Footprint of the DWH Oil in the Gulf: Soft Sediment Faunal Impact

Paul Montagna

TEXAS A&M UNIVERSITY CORPUS CHRISTI | HARTE RESEARCH INSTITUTE FOR GULF OF MEXICO STUDIES

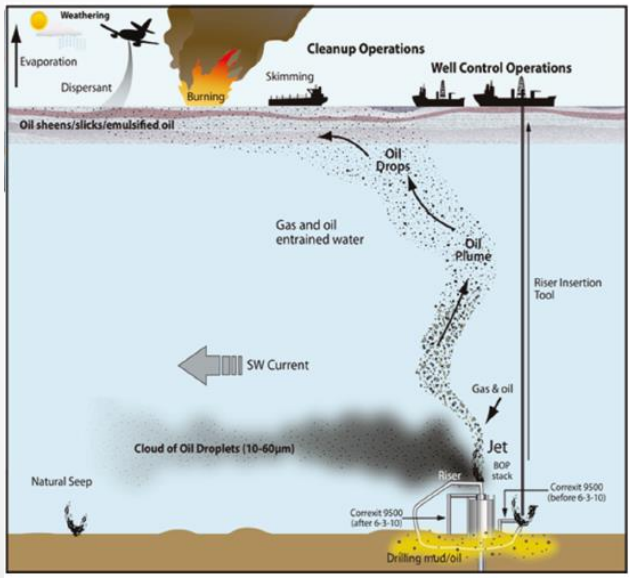
Notes

- Acknowledgements:
  - Funding: BP supported the Fall 2010 cruises
  - NOAA via a subcontract from Industrial Economics supported analyses
  - Work performed to support Deep-Sea Benthic Technical Working Group as part of the Natural Resource Damage Assessment (NRDA) process
- Disclaimers:
  - The views expressed are mine and not attributable to the agency or company.
- Collaborators
  - Jeffery Baguley, University of Nevada-Reno
  - Jeffery Hyland and Cynthia Cooksey, NOAA
  - My laboratory with a lot of great people

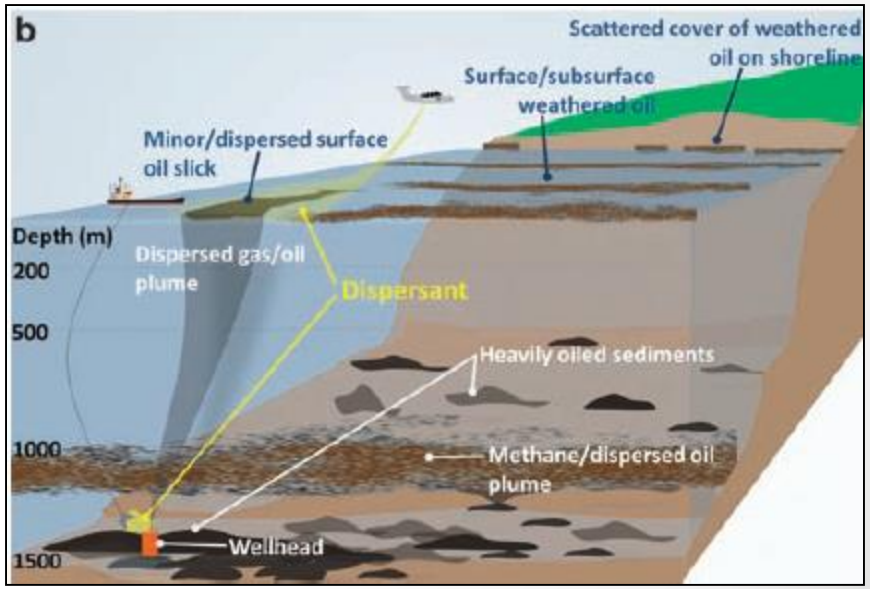
But Mostly, My Lab Mates

Oil Reached the Bottom

- DWH presented two challenges:
  - Familiar buoyant oil, fouling and killing organisms at the sea surface; grounding on shorelines.
  - Novel subsurface retention of oil as finely dispersed droplets and emulsions
- Need to determine impacts to the deep-sea benthos

