Oil on Troubled Waters: Response and Outlook for Recovery in the Gulf of Mexico

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Uses of Petroleum

% Consumption

- Transportation = 67%
- Residential/Commercial = 6%
- Industrial = 25%
- Electric Utilities = 2%
U.S. Fuel Consumption

- Energy Needs → Natural Gas + Oil = 62%
- Transportation → Natural Gas + Oil = 100%
- Need is Growing
- U.S. Demand > 3x U.S. Production
  - Foreign Sources
  - Foreign Supply = Transportation = Oil Spill Potential
Sources of Oil

(Source: NAS, 2003)
Natural Seeps

- Large Input
- Ecological Impacts Limited
- Slow Release
- Biota Acclimated
Marine Oil Spills

- Tankers: Trend is Decreasing
  - Double Hulls
- Tailor Response to Spill
- Natural Disasters Increasing Impact
  - Damage to off-shore platforms/rigs and pipelines
- Increasing Drilling and Arctic Transport
Southern Louisiana and Gulf of Mexico Oil Wells and Pipelines

- Red dots = on-shore wells
- Brown dots = off-shore wells
- 63,000 miles of pipeline links wells to refineries
Coastal Response Research Center
Crude Oil

- Hydrocarbon Mixture
  - 4+ Carbons + H (97% of Oil)
    - Straight, Branched + Cyclic Chains (C-C) (>90% of Crude)
    - Aromatics (1+Rings – C=C) (1-2% of Crude)
    - Multiple Rings = PAHs (0.2-7% of Crude)
      - Carcinogens

- Other Contents (3%)
  - S, N, O, Vn, Ni, Cr

- Composition of Crude Varies with Source
Crude Oil Characteristics

- Viscosity
  - Fewer C’s & More C-C Bonds = Less Viscose
- Density 0.7-0.99 g/cm³
  - H₂O = 1.0 g/cm³
  - Floats on H₂O
  - Some Sinking Oils
- Solubility ≤ 100 ppm
  - Water Soluble Fractions (WSF) = Toxicity
# Refining Crude Oil

<table>
<thead>
<tr>
<th>Product</th>
<th>#C</th>
<th>BP (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>3 - 4</td>
<td>30</td>
</tr>
<tr>
<td>Gasoline</td>
<td>4 - 6</td>
<td>30 - 140</td>
</tr>
<tr>
<td>Kerosene</td>
<td>10 - 14</td>
<td>165 - 200</td>
</tr>
<tr>
<td>Diesel</td>
<td>15 - 20</td>
<td>175 - 365</td>
</tr>
<tr>
<td>Fuel Residuals*</td>
<td>20+</td>
<td>&gt; 350</td>
</tr>
</tbody>
</table>

* Asphalt, Bunker, No. 6 Fuels
Crude in Environment (Weathering)

- Most Extraction and Transportation is Crude Oil
- Fate of Oil Release = Weathering
- Function of Environmental Conditions
  - Temperature (H₂O, Air)
  - Wind
  - Oil Type
  - Currents, Tides
Fate of Oil

- Evaporation
  - Volatiles = Few C’s
- Dissolution
  - More Soluble = Few C’s
- Photochemical Oxidation
  - (UV-Sun)
- Emulsification (Mousse)
- Transport
  - Vertical or Horizontal
- Sedimentation
- Stranding (Shorelines)
- Tarballs
- Biodegradation
- Ingestion
Biological Impacts

- Partitioning to Sediments and Water Column
- Bioavailability
  - Gills, Membranes, Particle Ingestion
- Bioaccumulation = Concentrated Up Food Chain
- Shoreline Stranding
- Tarballs
- Ice (In, On, Under Ice + Snow)
Biological Effects

- **Acute Release** – Large Releases, High Concentrations → Severe Impact on Health/Lethal
- **Chronic Release** – Small Amounts Released Over Long Time
- **Lethal Effects** – Death
- **Chronic (Sublethal) Effects** – Impairment of Functions/Activities
  - e.g., Impaired Growth and Reproduction
Biological Questions:

1. What Are the Biological Effects of the Spill?
2. When Has Complete Recovery Occurred (If Ever)?
3. Is Recovery to Pre-Spill Community?
4. How Clean Is Clean Enough?

All Compared to Natural Variation
Perturbation (e.g., oil spill)  Normal Variability

# of Individuals

Recovery

Spill Impact

(Source: NAS, 2003)
Issues in Assessing Biological Impacts

- Oil vs. Other Anthropogenic Impacts
  - What is Pristine?
  - Most Spills in Urban/Developed Coastal/Estuarine Environments
- Ideal = Before vs. After, Control vs. Impact (BACI) Observations
  - Multiple Sites (Spatial Gradient)
  - Multiple Times (Time Series)
Factors Affecting Toxicity

- Type of Hydrocarbons
- Concentration of Hydrocarbons
- Length of Exposure
- Ability of Organisms to Accumulate/Metabolize Hydrocarbons
- Fate of Metabolized Products
- Interference with Normal Metabolism
- Narcotic Effects on Nerve Transmission
Hydrocarbon Toxicity

- Volatiles Worst
  - Water Soluble, Move Easily Across Membranes into Cells
  - But Rapidly Lost Due to Evaporation
- PAHs
  - Persistent in Environment
  - Carcinogenic
Key Biota in DWH Spill

- Coral
- Oysters
- Shrimp
- Crabs
- Blue Fin Tuna
- Intertidal/Marsh Vegetation (Marsh as Nursery Grounds)
- Biota That Cannot Swim Away Are Most Impacted
Oil Spill Response in U.S.

