



Capabilities in Addressing the Gulf of Mexico Oil Spill
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I. Ecotoxicology and Wildlife Toxicology Research

The Ecotoxicology and Wildlife Toxicology Research Sections at The Institute of Environmental and Human Health (TIEHH) are comprised of faculty who conduct research throughout the United States and abroad. TIEHH focuses on exposure to, and effects of a wide variety of stressors on wildlife and ecosystems. Our approach often integrates complimentary field and laboratory studies. We are equipped for, and have expertise in, biochemical and physiological toxicology, with expertise in analytical chemistry, molecular biology, etc. In addition to the core TIEHH scientists, we benefit from numerous strong collaborative relationships with other faculty at Texas Tech University and scientists from around the world. Our research is funded by a variety of sources, including the U.S. EPA, NIEHS, NSF, USDA, DoD, DoE, SERDP, and numerous private corporations.

Many of our past and current projects involve the assessment of chemical exposure and effects on wildlife at Superfund Sites across the United States. We have extensive international experience, including projects in Central and South America, and Australia. We work with a variety of wildlife species, including large and small mammals, birds, amphibians, reptiles, and invertebrates. In all cases, our primary focus is the assessment of chemical and non-chemical stressors on the health and viability of wild animals. TIEHH has expertise with a wide range of stressors include petroleum products, metals, pesticides, military-related compounds, persistent organic pollutants, and endocrine-disrupting compounds. In addition to chemical stressors, we have expertise related to assessing the effects of land-use practices on wildlife, especially those associated with environments that are heavily influenced by industrial or agricultural activities.

II. Monitoring and Quantification of Impacts to Near-shore Biotic Resources

A. Problem Statement

As a consequence of the recently compromised and leaking oil well head in the Gulf of Mexico, impacts to intertidal and other coastal aquatic habitats are likely. Mechanisms or pathways of detrimental effects on marine, intertidal, and freshwater resources include: 1) direct flow of oil into estuaries and bays, 2) increase of sediment-sorbed polycyclic aromatic hydrocarbons (PAHs) and other petroleum-related contaminants, particularly within mixing and erosional zones where sediment-surface water contact is high, and 3) increased volume of airborne particulates resulting from wave action. Through these routes, numerous biological endpoints will potentially be impacted.

Marsh grasses and intertidal aquatic vegetation along the Gulf Coast are critical components of breeding habitat for many fish and invertebrate species, and important for reducing erosion processes. It is anticipated that oil-related damage to marsh vegetation could have widespread and long-term ecosystem impacts. Furthermore, loss of marsh vegetation could lead to increased erosion and subsequent saltwater intrusion, ultimately impacting coastal terrestrial habitats. Near-shore and marsh benthic fauna will be important indicators of direct environmental impacts and long-term environmental change. From an ecosystem perspective, benthic community respiration and primary production rates may be used for evaluating effects of oil-related contaminants to shallow subtidal areas, particularly in oxygen-depleted marsh sediments. Bivalves may be used *in situ* within shallow intertidal areas as indicators of exposure and for quantifying bioaccumulation oil-related organic contaminants. In addition, planktonic decapods may serve as a valuable indicator of near-shore impacts, and may represent a sensitive bioindicator of oil-related contamination.

B. Abilities, Expertise, and Skill Sets to Address the Problem

TIEHH scientists have a wide breadth of skill sets and abilities that are critical for solving problems related to oil contamination at the near-shore and marsh habitats of the Gulf Coast. Several of these are briefly outlined below.

1. Trophic Transfer of Hydrophobic Organic Contaminants

Scientists at TIEHH have extensive experience conducting trophic transfer studies on organic contaminants. These studies have included transfer of hydrophobic organic compounds such as polychlorinated biphenyls through aquatic trophic chains involving sediment, benthic invertebrates, fish, and fish predators. We have the capacity to collect sediments and invertebrate, fish, reptilian, and mammal tissues; quantify PAHs within these matrices; and generate estimates of bioaccumulation factors (BAFs) and biota-sediment accumulation factors (BSAFs). Oil contamination typically involves an extensive mix of hydrocarbons. Similar to previous work conducted on PCBs, PAH mixture profiles can be analyzed among tissues from different trophic levels using ordination techniques, facilitating interpretation of trophic relationships and generating better estimates of BAFs. We also have the capacity to further refine BAF estimates using isotopically defined trophic relationships using C, N, and S stable isotope signatures.

