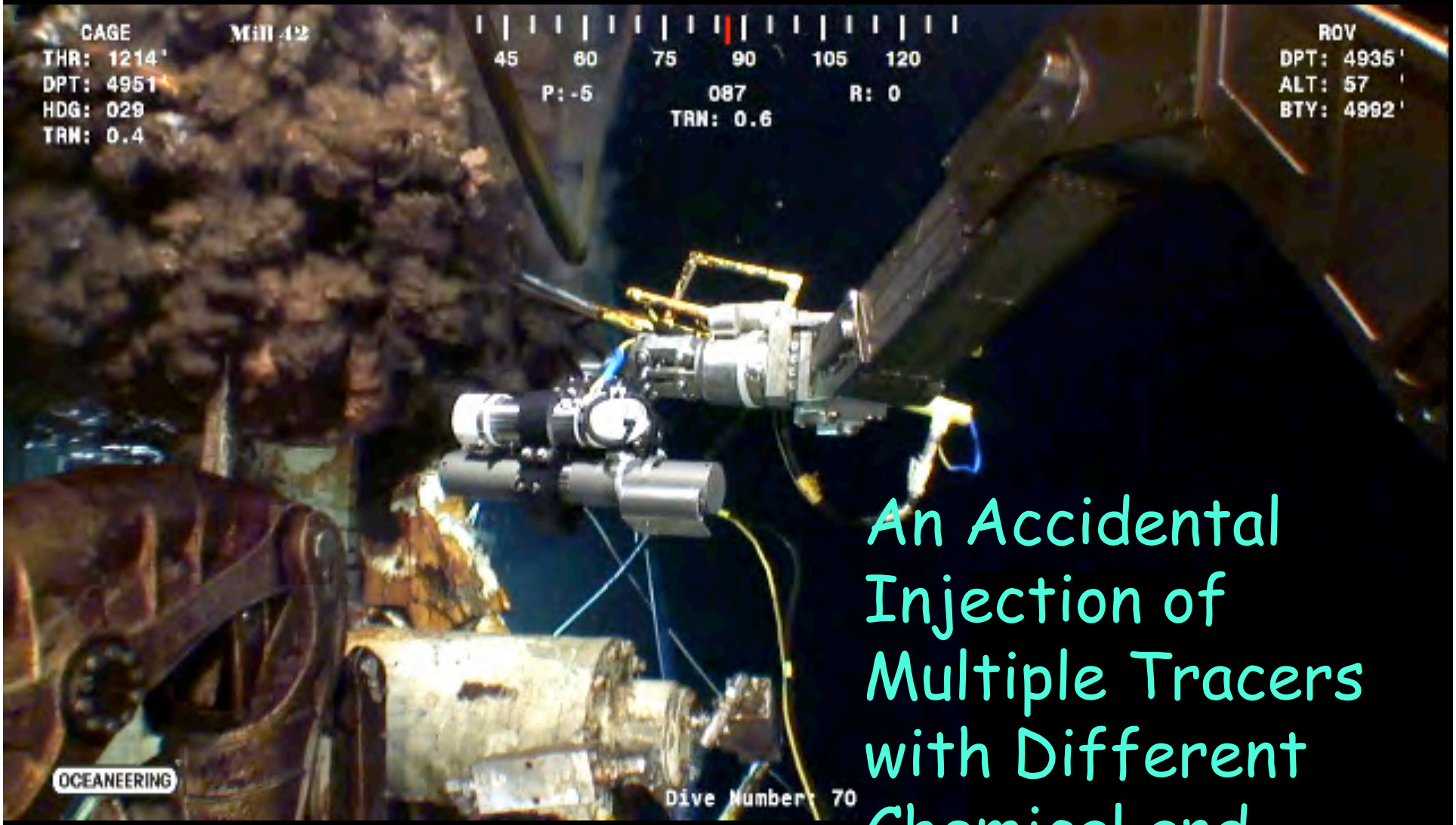
October 5, 2010

"Oil/Dispersant Fate & Extent" Deepwater Horizon Disaster

Chris Reddy
Woods Hole Oceanographic Institution
Woods Hole, MA



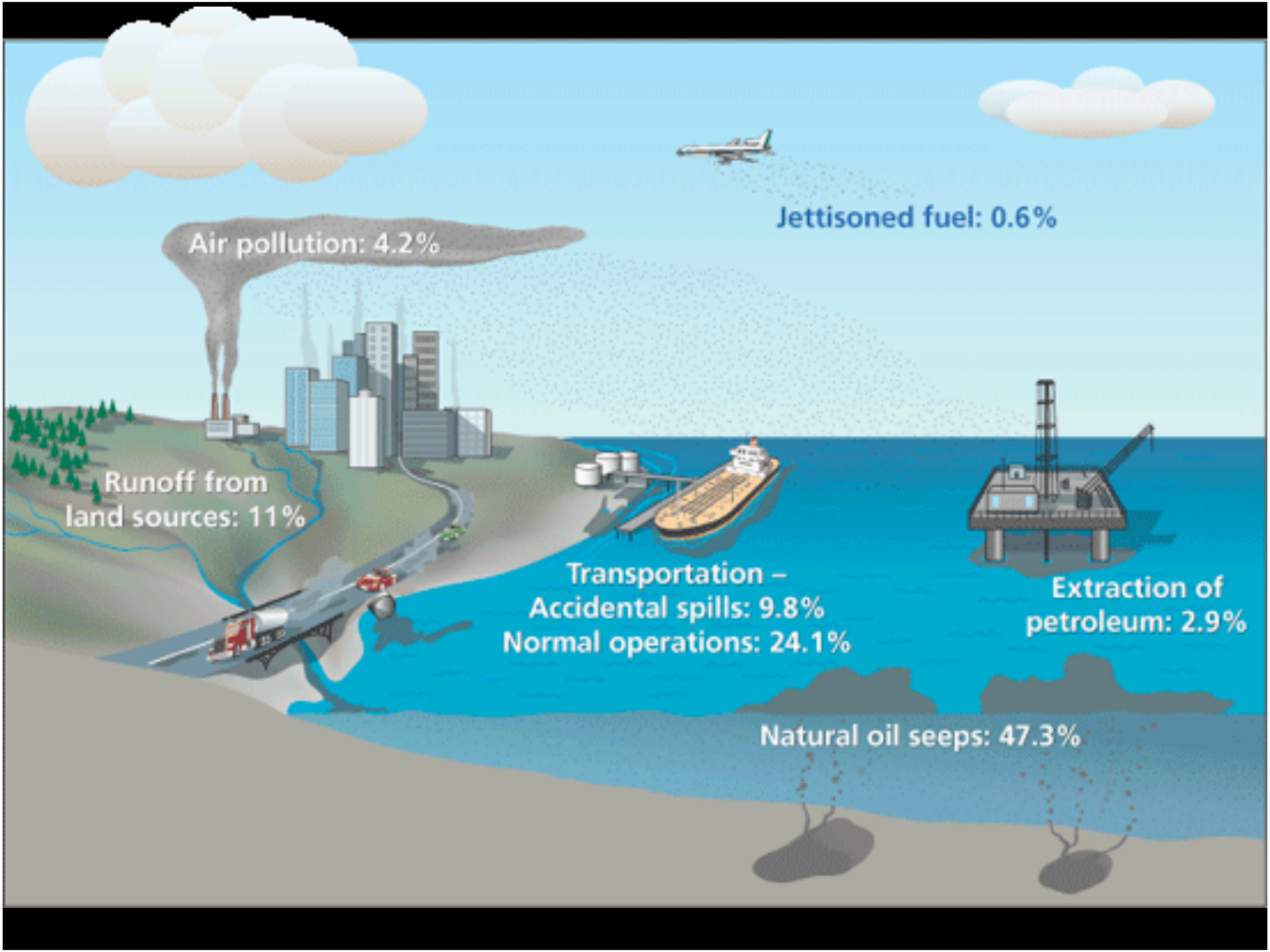
An Accidental Injection of Multiple Tracers with Different Chemical and Physical Properties


How Does Nature
Respond to an
Uninvited Guest?


