Deepwater Horizon Oil Spill (DHOS) in Perspective 8 Months Later: Perception vs. Reality

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In the mind of the American public, there have been two significant exposures of crude oil discharges, the *Ixtoc I* rig blowout, fire, and collapse thirty years ago (1979) and the *Exxon Valdez* shipping-related oil spill twenty years ago (1989). The *Exxon Valdez* incident is by far more familiar to Americans, in part because when it occurred there were many images of oiled birds and mammals generated by the news reports of the day. For the *Ixtoc I* incident, far less reporting information is available, and there certainly is not the public awareness that remains from the *Exxon Valdez*. However, there is a great deal of actual difference between the incidents.

Most comparisons of the two incidents to DHOS are largely invalid if you recognize the extremely different aspects of environment and location. The *Exxon Valdez* was a surface spill of a known volume in an enclosed system, in a cold water regime, Prince William Sound, Alaska. The *Ixtoc I* discharge was an uncontrolled bottom well blowout in the Gulf of Mexico in less than 200 feet of water and in the Bay of Campeche about 500 miles from the south coast of Texas. It produced over 100 million gallons over the 10 months of free flow before the wellhead was plugged. When comparisons of environmental impact are made, *Exxon Valdez* is purported to still have negative impacts on Prince William Sound. For the *Ixtoc I,* there is general agreement that impacts were deemed minimal after 3-5 years (http://www.mcclatchydc.com/2010/06/12/95793/ixtoc-the-gulfs-other-massive.html). In neither incident did the human population potentially impacted by the oil pollution approach that of the north-central Gulf of Mexico coast, the zone of impact for the DHOS.

As for the DHOS, the chronology of the spill occurring on April 22, 2010 is important, particularly given our technical naiveté concerning the disaster. In the 60 years or so of offshore drilling in the north-central Gulf of Mexico, there had never been a discharge of crude oil of the apparent and potential magnitude of that was produced by the blowout, fire, and collapse of the *Deepwater Horizon* drilling rig. The seminal words here are "apparent" and "potential" both reflecting, in part, the uncertainty with which the technical/management community of the Gulf was faced.

Given very little prior experience, the marine science community was misled by BP's persistent minimization of estimates of the amount of released gas and oil from the wellhead. The ongoing acceptance of those values by federal representatives exacerbated the concerns and heightened a skeptical reaction from nearly everyone involved. BP appears to have only grudgingly released video of adequate quality to allow the academic experts to provide estimates which were significantly higher than those provided by BP and their federal partners. The independently derived quantity estimates eventually proved to be more accurate than the BP estimates.

It should be noted that the unholy partnership between BP and the federal agencies (particularly the former Department of the Interior's Minerals Management Service and the National Oceanic and Atmospheric Administration), was not really a partnership of choice. In the wake of the *Exxon Valdez,* Congress passed the Oil Pollution Act of 1990. This legislation established a formal partnership between several federal agencies and the responsible party, in this case, BP. The logic for the partnership seemed powerful twenty years ago.

The concept involved having the responsible party pay up front and the partners would work hand in hand to develop the Natural Resource Damage Assessment (NRDA) methodology, thus avoiding (in theory) the anticipated lengthy litigation. That *Exxon Valdez* litigation was in fact only completely resolved a few years ago, almost 20 years after the case was opened! This legislated approach was used effectively in a number of oil spills prior to DHOS. It appears to have failed at the scale of DHOS, certainly in the arena of cost effective application.

Within the second month, the Gulf of Mexico marine science and commerce community had adopted a somewhat guardedly optimistic forecast. Given information on *Ixtoc I* impacts from scientists at the Harte Institute at Texas A&M University, Corpus Christi, and the fundamental understanding of oil in the Gulf of Mexico, it was no longer a question of if the area would recover, but rather how long it would take and would there be measurable alterations of the ecosystem. The ongoing debates over volume of material and use of dispersant technology continue to confound a broad consensus within the scientific community.

The use of dispersants was approved by a panel of experts and the governors of the affected states in an effort to minimize the exposure of the critical shoreline habitats of emergent marsh, submerged aquatic vegetation, oyster reefs, and beaches. Aerial

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application on the surface material was markedly inefficient because the surface distribution of oil residues was nearly chaotic. The surface material was consistently blown into windrows or physically dispersed by wind and waves and was far from uniform in distribution.

