GRI Year 1 Awards: Florida Institute of Oceanography

Dr. Jyotika I. Virmani, Associate Director, FIO

GRI Fall Meeting
October 19-21, 2011
New Orleans, LA
Florida Institute of Oceanography

- One of three designated Academic Infrastructure Support Organization in Florida:
  - University Press, University Library, and FIO (Dec. 2009)
- Administrate and coordinate statewide shared use resources to enable excellence in marine science research and education
- Consortium Members:
  - Department of Environmental Protection (FL)
  - Eckerd College
  - Florida A&M University
  - Florida Atlantic University
  - Florida Fish & Wildlife Research Institute
  - Florida Gulf Coast University
  - Florida Institute of Technology
  - Florida International University
  - Florida Sea Grant
  - Florida State University
  - Mote Marine Lab
  - New College of Florida
  - NOVA Southeastern University
  - Smithsonian Marine Station
  - University of Central Florida
  - University of Florida
  - University of Miami
  - University of North Florida
  - University of South Florida
  - University of West Florida

R/V Bellows

R/V Weatherbird II

Keys Marine Laboratory
FIO GRI Year 1 Award

- Total Block Award: $10M
- FIO established process for peer-review of proposals to distribute funds
- RFP resulted in 233 proposals, totaling approximately $60M
- 27 proposals funded
- From FIO receipt of block award to distribution of funds to PIs = 2 months
- PI meetings held
  - Initial meeting in August, 2010
  - Progress meeting in May, 2011
FIO GRI Year 1 Award Distribution

- Number of Institutions with co-PIs: 27
- Number of Investigators: 91
- Number of Institutions Involved > 30
- Number of Post-Docs > 15
- Number of Technicians/Other > 10
- Number of Students (G & U/G) > 45

- TOTAL SCIENCE PERSONNEL ~ 170

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<th>Institutions</th>
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<tr>
<td>Dauphin Island Sea Lab</td>
<td>Private Industry (ROFFS &amp; Bioplex Tech)</td>
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Initial, Pre-Award Oil Spill Related Findings

- Loop current involvement
- Discovery of sub-surface clouds of oil
- Confirmation of oil in water column
- Fingerprinting to match with BP spill

**Unknown & Ongoing**

- Impact on food chain
- Damage to estuaries
- Chemical dispersant effects
- Ecosystem short- and long-term responses

Images courtesy of USF
FIO GRI Year 1 Award Foci

1. Tracking and Identifying the Oil
   - 5 awards. PIs: F. Muller-Karger (USF), I. McDonald (FSU), R. Weisberg (USF), R. Zika (UM), D. Hollander (USF)

2. The Benthic and Coastal Story: Oil Impacts on Reefs, Sediments, and along the Shoreline
   - 9 awards. PIs: E. Proffitt (FAU), W. Paterson (UWF), G. Paulay (UF), S. Edge (FAU), P. Hallock-Muller (USF), B. Flower (USF), M. Huettel (FSU), R. Aronson (FIT), A. Zimmerman (UF)

3. Oil Through the Food Web: Lower Trophic Levels
   - 6 awards. PIs: J. Chanton (FSU), J. Cherrier (FAMU), W. Jeffrey (UWF), J. Lopez (NSU), D. Rumbold (FGCU), S. W. Wise (FSU), K. Daly (USF)

4. Oil Through the Food Web: Higher Trophic Levels
   - 7 awards. PIs: S. Laramore (FAU), C. Jagoe (FAMU), D. Grubbs (FSU), M. Heithaus (FIU), D. Kerstetter (NSU), G. Worthy (UCF), R. Hueter (MML)
Results to date
Tracking and Identifying the Oil

- Satellite data: Synoptic maps of surface oil distribution in offshore and coastal habitats, including reconstructing oil dispersion patterns as GIS layers.
- Real-time data collection, processing and distribution (via websites), includes products such as identification and highlighting areas under threat.
- On-going: prototype early warning and alert system development, including development of an inexpensive, multiple-band fluorometer for integration into airborne expendable devices to improve detection and mapping of subsurface oil.
- Analysis on surface oil distribution, including assessing magnitudes of natural seeps versus discharged oil.
- Analyses ongoing on hydrographic and biological samples collected from multiple cruises on Panhandle Bight shelf.
Results to date
Tracking and Identifying the Oil

