MOSSFA
MARINE OIL SNOW SEDIMENTATION & FLOCCULENT ACCUMULATION

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- Rapid Sedimentation caused by
  - Oil interactions with marine snow
  - Oil interaction with microbes
  - Oil interaction with clay minerals

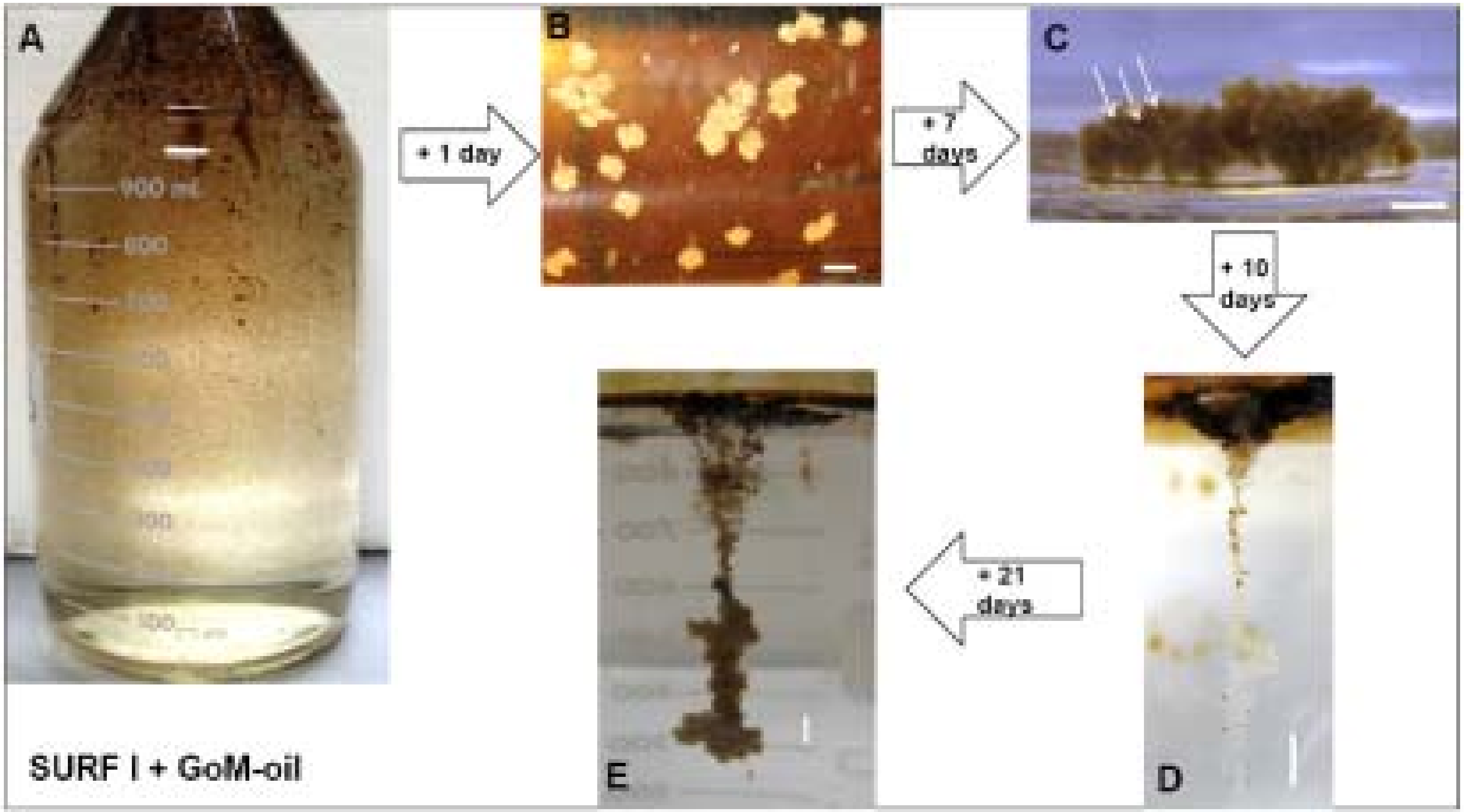
Daly, K.L., U. Passow, J. Chanton, and D. Hollander. 2016 Assessing the Impacts of Oil-Associated Marine Snow Formation and Sedimentation during and after the Deepwater Horizon Oil Spill. **Anthropocene**, http://dx.doi.org/10.1016/j.ancene.2016.01.006

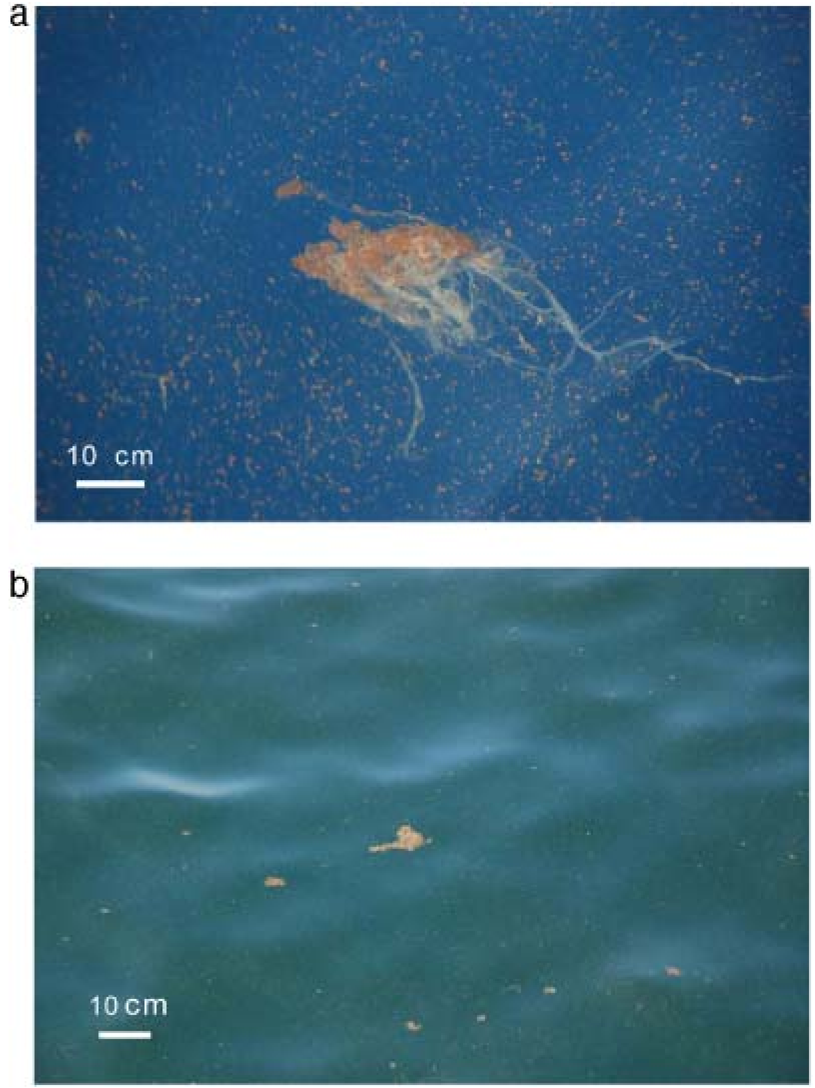
Participants in this work were funded by GOMRI consortiums, Ecogig, and C-Image, Deep-C,