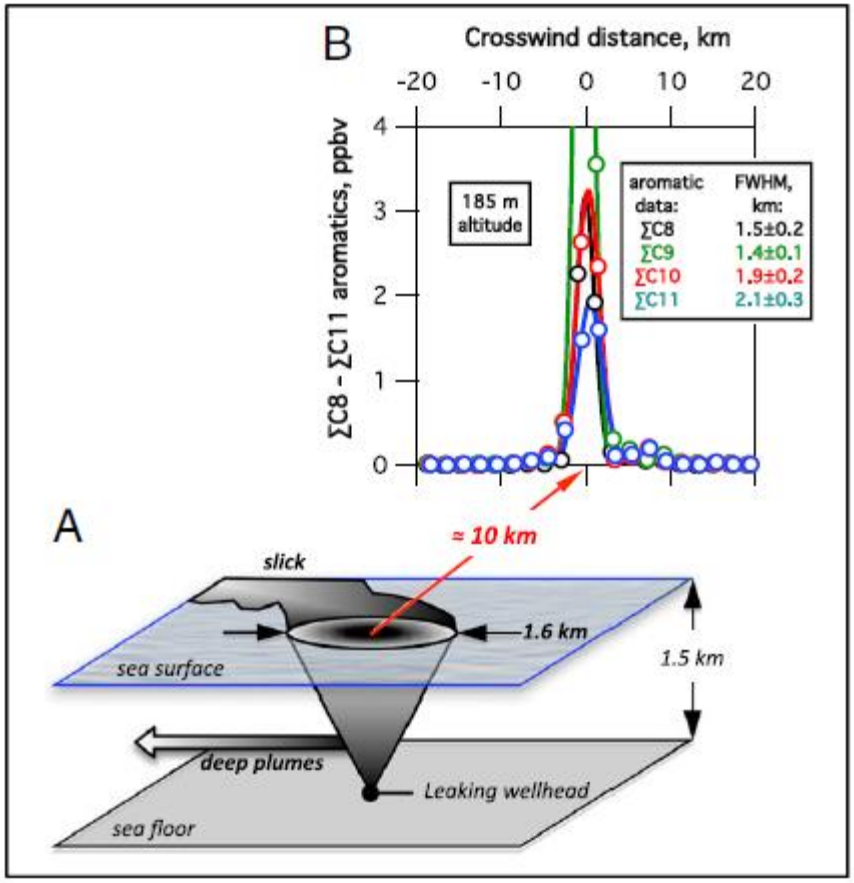


Source: Atlas and Hazen (2011) Environ. Sci. Technol. 45:6709–6715



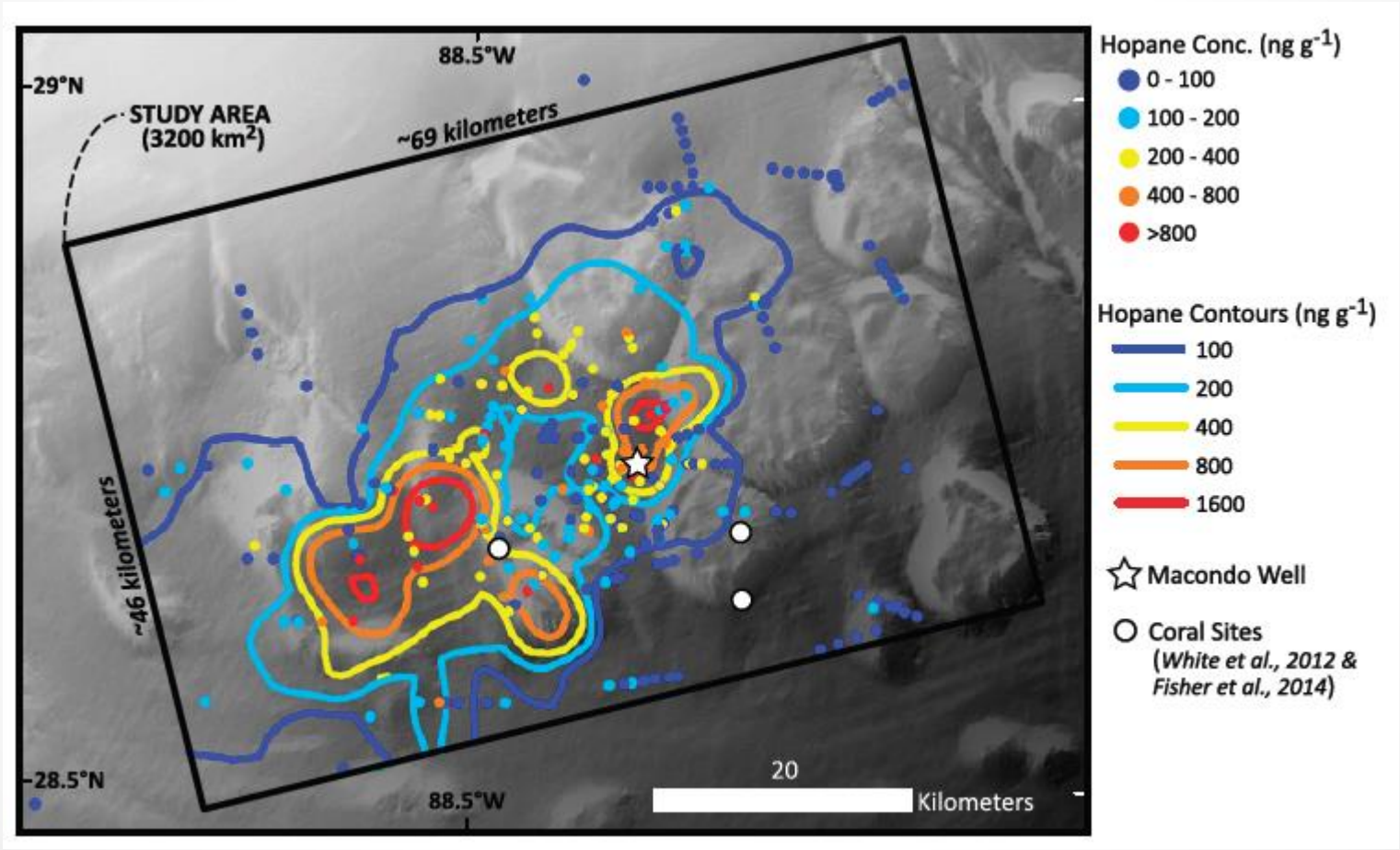
Source: Peterson et al. (2012) Bioscience 62:461

About 31% of the deep plume mass was initially transported in the form of trapped oil droplets



Source: Ryerson et al. (2012) PNAS

The fallout plume contaminated the ocean floor over an area of 3,200 km^2



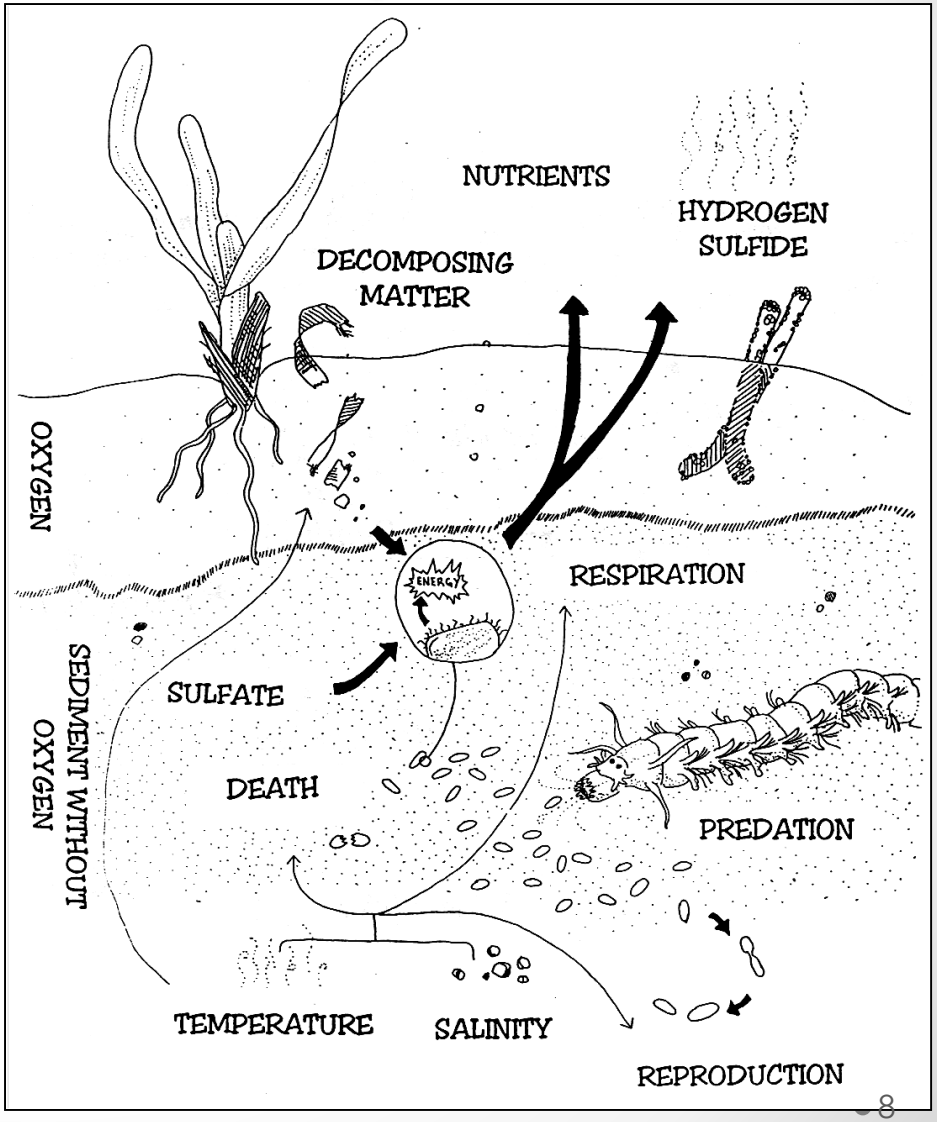
Source: Valentine et al. (2014) PNAS

Source: *New Yorker Magazine*

"I don't know why I don't care about the bottom of the ocean, but I don't."

Sediments are the "Memory of the Ecosystem"

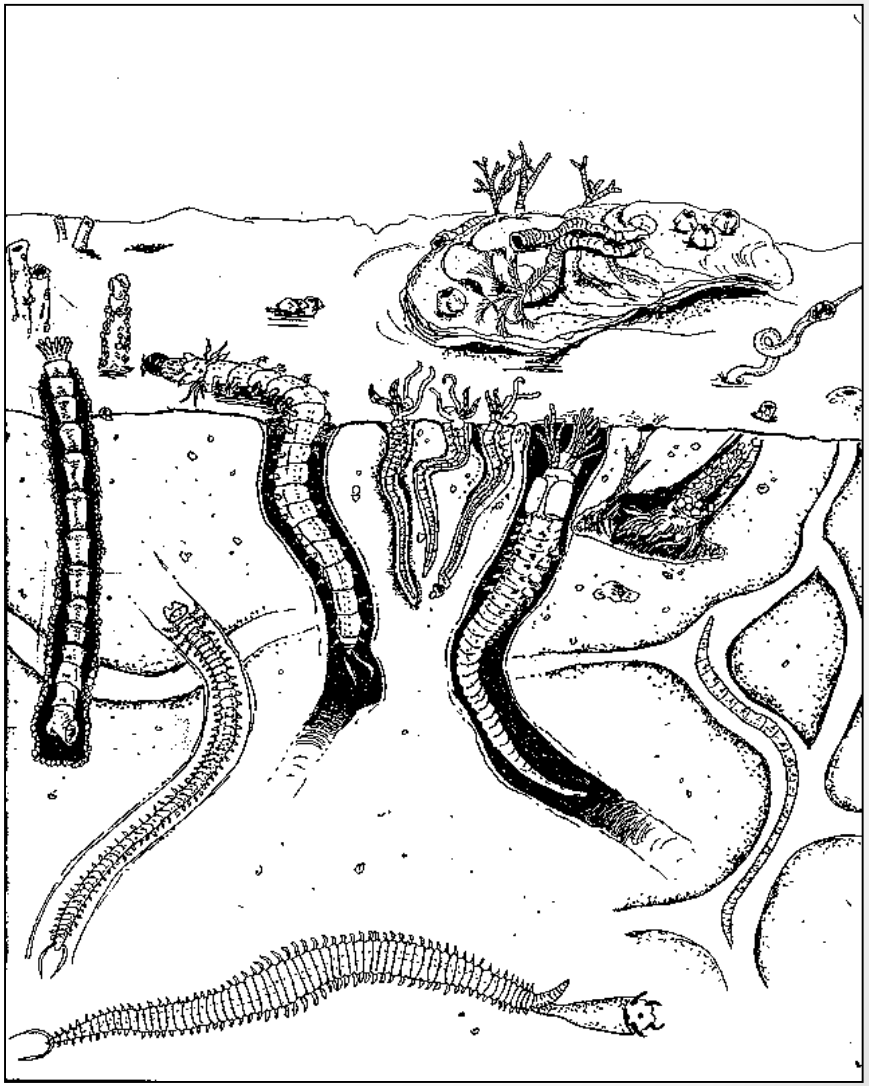
- Record of all events occurring in entire watersheds.
- Most materials are decomposed, but some remains as a permanent record.



