Deepwater Horizon Gulf Oil Spill

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Coastal Response Research Center (CRRC)

• NOAA’s Office of Response and Restoration and UNH spill partnership
• CRRC Mission:
  • Conduct and Oversee Basic and Applied Research and Outreach on Spill Response and Restoration
  • Transform Research Results into Practice
  • Serve as Hub for Oil Spill R&D
  • Educate/Train Students Who will Pursue Careers in Spill Response and Restoration
Today’s Topics

- Oil Drilling in the U.S.
- Deepwater Horizon (DWH) Drill Rig
- Oil Spill Basics
- DWH Spill Response
- Innovations During DWH Spill Response
- Key Issues During DWH

Oil Drilling in the U.S.
783 M metric tons = 230 billion gallons

(Source: Clark, 2001)

# = million metric tons/year
Barrel = 42 U.S. gallons
7 Barrels = 1 metric ton

~4,000 offshore platforms in Gulf of Mexico
Crude Oil Imports into the U.S.

- Total: 10.4 million barrels/day = 159 billion Gallons/Yr (2010)
- Imports Through Louisiana Offshore Oil Port (LOOP) Facility
  - Handles 13% of imported oil = 20.7 billion gallons/yr

Crude Oil Production in U.S.

- Total: 79.8 billion gallons/yr (2009)
- Alaska produces 9.9 billion gallons/yr
- Gulf of Mexico (GOM) produces 23.9 billion gallons/yr (30% of total domestic crude)
Oil Consumption in U.S.

- Total: 290 billion gallons/yr
- Transportation: 72%
- Industrial: 22%
- Residential/Commercial: 5%
- Electrical Power: 1%

Deepwater Horizon (DWH) Rig
Deepwater Horizon Rig

DWH Rig Facts

- 33,000 Ton Drilling Rig on Pontoons (Built 2001 / $350M)
- Derrick = 20 stories above top deck
- Held in position using GPS dynamic positioning controlled thrusters
- Crew = 126
- Owner: Transocean
Mississippi Canyon Block 252 (Macondo Site)

• BP Lease Site (MC252)
  • 10% BP’s oil from GOM
  • Cost: $34M to Minerals Management Service
• Transocean’s Marianas rig started drilling at MC252 October 2009
  • Damaged in Hurricane Ida
    • November 9, 2009
  • Drill pipe 5,000 ft of water + 4,000 seabed (9,000 ft total)

Macondo Site Drilling History (cont’d)

• ~9,000 ft more to drill to gas and oil reservoir (~18,000 ft total)
• Marianas replaced by Deepwater Horizon rig
  • Est $1M /day fee
• DWH arrives at Macondo site Jan 31, 2010 and starts putting down pipe
Macondo Site Drilling History (cont’d)

• BP and partners budgeted 51 days and $96.2M for this well
• By April 20, 6 weeks behind schedule and $58M over budget
• Personnel (126 people)
  • 80 Transocean employees
  • Drilling crew and vessel management
  • Some BP engineers/geologists
  • Service workers (e.g., food, laundry)
  • Floating city

DWH Well Blowout

• Occurred on April 20, 2010
• 11 people killed, all but one on “drilling floor”
• DWH Rig had drilled into oil/gas reservoir
• Testing new bottom of well; cement seal (Halliburton)
DWH Well Blowout (cont’d)
• Put in temporary cement plug – 3,000ft below top of well
  • “Temporary abandonment” until production platform brought in
• Skipped Schlumberger’s cement evaluation to save time and $128,000
• Positive pressure test
  • Increase pressure inside steel casing and seals to be sure they are intact
• Negative pressure test
  • Reduce pressure inside well to simulate situation after rig gone (no fluids should leak into well)

DWH Well Blowout (cont’d)
• Positive pressure test – acceptable results
• Negative pressure test
  • Began 5 pm, April 20
  • Pressure repeatedly increased – fluids leaking in?
  • Decided to try again using “kill line” on blowout preventer (BOP)
    • Results ok no pressure increase
    • Likely kill line was not working properly (clogged)
  • Decision – OK to open BOP and replace heavy drilling mud in drill pipe with seawater
    • Once that was done can put in cement plug
DWH Well Blowout (cont’d)

- 9:15 pm begin adding seawater into bottom of well (annulus)
- ~ 9:40 pm hissing and high-frequency vibration
- Then mud shooting out of gas buster on rig
- Then explosion
- All saved except 11 killed in explosion
  - Supply vessel & life raft (lowered 15ft to water)
  - Fire on rig & oil on water surface
  - Returned to shore on supply boat, except for very badly injured (by USCG helicopter to land)

