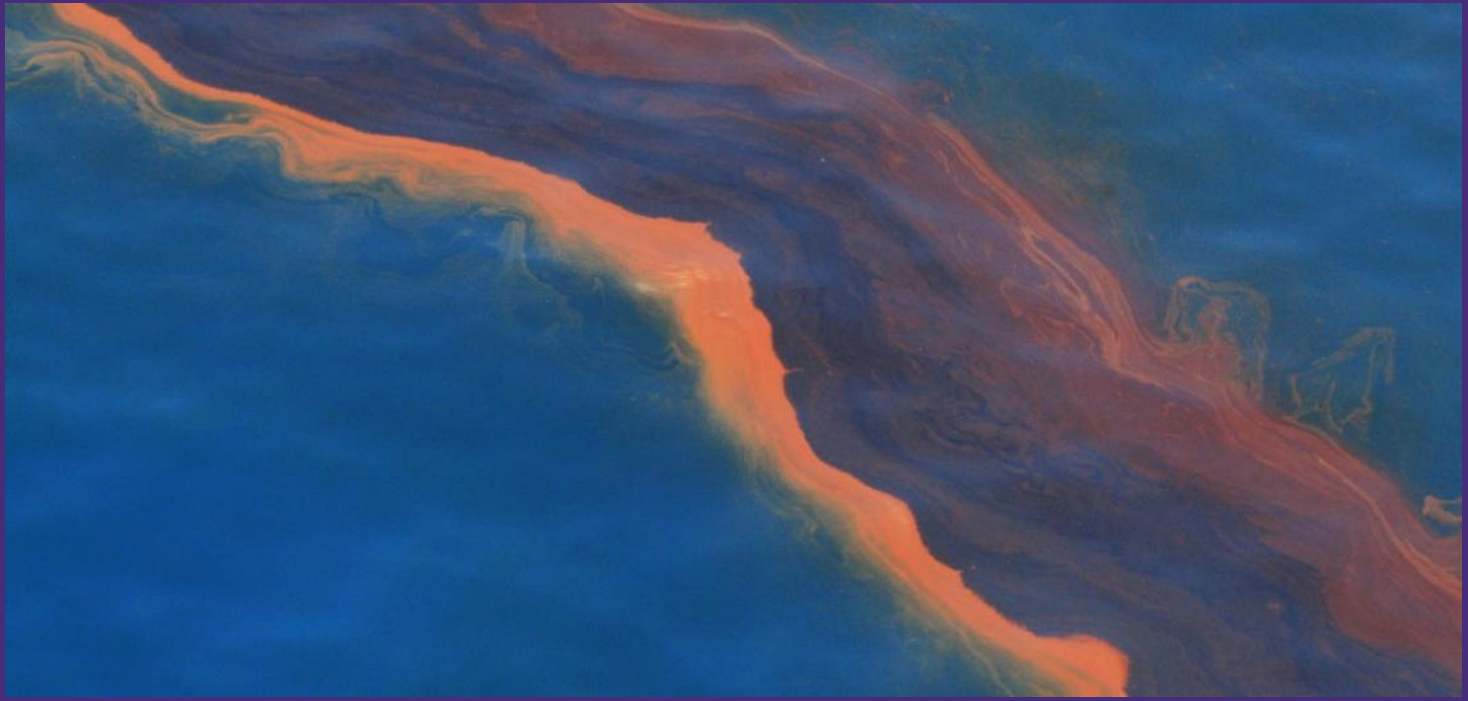
Leaky Wellbores: How They Impact Us and What We Can Do About Them

Ipsita Gupta

Assistant Professor

Petroleum Engineering



Source: National Oceanic and Atmospheric Administration (NOAA) - https://www.noaa.gov/noaa-launches-website-holding-millions-chemical-analyses

Louisiana State University
February 25, 2021

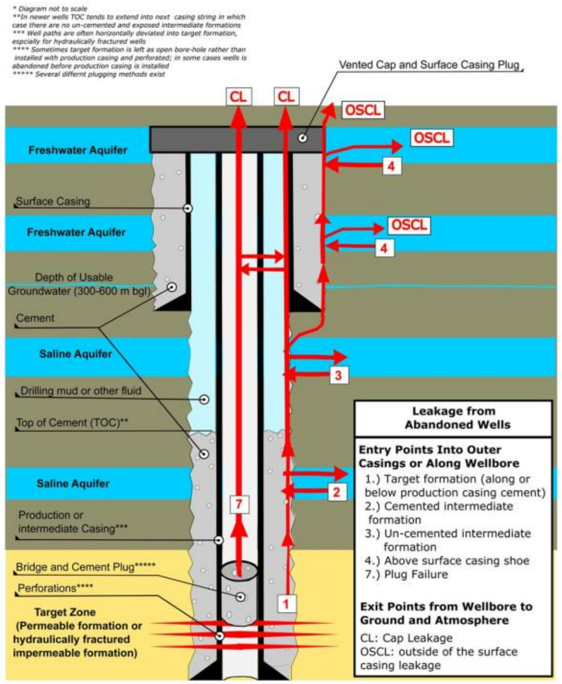
Biography: Research Interests

- Reactive Transport and Thermal-Hydrological-Mechanical-Chemical (THMC) Modeling for Energy and Environment
  - ❖ Wellbore Integrity - Cement-Rock-Fluid Interactions
  - ❖ Gas Hydrates
  - ❖ CO2 sequestration
  - ❖ Geothermal energy storage and production
- Basin-scale Hydrogeology – coupled heat flow, fluid flow and solute transport
- Integrated geology and subsurface engineering
- Broad range of Petroleum Engineering applications in Reservoir and Production Engineering, Worst Case Discharge, Geomechanics

What is a leaky well?

Leaky wellbores

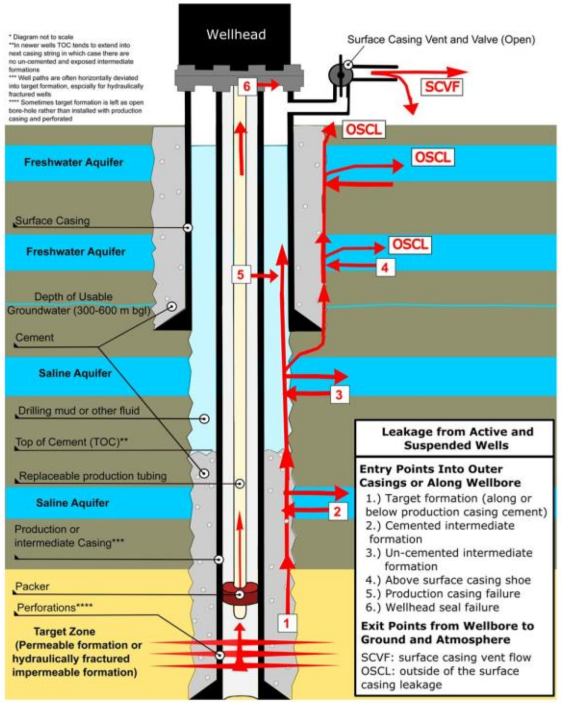
Schematic of an abandoned well and leakage pathways classified according to entry and exit points along the wellbore.