An Unprecedented Perturbation on
the Gulf of Mexico

Spinning different titles

- An attempt to highlight the numerous approaches one can study this spill.
- Provides opportunties for different scientists to collaborate.
- Also meant to highlight how "difficult" a task it is to study this spill.


Jettisoned fuel: 0.6%
Air pollution: 4.2%
Runoff from land sources: 11%
Transportation –
Accidental spills: 9.8%
Normal operations: 24.1%
Extraction of petroleum: 2.9%
Natural oil seeps: 47.3%

Fate and extent is difficult

- Release from 1500 m depth
- Sustained release, resulting in mixed signals (new on top of old)
- Multiple processes occurring
- Despite numerous research cruises, only a fraction of the Gulf has been sampled.
- Background signal from natural seeps and other activities.

Academia has a lot to offer

- There is a lot of us.
- We have access to newer technology.
- Untethered (besides teaching, etc.)
- More colleagues (more resources)
- Also, responsibilities as "academics"—to be unbiased arbiters of science.
- Constantly ask yourself "prudence" vs. "urgency"

Academic contributions

- Evidence of plume (s) by many groups
- Observed microbial degradation using novel techniques
- Polycyclic aromatic hydrocarbons analysis
- Flow rates measurements

→ More papers already published than from the Ixtoc disaster.

- Involved in numerous work groups, briefings, lending equipment, etc.

Mass balance/oil budget

- Will take years for a refined estimate.
- Thousands of samples in the queue.
- Many uncertainties
- Need to extrapolate these uncertainties

→ It will be a major victory to constrain major processes. For example, if we were to estimate that 40 to 60% of the mass released was evaporated.

- Two significant figures are unlikely.

The Fate of the Oil Spilled from the *Exxon Valdez*

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

DOUGLAS A. WOLFE
M. J. HAMEEDI
National Oceanographic and Atmospheric Administration Silver Spring, MD 20910

J. A. GALT
G. WATABAYASHI
National Oceanographic and Atmospheric Administration Seattle, WA 98115

J. SHORT
C. O'CLAIRE
S. RICE
National Oceanographic and Atmospheric Administration Auke Bay, AK 99821

J. MICHEL
Research Planning, Inc. Columbia, SC 29201

J. R. PAYNE
Sound Environmental Services, Inc. Carlsbad, CA 92008

J. BRADDOCK
University of Alaska Fairbanks, AK 99775

S. HANNA
Sigma Research Corporation Concord, MA 01742

D. SALE
Snow Otter Consulting Anchorage, AK 99501

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*).

The overall mass balance for the *Exxon Valdez* oil (Figure 1) shows the time courses for several major components of the spilled oil and their geographic distribution (inside vs. outside of PWS). The logarithmic time scale extends from about 2:30 AM on March 24, 1989, to October 1, 1992. Many of the estimates represented here are based on well-understood phenomena and are supported by direct measurements or observations. For others, however, quantitative information is almost entirely lacking, and the values shown are reasoned estimates that illustrate approximate ranges. The estimates for various compartments and processes have been reconciled with one another to derive the most accurate "big picture" of the oil's fate. Nonetheless, the mass balance must be viewed as somewhat speculative, requiring critical discussion of the data sources and uncertainties associated with the estimates.

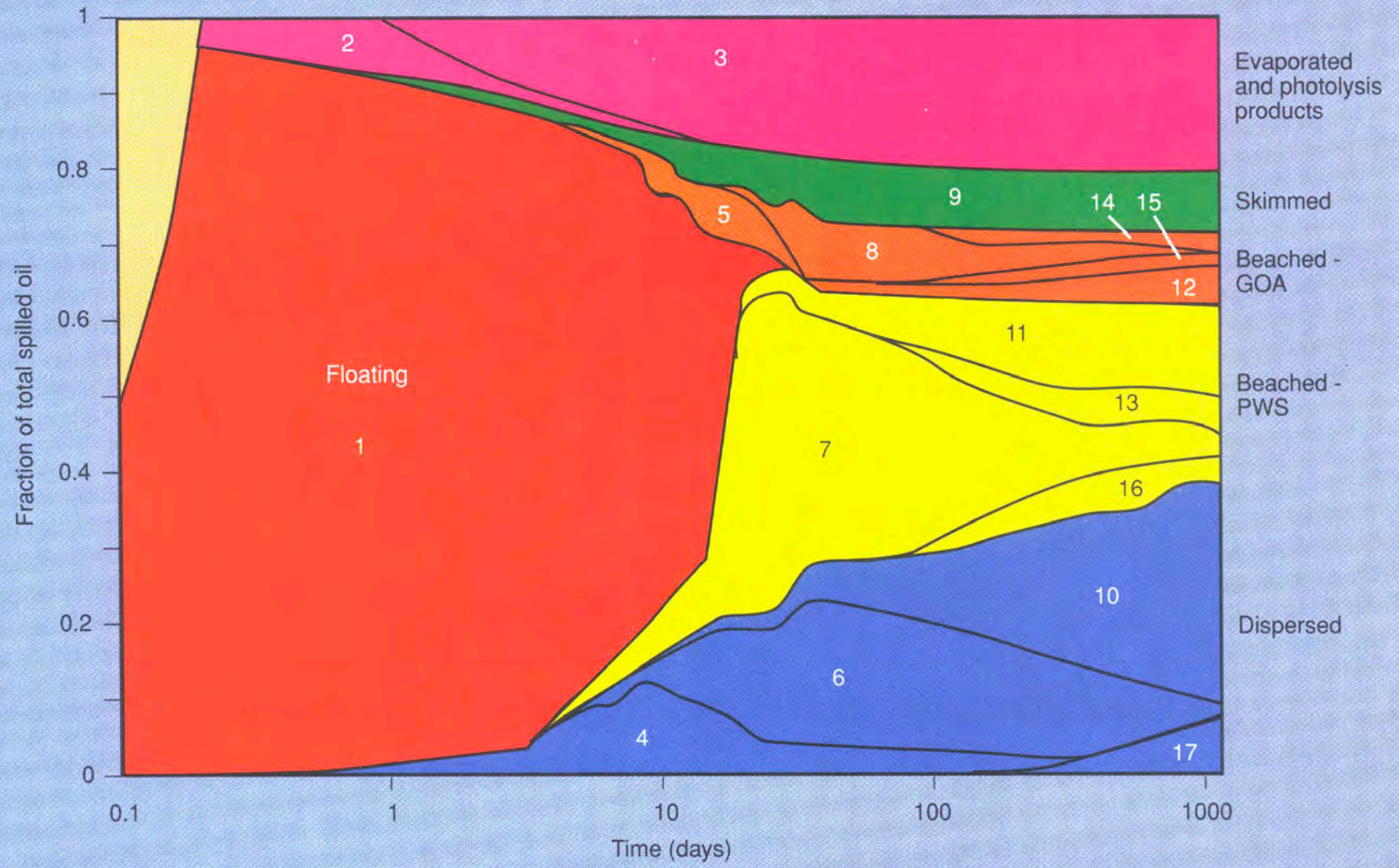
Transport and transformations of the surface slick

Figure 1 depicts the spill with a uniform rate of release for 5 hours after the grounding of the ship (*1,*

0013-936X/94/0927-561A$04.50/0

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.

