# Sediment Quality Triad in the Deep-Sea During Fall 2010

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October 25, 2011

- Acknowledgements:
  - Funding: BP and NOAA
- Disclaimers:
  - The views expressed are mine and not attributable to the agency or the company.

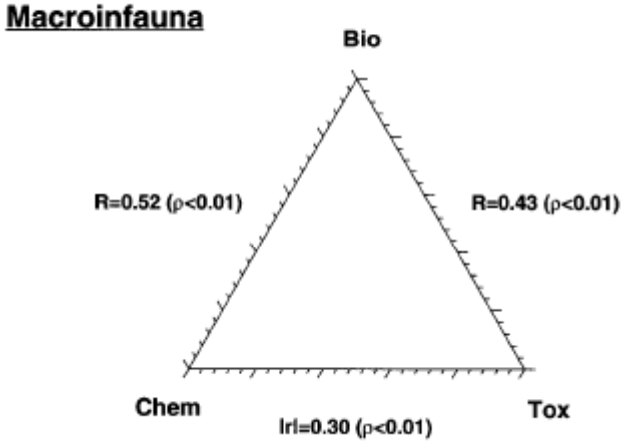
# Outline

- What we know about SQT
- What we know about Platforms
- What we know about the deep-sea
- What we found during Fall 2010 sampling

# Sediment Quality Triad Studies (SQT)

- Chemical Dose: contaminant concentrations
- Biological Response: in situ toxicity using the Microtox test
- Ecological Response: benthic communities

Used successfully in GOOMEX



# GOOMEX

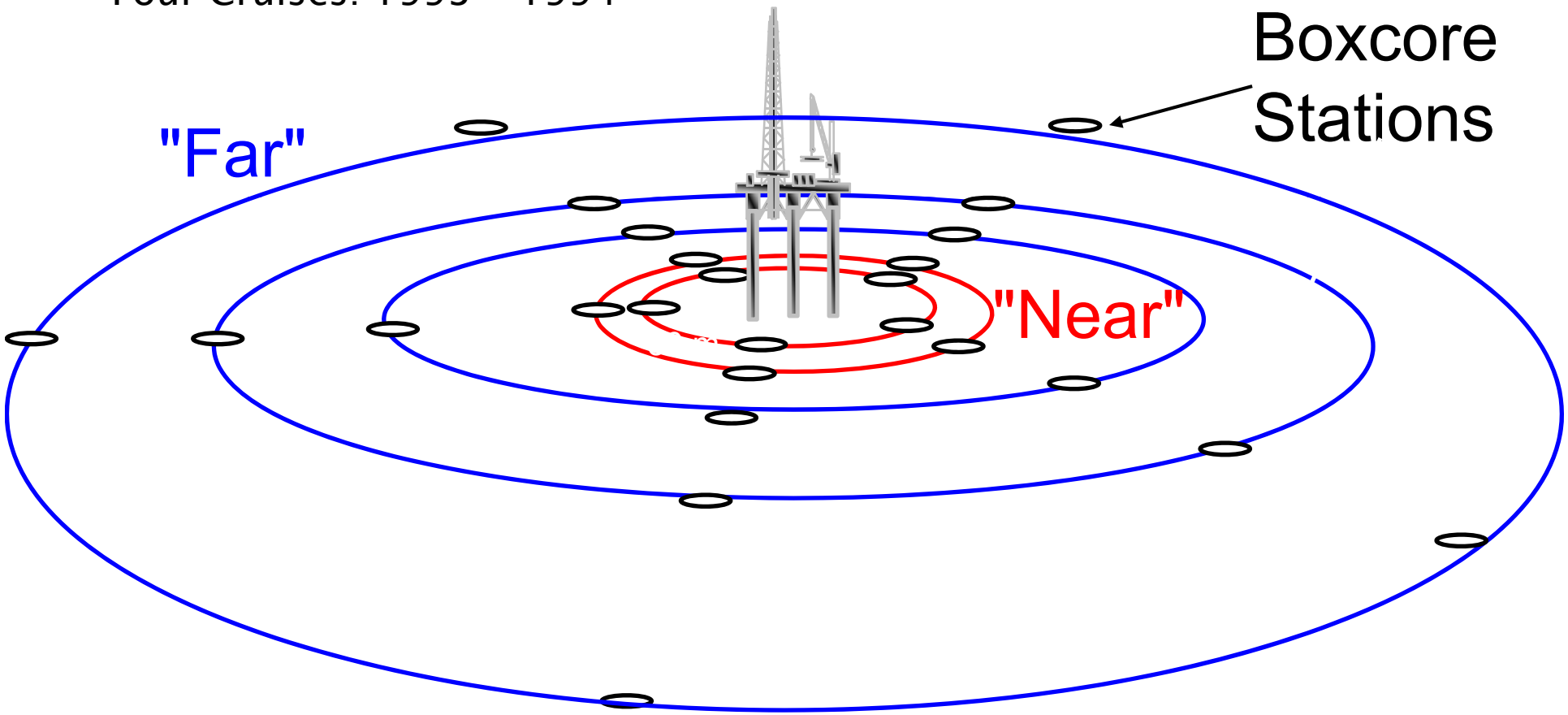
(Gulf Of Mexico Offshore Operations Monitoring Experiment*)

- Goals
  - Identify chronic, sublethal effects of offshore oil and gas production activities
  - Relate effects to a contamination gradient
  - Recommend monitoring strategies
- Team
  - GERG/TAMU, UT, UWO, UNC, NMFS, MMS