Joshua Wisen et al. PNAS 2020;117:2:913-922

PNAS

Schematic of an active well with leakage pathways classified according to entry and exit points along the wellbore.



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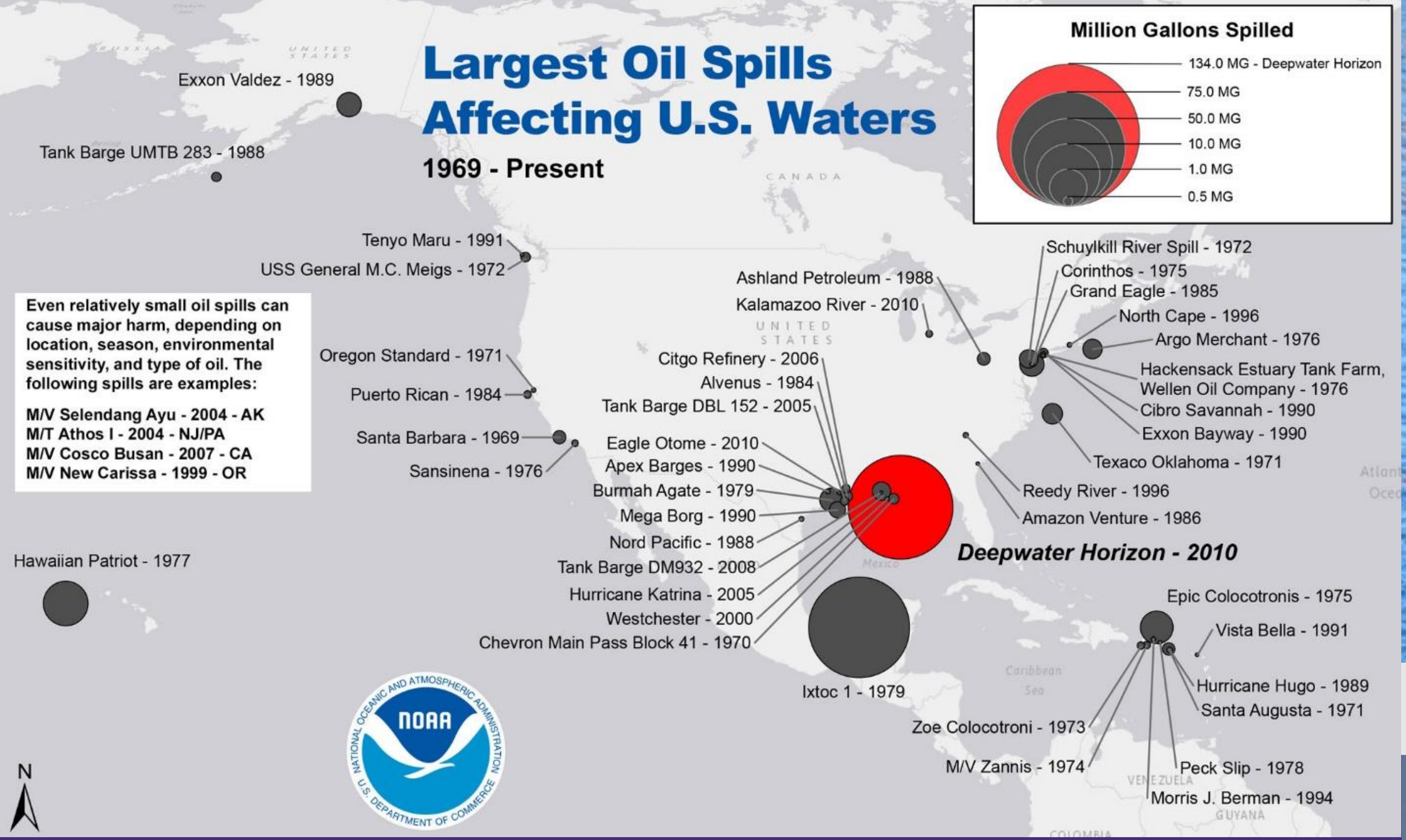
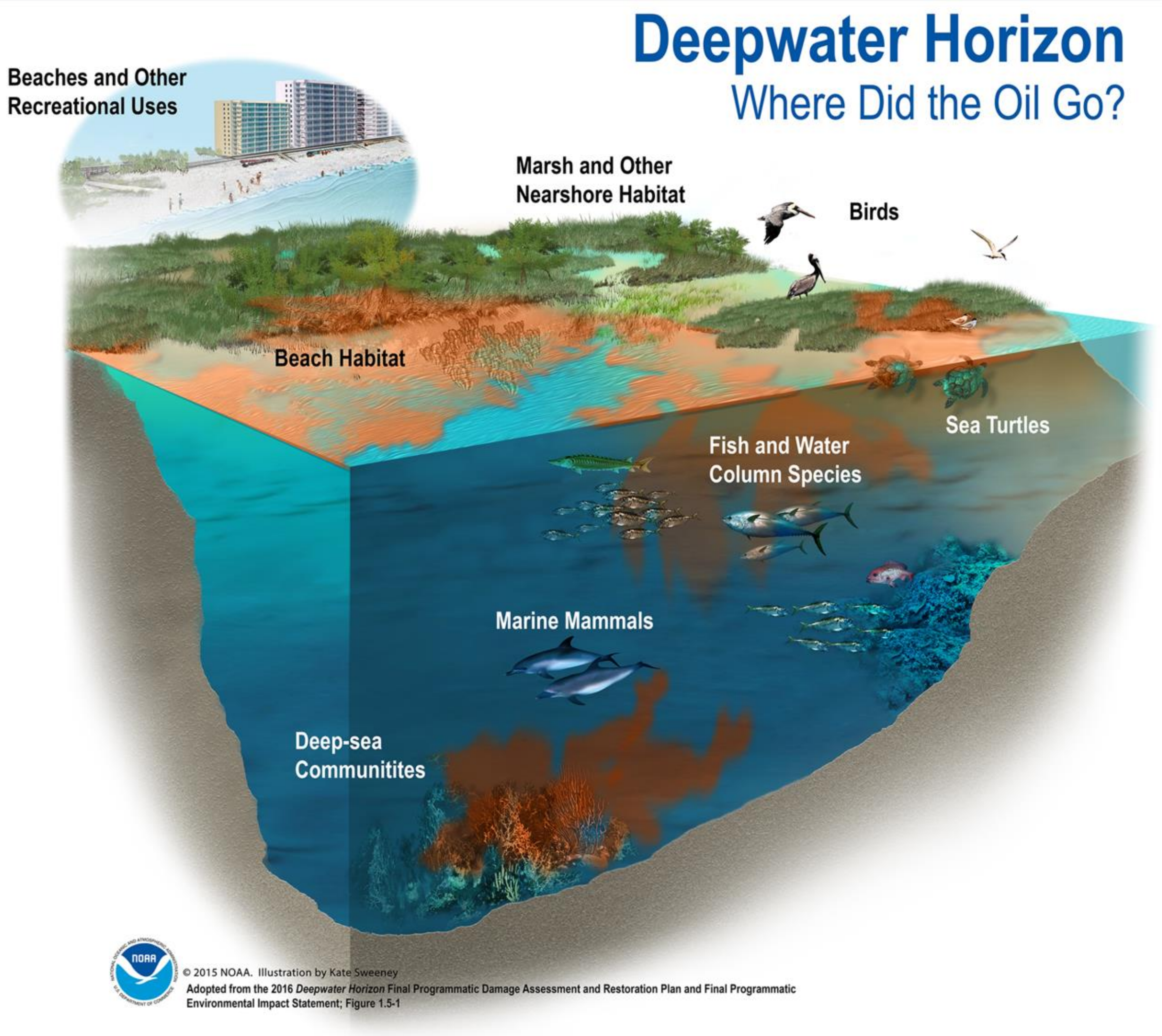


