MOSSFA

MARINE OIL SNOW SEDIMENTATION & FLOCCULENT ACCUMULATION

# AGENDA

## Tuesday, October 22

| | | |
|---|---|---|
| 8:30 am | Registration | |
| 9:00 am | Welcome & Logistics | *Nancy Kinner, CRRC, CSE, UNH* |
| 9:10 am | Participant Introductions | |
| 9:30 am | Overview: MOSSFA Working Group & Goals of Meeting | *Uta Passow, UCSB* |
| 10:15 am | *Break and Poster Session* | |
| 10:45 am | Presentation: Oil Associated Marine Snow | *Ali Khelifa, Environment Canada* |
| 11:15 am | Presentation: Deposited Oil Associated Marine Snow | *Samantha Joye, UGA* |
| 11:45 am | Presentation: Ecosystem Consequenc-es | *Joel Kostka, GA Tech* |
| 12:15 pm | *Lunch & Poster Session* | |
| 1:30 pm | Logistics of Breakout Groups | *Nancy Kinner* |
| 1:45 pm | Breakout Session I | |
| 3:45 pm | *Break and Poster Session* | |
| 4:00 pm | Plenary Report-Outs | |
| 5:00 pm | Poster Reception with Cash Bar | |
| 6:30 pm | Dinner (on your own) | |

# AGENDA

## Day 2

### Wednesday, October 23

| | | |
|---|---|---|
| 8:00 am | Recap/Recalibration | *Nancy Kinner* |
| 8:15 am | Breakout Session II | |
| 11:00 am | Plenary Report-Outs | |
| 12:00 pm | *Lunch* | |
| 12:45 pm | Breakout Session III | |
| 2:45 pm | Plenary Report-Outs/Summary & Path Forward | *Nancy Kinner & Uta Passow* |
| 4:30 pm | Adjourn | |

# MOSSFA
## MARINE OIL SNOW SEDIMENTATION & FLOCCULENT ACCUMULATION

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MARINE OIL SNOW SEDIMENTATION & FLOCCULENT ACCUMULATION

# BREAKOUT GROUPS I & II

## Group 1: Oil Associated Marine Snow

**Location:** Room 120

**Presenter:** Ali Khelifa

**Facilitator:** Kendra Daly

**Rapporteur:** George Jackson

Vernon Asper
Eric Chassignet
Meredith Jennings
Vijay John
InOk Jun
Sara Kleindienst
David Lindo
Ian MacDonald
Olivia Mason
Tinka Murk
Tamay Özgökmen
Elizabeth Simons
Evan Variano

## Group 2: Deposited Oil Associated Marine Snow

**Location:** Room 255

**Presenter:** Samantha Joye

**Facilitator:** Jeff Chanton

**Rapporteur:** David Hollander

Gregg Brooks
Arne Diercks
Clayton Dike
Markus Huettel
Rebekka Larson
Chris Martens
John Quinlan
Isabel Romero
Brad Rosenheim
Chuck Wilson
Don Zhao

## Group 3: Ecosystem Consequences

**Location:** Room 267

**Presenter:** Joel Kostka

**Facilitator:** David Hastings

**Rapporteur:** Carol Arnosti

Cameron Ainsworth
Amy Baco-Tyler
Carl Childs
Felicia Coleman
Wade Jeffrey
William Landing
Sara Lincoln
Joe Montoya
Steve Murawski
Claire Paris
Patrick Schwing
Arvind Shantharam
Kevin Shaw
John Walsh

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# BREAKOUT GROUPS III

## Group 1

**Location:** Room 120

**Facilitator:** Kendra Daly

**Rapporteur:** George Jackson

Amy Baco-Tyler
Carl Childs
Markus Huettel
Wade Jeffrey
Meredith Jennings
Samantha Joye
InOk Jun
Sara Kleindienst
Joel Kostka
Sara Lincoln
Steve Murawski
John Quinlan
Brad Rosenheim
Don Zhao

## Group 2

**Location:** Room 255

**Facilitator:** Jeff Chanton

**Rapporteur:** David Hollander

Cameron Ainsworth
Vernon Asper
Eric Chassignet
Vijay John
William Landing
David Lindo
Chris Martens
Tinka Murk
Tamay Özgökmen
Claire Paris
Patrick Schwing
Arvind Shantharam
John Walsh
Chuck Wilson

## Group 3

**Location:** Room 267

**Facilitator:** David Hastings

**Rapporteur:** Carol Arnosti

Gregg Brooks
Felicia Coleman
Arne Diercks
Clayton Dike
Rebekka Larson
Ali Khelifa
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# POSTERS

| | AUTHOR(S) | TITLE |
|---|---|---|
| 1 | Arnosti, C; Ziervogel, K; Yang, T; Teske, A | Oil-derived marine aggregates – hot spots of polysaccharide degradation by specialized bacterial communities |
| 2 | Asper, V; Dike, C; Diercks, A; Passow, U; Ziervogel, K | Marine snow abundance and distribution in the Gulf of Mexico |
| 3 | Baco, AR; Shantharam, AK; Wei, C-L; Rowe, G | Preliminary assessment of sediment macrofaunal community structure in the DeSoto Canyon following the Horizon oil spill |
| 4 | Brooks, GR; Larson, RA; Schwing, PT; Romero, I; Moore, C; Reichart, G-J; Jilbert, T; Chanton, JP; Hastings, DW; Overholt, WA; Marks, KP; Kostka, JE; Holmes, CW; Flower, B; Hollander, D | Sedimentation pulse in the NE Gulf of Mexico following the 2010 DWH Blowout |
| 5 | Chanton, J; Cherrier, J; Magen, C; Joye, SB; Montoya, J; Hollander, DJ; Graham, WM; Brunner, CA; Bosman, S; Mickel, A; Passow, U; Asper, V; Zhao, T | Tracers in the Gulf |
| 6 | Daly, K; Remsen, A; Kramer, K; Murawski, S | Marine Snow Distributions Following the BP Oil Spill |
| 7 | Diercks, A; Asper, V; Passow, U; Dike, C; Ziervogel, K | Hydrography and its implication to resuspension of sediments in the northern Gulf of Mexico |
| 8 | Dike, C; Asper, V; Diercks, A; Passow, U | Settling velocity of marine snow at a seep site and a spill site in the northern Gulf of Mexico |
| 9 | Gong, Y; Zhao, X; Cai, Z; Fu, J; Zhao, D | Interactions between dispersants, dispersed oil and sediments, and the impacts on the environmental fate of persistent oil components |
| 10 | Jeffrey, WH; Snyder, RA | Considerations on the interactions of microbial ecology and oil in the formation of marine snow |
| 11 | Kleindienst, S; Seidel, M; Ziervogel, K; Perkins, M; Field, J; Grim, S; Sogin, M; Dittmar, T; Allen, A; Passow, U; Medeiros, P; Joye, SB | Chemical dispersants used in oil spill response influence microbial community composition and evolution but not microbial activity |
| 12 | Lindo-Atichati, D; Paris, CB; Le Hénaff, M; Schedler, M; Valladares Juárez, AG; Müller, R | Simulating the effects of droplet size, biodegradation and flow rate on the subsea evolution of the oil plume from the Deepwater Horizon spill |
| 13 | Murk, T; Van Eenennaam, J; Zeinstra, M; Foekema, E | A story of marine algae and dispersants: How marine Algae and particles can greatly influence the fate and persistence of dispersed oil |
| 14 | Romero, IC; Toro-Farmer, GA; Watson, K; Brooks, GR; Larson, RA; Schwing, P; Muller-Karger, F; Hastings, D; Hollander, DJ | Levels, sources and transport pathways of hydrocarbons in deep-sea sediments after the DWH blowout in the Gulf of Mexico |
| 15 | Rosenheim, BE; Pendergraft, MA; Flowers, GC; Carney, R; Sericano, J; Amer, RM;, Chanton, J; Dincer, Z; Wade, TL | Carbon isotope distribution in Gulf of Mexico sedimentary organic material before and after the DWH spill |
| 16 | Schwing, PT; Romero, IC; Hastings, DW; Hollander, DJ; Brooks, GR; Larson, RA; Chanton, JP; Reilly, L | Mechanisms for benthic Foraminifera decline and incorporation of petroleum carbon following the Deepwater Horizon event |
| 17 | Simons, E; Speer, K; Hancock, C; Wienders, N | Lagrangian float and drifter analysis around DeSoto Canyon |
| 18 | Socolofsky, S; Jun, I-O; Dissanayake, A | Effects of dissolution on the fate and transport properties of rising gas bubble from the deep ocean |
| 19 | Variano, E | Effect of droplet size on droplet-floc collision kernels |