The use of the term residue is calculated because the quality of the oil released at a mile below the surface began to change the instant that the material entered the water column. Contrary to the cliché that "oil and water don't mix," some components of crude oil mix quite readily in water. In fact, many of the volatile organic compounds like benzene, toluene, xylene, etc. (collectively known as BTEX) are soluble, and a lot may not have reached the surface at all (http://www.nap.edu/html/oil_in_the_sea/reportbrief.pdf).

The light crude oil from DHOS was high in the percentage of these volatile compounds which are the principal components of gasoline. This solubility in water may have contributed to some of the discrepancies between the surface-derived estimates of volume released versus flow rates at the leak. The National Research Council's 2003 report stated:

"The most serious, in terms of fate problems for both shallow and deepwater, appears to be the limited validation of the dissolved component."

The application of dispersant at the leak 5,000 feet down was approved in an effort to improve the efficiency of the application process, but its actual effectiveness remains somewhat controversial. The dispersant use is logical in that the interaction of the surfactant components with the crude oil does form microscopic droplets or micelles which can dramatically increase the availability and therefore the rate of biodegradation of the oil constituents by the native microbial community. This material is not dissolved but becomes apparently something of a dynamic colloid, and it is disconcerting in that these "droplets" may be neutrally buoyant. This could partially explain the existence of the various plumes located at several depths including 3,000 feet below the surface reported by some academic marine institutions. While some details were originally questioned, these plumes were later confirmed by National Oceanic and Atmospheric Administration (NOAA) scientists (http://www.nytimes.com/2010/06/09/us/09spill.html).

The existence of a microbial community which uses crude oil carbon as a food and energy source is a consequence of the millennia of oil and gas exposure from natural seeps throughout the Gulf of Mexico, estimated to be as much as 40-50 million gallons per year from 600-1,000 discrete sites. Some of these microorganisms are capable of metabolizing and detoxifying the larger, more toxic, and relatively refractory polycyclic aromatic hydrocarbons (PAH), suspected of being carcinogenic and the only components of crude oil that are bio-magnified. The distribution of quantity and quality of the microbial community in the deeper waters of the Gulf of Mexico is poorly understood at best.

Nevertheless, all data available this winter support the proposal that the native microbial population did effectively assimilate the discharged carbon material and possibly at a rate far faster than any originally postulated by most of the scientific community. This conclusion is subject to some criticism from others who have used oxygen consumption as an indicator of microbial activity and are skeptical of reports that report dramatic levels of microbial respiration which are not accompanied by concomitant reductions of dissolved oxygen (http://www.examiner.com/political-buzz-in-national/noaa-report-on-gulf-oil-spill-draws-criticism-for-many-assumptions).

These results require a substantial advection of oxygenated water, which is not abundant at depth, considering that the last time that particular water mass saw the atmosphere was near the Arctic Circle quite a long time ago! There has been quite a controversy concerning the fate of the oil, particularly because of a report attributed to the administration, rather than NOAA, and interpreted by the media as the total elimination of the oil (http://www.canadafreepress.com/index.php/article/26751).

It would be much more accurate and effective to discuss the conversion of the tons of carbon which was initially in the complicated mixture of hundreds or thousands of petroleum hydrocarbon compounds into an equivalent number of tons of either organic or inorganic carbon materials, all eventually incorporated into the biosphere through incredibly complicated food webs. As long as you understand and accept the fundamentals of this process it may be fair to say that the oil is indeed gone.

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The challenge for the marine science community now is tracking the fate and effects of those carbon compounds which may be deleterious to specific components of the ecosystem including us, at the top of the food chain. The vast majority of the carbon has likely been incorporated into the incredibly diverse marine biological universe; primary producers and several tiers of consumers, and like it or not, eventually to us!

However there are some components of the original material which have much longer half lives in toxic forms that remain a concern to public health interests. The PAH compounds have variable direct toxicities and are classified as carcinogens at some levels. Although degradable by some microbes they are generally relatively resistant and may be bio-accumulated in organisms which lack a number of systems, both biochemical and physiological. PAH compounds are broken down through specific enzyme activities which are more present in vertebrates. Further, most vertebrates have fairly sophisticated excretory systems and livers that serve as personal waste dumps for the toxics where they do relatively little damage. So unless snapper liver suddenly becomes a delicacy, it is unlikely that they or any other fin fish constitute a public health hazard.

