Developing the Scientific Basis for Future Deep Blowout Response Strategies: Center for Integrated Modeling and Analysis of Gulf Ecosystems

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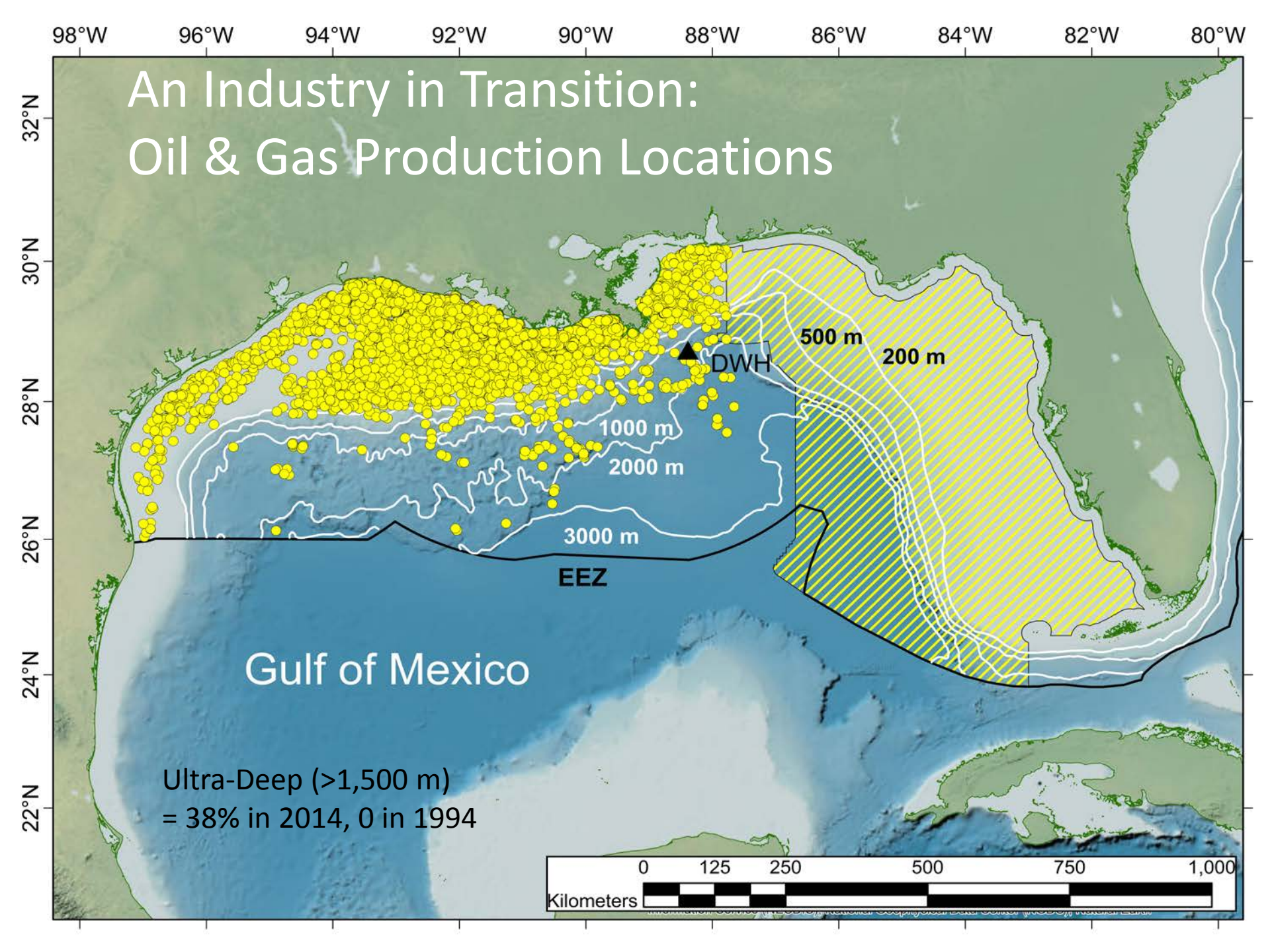
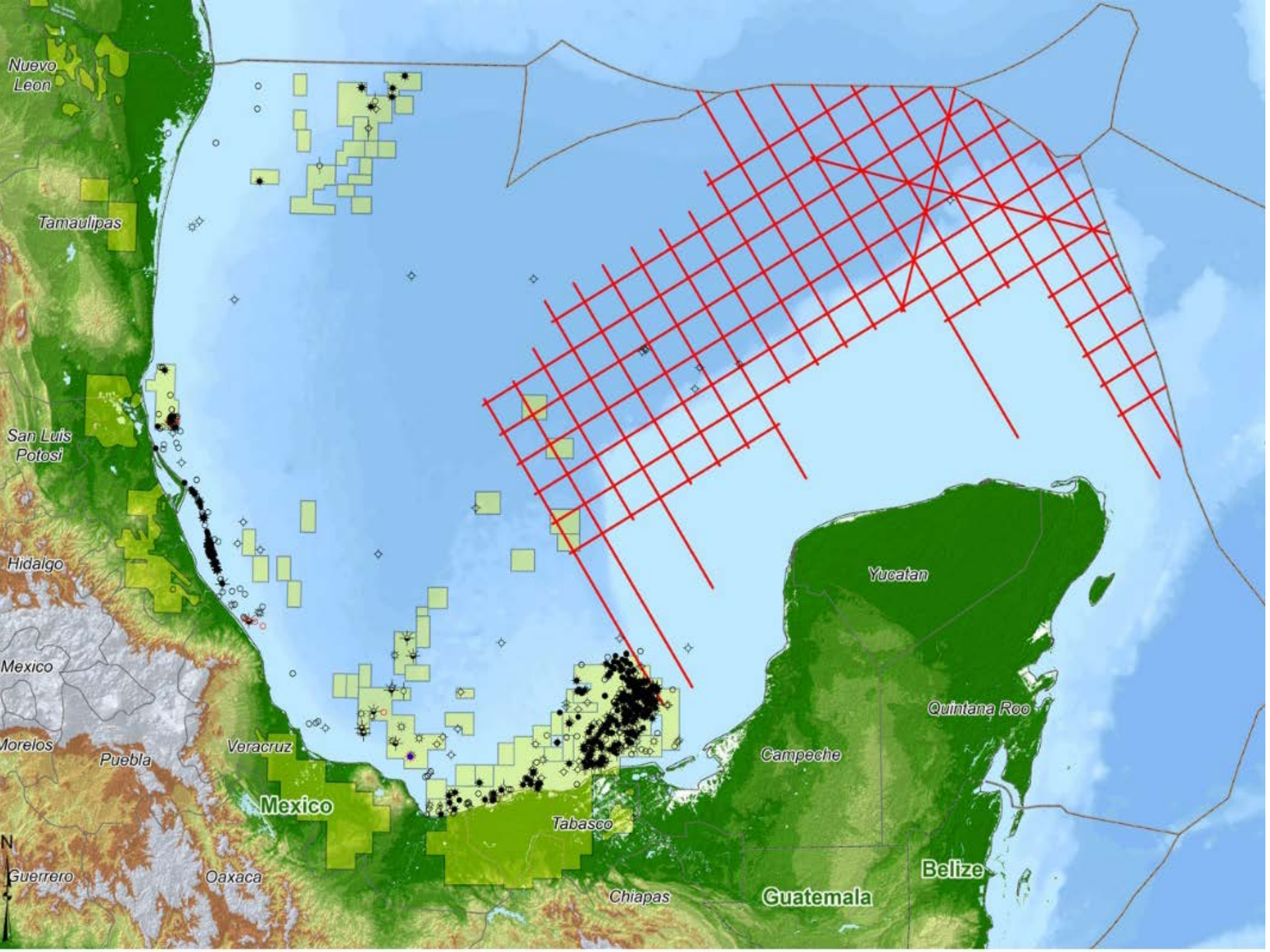
Clean Gulf Conference
Tampa
1 November, 2016