MOSSFA Working Group Meeting
October 22nd and 23rd
Florida State University Center for Ocean Atmospheric Prediction Studies (COAPS)
Tallahassee Florida

***Meeting Notes***

*October 22, 2013*
*Plenary Session*

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## I. Welcome/Background and Workshop Goals- (Nancy Kinner)

Welcome by Eric Chassignet of COAPS/FSU

Reasons for attending ( participants)

- See what others are doing
- Have moorings offering space for sensors
- Uta want to get better view of whole process/what others doing
- David Hollander- Interested in processes are going on and see what others are doing in sediments and linkage to water column
- Univ. Miami want to know how processes work to incorporate into models
- Interested in how snow may impact fish
- Working on local beaches and shallow water want to better understand snow and how it may impact shallows
- Developing large data sets interested in MOSSFA data
- V.J. Johns looks at green dispersants and interested how snow might be used
- Interest in how snow might impact mercury cycling
- USF Daly interested in collaborating with others
- Interested in physics of snow and oil interaction and how processes work
- Interested in the connectivity between water column and benthic boundary layer
- Grad students looking for good thesis ideas!
- GOMRI staff interested in how this workshop structure works and how might be utilized in the future
- Learn what is happening in snow research and how it might be used in the response to future spills /incident
- Interested in how microbes identified in the plume may interact with marine snow

**II. Overview of MOSSFA (Uta Passow)**

People working on same problem have different ways to describe snow
Murawski (C-Image)/Chassignet (Deepsea) / Highsmith (ECOGIG) proposed working group to GOMRI Board to increase discussion and information sharing.

Passow introduced pathways for marine snow/aggregates etc. utilizing figures. Gradients also are factors. High river influence has high nutrients and clays and low salinity. Low river influence has low nutrients, clays, higher salinity.

Lab experiments on the formation mechanisms of using different types of particles

- Oil snow/ microbial
- Marine aggregates
- Others

Oil in pelagic web shows carbon entering water column /food web. Is it good or toxic(oil carbon)?
Sediment trap data shows something of water column/sediment interaction (Daly data)
Data exists on sediments and incorporation of carbon
Data patterns in the benthos also available but shows different pattern –is there a reason?
Corals also show impacts/20%

Initial schematics (See initial diagrams) were developed by the Steering Committee to generate discussion in the breakout groups

Group 1
Oil-associated marine snow
River influence/Marine biota/oil dispersants
Formation petrographic/dispersant/pyrograpics

Group 2

Deposition, accumulation and biogeochemical fate of oil and associated flocs on seafloor

- Benthic Fauna smothering, bioturbation, C-input and toxics
- Petrogenic NC smaller droplets
- Clays, terrestrial organic matter

Group 3 impacts of Oil-associated snow and flocs

- Direct effects
- Inadvertent ingestion
- Intentional uptake

Goals of Workshop from Uta's presentation

Goals of this meeting:

1. Define processes/framework
2. What is spatial and temporal variation of processes
3. Manifestation in sedimentary record
4. Effects (biological and chemical) of processes and manifestation (and impacts) on ecosystem assessment
5. Define research questions for each process in framework
6. Identify what is needed for research strategy (i.e., what is being address, what is not being addressed, define gaps and how to address these gaps)

Comments:

Ultimately we should get it into models

Need to understand individual processes of different particles

Group 1 include Sun in discussion since it impacts processes

**IV. Goals of the Meeting (Kinner/Passow)**

- Primary Goal is to integrate ongoing studies and develop new ideas and collaborations to promote a comprehensive view of the factors controlling the formation and deposition of oil-associated marine snow and its accumulation as flocculants on the seafloor, in the context of oil and gas release and dispersant application in the marine environment.

- Define Processes/frameworks
- Understand spatial and temporal variation of each process
- Delineate the manifestation in sedimentary record
- Determine effects (biological and chemical impacts) of processes and manifestation on ecosystems
- Once understood, the information on processes, manifestation in the sediments and effects can feed into numerical models of the behavior and effects of oil to predict ecosystem response to spills.

Processes<br>Manifestation<br>Response → Numerical Models → Prediction of Ecosystem Effects

## V. Theme Talk I. Processes and Pathways (Kendra Daly)

Overview for processes of Marine Snow formation

- Provides micro habitats
- Food for macrofauna
- Increases settling velocity

Several pathways from experimental research
Richard Lee oil droplets in fecal pellets of Doliolids 36/90% of oil could have been incorporated into fecal pellets(presentation.
Uta's Passow papers on formation of snow in presence of oil droplets show presence of oil

C-Image results in 2010 show two factors may have contributed to large marine snow formation: 1) river influence -a large release from Mississippi and 2) the spill
Phytoplankton anomaly occurred in northern Gulf in 2010 showed higher chlorophyll a. and in higher zooplankton as well.
In 2013 Chlorophyll a. was higher again
Much higher marine snow occurred in August 2010.
In 2013, even though Chlorophyll a. was higher the marine snow was not high.

Sediment trap data not available for 2010
Uta's sediment traps flux higher in 2010. August not been observed
Skeletonema not observed in subsequent years (deep trap).

## VI. Theme Talk II. Accumulation Rates I (Samantha Joye)

Major differences between the Macondo and Exxon Valdes

- Temperature
- Dispersants
- Depth

Oily sediments were found on the floor

Cruise in Sept 2010 oil and snow observed in sediments

Vertical contributing mechanisms

- Bio-emulsification
- Dispersants
- Ash fallout from burning

Lateral mechanisms (Hollander)

Evidence of accumulation

- Cores
- Thorium 234 evidence (3 month half-life) shows a lot of sediment in 3 month period. PAH and TPH deposition was found weathered and not possible to fingerprint totally to DWH

Barium from drilling muds also found

Burning

- Pyrogenic signatures- elemental Carbon from pyrogenic input. Some soot landed on sea floor but not sure exact amount

Microbial activity

In sediments- microbial activity not observed in sed and oily layer based on sulfur reduction

Reduced benthic activity and health of some benthic species

## VII. Theme Talk 3. Effects (Joel Kostka)

Effects in water column ecosystems and effects in benthic
Not much information available on near-shore mostly deepwater sampling
From the microbial perspective
In water column there was a decrease (using radio carbon) in productivity with the largest decrease in smaller fraction.

Microbial ecology of hydrocarbon degradation (bacterial smaller particles and viruses)
In the water column there is a shift in pop structure and diversity and also a shift in the succession of population.
Effects on oil microbes deep water—only a few species of bacteria
Cores sectioned very finely
Thorium 234 used to show high deposition after spill
Decline in Th234 from 2010 to 2013.
Romero can separate the source of sedimentation based on hydrocarbon identified.
Hastings study of metals and forams shows the deposition layer that occurred

Montagna found impacts to benthic macrofauna out to 3 km from the source?
Correlated to TPH, PAH Barium and distance to wellhead
Map of macrofauna and c14 abundance show pattern of impacts to the Ne from ell
In Desoto canyon not sure yet if fauna are natural o oil related differences in
Coral injuries showed retracted polyps
Areas of high oil and dispersant concentration show impacts

## VIII. Plenary Report Out I

Group I Processes and Pathways
Presented by Tinka Murk
Report out:

1. They can live with the diagram
2. Physics of turbulence and large scale processes impact the model
   Impacts can come from: 1)entrainment from above, 2) changes on ascent from hydrate production, and 3)photochemistry
3. New complex diagram on process/formation of snow was created
4. Questions :
   - Did they consider different oil types—no
   - Concept of oil mineral aggregation—discussed but no answer yet
   - Focused on bacteria mucous to start process

Group II Accumulation Rate/Fate
Presented by Chris Martens/Rebekka Larson/Clayton Dike
Report out:
Developed new diagram to accompany original identifying source, fate, and potential reentry into water column
Potential for lateral movement of snow – seen in snow camera in Mississippi Canyon station of ECOGIG
What happens in the floc layer?

1. Deposition vs accumulation
2. What is the long term signature event? What signal will be preserve?
3. Different transport vectors affect preservation
4. Recycling into the water column and food web occurs
5. Mineral surface area is important
6. Is flocculation of oil a desirable fate?