2. Toxicity Identification Evaluations (TIEs)

Several TIEHH scientists have expertise in performing Toxicity Identification Evaluations (TIEs) on porewater and sediment. TIEs facilitate identification of the sources of toxicity in an aqueous or sediment sample via systematic removal of the toxicity associated with different classes of contaminants. On the Gulf Coast, it is likely that current stressors exist within near-shore and marsh habitats that are not related to oil, such as elevated ammonia and nutrient levels. It will be imperative in the future assessment of sites that are impacted by the current oil contamination to separate toxicity due to present stressors (e.g., ammonia, metals, pesticides, etc.) and toxicity associated with PAHs and other oil constituents. In a past study, we have successfully conducted sediment and pore-water TIEs to distinguish toxicity due to non-polar organics including PAHs, metals, and ammonia in benthic invertebrates. Furthermore,

we have experience for accounting for the unresolved complex mixture (UCM) during a sediment TIE, which includes the combination of oils, grease, and PAHs.

3. Aquatic and Sediment Toxicity Testing

TIEHH is fully equipped for conducting standardized and modified aquatic and sediment toxicity testing. A number of faculty and staff are knowledgeable and experienced in conducting NPDES permit toxicity testing following EPA standardized methods. Toxicity testing will play a role in assessing oil-related impacts to near-shore and marsh sediments by providing a biologically relevant measurement of the bioavailability of PAHs and oil constituents bound to sediment matrices. Generation of a toxicity database that includes endemic organism and standardized testing organism responses to sediments of Gulf Coast marshes will be invaluable. Information from this database can be used for generating estimates of toxic units for similar sediments in which only PAH concentrations are assessed. This will be very useful for assigning potential risk to contaminated sediments, and can be applied to widespread coastal surveillance sampling data.

4. Biotic Sampling / Community Assessments

Several TIEHH scientists also have expertise in conducting aquatic community assessments using standardized approaches such as EPA Rapid Bioassessment Protocols (RBPs) and ecological-based approaches. These assessments are frequently used to assess ecosystem health and functioning and can be used for development of indices of biotic integrity (IBIs) for specific habitats. TIEHH scientists have expertise in examining community responses using direct and indirect ordination techniques and for identifying and prioritizing biotic and abiotic stressors important for structuring aquatic communities. These types of assessments will invariably need to be conducted in order to assess higher-level impacts to marsh and intertidal communities.

III. Expertise and capabilities for Oil Spill Response

TIEHH scientists have extensive expertise in endangered species toxicology as well as in assessment of exposure to PAHs and oil-related compounds. Expertise includes non-lethal and minimally invasive sampling of endangered species, development of cell and organotypic cultures, mechanistic toxicology, biomarkers (including cytochrome P450 expression), functional genomics, proteomics and enzymatics.

At TIEHH, we can study the capability of harmful chemicals associated with oil spills in regards to DNA damage, neoplastic transformation, and disease states. Additionally, these same types of endpoints can be studied in wildlife after exposure to agents used to treat the acute dangers of oil spills such as surfactants and detergents.

Examples of endangered, threatened, or protected species for which the laboratory has conducted or is currently conducting research include: most cetacean species living in U.S. waters, sea turtles (loggerhead, green, kemp's, ridley's, hawksbill and leatherback), polar bear, and sturgeon.

1. Expertise in cytochrome P450 expression as biomarker of exposure to oil-related compounds

- a. Expertise and capabilities to detect expression via catalytic activities, mRNA expression or immunohistochemistry.
- b. We are the first and only laboratory to have sequenced CYP1A in a reptilian species (loggerhead sea turtle)
2. Unique resource of sea turtle cell cultures
 - a. Loggerhead sea turtle cultures have been developed in the laboratory and are being characterized
 - b. These cultures enable in vitro research on the impact of oil-related compounds on sea turtle cells
 - c. Endpoint capabilities include: cell death, clonogenic toxicity, cytochrome P450 expression, and chromosome damage
3. Unique expertise in the creation of endangered species cell cultures
 - a. Expertise in reptilian cell culture
 - b. Expertise in cetacean cell culture
 - c. Expertise can be transferred to any bird and terrestrial mammals for which permits are obtained
4. Unique expertise in organotypic cultures of endangered species
 - a. These cultures can allow us to run proteomic profiles and detect exposure-linked changes in protein expression
 - b. These cultures can allow us to investigate an overall stress response in the exposed animal