Bio-accumulation or magnification by food items provides a mechanism for the re-concentration of potentially toxic materials that may have been diluted far below dose levels of any concern. This process requires consumption of a great deal of the tainted material over quite a long time coupled with a varying capacity to metabolize or eliminate. It is possible that reef fish residing in the area could accumulate PAH compounds in their livers but it will take some time, probably years and we do not have data that would indicate significant accumulation in the edible portions of the fish.

Shrimp have less sophisticated metabolic and excretory systems and may acquire PAH compounds. But given their relatively short life cycle, it is unlikely that shrimp are a high risk food item. Most studies in the aftermath of oil exposure have not revealed accumulations reaching levels of concern.

Oysters, however, are virtual "sponges" for all matter of organic pollutants, bacteria, viruses and heavy metals. Given that they don't reach harvestable size for about three years, those exposed to oil-derived carbon may constitute a risk that will require careful, long term monitoring. Because of these very characteristics and that they are consumed raw, Gulf oysters are the most carefully tested seafood in our country.

The last crude oil component of concern is the longest lived, least easily degraded, and the least toxic of all constituent compounds. These are referred to as asphaltenes and are indeed what we are most familiar with as asphalt and make up the bulk of what we call "tar-balls."

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Tar-balls and asphalt seeps are part of the background petroleum hydrocarbons of the Gulf and have been recognized on the beaches for generations. The tar-balls are accumulations of the asphaltenes, usually covered with sand because the heavy aggregate is sticky and they may have encapsulated some of the other components including volatiles and PAH compounds. But they are not routinely part of the human food chain, even though there are stories of old-timers who claim to have treated it like chewing gum.

The asphaltene fraction of the original spill may be as low as 2%, but this has not been calculated with any accuracy, and high variability is the rule rather than the exception. Even at that low figure, we are dealing simplistically with at least 4 million gallons of "tar" and we are clearly going to be encountering more than we are accustomed to for an unknown period of time. While tar-balls are functionally non-toxic, they are aesthetically unattractive and will constitute an ongoing threat to the beach economies. The threat will be larger as long as the public thinks there is a health hazard. It seems clear that the beach communities are going to be facing years of ongoing tar-ball exposure and subsequent clean-up, presumably at BP's expense.

The other tar-ball issue also depends on the assumption that they are going to be around in larger numbers than ever encountered over past decades. Deep water shrimpers recently reported tar-balls from areas near the DHOS. The response of the National Marine Fisheries Service was to close the royal red shrimp fishery out of an abundance of caution.

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Subsequent analysis of shrimp from the area exposed to the tar-balls revealed nothing of public health consequence – that of course, never made the media. Current research does indicate that the tar-balls do physically encapsulate other residues from the original material and may include both VOC and PAH compounds. Whether these can ever enter the food web at levels of concern remains a question of largely academic interest. However, there is a clear and certain danger that the various media elements could easily turn that into a matter of grave concern in the minds of tourists.

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To provide a better understanding of the Exxon Valdez and Ixtoc I incidents, I found the following sites. There is a lot of opinion and some fact in each of these articles. *—Paul Looney, Newsletter Editor*

http://www.incidentnews.gov/incident/6250

http://sweetness-light.com/archive/anyone-remember-mexicos-ixtoc-i-leak

http://news.discovery.com/earth/gulf-oil-spill-ixtoc.html

http://seattletimes.nwsource.com/html/nationworld/2011931961_ixtoc23.html

http://content.usatoday.com/communities/greenhouse/post/2010/05/wildlife-effects-from-oil-spill-could-last-years-scientist-says-/1

http://www.msnbc.msn.com/id/37514348/ns/disaster_in_the_gulf/

DOI Report on IXTOC – Economic Impacts: http://www.gomr.boemre.gov/PI/PDFImages/ESPIS/3/3929.pdf

http://www.guardian.co.uk/environment/2010/jun/01/gulf-oil-spill-ixtoc-ecological-tipping-point

Another DOI report – Biological Impacts: http://invertebrates.si.edu/mms/reports/IXTOC_exec.pdf

Claims that impacts lasted years: http://www.bbc.co.uk/news/10307105

NPR report: http://www.npr.org/blogs/thetwo-way/2010/05/one_gulf_oil_spill_went_for_ne.html

Impacts to fisheries gone after three years: http://www.nature.com/news/2010/100714/full/466304a.html

Press Register Article – 2.5 to three years after Ixtoc biological resources showed little effect:
http://blog.al.com/live/2010/09/ixtoc_spill_still_contaminates.html