Questions;
Should we add bioturbation and continued other sedimentation to the model?

Group III Effects
Presented by Wade Jeffrey
Report out:

1. Diagram is missing ecosystem perspective and complexity
2. Need to link to biogeochemical cycle
3. Diagram of inset triangles and interaction was developed

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Tallahassee Florida

***Meeting Notes***

*October 23, 2013*

**IX. Recap/Recalibrate**

**X. Plenary Report Out II**

Group I Processes and Pathways
Presented by Vern Asper
Report out:
What we know: Aggregates formed quickly; did it have something to do with oil?
What was role of dispersants in forming plume?
What is the interaction of oil and particles from river input?

River input has several effects: how did it impact the snow formation, particles from river
How did particles from burning interact in the formation of marine snow
Sahara particles did they have impact and make it sink

Fresh oil doesn't ink is it weathered oil that makes it work?
Pickering emulsions how and do they interact
Low does the surface interaction make the process of the snow detach and sink
What is the role of zooplankton in the process?
Gelatinous zooplankton- how are they involved?

Hurricane Bonnie—how did the physics of situation impact sinking (after Bonnie there was much reduced surface oil)

How did the snow reach the bottom?
Are zooplankton changing the particles as they sink/
Loss of benthos did it change bioturbation process?
What do we know of natural seeps and how it interacts? Need more baseline data

What we know on snow in surface – there is data on snow formation from from field and lab

Group II Accumulation Rate/Fate
Presented by Brad Rosenheim
Report Out:
The proposed figure is good and demonstrates changes observed in space and time.
What we know:

- From process data which we can imply from fewer samples
- Need more spatial data to show extent
- Know fluxes, Rates Profiles/distributions ( see notes on details)
- Know ecosystem characteristics

Needed- timing of formation and the reason for algal vs. bacterial action
Need more information on stratigraphy changes
What persists- is it still toxic?
Need more information on microbes, communities, redox and SOD interactions
Need more information on sea floor processes and overlying sediments
Need to develop time scales for processes and events
Need more information linking water column and bottom-Benthic-pelagic coupling related to snow
Need access to more equipment to work in the deep sea
David Hollander--. Thorium 238 can help to with timing of events in the sediment in time scales of months
Questions:
Uta discussed the flux data from sediment traps and composition for POC. Uta dry weight in trap not as dramatic as the POC
Vern Asper if we had ROV data at site from BP maybe we could see settling was happening and also how sedimentation was happening (NOAA may be able to obtain)
Dave Hollander made plea for multi-center approach for future spills from MOSSFA and sediment group

Group III Effect

Presented by Patrick Swing

Report Out:

New figure is:

1. Unpack triangles
  - Organism level
  - Community level
  - Ecosystem level
2. Benthos
3. Deepwater - different for the ecosystem
4. Surface waters- different for ecosystem
   Need help on plankton from Group 1
5. Needs Temporal and spatial extent
   Lab mesocosm experiments
   Process rates

Questions:

Kendra Daley: Need for baseline data and information on natural seeps

Did they discuss coupling monitoring and dilution over time--- No

Did they focus on toxic impacts in sediments and water column—No focused mostly on snow event and understanding problem—

Was any discussion of dropping out one part of food web and how that would impact anything--beyond plankton? No. Group 2 discussed the loss of phytoplankton and carbon but not answered yet. David Hollander indicated some data is being collected but it needs to integrated some nested models in the future.

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Tallahassee Florida

***Meeting Notes***

*October 23, 2013*

## XI. Plenary Report Out III

Group I Processes and Pathways
Data needs/questions

Use mesocosms as important experimental tools to understand what happened.
Importance of weather and seasonal changes.

How big was snow path as sink for oil? What were controls? How could it be manipulated to enhance or minimize vertical flux? What is the relative impact for resources of concern? If you double flux, will it have a significant impact on human resources or benthic communities? How do effects scale with size and other properties of spill?

Different breakdown of aggregate formation agents: algae, bacteria, mineral, dispersants.

One impact is stripping of nutrients from surface. How sensitive is it to the amount of marine snow/ corexit?

What is effect of river and how can we modify them? Two potential effects are nutrient (increased by diversion) and sediment (decreased by diversion) inputs.

How does an oil layer + dispersant change mixing regime in surface layer? Role of turbulence in mixed layer?

How does biology affect the coagulation / formation of marine snow?

What are the components of marine snow?

What should be measured next time?
-PITS traps
- Water column collection of marine snow

What are the scaling effects? How big a physical extent would you need to get massive export? Taylor platform shows marine snow enhancement (10s bbl/d). Has riverine input of clay magnified problem? In contrast, natural seeps further offshore do not show same formations. What about natural seeps off LA, CA.

What are the big picture questions?

- How does it affect human affects?
- How it will affect ecosystems?
  - Strip nutrients
  - Impact the bottom
- What can we predict?
- What do we need to predict more?
  - Size distributions of source particles
  - Phytoplankton concentrations/primary production
  - Surface DOC concentration
  - TOC(POM+): microbe, phytoplankton, zooplankton
  - Presence of genes coding for biosurfactants and emulsifying compounds
  - Thermodynamics of biopolymer formation in presence of oil and surfactants
  - Size and types of particles, especially inorganic particles and impact of dispersant on their surface properties
  - Response of the benthic community to inputs of organic/oil matter. Role of community composition. Shelf vs. deep community differences.
  - Nutrient concentration in surface waters
  - Coding for hydrocarbon degradation genes, ability to work with dispersants. Know the ability of the community to reach to inputs.
  - Water column community of organisms
  - Oil composition and state
  - Physics: mixing and adjective processes
  - Atmospheric/weather/seasonality/UV

**Five minute summary:**

Products:

Synthesis products

Times series nutrient fields

What difference did river diversion make?

Role of turbulence in forming marine snow

Response measurements

Other systems as proxy sites to understanding size dependency of scale

Predictive wish list

**Questions:**

What Is role of convergence zones? Could it lead to intermingling of algae and oil and downward movement of oiled phytoplankton?

There was a question of whether marine snow was observed in Campeche. One thought is that these were tar balls

Group II Accumulation Rate/Fate

Data Sources

Google maps: Click to site, Profiles, Active research,

View of oil coverage, dispersant, burning, Mississippi and tributary discharge (nutrients, clays)

Temporal variations, Data base map

Timing of blizzard event, singular or multiple events

Regional controls- hot spots, where to go

Sediment to water column linkages to upper trophic levels

Use starting and stopping point to inform experimental studies

Net effects on organisms: pelagic and benthic

Development and Application of Nested numerical models

Aggregation, NPZ, Far-field hydrodynamics with oil module, Ecosystem Scale

Source, flux, processing (including water transport), Deposition, Spatial and time functions, impacts on various trophic levels, mathematical terms for each level

Better Prepared:

**Need to show MOSSFA was significant:**

How much oil landed on sediments, depressed microbial processes, macro-/micro-faunal, corals, benthic dependent fish (PAH, immune response, enzymatic change, growth rates, landings/populations), food-web habitat alteration, food web-trophic dynamics,

Historical background versus DWH

Economic impact

Time scales of processes and measurements

Economics vs benefits

Response times

Response Strategies

Quick academic response: Ricker response teams

**Parameters of significance:**

Source Inputs (organics-algal, terrestrial, microbial), concentrations of HC or Oil snow, water transport, flux, particle formation, particle formations/sorption, sinking rate, deposition rate, oil uptake, or O2, bioturbation, microbial rate, allothonous inputs, event deposition,

**Model Parameters**,

Vertical flux, spatial extent, temporal variability

Role of MR: Compare surface coverage with sedimentary HC coverage (compositional comparison (is MR there), hypothesize difference is transport term

Group III Effects
Report Out:
Data Needs

**MAPS and INVENTORIES**

-A picture of the current spectrum down to the bottom;
-Seafloor map of marine snow event. Spatial extent, thickness.
-Stratigraphic framework of NE Gulf
-Pre-spill/ post-spill comparisons for prokaryotic and eukaryotic microorganisms (community comp in water col).
-Product input for maps/models:
Temp, Oil cover, Wave height, Burned oil, also location, Dispersant, Wind, natural seeps, Currents/Salinity

*Also have this for sub-surface* (i.e. need to have currents, other physical/biological factors for subsurface ocean). Collect some of this information via sediment traps, measurements of resuspension, redeposition . Current speed, differential between bottom and above the bottom, get estimate of sediment load being carried

**OTHER LOCATIONS that are important:**

-Eastern G of Mexico: bidding is open on lease blocks
-Arctic

**PROCESSES**

-Quantitative estimate of oil fate via snow (how much oil removed, how much of it ended up in the water col, in the sediments etc.)
-Taylor Energy site could be a great source of samples to develop in the lab a mechanistic model of oil snow formation
- Coupled physical/biogeochemical models

-Coupling of benthic and water column environments
- mechanistic model of snow formation: look at the different factors (surfaces, phytoplankton types, dispersants, oil, other variables.) Use as a tool to predict extent of snow formation under different conditions/environments

**RESOURCES THAT LIMIT OUR ABILITY to achieve our goals (spatial/temporal coverage)**

Gaps: Ship-time, ROV time, equipment that works in the deep benthic environment
Resources: too few people to collect samples/analyze data/do experiments

## XII. Next Steps (Nancy Kinner)

Group 1: mechanisms

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***Meeting Notes*** ***Breakout Group Number___1___________***

*October 22, 2013*

Breakout Session I

Question:

- Refine the conceptual diagram for your topic.