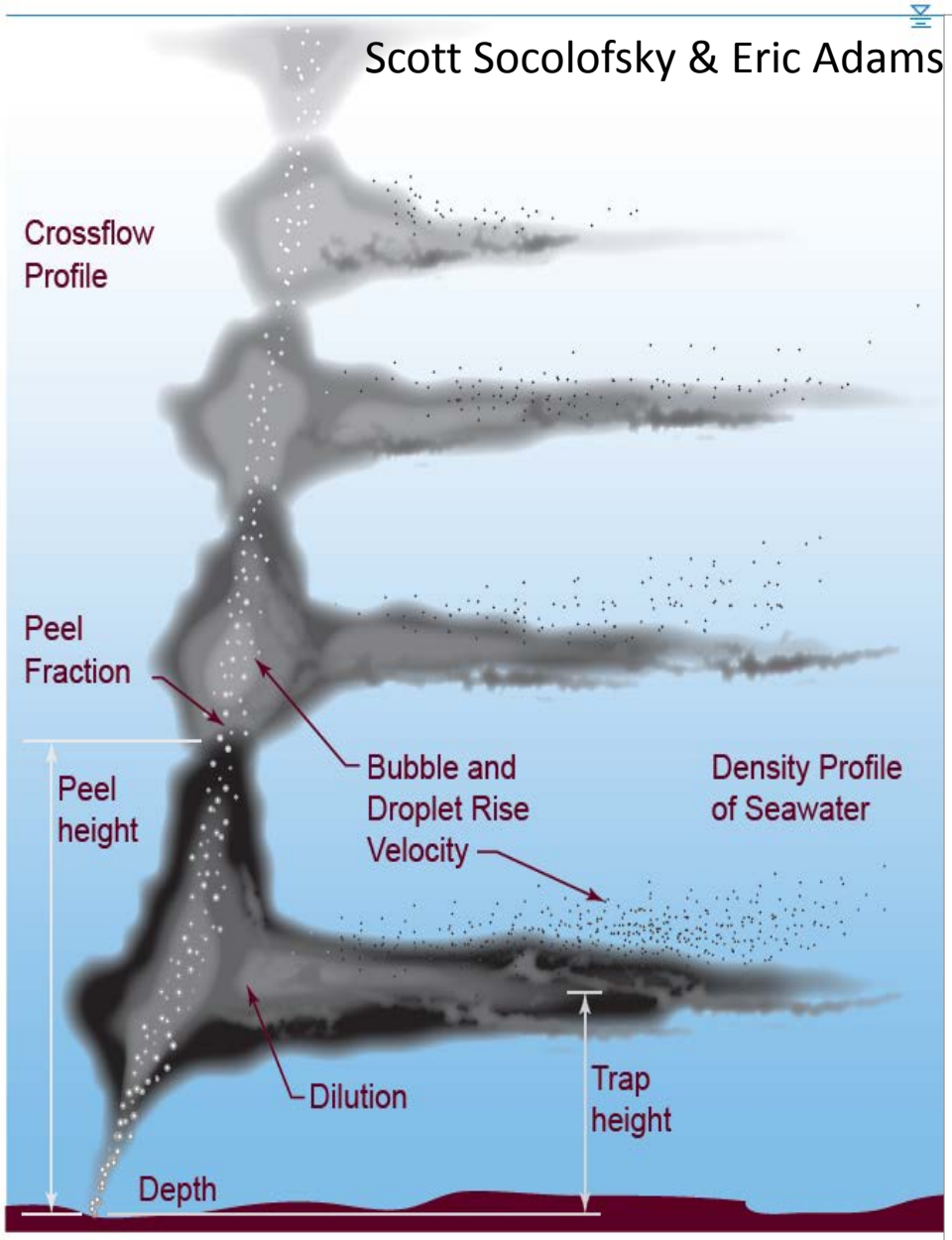

An Industry in Transition:
Oil & Gas Production Locations
98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
80°W
32°N
30°N
28°N
26°N
24°N
22°N
DWH
500 m
200 m
1000 m
2000 m
3000 m
EEZ
Gulf of Mexico
Ultra-Deep (>1,500 m)
= 38% in 2014, 0 in 1994
0
125
250
500
750
1,000
Kilometers

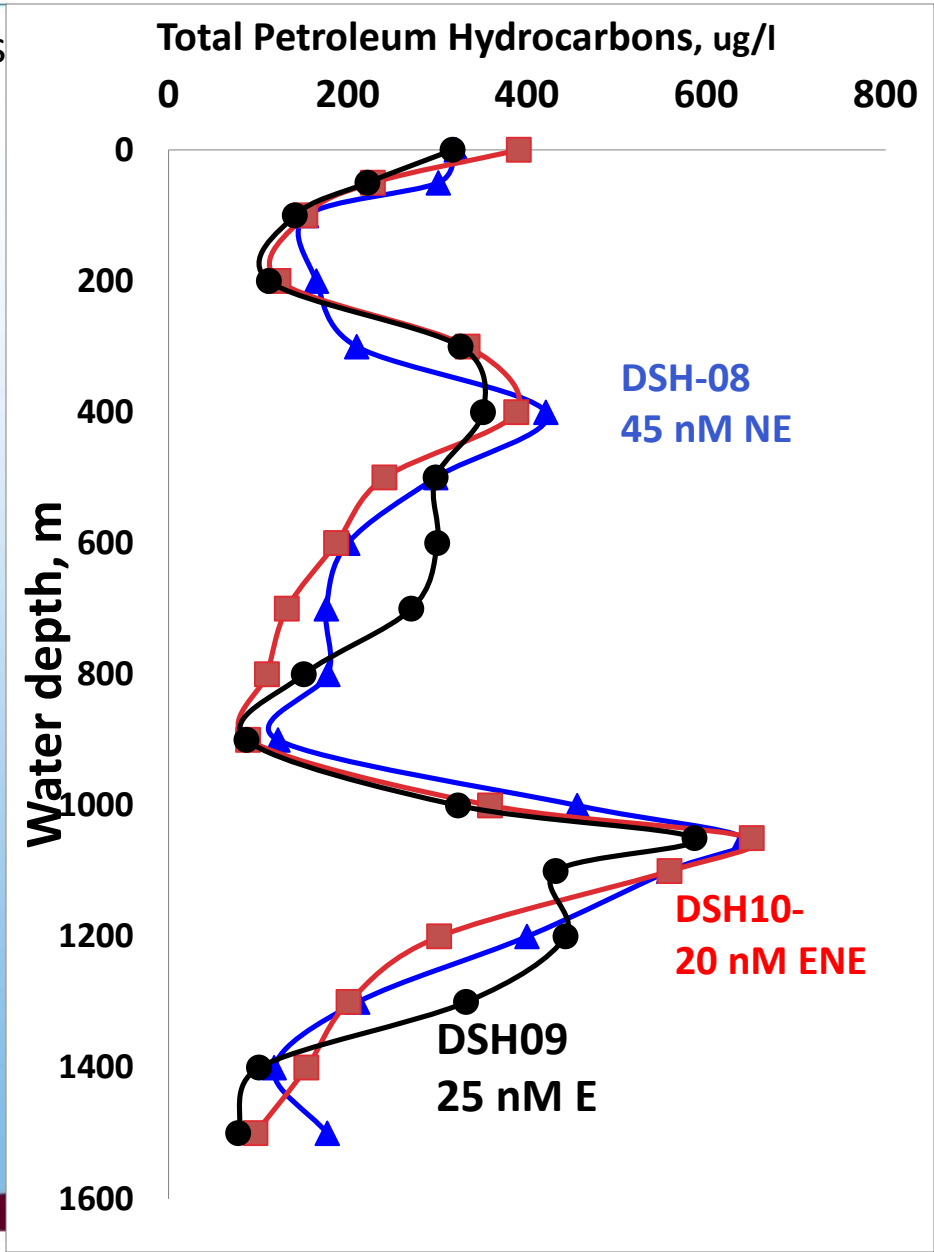

Nuevo Leon
Tamaulipas
San Luis Potosi
Hidalgo
Mexico
Morelos
Puebla
Veracruz
Mexico
Guerrero
Oaxaca
Tabasco
Chiapas
Campeche
Yucatan
Quintana Roo
Belize
Guatemala
N

