The Deepwater Horizon Gulf Oil Spill

LSUHSC-Currently Funded Research

PI Last Name	Name of Project	Agency	Department	School	Prime	Sub1	Sub2	Effective Dates
Trapido	Health Effects of MC252 Gulf Incident	NIH-NIEHS	Public Health/Epidemiology	SoPH	LSUHSC			11/15/2010 - 10/31/2012
Estrada, Fouad, Dennis	Impact of Man-made Disasters on the Underserved: Lesson Learned from BP Oil Spill	NIH-NCMHD (sub to UAB)	SSSCC	SoM	University of Alabama at Birmingham	LSUHSC-NO	Dillard	03/24/2011 – 03/23/2012
Phillips-Savoy	Gulf Coast Health Alliance: Health Risks Related to the Macondo Spill (GC-HARMS)	NIH-NIEHS (sub to UT Medical Branch at Galveston)	Family Medicine	SoM	University of Texas Medical Branch at Galveston	LSUHSC		06/01/2011 - 05/31/2016
Trapido	The Women and [Their] Children's Gulf Health Consortium	NIH-NIEHS	Public Health/Epidemiology	SoPH	LSUHSC		Columbia University	06/27/2011 - 04/30/2016
Trapido	Health Effects of MC252 Gulf Incident (competing supplement)	NIH-NIEHS	Public Health/Epidemiology	SoPH	LSUHSC	ClinForce LLC		11/15/2010 – 10/31/2012
Osofsky and Osofsky	The Mental and Behavioral Health Capacity Project of the Gulf Region Health Outreach Program	British Petroleum (BP)	Psychiatry	SoM	LSUHSC	USM	Univ of So. AL	
Osofsky	Needs assessment and evaluations of mental health symptoms for individuals affected by the Deepwater Horizon Event	State of LA, Dept. of Children and Family Services	Psychiatry	SoM	LSUHSC			08/02/2010 - 10/02/2010
Osofsky	Provide mental health assessments and screenings for adults, adolescents, and children; brief follow-up evaluations for individuals needing services; evidence based mental health services, and; community wellness forms, training and consultation for mental health and substance abuse clinicians and providers in the Gulf Coast Oil Spill impacted communities.	State of La., Dept. of Health and Hospitals, Office of Behavioral Health, Louisiana Spirit Coastal Recovery Counseling Program	Psychiatry	SoM				10/01/2010 - 04/30/2011

Background

Top Oil Spills

- The Gulf War Oil Spill - Persian Gulf - 136,000 to 1,500,000 tons
- Deepwater Horizon- 716,000 tons
- The Ixtoc I oil well - Gulf of Mexico - 470,000 tons
- The Atlantic Empress/Aegean Captain - Trinidad - 287,000 tons
- Fergana Valley - Uzbekistan - 285,000 tons
- Nowrus oil field - Persian Guld - 260,000 tons

Oil Spilled

- The amount of oil released from the spill site peaked at about 62,000 barrels/day (Robertson and Krauss 2010) until the well was permanently capped on 15 July 2010.
- The U.S. Geological Survey (USGS 2010) estimated that as of 1 August 2010 4.4–5.4 million barrels of oil were released.
- In addition, approximately 1 billion ft^3 of natural gas has been flared, well over 265,000 barrels of oil have been burned, and > 1.8 million gallons of dispersant (primarily Corexit 9500 but also Corexit 9527) have been applied.
- More than 100,000 workers have been involved with spill training and cleanup efforts

Number of Spills By Location

	PLACE	Nº OF SPILLS
1st	Gulf of Mexico	267
	Northeast USA	140
	Mediterranean Sea	127
	Persian Gulf	108
	North Sea	75
	Japan	60
	Baltic Sea	52
	United Kingdom and English Channel	49
	Singapur and Malasia	39
10th	West coast of France and Northwest of Spain	33
	Corea	32

Last 30 years:

- 1975 *Polycommander*
- 1976 *Urquiola*
- 1978 *Andros Patria*
- 1992 *Aegean Sea*
- 2002 *Prestige*

2 longitudinal studies, maximum of 4 years f-up, and they were on Mental Health

Journal of Applied Toxicology

Table 1. Oil spills for which epidemiological studies on the effects on human health were reported (ordered by spill size)