Source: NOAA - https://response.restoration.noaa.gov/sites/default/files/2015_largest-oil-spills-us-waters_noaa.jpg

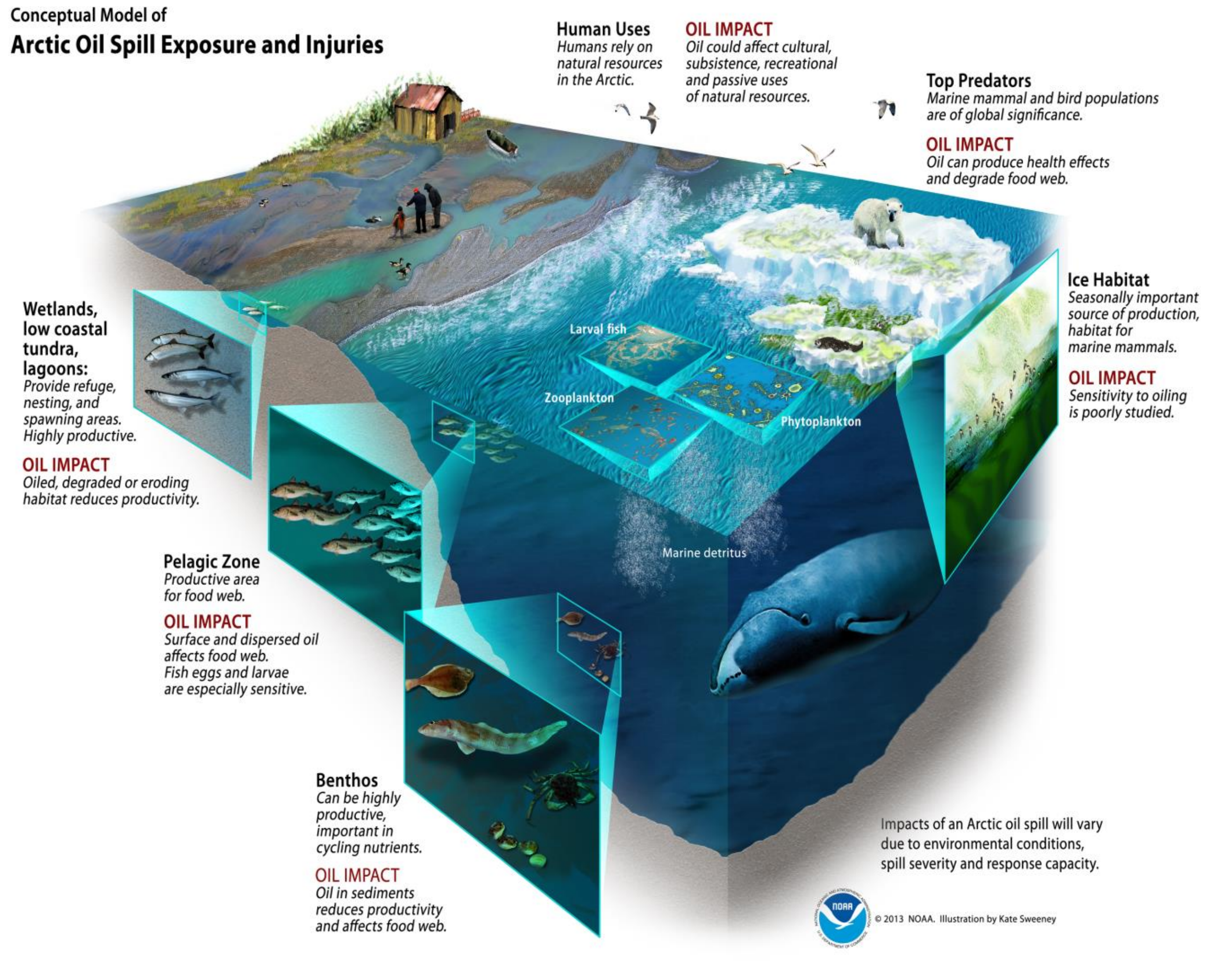
Occurrence – Land and Sea; Impacts - Small and Big

Source: NOAA - https://response.restoration.noaa.gov/about/media/where-find-orr-and-other-noaa-information-deepwater-horizon-oil-spill.html