Strive for precision: dispersants

- Concerned about the impacts of

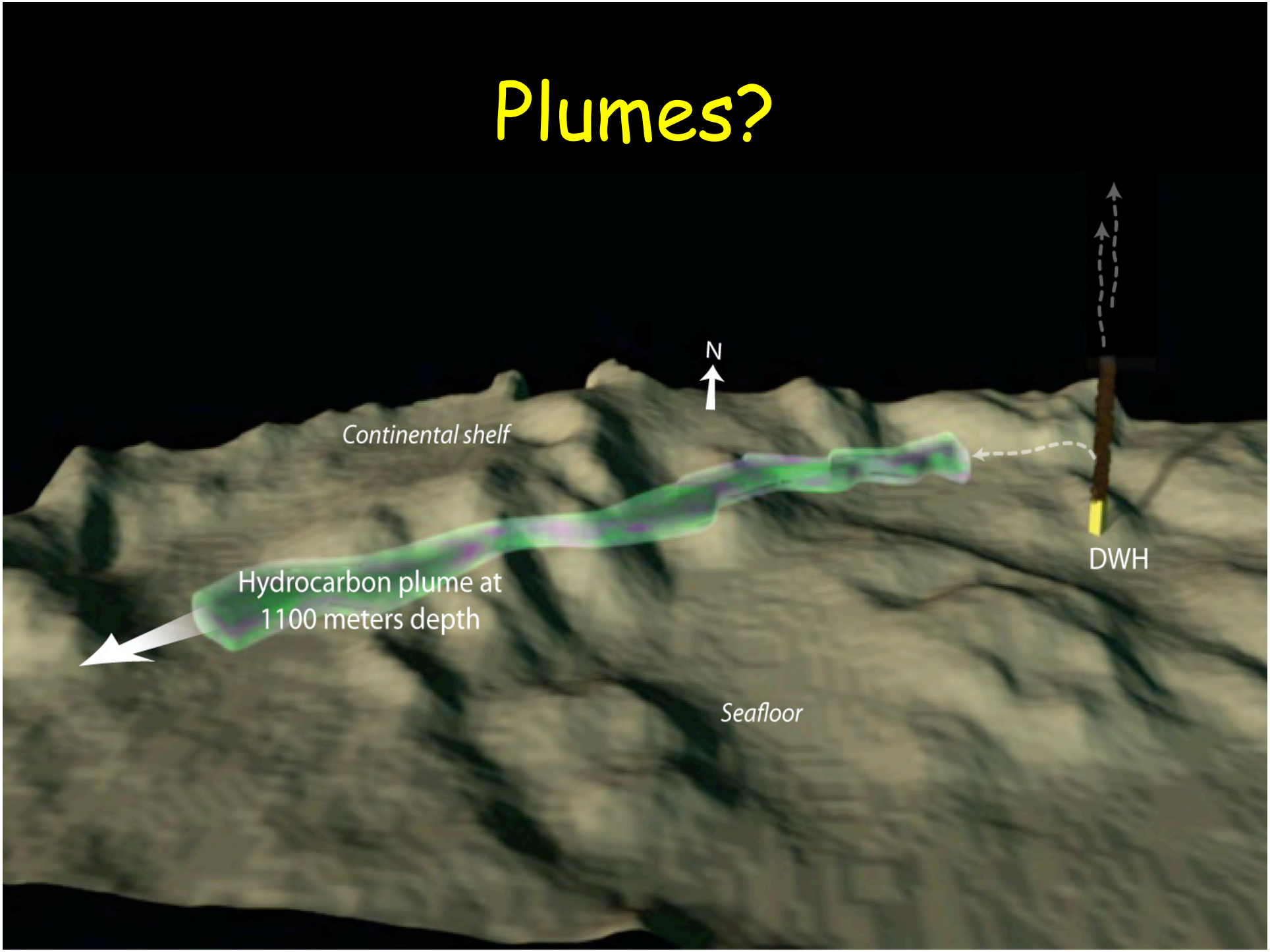
1. Dispersants?
2. Mixtures of petroleum hydrocarbons and dispersants?
3. Dispersed hydrocarbons?

Lots of work underway but must realize these differences.

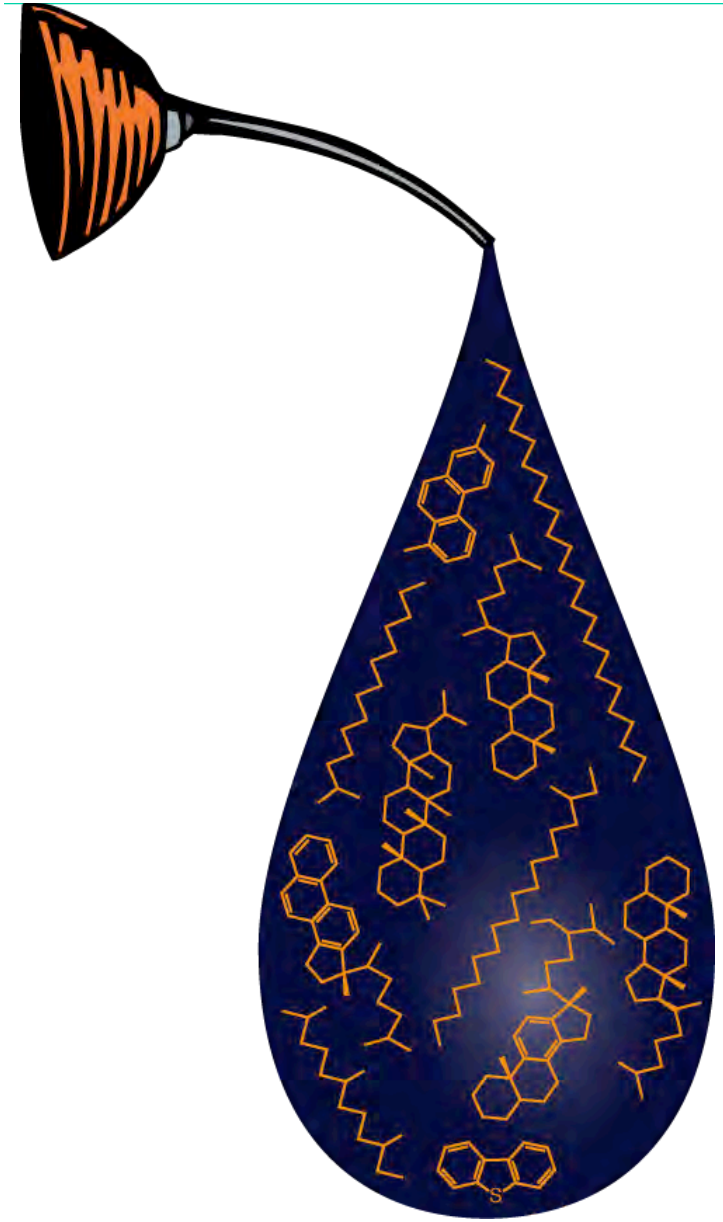
What's the deal with the plumes?

