Transport and Fate of Hydrocarbons and Dispersants: Water column

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Source oil from Macondo Well ≠ Surface slick ~2km from the disaster
Provide overview: water column

- Any hydrocarbons and dispersants in the water column?
- Specifically, the existence of subsurface plumes.
- Examine if biological or other processes are occurring.
- Mass balance?
Sentry recovery
Isobaric gas-tight sampler
Recovery

Recovery is too often understood as a binary condition (like a broken leg).
In reality, recovery of the Gulf ecosystem is far more complex, with multiple injuries to many interrelated parts, each with its own schedule and ability to recover.

_We cannot put the Gulf of Mexico in a MRI_
Studying this spill will be hard

- Release from 5000 feet depth
- Sustained release, resulting in mixed signals
- Multiple processes occurring
- A fraction of the Gulf has been sampled.
- Background signal from natural seeps
- Will take another year or so for better snapshot on where did oil go.
- Must be committed to study spill short- and long-term
Academic liaison at Unified Area Command (Sept 2010)

- Most rewarding time of career
- Learned the other side (firefighting)
- Understood importance of problems
- Used knowledge I had gained
- Secured equipment, help, and advice from colleagues
- Recommend that academia be made available during similar times.
Research is moving along at understanding the fate and transport of the petroleum hydrocarbons. Not all hydrocarbons floated to the surface. Plumes detected but not rivers of “oil.” Understanding the fate of oil will take years. Interacting with local, state, and Federal officials as well as BP employees rewarding and highly recommended.
We don’t live in a CSI world

- Data does not come in 8 seconds.
- Accurate interpretations are not instantaneous.
- Not one person will have all of the answers.
- It is very reasonable to expect some questions never answered.
The Fate of the Oil Spilled from the Exxon Valdez

The Mass Balance Is the Most Complete and Accurate of Any Major Oil Spill

Just after midnight on March 24, 1989, the 987-foot tank vessel Exxon Valdez grounded on Bligh Reef in Prince William Sound (PWS), Alaska, releasing approximately 10.8 million gallons (~35,500 metric tons) of North Slope crude oil into the Sound. During the following eight weeks, oil was spread by winds and currents into the Gulf of Alaska (GOA) and along about 1750 km of shoreline, extending up to 750 km from the original spill site (1-3). We have analyzed published and unpublished information on the various processes that affected the distribution and transformations of the spilled oil and reconstructed a spatial-temporal mass balance up through the summer of 1992 (4). In this article, we present our conclusions and a brief overview of the supporting observations. Other authors have reviewed the wide variety of physical, chemical, and biological processes that begin almost immediately to transport and transform crude oil when it is introduced into the marine environment (5-10).

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FIGURE 1
The fate of Exxon Valdez oil: Overall mass balance from March 24, 1989 to October 1, 1992

1 = Floating in Prince William Sound (PWS); 2 = evaporated hydrocarbons; 3 = atmospheric photolysis products; 4 = dispersed in PWS; 5 = floating in Gulf of Alaska (GOA); 6 = dispersed in GOA; 7 = beached in PWS; 8 = beached in GOA; 9 = retrieved by skimmers; 10 = biodegraded in water; 11 = biodegraded on PWS beaches; 12 = biodegraded on GOA beaches; 13 = retrieved (cleaned up) from PWS beaches; 14 = retrieved from GOA beaches; 15 = eroded and dispersed from GOA beaches; 16 = eroded from PWS beaches to shallow subtidal zone; 17 = oil residuals to offshore sediments. Greater detail is provided for the "Beached-PWS" section of this mass balance in Figure 2.
Deepwater Horizon
50-miles away from spill
Memorial Day
Deepwater Horizon
50-miles away from spill
July 12, 2010
ROV images, June 1, 2010; 500 meters near the broken riser pipe.
Deepwater Horizon oil

FID Signal

benzene

toluene

ethylbenzene

m-xylene

p-xylene

c-xylene

n - alkane number
What we found on the web

22 Mile River Of Oil
Confirmed From BP Well And Not Natural Seeps
Originates 5-7 Miles From Well - Past The Biloxi Dome
1.6 Miles Wide
600 Feet Deep

Red, White and Green Spheres
Hydrocarbon Anomalies

BP Well

DWH

Continental shelf

Hydrocarbon plume at
1100 meters depth

Biloxi Dome

Seafloor

Pink and Red Cylinders
Leaks From Sea Floor

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What’s in the plume?

- **(a)** Station 19: 2.3 km SW of MW
- **(b)** Station 13: 6.1 km SW of MW
- **(c)** Station 14: 16.5 km SW of MW
- **(d)** Station 18: 27 km SW of MW

**Graph Details:**
- Y-axis: Depth (m)
- X-axis: Concentration (µg L⁻¹)
- Labels:
  - • benzene
  - • toluene
  - • ethylbenzene
  - • total xylenes

Legend for Points:
- Benzene
- Toluene
- Ethylbenzene
- Total xylenes
Mapping a Deep Plume from the Deepwater Horizon Blowout
Water collected in the plume
Subsurface plume in June 2010

- Continental shelf
- Hydrocarbon plume at 1100 meters depth
- Seafloor
- N
- DWH
Florida; Buzzards Bay (1969)

Cosco Busan; San Francisco Bay (2007)

Bouchard 120; Buzzards Bay, MA (2003)

Natural oil seeps; Santa Barbara, CA (everyday)