**Canadian Journal of Fisheries and Aquatic Sciences* (1996) 53:1584-2654. (8 papers)

# GOOMEX Sampling scheme

Bulls-eye Design: 50, 100, 200, 500, 3000 m
Four Cruises: 1993 - 1994



# Summary of GOOMEX Results

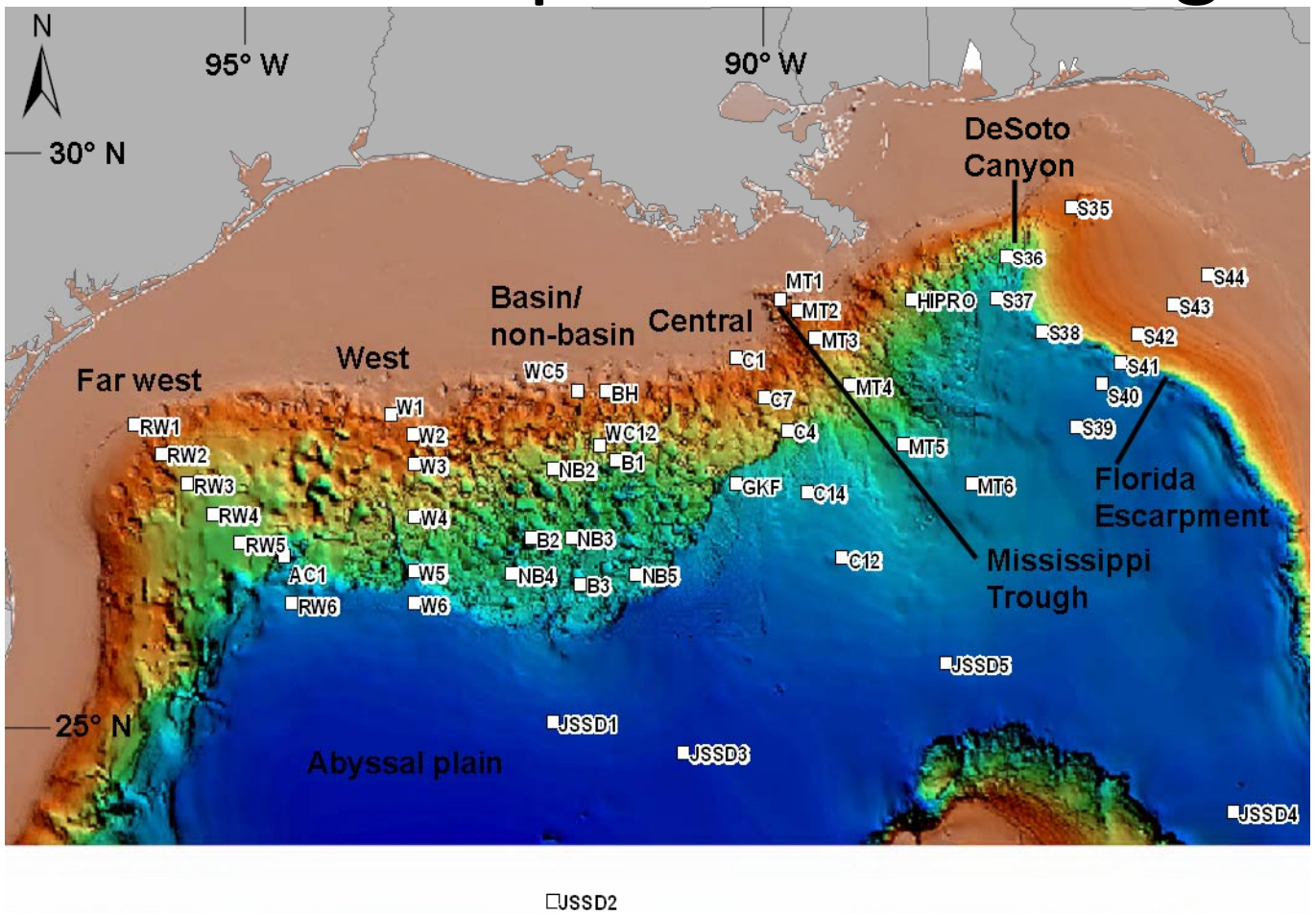
- Geology- Coarser within 100 m of platforms
- Chemistry-Elevated contaminants within 100–200 m of platforms
  - Bottom shunting caused most contamination
- Biology- Responses within 100 m of platforms
  - Molecular biomarkers (megafauna)- No response
  - Megafauna community– No response
  - Genetic Diversity– Reduced within 100 m
  - Toxicity– Within 100 m at 2 platforms
  - Macrofauna/Meiofauna– Community change within 100 m
    - Increased deposit feeders (worms) relative to surface feeders (crustaceans)
    - Decrease in crustacean populations
    - Increased abundances, but decreased diversity

# Deep Gulf of Mexico Benthos (DGoMB*)

- Determine in greater detail the structure and function of northern Gulf of Mexico continental slope communities
  - Bacteria→Meiofauna→Macrofauna→Megafauna
  - Grain size→Trace metals→Organics→Geochemistry
  - Physical setting
- Infer relationships with local conditions and major driving processes by testing specific hypotheses
- Cruises over 3-year period (2000–2002)

**Deep-Sea Research II* (2008) 55: 2535-2711 (21 papers)

# DGoMB experimental design



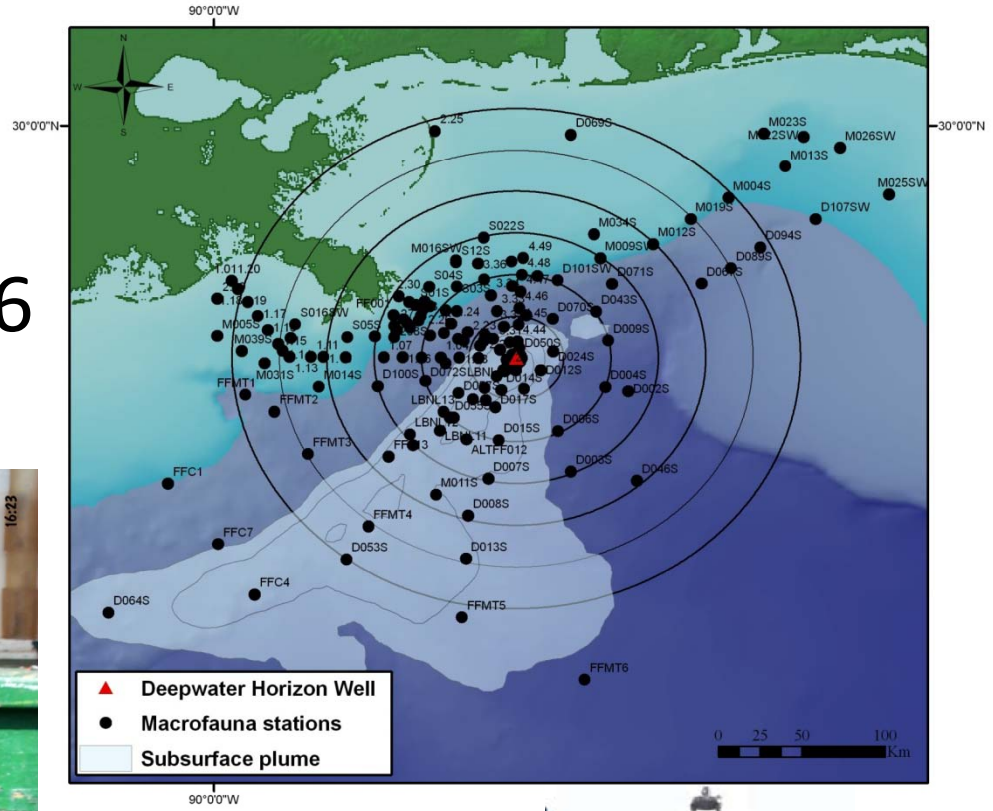

- $H_{01}$ – Depth
- $H_{02}$ – Longitude
- $H_{03}$ – Basins
- $H_{04}$ – Canyon
- $H_{05}$ – Escarpment
- $H_{06}$ – Primary Prod.