Ship name	Date	Location	Spill size (t)
MV Braer	5 January 1993	Southwest Shetland islands, UK	85,000
Sea Empress	15 February 1996	Milford Haven, UK	72,000
Prestige	19 November 2002	Galicia, Spain	63,000
Exxon Valdez	24 March 1989	Bligh ref, Prince William, Alaska, USA	37,000
Tasman Spirit	26 July 2003	Karachi, Pakistan	37,000
Erika	12 December 1999	South Penmarch, Brittany, France	20,000
Nakhodka	2 January 1997	Northeast Oki Island, Sea of Japan, Japan	>6,000

IN VITRO STUDIES AND STUDIES ON THE EFFECTS CAUSED BY TRANSFERENCE TO THE FOOD CHAIN

Table 2 displays a summary of the studies included in this section. All of them analyzed effects induced by oil spilled from *Erika*. Amat-Bronnert *et al.* (2007) performed an *in vitro* study in two human cell lines, one from hepatoma and another one from bronchial epithelium, treated with an *Erika* fuel extract. DNA adducts performed by ^{32}P-postlabelling method were only

The studies presented in this section show evidence for the bioaccumulation of oil compounds and their transference to the food chain in oil-contaminated marine food, and demonstrate the induction of DNA damage by the products generated by metabolic enzyme activity transforming many polluting agents into even more toxic intermediaries. In this regard, Bro-Rasmussen (1996) indicated that toxic chemicals at low concentrations will not immediately kill humans; however, depending on their potential to bioconcentrate when climbing the food chain, persistent chemicals may create a human hazard in the case of chronic ingestion. For this reason, *in vitro* and *in vivo* studies that consider

- Although long-term follow-up is essential to assess potential impacts of oil spill exposures on cancer and other chronic diseases, essentially no long-term epidemiologic studies have been reported in the literature, nor has population research been conducted on the health effects of exposure to oil, its breakdown products, and dispersants via the food chain.

Almost No Epidemiologic Studies!

- Data are available on acute health effects in humans exposed to 7 of 39 large oil spills documented throughout the world (reviewed by Aguilera et al. 2010).
- These relatively short-term cross-sectional studies have documented acute disorders, including low back pain, headache, inflammation of the eyes and throat, nausea, injuries, lower respiratory tract effects, and psychological effects including depression.
- To date, workers involved in fishing and clean-up in Louisiana—the most heavily impacted state—have reported headaches, nausea, breathing difficulties, cough, throat irritation, eye irritation, and injuries (Lousiana Department of Health and Hospitals 2010)

Material Safety Data Sheet: Crude Oil

- May cause irritation or more serious skin disorders! May be harmful if inhaled! May cause irritation of the nose, throat, and lungs, headache, dizziness, drowsiness, loss of coordination, fatigue, nausea and labored breathing.
- May cause irregular heartbeats. Avoid prolonged or repeated liquid, mist, and vapor contact with eyes, skin, and
- respiratory tract.
- Sulfur compounds in this material may decompose to release hydrogen sulfide gas which may accumulate to potentially lethal concentrations in enclosed air spaces. Vapor concentrations of hydrogen sulfide above 50 ppm, or prolonged exposure at lower concentrations, may saturate human odor perceptions so that the smell of gas may not be apparent.!
- Long-term tests show that similar crude oils have produced skin tumors on laboratory animals.
- Crude oils contain some polycyclic aromatic hydrocarbons which have been shown to be carcinogenic after prolonged or repeated skin contact in laboratory animals

Hazards

- Heavy fuel oils are classified as possible human carcinogens [International Agency for Research on Cancer (IARC) 1989], and there is ample evidence in laboratory animal studies that heavy oil is carcinogenic/
- Exposure to heavy oil and related contaminants may be able to increase cancer risk indirectly through, for example, mechanisms related to stress, immunosuppression, or endocrine disruption.