Mechanism of oil sedimentation

- 1. Interaction of petroleum-derived compounds with the high concentrations of marine snow and suspended particulates at the surface *(Passow et al, 2012; Ziervogel et al, 2012; Joye et al, 2014; Kenner et al, 2014).*

Uta Passow UCSB


A
B
C
D
E
+ 1 day
+ 7 days
+ 10 days
+ 21 days
SURF I + GoM-oil


a
10 cm
b
10 cm

Oil Sedimentation.

- 2. Surface burning likely consumed 5-6% of the oil *(Lehr et al 2010),* and allowed black carbon and ash to fall to the seafloor *(see Koelmans et al 2006; Mari et al 2014).*
- 3. Zooplankton can transport oil to the sediment in their fecal pellets following ingestion (Muschenheim & Lee 2002).

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Oil Sedimentation.

4. MOSSFA- like event in the deep water plume at 1000-1300 m.

Valentine et al., 2014

- Microbial density was high in this plume *(Hazen et al 2010)*,
- *Colwellia* produce floc consisting of oil, carbohydrates and biomass when incubated with MC-252 oil *(Baelum et al., 2012).*
- Microbial produced floc captures the suspended hydrocarbon-rich particles, formed OMAs, and led to the deposition on the seafloor.
- *Colwellia* was also abundant in the surface sediments in the area *(Mason et al, 2014).*

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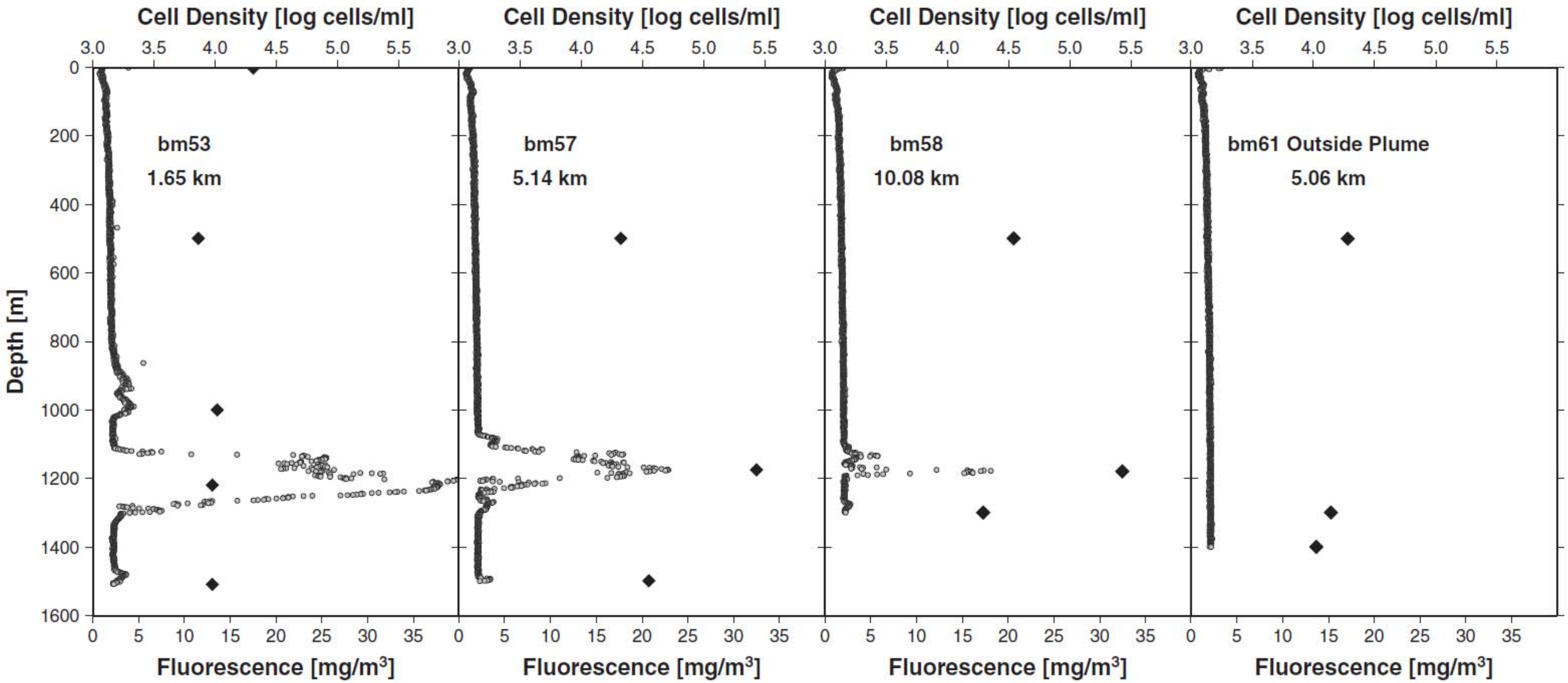
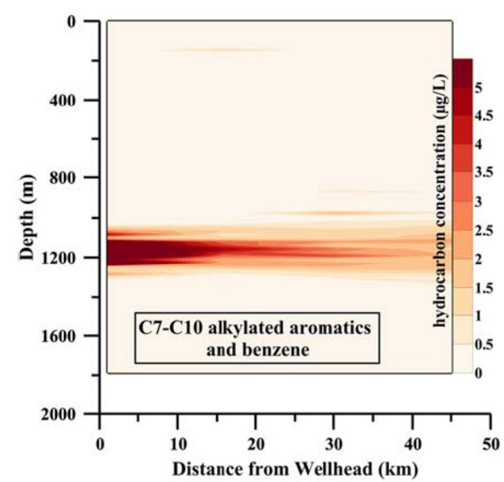