Source: Montagna et al. (1996) CCBNEP #8
http://cbbep.org/publications/virtuallibrary/ccbnep08.pdf

Benthos Characteristics

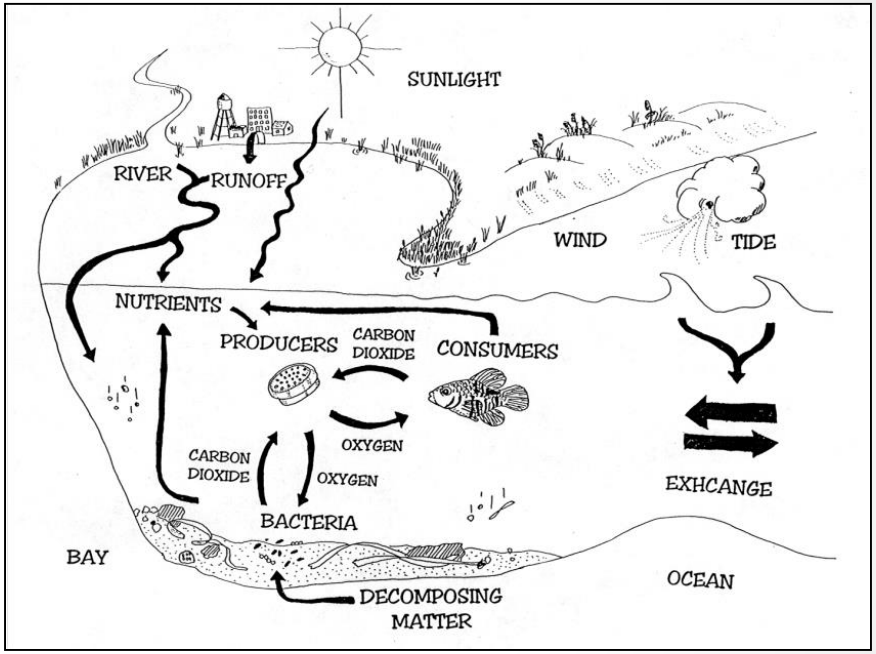
- Benthos are:
  - sessile
  - relatively long-lived
  - diverse
  - well known
  - respond to food from above



Source: Montagna et al. (1996) CCBNEP #8
http://cbbep.org/publications/virtuallibrary/ccbnep08.pdf

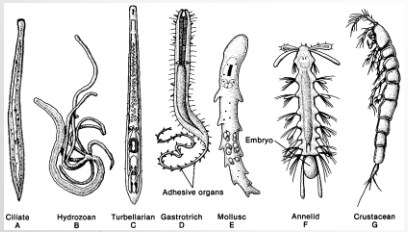
Benthos are Integrators

- Benthos affected first
- Thus, benthos are integrators
  - overlying water column is dynamic
  - benthos sample and integrate ephemeral events over long times scales



Source: Montagna et al. (1996) CCBNEP #8
http://cbbep.org/publications/virtuallibrary/ccbnep08.pdf

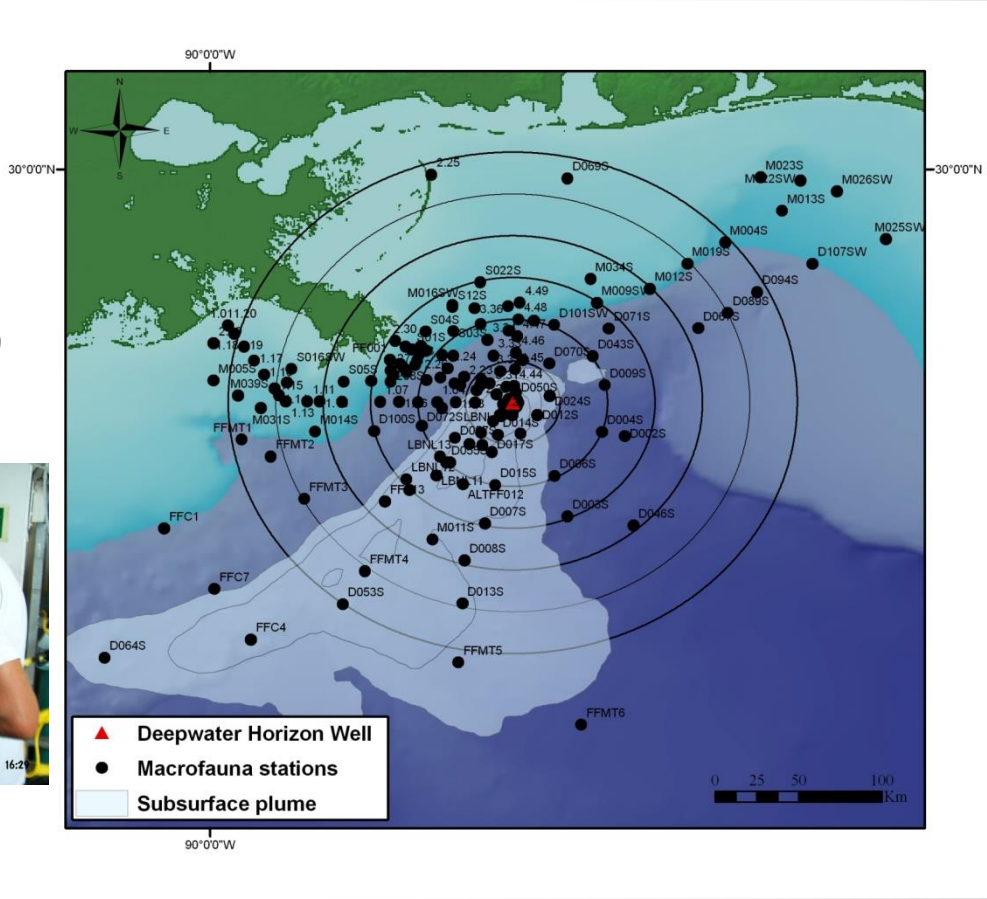
Why Care About Deep-Sea Benthos?



