"Secondhand" MOSSFA in the Deep Gulf of Mexico – a Smoking Gun

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Crew of the Point Sur

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ECOGIG
REDIRECT
Resuspension, Redistribution and Deposition of DwH Recalcitrant Hydrocarbons to offshore Depocenters

Firsthand MOSSFA

~May 2010

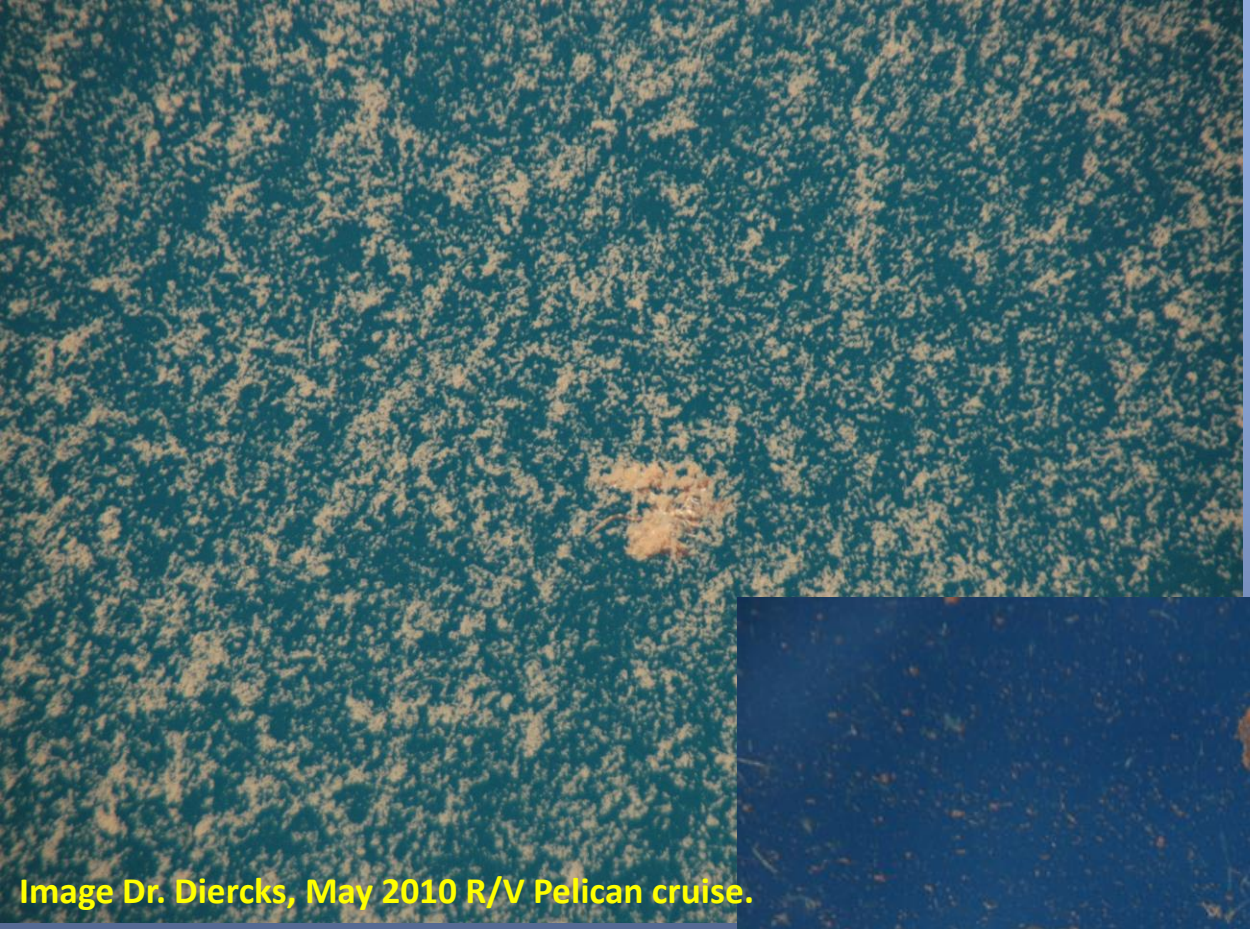

Image Dr. Diercks, May 2010 R/V Pelican cruise.

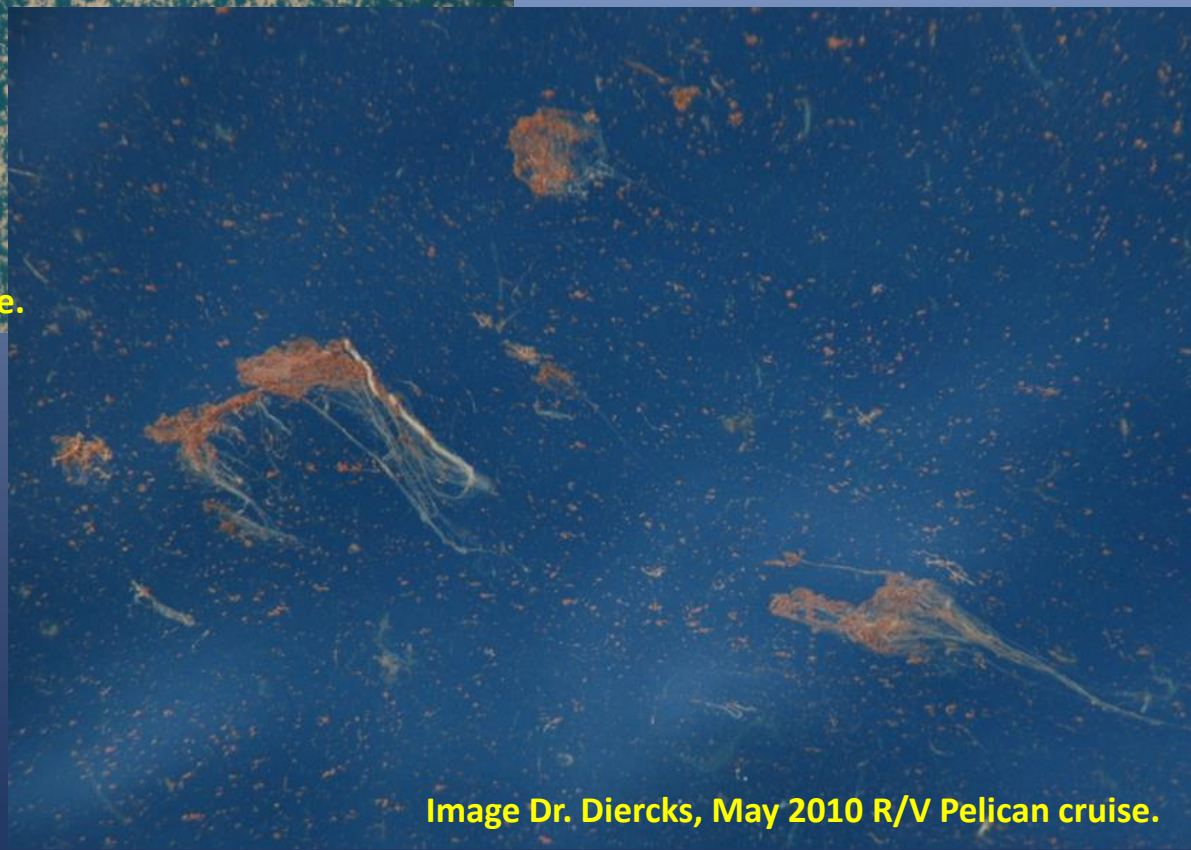

Image Dr. Diercks, May 2010 R/V Pelican cruise.