Overview

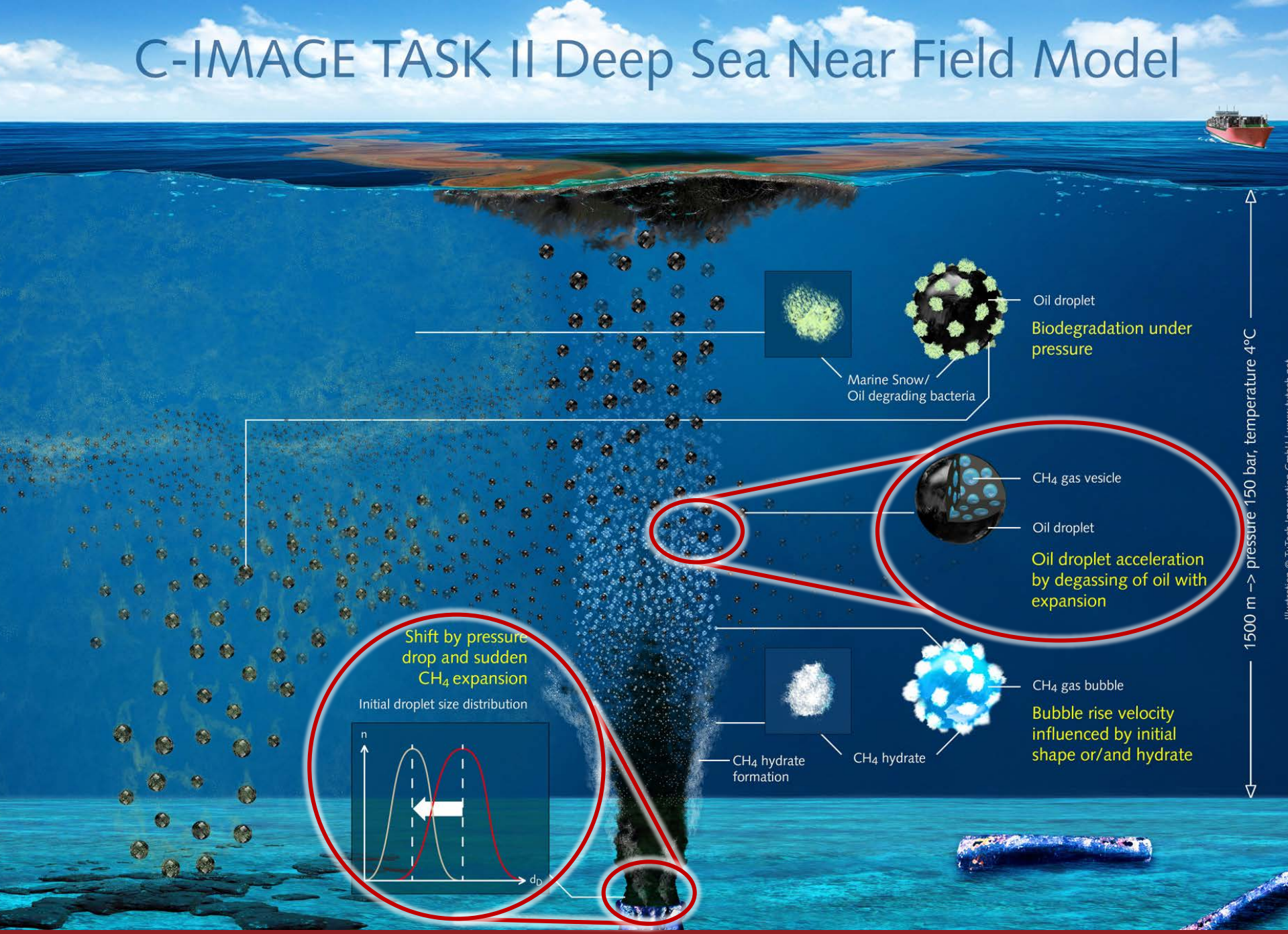
- ✓ Resolving the dilemma of deep dispersant injection
- ✓ Is manipulating marine snow a viable response strategy?
- ✓ Houston, we have a baseline!