Hazen et al., 2010

Spier et al., 2013



DSH-08 December 2010
26 nm NE – 1115 m Sediments

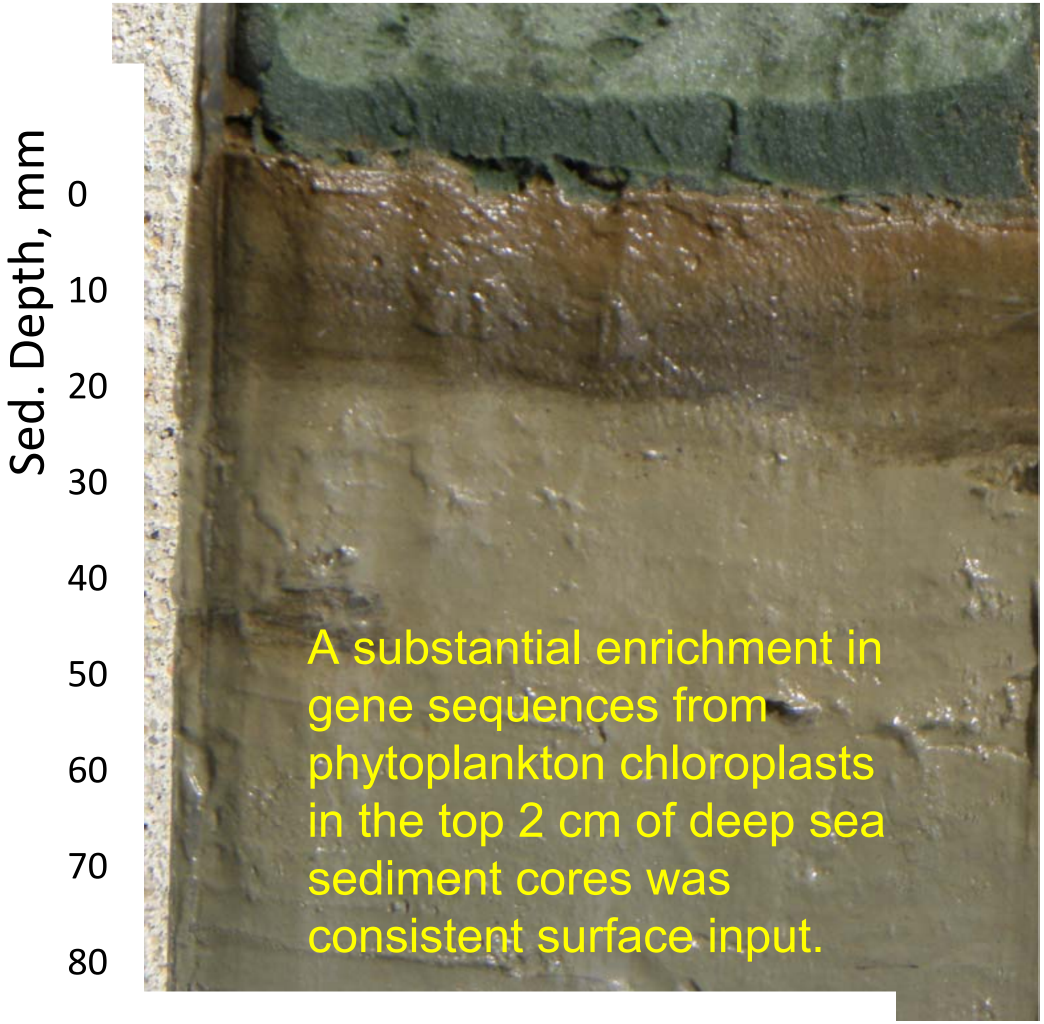
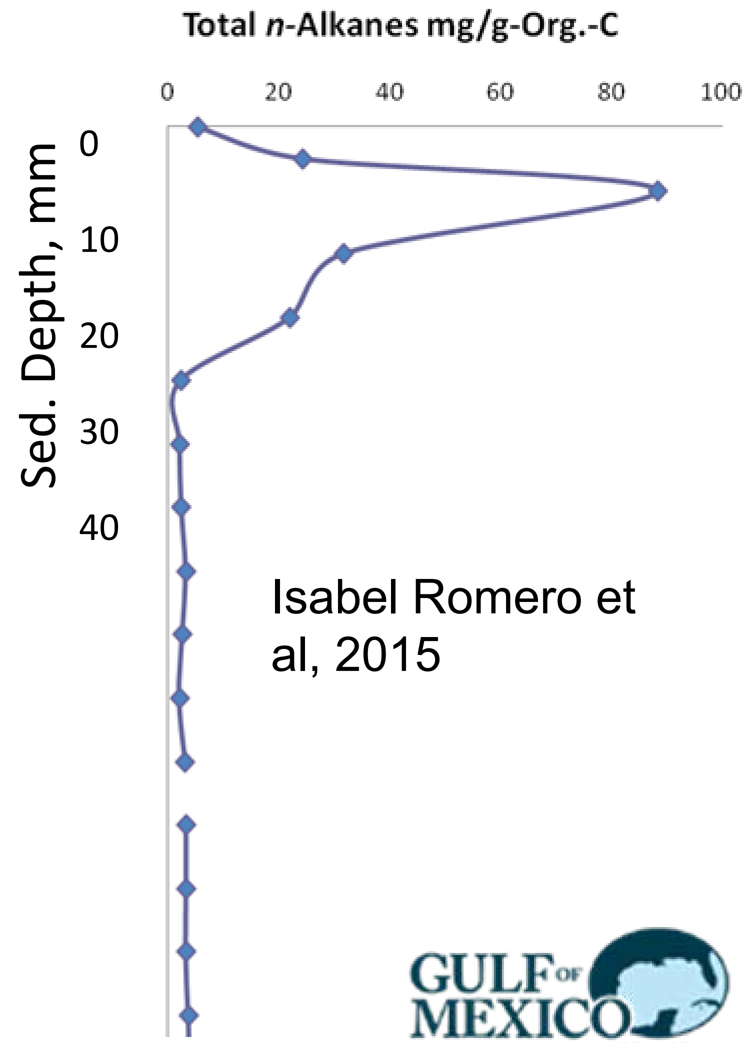
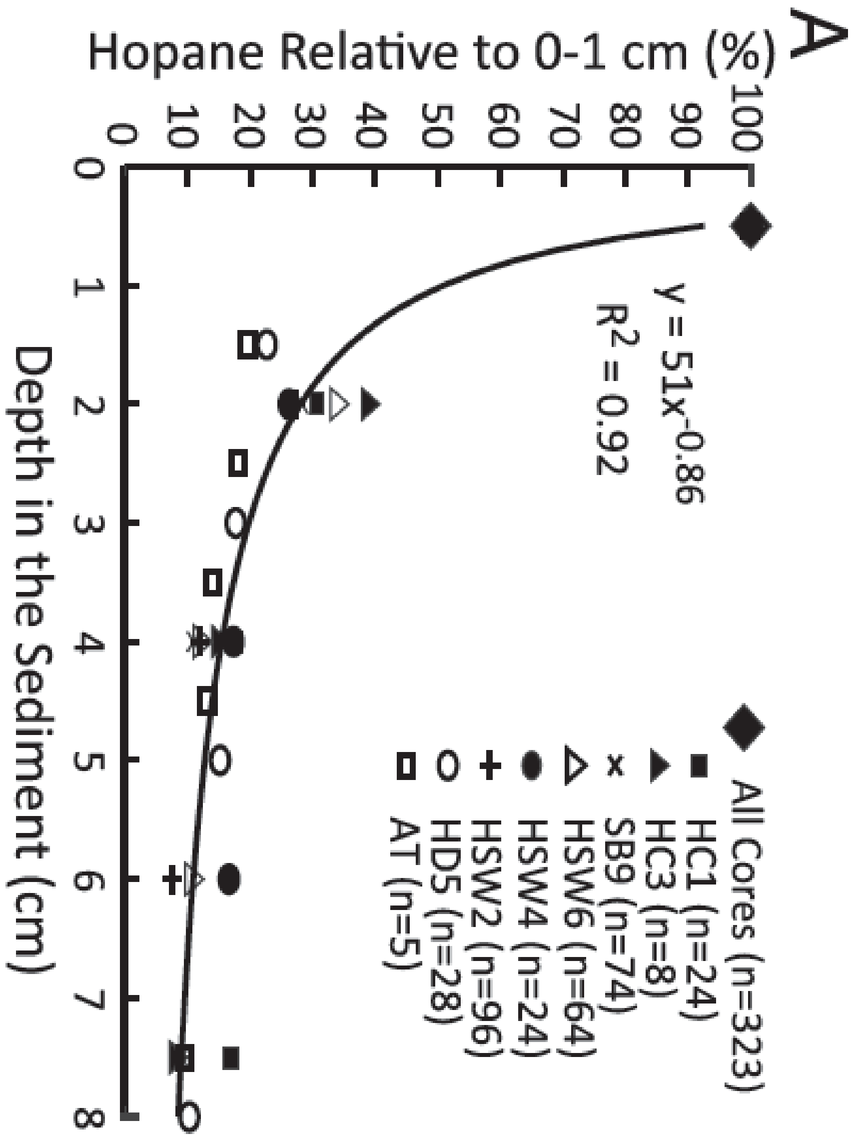