- Big deal?—huge load?, toxic?, etc
- Just an academic result?
- Something to compare to the Norwegian controlled release in 2000? and models?
- Sensationalized phenomena?

Plumes?

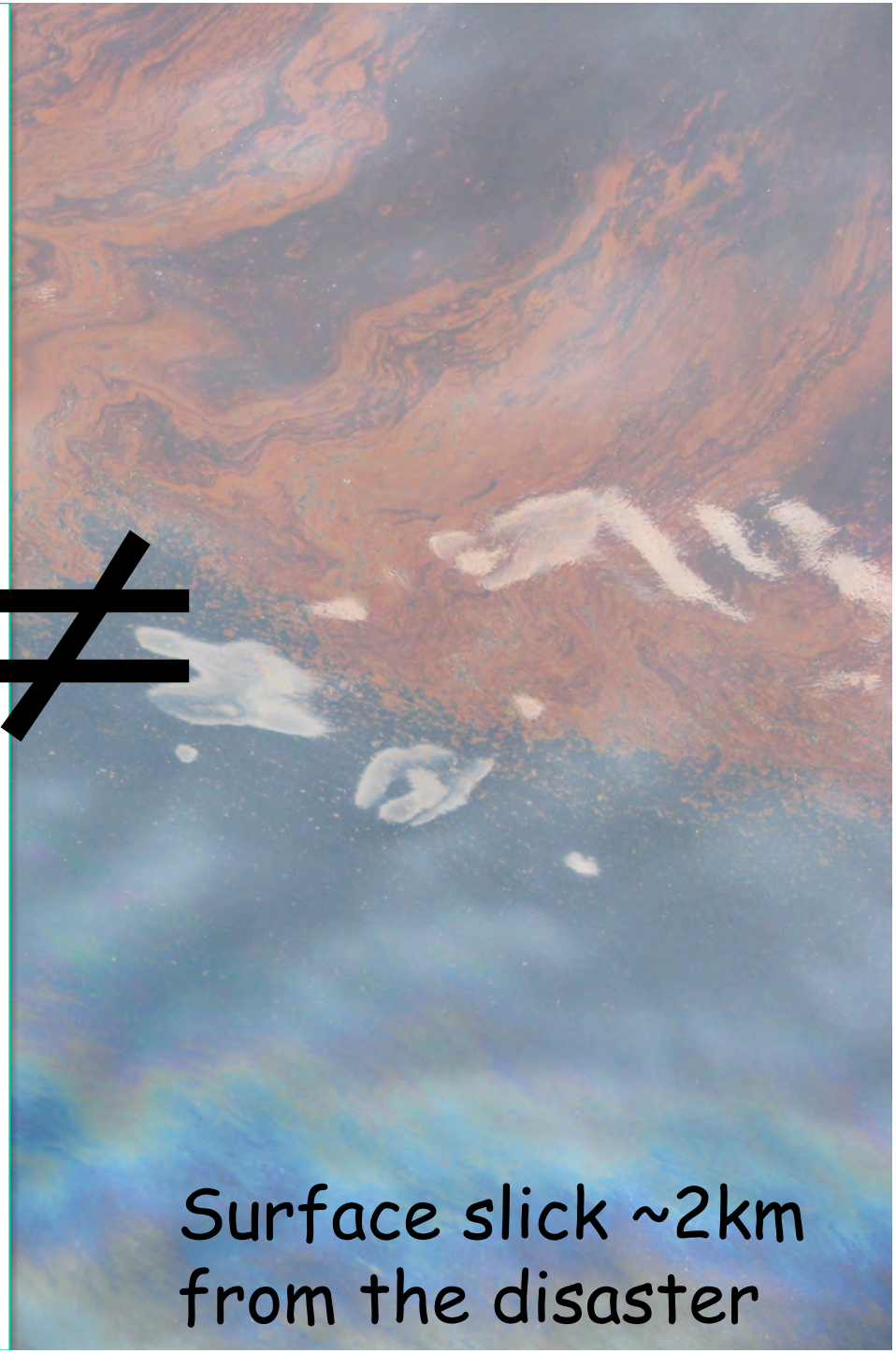

N
Continental shelf
DWH
Hydrocarbon plume at
1100 meters depth
Seafloor

Water collected in SW plume (late June ; 1100 m)

