Organic Contaminants and Trace Elements in Water and Sediment Sampled in Response to the Deepwater Horizon Oil Spill

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Deepwater Horizon oil spill

April 20 – July 15, 2010

- Macondo-1 well in Gulf of Mexico
- 4.9 million barrels of Macondo-1 (M-1) well oil
  - Light, sweet Louisiana crude (<1% S)
  - Subject to weathering

U.S. Coast Guard

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Today's talk

- OWQ study design

- Data issues and analysis

- Results by contaminant class / medium
  - Occurrence: pre-landfall vs. post-landfall
  - Exceedance of benchmarks: EPA, supplemental

- Comparison to Macondo-1 well oil fingerprinting (Rosenbauer et al. 2010)

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Pre-landfall sampling:

May 7 to July 7, 2010

- Assess baseline conditions prior to oil landfall
- 70 Pre sites were sampled, incl. beaches, barrier islands, coastal wetlands
- 5 States: TX, LA, MS, AL, FL
- 1 water, 1 sediment sample

Post-landfall sampling:

Oct 4 to 14, 2010

- US Coast Guard: actionable levels of oil-related chemicals
- 48 Pre sites + 1 new site (Aug 23) were sampled based on observation of oil, trajectory modeling, oceanography
- 5 States, espec LA, MS, AL
- 1 water, 1 sediment sample

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Contaminant analysis

Contaminant	WATER: Pre	WATER: Post	SEDIMENT: Pre	SEDIMENT: Post
PAH/SVOC	NWQL		NWQL	
Oil & grease	TAL-FL		TAL-CO	
VOC/BTEX	NWQL		–	–
Petrol HC/GRO	TAL-FL		–	–
DRO	–		–	–
TEs	NWQL		USGS SCL	
Nutrients	NWQL		USGS SCL	
Carbon	USGS OCRL		USGS SCL	

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Contaminant analysis

Contaminant	WATER: Pre	WATER: Post	SEDIMENT: Pre	SEDIMENT: Post
PAH/SVOC	NWQL	TAL-FL	NWQL, TAL-VT	TAL-VT
Oil & grease	TAL-FL	TAL-FL	TAL-CO	TAL-FL
VOC/BTEX	NWQL	TAL-FL	–	–
Petrol HC/GRO	TAL-FL	TAL-FL	–	–
DRO	–	TAL-FL	–	–
TEs	NWQL	TAL-FL	USGS SCL	USGS SCL
Nutrients	NWQL	TAL-FL	USGS SCL	USGS SCL
Carbon	USGS OCRL	USGS OCRL	USGS SCL	USGS SCL

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Data issues

- Changing target analyte lists
- Multiple laboratories
- Variable reporting levels (RL)
- Lots of censored data (nondetections, <RL)

- Limit comparison to analytes in common
- Use QC data
- Censor data at common RL for some analytes
- Use methods applicable to censored data