• Computer models: suite of very high-resolution computer models, including near-real time and coupled models with data assimilation are under development
  • Simulate dispersion and pathways of oil from offshore to the Gulf coast region and subsurface.
  • Include hand-edited bathymetry along northern coastal areas for accuracy
  • Models are being refined, but can be used for future spills – domain includes pathways to Gulf Stream
• Ongoing: numerical experiments to understand role of waves on transport of surface oil, coupled models, model verification

Images courtesy of FSU

Image courtesy of USF
Results to date
Tracking and Identifying the Oil

- Chemical Analyses: investigate distribution of oil and dispersant (Corexit 9500) using multi-dimensional fluorescence techniques and Parallel Factorial Analysis (PARAFAC) modeling
  - Active fluorescence components detected from both BP oil contaminated seawater and from its hexane extracts
  - PARAFAC modeled samples show similar spectral profile as oil and Corexit standards
- Investigation of sub-surface hydrocarbon plumes formed from DWH
  - More toxic than crude oil due to soluble BTEX compounds
  - 10-30% of oil molecules degrade slowly and are persistent
  - Subsurface and sedimentary oil can be chemically fingerprinted
- Sedimentary oil and impaired benthic ecosystems investigation ongoing
- Impacted benthic environment – lack of bioturbation
- Multiple mechanisms of oil deposition:
  - Toxic sub-surface plumes intersect continental slope – “Bath Tub Ring”
  - Enhanced aggregation and sinking of oil and detritus particles – “Dirty Blizzard”

*Image courtesy of U. Miami: Emission/Excitation of Florida Strait sample (left) & BP Oil Contaminated sample*
Results to date
The Benthic & Coastal Story: Oil Impacts on Reefs, Sediments, and along the Shoreline

• Oyster Reefs: Collected >700 oysters from 17 sites from south Florida to Texas (40-50 per site)
  – provide comprehensive 2010 baseline data
    • Genotyped >400 oysters from 9 of 17 sites
    • No evidence of PAH in oyster tissue (above normal background levels)
    • Abundance variation among and within regions
• Ongoing: population genetics – any impact on reduced recruitment and gene flow and assess genetic diversity
• Coral Sponge Reefs: biodiversity assessment of communities on WFS to establish baseline data
  • ~2000 vouchered lots, ~5500 photos, ~1100 DNA samples, ~700 species
  • Numerous new records, potential new species
  • On-line field identification resource in preparation

Coscinasterias tenuispina
- First GOM record outside one in Cuba
- Second record in US
- Common at five stations
- Voracious macrocarnivore

Images courtesy of UF
Results to date

The Benthic & Coastal Story: Oil Impacts on Reefs, Sediments, and along the Shoreline

- Recent ROV survey found evidence of damaged coral on outer shelf – cause to be determined
- Reef building corals: on-going diagnostic tool development and integrated assessment of potential oil and dispersant impacts
  - Designing microarray with genetic biomarkers indicative of oil/dispersant exposure
  - Identifying sublethal impacts
  - Interaction and response of oil stress with other stressors
- Reef and hard-bottom community bioindicators (foraminifera): testing underway for toxicity and sublethal effects of crude oil and dispersants. Investigating:
  - Mortality, changed in color or motility, growth rates
  - Photosynthetic responses – including altered bleaching susceptibility
  - Asexual reproduction
    - Number of young produced
    - % young deformed

Image courtesy of USF
Results to date
The Benthic & Coastal Story: Oil Impacts on Reefs, Sediments, and along the Shoreline

• Reef communities: hydrological and biological samples from multiple cruises in northern Gulf reef communities
  • Fish tissue tested for PAH exposure
  • Examine oil effects on community structure, condition, growth, diet and trophic effects
  • Decrease in some reef fish stocks from 2009, physiological changes (e.g. fish lesions) and other strange symptoms in fish – cause not yet known, work ongoing