- Reservoirs of marine biodiversity in many places (e.g., DWH well site is in zone of high benthic species richness).
- Serve as bioindicators in many ecological health studies.
- Legal authority for including it as a NRDA public trust resource within the 200 nm EEZ (OPA 1990).
- Two main groups:
  - Macrofauna (medium size) >0.3 mm
  - Meiofauna (small size) >0.044 mm and <0.3 mm

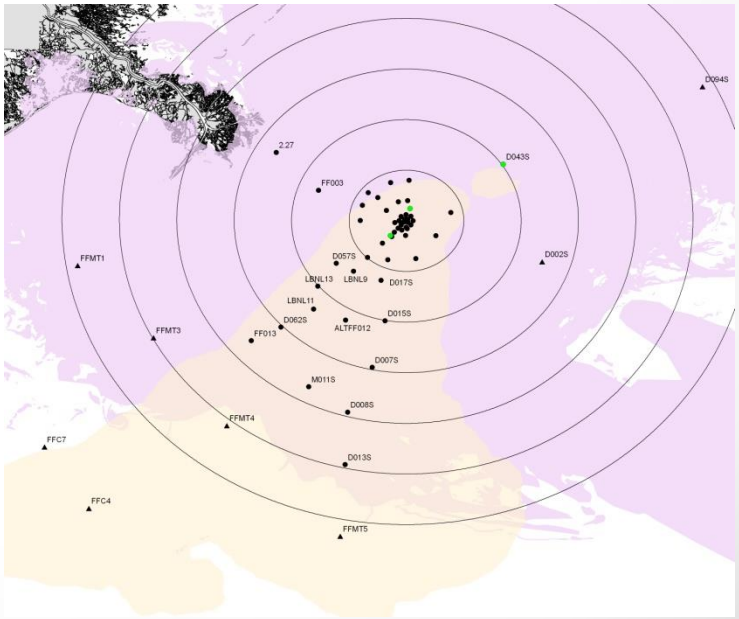
2010 Deep-Sea Soft-bottom Sediment Sampling Plan

- Deep-sea benthic missions were carried out by BP and NOAA from 16 Sept. – 24 Oct. 2010
- *R/V Gyre* and *R/V Ocean Veritas*
- 169 stations for
  - Chemistry
  - Sediments
  - Infauna
    - Macrofauna
    - Meiofauna



Deep-Sea Soft-bottom Sediment Sampling Plan

- NRDA Analyses of Response Samples
  - A subset of stations (58/169) designated as priority samples because of deep-sea location and proximity to MC-252 wellhead
  - Macrofauna collected on 300 micron sieve
  - Meiofauna collected on 45 micron sieve
- Sediments sampled with multicorer

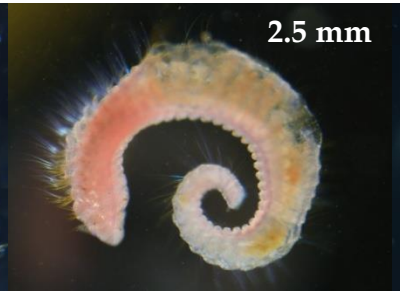


Examples of Common Macroinfauna from the Gulf of Mexico Deep-Sea

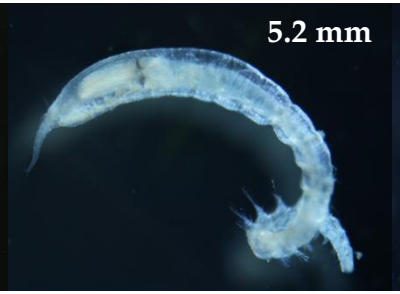
Polychaete Worms

Phylum: Annelida
Class: Polychaeta

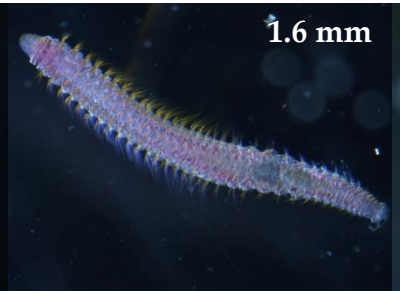
Family: Syllidae



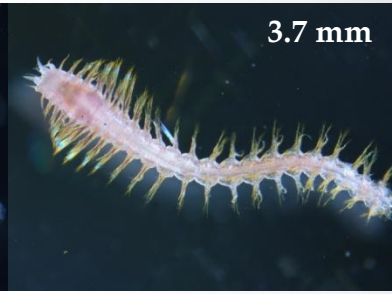
Family: Paraonidae



Family: Glyceridae



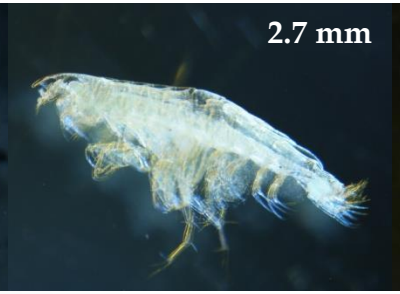
Family: Cossuridae



Family: Nereididae

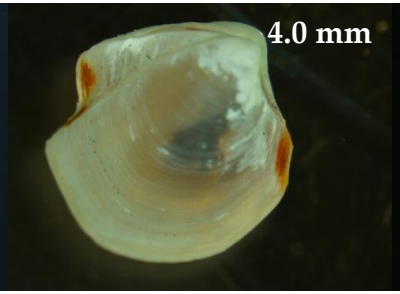
Crustaceans

Phylum: Arthropoda
Class: Malacostraca
Order: Tanaidacea

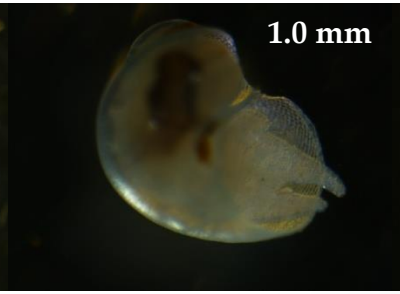


Phylum: Arthropoda
Class: Malacostraca
Family: Phoxocephalidae

Mollusks



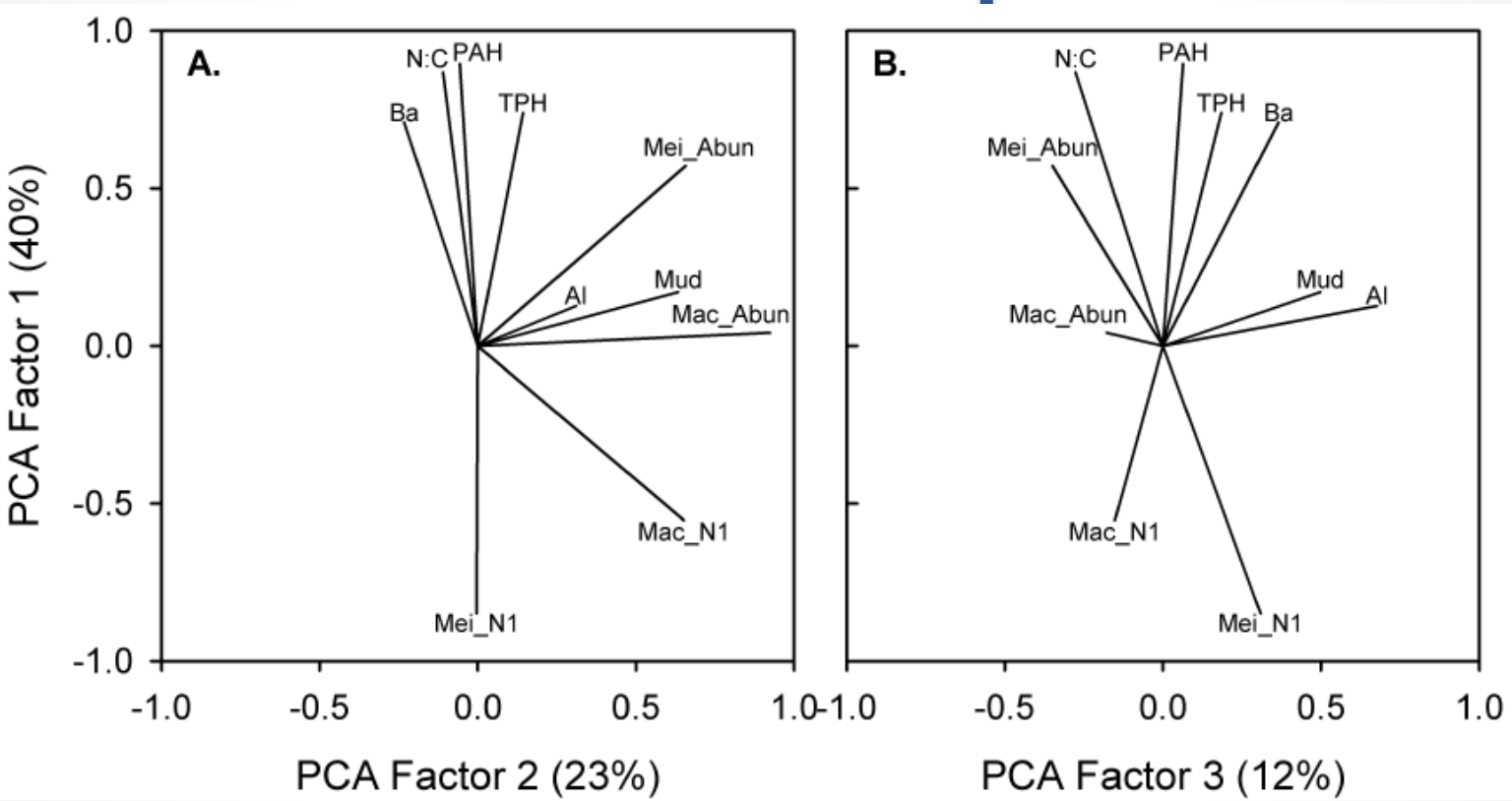
Phylum: Mollusca
Class: Bivalvia
Family: Thyasiridae