Exxon Valdez references

History and summary of today's impacts: http://greenanswers.com/blog/161681/exxon-valdez-today

http://www.eoearth.org/article/Exxon_Valdez_oil_spill?topic=58075#gen7

Exxon Valdez Oil Spill Trustee Council Report: http://www.evostc.state.ak.us/recovery/lingeringoil.cfm

NOAA Information: http://oceanservice.noaa.gov/education/stories/oilymess/welcome.html

Yale Article: http://e360.yale.edu/feature/twenty_years_later_impacts__of_the_exxon_valdez_linger/2133/

Science Daily Article (12/23/03): http://www.sciencedaily.com/releases/2003/12/031219073313.htm

Deepwater Horizon

The following link is the Keynote address by Jane Lubchenco, Ph.D., NOAA administrator made at the Center for American Progress, in Washington, DC on Feb. 9, 2011, titled: "Beyond Recovery: Moving the Gulf Toward a Sustainable Future"
http://www.noaanews.noaa.gov/stories2011/20110209_restorethegulf_keynoteaddress.html

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It remains unclear whether these residual carbon forms will impact the ecosystem at any scale, and the human component in particular. One of the more obscure positive developments from the incident may be a heightened awareness that there is a legitimate human component in the ecosystem models. Certainly it should never be clearer that the socioeconomics of the coastal community is deeply dependent on the ecosystem services provided by the natural system. That service may be as obvious as market value of seafood or as appreciated as the non-market value of a sunset on the beach!

The rather interesting technical challenge facing the environmental community may be that of closing the gap between the public perception of the oil spill and the reality of where we stand almost a year after the event. Unfortunately perceptions are real and the resiliency of the natural system has not been matched by the human component of the integrated model.

Between the seafood industry losses across the north-central Gulf Coast and the drop in beach visitation, predominately to the east of Louisiana, the economic recovery cannot be accurately estimated. However, the losses have run into the billions. The irony may be that the quantifiable environmental damage diminishes as you move from Louisiana to the panhandle of Florida while the economic losses go much higher.

If the economic loss to Louisiana eventually attributed to the drilling moratorium is discounted, Alabama may emerge as the state most adversely affected by DHOS (http://crcalabama.org/wp-content/uploads/2010/12/CRC-Book-Download.pdf). The truly greatest challenge to socioeconomic recovery in the region is that of narrowing the gap that exists between the public perception of health risk and the remarkable capacity of the natural ecosystem to accommodate and largely detoxify the worst episodic environmental insult ever visited upon the Gulf in its long history of human exploitation.

Another irony that is confounding assessment of the DHOS impact is the early reports of enormous populations of reef fish, sharks and other normally targeted species, including shrimp. The cessation of fishing by federal fiat due to an abundance of caution may have truly created a serious, but positive, complication in the apparent increases in populations of animals that would have normally been heavily fished during the period of the spill.

No one has suggested that the spill did more good than harm, but these early observations certainly fly in the face of the original expectations of mass mortalities in the natural population. There were most certainly large losses among the planktonic organisms that include eggs and larvae of fishery species. But those impacts won't be evident for some time. They may not be observed at all in the longer lived species that may simply outproduce any losses attributable to the summer of 2010.

The seafood appears to be abundant and is indeed safe to eat while the beaches are among the finest in the world. It remains to be seen if Spring Break and the summer visitation levels demonstrate a resiliency in any way comparable to that of fish stocks. Go fishing!

Dr. Crozier received his Ph.D. in Marine Biology from Scripps Institution of Oceanography. Dr. Crozier has spent most of his professional career in Coastal Zone Management, or as he describes it "applied marine ecology." He has been the Executive Director of the Dauphin Island Sea Lab at the mouth of Mobile Bay since 1979. Dr. Crozier received NOAA's Walter B. Jones Coastal Steward Award *for 1999/2000 and has been honored by the State of Alabama as a science educator. He currently chairs the Principal Members of the Gulf of Mexico University Research Collaborative, a consortium of State consortia from around the Gulf. The Collaborative has been organized to provide coordination of the academic community in response to the ten year-long Gulf Research Initiative in the wake of the* Deepwater Horizon *Oil Spill and Gulf restoration planning.*

J.D. Crowe, editorial cartoonist at the Mobile Press Register *has generously allowed liberal use of his insight into the human impacts of this environmental catastrophe. You can follow his work at* http://blog.al.com/jdcrowe/index.html.