MOSSFA

Marine
Oil
Snow
Sedimentation and
Flocculent
Accumulation

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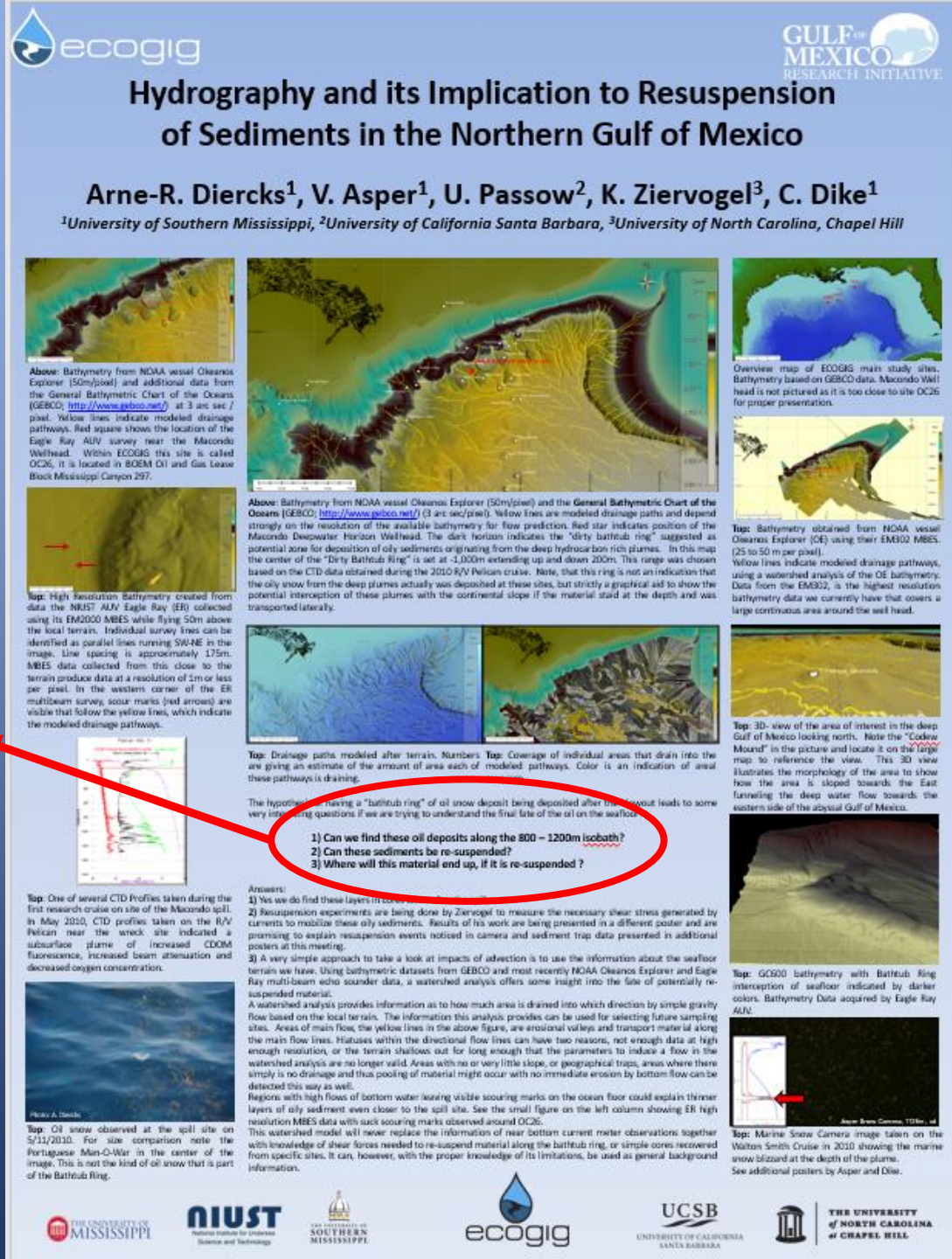
2013 MOSSFA Workshop

1) Can we find these oil deposits along the 800 – 1,200m isobath? ("Dirty Bathtup")

2) Can these sediments be re-suspended?

3) Where will this material end up, if it is re-suspended?



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"SECONDHAND" MOSSFA

- What is "secondhand" MOSSSFA? (**re**-suspended – **re**-distributed – **re**-deposited)
- How do we know we have secondhand MOSSFA?
- How do we differentiate between primary flux and secondhand flux in our data?
- Lateral Transport of resuspended MOSSFA.
- Secondary deposition and potential effects on benthic communities.

What is “secondhand MOSSSFA”?

resuspended – redistributed – redeposited snow aggregates

Resuspension, Nepheloid Layers

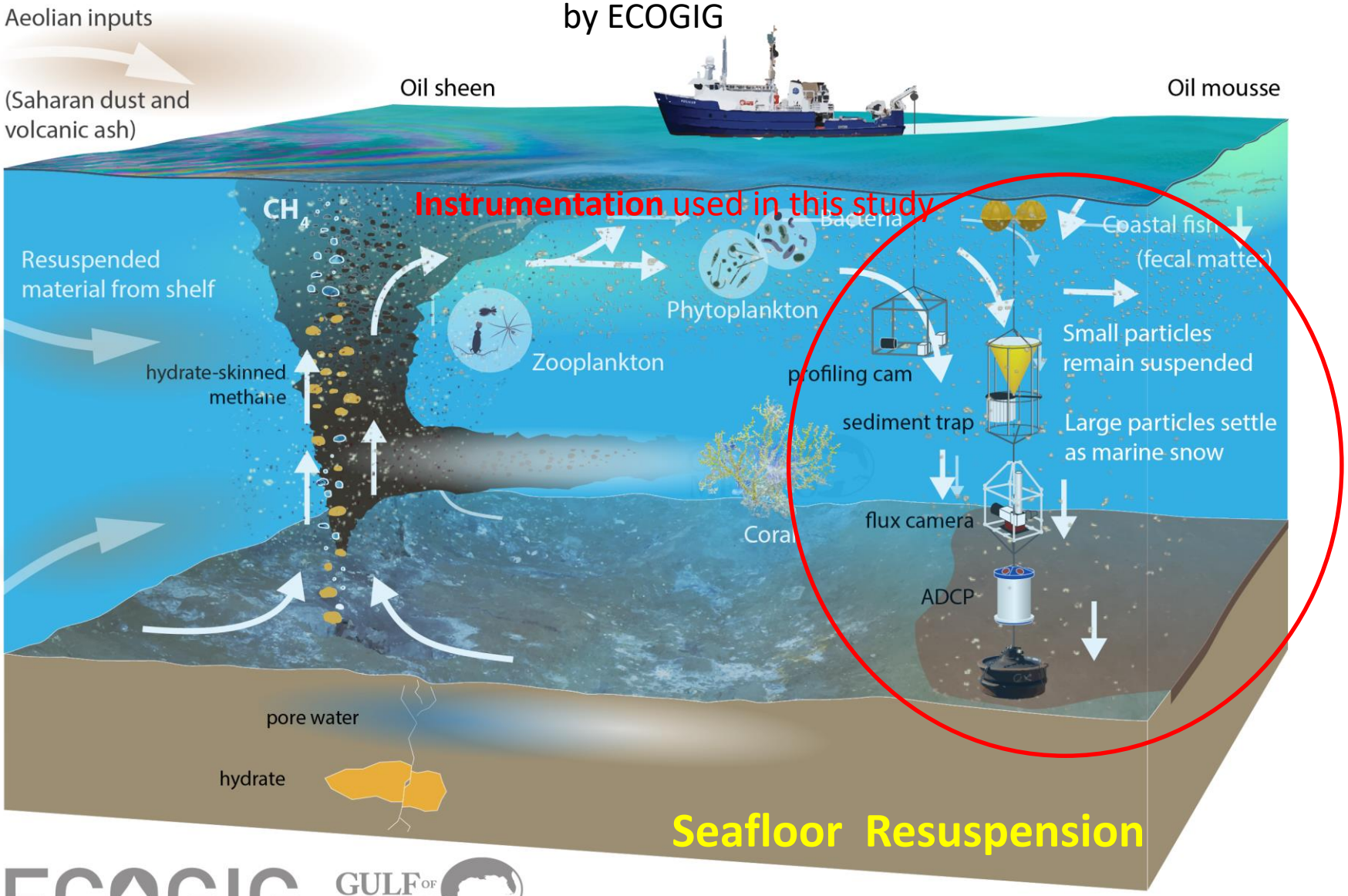
Normal Marine Snow Image

Images: Dr. Diercks, 2016, Marine Snow Profiling Camera System

Time between images 6 seconds. Camera frame set down on the seafloor, due to pinger malfunction.

Marine Snow, Oiled Marine Aggregates (OMA), and Marine Oil Snow Sedimentation and Flocculent Accumulation (MOSSFA)

Early conceptual diagram to explain deep sea processes associated with the oil Spill, developed by ECOGIG



ECOGIG

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not to scale

How do we know we have “secondhand” Flux?

We look at data from: Time Series Sediment Traps
Flux and Profiling Marine Snow Cameras
Current Measurements (ADCP & Current Meters

Flux specific data from two stacked time series sediment traps were combined with size-specific in-situ settling speeds of settling aggregates obtained by moored flux cameras, particle size distributions from a lowered profiling camera, current speed and directions from moored current meters were combined with to identify resuspension events of different scales and magnitudes in the deep Gulf of Mexico.

We defined three categories of deep (> 1,000 m) resuspension :