Phylum: Mollusca
Class: Gastropoda
Family: Choristellidae

Phylum: Mollusca
Class: Aplacophora
Family: Chaetodermatidae

Multivariate Analysis to Define Footprint

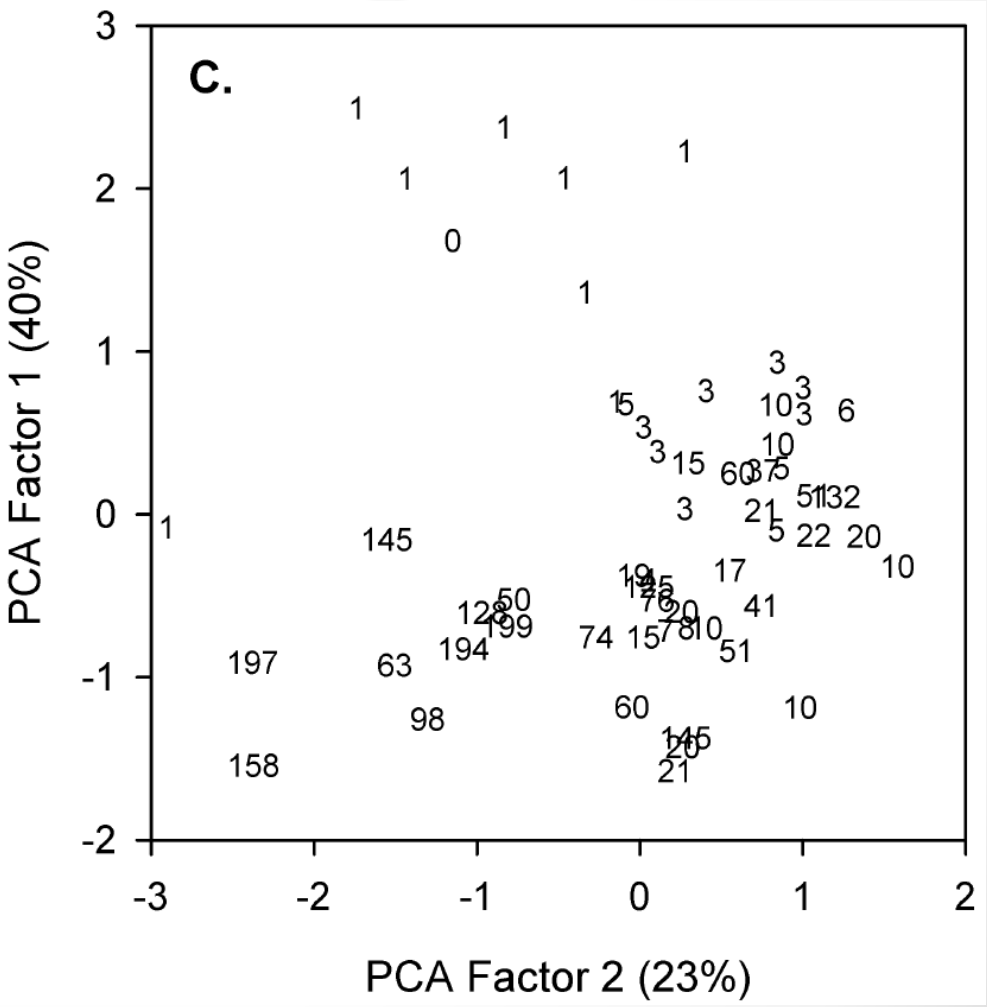


- PC1 defines chemical footprint (PAH, TPH, BA) and biological response (high N:C, low meiofauna and macrofauna diversity
- PC3 defines natural background of mud, Al, and macrofauna abundance

Source: Montagna et al. (2013) PLoS ONE 8(8): e70540.

Multivariate Analysis of Spatial Footprint

- PC Station Scores
- Distance from wellhead correlated to high PC values (i.e., high oil and low diversity)



Symbol=Distance from wellhead

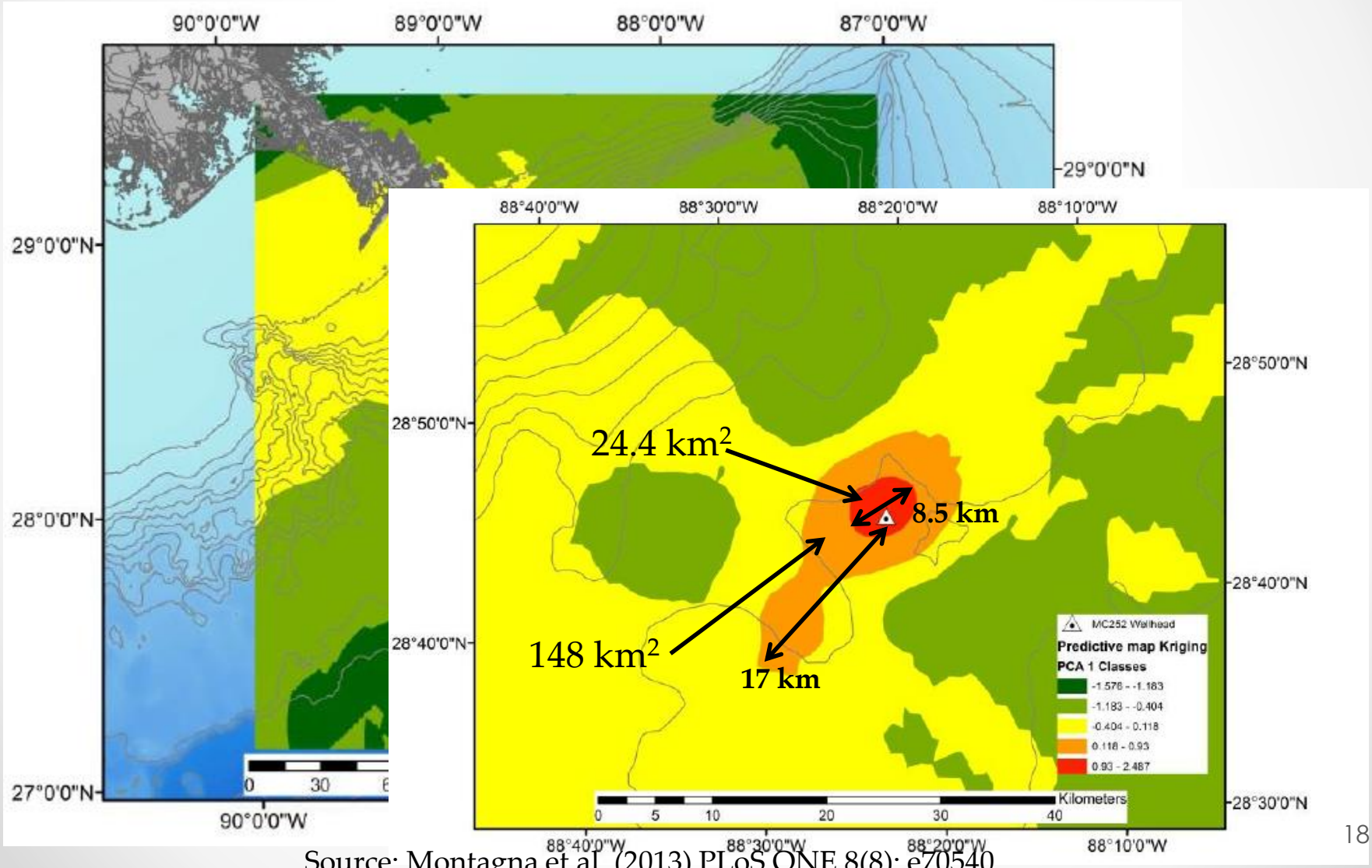
Multivariate Footprint vs. Wellhead and Seeps

Station Location	Pearson Correlation (probability)		
	PC 1	PC 2	PC 3
Wellhead	-0.487 (0.0001)	-0.403 (0.0018)	-0.320 (0.0144)
Seep	-0.248 (0.0604)	-0.188 (0.1568)	-0.496 (<0.0001)
Depth	0.046 (0.7339)	-0.435 (0.0006)	-0.217 (0.1022)

- Inverse correlation between "oil spill footprint" variables (PC1 = high PAH, TPH, Ba and low diversity) and distance from wellhead
- No correlation between "oil spill footprint" and distance from seeps, or water depth
- PC1 (i.e., oil spill footprint) not confounded with seeps

Source: Montagna et al. (2013) PLoS ONE 8(8): e70540.