Questions from open session:
-role of charge interactions in coagulation process.
- importance of photochemistry and photobiology
- surface vs subsurface plume roles

Additions:
Need for physical data for model calibration

Turbulence

Soot/pyrogenic

Entrainment moving vertically
- interactions w hydrates/gas bubbles

= lateral movement of particles from shelf, interaction with rising oil

- Marine snow formation in subsurface plumes

Larger scale physical processes through the water column

What increases density?

Sieving of falling particles

Use of Matrix approach to describe factors affecting different properties (verbs and nouns)
Top row:
Oil dispersion, riverine influence, marine biota, physical ,
Rows: Formation, Sinking, buoyancy, benthos
“Pickering emulsions”

Surface charge effects

Bullet points:

1. Stayed with basic triangle. No squares or pentagrams (Nouns)
2. Add factors:
3. Issues that need further work (verbs).

Rob Ricker:
Nancy -- could you please ask Group 1 to consider physical weathering such as photooxidation of the oil and consequent changes in charge to oil compounds (i.e, formation of oxygenated hydrocarbons), and how this might affect aggregations and marine snow formation.

Another point to raise with Uta: could you please ask her to juxtapose the 2010 sedimentation event with the magnitude of sedimentation events in other "non-spill" years.

Could you raise with Kendra (at the appropriate time) a question about her reference to the findings of oil ingestion by doliolids.  Does she know if anyone in this group analyzed any of the animals (pyrosomes, related to doliolids) that were documented as part of a kill at the time of the spill and active release from the well head.

QUESTIONS AFTER TINKA'S PRESENTATION

What is effect of oil characteristics?

What is role of Saharan dust?

How does marine oil interact for the formation of aggregates.  Direct as opposed feedstock. Role of dispersants.

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***Meeting Notes*** ***Breakout Group Number_______________***

<u>Breakout Session II</u>

Questions:

- What data exist regarding the different aspects of the conceptual diagram for your topic?
- What data are being collected?
- What data need to be generated by new projects?

Start with diagram.  Follow the oil.

A: Input: Physical and chemical characteristics of oil. Size, hydrates, amount.
Do we get aggregate formation?
EPS (excreted material) vs natural.
How important is resuspension in formation of particles?
What determines drop formation size?
What is the effect of dispersant addition at depth?

B: Formation of subsurface plume

Direction of plume advection, along or cross isobaths

Fn of stratification, current flow

Formation of drops in plume, size distribution

Role gas / oil ratio

C. Interaction with subsurface particle plume

Role of dispersant

Size of particles

Could use transmissometer and AC9 to do an analysis

D. Near surface / mixed layer influences

1. River input

Nutrient- data are available

Phytoplankton/species

High density particles. Some information on particle concentrations, size distributions

Shallow mixed layer

2. Aerosol/ soot

High density particles

Saharan dust vs Mississippi river. Interacts with dust layer.

Soot data are available on line from feds

Data are probably available to scope out the importance of these sources

3. Photochemical/ weathering

What did happen? Info

4. Biological transformations
   Biopolymer production
   Influence of composition/ dispersants
   Surface properties and transformations
   "Pickering emulsions"?

5. Aggregation
   Surface boundary condition
   Differential settling/ rising
   Nature of particles (

6. Feeding
   Lab experiments are usually done on coastal zoos, which seem to be very resilient. Other expts suggest subtle effects.
   Relatively little fecal pellets (Aug 2010)

7. Physics
   Extensive data exist. Could be analyzed and put into sedimentation models.
   Did hurricane affect sedimentation?

E. Midwater processes. At 200 m/d 5-10 d.
   Continuing biological transformation, density and size and mass. Have experimental microbial data.
   Are zooplankton changing the particles

F. Benthic interactions
   What is role of natural seeps, natural marine snow
   Smothering of critters
   Feeding
   Bioturbation. Low?.

Oxidation.

Can we use benthic record to tell us about relative roles of different processes?

G Resuspension

Bottom currents

Resuspension and dispersion

Dis aggregation and reaggregation

Audience questions/points

- Rainfall chemistry in Pensacola area had normal chemistry associated with dust. Note that this was for annual iron flux; need to look at monthly. Suggest that there was no big Sahara dust input during oil spill. Monthly data actually show that June 2010 had a higher flux than other months of the year, but not atypical for different Junes.

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*October 23, 2013*

***Meeting Notes*** ***Breakout Group Number______________***

<u>Breakout Session III</u>

Questions:

- What syntheses are needed to develop a holistic picture of what happened with respect to Marine Snow during the Deepwater Horizon Incident?
    - Synthesis products include: visual products (e.g., distribution maps; schematic diagrams of critical process for numerical modeling); budget calculations (what kind); predictive numerical models
- How do these products help compare what happened to Marine Snow during the Deepwater Horizon event to historical conditions (non-spill)?
- How will these products help improve future oil spill response actions (e.g., timing of release of Mississippi River flows into the Gulf of Mexico)?

Use mesocosms as important experimental tools to understand what happened.

Importance of weather and seasonal changes.

How big was snow path as sink for oil? What were control? How could it be manipulated to enhance or minimize vertical flux? What is the relative impact for resources of concern? If you double flux, will have a significant impact on human resources or benthic communities? How do effects scale with size and other properties of spill?

Different breakdown of aggregate formation agents: algae, bacteria, mineral, dispersants.

One impact is stripping of nutrients from surface. How sensitive to amount of marine snow/ corexit?

What is effect of river and how can we modify them? Two potential effects are nutrient (increased by diversion) and sediment (decreased by diversion) inputs.

How does an oil layer + dispersant change mixing regime in surface layer? Role of turbulence in mixed layer?

How does biology affect the coagulation / formation of marine snow?

What are the components of marine snow?

What should be measured next time?
-PITS traps
- water column collection of marine snow

What are the scaling effects? How big a physical extent would you need to get massive export? Taylor platform shows marine snow enhancement (10s bbl/d). Has riverine input of clay, nuts. In contrast, natural seeps further offshore do not show same formations. Natural seeps off LA, CA.

What are the big picture questions?

- How does it affect human affects?
- How it will affect ecosystems?
    - Strip nutrients
    - Impact the bottom
- What can we predict?
- What do we need to predict more?
    - Size distributions of source particles
    - Phytoplankton concentrations/primary production
    - Surface DOC concentration
    - TOC(POM+): microbe, phyto, zoo
    - Presence of genes coding for biosurfactants and emulsifying compounds
    - Thermodynamics of biopolymer formation in presence of oil and surfactants

- Size and types of particles, especially inorganic particles and impact of dispersant on their surface properties
- Response of the benthic community to inputs of organic/oil matter. Role of community composition. Shelf vs deep community differences.
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**Five minute summary:**

Products:

Synthesis products

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Response measurements

Other systems as proxy sites to understanding size dependency of scale

Predictive wish list

**Questions:**

What Is role of convergence zones? Could lead to intermingling of algae and oil and downward movement of oiled phytoplankton.

There was a question of whether marine snow wer observed in Campeche. One thought is that these were tar balls.

Regulators would love maps showing any effects, benthic and surface, of effects of marine snow formation. Refers to historical sedimentation results (?). how does this relate to coral impacts.