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Example: systematic differences in RL
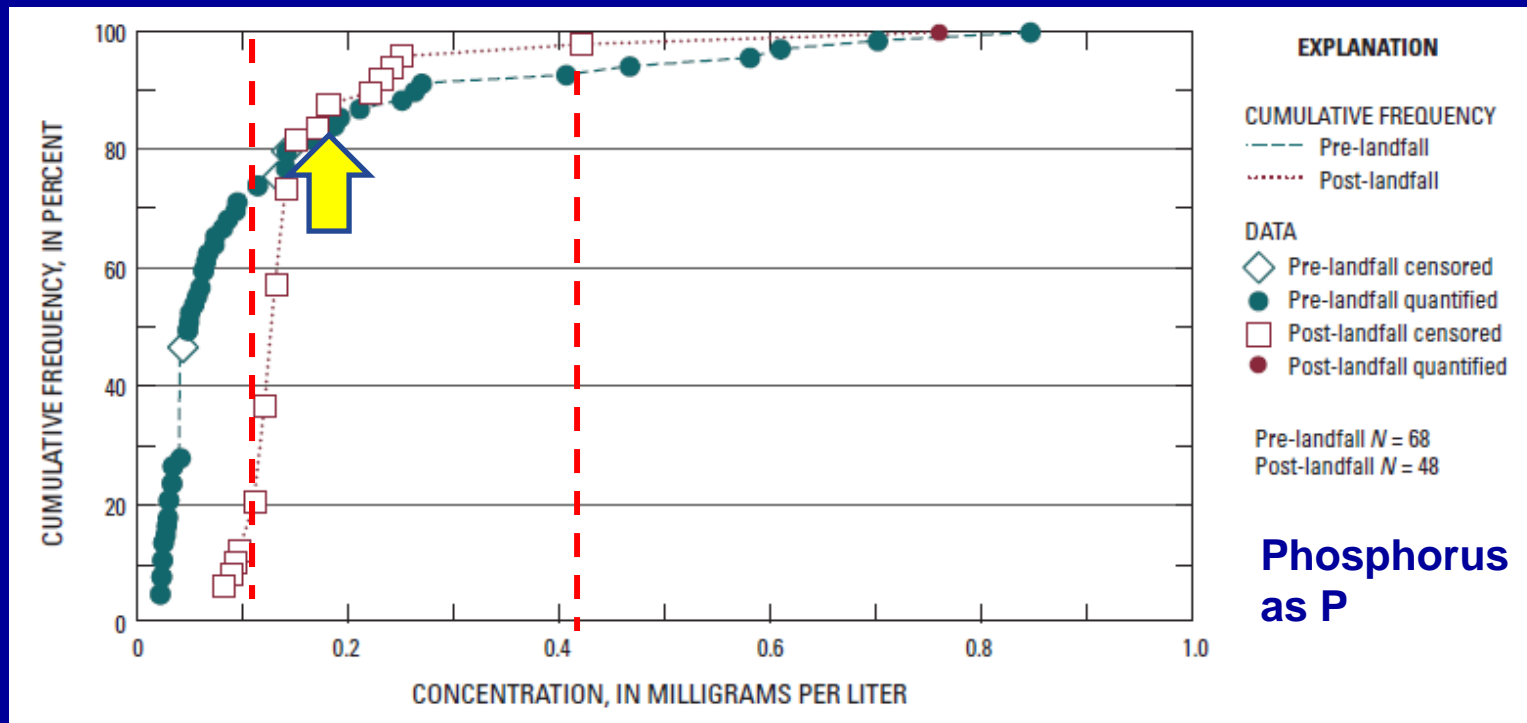
- RL was lower for Pre (0.05 mg/L) than Post samples (0.08–0.4 mg/L)
- Pre: 60% of samples were mostly detections of 0.05 mg/L or below
- Post: 60% were nondetects in range of <0.08 to <0.12 mg/L
  ➡ Censor (less sensitive method)

Trace elements: Water

- ## Occurrence:
  - Data limitations: (i) one sampling period, (ii) high/variable RLs
  - Above optimal censoring threshold:
    - Post > Pre: Ba, Ca, Mg, Mo, K, Na
    - Pre > Post: Ammonia, P

- ## Benchmarks:
  - Human health exceedances (V, Ni): none
  - Aquatic-life exceedances : 47% of samples
    - Minimum of: 29% Pre and 93% Post
    - Cannot compare statistically because (i) some TEs with benchmark exceedances were analyzed during only 1 period and (ii) some censored samples had RL > benchmark.