Dispersants

- Oil is toxic at 11 ppm while Corexit 9500 is toxic at only 2.61 ppm; Corexit 9500 is four times as toxic as the oil itself.
  - Dispersants are a relatively common product used to clean and control oil spills in the ocean.
  - On a basic level, dispersants work the same way dishwashing liquid works on grease: they break up the oil into tiny droplets by attaching to the oil which then becomes diluted in the water.
  - Corexit, the dispersant BP is currently using, contains a surfactant and a solvent. Surfactants are long molecules that are hydrophilic (water-seeking) on one end and oleophilic (oil-seeking) on the other.
    - One end grabs an oil molecule, the other, a water molecule. By reaching across the oil-water boundary, the surfactant lowers the tension that keeps the two substances separate.
  - Smaller, dispersed droplets are less threatening for two reasons: they present more surface area to the water, so ocean bacteria can degrade the oil faster; plus, the small droplets are much slower to rise to the surface, keeping the oil at sea instead of in coastal wetlands and giving the bacteria more time to do their magic.
- On the other hand, sprayed subsurface, they do not allow a true picture of the amount of oil there was.

Dispersants

- Small amounts of Corexit-oil have already been detected in crabs and oysters. The chemical and toxic compound will naturally climb up the food chain since the process cannot be stopped or reversed.

C-130 DROPPING DISPERSANT IN THE GULF TECHNICAL SERGEANT ADRIAN CADIZ VIA WIKIPEDIA

Dispersant: Corexit 9500 and 9527

- From Corexit, we are also concerned about Bis (2-Ethylhexyl) Phthalate (DEPH) For environmental exposure, there are concerns for children with regard to testicular effects, fertility, and toxicity to kidneys, on repeated exposure, as a consequence of exposure via food locally near sites processing polymers with DEHP, or sites producing sealants and/or adhesives, paints and lacquers or printing inks with DEHP.

Corexit 9527

- Corexit 9527 includes 2-butoxy-ethanol, which according to the N.J. Dept. of Health "may be absorbed through the skin; should be handled as a CARCINOGEN -- WITH EXTREME CAUTION; can irritate the skin and eyes with possible eye damage; can irritate the nose and throat; can cause nausea, vomiting, diarrhea and abdominal pain. can cause headache, dizziness, lightheadedness, and passing out and may damage the liver and kidneys.

Corexit

- Estimated amount used in the Gulf- 1.8 million gallons
- The components of COREXIT 9500 and 9527 are:

CAS Registry Number	*Chemical Name*
57-55-6	1,2-Propanediol
111-76-2	Ethanol, 2-butoxy-*
577-11-7	Butanedioic acid, 2-sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt (1:1)
1338-43-8	Sorbitan, mono-(9Z)-9-octadecenoate
9005-65-6	Sorbitan, mono-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs.
9005-70-3	Sorbitan, tri-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs
29911-28-2	2-Propanol, 1-(2-butoxy-1-methylethoxy)-
64742-47-8	Distillates (petroleum), hydrotreated light

*Note: This chemical component (Ethanol, 2-butoxy-) is not included in the composition of Corexit 9500.

Mechanisms

- Crude oil, which directly contaminated land, sea and the air, oftenhas many toxic effects.
- Cell membranes of all living cells have large hydrophobic or an oil-like composition. The lipid or naturally-oily components of cell membranes interacts strongly with many of the toxic components of oil.
- Benzene, toluene, xylene, gasoline, naphthylene are some of the chemical compounds that can dissolve or deform cell membranes and cause cell death.
- Damaged cell membranes permit critical cell molecules to leak out of the cell and this contributes to cell death.
- Benzene-ring compounds and other crude oil chemical components are known carcinogens . These compounds, if they reach the nuclear DNA, may cause mutation, cell malfunctions, or even cancers.

OSHA's Concerns

- Benzene (crude oils high in BTEX, benzene, toluene, ethylbenzene, and xylene),
- Benzo(a)pyrene (a polycyclic aromatic hydrocarbon reproductive , formed when oil or gasoline burns),
- Carbon dioxide (inerting atmosphere, byproduct of combustion),
- Carbon monoxide (byproduct of combustion) Ethyl benzene (high in gasoline),
- Hydrogen sulfide (oils high in sulfur, decaying plants and animals),
- Methyl tert-butyl ether (MTBE) (octane booster and clean air additive for gasoline, or pure MTBE)- potentially carcinogenic in humans; carcinogenic in animals
- Polycyclic aromatic hydrocarbons (PAHs) (occur in crude oil, and formed during burning of oil),
- Sulfuric acid (byproduct of combustion of sour petroleum product),
- Toluene (high BTEX crude oils), Xylenes (high BTEX crude oils).