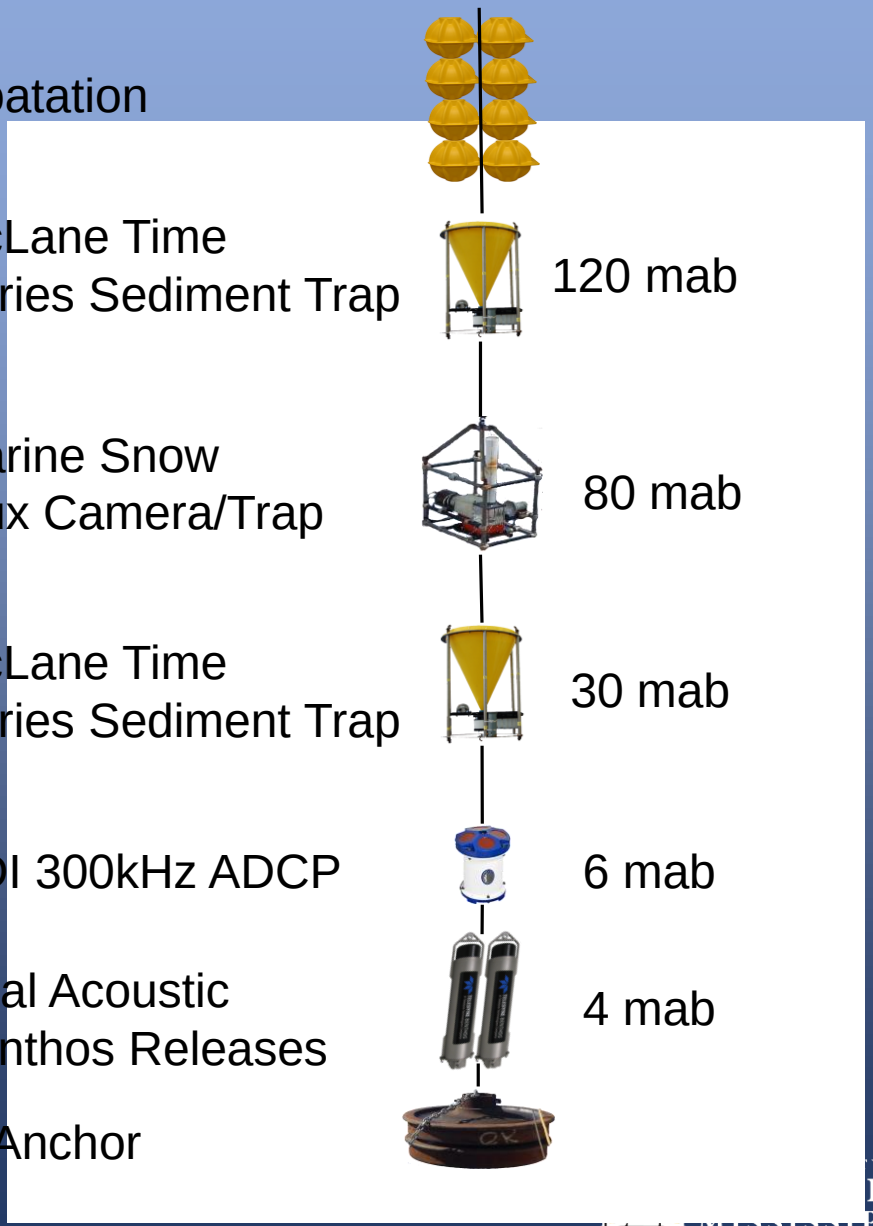
Small-scale-local events

Small-scale-far-field events

Large or hurricane-scale events

Diercks, A.-R., C. Dike, V.L. Asper, S.F. DiMarco, J.P. Chanton, U. Passow. (2018) Scales of seafloor sediment resuspension in the northern Gulf of Mexico. *Elem Sci Anth.* 2018;6(1):32. DOI: http://doi.org/10.1525/elementa.288

Time Series Sediment Trap mooring array with Flux camera and RDI ADCP



Mooring designed and operated by the ECOGIG consortium

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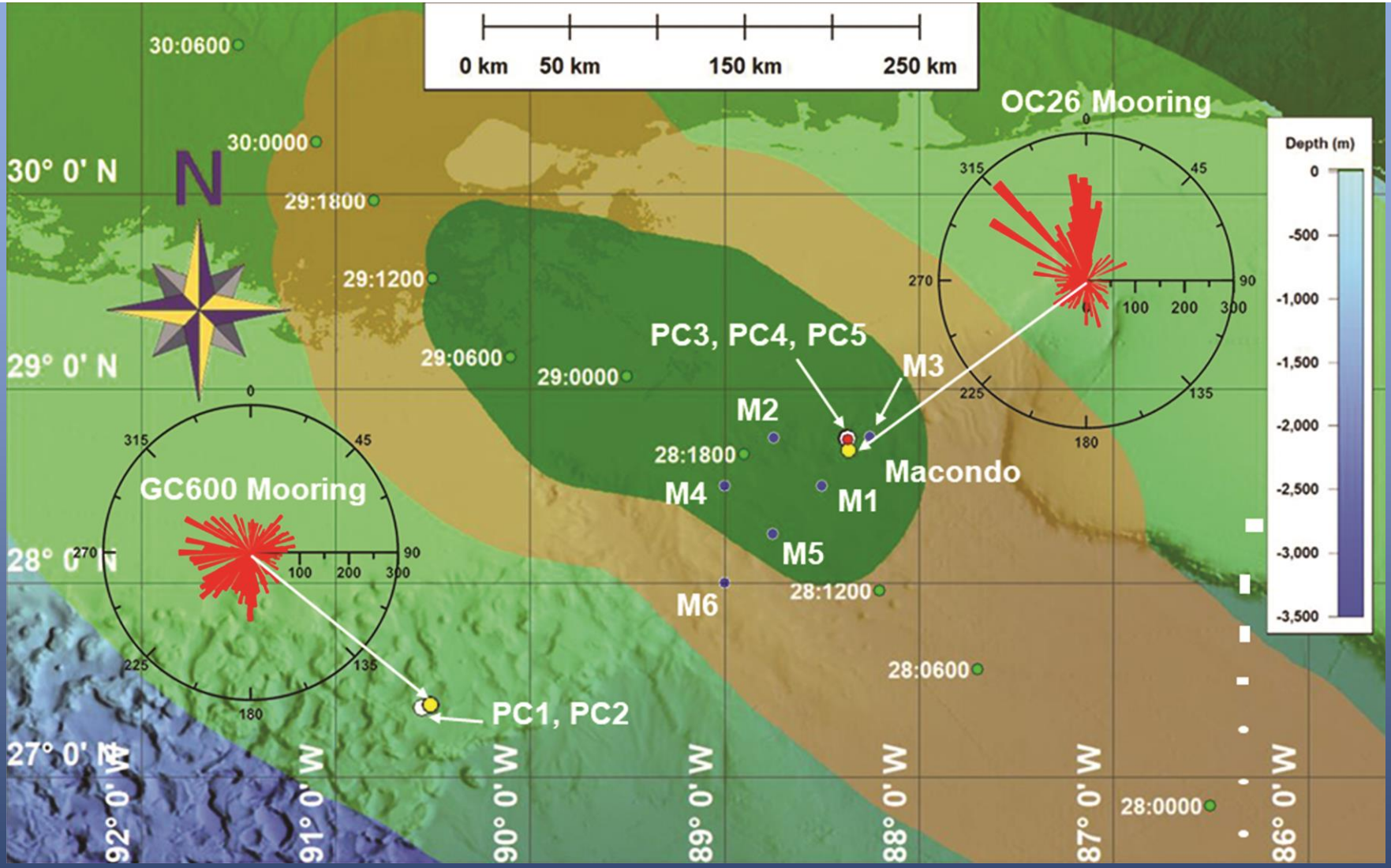
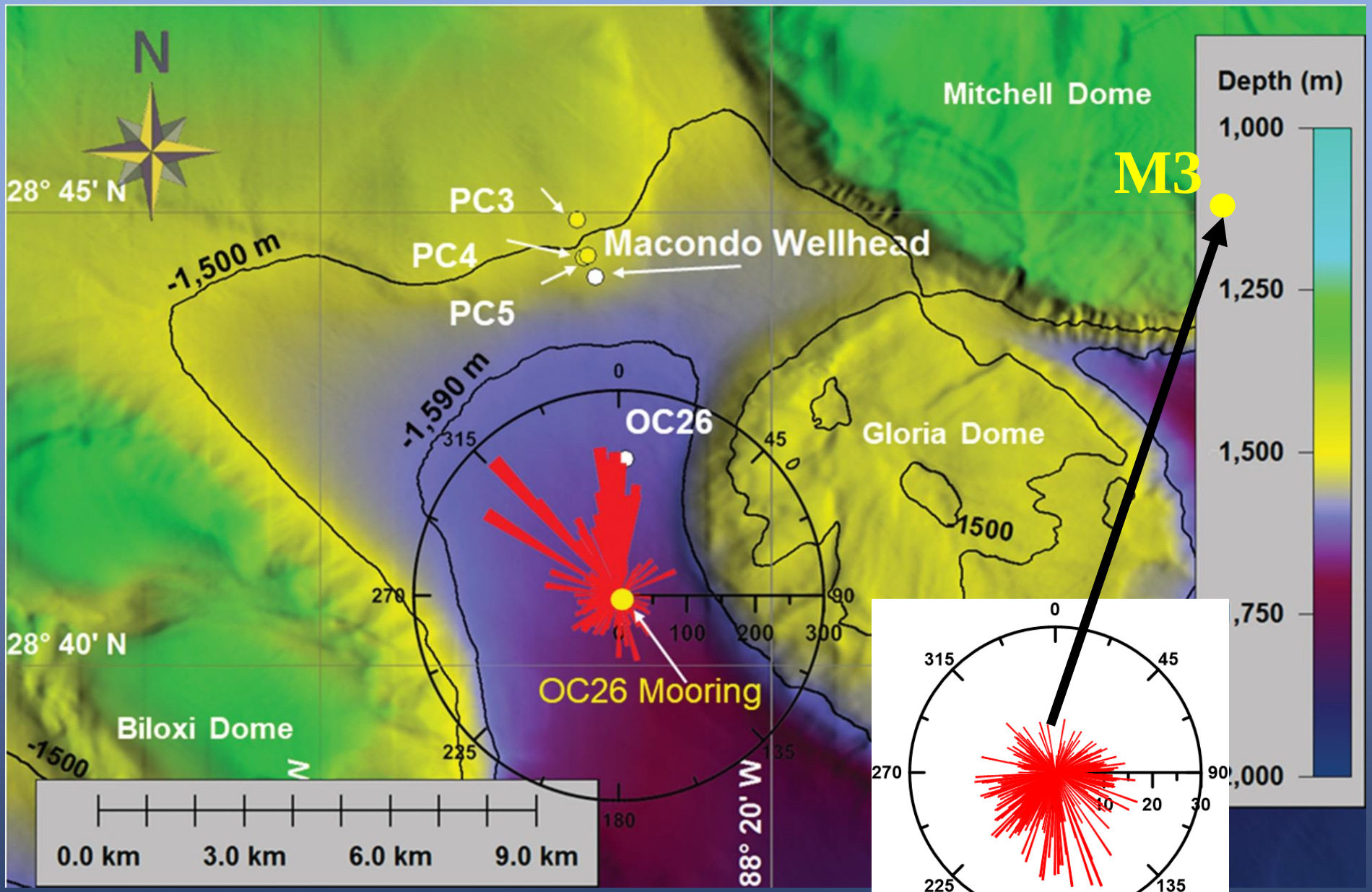
Diercks, A.-R., C. Dike, V.L. Asper, S.F. DiMarco, J.P. Chanton, U. Passow. (2018) Scales of seafloor sediment resuspension in the northern Gulf of Mexico. *Elem Sci Anth.* 2018;6(1):32. DOI: http://doi.org/10.1525/elementa.285