Chemistry & Physics of Deep-water Blowouts





C-IMAGE TASK II Deep Sea Near Field Model



Influence of Δp and CH_4 saturation

TUHH
Hamburg University of Technology

pure LSC

Jet of „dead“
Surrogate Oil

replayed at 5 fps

$\Delta p_{nozzle} = 50\ bar$

$Q_{oil} = 1.6\ l/min$

LSC saturated with CH_4

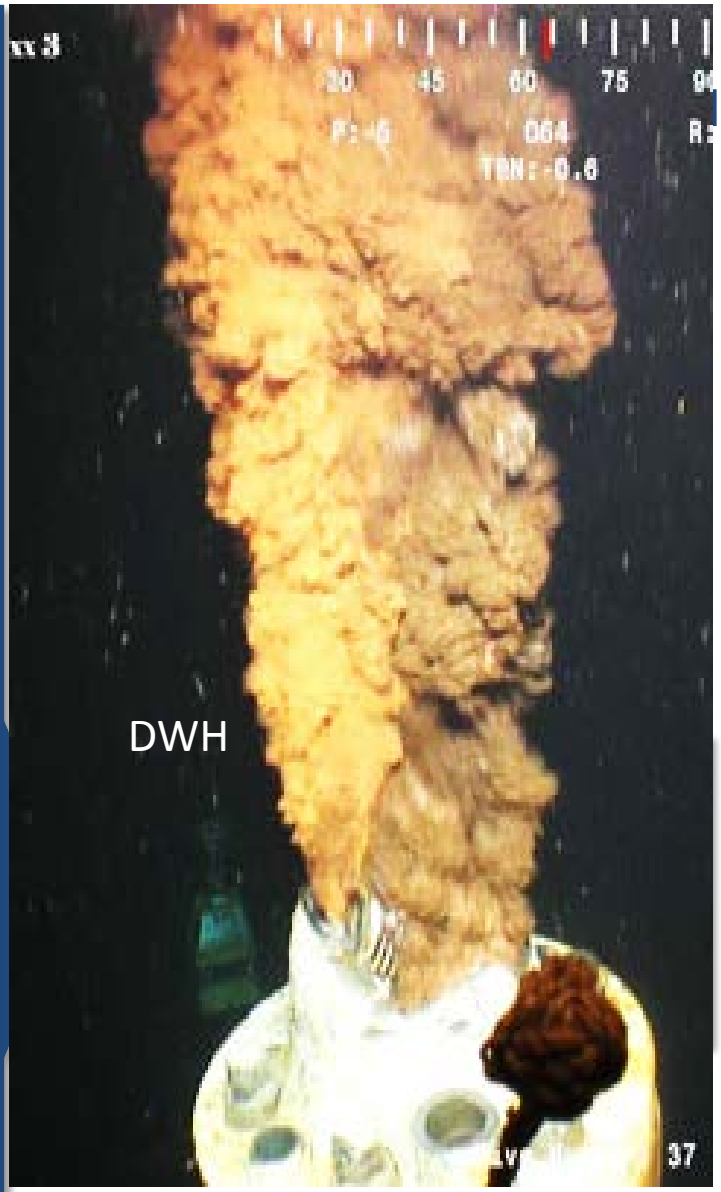
Jet of „live“
Surrogate Oil

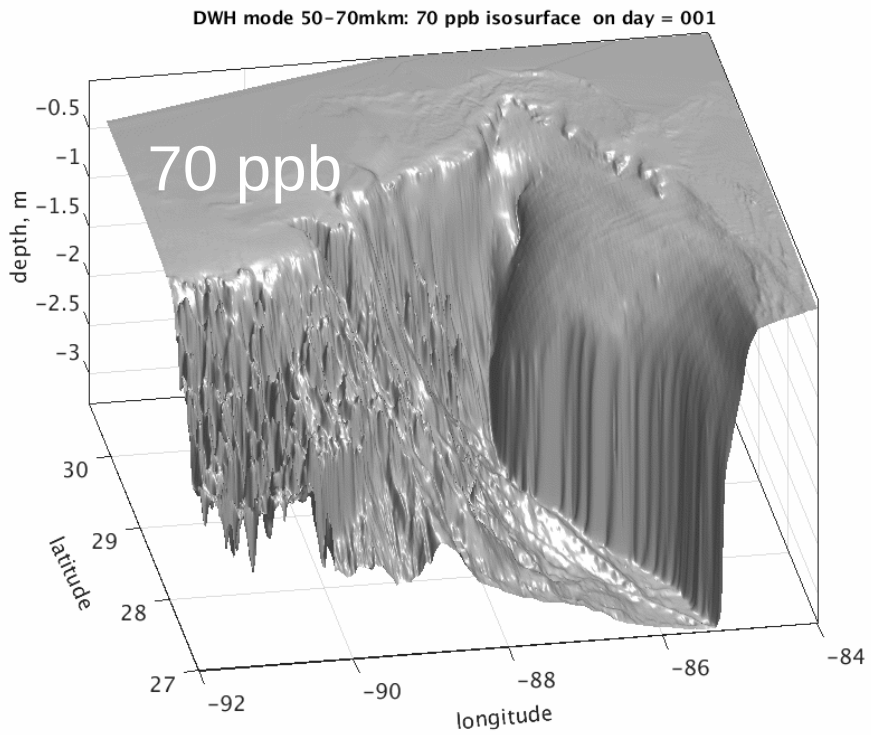
saturated with CH_4

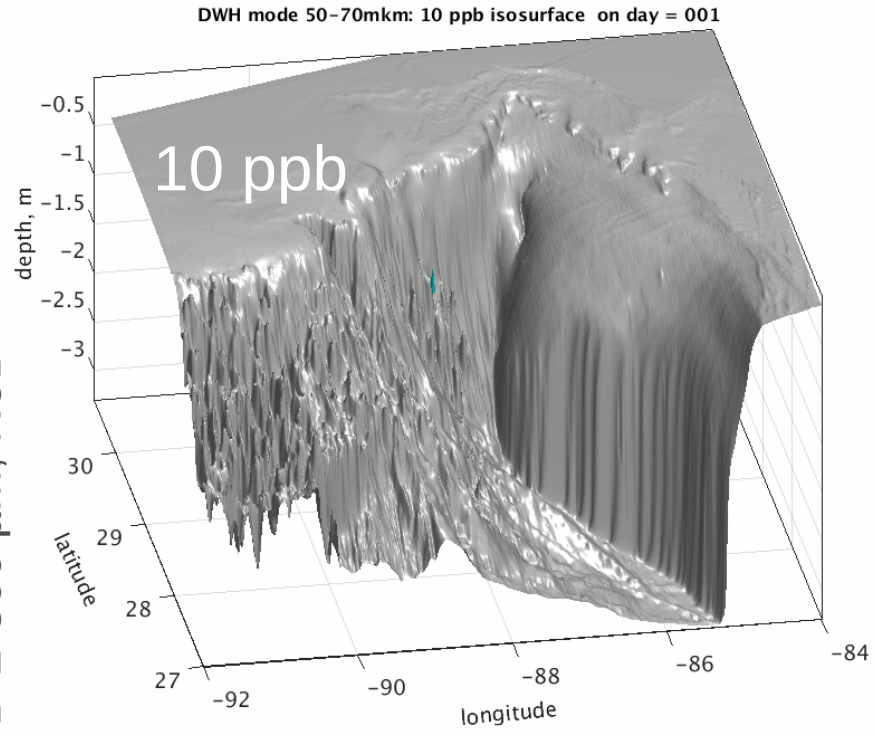
replayed at 5 fps

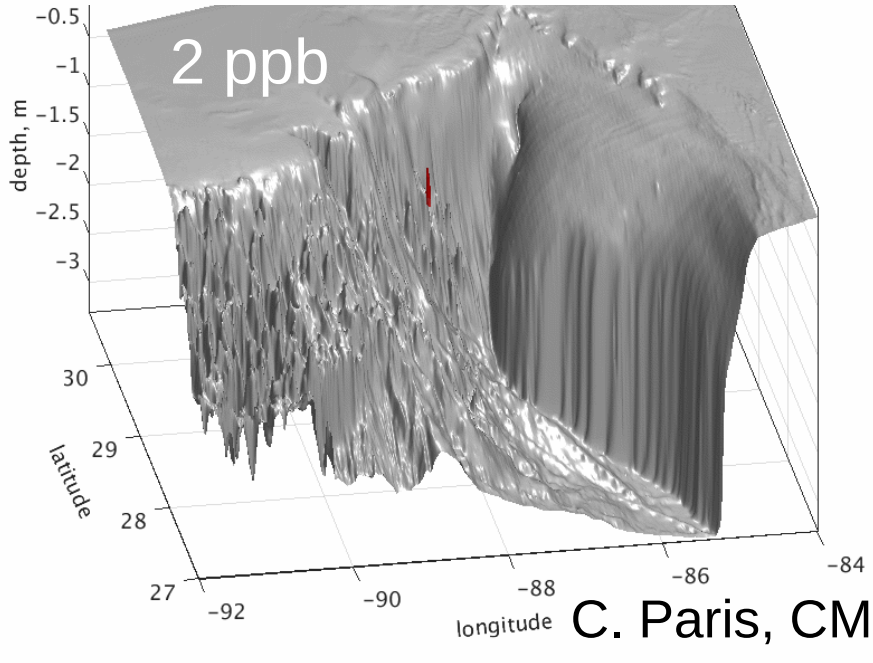
$\Delta p_{nozzle} = 50\ bar$

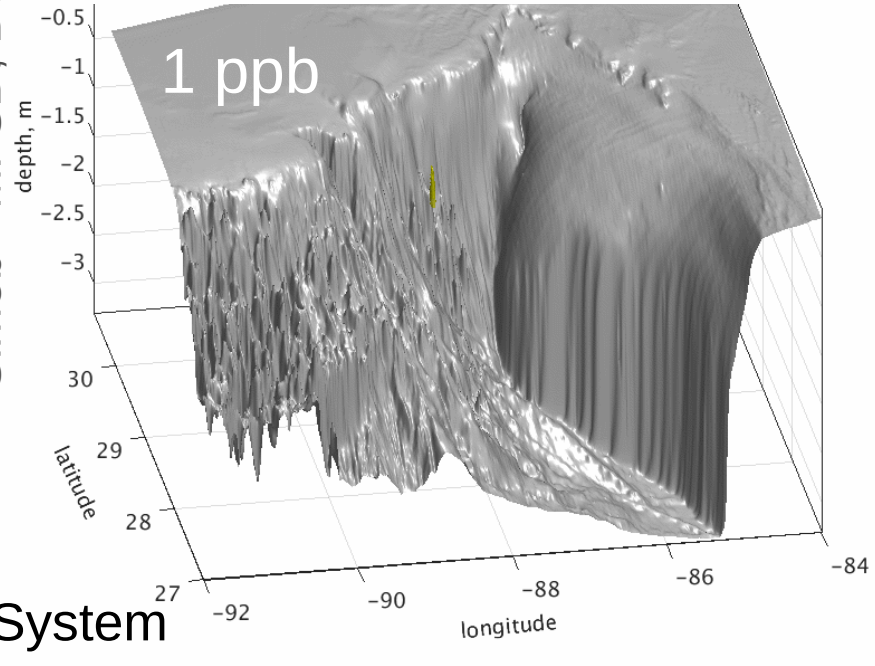
$Q_{oil} = 1.6\ l/min$







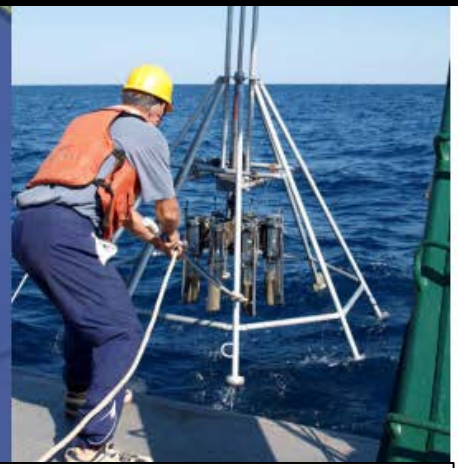




Sim3b - MFSD, DSD 1-300 µm, NoD

C. Paris, CMS System

Sediment Coring Sites in nGoM



Sediment Collection:

- Multicorer- 8 core/deployment
- Aug & Dec ‘10, Feb & Sept ‘11, Aug ’12-’16, ‘17 (proposed)
- Cores extruded @ high resolution
- 2 mm to 20 cm, 5 mm to 60 cm
- Immediately frozen or refrigerated

Methods:

1. Geochronology
   (^{234}Th, ^{210}Pb, MAR-gm/cm2/yr)
2. Sedimentology
   (Grain size , clays)
3. Organic Geochemistry
   (Org-C, aliphatic, PAH, polars)
5. Benthic Foraminifera
   (mortaility, recovery)
5. Microbial Ecology
   (community structure)
6. Redox metal chemistry
   (MnO_2- oxic, Re- anoxia)
7. Bulk ^{14}C
   (Org-C source indicator)