IV. Modeling Oil Spill Trajectories and Impacts on Wildlife and Marine Organism Populations

A. Oil Spill Trajectories

To predict the impacts of oil on the wildlife along Texas' Gulf coast, we first predict the amount of oil reaching the shoreline coast and the near shore ecosystems. We propose to use a suite of oil spill trajectory models including GNOME, OSRA, and Texas General Land Office oil spill GIS and trajectory models.

GNOME (General NOAA Operational Modeling Environment) is the oil spill trajectory model used by Office of Response & Restoration (OR&R) Emergency Response Division (ERD) responders during an oil spill. GNOME can be used to:

- Predict how wind, currents, and other processes might move and spread oil on the water.
- Predict how oil trajectories are affected by uncertainty in current and wind observations and forecasts.
- Predict how spilled oil is weathered, i.e. changed chemically and physically during the time that it remains on the water surface.

OSRA (Oil-Spill Risk Analysis) developed by the U.S. Department of the Interior Minerals Management Service was used to simulate hypothetical oil spills uniformly in space and time from within the study areas that encompass the offshore waters within the Gulf of Mexico. The study areas were divided into 75 hypothetical spill sites, which were used to represent oil spill risks from platforms. The Texas General Land Office (TGLO) is the lead state agency for oil spill management. TABS provides critical, real-

time offshore surface current information to drive trajectory models that predict the movement of oil spills.

B. Population-level Impacts

A major concern regarding the ecological impacts of the oil spill is the near and long-term effects on exposed animal populations. While the negative effects on individuals is clear, less apparent are the effects on populations as a whole, which operate and function on a spatial scale beyond that of the oil spill. To gain a better understanding of the population-level impacts requires the use of population modeling that can be used to place what we understand and estimate as individual-level impacts in a population level context. The use of stochastic population models, in particular, would prove useful in projecting how current effects impact populations and perhaps more importantly, can be used to project how certain cleanup levels may impede or enhance population recovery of impacted birds, fish, sea turtles and marine mammals.

Adequately parameterized population models can be used to facilitate environmental management by directing efforts towards the conservation of species and life stages likely to yield the greatest return on effort. The use of elasticity analyses, for example, can indicate which life cycle stages (e.g., hatchlings, juveniles, adults, eggs) that are important for population dynamics or the conservation impact of life cycle stages that are most easily protected. As an example, demographic analyses have shown that protection of sea turtle juveniles and adults has very high conservation value while protecting egg masses has relatively less positive impact largely because of high natural hatchling mortality.

The use of oil spill trajectory models and stochastic population models will be included in an overarching, probabilistic ecological risk assessment framework for animals in the Gulf Region. These efforts and models will prove invaluable for assessing the impact of the oil spill on exposed animals and will aid in remediation and recovery efforts.