White dots indicate locations of profiling camera casts PC1 to PC5. Yellow dots indicate locations of sediment trap moorings. Red dot indicates the location of the *Macondo* wellhead. Brown area indicates Hurricane Isaac wind swath with wind speeds > 64 mph; brown, wind speeds > 49.33 mph; and light green, wind speeds of. > 39 mph. Locations of the center of the hurricane eye are plotted as green dots with day and time in August of 2012 Blue dots mark **the M1 to M6 mooring locations** where the **Gulf Integrated Spill Research (GISR)** consortium deployed single-point current meters. Polar diagrams depict ADCP current measurements from the sediment trap moorings from 25 August 2012 to 15 September 2012, the passage of Hurricane Isaac. Currents are plotted with the indicator point from the center in the direction of the flow.



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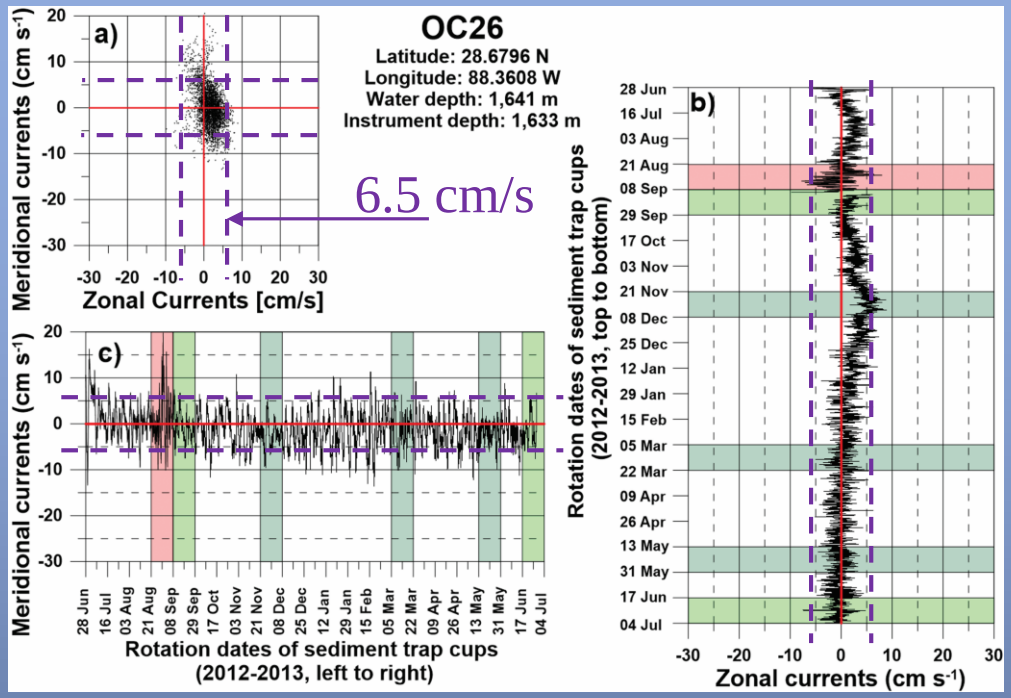
Zonal and meridional flow at OC26 and M3

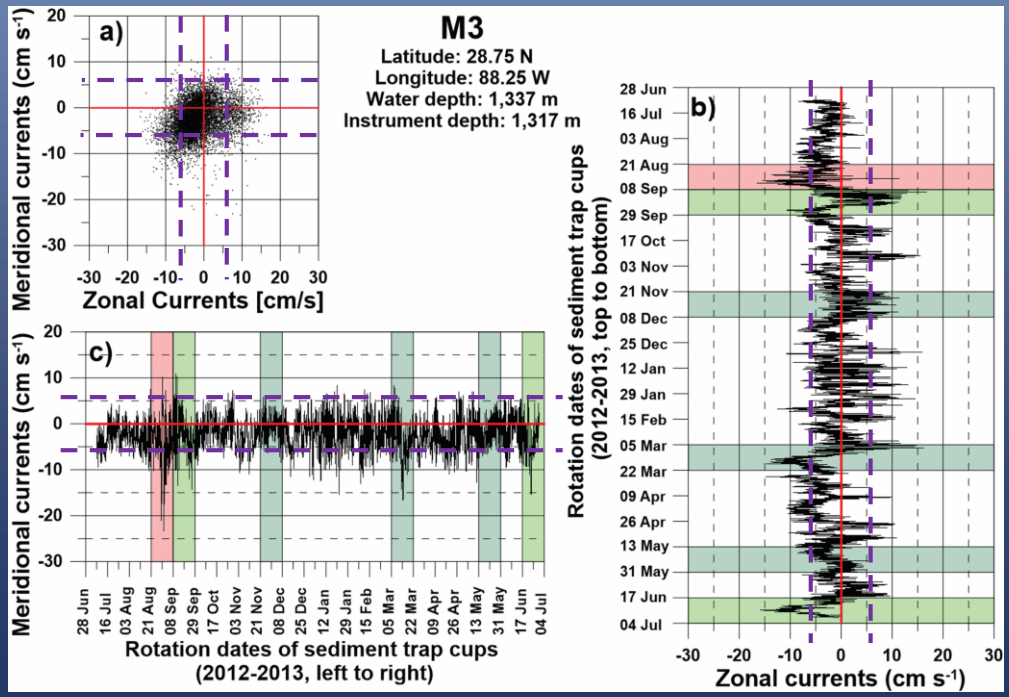


Panel a) presents meridional versus zonal flow at the site from 28 June 2012 to 4 July 2013, covering the sediment trap deployment period.

Panel b) displays the hourly meridional flow of the measured currents

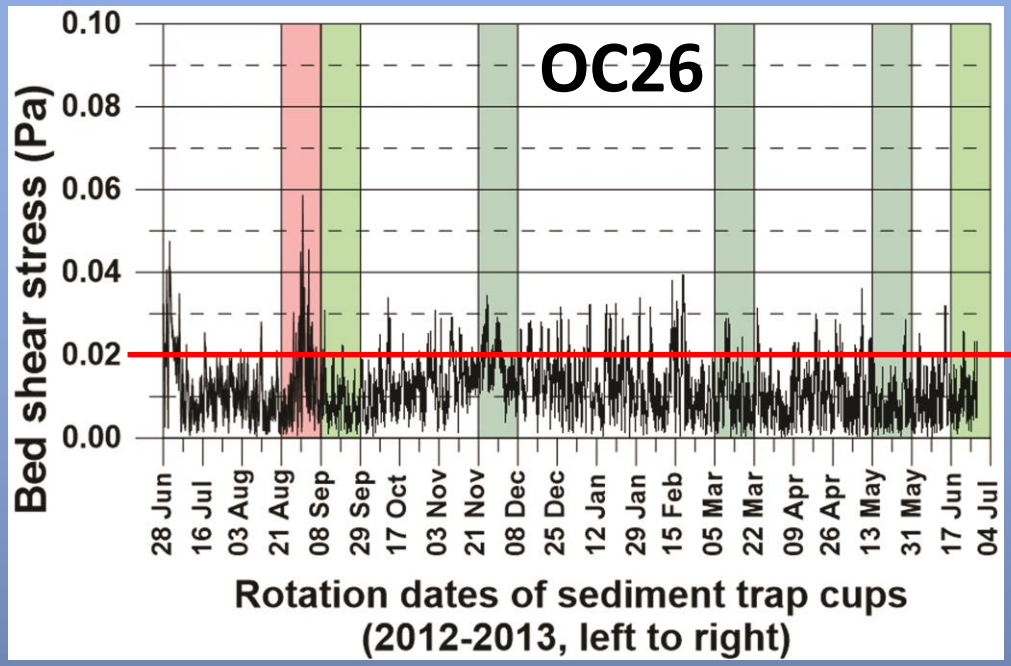
Panel c), the zonal currents.