November 2010 | June 2011 | April 2012 | October 2012
December 2010/February 2011 | September 2011 | August 2012

C-IMAGE primary site
C-IMAGE secondary site

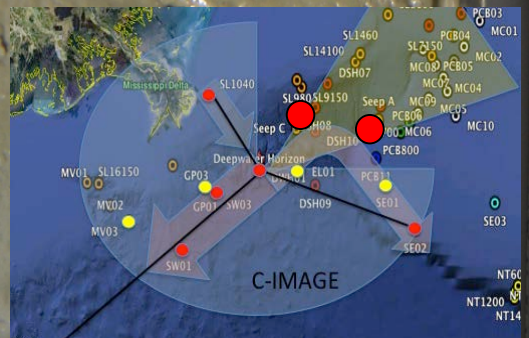
Sediment Cores Dec., 2010
1000-1200 m. “Plume Depth”

1047m Sediments
PCB-06 DeSoto Canyon
70 nm ENE of DWH

1115 m Sediments
DSH 08 (N-S line)
20 nm NE of DWH

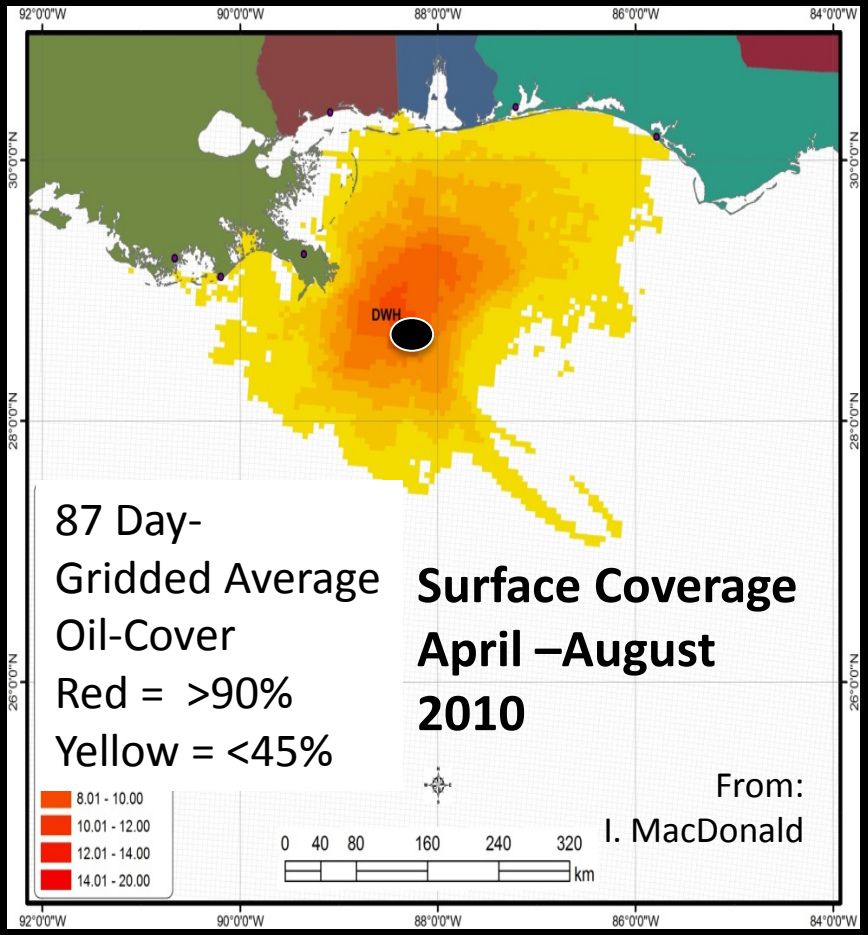
5 cm

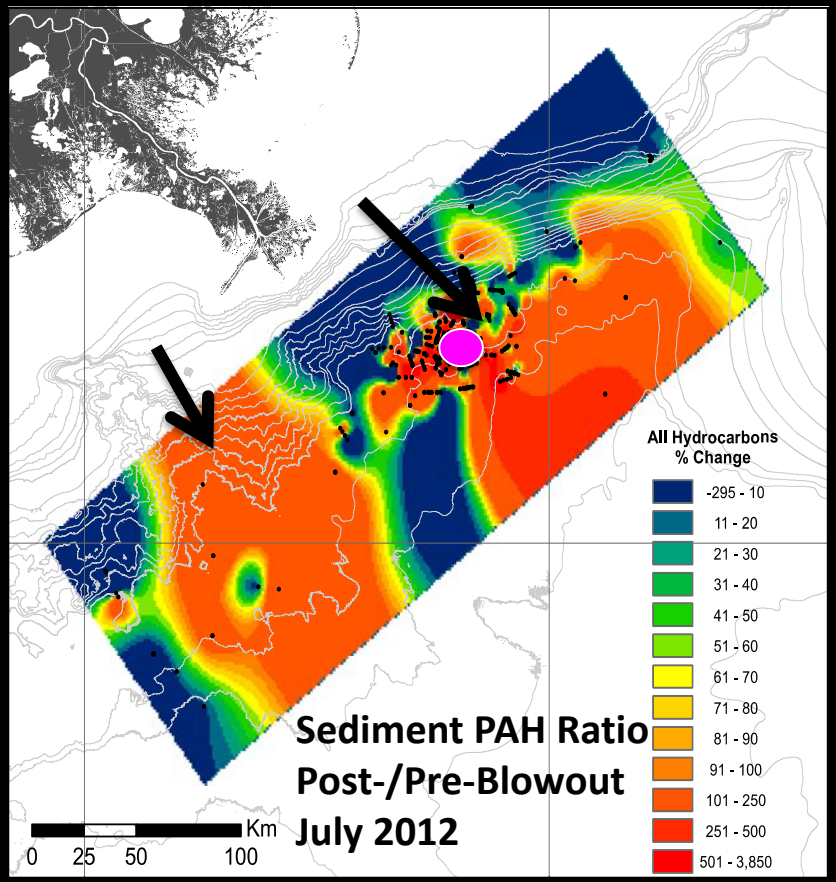
Look Closely….
Why no Bioturbation?