# Summary of DGoMB results

- Trace metal chemistry
  - No indication of anthropogenic input trace metals Be, Co, Cr, Fe, Si, Ti, V, K, Mg, Ca, Sr and Zn, based on normalization to Al
    - These metals derived from trace-metal-rich Mississippi River outflow
  - In contrast, a general enrichment of the elements Ba, Ni, Pb, Cd, As, Cu and Mn, which show considerable scatter when normalized to Al
    - These metals identified as drilling byproducts in GOOMEX
- Total PAH concentration ranged from not detected to 1033 ng/g with a mean of **<u>140</u>** ng/g

# MC-252 Incident data

- Deep-sea benthic mission was carried out by BP and NOAA from 16 Sept. – 24 Oct. 2011
- 169 stations
  - Chemistry
  - Microtox
  - Infauna




# Microtox Analyses

- Method
  - Response of luminescent bacteria, a freeze-dried preparation of a specially selected strain of the marine bacterium *Vibrio fischeri*
  - The results are normalized and the $EC_{50}$ (concentration producing a 50% reduction in light) calculated
  - Low $EC_{50}$ values are toxic
- Ecological relevance
  - Comparable to amphipod exposure
  - Has good sensitivity to a broad range of toxic substances
- Expedient: small sample, fast analysis, and cheap

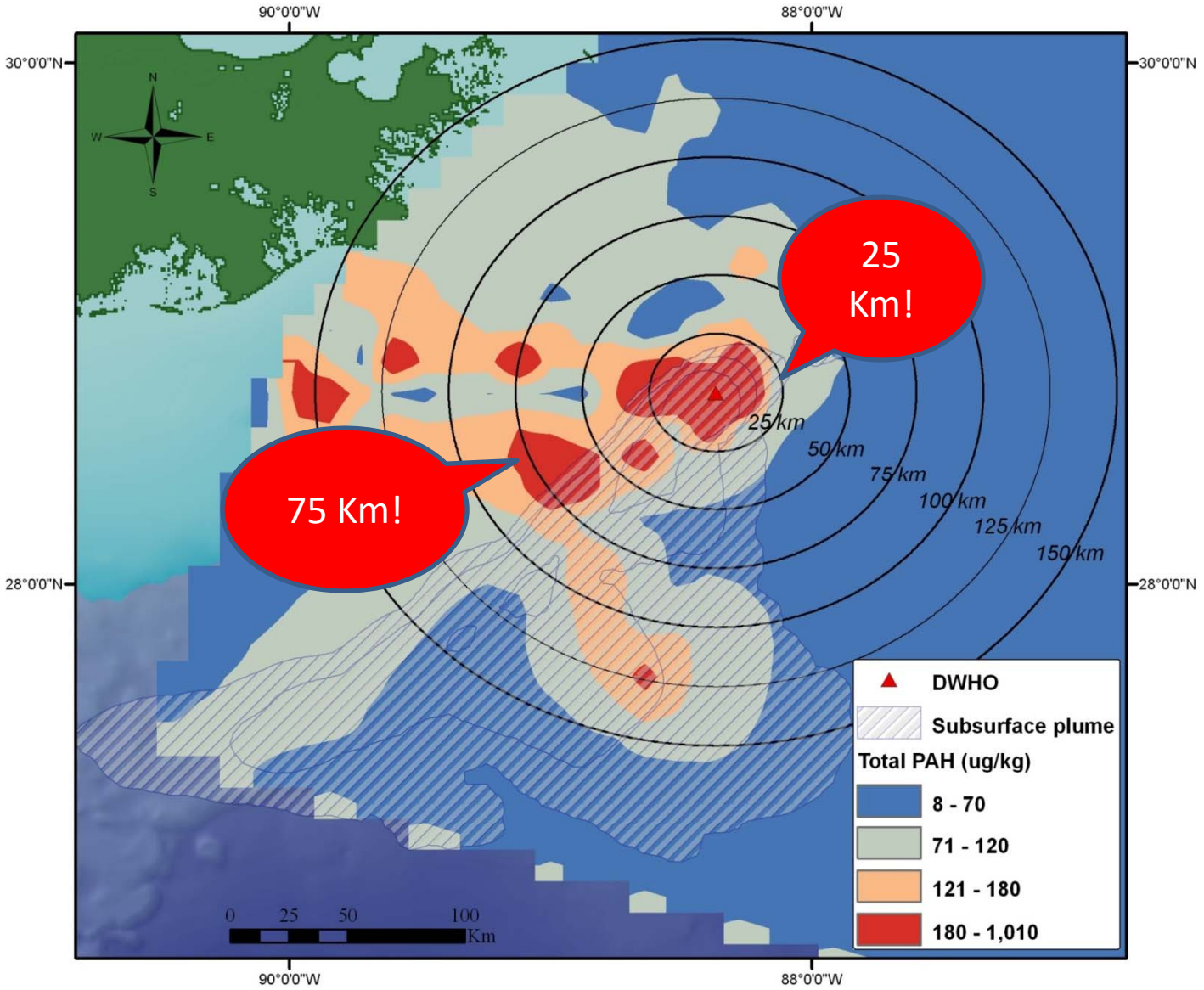
# Microtox Analyses Problems

- Many false-positives (common to all toxicity testing)
- Need data for trace metals, hydrocarbons, ammonia, sulfide, and sediments to interpret the response

| | Contaminants | |
|---|---|---|
| Biological Response | No | Yes |
| No | ✓ | ☹ |
| Yes | ☹ | ✓ |