- Time intervals are marked corresponding to the trap schedule.
- **Red** = large-scale resuspension
- **Light green** = small-scale **near field** resuspension
- **Dark green** = small-scale **far field** resuspension



Diercks, A.-R., et al, (2018)
DOI: http://doi.org/10.1525/elementa.285

Bed shear stress at OC26 and M3



Bed shear stress was calculated using actual current measurements, kinematic viscosity of seawater at 4°C, and the height of the single point current meter above the seafloor (20 mab) at M3 and the height of the first bin of the ADCP measurement (18 mab) at OC26

- Time intervals are marked corresponding to the trap schedule.
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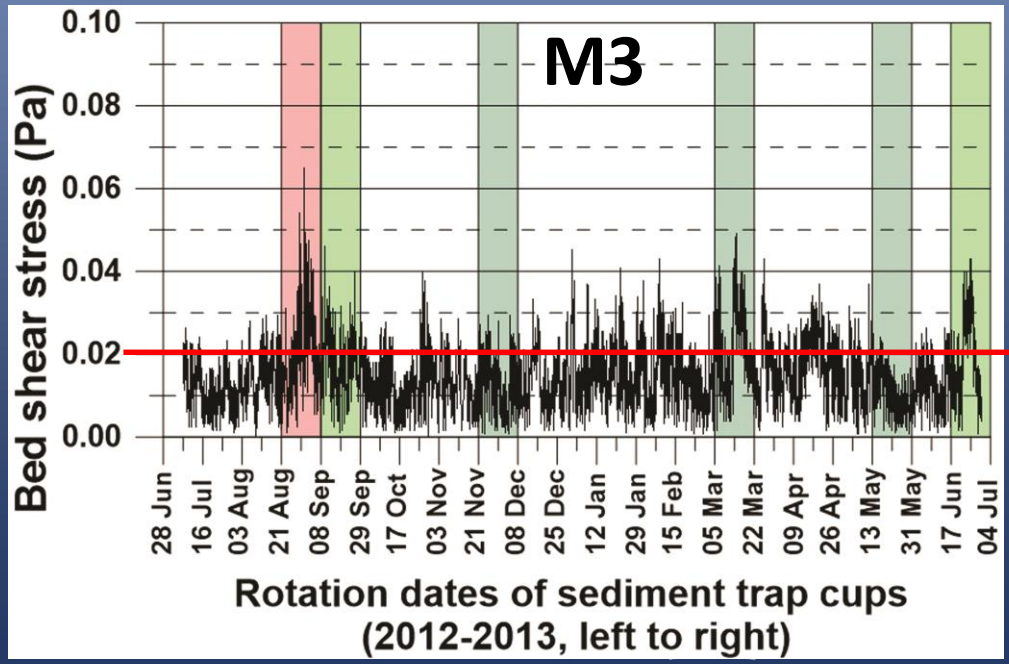

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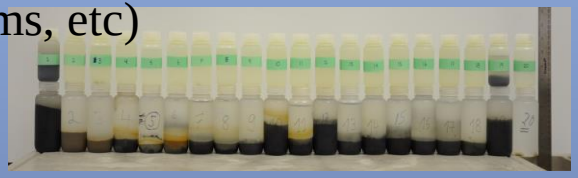
Two types of information from our stacked sediment traps:

1. Individual Cups from each trap give us a time series data set

Individual cups provide time series of total vertical flux over time.

Example: high flux events (spring plankton bloom, storms, etc)
low flux times are winter months



2. Comparison of cups from the same time between trap will provide information about source of material or mechanism

POC / DW ratio:

High ➔ primary input from surface
Low ➔ resuspended material from seafloor

LSi flux comparison between upper and lower trap

If different ➔ different sources or forcing factors

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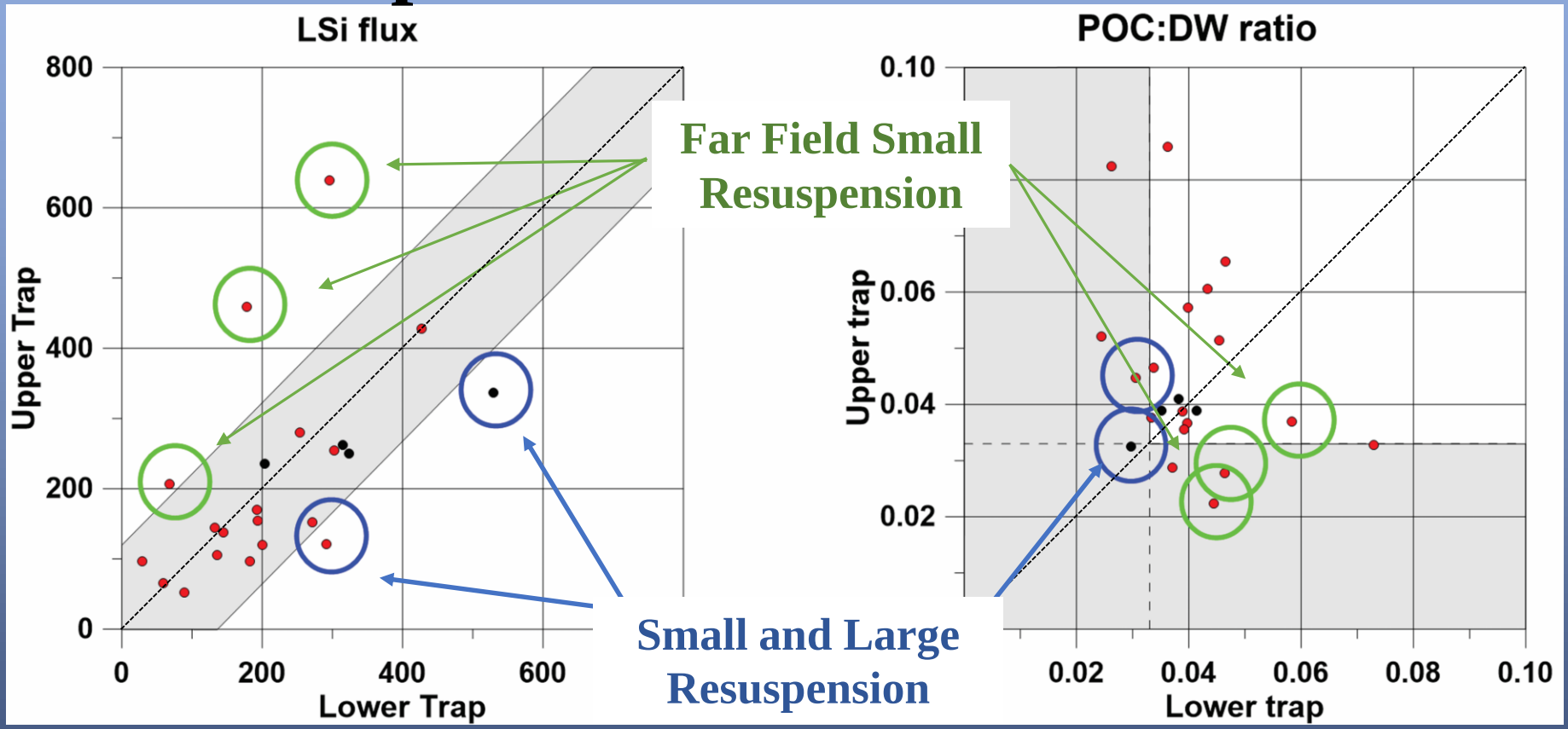
How do we differentiate between primary flux and secondhand (resuspended) flux?

Resuspension Scale Classification



Gray-shaded area = sampling periods in which no clear resuspension signal was detected.

Gray-shaded area = condition for POC:DW being less than 3.3% in both traps.

Both conditions have to be met

Diercks, A.-R., C. Dike, V.L. Asper, S.F. DiMarco, J.P. Chanton, O. Pasternack (2018) Scales of seafloor sediment resuspension in the northern Gulf of Mexico. Elementa 2018;6(1):32. DOI: http://doi.org/10.1525/elementa.285

How do we differentiate between primary flux and secondhand (re-suspended) flux?

Re-suspension events were characterized within sediment trap samples by comparing the POC content against sample dry weight and lithogenic silica (LSi) flux.

The ratio of POC to Sample Dry Weight was identified as an indicator for material collected in the sediment traps originating from resuspension events.

Diercks, A.-R., C. Dike, V.L. Asper, S.F. DiMarco, J.P. Chanton, U. Passow. (2018) Scales of seafloor sediment resuspension in the northern Gulf of Mexico. *Elem Sci Anth.* 2018;6(1):32. DOI: http://doi.org/10.1525/elementa.285

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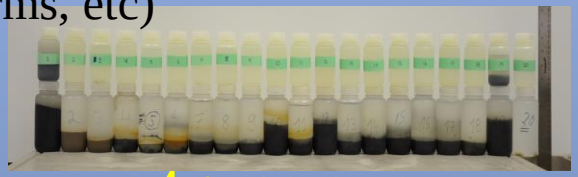

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POC / DW ratio: High ➔ primary input from surface
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LSi flux comparison between upper and lower trap

If different ➔ different sources or forcing factors

Far-field small scale if only in upper trap
Near field small scale if only lower trap
Large scale if in both traps

