

**Assessing Natural Resource Damages
from the BP *Deepwater Horizon* Gulf of Mexico Oil Spill:
Lessons Learned from the *Exxon Valdez* Experience
[18 May 2010]**

It is critically important that we do all we can to ensure that the pre- and post-impact status of ecosystems, including contaminant levels, are documented as rigorously as possible in at least those parts of the Gulf coast that are most sensitive, most biologically productive, and most important for wildlife and habitat conservation. These areas include the estuaries and especially the marshes and wetlands behind the barrier islands along the coast, which are the breeding and nursery grounds of myriad aquatic, intertidal, and avian species. Given the widespread and intensive application of chemical dispersants and uncertain fate of oil from a deepwater source, however, it also is critical to be sampling pelagic and benthic communities as well.

We have not had the opportunity to review or be briefed on current damage assessment and monitoring activities in the Gulf, but each of us (see below) is a veteran of the damage assessment and restoration science programs in Prince William Sound and the northern Gulf of Alaska following the *Exxon Valdez* oil spill (EVOS). Based on our collective experience, we offer the following suggestions with respect to the current situation in the Gulf of Mexico. This is not a comprehensive list of suggestions; some of these items may be obvious and others not. If there is interest in doing so, any or all of us would be pleased to discuss these ideas further. Our contact information is below.

Organizational

1. Put in place a strong coordinating scientific body, including at least a core group of external peer reviewers who remain in place on an extended basis, thus providing continuity in perspectives. Such a structure will help ensure coordination and cull unnecessary or marginal studies (which often are previously unfunded projects that agencies have wanted to do for a long time) that come out of the woodwork in times of crisis. Coordination needs involve meeting the challenge of forging an ecosystem-based natural resource injury assessment that acknowledges the interconnectedness among resources and creates explicit linkages among injury assessment studies. An effort should be made to include experts who have experience with comparable oil spills, such as the IXTOC I or other spills in subtropical waters.
2. Transparency is essential. The public will want to know what is being studied and what is being learned. While some of those details may be sensitive, it is crucial to share whatever can be appropriately shared about impacts. This will allay unnecessary fears and concerns about secrecy. The Unified Command/response organization has already provided a web page to coordinate and share news. Something similar is one tool that would help with communication about the scientific effort with the public and with coordination among researchers.
3. Institute integrated ecosystem-based studies on what are anticipated to be the hardest hit areas as a means to coordinate and merge—both conceptually and operationally-- otherwise could be disparate efforts of various federal, state and local agencies, as well as universities and private companies, across the Gulf of Mexico. Integrated

studies will produce the best and most useful science, as well as be most efficient from an organizational standpoint. Only by constructing an ecosystem context for the injury assessment studies can indirect effects of the spill be inferred and evaluated, such as consequences of impacts on competitors, prey, and predators that can include trophic cascades.

Scientific

1. Put integrative water quality samplers, such as semi-permeable membrane devices (SPMDs), in key habitats and make use of bivalves, such as oysters, with existing histories of PAH analyses. It is critical to establish chemical baselines that will enhance the capacity to infer impacts of the spill wherever damage is most likely to occur. Suspension feeders, such as oysters, are very efficient at accumulating particulate matter, including oil micro-droplets that may result from natural or artificial dispersion of oil into the water column.
2. Deployment of SPMDs, preferably spiked with performance reference compounds (i.e., selected perdeuterated PAH), permits time-integrated detection of background non-polar organic contaminant concentrations at the parts per trillion level. While it will take perhaps a week or two to procure and deploy SPMDs (commercially available from Environmental Sampling Technologies [St. Joseph, MO]), their deployment now and retrieval after another two weeks will give an unparalleled indication of background contamination levels. The ability of contaminants extracted from SPMDs deployed prior to impacts from the *Deepwater Horizon* accident to elicit CYP1A responses in standardized test organisms, such as rainbow trout, is an especially powerful approach for evaluating the effects of potentially confounding background contaminants.
3. It is likely that the sea surface microlayer fauna will be greatly affected, so sampling this (control and impact) may provide measures of damage, especially to floating fish eggs and to larval stages of fish and crustaceans. We missed this in EVOS.
4. Take advantage of those organisms and habitats that have the best baselines and timelines of data and research prior to the spill as possible indicators. Such information can permit application of the rigorous and potentially powerful statistical assessment approach, the Before-After-Control-Impact design, abbreviated as BACI.
5. Documenting the physical properties and chemical composition of the oil from the reservoir tapped by the *Deepwater Horizon* is crucial to anticipating the behavior and biological effects of the oil, as well as for confirming the provenance of oil collected from impacted environments. These tests and analyses should be conducted on oil samples collected before and after contact with seawater. Physical tests on oil collected prior to seawater contact should include measurements of viscosity, compressibility and density as functions of temperature and pressure. Chemical composition analyses should include measurements of normal alkanes beginning with methane through at least tetracontane (n -C₄₀), aromatic hydrocarbons from benzene through 6-ring polycyclic aromatic hydrocarbons (PAH) including alkylated homologues bearing up to four alkyl carbon atoms, and alicyclic biomarkers analyzed by gas-chromatography/mass spectrometry at m/z 191, 217 and 218. These

measurements should also be done on samples at various states of weathering to document how composition changes.