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Trace elements: Sediment

- ## Occurrence:

  – Strong acid digestion → total in sediment matrix

  – Above optimal censoring threshold: whole sediment

    - Post > Pre: Ca, Carbon, Na, Sr
    - Pre > Post: Pb, Hg

 – Fine sediment (<63 μm): these differences disappeared

- ## Benchmarks:

  – Look for elements at potentially toxic concentrations that are also enriched relative to baseline

  – 16 of 122 samples (i) exceeded upper screening-level benchmarks AND (ii) were enriched relative to baseline concentrations in the same element:

    - Ba (14), V (5), Al (3), Mn (3), As (2), Cr (2), Co (1)

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Organic contaminants: Water

- ## Occurrence:
  - – Detection frequencies were typically low and comparable for Pre vs. Post samples
  - – Post > Pre: Toluene

- ## Benchmarks:
  - – Human health exceedances (benchmarks available for 11 compounds): None
  - – Aquatic-life exceedances: 1 Post sample (LA) exceeded EPA's benchmark for PAHs+BTEX

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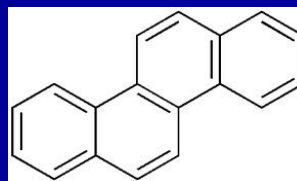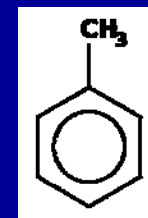
Organic contaminants: Sediment

- Occurrence:
  - Most PAHs were detected in both sampling periods (despite low sediment-TOC)
  - Post > Pre: 20 PAHs (3 parent, 17 alkyl)
  - Differences still significant after OC-normalization
  - Significant differences: usually due to 6–7 sites

- Benchmarks
  - 1 Pre sample (TX) exceeded EPA's benchmark for PAH mixtures
  - Empirical sediment-quality benchmarks (conc'ns historically associated with adverse effects in field)
    - 70% no-effect range, 27% probable effect range
    - Pre and Post not significantly different