Photo from David Hollander.



Isabel Romero et al, 2015



D. Valentine et al., 2014

Again consistent with deposition from above

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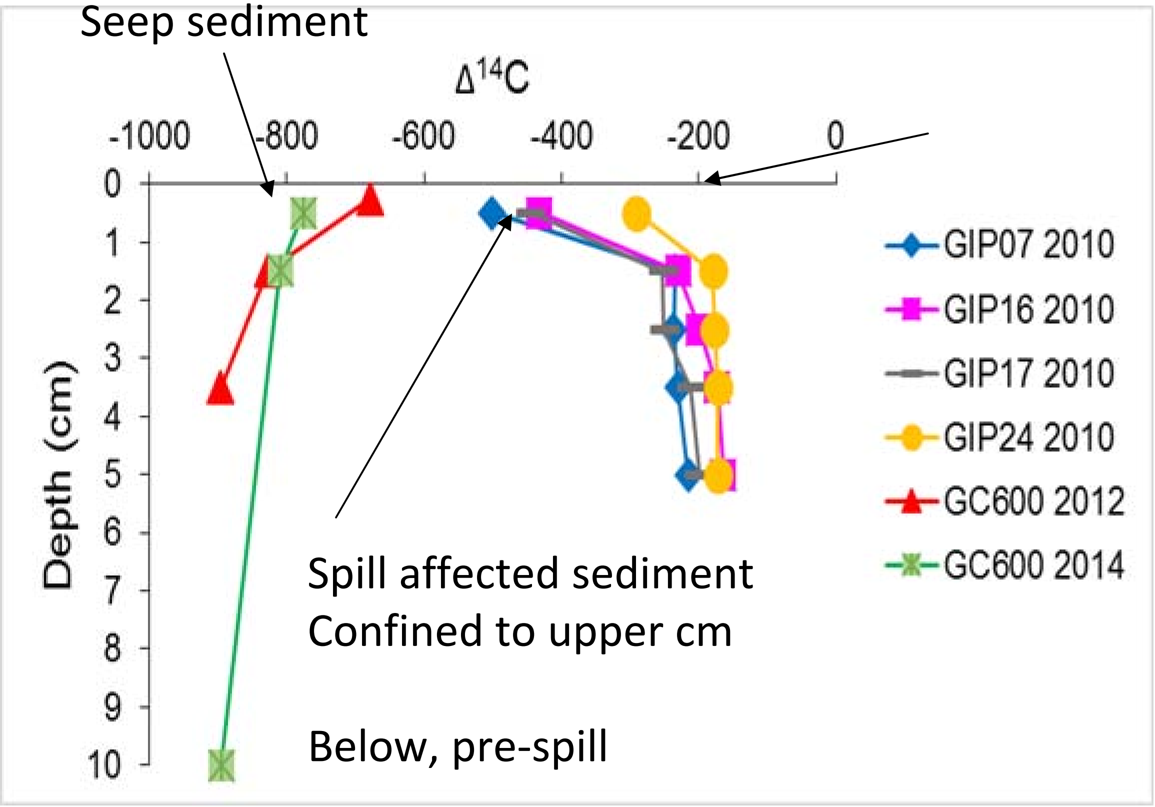
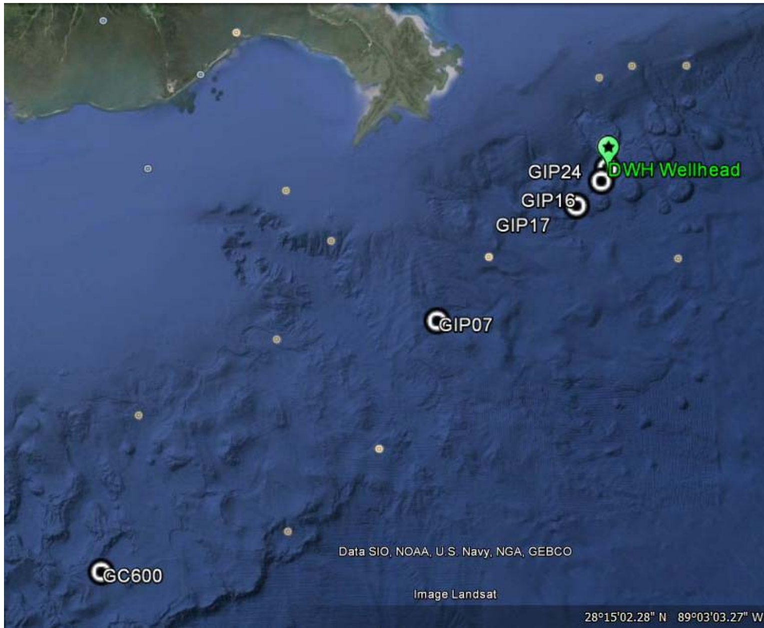
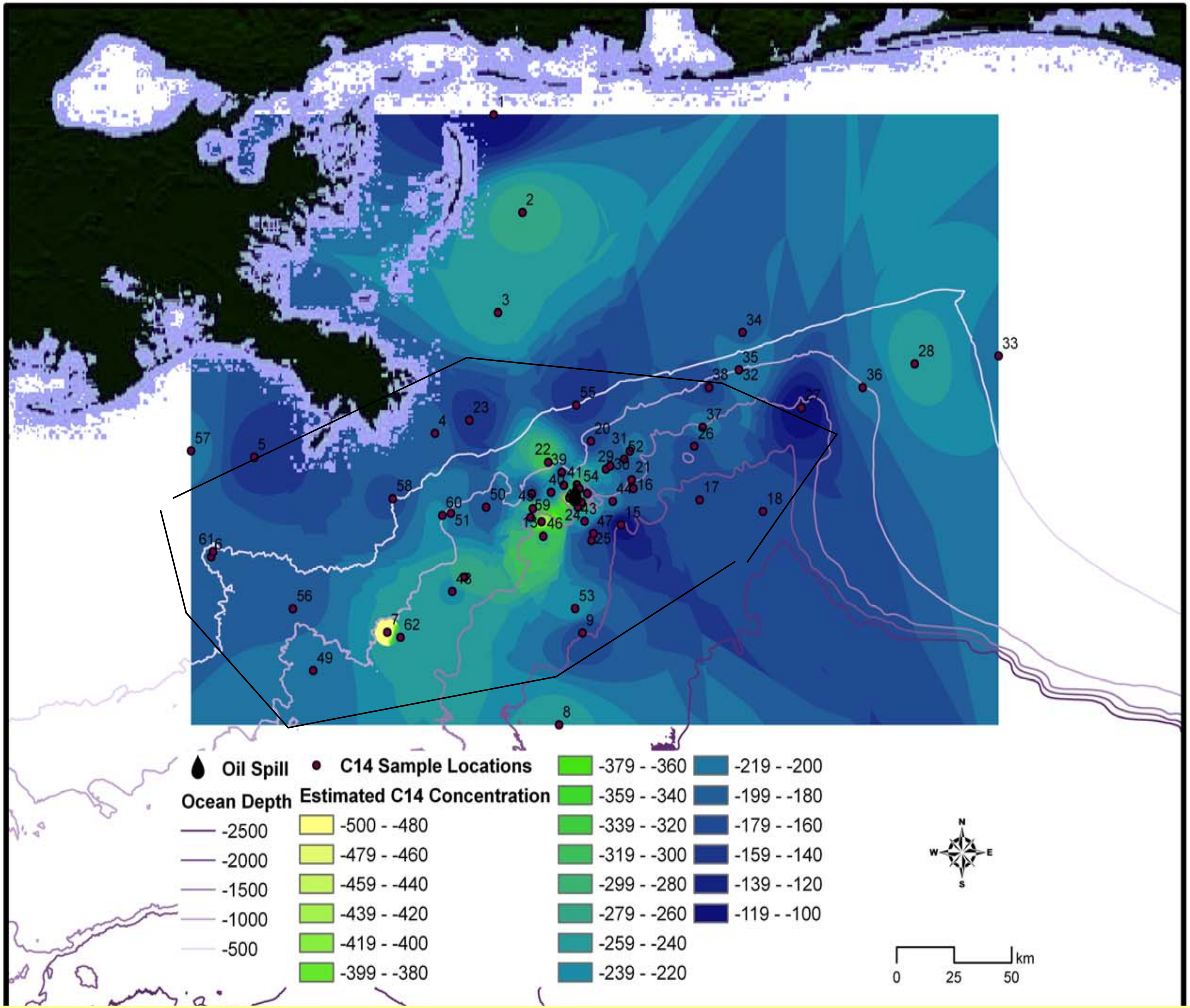
Fossil Carbon Penetration DwH