Source: NOAA -https://darrp.noaa.gov/oil-spills/deepwater-horizon

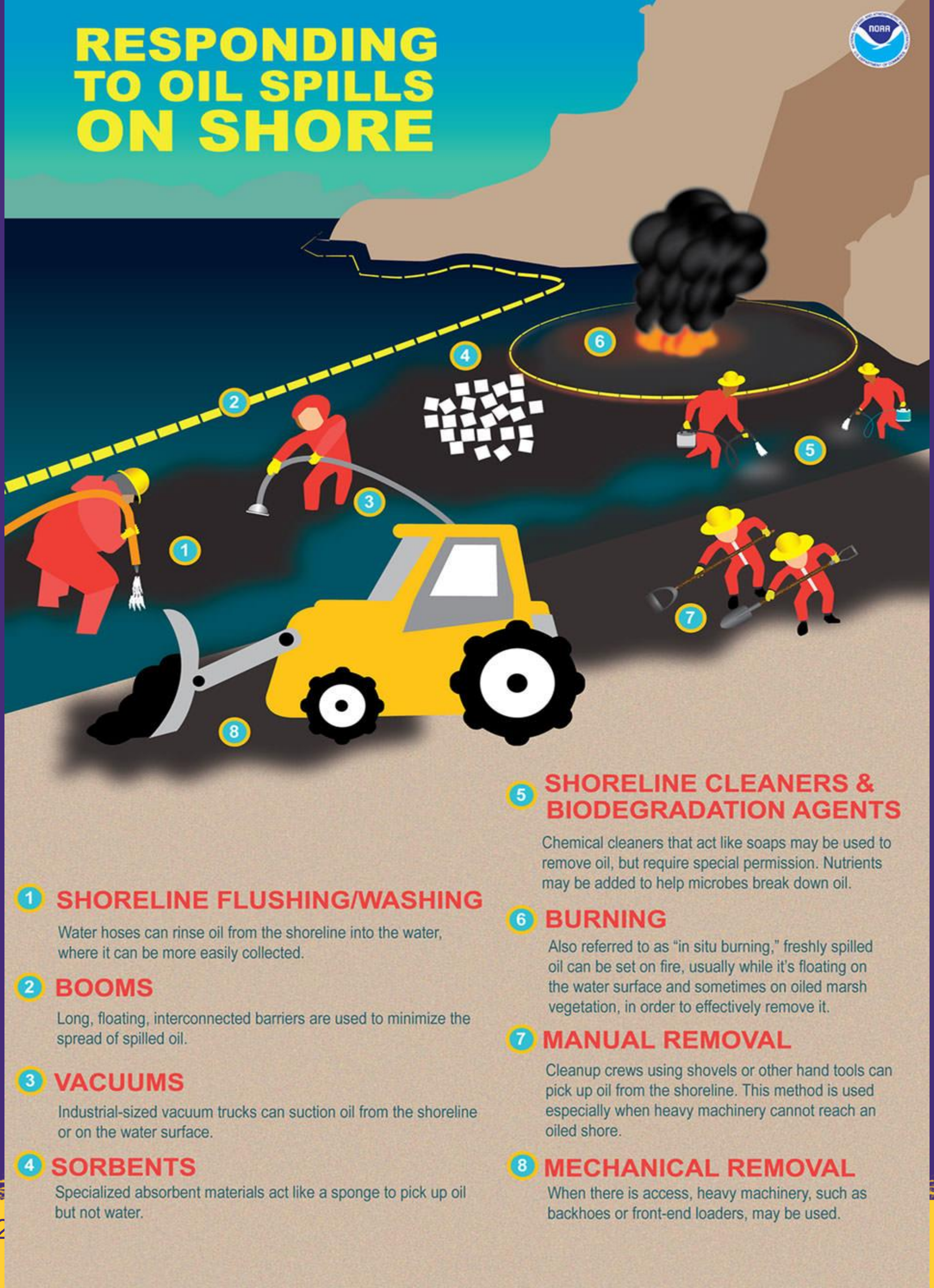


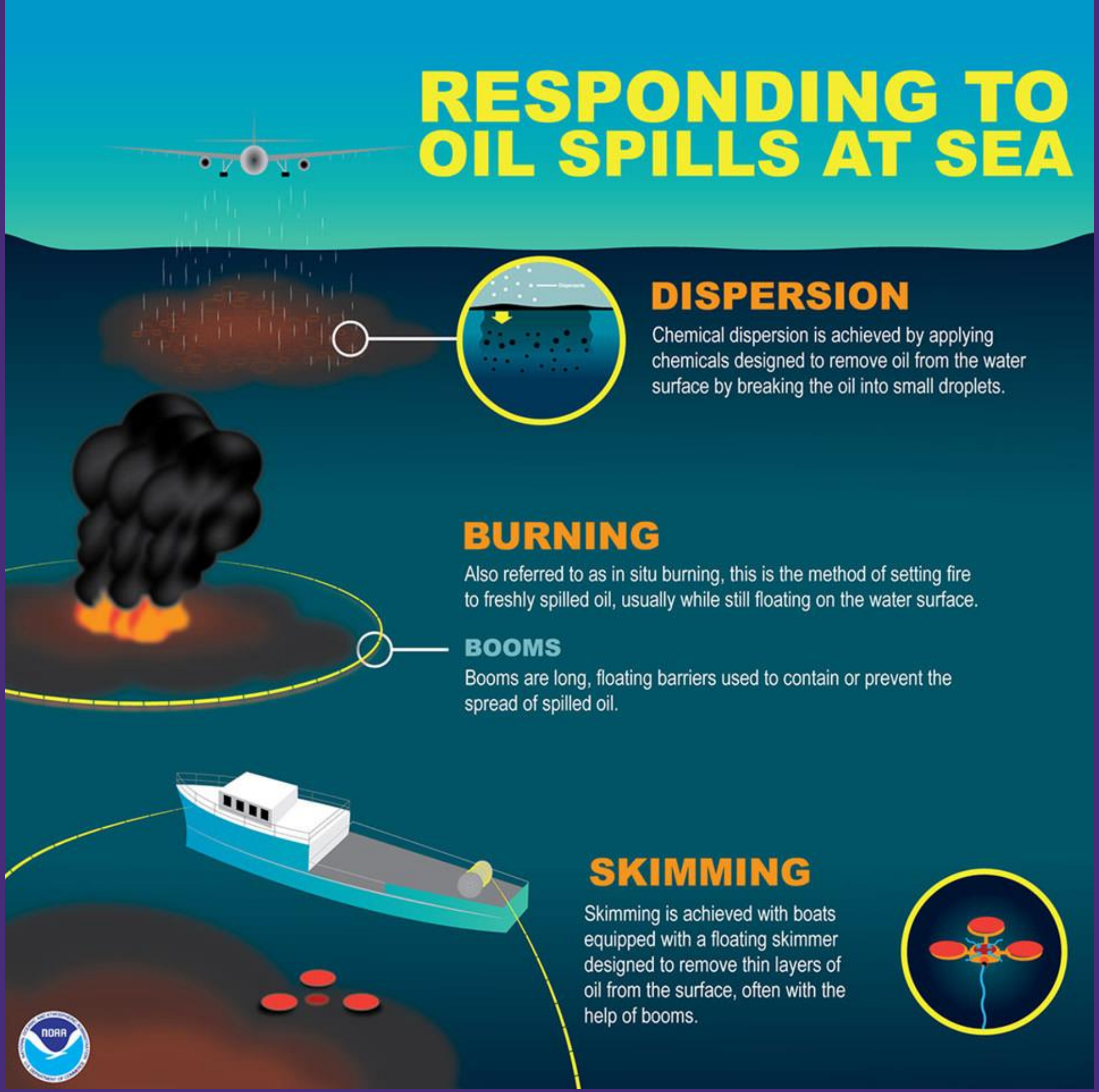
https://www.fisheries.noaa.gov/feature-story/restoring-gulf-10-years-after-deepwater-horizon-oil-spill?utm_medium=email&utm_source=govdelivery



https://response.restoration.noaa.gov/sites/default/files/arctic-food-webs-human-uses-oil-impacts-illustration_noaa_katesweeney.jpg

What can we do about them?