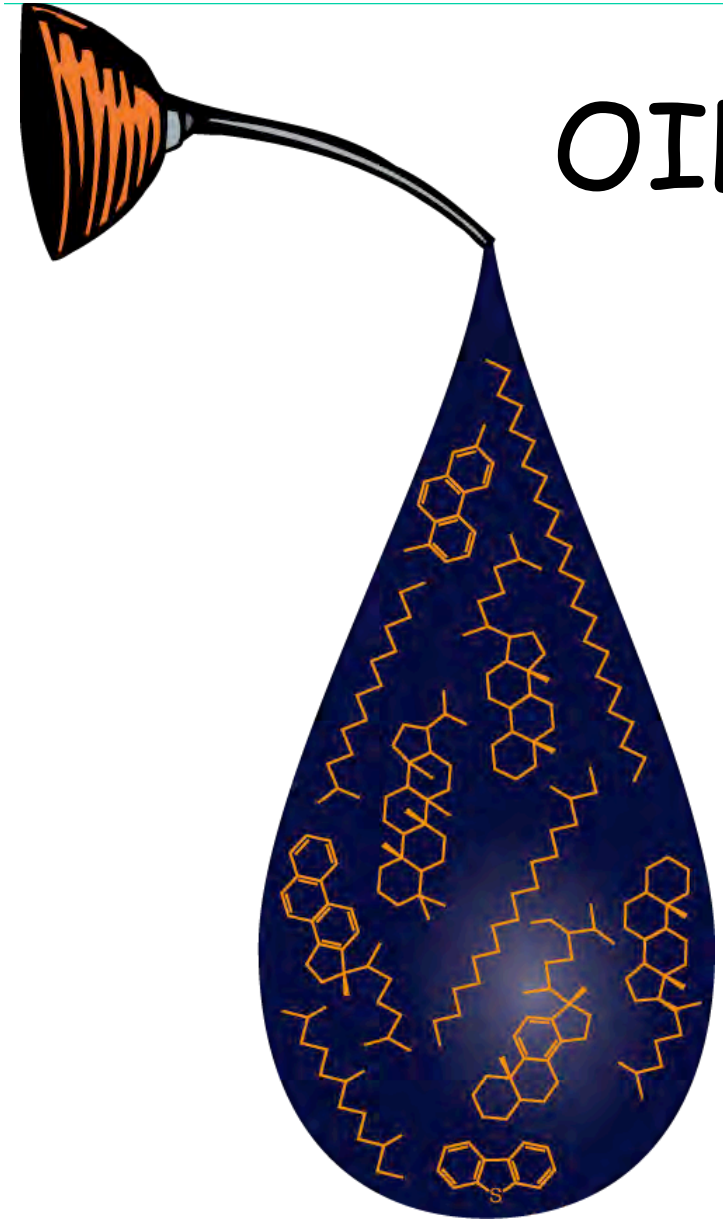


Source oil from
Macondo Well

≠



Surface slick ~2km
from the disaster



OIL

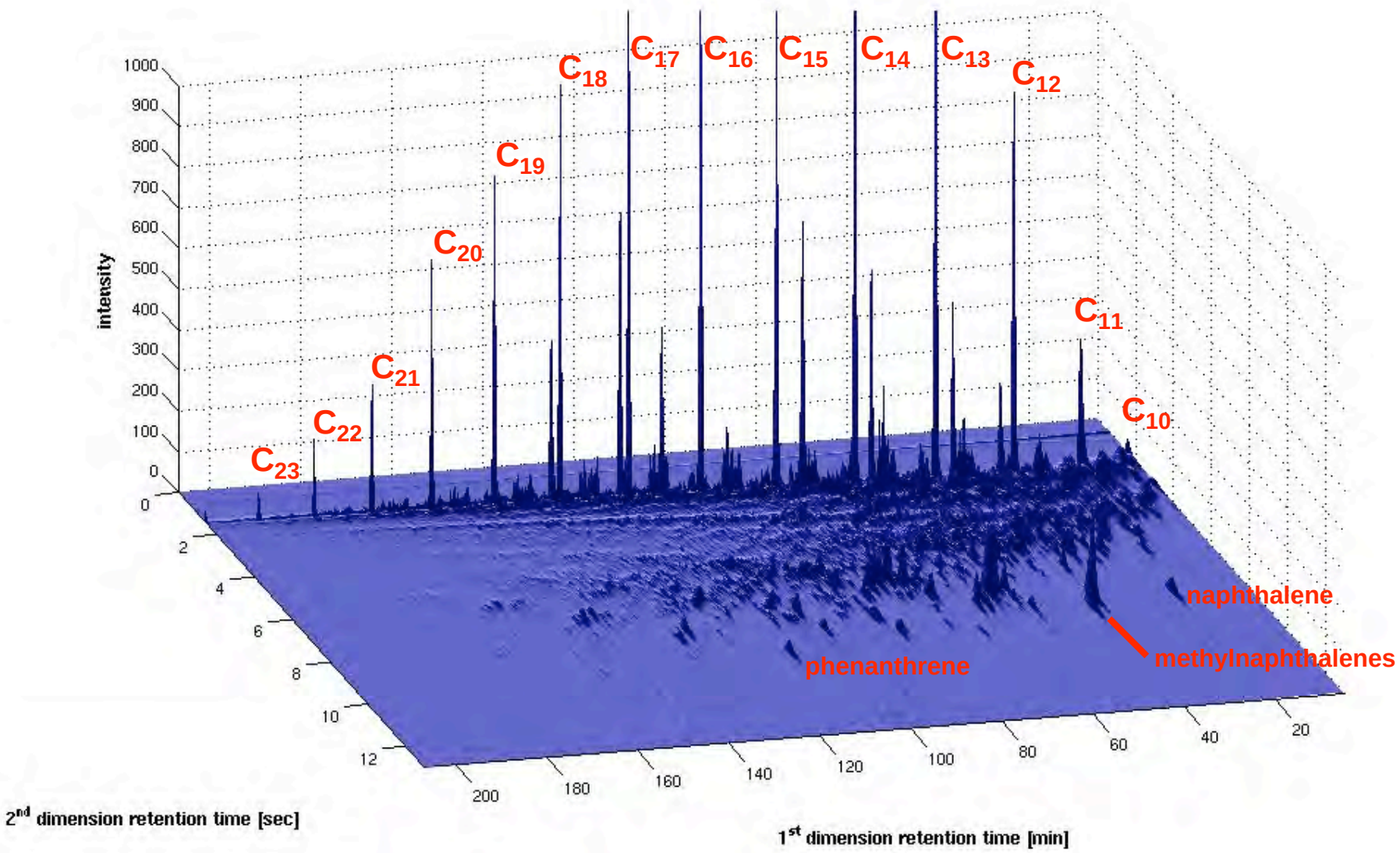
Source oil from Macondo Well