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***Meeting Notes*** ***Breakout Group Number Group 2***

*October 22, 2013*

Breakout Session I

Question:

- Refine the conceptual diagram for your topic.

Change in density, salinity and effects on settling.
Nutrient delivery and clay transport,
N-Limited, blooms, large flocs
Floc on normal background sediments

- Note background, organic matter inputs, resuspension/re-deposition
- Chemical & tracer profiles, e.g. 14C , POM, recycling, microbial repackaging/metabolism
- Lithogenic component: 85% of sediment traps, siliciclastics
- Planktonic inputs carbonates
- Flux rates changes not composition,
- Cores comparison: source of OM change petro to pyrogenic
- Spatial comparison: wellhead vs Desoto
- Lateral plumes: MR outfall vs deep water
- Dispersion along isopycnal
- Sinking of Marine Snow?? See fining upward,
- Near bottom date from landers, Topographic flows
- Long term accumulations vs short term deposition
- Marine oil snow- needs presence of oil and dispersants
- Does not need 50 % could sink with 1% OM oil
- Trap data- during pulse more organic but after pulse see
  - Dominant of lithic august highest
- How long with the tracers last….?
- Biology without dispersants effective at depositional processes
- Role of dispersants in decomposition, microbial
- What are processes that effect floc layer?
  - Macrofauna, suspension, topography
  - Physical, biology, and microbial processes
- Topographic controls, Accumulation of PAHs, post/pre,

Differential benthic foraminifera recovery

Monolayer hypothesis, surface area of clays related to OM

Trapping and removal of microbial decomposition,

Bioturbation differential recovery,

Molecular distinction in mechanisms, plume to marine snow

Adding dispersant transfers PAHs, irreversible

Persistence in the environments, sediments

Time scales of component analysis, tools for indicating

Degradation versus persistence

Need organic petrology, Soot, Organo-mineral-biopolymer

Is there degradation of pyro-sources…time marker?

What are the signatures preserved?

Palynology-

Refine Conceptual diagram,

Add Chris M. diagram of profiles to conceptual diagram

Key Points:

Deposition or accumulation

Long-term signature of event and its persistence

What's going on in the floc layer?

Shallow system deposition vs deep sea-

Delineate plume versus snow

Re-entry into food web

Time scales of significance

River inputs and lithogenic and nutrient inputs

What happens in the floc layer?

What is the long term signature accumulation?

Sinking important vector

Reentry into food web

Mineral surface area: organic content (PAH, pyrogenic, petrogenic, biopolymers),

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***Meeting Notes*** ***Breakout Group Number II***

<u>Breakout Session II</u>

Questions:

- What data exist regarding the different aspects of the conceptual diagram for your topic?
- What data are being collected?
- What data need to be generated by new projects?

<u>Existing Data:</u>

What we know:
    Pre-, During and Post the Deepwater Horizon blowout event
    Have limited set of time series cores at exploratory sites:
        (2010, 2011, 2012, 2013 , need to continue)
        Outer shelf and slope, largely
    Characterize the pre-event background conditions
Fluxes
    Sediment Accumulation Rates,
    Oil- Petrogenic /Pyrogenic, benthic ecology at selected sites
Rates:
    HC decomposition, respiration rates at “hot-spots” (need Sed O2 demand)
    Sedimentation rates (need broader regional coverage)

Profiles/Distributions: (at limited sites)
    Tracers (radio-isotope, biomarkers), oil (petro- and pyro) , chronology, stratigraphy, sedimentology, microbiology, stable isotopes to org.-C sources
    Existing distribution inform process sites to allow benthic –pelagic coupling

Ecosystem characteristics:
    Benthic foram- microfauna

Macrofauna,

Benthic dependent fisheries (habitat- food, burrowing, vectors of contamination)

Needed:

Timing of different floc type formation- distinguish
- (biological vs chemical- a hypothesis)
- Algal vs bacterial
- OMAs

Stratigraphic changes: nature, texture, composition
- Organic petrography, molecular approaches,
- Tracers (DOSS+, 14C)

What controls persistence and preservation potential of HCs
- Toxicity, microbial communities/function,
- Redox, aerobic vs anaerobic, Sediment oxygen demand

Role of sea-floor processes
- Bioturbation, near-bottom currents, sediment resuspension,
- benthic recovery, gravity flow

What comprises the overlying sediments?
- Sedimentation rates/MAR, nature of material (clays, lithics)
- Sources of Org.-C, steady vs non-steady state processes

Fluxes, Rates and Sediment Profiles
- Should create mathematical coherence
- Terminal metabolic pathways, O2 cycling/respiration

Time scales of processes – table
- Include: spill event, snow formation, dilution/degradation/redistribution in water column,
- biological response

Sediment focusing
- $^{14}C$, $^{234}Th$, - re-measuring at times in future to assess changes – oil doesn't just land

Linking water column and sediment
- Flux to Flux
- Sediment resuspension and exhumation compared to circulation

Dilution of hydrocarbons and dispersant
- Spatial Heterogeneity
- Focusing into sedimentary reservoir or other sinks

Persistence HC in the environment:
- Sediments rates of decomposition
- How fast and at what rates are HC entering into food web
- Benthic – Pelagic coupling
- Episodic events

Ecosystem recovery
- Benthic micro- macro-fauna
- Bioturbation depth

Community changes –regime changes, unidirectional changes

Significant and implications

Recovery time - spatial heterogeneity

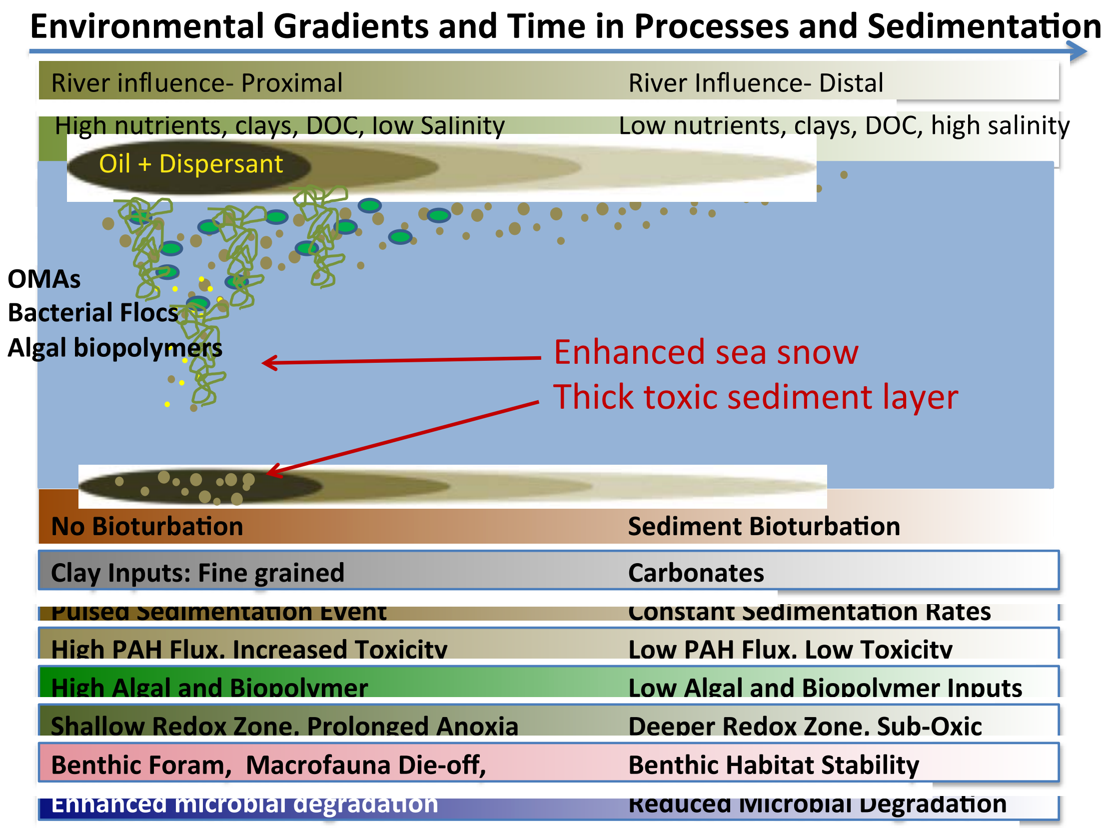
What controls recovery? Why are some sites not recovering?

