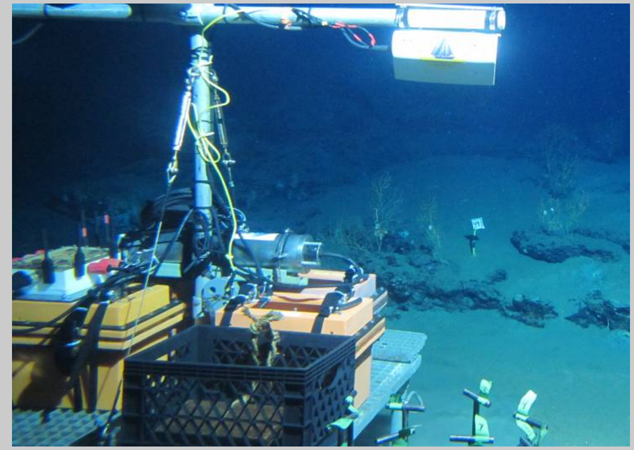


Benthic macro/mega-fauna ecology

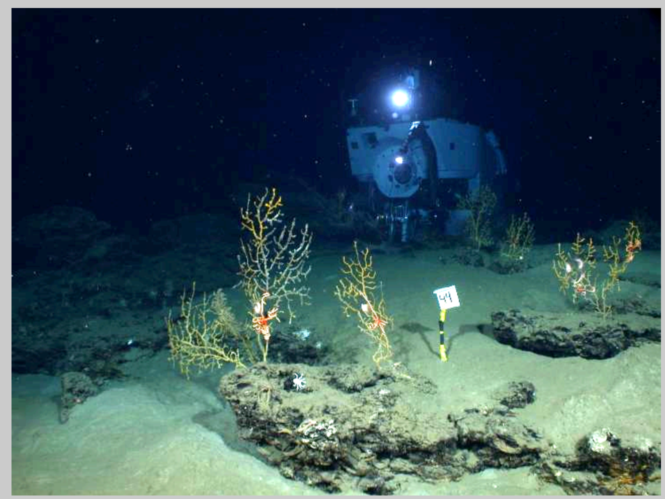
Establish stations to **monitor/assay sub-acute damage** to deep cold seep and coral communities

Monitor recovery, or evidence of continuing decline of coral communities known to have been acutely impacted

Relate to microbial communities by characterizing the cold seep and coral communities associated with the geochemical and microbiological study sites and monitoring responses over time in conjunction with geochemical and microbiological monitoring



Time lapse camera Dec. 2010



March, 2011: Corals impacted by DWH, 7 miles away

Toxicology Experiments

Effects of crude oil and the dispersant Corexit 9500A on the black coral *Leiopathes glaberrima*

- Oil: 5µL Louisiana Sweet Crude oil in 1 L seawater
- Dispersant: 0.5µL in 1L seawater
- Oil + Dispersant: 5µL oil + 0.5µL dispersant 10:1 ratio
- Controls