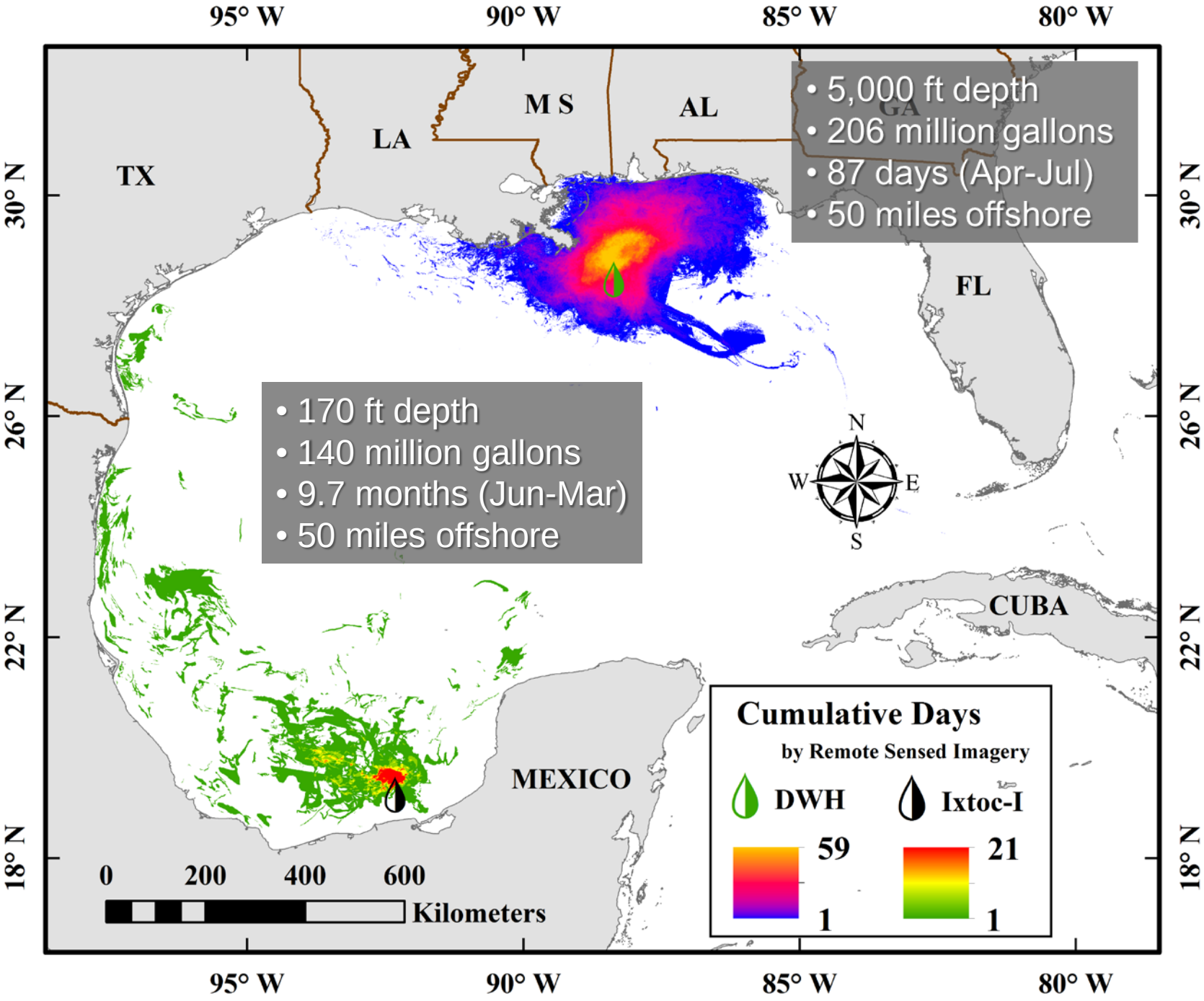


Major Sediment Discoveries by C-IMAGE

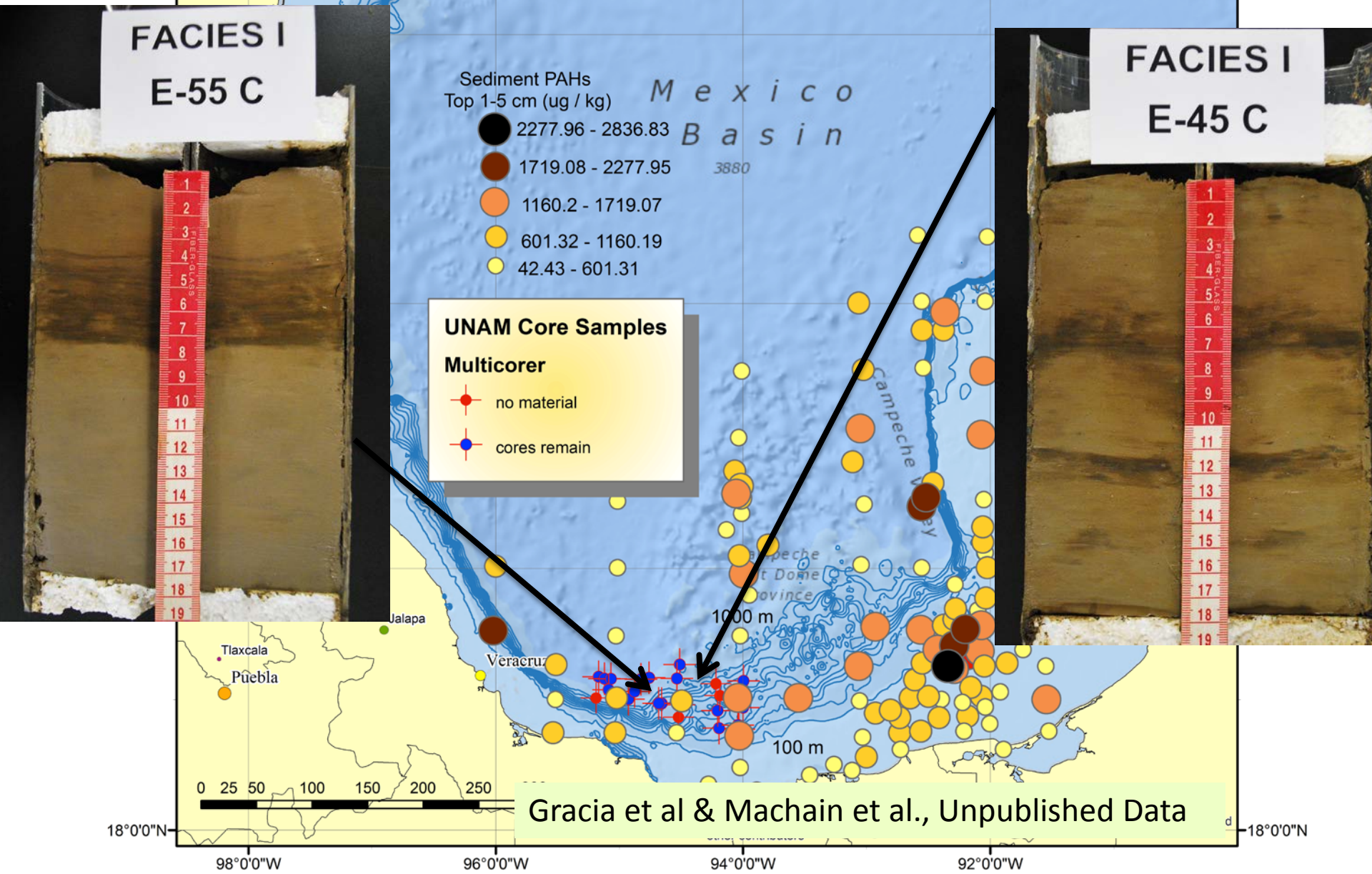
- Significant quantities of oil remain trapped in deep-sea sediments (4-10% of the total oil released to the ocean)
- Spatial & temporal offset between surface oil coverage & "foot-print" of sedimentary oil deposition