Upper trophic levels: fisheries

Need for rapid response team:

i.e., Hercules 265 – GoMRI cooperative multi-center

Sediment observing systems: need technology innovation to support research



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***Meeting Notes*** ***Breakout Group Number II***

<u>Breakout Session III</u>

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Development and Application of Nested numerical models

Aggregation, NPZ, Far-field hydrodynamics with oil module, Ecosystem Scale

Source, flux, processing (including water transport), Deposition, Spatial and time functions, impacts on various trophic levels, mathematical terms for each level

Better Prepared:

**Need to show MOSSFA was significant:**

How much oil landed on sediments, depressed microbial processes, macro-/micro-faunal, corals, benthic dependent fish (PAH, immune response, enzymatic change, growth rates, landings/populations), food-web habitat alteration, food web-trophic-dynamics,

Historical background versus DWH

Economic impact

Time scales of processes and measurements

Economics vs benefits

Response times

Response Strategies

Quick academic response: Ricker response teams

**Parameters of significance:**
Source Inputs (organics-algal, terrestrial, microbial), concentrations of HC or Oil snow, water transport, flux, particle formation, particle formations/sorption, sinking rate, deposition rate, oil uptake, or O2, bioturbation, microbial rate, allothonous inputs, event deposition,

**Model Parameters**,

Vertical flux, spatial extent, temporal variability

Role of MR: Compare surface coverage with sedimentary HC coverage (compositional comparison (is MR there), hypothesize difference is transport term,

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***Meeting Notes*** **_Breakout Group Number_____3__________**

*October 22, 2013*

<u>Breakout Session I</u>

Question:

- Refine the conceptual diagram for your topic.

Does arrow color signify anything? No---colors are uniform for classification of information.

Haven't here sorted out C, N, and energy effects.

All arrows are equally weighted; do we need to weight them differently? Can we distinguish weights of events? How frequently do events occur?

WRT microbial loop, trophic levels: rxn depends on whether C is link or sink in food chain (methanogens to algal organisms, oil then nutrition). Can also affect BGC cycles by killing things---how do we distinguish link vs sink questions.

Note also no N, P in oil; might need to throw in nutrients to make oil go away..

How put in more biogeochemical questions into current framework?

Have to start representing fluxes of C, energy explicitly. Current version represents control linkaeges, not actual fluxes.

Another control: effect of oil on natural BGC of sediments, etc. For example, killing nitrifiers. Also, retarded Sulfate reduction. Impacts on BGC cycles by affecting selective taxa.

Certain trophic levels are links, sinks in BGC cycling.

Respiration, foraging efficiency, reproduction: all also important, not just mortality and growth. (Things that are missing in current version of fig).

Why assign a motivation (intentional vs inadvertent?) Start w/ boil processes; see how different effects impact organisms in positive or negative manner. Central life processes affected in fundamental manner.

What hit the bottom? Lots of stuff---diatoms, bacteria, EPS/aggregated stuff.

Redrawing the diagram: 3 pts. of triangle don't fall into same class, could do 2 sided, direct and indirect effects. Maybe direct effects on one side, indirect effects on other, then have subcategories within each of the sides.

At what level is diagram pitched? Are we working at organismal level, or are we looking at ecosystem level, population level?

We're getting into fluxes; not that not every single flux will have same effect on specific organisms. Some affect same populations but in different directions for different types of organisms.

Can we write an equation: body growth is a combo of different factors (a+ b+ C, a goes down, b goes up, what's effect on C.)

Categories: only foraging is metazoan specific, the rest of the categories would fit any level of organism. Zooplankton migration affected by oil as well.

Too complicated for a single equation; can we do a visualization of positive and negative effects in some manner? Growth equals consumption plus assimilation efficiency, growth related to recruitment, how frame so that different variables can be included?

We are burrowing in too deeply, looking too fine-grained; want pop model, want it embedded in ecosystem model. Would be useful to look at fluxes, maybe bin organisms together to look at how oil, gas go through ecosystem, need to conceptually capture some of pop level behavior. Big pix is what they were after with big cut, maybe go for this level of ecosystem impact. Try to connect boxes in big picture, and then see where we need to embed finer grained analysis…

Go back to two-sided triangle, direct and indirect effects. Then subdivide into negative and positive outcomes on each side, direct and indirect. Good/bad, then from there figure out which processes, levels of orgs to go to.

Start with triangle, do benthos, geochem cycling, and water col as the three points. Problem is that biogeochem cycling fits everywhere.

Want surface and deep water boxes, and benthos.

Do we want first level of organism to be environment/location, or direct/indirect? Are processes locations specific?

Hard to integrate how we'll look at this at org, community, ecosystem level. We are considering them in 2 separate spheres. Biogeochemical, direct/indirect effects, then respiration/growth….

Some of complexity sorted when BGC mapped onto specific orgs, processes. Have a whole suite of things associated with BGC cycling, with benthic and pelagic communities, things happen within each that affect BGC cycles.

We haven't talked about humans… they're not essential; depending on how we look at things…do we include human beings as separate component? More socioeconomic view? The so-what factor is how it affects people. Health of ecosystem is important for socioeconomic stuff that is at a level above the diagram here. How do we move up to community-level ecosystem impact?

Usually it's the human impact on the ecosystem; but the ecosystem here is starting to affect humans. Hg can bio-accumulate via phytoplankton, only a few more layers to get it into people. Phytoplankton will bioaccumulation more Hg, this would be the ecosystem impacting humans (humans affect ecosystem by letting all the oil out) Asthma rate goes up w/ oil spill.

Hunch that the assignment doesn't include humans explicitly here (i.e., at this level not including human impact)

Why not make these levels the levels of the diagrams? Use the top three: BGC cycling, then impacts on individual orgs, then levels of community, then ecosystem as a whole, then ecosystem function; Then a continuum of indirect, then direct effects. Within each box record, above and below positive and negative, direct and indirect effects.

Where do more detailed aspects of existing diagram go (e.g., ingestion, reproduction, etc.)? Want to know effects, need them as levels of diagram.

Remove intentional vs inadvertent in diagram. It's a cascading process.

We have 2 different methods emerging, pop-centric, and on the L is process-centric/oriented view. Can the 2 be combined in 1 diagram? Maybe need 3 D, or more than one diagram. RH side has advantage that it can be generalized to anything: for any effect on something living, will fall into one of the 6 categories. Not sure what diff is between community and ecosystem.

Want to get more specific about effects on community and ecosystem. Advantage of L side is that there's a lot of useful specific info.  Could take all elements from L and put into R, if it's big enough. $2^{nd}$ diagram could be a food-web diagram, map effects of oil on food web diagram.

With such a fig, all boxes state variables, all arrows would be processes, focused on C, en transfer between diff levels. Would have intrxn between them as well.

Could have 2 food webs and have intersection between them.

Stymied about RH, LH diagrams. Seem very different. RH is broad, no specifics to it. Each of the processes in LH diagram becomes positive or negative factors on RH fig. Neither is right or wrong, they feed off each other.

LH doesn't encompass any of the 3 bottom levels shown on the R (community, ecosystem, ecosystem function). Also in terms of what data needed, what data there, diagram on LH side goes towards existing data, what is needed in new projects. Don't yet have that in RH diagram.

If we go back to the organismal level, main level need in discussion (trying to simplify). How do we get to organismal level? Magnitude of ripple rings is really important. Could make a diagram on Left Hand side for everything on the Right Hand side.

Orgs create BGC cycles; need them above the BGC cycles.

Goal is to show impact of oil associated particles in water col on seafloor. Both of these RH diagrams (newly generated) are not very specific about what we need. Both need something to be added in. RH side has room for lots of detail on the +, - bits.

Could put community, habitat effects, predation/prey interxn, specify comp, diversity, also.

LH is from oil perspective; one on RH is from Victims' perspective.

Is there something missing/wrong/needing to be changed in terms of direct, indirect effects?

Yes, missing impacts on diversity, abundance.

For organisms:  could be a pyramid representing trophic food chains. Maybe embed a food web in the community box. Maybe the triangle could rep the ecosystem; food web can come beneath community.  Will have different impacts on different aspects of community: one org killed off, other grows into niche. Look how components of community change, to get at ecosystem function and change.