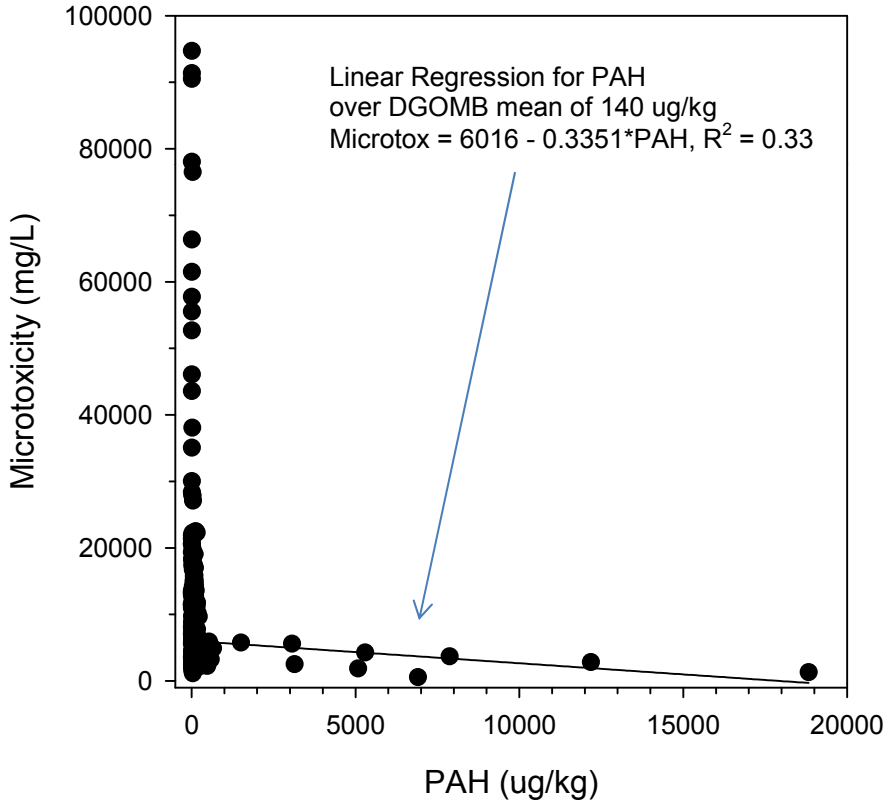
# PAH Concentrations

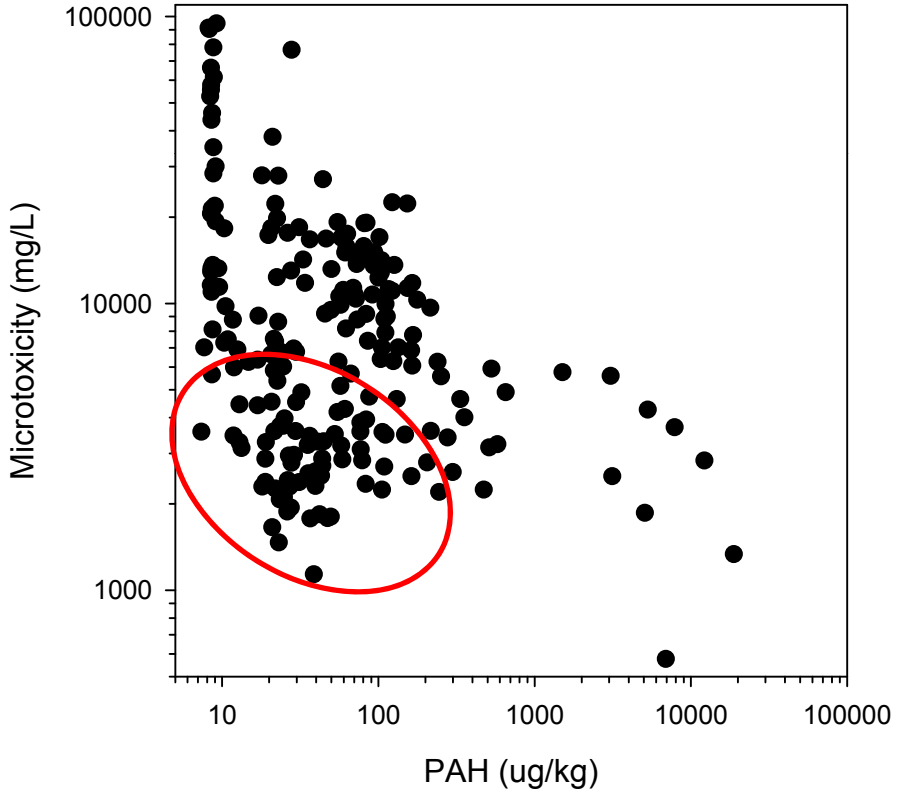
Operational Science Advisory Team (OSAT) Report – 17 Dec 2011