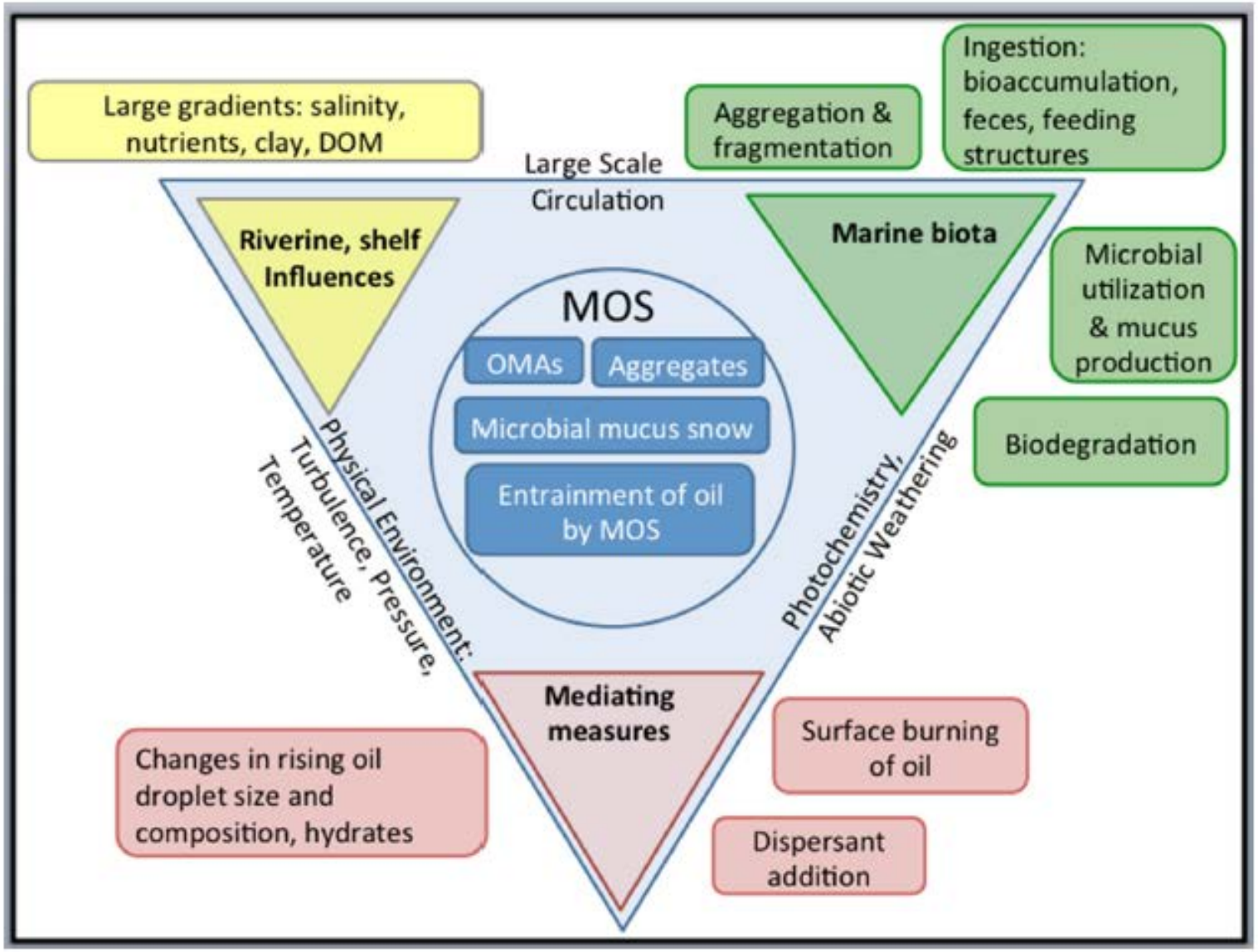

95° W
90° W
85° W
80° W
30° N
26° N
22° N
18° N
TX
LA
M S
AL
GA
FL
CUBA
MEXICO
• 5,000 ft depth
• 206 million gallons
• 87 days (Apr-Jul)
• 50 miles offshore
• 170 ft depth
• 140 million gallons
• 9.7 months (Jun-Mar)
• 50 miles offshore
N
W
E
S
Cumulative Days
by Remote Sensed Imagery
DWH
Ixtoc-I
59
1
21
1
0
200
400
600
Kilometers

IXTOC Sediment Core Locations
Surface Sediment PAH Distribution & Concentrations

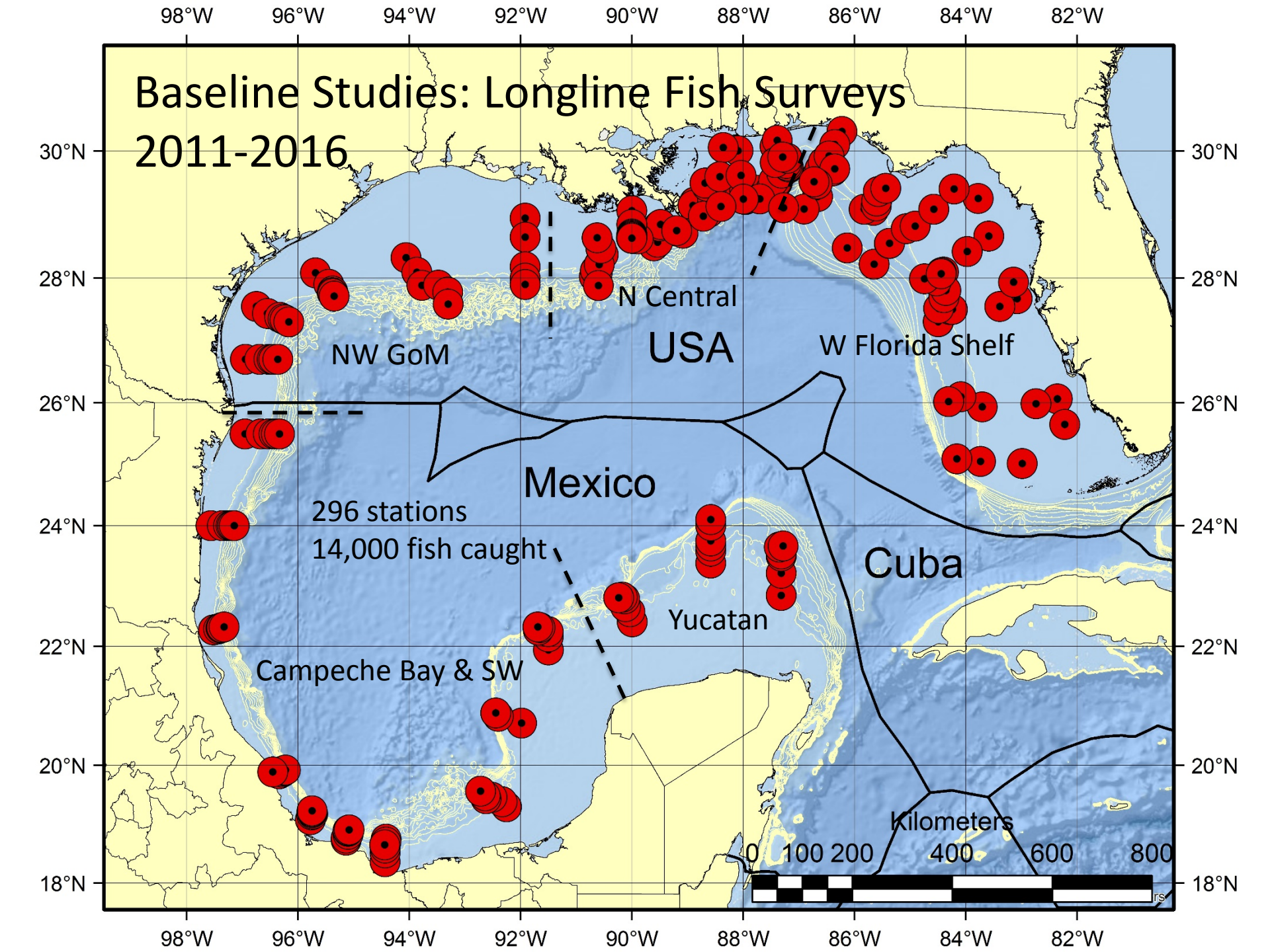


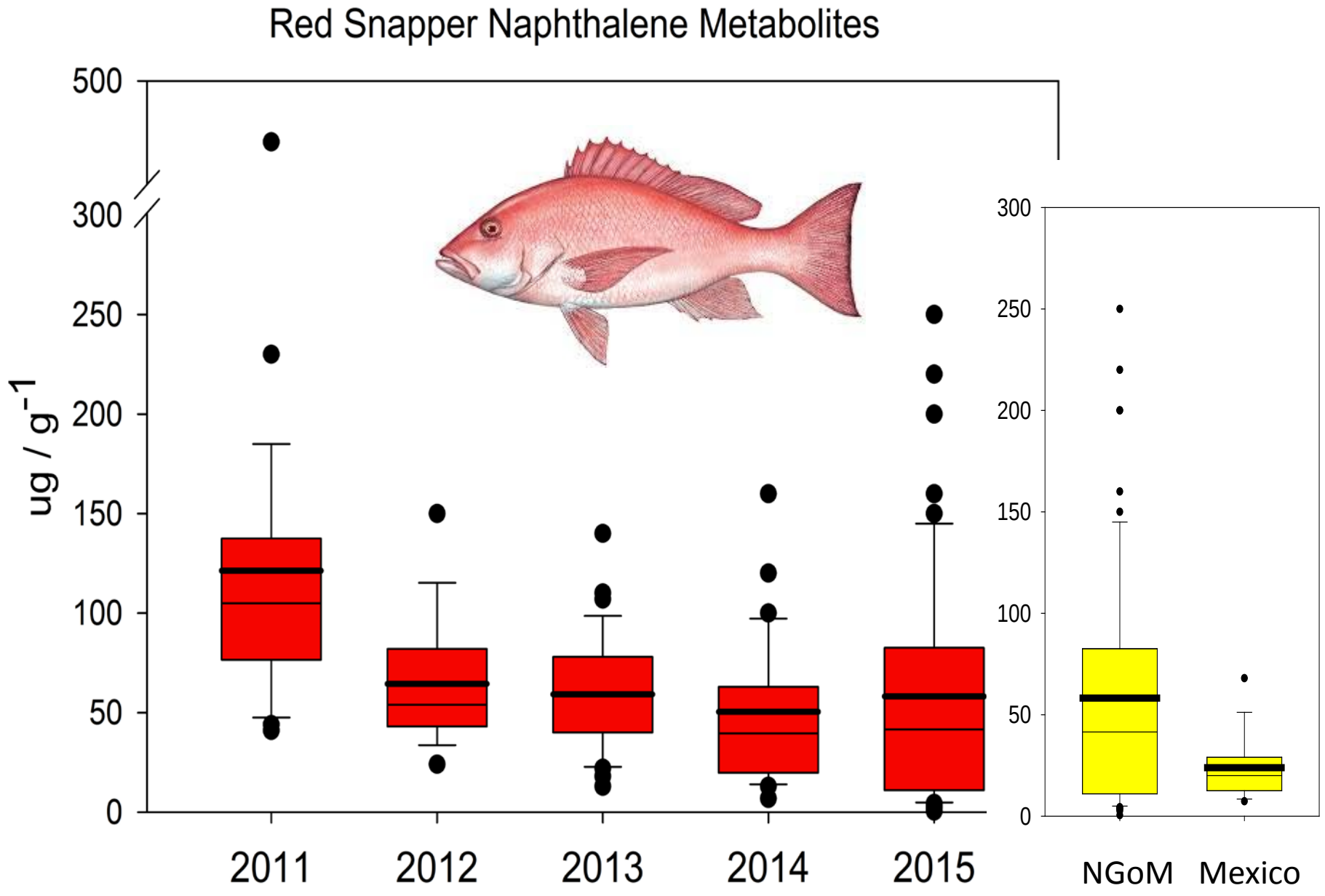
Gracia et al & Machain et al., Unpublished Data