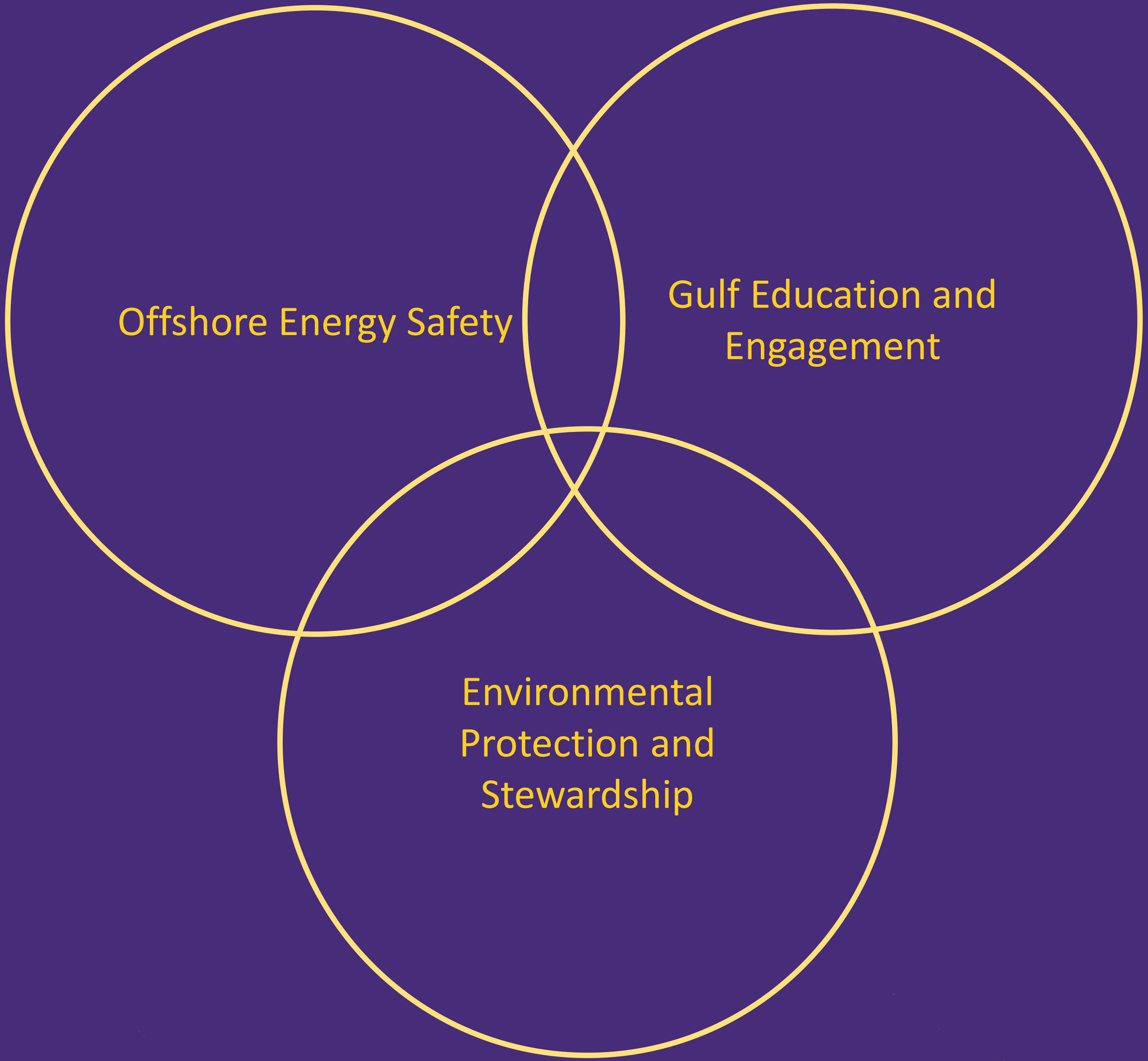
Source NOAA - https://oceanservice.noaa.gov/facts/spills-cleanup.html

But……what could we do before they occur?

A preventative strategy

= Responsible energy engineering

Research and Teaching Areas in Relation to GRP Initiatives



Research Questions

- How long does cement last under subsurface conditions? When can they start losing “integrity”, becoming “leaky”? Can we “predict” longevity?

- How much oil could spill? From leaks. From blowouts.

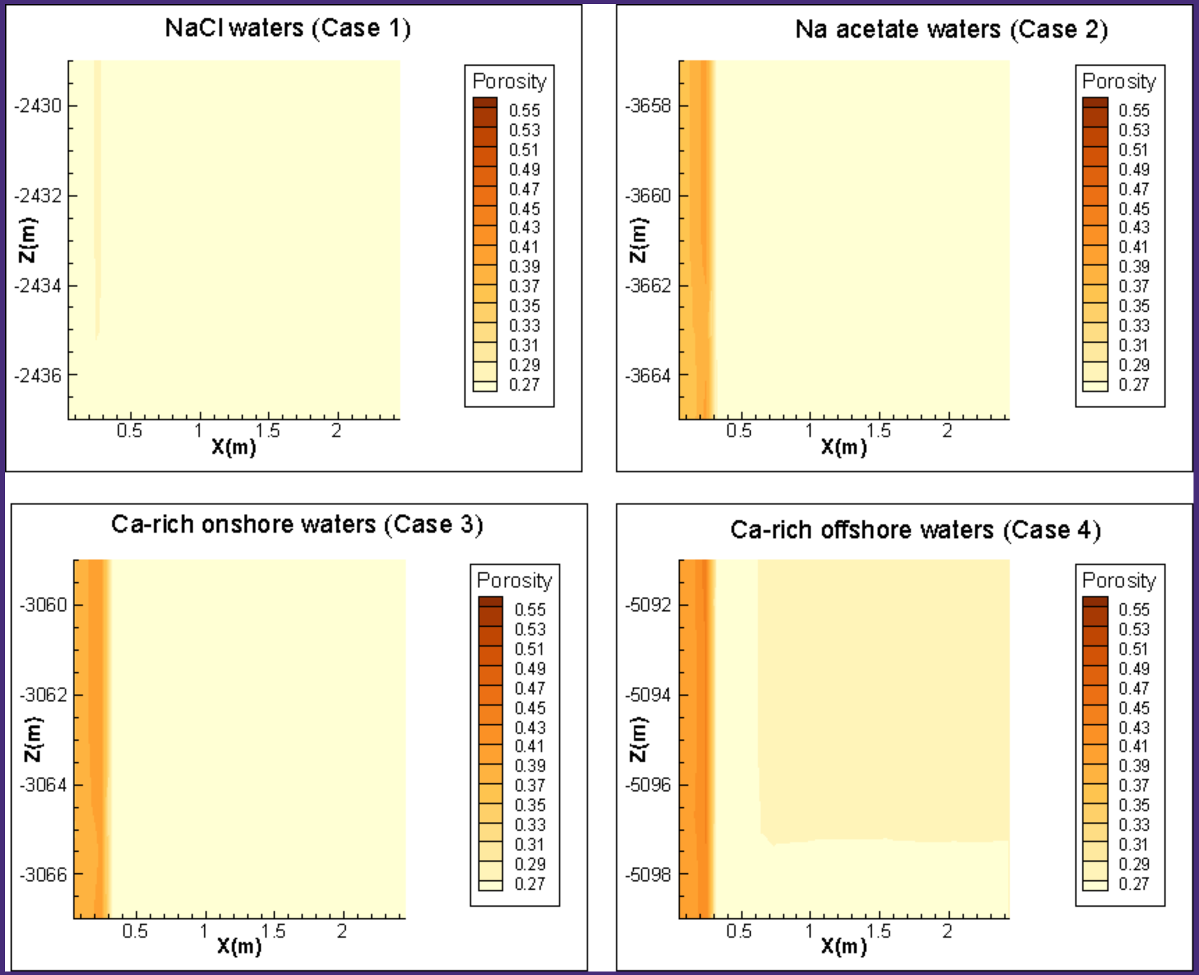
- If oil spills, how long will they remain in the sediments/contaminated zones?