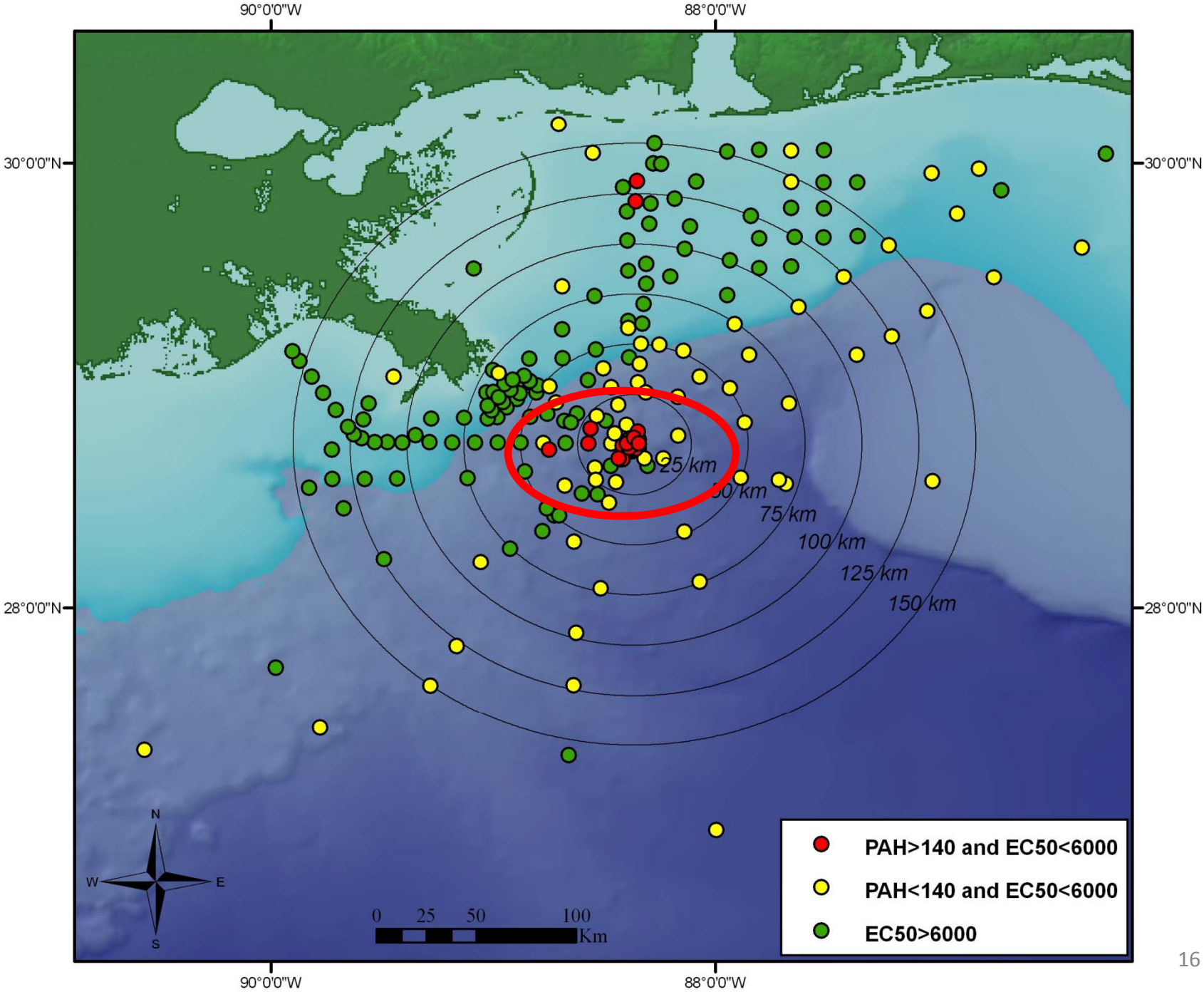


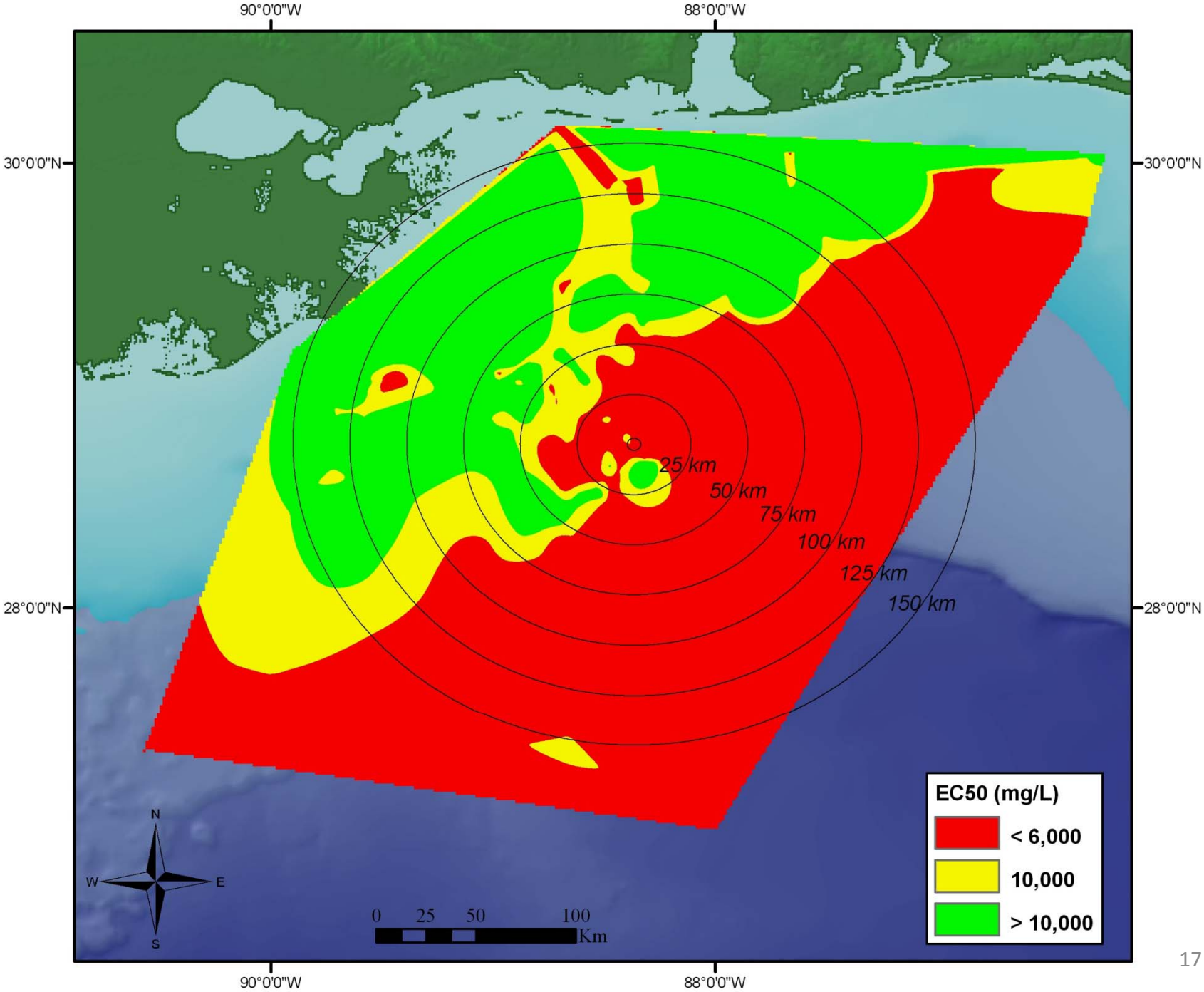
# Microtox vs. PAH

## To Develop a Threshold (6,016 EC50 Units)




90°0'0"W
88°0'0"W
30°0'0"N
28°0'0"N
25 km
75 km
100 km
125 km
150 km
N
W
E
S
0 25 50 100
Km
PAH>140 and EC50<6000
PAH<140 and EC50<6000
EC50>6000


90°0'0"W
88°0'0"W
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28°0'0"N
25 km
50 km
75 km
100 km
125 km
150 km
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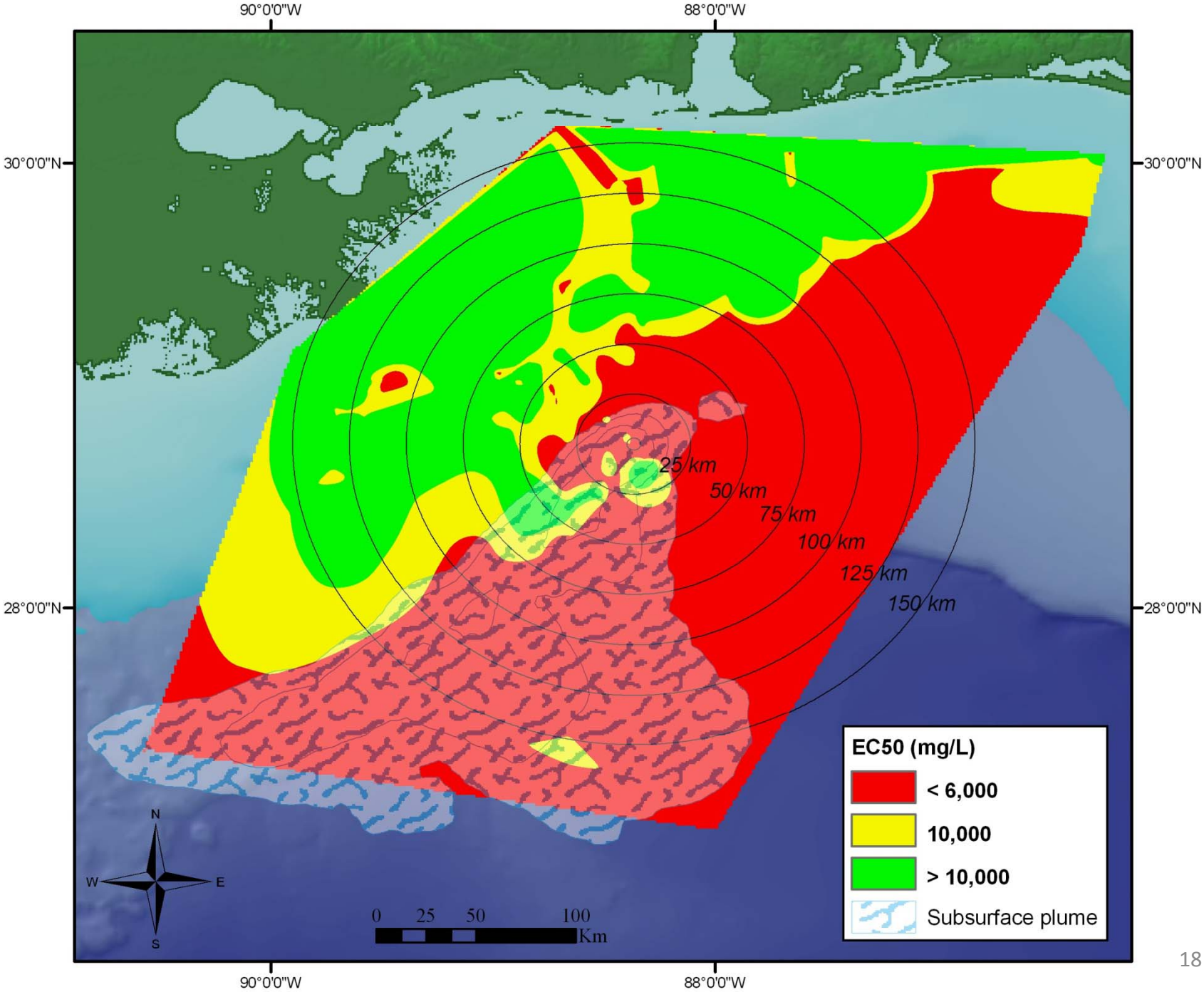
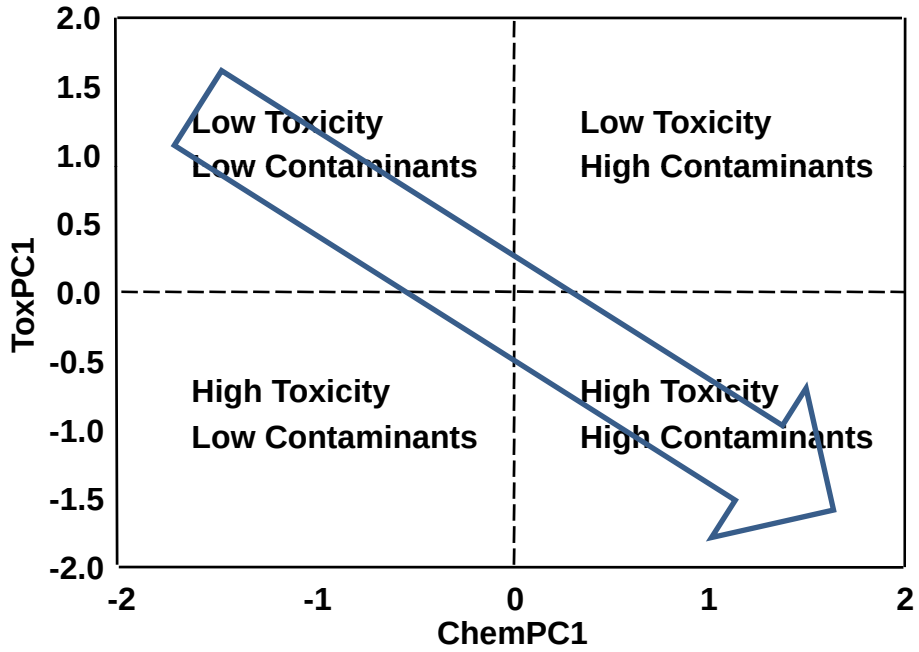
0 25 50 100
Km
EC50 (mg/L)
< 6,000
10,000
> 10,000