6. The most useful pre-impact information on baseline levels of exposure to organic toxicants includes documentation of basal levels of the liver enzyme cytochrome P4501A1 (CYP1A), which requires excision of liver tissue and immediate storage in liquid nitrogen. This enzyme is induced in response to exposure to many of the toxic components in crude oil and is one of the most sensitive indicators of exposure available. Other environmental contaminants also can induce CYP1A (e.g., PCBs), so documenting pre-impact levels will be extremely valuable for detecting induction if oil contaminants in fish habitat. For fish, the most useful species would be one that is easily collected, abundant and widely distributed along the coastal estuaries, but don't forget the pelagic environment, especially given the widespread use of dispersants, which is presumably dispersing oil widely in the water column. In the case of EVOS, some of the best documented lingering effects were found in harlequin ducks, a diving species that feeds largely off benthic mollusks that were associated with oil-contaminated sediments.
7. Pre-impact samples of benthic infauna on Gulf beaches, tidal flats, and salt marshes are very important. These invertebrates of sedimentary habitats are largely sessile, thus showing clearly any spatially explicit oiling impact, and serve as prey for many bottom-feeding fishes, shorebirds, ducks, and crustaceans, such as the commercially important blue crab. The statistically most powerful design for sampling impacts to shoreline communities involves pairing oiled and control sites, where pairing is done to ensure environmental similarity in all physical, chemical, and sedimentary conditions prior to the spill. Such paired designs, using replicate pairs of oiled and control sites, can minimize confounding by differences in the pre-existing environment.
8. Identify any ongoing biological sampling efforts (e.g., National Status and Trends Mussel Watch, bird surveys, etc.), and especially those for species at risk and of concern, and then maintain and enhance the sampling effort in the context of creating a sampling design that permits a rigorous assessment of spill impacts.
9. The obvious bears stating: longer time series and more frequent sampling will enhance statistical power to detect change. Monitoring programs need to be designed to distinguish oil-spill responses from unrelated spatial and temporal variation in the ecosystems that are affected.
10. Coordinate offshore chemical and biological sampling with onshore efforts, so that when the wide scope of initial studies is eventually scaled back, you will be able to collapse the effort and retain maximum logistical efficiency. Another way of saying this is that all other considerations being equal, co-locate as many different chemical/biological studies as possible at the same stations. This approach is essential to integration of studies that must be done to provide the ecosystem-based approach, which is the only means of inferring broader indirect effects of the spill. The routine models used to estimate natural resource impacts of oil spills by matching oil concentrations, transport, chemical transportation, and fate to spatial distribution of biological resources only address short-term acute impacts of separate species, thereby seriously underestimating ecosystem impacts of the spill.

11. It is likely that the sea surface microlayer fauna will be greatly affected, so sampling this (control and impact) may provide measures of damage, especially to floating fish eggs and to larval stages of fish and crustaceans. We missed this in EVOS.
12. Make sure QA/QC procedures are in place. Perhaps best to adopt those of NOAA NRDA group rather than inventing new ones.
13. Typically, only a small proportion of the marine birds, mammals and turtles that are killed by a spill are ever recovered at sea or ashore. Given that a number of factors, such as the type of oil, wind patterns, distance from shore, scavenging rates, and taxon-specific buoyancy of carcasses affect the recovery rate, it is necessary rigorously design and implement carcass recovery efforts and experiments to estimate loss rates and enable accurate estimates of the total numbers of wildlife mortalities.
14. Given recent evidence of subsurface oil in the deeper waters of the Gulf of Mexico, much more attention should be focused on the size and trajectory of the submerged oil plume, its impacts to deepwater benthic communities, and the associated deepwater use of chemical dispersants. The impacts of the *North Cape* oil spill at Point Judith, Rhode Island, should be examined to help design impact assessment studies for the *Deepwater Horizon* spill because this spill occurred during windy and wavy conditions that mixed and dispersed the oil throughout the water column, resulting in substantial mortality of lobsters and crabs from the sea floor. Some crustaceans are highly sensitive to oil and other toxicants, making the blue crab and shrimps of the Gulf coast important targets of impact studies.
15. Initiate laboratory studies of toxicity in mecososms that can best reproduce natural field conditions to augment the field assessment studies. These toxicity studies should involve collection of freshly released *Deepwater Horizon* oil and also deploy oil at various stages of aging and weathering in the testing. Experiments should run tests of oil alone and very critically oil combined with dispersants. The tests should not end with the typical short-term 3-5 day acute toxicity tests but should include treatments to assess chronic impacts of longer-term (months) exposures, perhaps pulsed so as to replicate the continuing delivery of *Deepwater Horizon* oil into the Gulf.

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