Washington Post 9-06-2010

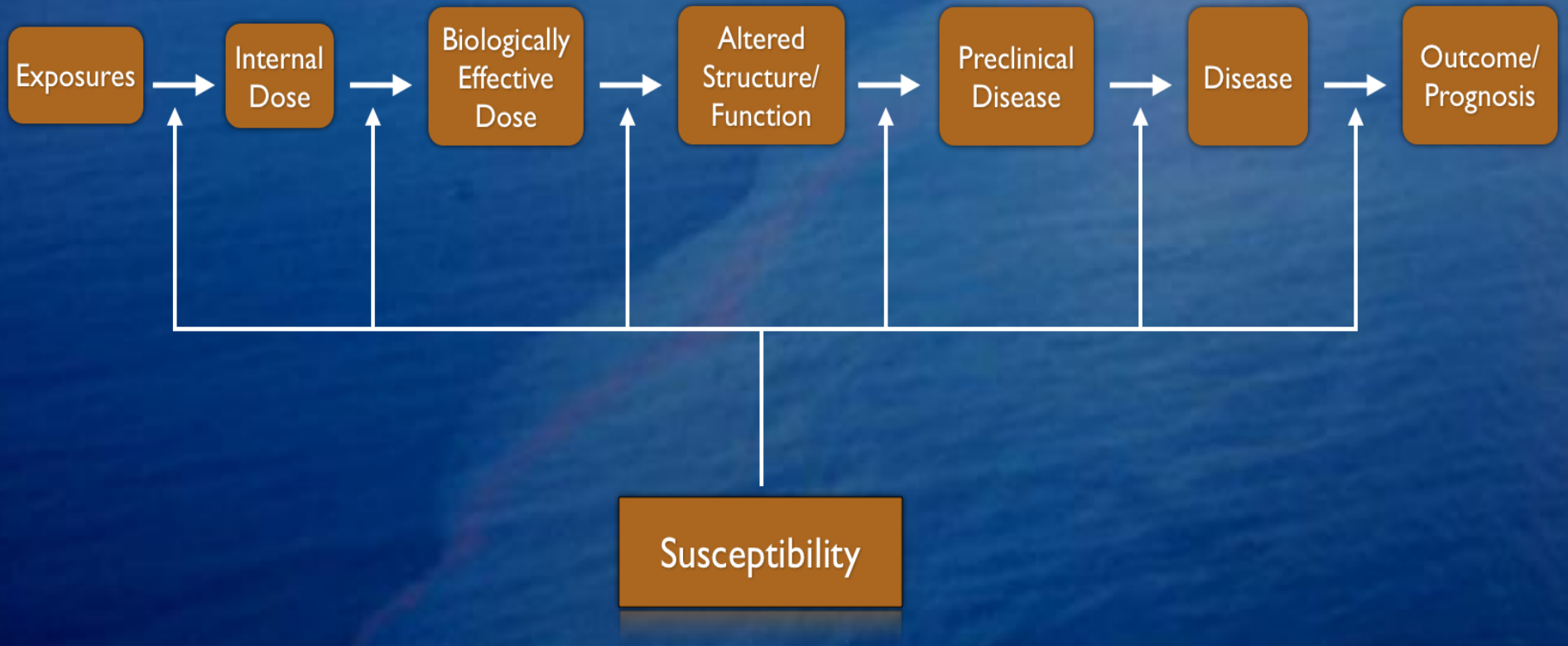
- If Alaska is any indication, the first year after a spill is not the hardest. It's the years afterward when the environmental, cultural and societal consequences really surface.

What happens to the contaminated materials?

- “I would not be as concerned about the crude as I would be about the degreasers in the dispersants, propylene glycol (in both Corexit 9500 and 9527) and, especially, butoxyethanol (in 9527 used initially until world supplies ran out). These chemicals could enter ground water. Both are hemotoxic, PG is nephrotoxic in high doses; and BE is converted to ethylene glycol by hepatic metabolism in rodents and, possibly, in man; and is an animal carcinogen. BE is a monobutyl ether, just like MTBE, which enters ground water easily from leaking underground gasoline storage tanks. EPA knows this well.”