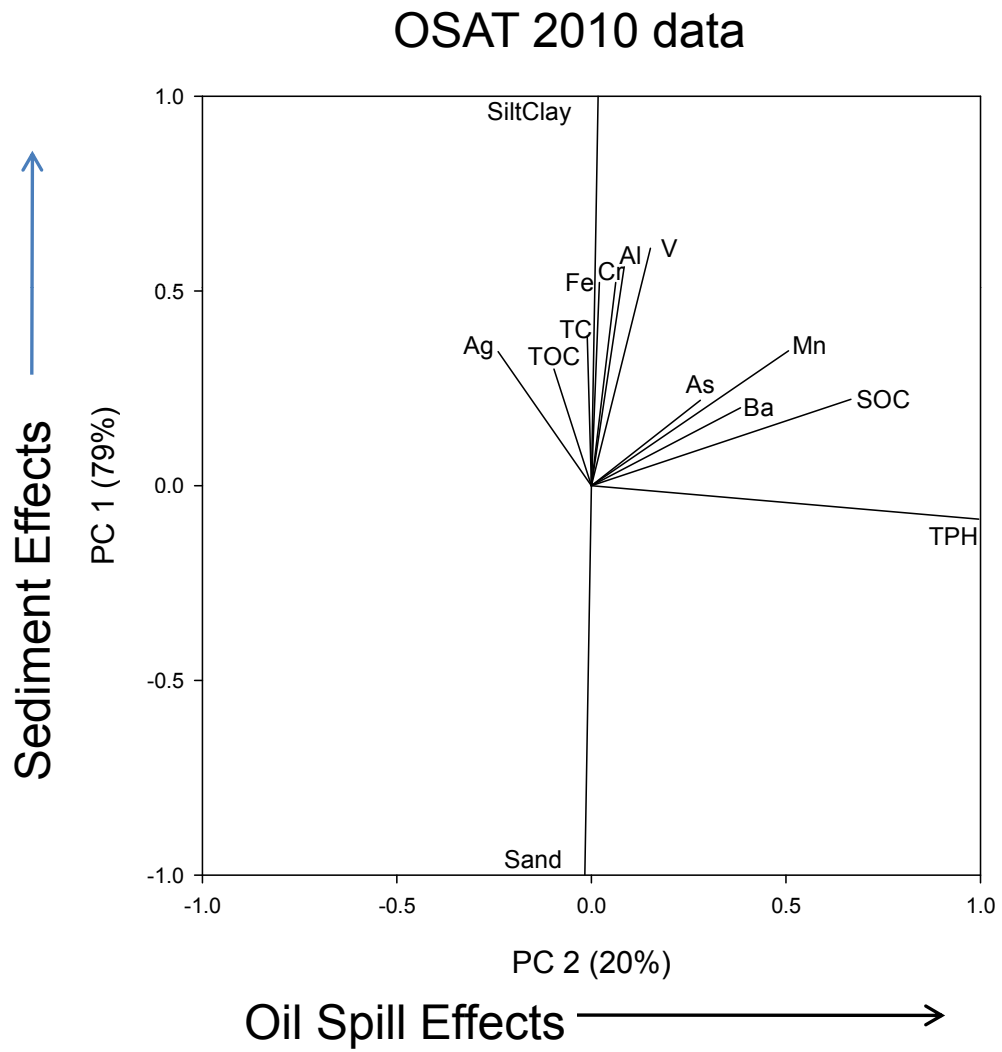

90°0'0"W
88°0'0"W
30°0'0"N
28°0'0"N
25 km
50 km
75 km
100 km
125 km
150 km
N
W
E
S
0 25 50 100
Km
EC50 (mg/L)
< 6,000
10,000
> 10,000
Subsurface plume