- OPA (Oil Pollution Act) 1990
  - Federal/Congressional Response to Exxon Valdez in 1989
  - National Contingency Planning by Government and Industry (NCP)
  - Federal Gov’t Directs All Public/Private Response Efforts
  - Area Committees (State, Fed, Local Gov’t) Develop Detailed Location Specific Plans
  - Owners/Operators of Vessels, Platforms and Facilities Prepare Response Plans
Oil Spill Liability Trust Fund (OSLTF)

- Owner/Operator Is Liable for Cleanup and Damages (For DWH = $75M)
- If Source Unknown, OSLTF Covers Costs
  - Revenue Source = Fees on Oil
- Fund Provides $1B/incident
- Administered by U.S. Coast Guard
- National Pollution Funds Center (NPFC)
National Response Center

- U.S. Coast Guard
- On Duty 24 hr/7d
- Receives Report of Spill
- Activates National Contingency Plan/Federal Role
- Notifies On-Scene Coordinator (OSC)
On Scene Coordinator

- Federal Official Responsible for Monitoring + Directing Spill Response
  - Coordinate With All Federal, State, Regional and Local Parties
  - USCG (Coastal + Great Lakes)
  - EPA (Inland)
- Direct Activities If:
  - Source Unknown
  - Spill Beyond Owner/Operator Abilities
  - Spill Substantial Threat to Public Health/Welfare
Steps in Response

1. Assessment
2. Monitoring
3. Response Assistance
4. Evaluation
Assessment

- Size/Nature of Spill’s Potential Hazards
- Resources Needed to Contain and Cleanup
- Ability of Responsible Party (RP) to Handle/Cleanup
Monitoring

- Most Spills Are Small & Handled by RP or Local Response Agencies
- Monitoring Ensures Actions of RP Are Appropriate and Working
Response Assistance

- If OSC Determines Federal Assistance Needed
  - Obtains Personnel + Equipment Needed
  - Determines Who Pays
Evaluation

- After Response, OSC Files Report on Spill + Actions
- Identifies Problems + Successes
- Makes Recommendations for Improvements
National Response Team (NRT)

- Plan and Train for Emergencies, Distribute Response Information
- Interagency Group
  - USCG
  - FEMA
  - DoD
  - DOE
  - USDA – Inland
  - NOAA (Natural Resource Trustee)
  - HHS (Health)
  - DOI (Fish/Birds and Inland)
  - DOJ
  - DOT
  - DOL
  - NRC
  - Treasury
  - GSA
Regional Response Teams (RRT)

- 13 in U.S. (Geographic Regions)
- Respond to OSC with Technical Advice, Equipment, Personnel
- Develop Regional Contingency Plan So Roles Clear During Spill
- Training/Simulation
- Coordination Among States Within Region
Spill of National Significance (SONS)

- SONS is rare catastrophic spill which exceeds response capabilities of local and regional teams

- Possible criteria:
  - Multiple response regions or nations affected
  - Significant and widespread public health, welfare, environment, or economic impacts
  - Protracted discharge or cleanup period
  - Significant public concern and demand for action
  - Actual or potential high level of political or media interest

DWH was SONS!!!!!
Response Selection

- When: How Recently Did Spill Occur?
- Where is Spill?
  - Bay, Estuary…
  - Beach, Salt Marsh…
- Type of Oil + Condition
- Volume Spilled
- Weather Conditions
  - Personnel Safety
  - Effectiveness of Response Equipment
- Resources to Protect
Drivers of Response Selection

- **Current**
  - Habitat(s) Impacted
  - Natural Resources Impacted

- **Future**
  - Economics
  - Stakeholders Views (Pre-Spill Involvement)
  - Performance Metrics (Quantitative vs. Qualitative)
Common Responses

- Tracking
- Sorbents
- In Situ Burning
- Booms
- Dispersants
- Surface Washing

- Natural Attenuation
- Bioremediation

National Contingency Plan Product List (EPA)
Common Responses

- Tracking: Allow Natural Weathering Processes to Clean-Up Oil
Common Responses

- **Sorbents: Materials Applied to Oil on Surface that Absorb the Oil**
  - e.g., Poly-plastics, Straw
  - Materials Removed from Surface After Oil Is Sorbed to Them
  - Disposed by Burning or in Landfills
Common Responses

- Booms: Capture Oil or Deflect It from Critical Area
Common Responses

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CRRC Website:
www.crrc.unh.edu