V. Remediation Strategy for Oil Spill Clean-ups

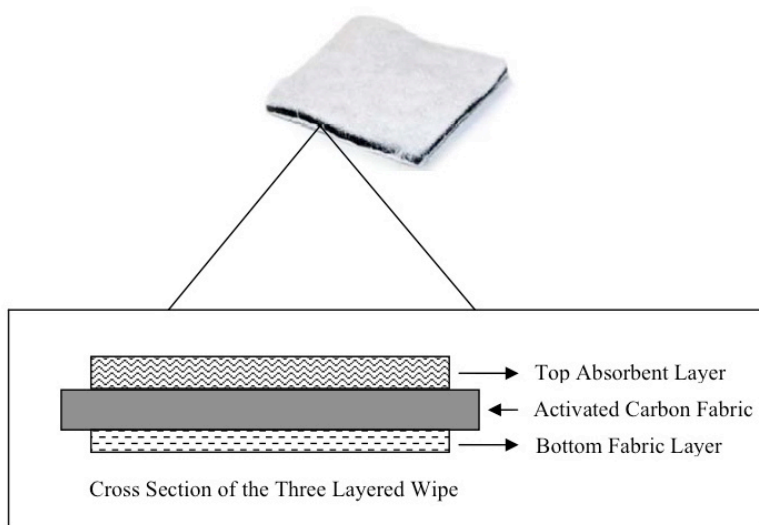
Nonwoven Oil Absorbent Pads

The Institute of Environmental and Human Health (TIEHH) is well placed to deliver cost effective absorbent materials that can soak up oils. Research has shown that cotton fibers can absorb higher amounts of crude oil than synthetic fiber based materials. TIEHH has the expertise to develop and advise the industries for quickly developing cotton based high-loft absorbent substrates using needlepunching and thermal bonding nonwoven technologies. These technologies are available at the Nonwovens & Advanced Materials Laboratory at TIEHH. This laboratory has been developing nonwoven wipes and pads for toxic clean-ups for a decade and is nationally recognized in this area. Low quality cotton that does not find applications in apparel markets can be used to develop absorbent products that can absorb oils. Unbleached cotton has attraction to oil and this characteristic of cotton will be of immense help to develop oleophilic absorbent products.

In addition, as the crude oil contains aromatic hydrocarbons, which are volatile in nature, there is also a need to have adsorbent and absorbent products to contain the off-gassing vapors. In this regard, the technology developed at TIEHH, "*Fibertect*" which is already in the market, will be very useful. This *Fibertect* wipe has activated carbon in the core, which

can be used to hold the obnoxious vapors and the oleophilic absorbent layers on the top and bottom of the wipe can soak up the oil. The absorbent pad is shown in the appended Figure.

TIEHH can coordinate to obtain bulk quantities of oil absorbent products and the *Fibertect* pad for oil spill clean-ups. TIEHH has extensive experience and knowledge on the nonwoven textile products such as *Fibertect* pads, which can be conveniently used for oil absorption and clean-ups.



Nonwoven Oil Absorbent/Decontamination Pad

VI. Description of TIEHH Analytical Facilities

A. General

The analytical support infrastructure will be provided within The Institute of Environmental and Human Health (TIEHH) at Texas Tech University. This infrastructure includes 2 Organic Prep Labs (1975 sq. ft) and an Instrument Laboratory (1318 sq. ft), and a Metals Prep and Analysis Laboratory (960 sq. ft). Our preparatory facilities include 130 linear feet of hood space with supporting bench space. All needed extraction, isolation, and evaporation equipment is in place in these laboratories.

Personnel within these laboratories include three faculty, two senior staff, and 10 graduate students. Together we provide and develop state-of-the-art analytical methods for the determination of toxic chemicals in environmental samples including water, air, soil, and biological matrices.

We are also capable of collecting, transporting, processing, and analyzing field samples from all biotic and abiotic environmental matrices under chain of custody.

B. Analytical Instrumentation

Instruments currently in place in the analytical/environmental laboratories include:

- Four Hewlett-Packard (HP) quaternary pump Liquid Chromatographs with Variable Wavelength Absorbance Detectors

- One HP quaternary pump LC with a Fluorescence Detector
- Four HP 6890 Gas Chromatographs equipped with dual ECD, FPD/NPD, FPD/ECD, ECD/FID Detectors;
- One HP 6890/5973 GC/MSD
- One HP 6890/5973 Purge and Trap GC-MS with autosampler
- One ThermoFinnigan LCQ Ion trap LC-MS-MS with autosampler,
- One ThermoElectron Graphite Furnace/Flame Atomic Absorption Spectrometer
- One Perkin Elmer Flow Injection Mercury System (FIMS-100),
- Three Dionex Ion Chromatographs with Conductivity Detectors,
- One Beckman Liquid Scintillation Spectrophotometer.
- TIEHH and The Department of Geosciences Co-own a Leeman Lab Inductively coupled Plasma Spectrophotometer, and a laser ablation Inductively Coupled Plasma-Mass Spectrometer.

Laboratory instrumentation also includes two Dionex Accelerated Solvent Extractors and four preparative HPLCs (Beckman and Waters brands). Numerous standard extraction and sample concentration systems are also in place.

Our most recent relevant publication: Kendall, Lacher, Cobb, and Cox (Eds). 2010. "Wildlife Toxicology: Emerging Contaminant and Biodiversity Issues", CRC Press/Taylor & Francis Group, 340 pp.

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