What's distinction between communities and ecosystems? Ecosystem includes abiotic factors. Do we need to keep orgs in there? Effects on orgs included within ecosystem structure. Community captures mortality, consumption, respiration, growth…

Need all the levels, so much happening at each level, only way to talk about it is to include all the levels in the diagram. Talking about diff processes, end products, much more complexity than what's just happening to an org/community…

What about 2 diff diagrams? On LH, have the specifics that we measure. On Right hand, not much that we can measure at the individual level. Do we want to keep both? Toss them?

Could make everything on LH a sub-section of every box on the RH side.

For pops, predator-prey interactions, habitat effects, community/biodiversity/resilience effects.

Behavior: going to affect orgs. May affect community level (predator-prey interaction), also pop levels.

For each elements of RH diagram, can make a table that has a column for each of the items on the LH side. Could then put plus, minus on tables.

What are we missing on LH side? Still need to build components that flow into the syst. How is the ecosystem going to function. Have we ID'd sufficient components when we put them in? Diagram on RH side is essential in order to understand sys.

Box and arrow diagrams are visually simple, easy to understand, consistent visual coding to capture major controls. RH side is impt, valuable, but have danger of getting so fine-grained that we won't be able to show the big picture.

LH diagram: things that will affect diff levels of trophic structures to diff extent. Can we do a trophic pyramid that reps the ecosys, each level would be a collection of orgs that are affected in diff ways. Some of things on LH don't affect all things in trophic scheme equally; allows one to look at specific elements, think about what orgs/processes should be examined. Trophic pyramid implies levels, arrows, fluxes moving back and forth.

If we had a good internet connection, someone prob has a great marine ecosys diagram w/ pelagic and benthic, then take LH diagram, apply it to someone's ecosys model. What to look at perturbations on ecosys, need ecosys model.

Do a triangle on RH side: BGC, orga, community, ecosys from bottom up. What part of ecosys are we looking at, depends on what the structure of the ecosys is.

What's missing on the LH side? Anything wrong? Community level effects, organism effects are missing. Not clear where consumption, respiration come in. Things on LH diagram don't necess have effects at both levels. Ultimately, get rid of intentional and inadvertent uptake: just use uptake…

But if things intentionally grazing on things with oil, might have more rapid transport to deep sea. Adsorption vs ingestion should be separated. Drop 'intention' as part of the text. Not a very clean distinction.

Uptake allows distinction between eating something and absorbing something.

Maybe a list of pos and neg effects at diff levels, then figure out what the best hierarchy is, sort it out.

Finding right level of hierarchy is an issue.

If ult goal is 'what measurements should we make', need to figure out sys response. Need a complex ecosys model. Need a functioning ecosys model to determine "what if?"

This is hard, but it's needed.

Same problem with Deep-C workshop. Don't know how Gulf functions when it's not impacted. Can't determine impact of oil spill if don't understand it w/o oil. Need a really good model.

List all pos, and neg effects. Figure out hierarchy from there.

Change hierarchy.

LH triangle could rep org, then pop, community, ecosys, etc.

Add in triangle with bifurcating arrows, pos and neg effects.

For pop, measure biomass, for community, measure diversity; for ecosys, measure.

Uta's diagram looks great….we just had a90 minute validation exercise…

Don't see what can be measured on RH, is a framework to populate with the stuff on the LH side.

Some of arrows would be more or less prominent in diff levels of the sys: microscopic view of one level of a food web.

One corner upper water col, then benthic, then deep water col ---meaning of the triangle.

Embedded in tips of triangle are then positive and negative effects coming out of each tip

For multiple triangle models, then would have to have diff things on tips representing key effects.

Maybe the root of the problem is trying to coordinate and include too much info Have to decide what Is the most basic level, then build from there. Diagram is a framework for discussion.

Organisms, populations, community, ecosystem are the potential categories The corners are benthos, deep sea, and surface. Then positive/negative is applied for each of the levels. All process on LH side fit into RH multi-stacked triangle model. Tip of framework is species, then examine each of the other factors on LH side.

End up with diff Q at diff levels of the triangle diagram.

Can begin to put some processes, ecosystem components up on multi-triangle model to lead to direct measurable. For example, could have arrow from outside: bioaccumulation, predator-prey,

Fractal: zoom in, look at diff levels, and would see for every process this diagram could be applied. Some cases, things would stop at individual level, some would go to organismal level, and some would go up.

Tomorrow we will deal with the data end of things…

Is there anything that will stop at one level? Every effect could be described by an arrow, the direction of the vector could indicate where it's more significant. The length of the arrow could be proportionate to the strength of the process. Could have quantitative aspect to it if want to generate it as a modeled process.

By default, Wade is anointed to present our presentation.

Diff timescales will also be significant.

As oil C enters microbial loop, is it respired, or passed on to grazers?

Embedded triangle has ability to impose effect: rainout of material to benthos, starts at ecosystem level, then goes to individual level. An effect can be imposed at any level, and then it could go in different directions. From the benthos corner in (as example of oil snow on sediment) Flocculation: removes a big chunk of phytoplankton out of upper water col. Diagram allows one to impose effect at level at which it will have biggest impact. Potential for going in both directions is also good. Any effect listed on LH can be imposed on any level at RH, and can ripple in any direction.

Can we come up with 5 std arrows to put on each diagram? In introducing this, say we started with diagram, ended up with a framework to look at all of this. For general audience, describing this as a framework, as a way to look at system, would help convey why we ended up there. This is a framework for looking at specific processes.

*((comments below from Discussion)):*

Is sinking oil a good think for the environment?

Something policy makers want to know: should oil stay on surface, or is it better if it sinks

If want to look at perturbation on system, need an adequate ecosystem model of the GOM. Need it in order to impose a perturbation, examine effects, and watch it ripple thru model, see what outcome will be. Predictive ecosystem model to test scenarios is ultimate goal.

Consider whether processes are concentration (oil-concentration) dependent…

Did discuss trophic levels, time-dependency.

Models: they are being worked on, will be out soon (these are ecosystem models of various sorts)

What happens with a tipping point situation? Can this be portrayed on the fig (maybe an example of the arrows going either way on the diagram?)

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*October 23, 2013*

***Meeting Notes*** ***Breakout Group Number_______3________***

Breakout Session II

Questions:

- What data exist regarding the different aspects of the conceptual diagram for your topic?
- What data are being collected?
- What data need to be generated by new projects?

Work on the macrofauna/meiofaunal triangle:

Vertical flux measurements from sediment traps showing impact of oil from surface to deep

Benthic macrofauna: ID orgs, counting, check abundance, community structure, and diversity of macrofauna in benthos, comparing affected and unaffected areas
Meiofaunal being done in ECOGIG, also Landers at Troy State through RFP project

Abundance and species level community structure of forams also being done.
Influx of nanno plankton from the surface to the benthos is also being done (impact of surface water orgs sinking to benthos)

Redox boundary issues: redox conditions in sediment changed due to influx of snow material

Hg in benthic macrofauna is also currently being measured (samples collected, in process)

So for the fig, we have the triangles, and in each, we have a mosaic of sub-triangles, with individual orgs, etc.

**Existing data for macro/meiofaunal organism levels**
-abundance, macrofauna
-community structure
-14, 13 C isotopic data
-foram abundance, at species level
-Hg in macrofauna
-coccolith/nanopplankton
-physiology, reproduction/toxicity/bioaccumulation in macrofauna

At community macro/meiofaunal level:
-diversity, species composition is being determined

**At ecosystem level, listing first benthic environments:**
-Hg is needed
-mineralogy is needed
-need organic chemical comp of sediments: total lipids, total CHO, total AA

Already have
-C/N
-isotopes
-sediment accumulation rate
-carbonate, grain size, geochronology, mass accumulation rate
-Th isotopes
-rates of SR (This falls under a need)
-pore water and solid phase geochemistry is being done
O2 profiles
-PAHs in sediments

--just added microbial communities to macro/meiofaunal

-Reminder that we need to focus on the snow/ snow effects on these levels…

For Hg: snow as a scavenging vehicle to bring Hg to sediments, traced through isotopes

Hydrolytic enz activities, community production, metagenomics also for microbial community

Mega, macrofauna, meiofauna, microbial communities are all being added together…

Epifauna impacted by snow event:
Corals, crabs being worked on; different types of fish

Need: understanding spatial extent, temporal extent of marine snow event
Is this a short-term impact of something that happened for a few months, or is we looking at lingering impact?
    -see continued decline in foram community

-see diffs in microbial community metabolism in sediments over longer timescales

**Moving to the water column:**

Deep pelagic: we have less information on orgs (other than microbial community) compared to benthos

At community level, similar things being done as with benthic microorganisms

**Ecosystem level:**
Salinity, T, depth,
Hydrocarbon characterization
Nutrients
Oxygen profiles
Transmissometer data
Fluorescence
DOM
Snow-cam
ADCP (currents)
N fixation (in areas of methanogens)
Methane profilers (time course series from landers)
Methane consumption and uptake

**A need throughout:**
More process rates
(note: that many of things listed above are being carried out only at 1- 3 sites…not much spatial/temporal coverage)

Throughout water column: need more particle-specific studies at the community level

Need more processes and rates (also a reason to have more lab-based mesocosm experiments) to study events/snow effects

Note for deep pelagic: bioaccumulation in fish is being studied (PAHs, HC byproducts, Hg)

Upper water column: (broadly the photic zone)
Organismal, community, and ecosystem-

What has been done in terms of phytoplankton and the oil spill? Have looked at phytopl production effects (Wade), some community shift work (microscopy) with mesocosm work. Comparatively little work compared to other trophic levels.