≠

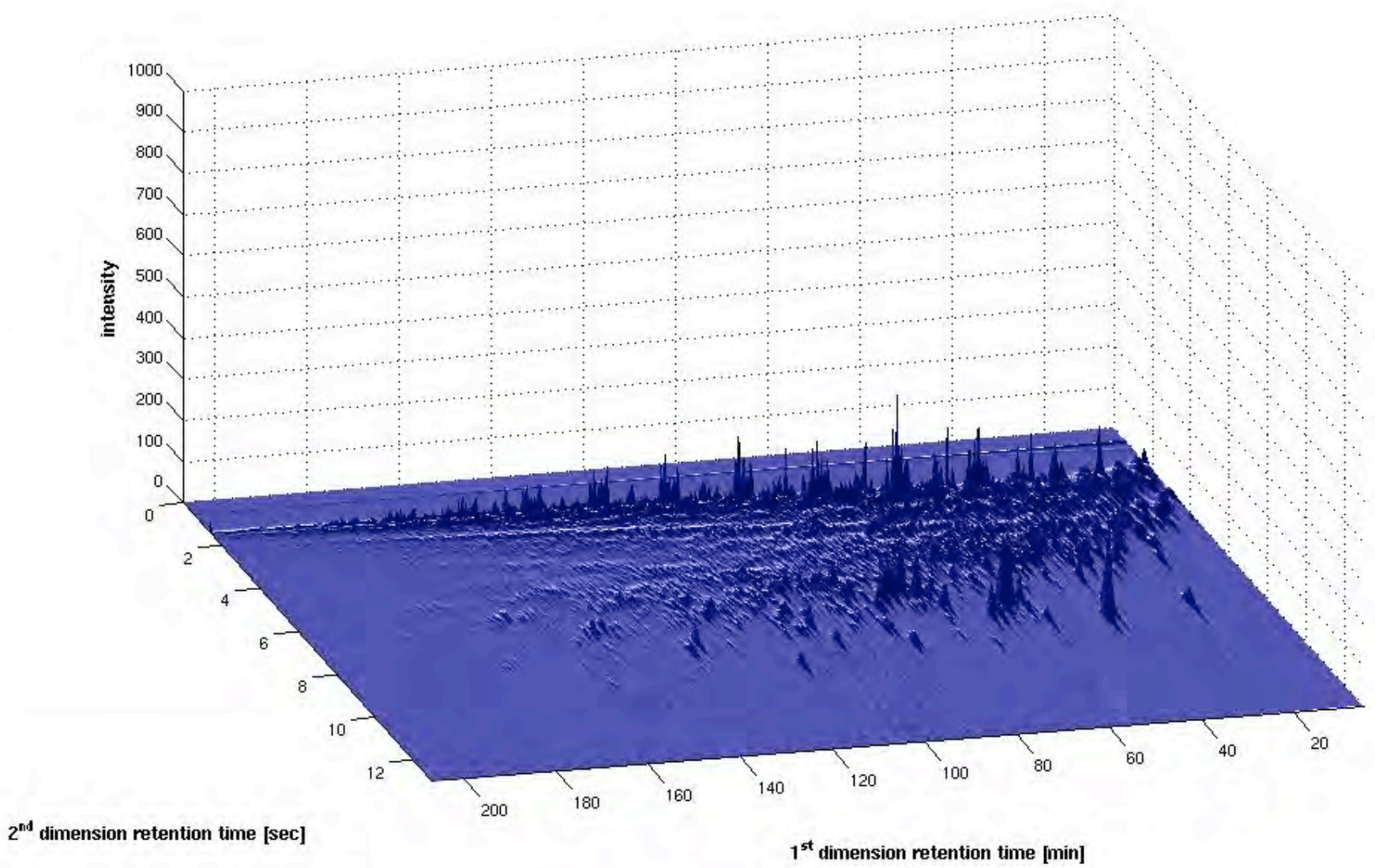
MIXTURE OF PETROLEUM HYDROCARBONS

Surface slick ~2km from the disaster

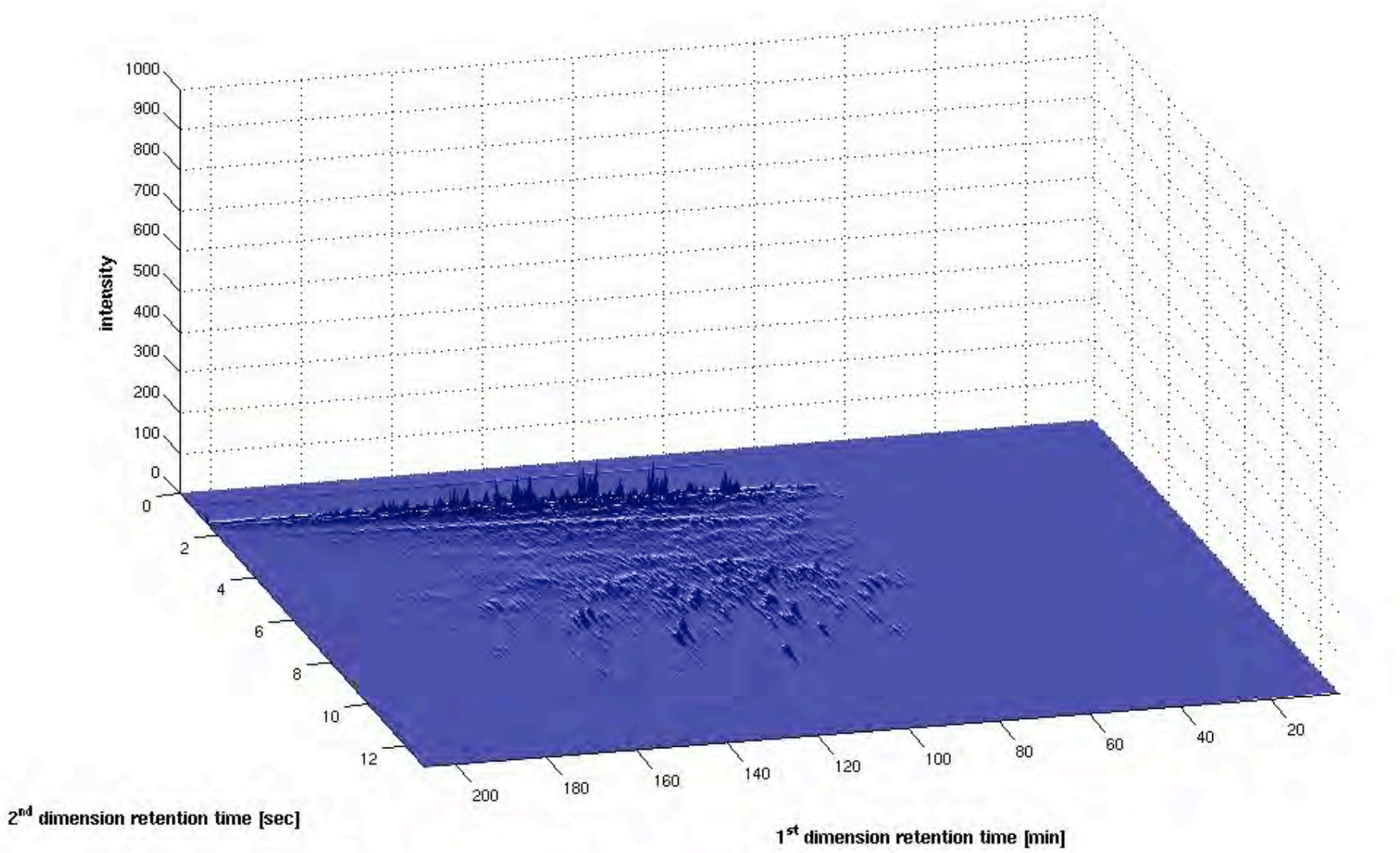
GCxGC chromatogram of fresh diesel fuel