- Can we predict leaks and possible fractures ahead of time?

Example 1: Predicting Longevity

- Use physics (flow and transport) + chemistry (composition) + math (modeling) to study how long cement/plugs last under subsurface conditions?

- Cement + Brine Reactions; Cement + Rock + Brine Reactions.



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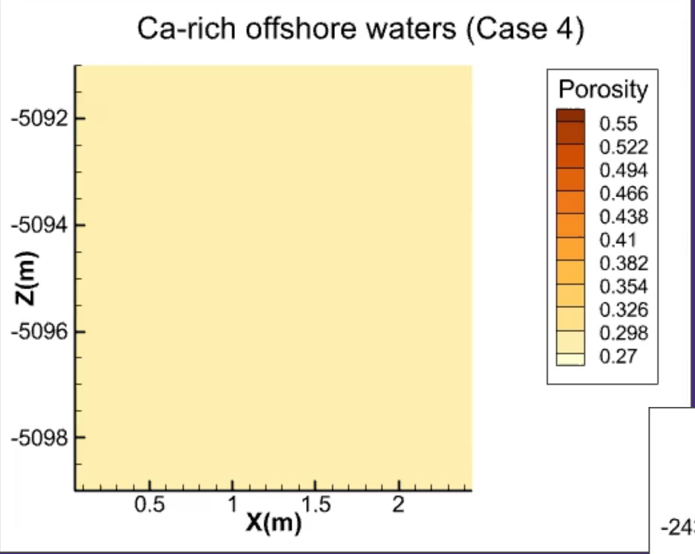

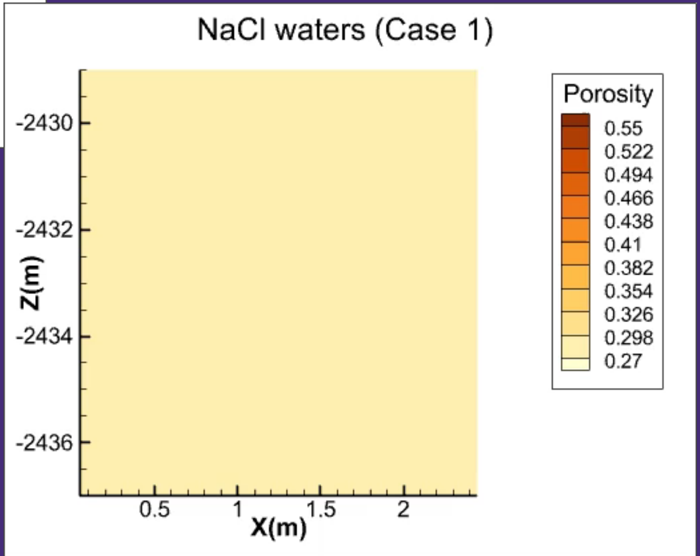

Temitope Ajayi PhD Research

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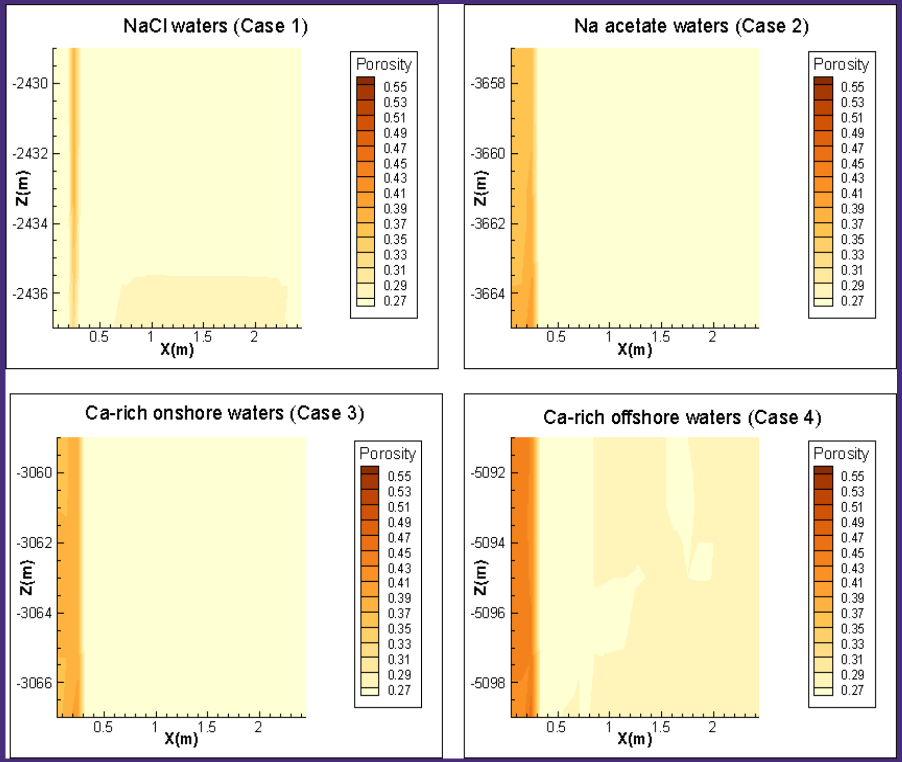
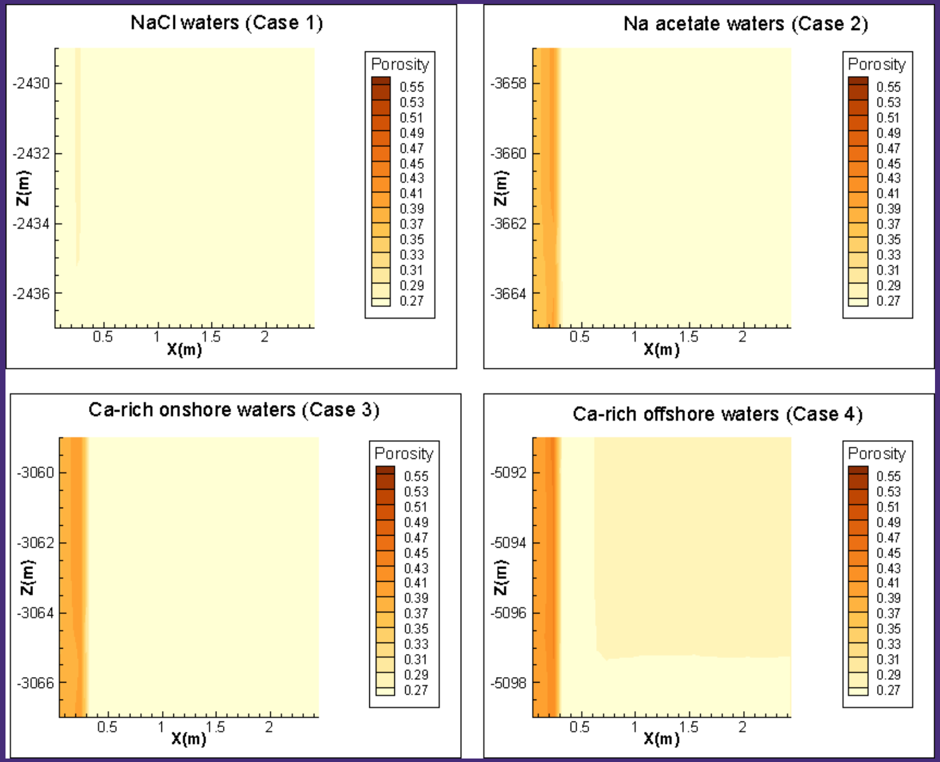