Oil deposition from above

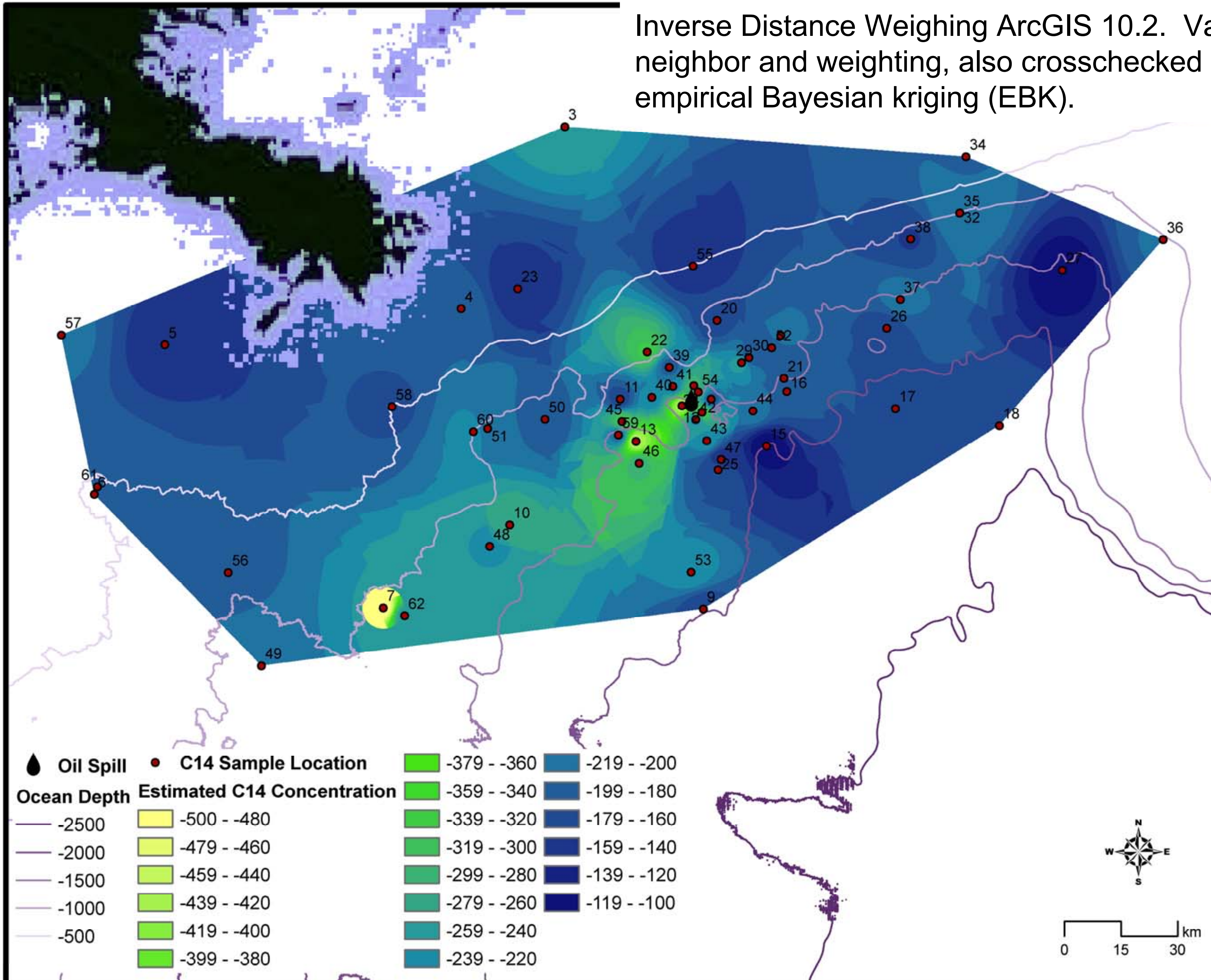




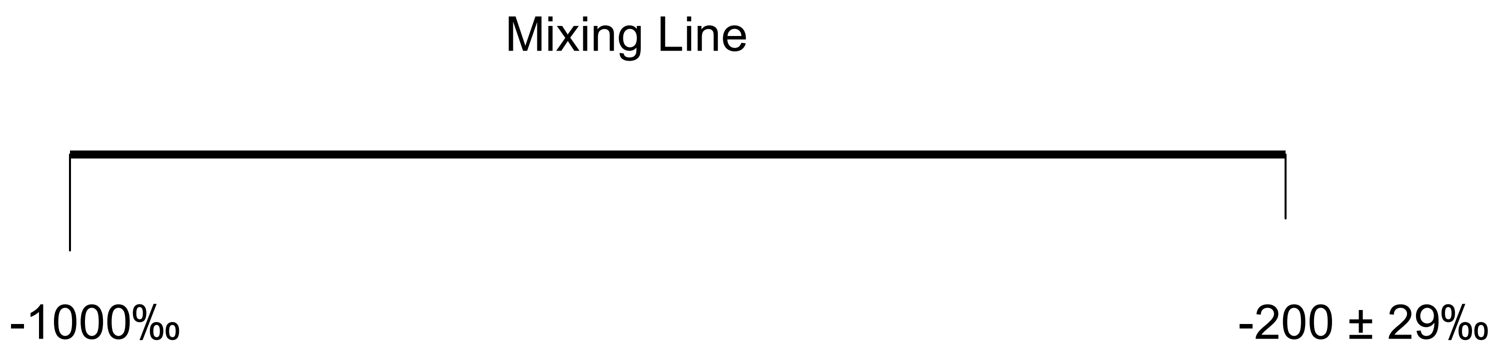
Brighter colors depict more ^{14}C depleted petro-residues, Chanton et al., 2015

Environmental Science and Technology, 49, 847−854 es-2014-046524. doi. 10.1021/es5046524

Inverse Distance Weighing ArcGIS 10.2. Varied neighbor and weighting, also crosschecked with empirical Bayesian kriging (EBK).