• Offshore Sediments: multicore sediment sampling of >40 sites on multiple cruises
  • 18 month time series of sediment cores
  • oiled sediments at water depths of 900, 1000, 1520m in DeSoto Canyon
  • Sites within and near DeSoto Canyon >100x increase in sediment accumulation rates from mid-2010 to early 2011
  • One site with oily sediment layer (<1cm thick in August 2010) overlain with 2-3 cm layer in Dec, and 8-9 cm layer in Feb 2011
  • Commonly laminated indicating lack of bioturbation
Results to date
The Benthic & Coastal Story: Oil Impacts on Reefs, Sediments, and along the Shoreline

• Beaches: mechanical deep cleaning process removed compacted oil layers buried in Florida beaches but also deposited a layer of sand mixed with small oil particles.
  • Found increased oxygen consumption in this layer
  • Initial rapid growth of oil-degrading bacteria and fungi now shows a decline
  • Rapid oil degradation shown for bacterial strains isolated from FL sand
  • Oil contamination in beach sand caused increase of Vanadium & Nickel concentrations

• Marshes: assess impact of oil on salt marshes and adjacent sea grass habitats in NGOM
  • Evidence that oil droplets from dispersant and natural biodegradation entered microbial and planktonic food webs
  • Early results show no significant divergence in trajectories of nekton assemblages – need longer time series to assess full impact
  • Average of 12m of above and below ground marsh grass death in oiled areas of Barataria Bay
  • Slow re-colonization of die-off areas occurring through plant clonal growth
    • But also 140% increase in shoreline erosion rates at oiled die-off marsh sites observed.

Image courtesy of FSU
Results to date
Oil Through the Food Web: Lower Trophic Levels

• Bacteria, Phytoplankton:
  • Toxic and mutagenic response of phytoplankton/bacteria at base of food web
  • Oil and Corexit have little effect on production of DOC by phytoplankton but reduce the uptake of that DOC by bacterioplankton
• Oil provides a new carbon source for bacteria
• Work in progress using cruise samples from northern Gulf:
• Elevated methane concentrations within DeSoto Canyon
  • Data collected within 10km of DWH in 2009 showed max. concentrations of 25nM
  • Data collected 20-140km from DWH in May 2011 showed max. conc. > 130nM
• $^{14}$C is a tracer for petro-products in the food web. Oil spill released radiocarbon dead organic matter.
• Analysis of $^{14}$C to look at how carbon from oil/dispersant enters the food web. Two methods:
  • Microbial loop, or
  • Filter feeders or deposit feeders
    • $^{14}$C depletion in some benthic organisms observed in Barataria Bay

Image courtesy of FSU/FAMU
Results to date
Oil Through the Food Web: Lower Trophic Levels

• Looking at impact of oil on ecologically and commercially important plankton in Gulf – preliminary assessment: find toxic impacts, but insufficient data at the moment to be able to determine if all of this is from oil or other causes
  • Sampling of diatoms, coccoliths, and related protists in Gulf of Mexico to establish a baseline for phytoplankton
• Plankton community response to oil spill last August:
  • Phytoplankton photosynthetic capacity decreased (DCMU)
  • Phytoplankton diversity decreased
  • Marine snow concentrations relatively high
  • Total zooplankton concentrations increased between May and August
• However, little baseline data to interpret results and continuous sampling needed to assess spatial and temporal changes in plankton community
  • Further Zooplankton analysis was done over the summer – results pending
Results to date
Oil Through the Food Web: Lower Trophic Levels

- Sponges: Important because oldest animal group (>500 million years of evolution) & common benthic resident of diverse marine ecosystems
  - One sponge may filter ~20,000 L of seawater/day
  - ~10,000 species in Gulf of Mexico
- Baseline studies with molecular genetics and electron microscopy methods to understand role of sponge microbial symbionts.
  - Experiments on oil and dispersant impacts on sponges are ongoing.
  - Sponge microbial taxonomic profiling with thousands of DNA sequence reads from Florida sponges

Images courtesy of NSU
Results to date
Oil Through the Food Web: Higher Trophic Levels

- Dispersant is more toxic than oil and $\geq$ to dispersed oil for plankton and shrimp larvae
- Oil and dispersant Conch, oyster, and microalgae experiments underway
- Frequent sampling of northern surf, intertidal sand, and fish along northern Gulf coast since May 2010. Analysis underway on oil exposure in sediment, coastal waters and biomarkers of exposure in fish.