Small Scale Resuspension Event: Particle abundance profiles of PC3 to PC5

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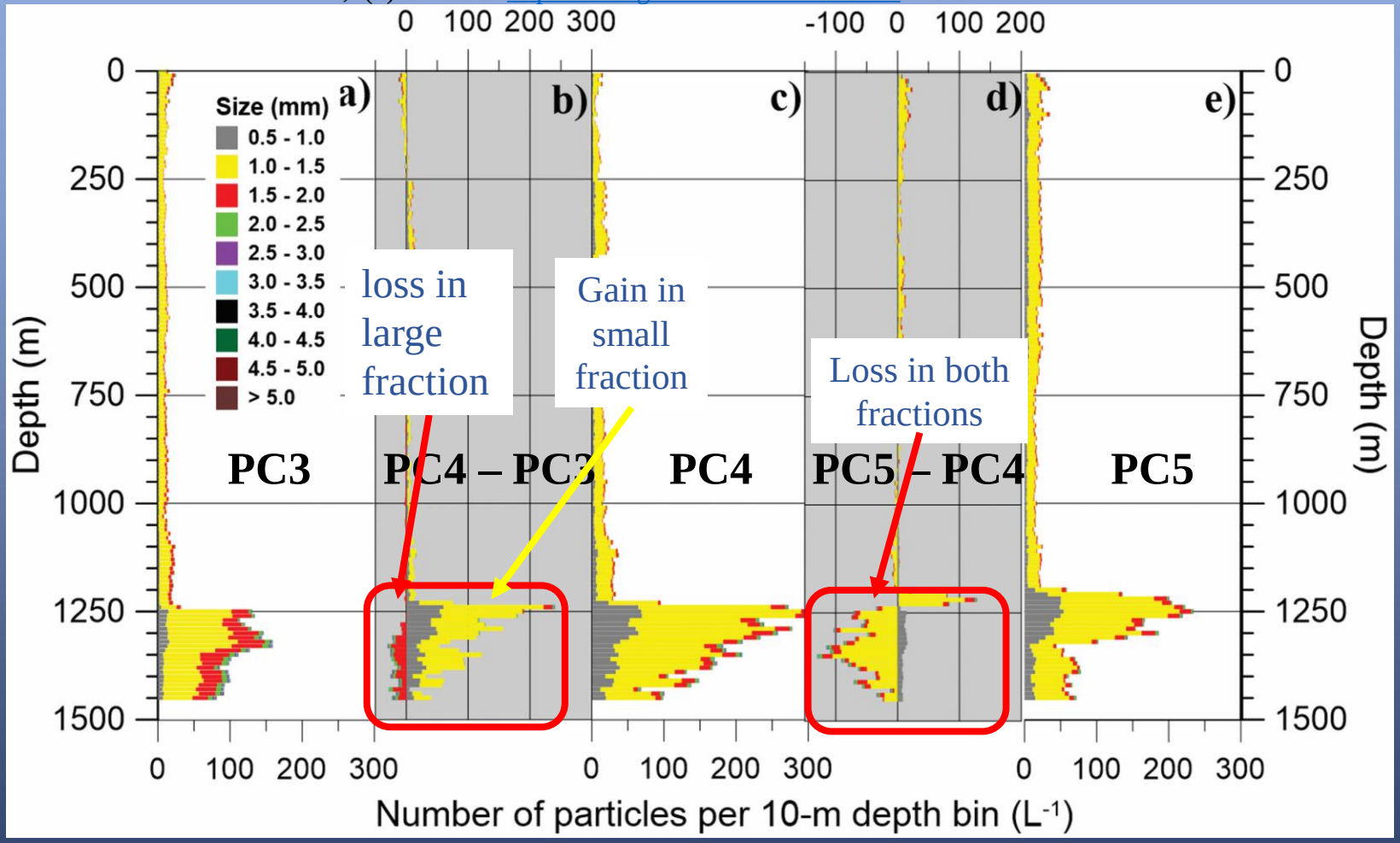
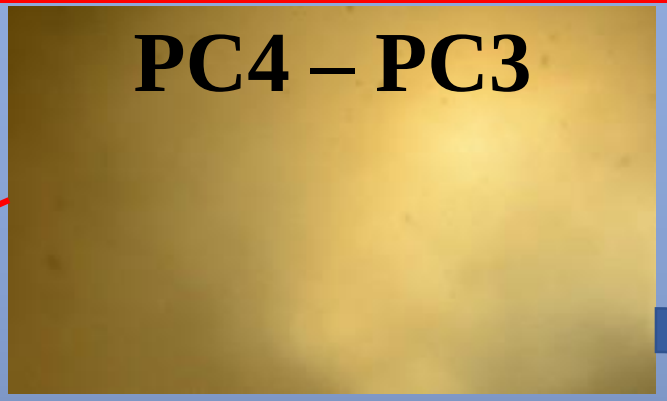
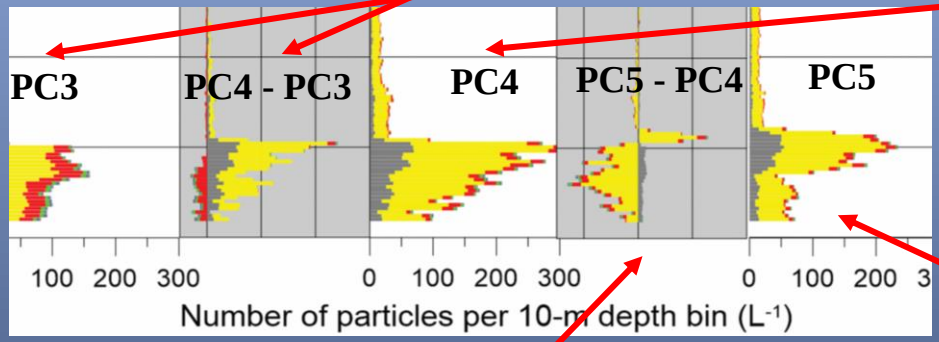


Colored bars present the 10m vertically binned size specific particle concentrations of PC3 (a), PC4 (c) and PC5 (e) and the changes in particle distribution between PC3 and PC4 (panel b), PC4 and PC5 (panel d). Strong changes below 1,300m are visible with an apparent loss of particles >1.5 mm, even though total number of particles had increased. Temperature and salinity data taken during the three casts indicate that no changes in water mass had occurred.

Conceptual model





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Lateral Transport (Redistribution, based on seafloor morphology, current meter records)

Current vectors at sites M1 to M6 and OC26, 26 August to 16 September 2012. Shaded grey box marks the period when Hurricane Isaac moved across the moorings. Vertical grey bars mark the times of the five different profiling camera casts PC3, PC4 and PC5.