Cement, shale, brines



Cement, sandstone, brines

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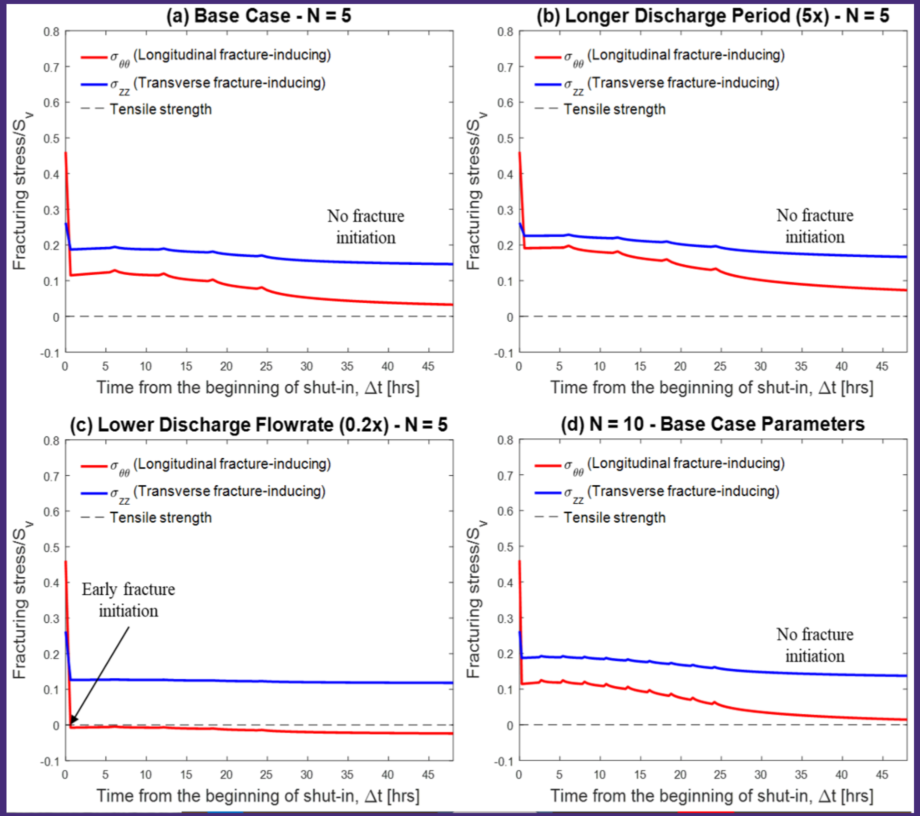
Example 2: Predicting Fracturing

- Use physics (flow + mechanics) + math (modeling) to study if fractures can initiate after blowouts occur – but do this before even drilling a well to avoid/minimize chances of it from occurring altogether.