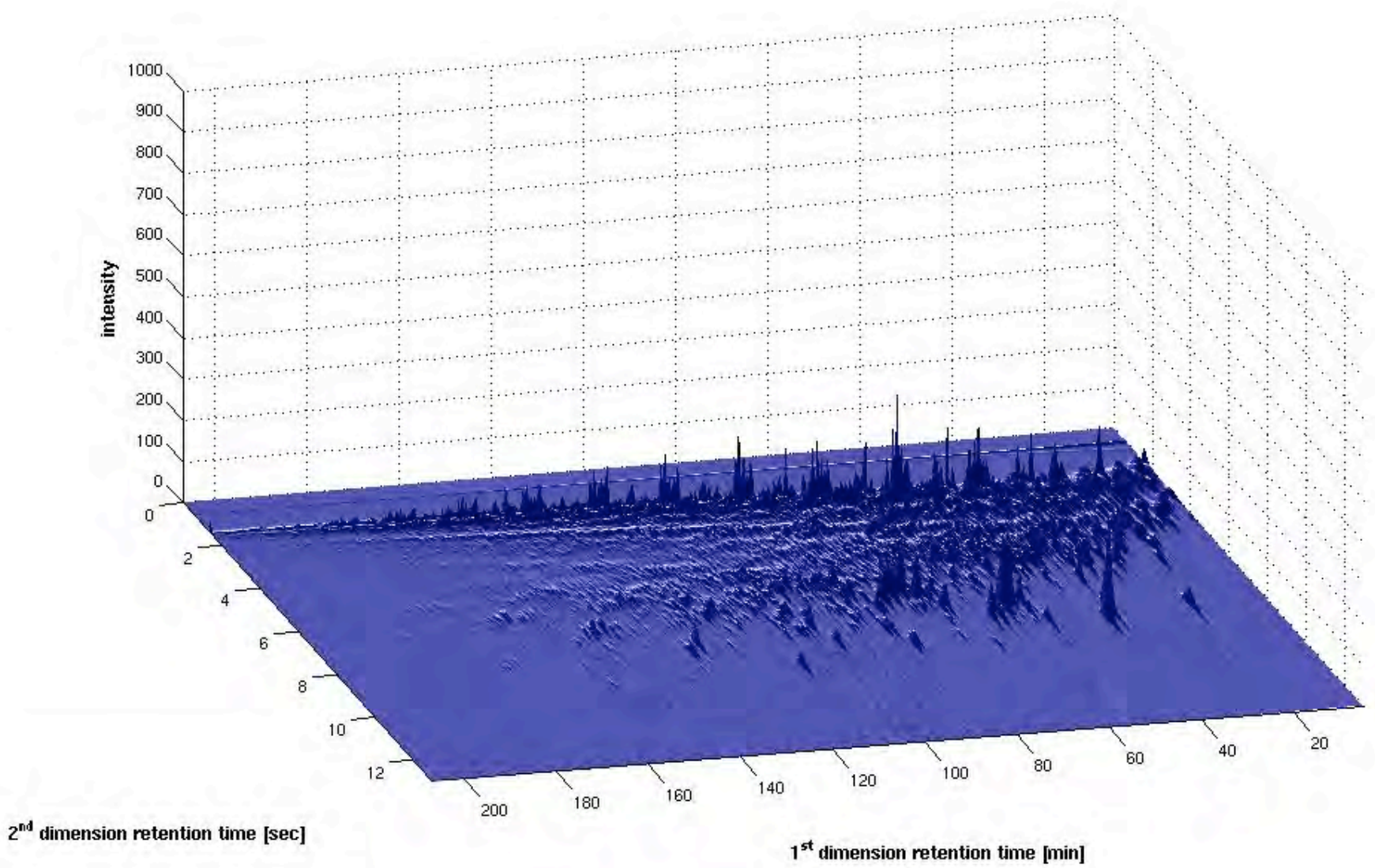
Fresh diesel fuel without alkanes



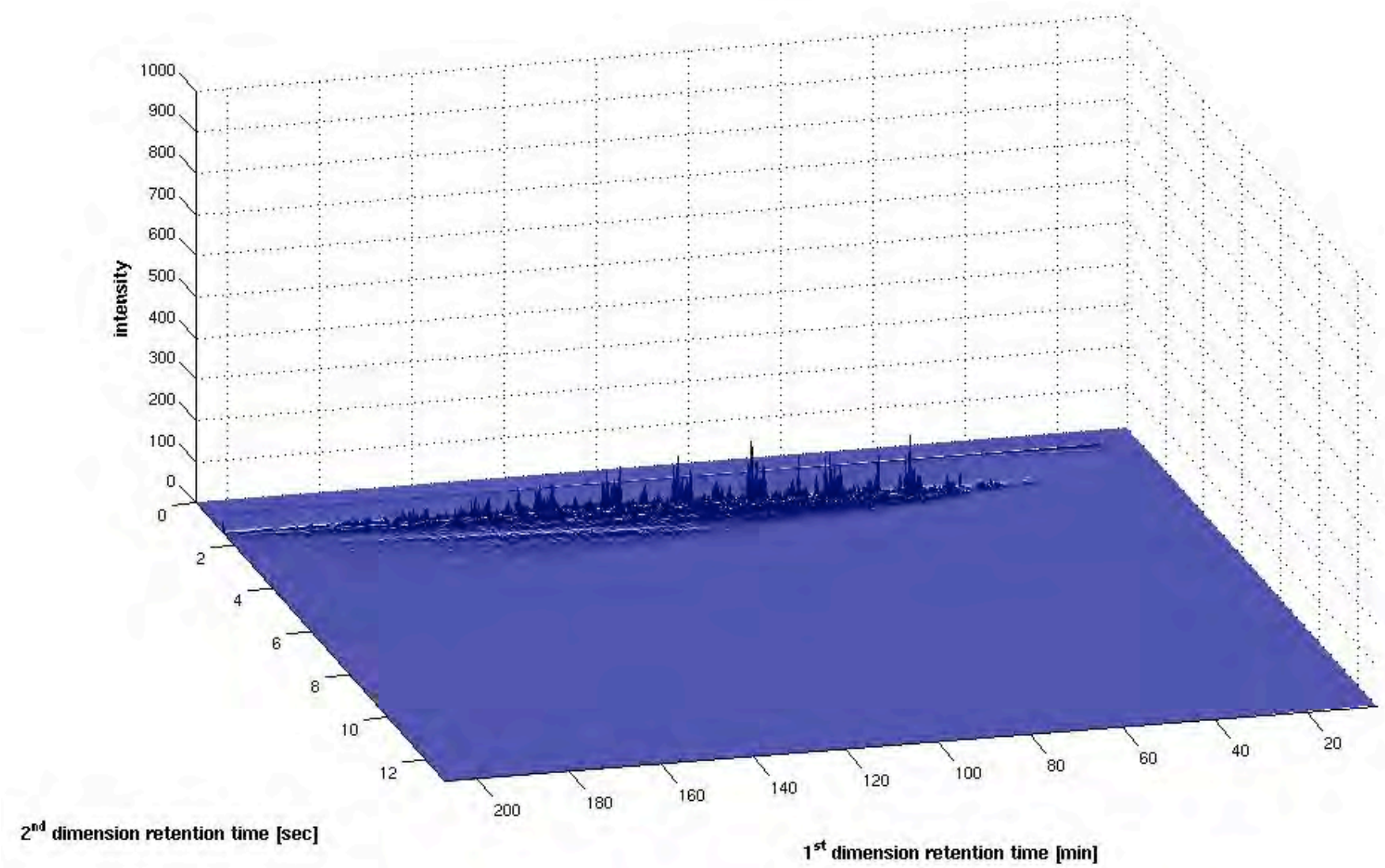
Fresh diesel fuel without alkanes; 75% evaporated (model)