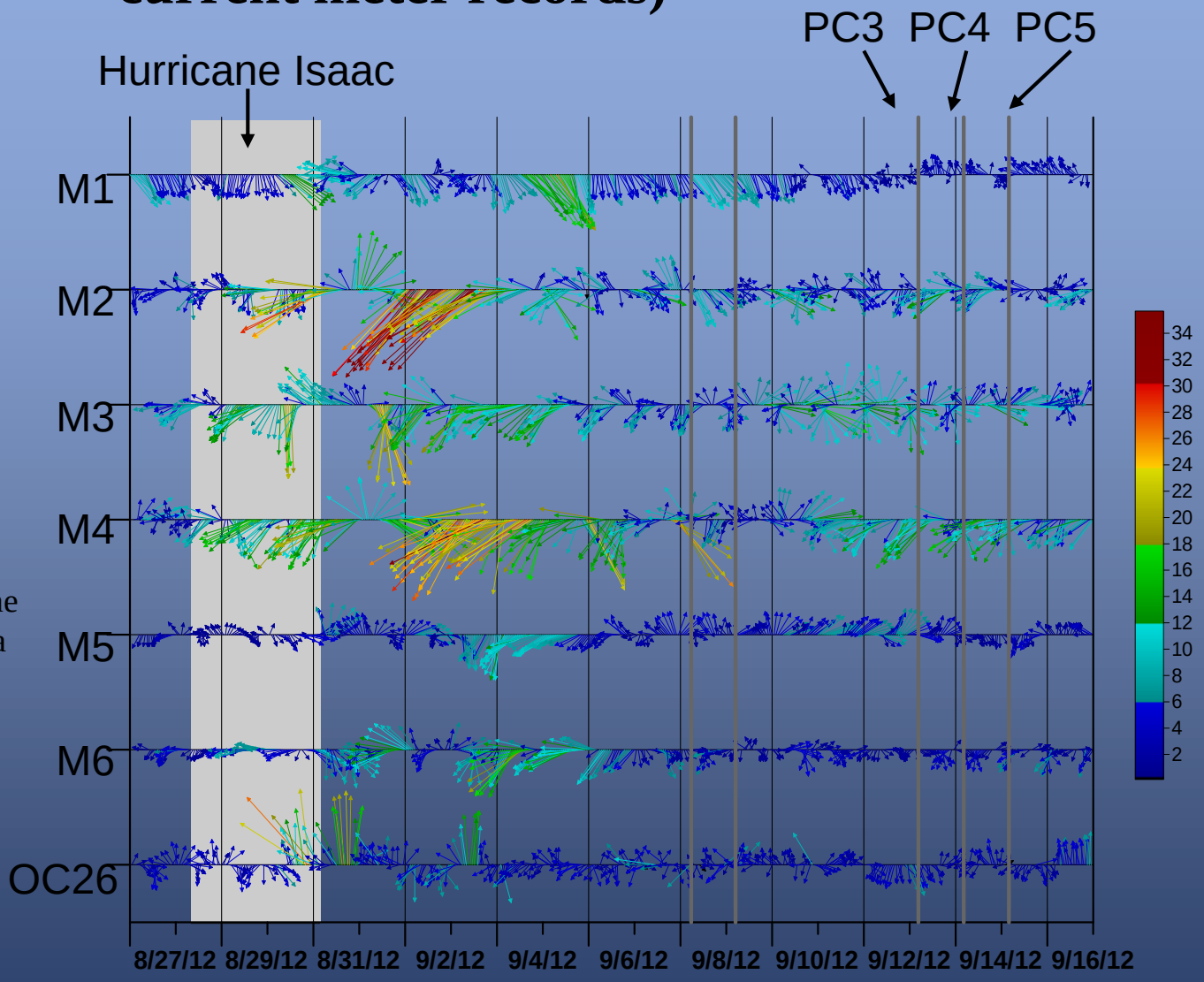

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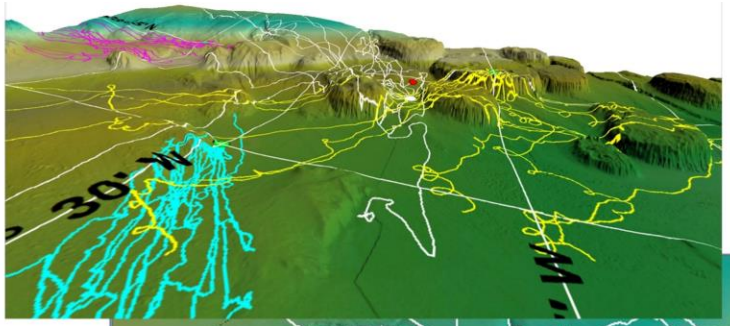
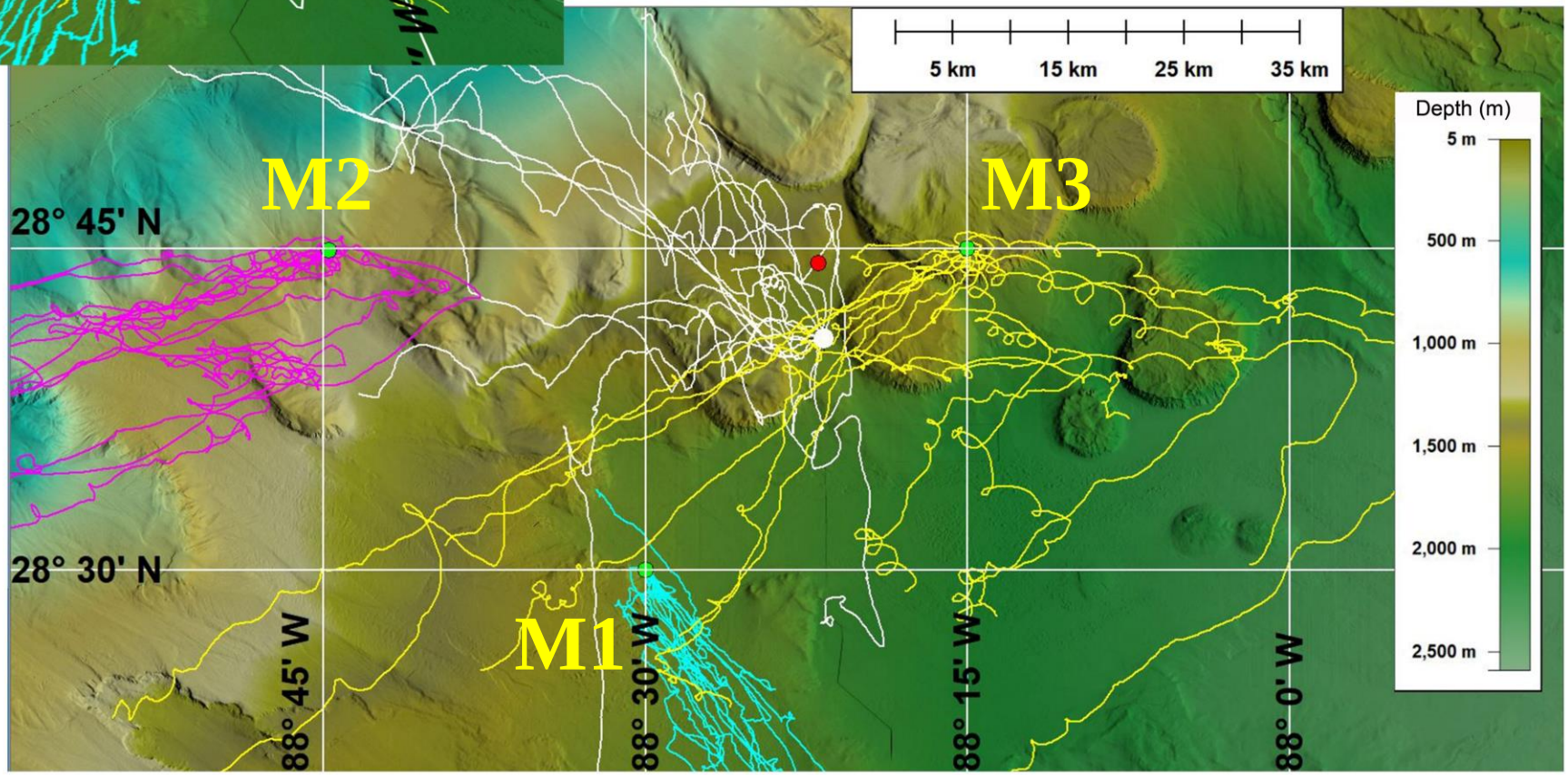
Diagram of seafloor around DWH

3D Block Diagram of seafloor morphology.



Lines represent 18 days of current meter measurements, linked to the length of the sediment trap schedule. Currents are plotted as flow towards the mooring, presenting the flow in relation to the diverse morphology of the area potentially supplying material to the trap.

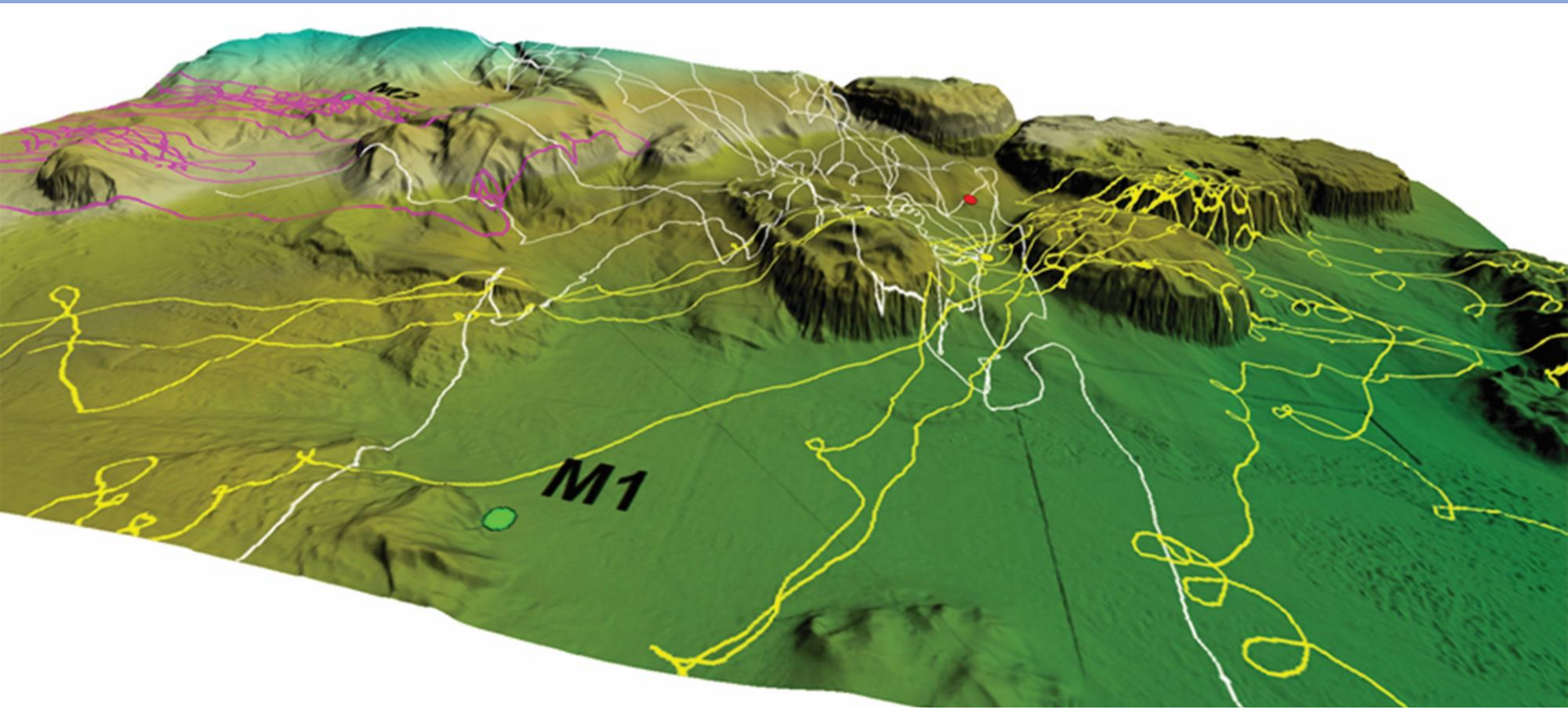
Base map : https://eos.org/project-updates/a-1-4-billion-pixel-map-of-the-gulf-of-mexico-seafloor



Diercks et al. (2018) DOI: http://doi.org/10.1525/elementa.285

Block Diagram of seafloor around DWH (Red Dot)

Potential source areas for resuspended material collected in a sediment trap



Block Diagram of seafloor topography in the vicinity of Macondo Well with current meter data overlain as vector addition. Presenting the potential source areas for resuspended material collected in a sediment trap and imaged by the flux camera deployed approximately 5 km south of the Macondo well (yellow dot). Lines represent 18 days of current meter measurements. Currents are plotted as flow towards the mooring, presenting the flow in relation to the diverse morphology of the area potentially supplying material to the trap samples.