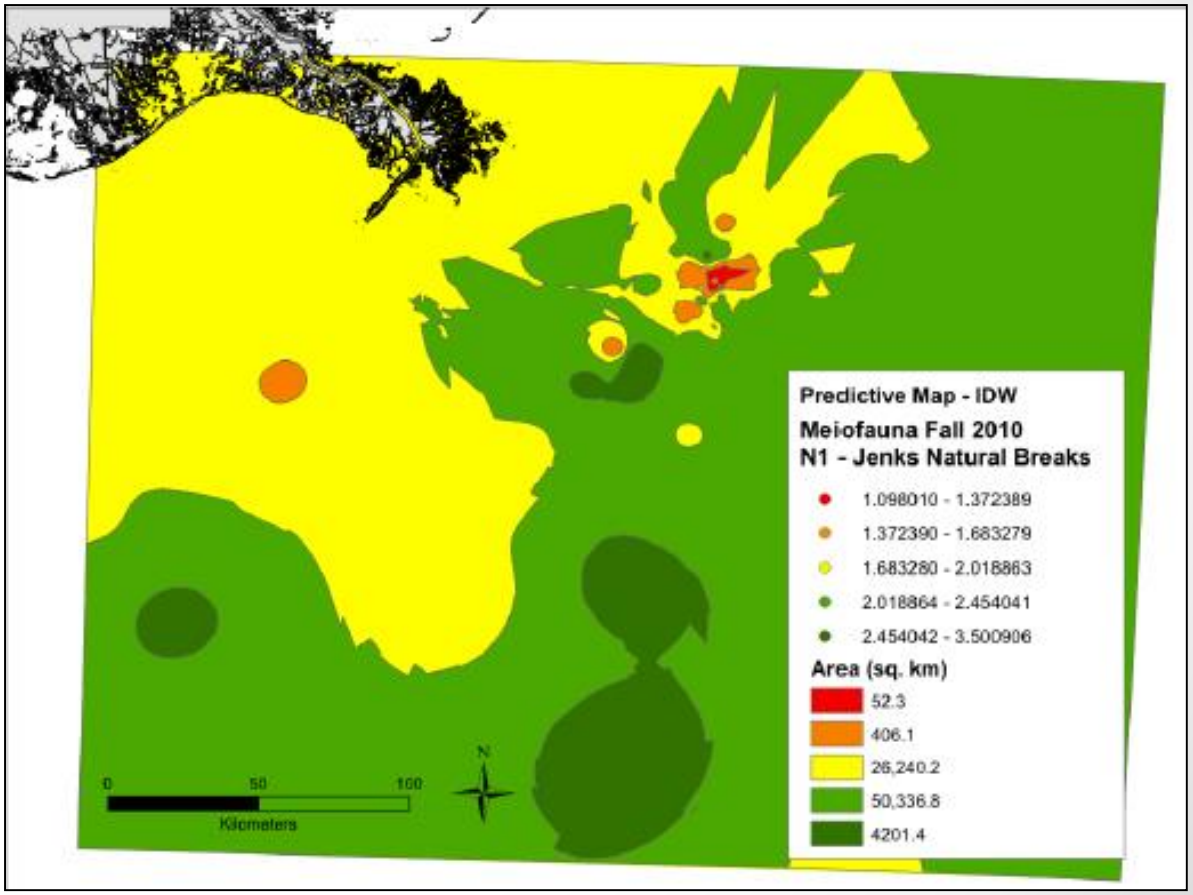
Kriging to Predict Footprint



Source: Montagna et al. (2013) PLoS ONE 8(8): e70540.

Footprint May Be Larger

- Based on meiofauna community structure
  - Severe zone = 52 km^2 which is 2.1X greater
  - Moderate zone=406 km^2 which is 2.7 X greater