Personal Communication: James Diaz, Environmental Toxicologist , LSUHSC

Research Paradigm



Epidemiologic Issues: Population

- Oil Rig Workers
- Clean-up Workers on/in Gulf, Shore
- Corexit Sprayers
- Families of workers
- Workers at municipal dumps
- Wildlife cleaners
- Persons whose income on fish, shellfish
- Special Populations
  - Pregnant women, Children, Immunocompromised, persons with other health conditions or exposures
- Communities
- Visitors to local beaches

Epidemiologic Issues: Assessing Exposure of Workers

- Direct, indirect
- Time dependent
- Use of protective gear
- Exposure may have occurred before and after
- Exposure- to oil, to dispersant, on/in water, in air, flaring of natural gas
- Weather- heat related inhalations
- Biological specimens will be substantially after major exposures
- Oil is already in Gulf; compounds in dispersant in common use
- Mississippi river contents
- Environmental samples

Epidemiologic Issues: Context of assessing exposure

- Major employers: harvesting seafood, oil rig work, maintaining boats, tourism
- Willingness to talk to researchers, give biological specimens
  - Community weary of being studied and are highly stressed: Hurricanes Cindy, Katrina, Rita, Economic Recession, Deepwater Horizon
    - Need to be able to answer concerns
    - Community Participatory Research
- Lack of trust of outsiders
- In LA: Cajun, Croatian, Vietnamese, Hispanic, African American, White, non-Hispanic, non-Cajun, Islanos

Epidemiologic Issues: Outcomes

- Physical-Short, Intermediate and Long Term
- Mental Health-Short, Intermediate and Long Term
- Behavioral Issues: Substance Abuse, Violence, etc.
- Use of health care services
- Community Resilience
- Economic Consequences: Loss of income, change of diet

Other Epidemiologic Issues

- Confounders and/or interaction factors
  - e.g. smoking , diet, use of protective gear, comorbidity, prior and subsequent employment, income, education
- Organizing data:
  - Environmental sampling- where, what was collected, what depth, weather conditions,
  - Interviews
  - Biological sampling- water, air, FEV, sputum, blood, urine, saliva, hair, nail clippings
  - Health information from various sources
  - Income
  - GIS

Amount of Cleanup

- BP estimates that the cleanup is about 90% complete; 10% of oil is in still in water.
- 25% is estimated by researchers from Georgia Sea Grant 2010; 9NOAA) 2010].

Petroleum Hydrocarbons

- The International Agency for Research on Cancer (IARC) has determined that one PetH compound (benzene) is carcinogenic to humans. IARC has determined that other PetH compounds (benzo[a]pyrene and gasoline) are probably and possibly carcinogenic to humans. Most of the other PetH compounds are considered not to be classifiable by IARC.

Potentially Vulnerable Populations

- Exacerbations of Chronic Diseases
- Exacerbation of HIV
- Asthmatics
- Oral and Genital Herpes
- Rheumatoid Arthritis Flare Ups
- Persons on Medications

Stress and Mental Health

- Adults
  - Depression
  - PTSD
  - Anxiety Disorders
  - Increased Substance Abuse
  - Increased Violence, Suicide
- Children
  - Emotional and Social Conflicts
  - Ability to concentrate
  - Increased fear about future

Biomonitoring the Effects of Crude Oil Exposure

- Define Subjects
- Assess Exposure
  - VOCs
  - PAHs
  - Heavy Metals
- Monitor Health Effects
  - Organ Systems
  - Psychosocial
  - Cells
  - Molecule

Monitoring Health Effects of Crude Oil Exposure

Organ Systems/Diseases

- Respiratory - Asthma/AHR/COPD
- Renal – Heavy metal toxicity
- Endocrine – Cortisol
- Reproductive - Genotoxicity
- CNS – Headache, Depression

Monitoring Health Effects of Crude Oil Exposure

Cell and Molecular Biomarkers

- Aryl hydrocarbon Receptors → CYP1A, COX2
- DNA damage, Histone modifications
- RNA transciptome, miRNA expression
- Plasma antioxidant capacity, GSH, cortisol
- Stress-response proteins

Exposure Measurements

- Detailed exposure measurements
  - Environmental
  - Occupational
  - Mental health
  - Behavioral
  - Biomarkers
  - Physiologic measures, e.g. PFT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NIEHS **GuLF (Gulf Long-term Follow-up) Study Concept**

- Health areas of interest include, but are not limited to, respiratory, cardiovascular, hematologic, dermatologic, neurologic, cancer, reproductive, mental health, immunologic, and renal