# Analyses to Link Biological Response to Environment

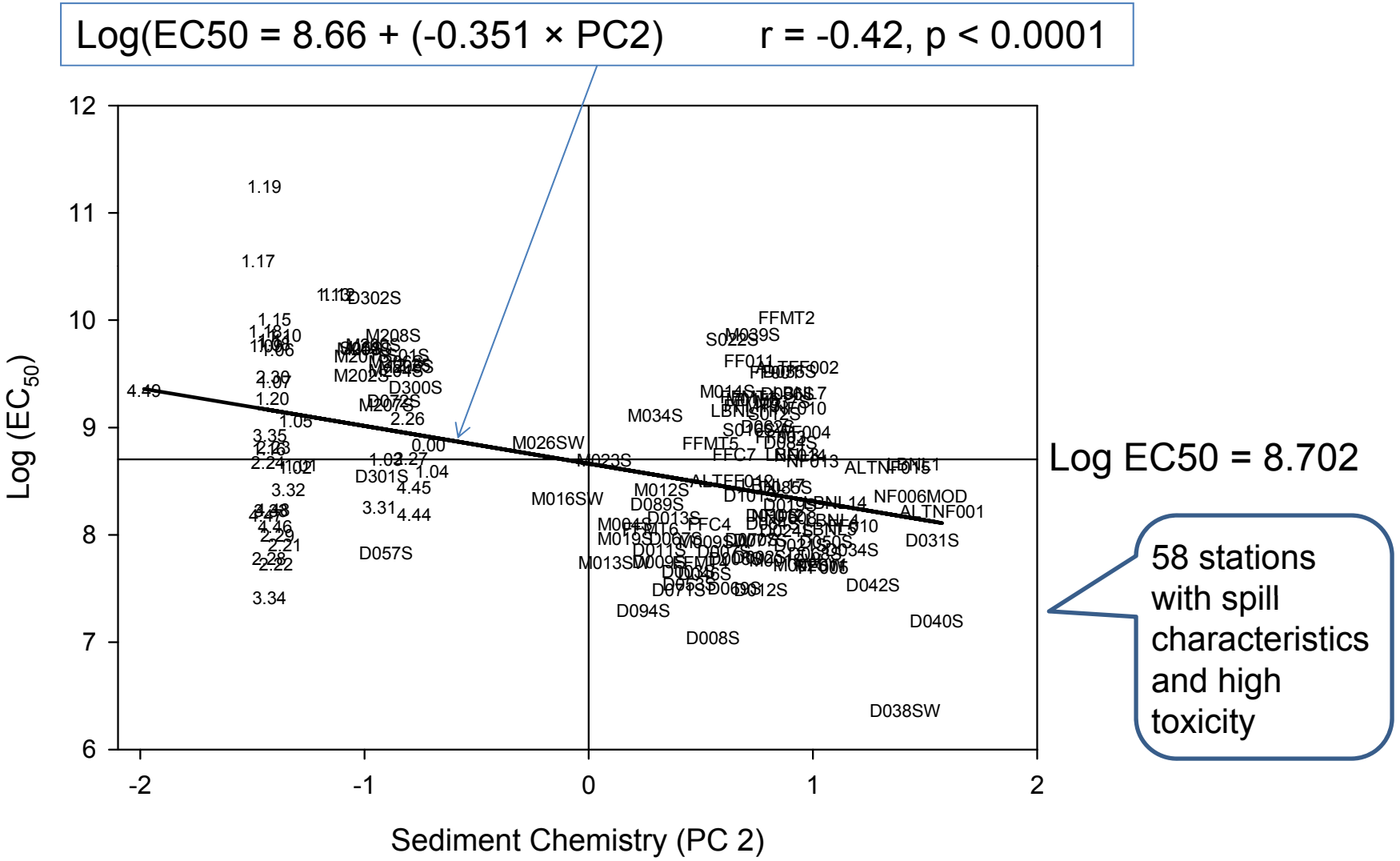


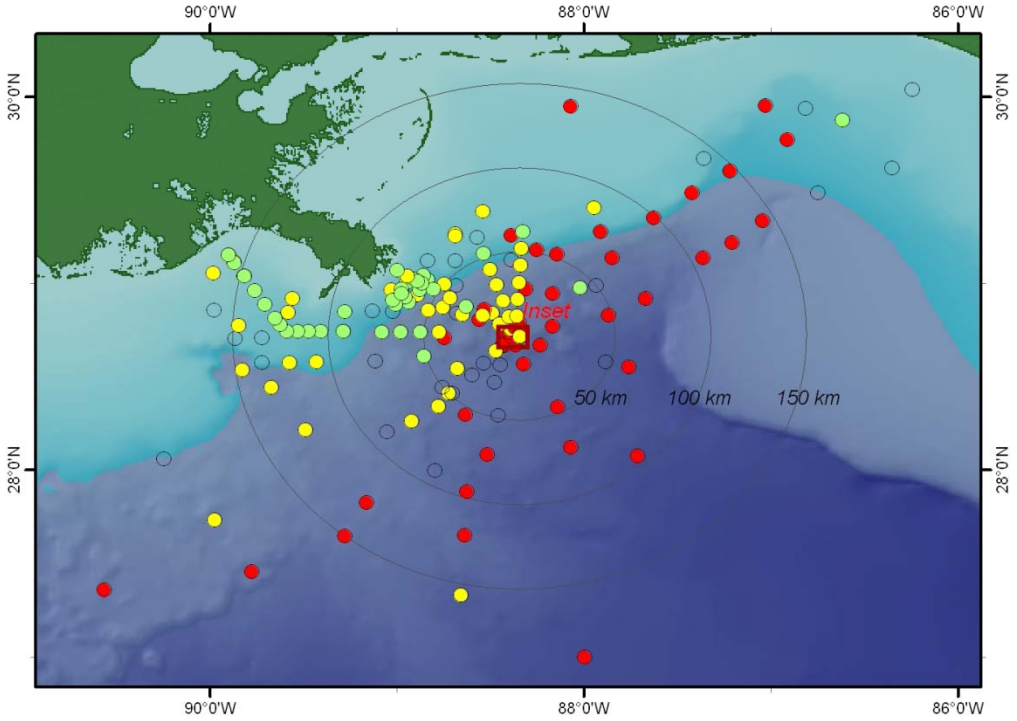

Source: Long, Carr, Montagna. 2003.

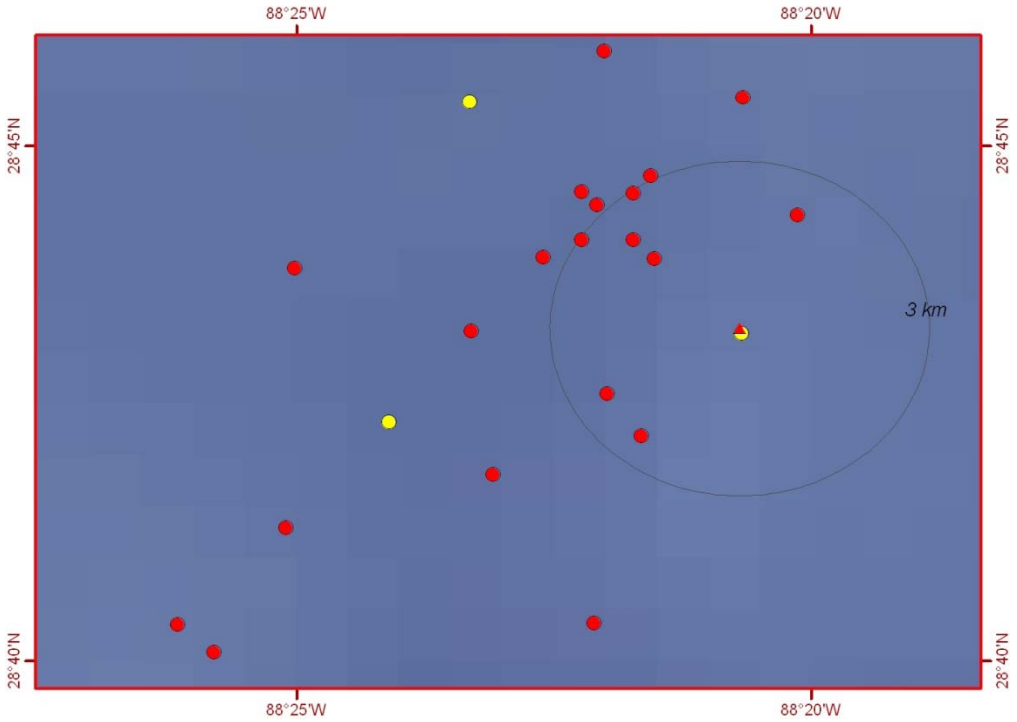
# Analyses to Link Biological Response to Sediment Environment Variables