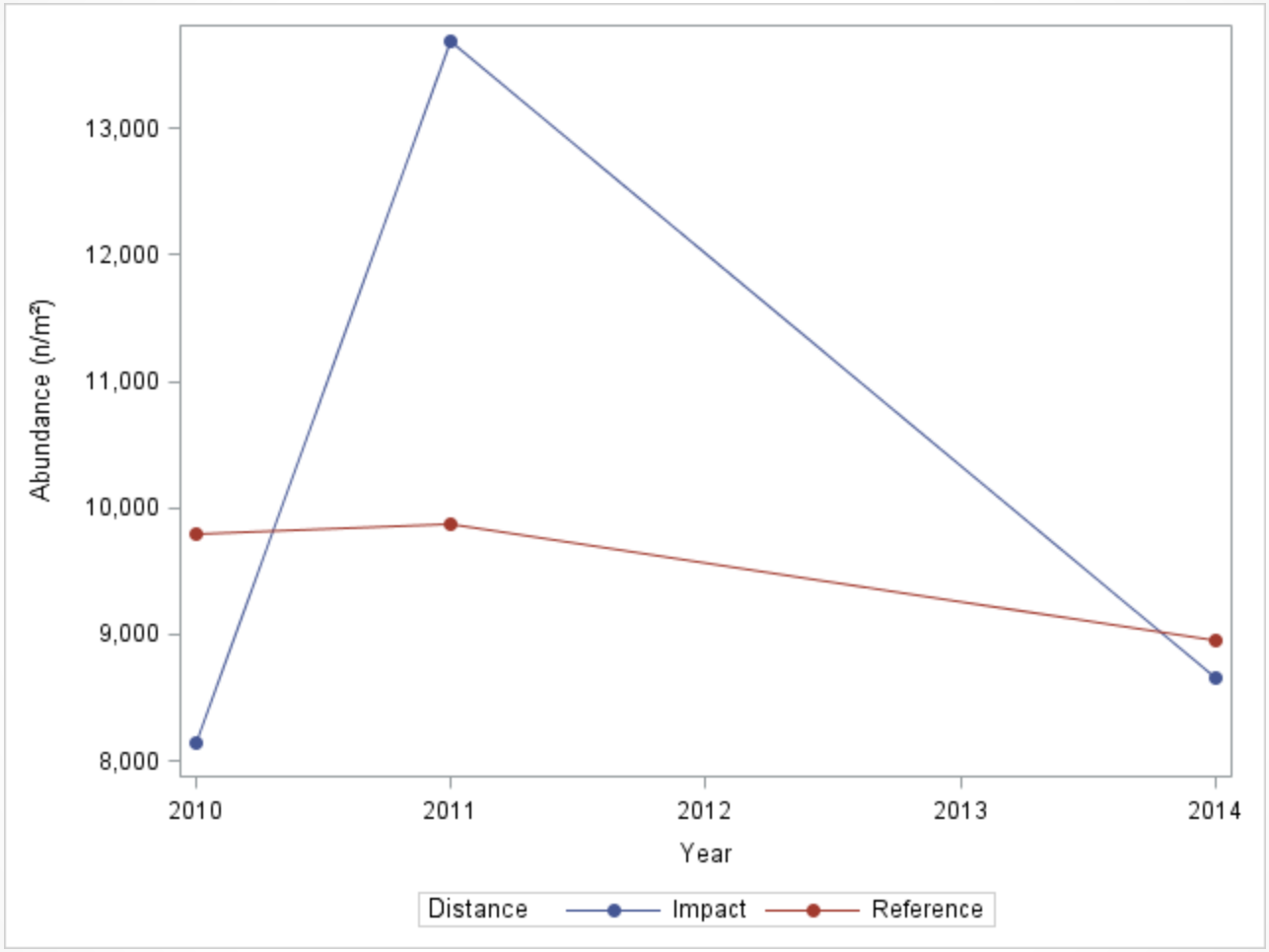


Source: Baguley et al. (2015) MEPS 528: 127-140

Impacts Over Time

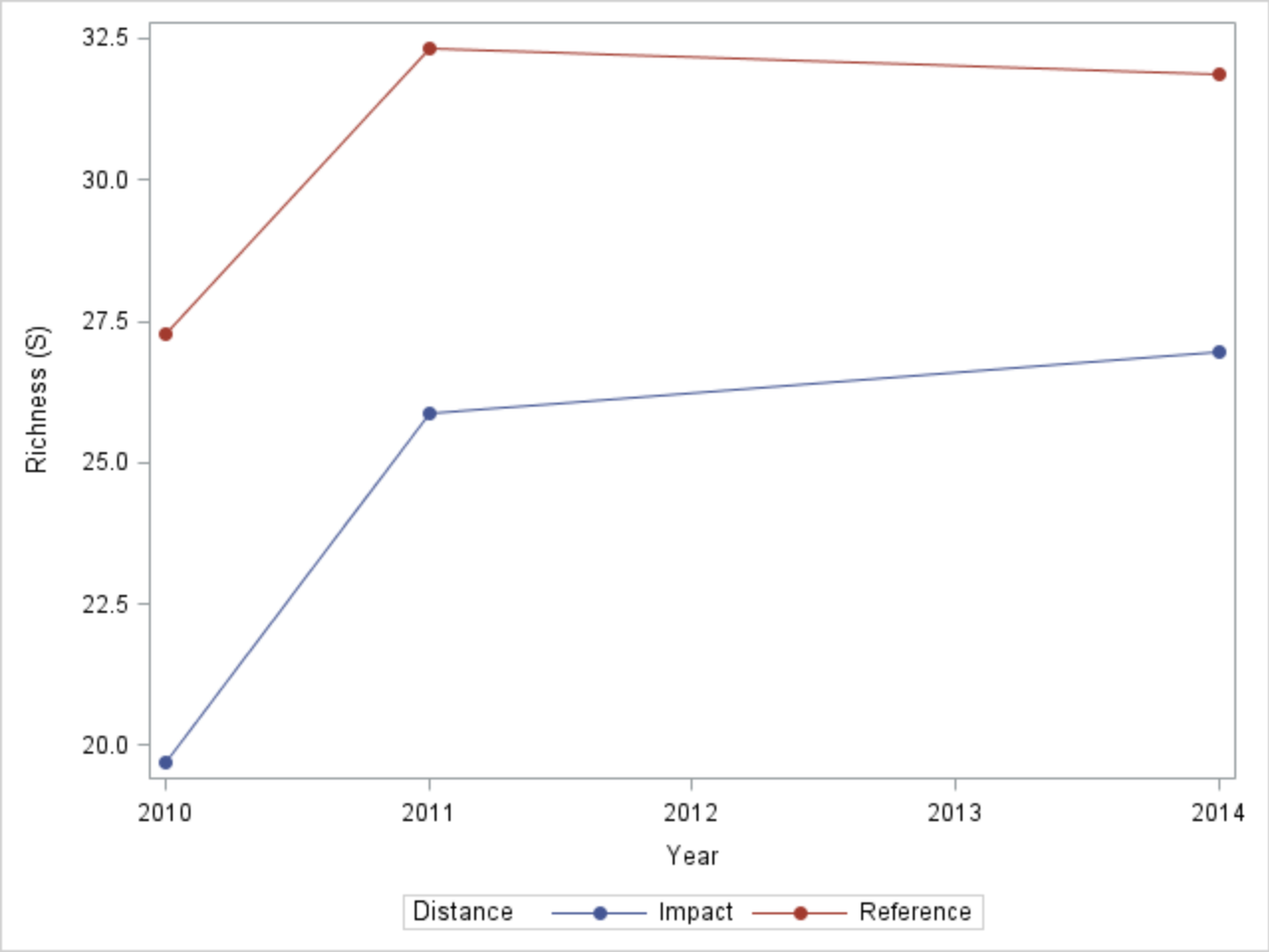
- Resampled 32 Stations in:
  - May-June 2011
  - May-June 2014
- Divided stations into two areas:
  - 20 stations in impact zone= Severe and Moderate impacts
  - 19 stations outside the impact zone
- Macrofauna and Meiofauna

Macrofauna Abundance



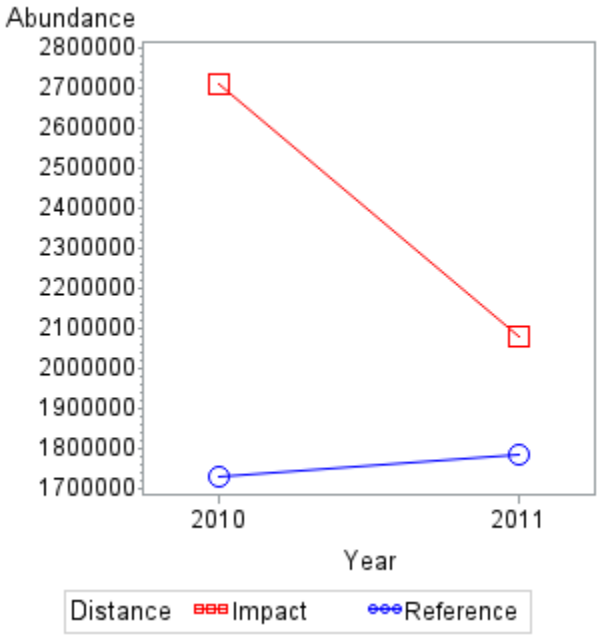
- Apparent recovery in 2011, but no 2014