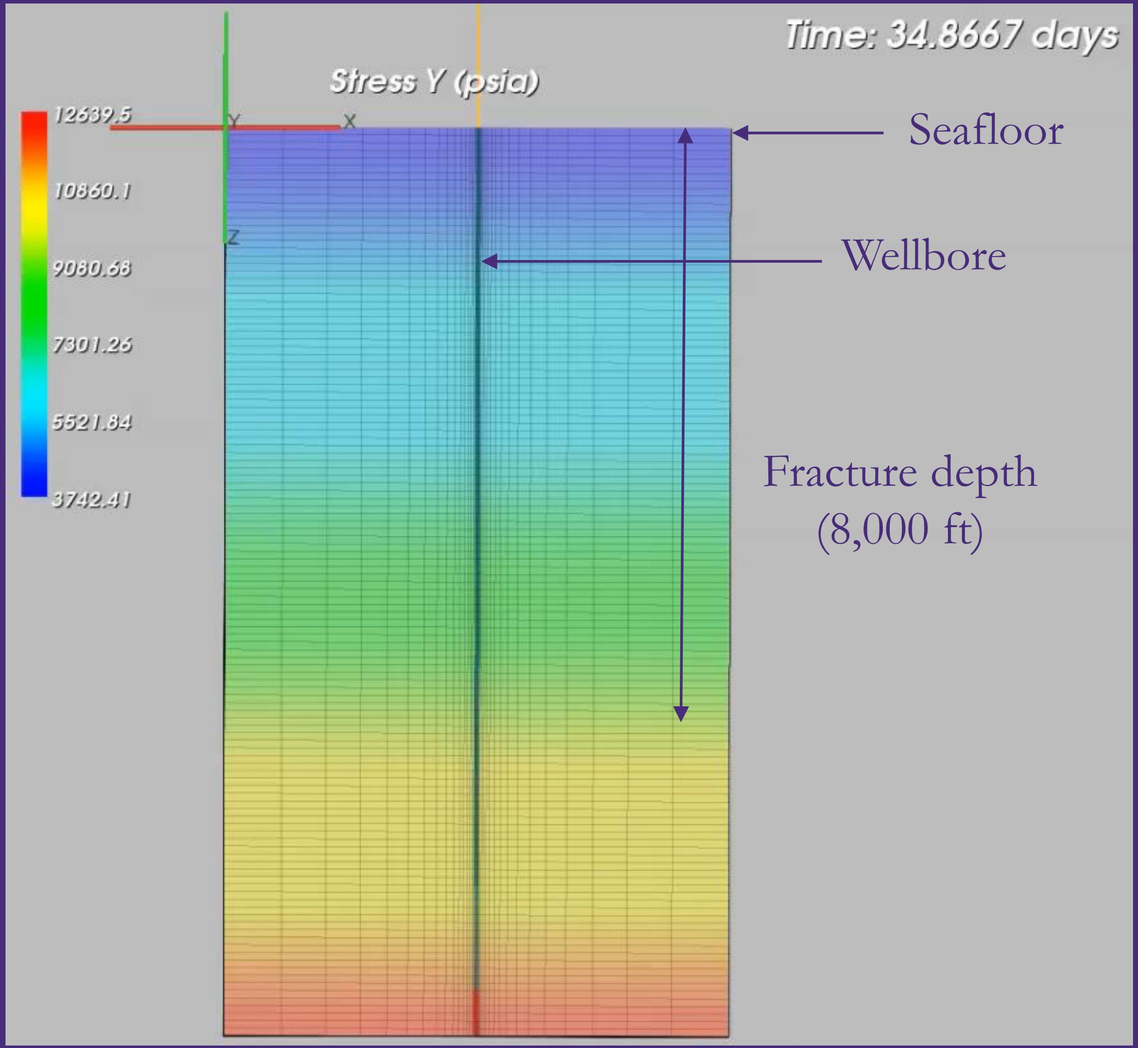


Longitudinal ($\sigma_{\theta\theta}$, red lines) and transverse (σ_{zz}, blue lines) fracturing stresses for four different combinations of shut-in parameters. Fracture initiation takes place when either of the two lines becomes more negative than the black dotted-line, indicating the tensile strength of the rock, T. (a) Base Case parameters with number of shut-in steps, $N = 5$, (b) a 5-fold increase in the discharge period preceding the capping stack shut-in (5 days, compared to 1 day) compared to the Base Case, (c) a 5-fold decrease in the discharge flowrate (31,008 barrels/day, compared to 155,040 barrels/day) compared to the Base Case, and (d) Base Case parameters with $N = 10$. Following this evaluation, an optimal capping stack shut-in strategy can be selected such that any fracture initiation will be prevented. This analysis can be performed prior to drilling considering relevant scenarios for draft contingency plan in the event of a blowout. This image is reproduced with permission from the Society of Petroleum Engineers Copyright Clearance Center. *Reference:* Michael, A., and Gupta, I. (2020). Fracture Prevention Following Offshore Well Blowouts: Selecting the Appropriate Capping Stack Shut-In Strategy. Society of Petroleum Engineers. *SPE Drilling & Completions*, doi:10.2118/199673-PA.

Andreas Michael PhD Dissertation

Example 3: Predicting Broaching

- Use physics (flow + mechanics) + math (modeling) to study if fractures can propagate after blowouts occur – but do this before even drilling the well.



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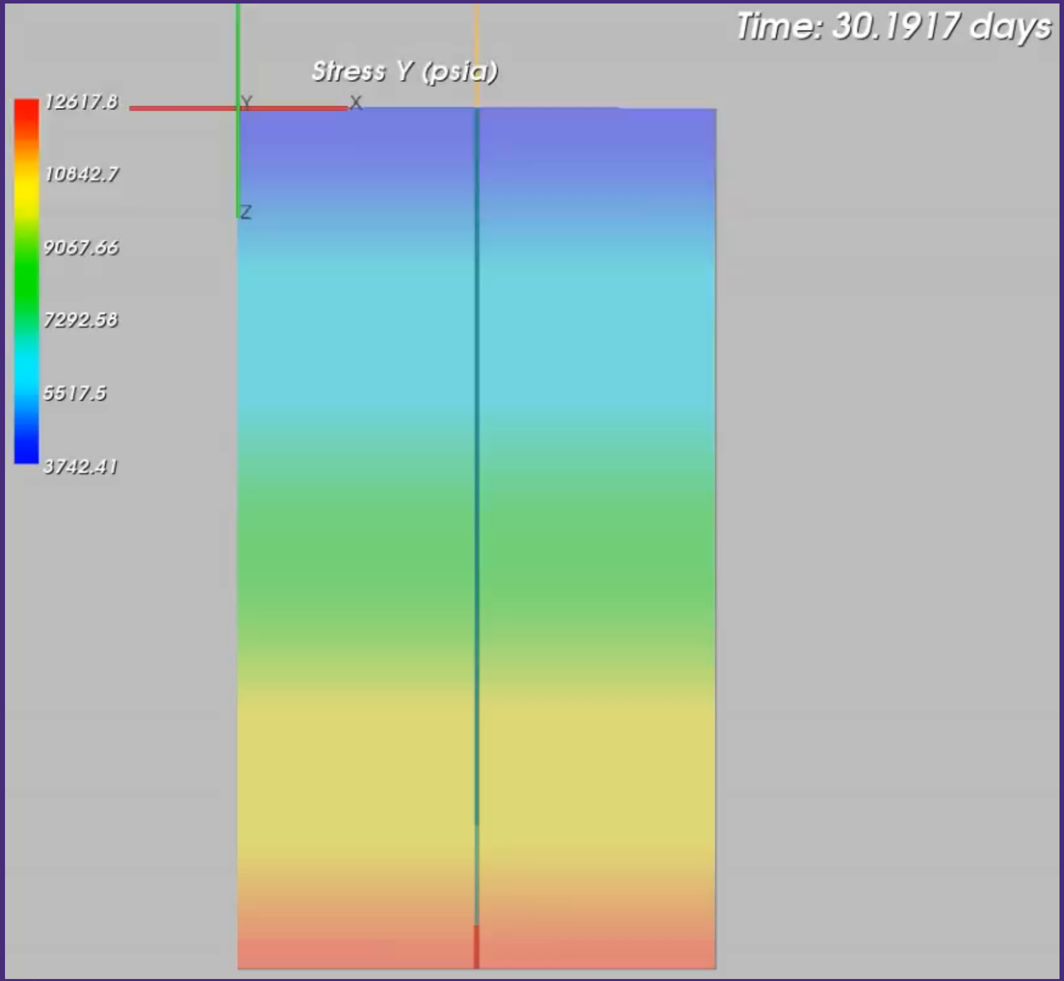

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Conclusions

- Using science, math, engineering and technology we can study:

- leaks and spills from oil and gas wellbores/pipelines,
- their impact on health, safety and environment,
- clean up processes,
- and equally important – employ predictive, preventative strategies for responsible energy engineering.

Is this all we do or can do?

NO!

We do much, much more!!!

But, I hope I have conveyed to you that:

Responsible Energy Engineering is Important for our Health, Safety and Environment.

References:

Ajayi, T. and Gupta, I. “Long term assessment of the geochemical integrity of offshore wellbore cement– results from numerical modeling”, Journal of Petroleum Science and Engineering, Volume 201, 2021, 108443, ISSN 0920-4105, https://doi.org/10.1016/j.petrol.2021.108443. Elsevier.

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Questions