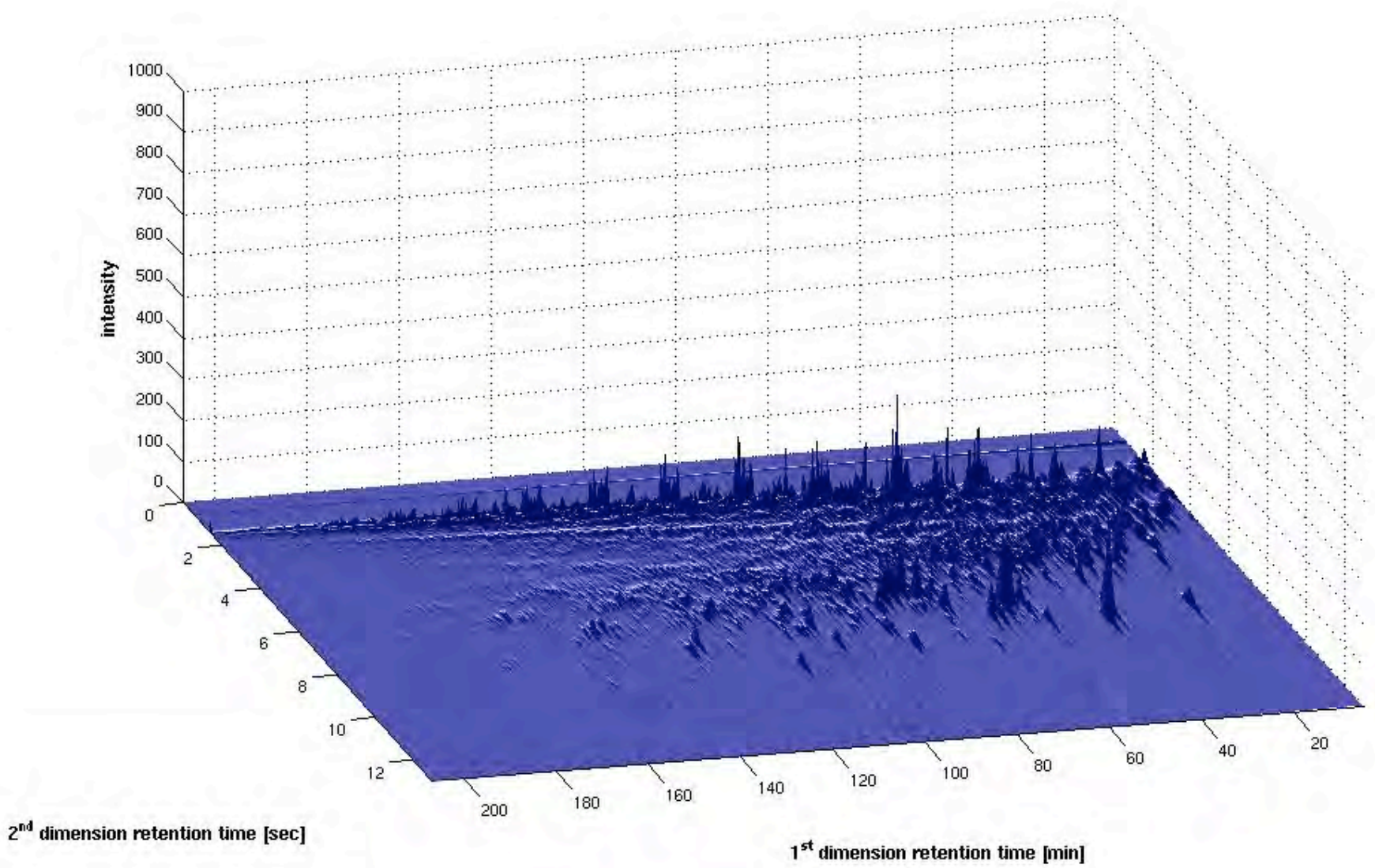
Fresh diesel fuel without alkanes



Fresh diesel fuel without alkanes; 75% water-washed (model)



Fresh diesel fuel without alkanes



Mixtures of hydrocarbons are changing

- Care should be taken that employ bulk analyses and convert to a "total" amount. The following is less than ideal:

→Total fluorescence * factor = total hydrocarbons in a sample

Buying a house

- Mass balance is important but also important where did specific compounds go?
- Spills are like buying a house, "location, location, location"
- Think past "bulk" hydrocarbon but on a compound-specific basis; provide invaluable clues on processes.

Is there a silver lining around this cloud?

- Anthropogenic releases of chemicals have been powerful tools for earth and environmental scientists (radiocarbon, Freons, lead, etc).

- Will this spill teach us something new about the Gulf of Mexico or the ocean in general?

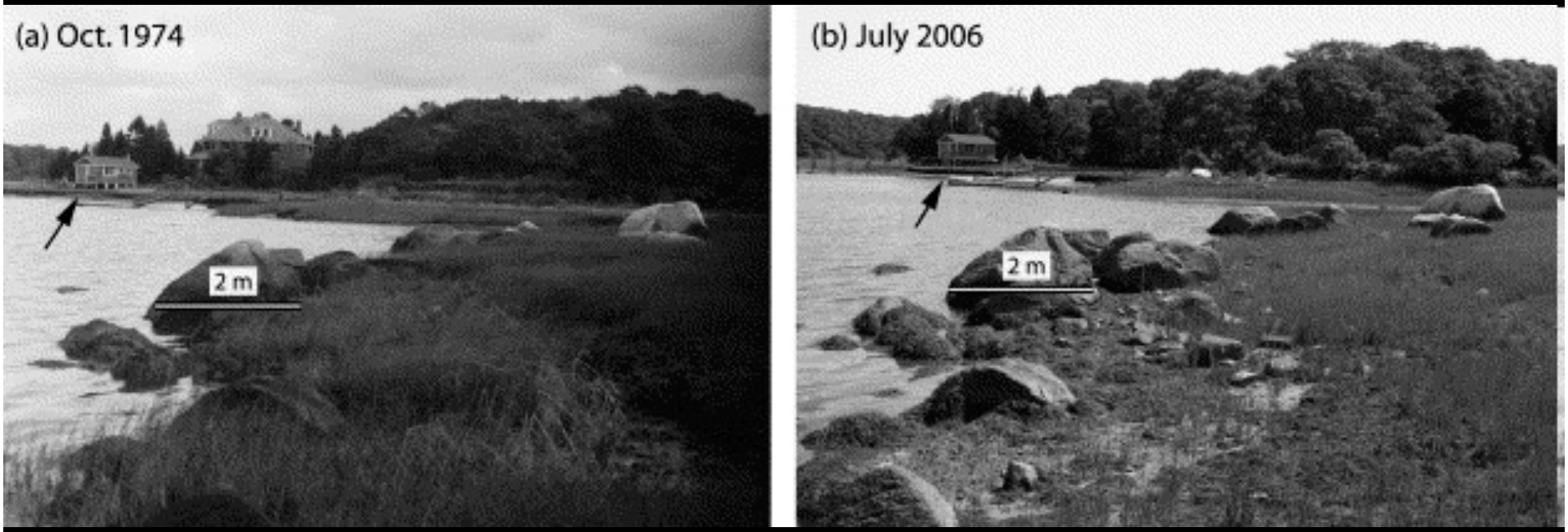
What can we develop or learn that will be fruitful in future spills?

- Initial studies will be very useful in new regulations or efforts to enforce current regulations.
- While we always plan for the last war, what can we do to help responders/scientists whether in deepwater, the Arctic, biofuels, etc?

My two cents

- Be shameless but lawful in the pursuit of samples/data/access.
- Take photos,
- Use chain-of-custody forms,
- Take samples even if you don't have the funds (when appropriate).
- Ask government officials on what you can do?
- Too many meetings already planned. Is this a good thing?

Take a lot of pictures



My two cents (II)

- Laboratory studies—very careful.
- When you publish, load-up the supplemental information.
- Look and ask for "set-asides"
- Are you short term or long term?
- Do great science.

Summary

- Get samples (tick tock)
- Patience
- Many samples in the queue
- Recognize that oil started to change quickly.
- Embrace analytical data and results from colleagues.
- Recognize limitations associated with big pictures calculations.

Panel (this afternoon)

Chair - Elizabeth North, U. Maryland, HPL/UMCES
-Ajit Subramaniam, Columbia University, Lamont Doherty Earth Observatory
-Michelle Wood, NOAA/AOML
-Robert Rosenbauer, USGS
-A.R. (Ravi) Ravishankara, NOAA