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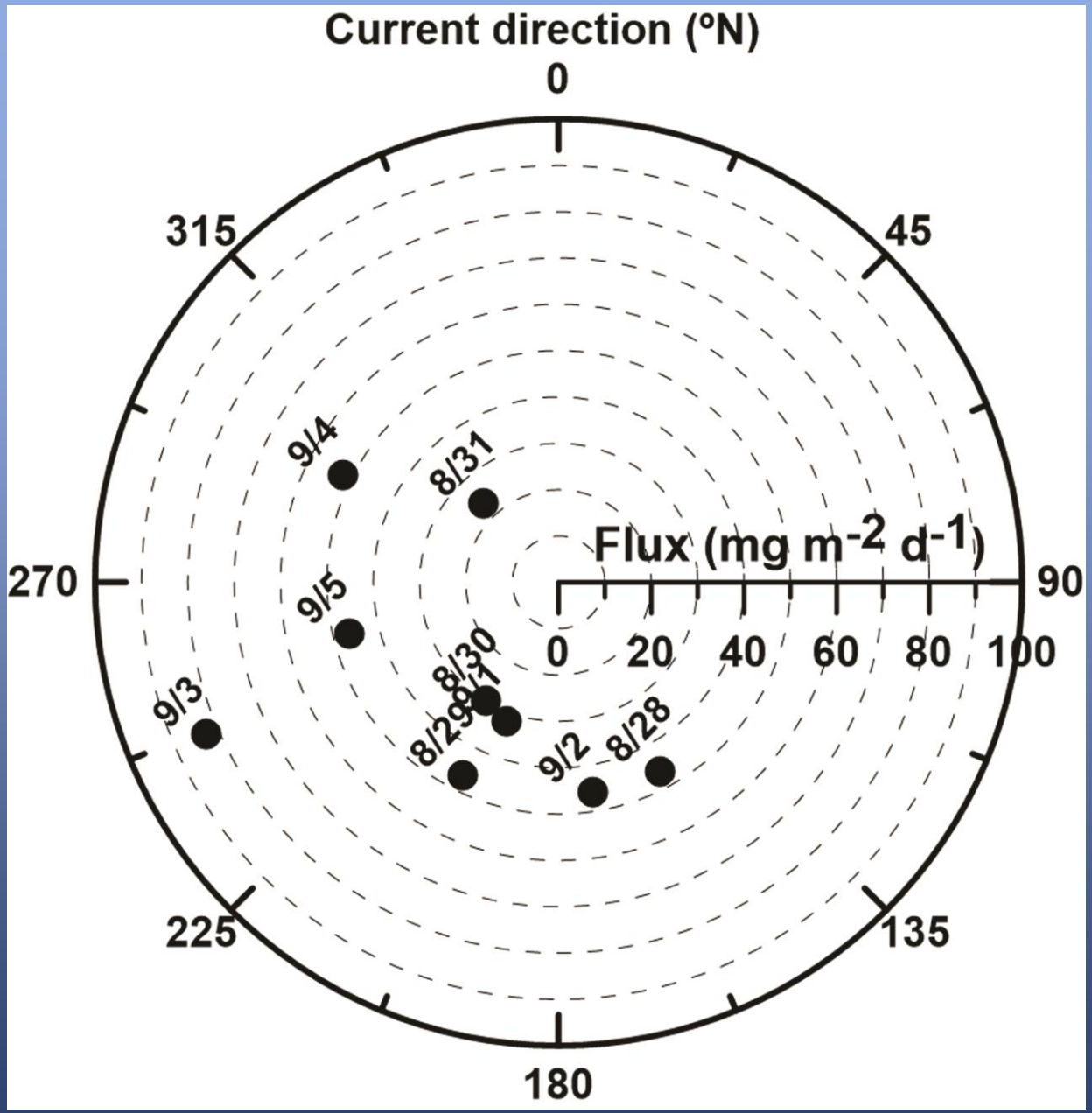
Polar diagram of daily mean particle flux calculated from camera data versus daily mean current direction



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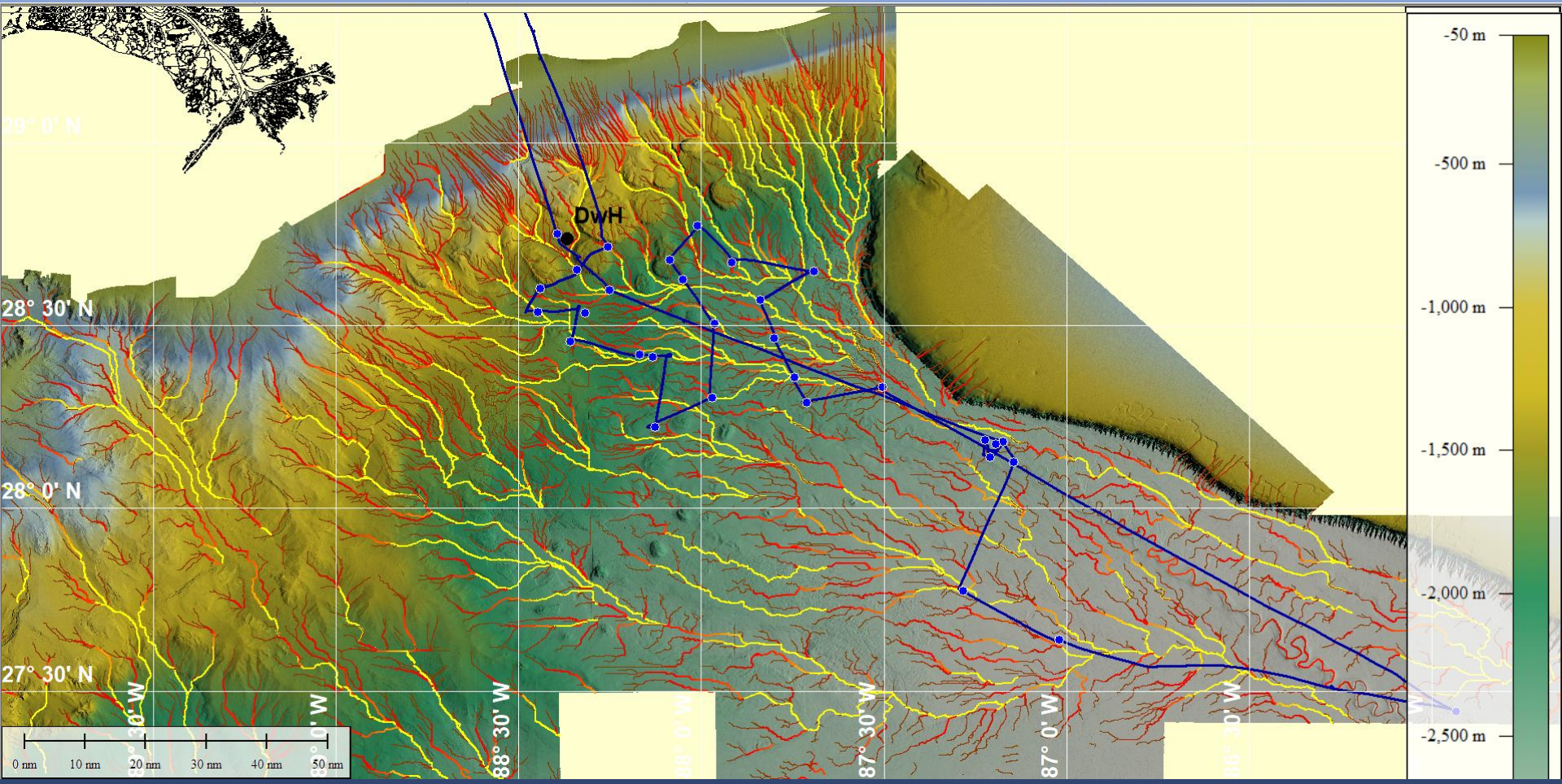
Watershed analyses presenting major drainage pathways, modeled for the GOMRI funded Resuspension, Redistribution and Deposition of DwH Recalcitrant Hydrocarbons to offshore Depocenters project

Diercks (2018, unpublished data)



Base map: Kramer and Shedd: https://eos.org/project-updates/a-1-4-billion-pixel-map-of-the-gulf-of-mexico-seafloor.

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Summary

We know we have resuspension events that remobilize material from the seafloor in the area of the initial deposition of the MOSSFA event.

We also have data that support the redistribution.

We have indication from an independent study (Charles Fisher's group) that point to a potential secondhand exposure of corals near MC344.

We have a large area of seafloor >87% in our study area, that has small slope gradients and an intricate drainage system that is receiving remobilized material from the high energy slopes in the area of the oil spill.

Too early to say what the final outcome of the redistribution of the secondhand MOSSFA will be, but preliminary data do show that we have redistribution of this material in our core samples collected to the SE of the DwH site.

ACKNOWLEDGEMENTS

- US National Oceanic and Atmospheric Administration - NOAA
- US National Science Foundation - NSF
- We also thank the Captains and crews of the R/V *Pelican, R/V Point Sur* and *R/V Endeavor* for all their efforts to make this such a successful trip.
- This research was funded by a grant from the Gulf of Mexico Research Initiative

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Questions?