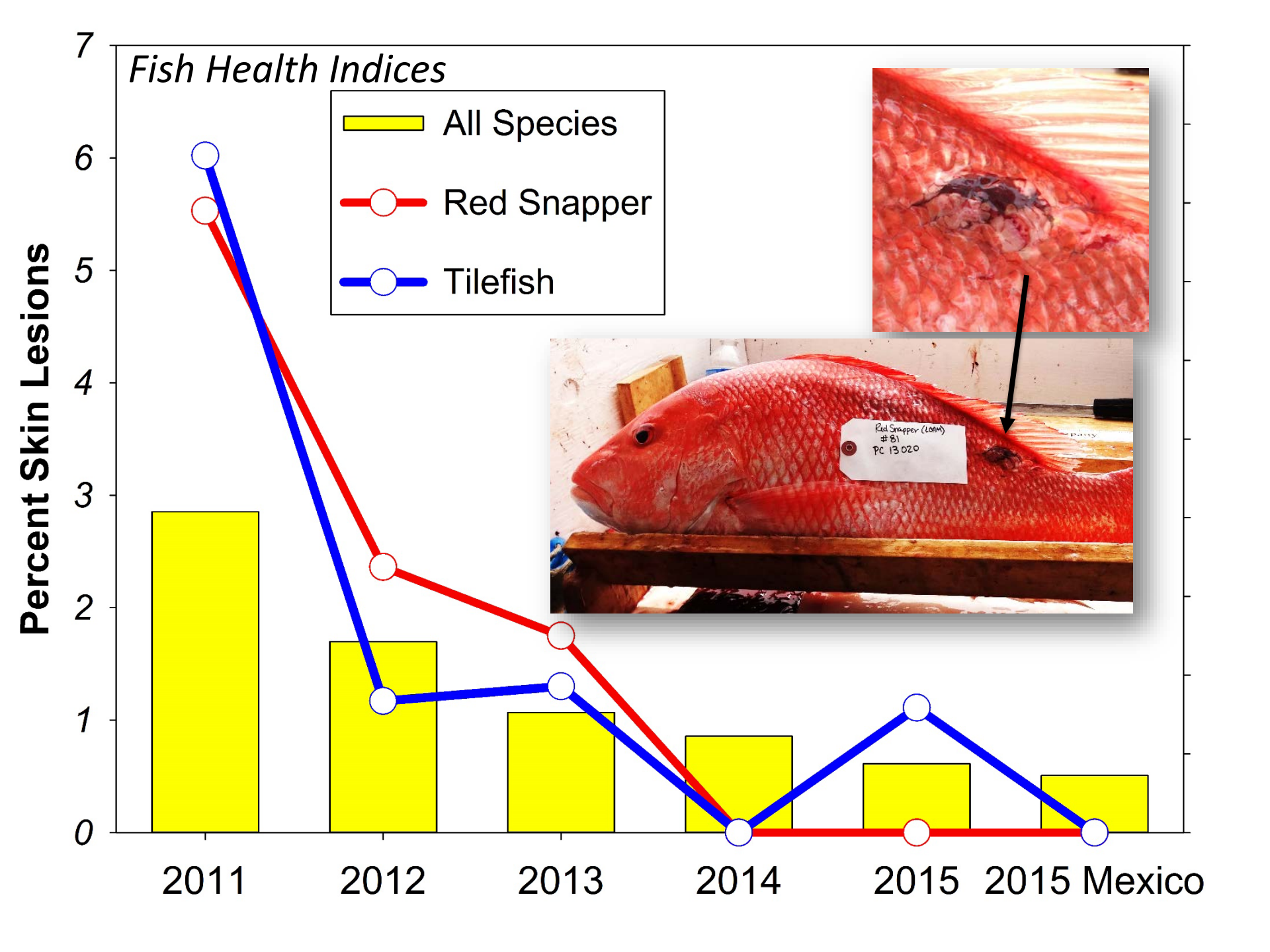
What Factors Determine a Marine Snow Event?



Daly, K., U. Passow, J. Chanton and D. Hollander. 2016. Assessing the impacts of oil-associated marine snow formation and sedimentation during and after the Deepwater Horizon oil spill. Anthropocene 13:18-33.


Baseline Studies: Longline Fish Surveys
2011-2016
98°W
96°W
94°W
92°W
90°W
88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
22°N
20°N
18°N
N Central
USA
NW GoM
W Florida Shelf
Mexico
296 stations
14,000 fish caught
Cuba
Yucatan
Campeche Bay & SW
Kilometers
0 100 200 400 600 800


Red Snapper Naphthalene Metabolites
ug / g-1
500
300
250
200
150
100
50
0
2011
2012
2013
2014
2015
NGoM
Mexico


Fish Health Indices
All Species
Red Snapper
Tilefish
Percent Skin Lesions
0
1
2
3
4
5
6
7
2011
2012
2013
2014
2015
2015 Mexico
Red Snapper (LOAM)
#81
PC 13020

Summary

- ✓ The relative contribution of dispersants to deep plume formation is a high priority, but is as yet unresolved
- ✓ MOSSFA is probably more prevalent that once assumed, to what extent is it predictable? Can or should marine snow be considered a response strategy?
- ✓ Considerable new baseline information available in the advent of another large-scale spill, but not at the facility level. Policy?


Questions?

Backup Slides

C-IMAGE II- A Global Consortium of 18 Institutions

Objective: *to advance understanding of the fundamental processes and mechanisms involved in marine blowouts and their environmental consequences, ensuring that society is better-prepared to mitigate such future events.*

- University of South Florida (Lead)
- Florida Institute of Oceanography
- Eckerd College
- University of Miami
- University of West Florida
- Florida State University
- Mote Marine Lab
- Technical University of Hamburg (Germany)
- University of South Alabama
- Texas A&M University
- Wageningen University (Netherlands)
- University of Calgary (Canada)
- Scripps Institute of Oceanography
- Pennsylvania State University
- Hart Research Institute, TAMU
- UNAM University (Mexico City)
- Georgia Tech
- Woods Hole Oceanographic Institution

C-IMAGE-II

Some Critical Questions Yet to be Fully Answered...

- What conditions (e.g., clay particle density, oil volume, dispersant use, etc.) lead to MOSSFA formation and mass accumulation? Can we predict when MOSSFA will occur?
- What constitutes a "resilient" ecosystem to perturbations such as marine blowouts?
- How persistent are PAHs and other oil components in the environment? In biota? How does DWH relate to other sources in the pollution budget of the Gulf of Mexico?
- What was the relative contribution of dispersants and ambient conditions to the formation of deep oil droplet plumes in DWH? How would this change with a different crude, depths, temperatures?
- Why did models of bacterial degradation fail to predict the lack of hypoxia in deep plumes formed of degrading oil droplets?

GULF OF MEXICO RESEARCH INITIATIVE