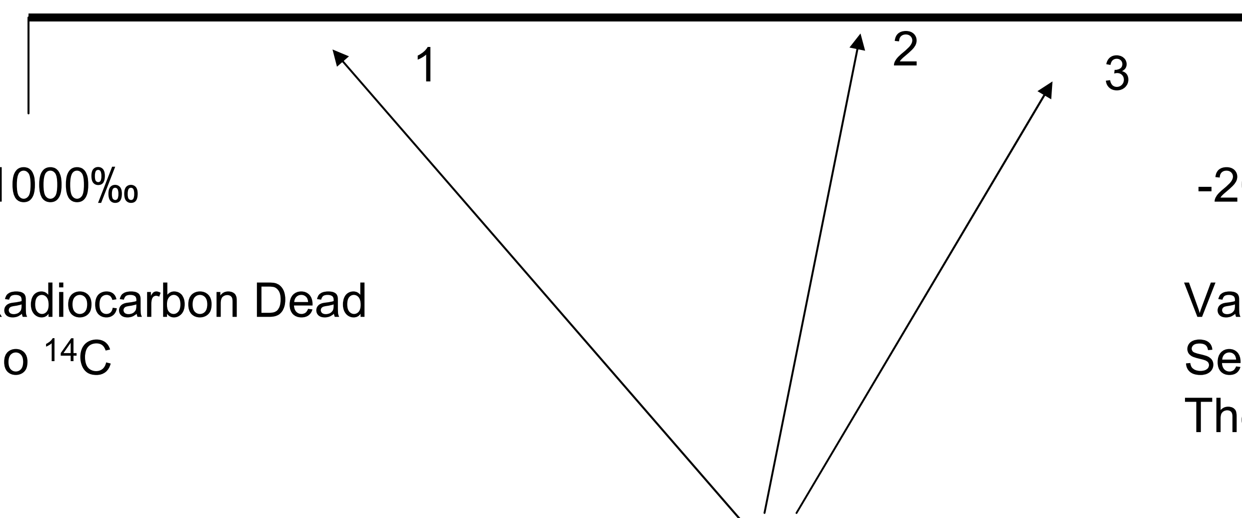


Two endmember model for sediment studies



Two endmember model for sediment studies

Mixing Line $\Delta^{14}C$‰



-1000‰

Radiocarbon Dead
No ^{14}C

-200 ± 29‰

Value of surface
Sediments prior to
The oil spill

Position on mixing lines gives % dilution with petrocarbon
1 more than 2, 3.

Two endmember mixing model

- $\Delta^{14}C$ of -1000‰ for petro-carbon
- Average underlying oiled surface layer, -200‰ (± 29‰)
- Measured value *1 = x (-1000‰) + (1-x) (-200 ± 29‰)
- Give fraction of organic matter that is fossil,

- *% OC, * (1-ϕ) times area of each section, integrate to 1 cm depth….. Gives fossil carbon flux1.6-2.6 x 10^{10} grams oil-derived C

- Divide by amount of oil from spill

- Gives 0.5 to 9.1% of spill oil went to the seafloor.
- Best estimate, 3-5%.
- Valentine et al., 2014→ hopane approach 1.8 to 14.4% of total.

So what?