# Linking Microtoxicity to Environment






# Toxicity vs. Contaminants

Uncolored=missing data

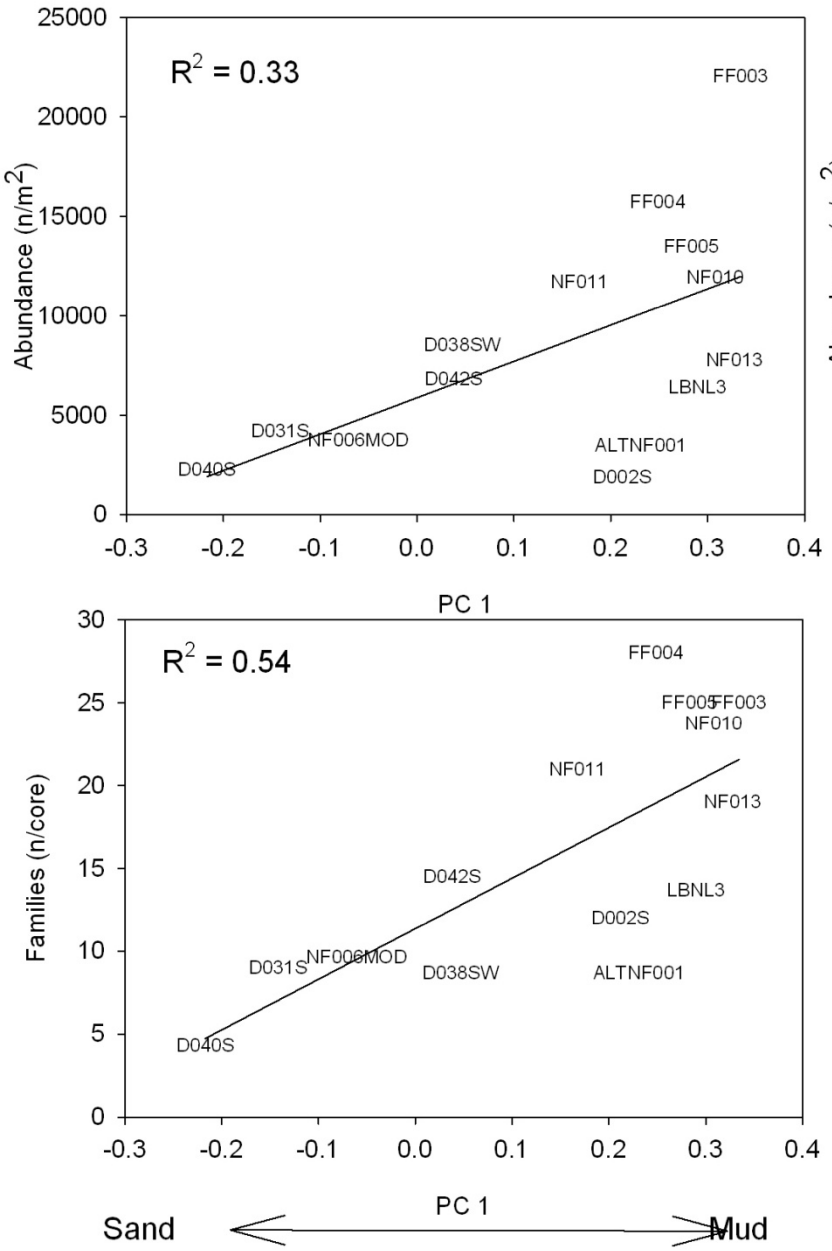
**Color Key:**

| | |
|---|---|
| **PC2<0 + Log $EC_{50}$>8.7** | **PC2>0 + Log $EC_{50}$>8.7** |
| **PC2<0 + Log $EC_{50}$<8.7** | **PC2>0 + Log $EC_{50}$<8.7** |

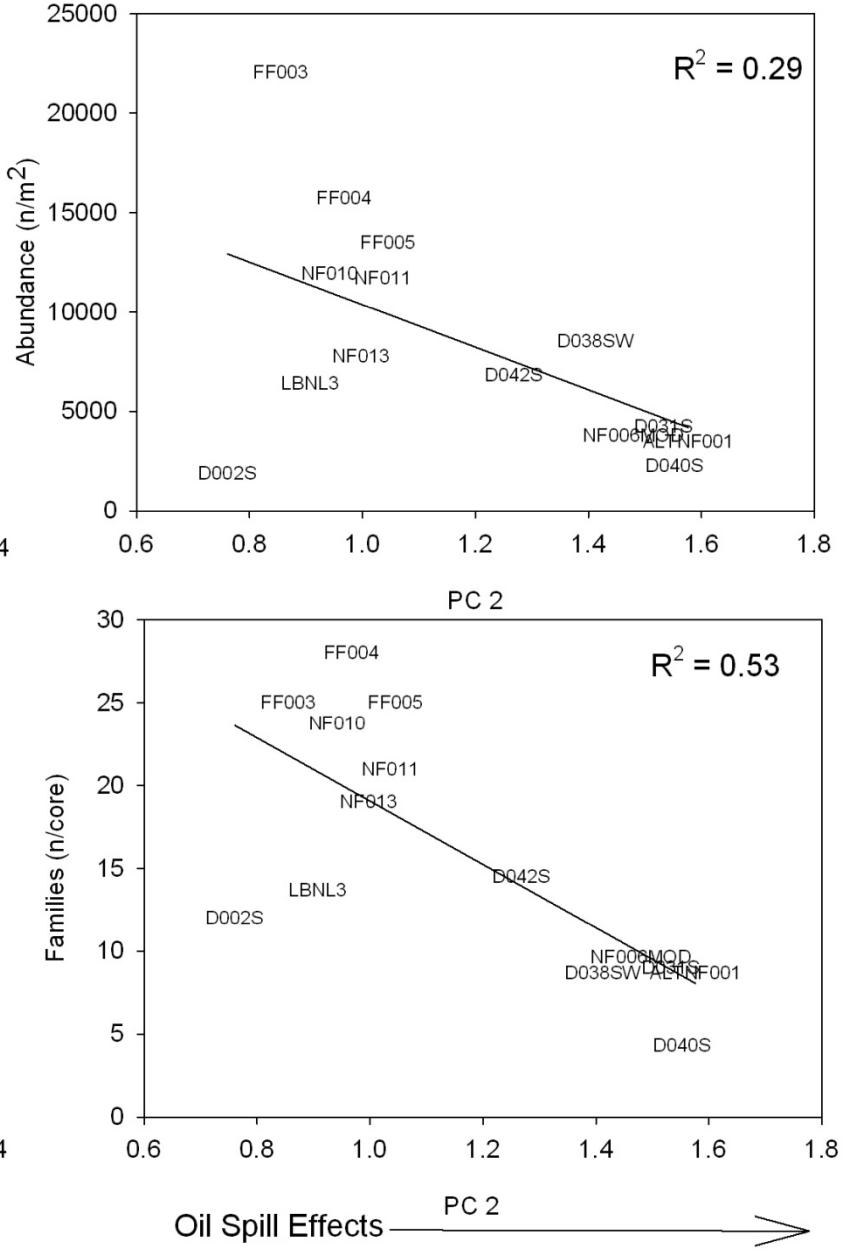
← Toxicity

Contaminants →

## Macrofauna vs. Sediments




## Macrofauna vs. Contaminants



# Preliminary Summary

- There is wide-spread oil on the bottom of the deep offshore environment
- There is strong toxicity up to 25 km away, and weaker toxicity everywhere in the deep-sea
- There is a correlation between the chemical signature characteristic of drilling effects and toxicity
- There is a correlation between the chemical signature and decreases in benthic diversity and biomass

# Thank you

# Questions?