DWH Oil Spill

- 1:30 am (April 21) DWH rig listing; secondary explosions & fire
- 2:50 am (April 21) rig spins 180°; GPS dynamic positioning dead
  - DWH moved 1600 ft from well
- 3:15 am DWH listing heavily, fire continues & fire boats spraying water on rig
- 1:27 am April 22 DWH sank
- Not clear whether oil leaking from well
  - Debris, multiple sites from collapsed pipe; rig fuel?
DWH Blowout Causes

• Lots of individual mistakes
• Excellent source of information in:
  • Presidential Commission Report
    (www.oilspillcommission.gov)
  • Final Report to BOEMRE: Forensic Examination
    of DWH BOP (March 20, 2011)
  • Report of Investigation into the Circumstances
    Surrounding the Explosion, Fire, Sinking and
    Loss of Eleven Crew Members Aboard the DWH
    (DRAFT), Volume I (April, 2011)
**Crude Oil Properties**

- **Usually Floats on Water**
  - May sink if associated with sediment particles
- **Composition Varies with Source**
  - Louisiana Sweet Crude Oil – lighter than Alaska North Slope crude
- **Some Solubility**
  - Soluble is most toxic fraction
- **250+ Hydrocarbons**
  - Mostly carbon and hydrogen

**Weathering of Oil**

- **Natural Processes**
- **Function of Environmental Conditions**
  - Temperature (H₂O, Air)
  - Wind
  - Oil Type
  - Currents, Tides
DWH Spill Response
Overview of DWH Spill

- DWH blowout ~50 miles off Mississippi River Delta
  - 5,000 ft of water
  - 13,000 ft of sediment/rock
  - Total rig to oil reservoir ~ 18,000 ft (~3.5 miles)
- April 20 – Explosion on rig/fire
- July 15 – Well killed from top ending release
- Total Oil Release (est.) = 200 Million Gallons
- Largest ACCIDENTAL Oil Spill in Recorded History!

Estimated Footprint (DWH vs. Valdez)

Estimate of Exxon Valdez oil footprint ~470 mi by 50 mi
DWH Response:

200 million gallons of oil released over 87 Days

Lots of oil over long time

Oil was in patches, not one continuous slick

Oil plumes were on surface and at depth

“We faced a new spill every day for 3 months!”

Top Priority = Stop Fire, Rescue People
Other Priorities - Stop Source of Leak

- Start relief wells
- Install “cap” to stop flow
  - High ambient water pressure, cold and dark
    - 2200 psi
  - High exit pressure of oil, hot (212°F)
    - 6500 psi
  - Well head ~ 7 inches diameter; 1 mile below water’s surface
Final Response Mode:
Prior to Top Kill
Other Priorities - Minimize Damage to Natural Resources

- Identify natural resources at risk
- Crabs, shrimp, oysters, blue fin tuna, charismatic marine mammals
- Recreational beaches
- Commercial fishing
- Subsistence fishing

Other Priorities – Minimize Damage to Natural Resources

- Protective booms
  - ~5,500 miles of boom deployed
- Capture oil in booms (Mechanical Recovery)
  - Skim oil off surface
  - Burn oil on surface
- Disperse oil
- Weathering of oil
  - evaporation
Oil Collection Booms & Skimmers

- Lots of vessels & boom (Vessels of Opportunity)
- Improved designs work in small waves
- Often weather was not conducive to mechanical recovery
  - 20+ mph winds and 3+ft waves on-shore
- Encounter rate low – Big plume and oil “spotty”
- No night skimming

DWH: State-of-the-Art Mechanical Recovery
**DWH: Rising Plume Effect**

- Rise = 1 mile from well to GOM surface
- Plume on surface = 100 mi long
- Swath width per skimmer = 200-500 ft
- Multiple boats – 1750 ft

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**In Situ Burning**

- Lots of R&D since *Exxon Valdez* in 1989
- Protocol/Standards
  - Fire retardant boom
  - Ignition
  - Oil thickness
Dispersants

- Not used in U.S. much
  - Dilution not typical solution to pollution
- Waves mix dispersant with oil
- Dispersant breaks up oil plume into tiny droplets
- Tiny droplets stay suspended in water
  - Oil biodegradation

Dispersant Use

- 2.1 million gallons
  - Corexit 9500
    - 2nd largest use ever
- Used on surface
  (Sprayed from boats & airplanes)
- Injected into plume as leaves well
  - Subsurface injection never done before
Rationale for Dispersant Use

- Spill so big and prolonged
  - “New” spill every day for 87 days
- Sensitive nearshore and salt marshes
  - Reproductive season
  - Winds & waves blowing oil on-shore
  - Mechanical recovery & burning & boom protection could no work in these conditions
- Trade-off dispersants: Lesser of two evils vs. oiling on shore and in coastal shallows