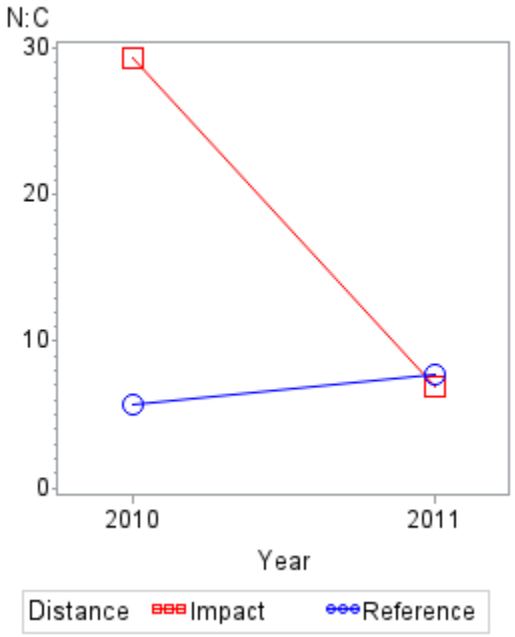
Macrofauna Diversity

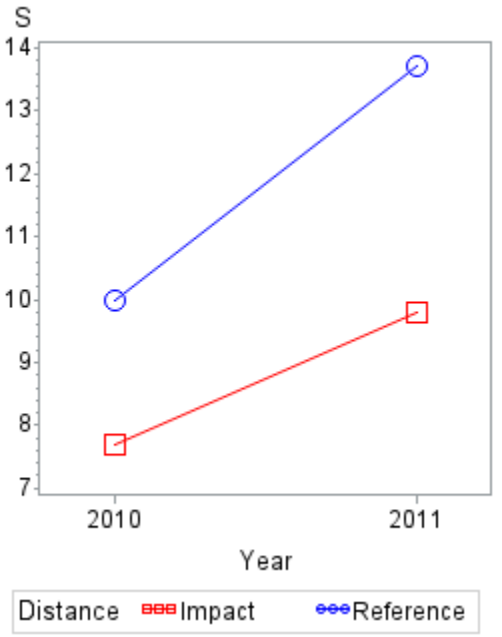


- No recovery in 2011or 2014

Meiofauna

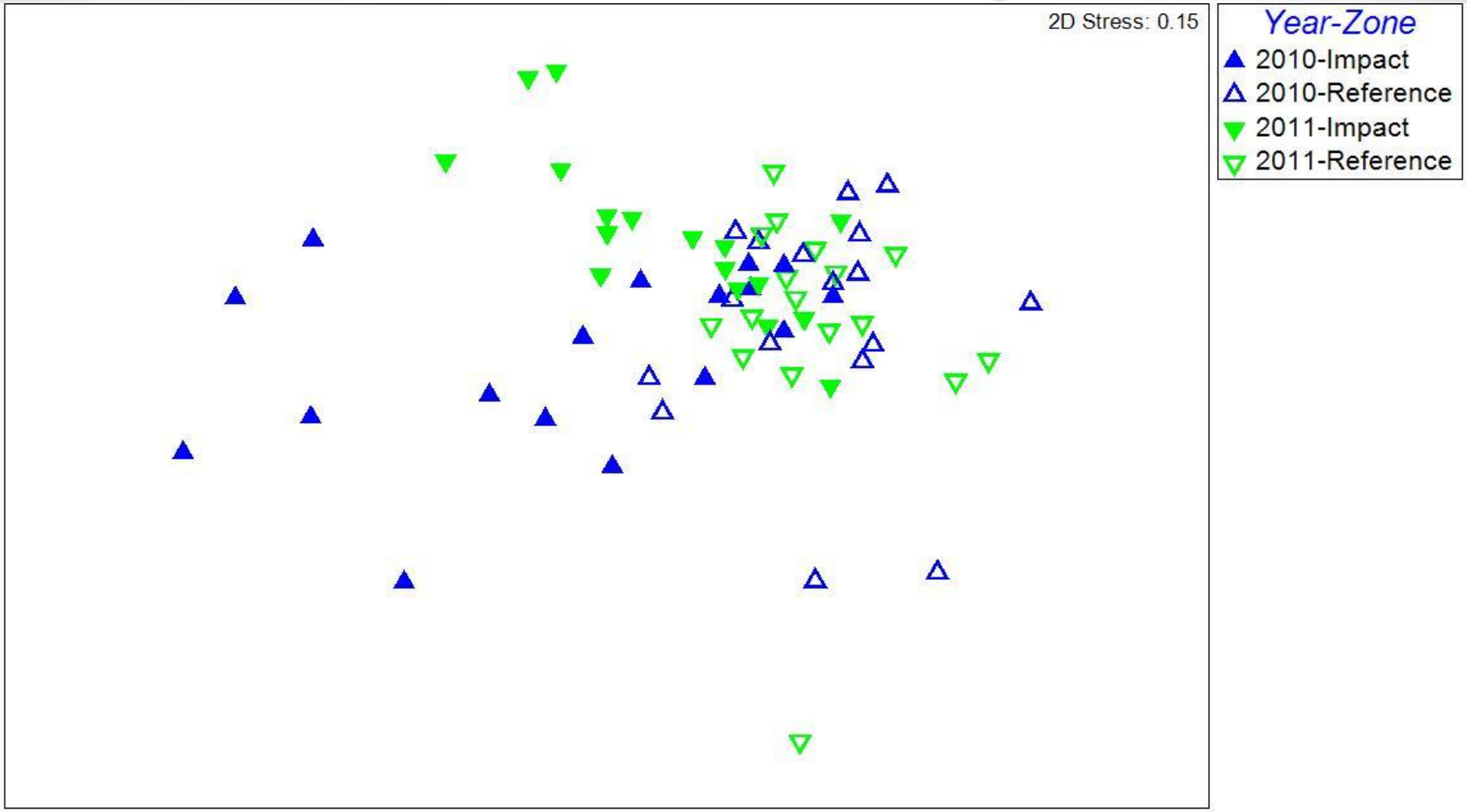






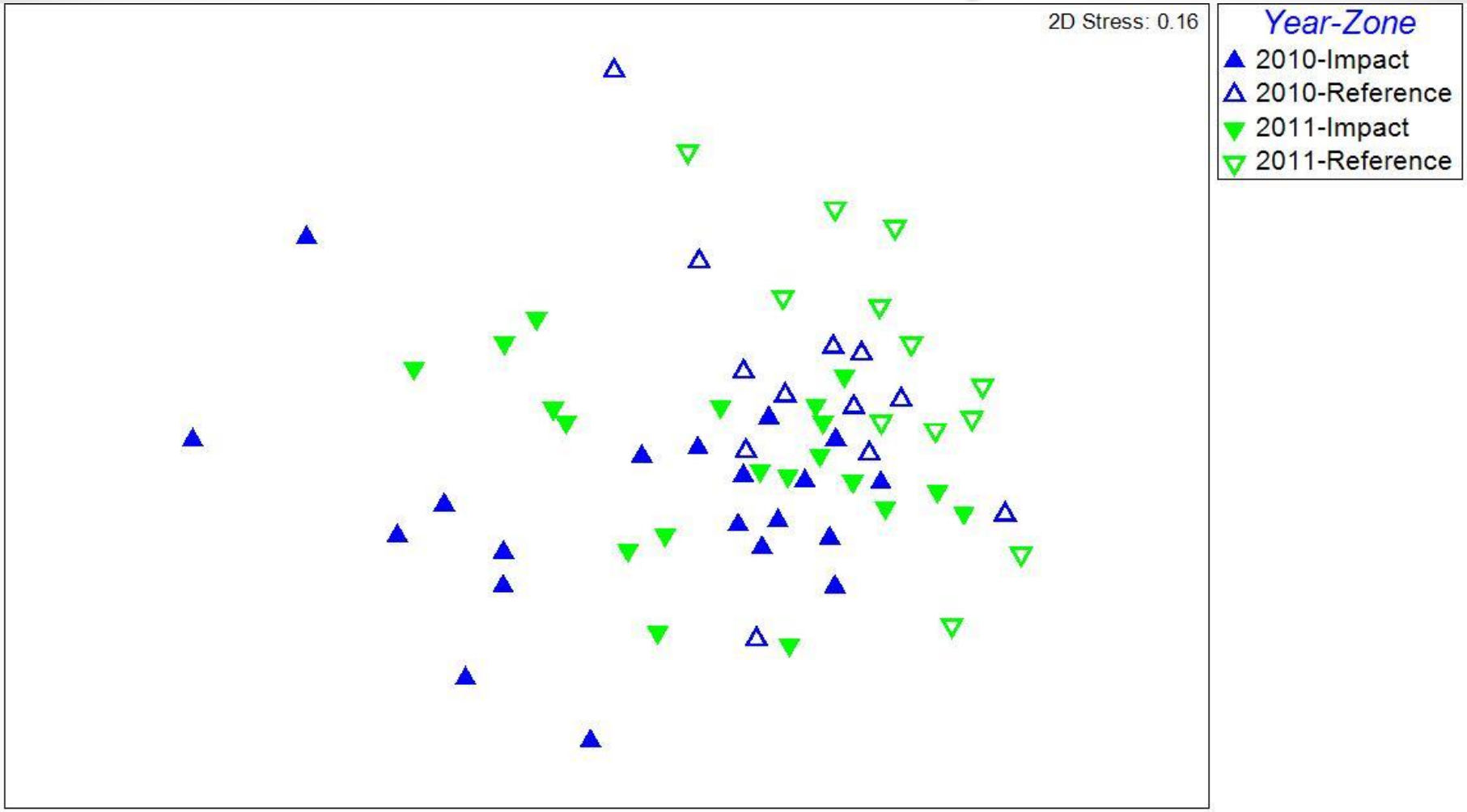
- Abundance recovery in 2011, but not diversity

Macrofauna Community Structure



- No recovery because solid symbols similar
-

Meiofauna Community Structure



- No recovery because solid symbols similar
-

Summary

- The deep-sea footprint of the oil spill can be defined with high concentrations of oil and drilling mud indicators, and low diversity
- There was a wide-spread oil footprint on the bottom consistent with deep-sea plume trajectories
- Macrofauna and Meiofauna diversity has not recovered after four years
- Community structure differences from background still persist