Images courtesy of FGCU
Results to date
Oil Through the Food Web: Higher Trophic Levels

- Faunal assemblages similar between regions and are mediated by depth and water temperature; 85% of fishes captured <600 m deep.
- Species assemblages are: 200-600 m dominated by dogfish (Squalidae), hakes (Phycidae), and tilefish (Malacanthidae); 600-800 m dominated by gulper sharks (Centrophoridae) and lantern sharks (Etmopteridae); and 1,000-1,000 m dominated by cutthroat eels (Synaphobranchidae) and grenadiers (Macrouridae).

Image courtesy of FSU/FIU/UNF
Results to date
Oil Through the Food Web: Higher Trophic Levels

• 73 stations yielded 635 specimens from 38 species of deepwater fish collected from the continental slope and DeSoto Canyon
  • Myxini (2 species), Elasmobranchs (15 species) and Teleosts (21 species)
• Thousands of samples were collected for studies of life histories, toxicology, trophic structure, and phylogenetics.

Images courtesy of FSU/FIU/UNF
Results to date
Oil Through the Food Web: Higher Trophic Levels

- Liver and bile samples from dominant species used to examine spatial differences in exposure to PAHs:
  - Fish collected along Florida’s continental slope showed no exposure to PAHs, but nearly half of fish collected from Desoto Canyon showed signs of PAH exposure.
  - Higher occurrence in samples closer to the oil spill suggests these fishes may be exhibiting physiological responses to oil exposure. PAH metabolites in the bile will be used to evaluate this.

Images courtesy of FSU/FIU/UNF
Results to date
Oil Through the Food Web: Higher Trophic Levels

- Impact of oil on estuarine bottlenose dolphin populations in West Florida Panhandle:
  - No visual sign that animals were affected and normal adult/young ratio
  - Analysis of samples still on-going to assess other impacts
  - Likely impact through trophic deterioration – may take years to identify

- Investigating exposure and impact of oil from DWH on pelagic sharks and teleosts
  - Cyp1a1 activity is low
  - Bile FACs are low
  - No evidence of genotoxicity
  - No evidence of immunosuppression

Image courtesy of UCF

Image courtesy of MML, via Think Out Loud Productions
**FIO PI May Meeting: Looking Ahead Observations**

- Comprehensive set of measurements, developed over a long period of time, to establish background descriptions of water column and benthic properties for the Gulf of Mexico from which maps of background states and variability can be developed.

- To understand the baseline, need at least a decade of standard biological/chemical oceanography data near and around the oil fields.

- Samples of water column from well-head to surface above (including plankton, nutrients etc.) to establish pre-spill conditions at all oil wells.

- Repository of all oil samples that are being drilled in the NGOM to enable chemical and biological studies (pre and post event). Chemical fingerprinting and other analyses should be done and that information should be archived and easily and freely accessible to all.
FIO PI May Meeting: Looking Ahead
Recommendations

- Better access to take samples and to real-time data and more use of local and regional experts in such emergencies

- The response was most effective when a multi-disciplinary approach was used – need to keep that intact in order to make progress.

- Restoration requires that we know what to revert back to, therefore long-term baseline data is necessary.
Concluding Remarks

• To date: 31 scientific presentations and 15 publications published, in press, in review (inc. 3 book chapters, 1 Nature, 2 Science)

• Drilling will continue
  • Deep water drilling
  • Cuban drilling
  • Loop Current – will carry oil to parts of the Gulf that are removed from the wells

• Many critical research and monitoring areas still unknown. For example, how do we separate impacts from oil and other Gulf impacts, like Hypoxia.

Thank You and Questions?