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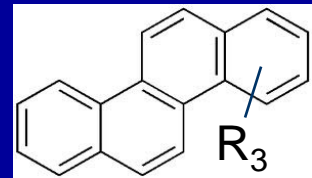
Geochemical oil fingerprinting
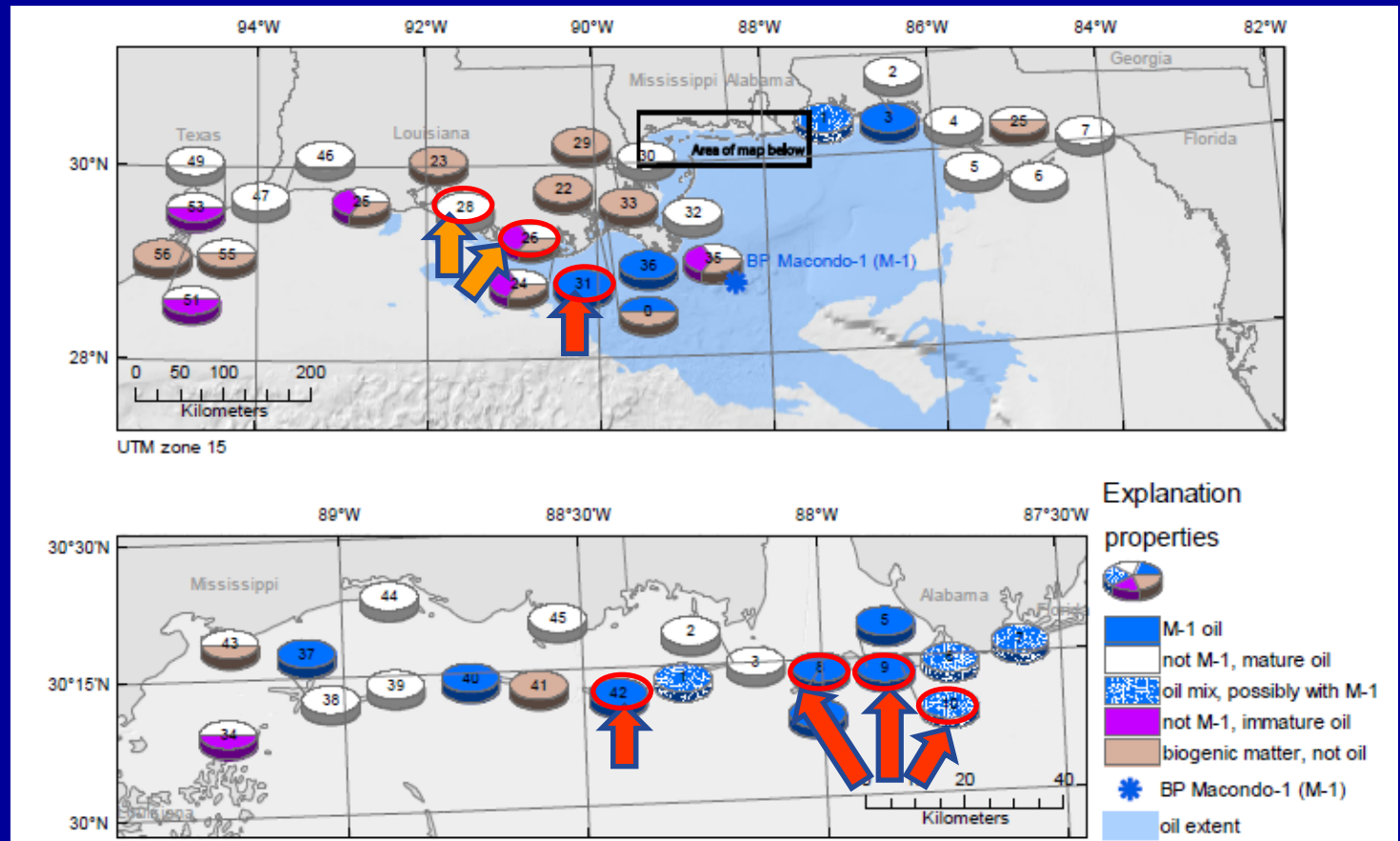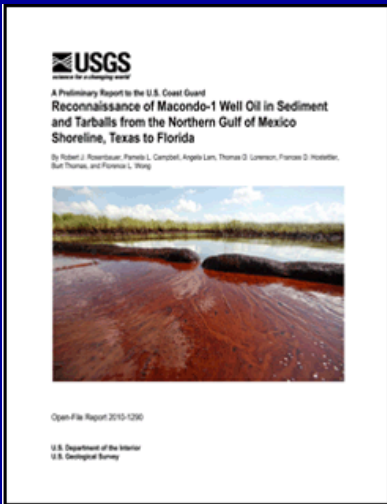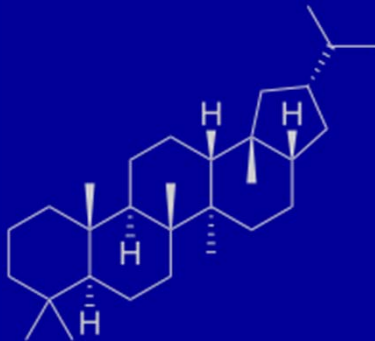
Rosenbauer et al. (2010)

Highlights

- ## Trace elements – Water
  - Aq-life benchmarks exceeded in ~50% water samples; minimum value (cannot evaluate relation to oil landfall)

- ## Organic contaminants – Sediment
  - M-1 oil may contribute to high PAHs at 5 sites
    - Post > Pre conc'ns: for 3 PAHs and 17 alkyl-PAHs
    - Of 7 sites with the highest PAH concentrations, 5 have M-1 oil fingerprint
    - These 5 sites exceed empirical sediment benchmarks (27% samples), but not EPA benchmark for PAH mixtures
    - EPA benchmark for PAH mixtures was exceeded only at 1 Pre-landfall site (TX)

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For more information:

- **Office of Water Quality:**
  http://water.usgs.gov/owq/deephorizonoilspill/
- **Organics/trace elements report :**
  http://pubs.usgs.gov/of/2011/1271/
- **Oil fingerprinting reports (Rosenbauer et al.):**
  http://pubs.usgs.gov/of/2010/1290/
  http://pubs.usgs.gov/of/2011/1014

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