Dispersant Use Controversy

- Issue of Dispersants into Water
  - Toxicity of dispersant
  - Toxicity of dispersed oil
  - Unknown deepwater ecosystem
- Final verdict still out
  - Acute vs. chronic toxicity
  - Not all of the data is available yet
Estimates of Fate of Oil

- Ultimate Fate of Dispersed, Evaporated, Dissolved and Other: (e.g., Biodegradation, Burial, Photo-oxidation, Uptake by Biota) is Unknown

Source: Oil Budget Calculator

Innovations During DWH Spill Response
**DWH: State-of-the-Art Monitoring Oil**

- Detection of subsurface oil
  - Measuring for leaks and natural seeps
  - Holographic detectors from biological oceanography
- Measuring oil flow from well
  - 4 methods used to get flow
- Tracking subsurface plume chemistry

**DWH: State-of-the-Art Managing Spill Response**

- Common Operating Picture
  - All responders see same, detailed information
  - Overlay layers of information to help make decisions
  - Where beaches located?
  - Where floating oil?
  - Decide boom placement to protect beaches at risk
DWH: State-of-the-Art Managing Spill Response

- Environmental Response Management Application
  - ERMA® - UNH/NOAA trademark
  - Developed by UNH Research Computing Center
  - Partnership with NOAA and CRRC
- [www.geoplatform.gov](http://www.geoplatform.gov) has hundreds of layers of data to overlay

[www.geoplatform.gov/gulfresponse](http://www.geoplatform.gov/gulfresponse)
Capping Leaking Deep Ocean Wells

- Industry’s $1B R&D company
  - Marine Well Containment Company
  - Created July 2010
  - ExxonMobil, Chevron, BP, Conoco-Phillips, Royal Dutch Shell, Hess, Statoil, Apache, Anadarko, BHP Billiton
- Interim subsurface cap stack
  - Shut in oil flow
  - Attach flexible pipes and risers to divert oil flow to surface vessels

Key Issues During DWH
The Imbroglio

Explosion of Science and Engineering Complexity

Public’s Limited Scientific and Engineering Literacy

Politics Local, State, Federal

24/7 Information Can we believe it?

imbroglio \im-BROHL-yoh\, noun:

1. A complicated and embarrassing state of things.
2. A confused or complicated disagreement or misunderstanding.
3. An intricate, complicated plot, as of a drama or work of fiction.
4. A confused mass; a tangle.
Scientific / Engineering Complexity

- Oil spill scientists/engineers
  - Very small & underfunded community
  - Insular
- Oceanographers & ocean engineers
  - Little knowledge of response issues or oil properties
  - Safety and response protocols at spill site
- Misunderstandings resulted between two groups

Scientific Literacy

- Complex response & science concepts to convey
- Literacy issue for public, government officials and reporters
- Responders and scientists are not always best teachers
24/7 Information
(Is it True?)

• Experts everywhere
• “Lure” of being rock star
  • Report data before fully analyzed
• What gets reported?
  • What will reporter report?
• Is what reported true?
  • Credentials of bloggers

Scientific Peer Review
vs.
24/7 Information

• Scientific peer review takes months
• Data reported in journals today is months old
  • Public thinks it is today
    • August journal articles report June’s data
• Data can seem contradictory when it is not
  • Camilli et al. vs. Hazen et al.
    • Both in Science August 2010
A Model Misunderstood

http://www.youtube.com/watch?v=pE-1G_476nA

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Politics

• Survey of GOM coastal residents
  • Public does not trust government or industry
  • Public trusts scientists (especially those who report data that supports THEIR world view)
• Hurricanes Katrina/Rita aftermath
  • Skepticism and discontent
• Politicians exploit the DWH situation
  • Louisiana berm boondoggle
Will DWH Really Change Anything?

- Deepwater drilling will occur
  - Brazil, West Africa
  - U.S.???
- Arctic drilling will occur
  - Norway, Canada, Russia
  - U.S. (Alaska)

Will DWH Really Change Anything?

- Arctic drilling
  - Harsh environment (cold and very dark)
  - Oil in & under ice
  - Little response equipment or personnel
  - Unknown natural resources/ecosystem
    - Fragile
  - Indigenous subsistence and cultural practices
- Alaskan desire to drill vs. environmental preservation
Will DWH Really Change Anything?

Short Term

- Federal legislation
- Improved command structure
- More drills and exercises
- Industry liability increased
- Better on site capping and prevention equipment

Will DWH Really Change Anything?

- Next spill will likely be different
  - Reaction vs. foresight
  - R&D “Flash in the Pan” effect for Exxon Valdez

\[ t = \frac{1}{k} \left( \ln \left( \frac{1}{R} \right) \right) \]

R&D Funding vs. Time

\[ t = \frac{1}{k} \left( \ln \left( \frac{1}{R} \right) \right) \]