A need: look at interaction w/ phytoplankton community parameters and snow…

Some of baseline data exists (on diatoms, trichos) looking at impacts of oil/dispersant on orgs, also prochlorococcus, synechococcus (UT-Port Aransas). Not looking specifically at flocs…

A major hole in our knowledge: baseline data on phytoplankton, individual species. Also little post-impact data are available. Impacts could be studied in mesocosm experiments.

Less done on micro-eukaryotes than on prokaryotes in terms of community comp

Some info on rates for bacterial communities, need for more process studies

((Section below: comments on presentation)):

Need for baseline info in order to understand oil spill impacts: what are effects of natural seeps on marine orgs in deep, what are major diffs between oil from spill, and seep-associated oil?

What sort of monitoring strategies would be useful to prove or disprove dilution theory? In other words, material enters the pelagic from the benthic? ((This was a group 2 question…not quite clear what the 'dilution theory' is…))

W/ dilution concept, talked about determining spatial heterogeneity, talked about focusing mechanism towards sediments; spatial char is an issue

What about toxicity (sub-lethal responses)? Will have these responses at different levels for different orgs?

What about toxicity of sediments? Ultimately should see upper trophic level responses.

Toxicity effects, important component through processes of f'mat and fate of oil aggs.

Was there any discussion of snow event as dropping out one component of the food web ---stripping C, N, and P out of surface water and taking it into sediments? This was discussed in one of the other groups; impacts on surface water productivity, etc. Ecosystem models, other types of models, data for ecosystem modelers (and MPZ modelers). Want to put processes into numerical frameworks to lots of other types of models, different nested models.

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<u>Breakout Session III</u>

Questions:

- What syntheses are needed to develop a holistic picture of what happened with respect to Marine Snow during the Deepwater Horizon Incident?
    - Synthesis products include: visual products (e.g., distribution maps; schematic diagrams of critical process for numerical modeling); budget calculations (what kind); predictive numerical models
- How do these products help compare what happened to Marine Snow during the Deepwater Horizon event to historical conditions (non-spill)?
- How will these products help improve future oil spill response actions (e.g., timing of release of Mississippi River flows into the Gulf of Mexico)?

**A picture of the current spectrum down to the bottom;** know what's going on at shelf and at slope. Is the tidal pulse a big player, Rossby waves, storm events…? How dynamic are currents at bottom, to what extent is marine snow being resuspended, where is it being moved? If snow isn't staying 'put' once it gets there, where is it going? Bottom resuspension processes (gravity flows, etc) should be known. Spatial changes, temporal changes also important. How do changes affect processes of resuspension and movement of flocculant material. Effectsof tidal events, hurricanes: long term mvt is more likely undulating, perhaps steady/predictable.

In sum, BW circ, spatial changes, longer timescale pattersn, event-driven episodes that may perturb patterns, may occur affecting snow event distribution and resuspension. Gravity flows also fit under episodic and unpredictable events.

Flow fields are absolutely critical: only currently have a few ADCP moorings, would like strings of instruments to get flows through water col, perhaps water col profiles via crawlers. APEX-type float for repeated profiles, would be nice to have glidres. In sum, more extensive spatial and temporal coverage, use cruises to do more focused coverage.

For Arctic: issues of mud volcanos, ice dynamics also important.

**Seafloor map of marine snow event. Spatial, thickness.**

**Quantitiative est of oil fate via snow:**

of how much oil removed from surface, what its fate was on the way down how much got to sed, how much was processed there, how much is buried.

Hurricane Issac: triggered a turbidity flow, buried a production platform under a few hundred feet of mud, Taylor Energy site, 20 nm offshore of Miss Delta. That surface oil slick merges with Miss River plume, makes mousse streamers----probably making snow, might be possible to conduct an expt using this systems. So how much oil is needed? This slick is pretty thin (sev microns) until it hits plume, doesn't get too thick. Is very close to particulate plume, might be a very good site to study in more detail.  Could examine coagulation on clay particles.  Could be good source of material for manipulative expts in lab, for comparisions in field. Probably 300 gal/day.

**Could be a great source of a mechanistic model of oil snow formation**, influence of factors such as particle input (natural) and also phytopl, flow, sed trap….different variables that influence on a mechanistic basis the formation of marine snow.  Could examine influence of a variety of natural variables on mechanisms/processes/ rates of formation of oil snow.  A model site, a way to get to a mechanistic picture. Can do shore-based expts. In 220 m of water. Awkward to core, pipes all over the place.

GC600 is a site where oil is consistently found at surface---natural seep site (1200 m water depth).  Note oil sources diff for GC600 and the Taylor Energy site.

GC185 is much shallower (580 m), another site that has been visited a lot.

**Strategraphic framework of NE Gulf would be a good synth product---**pre-event conditions. (This is something that has been started.) Looking at different timescales, days-weeks vs weeks-months vs yrs-decades (how something is recorded in the sed record) for diff processes.

Changes in redox as a funct of dist from Miss, as a funct of depth, as a funct of porewater chem: have chgs in redox sensistive metals, but not clear what is normal. Predictive porewater chem model: suboxic diagenesis would be v helpful.

Early spill: ev from snow cam, saw also stuff that looks like it was ascending, orangeish globs that were probably going down, also the normal snow that was white.

**Pre-spill/ post-spill comparisons for prokaryotic and eukaryotic microorganisms (community comp in water col).**

Gaps: Equipment, infrastructure, and people….
What technical development/equipment is needed? (access to existing infrastructure is needed: monitoring, ship-access, ROVs …)

Resources: the people to collect samples/analyze data/do expts

**Coupled physical/biogeochemical models**

**Coupling of benthic and water col environments**

OTHER LOCATIONS:
**Eastern G of Mex:** bidding is open on lease box:

Baseline studies are lacking in these areas. Used to be done by MMS, not any more. Seismic work by oil companies. Florida escarpment is very under-studied. Eastern lease area goes through Mobile Bay ; E of Mobile Bay used to be offlimits, now a big section in deep water is now open. This happened before the blowout, has been quietly ramped up. Will have another 20 y of exploration and production. 1500-2000m:

This is a huge gap in terms of baseline data---before driliing and exploration in central Gulf, a lot of work done. Bureau of Ocean Energy Management: are they going to do these sorts of studies/fund these sorts of studies?

**Need to have baseline studies in this area before a lot of drilling occurs in Eastern Gulf**. (integration, factors relevant to marine snow issues)

**Arctic:**
No studies of microbial/phytopl communities and marine snow formation in Arctic waters….controlling factors may be different. (need to consider this with a marine snow calculator, as below)

**Maybe a mechanistic model of snow formation**: look at the different factors, clays, phytopl types, dispesants, oil, other variables. Would need to combine with field distribution maps, use as a tool to predict extent of snow formation Use as a predictive tool.

Note that bact and phytopl can produce snow precursors: who is active in which area depends on a lot of factors

Product input:

Temp
Oil cover
Wave height
Burned oil, also location
Dispersant
Wind, natural seeps
Currents
Salinity

All work into a predictive mechanistic model for snow...

Also have this for sub-surface (ie, need to have currents, other phys/biol factors for subsurface ocean)
Sed traps, measurements of resuspension, re-deposition . Current speed, differential between bottom and above the bottom, get est of sed load being carried