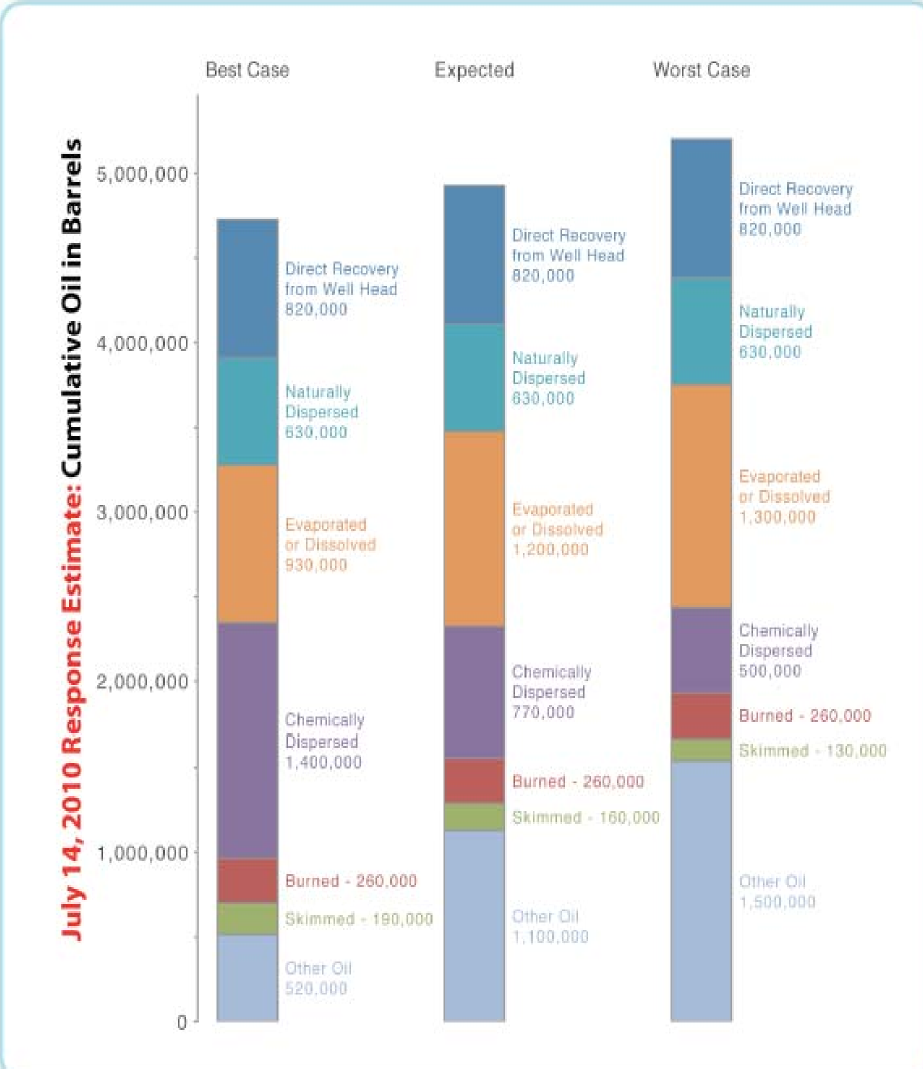


Figure 12: Response estimates produced by the Oil Budget Calculator showing best case, expected, and worst case volumes of the seven different portions that the calculator tracks individually, of the cumulative volume of oil discharged through July 14, 2010. These estimates served solely as a guide for the national response to the Deepwater Horizon MC252 Gulf Incident. The best and worst cases are defined in Appendix 1: they are the combinations of values of the seven variables depicted in each stack that correspond to the lower and upper endpoints of a 95% confidence interval for the volume of "Other Oil".

MOSSFA not included in 2010 Oil Calculator Oil Reckoning

No good model to predict it.

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So What cont.

- Petrocarbon breaks down more slowly in sediments due to oxygen limitation
- Sediments may serve as long term storage for hydrocarbons for as yet unknown periods.
- With that storage, there is potential for re-exchange with the water column due to either chemical or physical processes that occur in surface sediments including benthic predation, chemical degradation and infaunal mixing.

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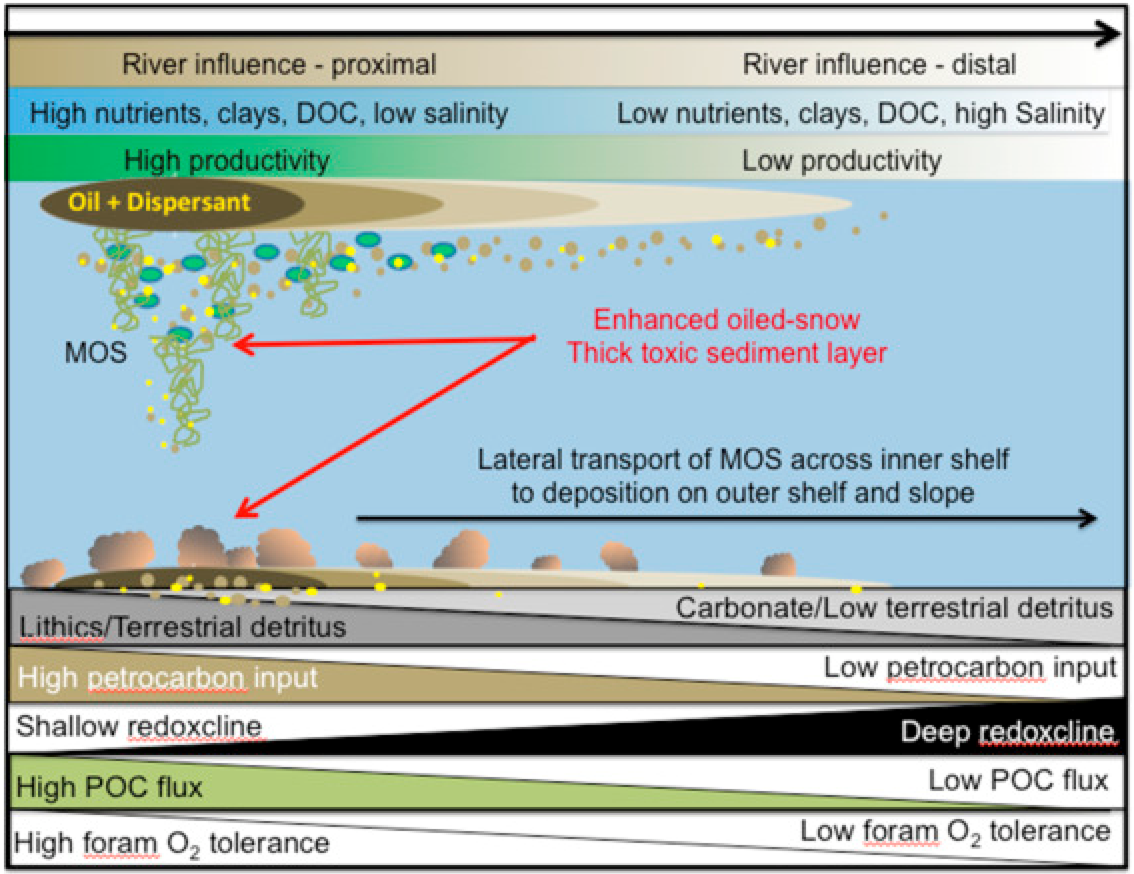

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Diagram illustrates the environmental gradients of material properties and fluxes associated with a point source of oil released in regions influenced by river outflow compared to offshore regions not influenced by riverine processes. Gradient shifts include the concentration and composition of suspended particles (clays to carbonate), the magnitude of particulate organic carbon (POC) and petrochemical fluxes to the seafloor, the depth of the sediment redoxcline, and the tolerance of benthic organisms, such as foraminifera, to different oxygen levels in sediments. Oil-mineral aggregations (OMAs) may sediment separately or in association with marine oil-snow (MOS). These environmental gradients overlap and interact with gradients generated by oil spills, e.g., oil and dispersant distributions, causing a complex temporal-spatial distribution of interactive effects.