3 Colonies
8 fragments
2 replicates

Sampled for RNA at hrs:
6, 24, 48, 72

Survivals

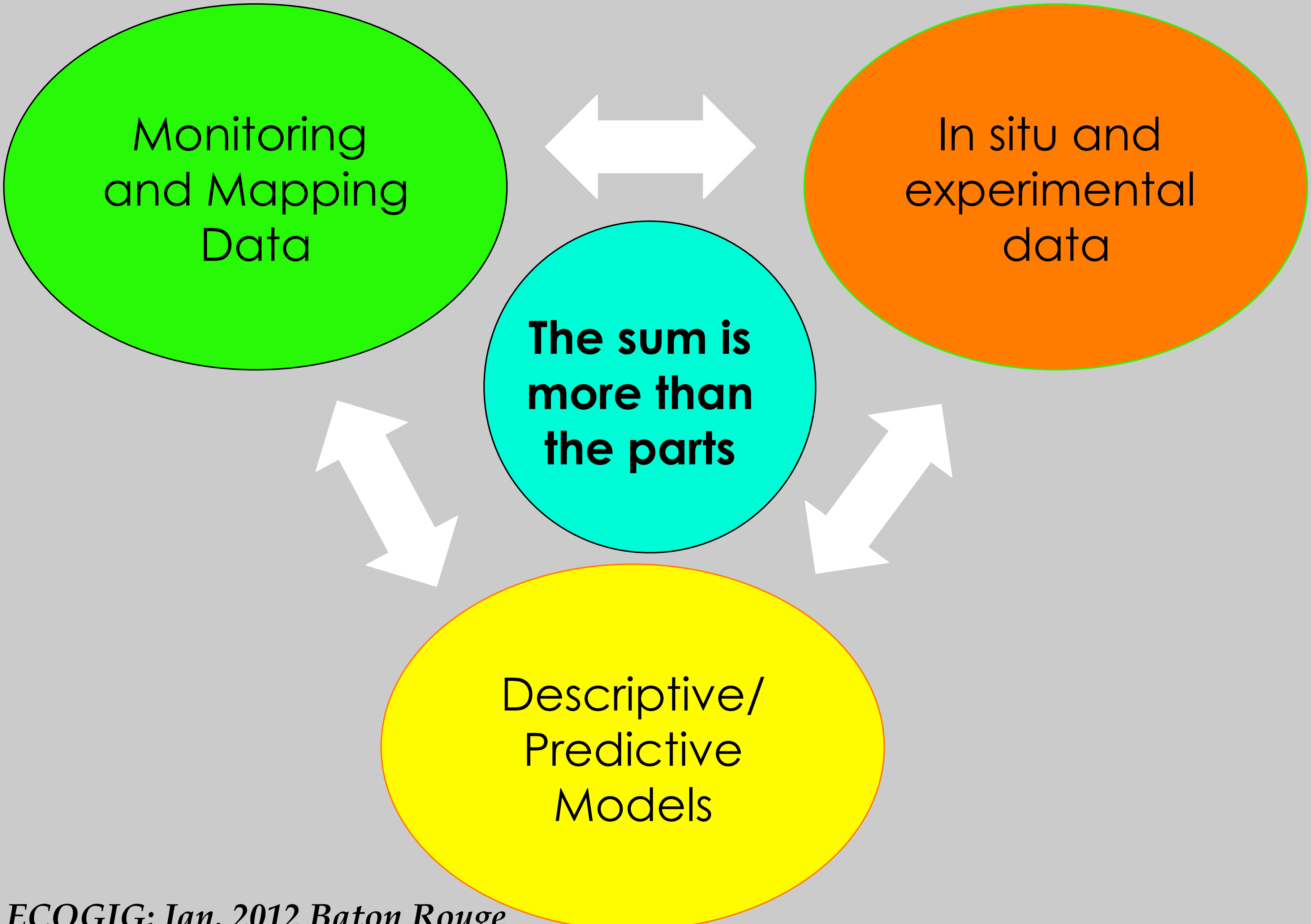
5 fragments in Oil + Dispersant (62%)

4 fragments in Oil (50%)

4 fragments in Dispersant (50%)

6 fragments in controls (75%)

Synthesis and Integration



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Our team includes:

Water column: ***Joe Montoya, Tracy Villareal, Andrew Juhl***

Biochemical: ***Chris Martens, Carol Arnosti, Laura Lapham, Jeff Chanton, Rachel Wilson, Howard Mendlovitz, Beth Orcutt, Pete Girguis, Geoff Wheat***

Remote Sensing: ***Ian MacDonald, Oscar Garcia, Ajit Subramaniam***

Sedimentation: ***Uta Passow; Vernon Asper, Arne Diercks***

Microbial: ***Andreas Teske, Samantha Joye, Barbara MacGregor, Andrew Allen***

Modeling: ***Annalisa Bracco, Christof Meile***

Megafauna: ***Chuck Fisher, Iliana Baums, Erik Cordes, Marc Slattery***

PAH & Dispersant Chemistry: ***Patricia Medeiros, Jennifer Field, Paul Blakemore, Yan Beizahn***

Education and Outreach

Education: 18 graduate students, 9 post docs, and 12 Undergraduates

Teaching: incorporation of ECOGIG research into graduate and undergraduate coursework

Individual PI outreach:

- presentations to the general public
- interaction with the media
- maintaining websites and blogs

ECOGIG wide outreach:

- project website
- video dissemination (coordinated through MS-AL SeaGrant)

Organization of ECOGIG

The organization chart below depicts the management structure of ECOGIG.