**Written Testimony of Carys L. Mitchelmore, Ph.D.**

**Before the House of Representatives Subcommittee on Insular affairs, Oceans and Wildlife Oversight**

**Hearing entitled "Our Natural Resources at Risk: The Short and Long Term Impacts Of The Deepwater Horizon Oil Spill" (Part 3 Of 7-part Series).**

**June 10th, 2010**
**(Testimony submitted June 8th, 2010)**

**Carys L. Mitchelmore, Ph.D.,**
**Associate Professor,**
**University of Maryland Center for Environmental Science,**
**Chesapeake Biological Laboratory,**
**P.O. Box 38 (1, Williams Street),**
**Solomons, MD 20688**

Chairman Bordallo and members of the Subcommittee. I am Dr. Carys Mitchelmore and I would like to take this opportunity to thank you for inviting me today to highlight some of the issues concerning the effects of oil spill dispersants and dispersed oil.

By way of background: I am faculty at the University of Maryland Center for Environmental Science, Chesapeake Biological laboratory. I have been conducting research and publishing books and articles for over 15 years concerning the impacts of pollutants, including oil and oil spill dispersants on many aquatic species. Today I am representing my views as a researcher in the field of environmental health. I began investigating the impacts of oil on marine organisms following the Aegean Sea Oil spill in 1992. Since then, as opportunities have arisen, I have carried out research investigating the effects of oil and it's constituent compounds on bivalves, corals, fish and reptiles. Specifically, in the last few years my focus has been on investigating the routes of exposure to and the toxicity of the dispersant Corexit 9500 and dispersed oil on sensitive species, such as corals (REFS 1-9). I was also co-author on the recent 2005 NRC publication on "Oil Spill Dispersants: Efficacy and Effects" (REF 10).

Unfortunate recent events in the Gulf have once again brought to the forefront issues pertaining to the impacts of oil, oil spill dispersants and dispersed oil in our marine and coastal ecosystems. My testimony today will focus on issues relating to the potential impacts and the uncertainties (data gaps) regarding oil spill dispersants and dispersed oil. The three key points I would like to raise today are the following:

**1. Limited data is available concerning the toxicity of dispersants and dispersed oil.**

- There are significant data gaps relating to understanding sublethal, delayed and long-term effects, particularly to sensitive species (e.g. corals).

**2. Ecosystem-based approaches.**

- Is bioaccumulation of oil in the food web enhanced or decreased with dispersants?
- Indirect toxicity issues can influence higher trophic level organisms.

**3. What and where are the data gaps?**

- What would help reduce the uncertainties in dispersant application decisions?
- Specifically what are some of the unknowns with the recent oil spill in the Gulf of Mexico.
    - Issues relating to the two drivers of toxicity; concentration and time.
    - New application methods (subsurface rather than surface).
    - Limited toxicity data regarding the less toxic dispersant alternatives.

**Overview and Introduction: What are dispersants and why are they used?**

When oil is spilled response decisions are quickly made based upon the best available science and on numerous and often continually changing variables. The use of dispersants is an environmental trade-off; the protection of one habitat at the cost of another. In the current Gulf of Mexico oil spill (Deepwater horizon (DWH) leak) dispersants are used to protect the shoreline (and surface) species at the expense of organisms residing in the water column and potentially those in the benthic (seabed) environment.

Dispersants are chemical mixtures containing solvents, surfactants and other additives, (including proprietary chemicals) that are used to facilitate and enhance the break-up with wave energy of the surface oil slick into small oil droplets that disperse into the waters below. They **do not** remove oil from the environment, they simply change the inherent chemical and physical properties of the oil and in doing so alter the oil's transport, fate and potential effects. The small droplets stay suspended in the water column and spread in three dimensions instead of two. The premise behind dispersant use is that this oil movement results in a plume of dispersed oil and dispersants that is quickly reduced to low levels with depth in the Ocean. In addition, this dispersal effectively increases the surface area to volume ratio of oil so that microorganisms that naturally degrade oil can be more effective in doing so.

The Gulf of Mexico contains sensitive coastal habitats, such as wetlands, that serve as nursery grounds to numerous species, including those that migrate long distances to these breeding areas. Oil coated shorelines not only decimate intertidal food reserves for ourselves (e.g. oysters, crabs, shrimp, fish) and other organisms but will also cripple recreational activities and local economies. Oil, if allowed to come to shore, can remain in those habitats (e.g. in the sediment) for long periods of time continually exposing and impacting local resources for years or decades following the oil spill.

Recently a scientific meeting (May 26-27$^{th}$) of over 50 experts from government agencies, academia and industry was convened specifically to provide input for the Gulf of Mexico's regional response teams (4 & 6) on the use and effects of dispersant and dispersed oil in going forward with future incident decisions. It was the consensus of the group that "up to this point…dispersing oil into the water has generally been less environmentally harmful" (see REF 18). However, concerns were made over the unknowns especially regarding the fate and potential long-term effects (discussed in later sections herein) of dispersants and dispersed oil and their continued long-term use. Therefore, some strong caveats were mentioned; that increased monitoring efforts and continued re-assessments should be made to ascertain that these trade-off decisions are still scientifically sound. I highlight these latter points.

With increased time these trade-off decisions could change given 1) the volume of dispersants used and the footprint (in space and time) of the impacted area in the water-column, 2) sensitive species movement into and out of different habitats (e.g. bluefin tuna and other species spawning in the open Ocean waters), 3) continued and increasing impact of oil onto sensitive shorelines, therefore, reducing the percentage of habitat saved by using dispersants. Of concern is that we do not (and probably never will) know the extent of the harm and loss of organisms in the water column and on the seabed. Mapping of who, what, and where species are in these habitats is limited or in the case of the seabed down at 5000ft, non-existent.

**Summary of what is known about the short and long-term effects of dispersants and dispersed oil.**

***1. Limited data is available concerning the toxicity of dispersants and dispersed oil.***

As concluded in both of the NRC dispersant reports (REFS 10, 11) limited toxicological information exists to fully assess the risks to organisms to dispersants and dispersed oil. Although this lack of toxicological data is not unique to oil spill dispersants. It is mirrored by the tens of thousands of chemical contaminants (again often proprietary mixtures) that are also being released into the environment. The majority of toxicity data regarding dispersants and dispersed oil address acute and short-term effects derived from laboratory toxicity tests. There is much more limited data available detailing the potential sublethal or delayed effects of exposure, which could be much more detrimental to a population in the long term. Examples of the major questions that arise are detailed in the following sections:

*a) How toxic are the dispersants alone?*

Although dispersants themselves would not be released into the environment alone, toxicity tests are required (for human and environmental safety) so that they can be approved for use (i.e. listed on the EPA's National Contingency Plan Product Schedule (NCPPS) table; see REF 12) and included on the products material data safety sheets (MSDS). However, many of the dispersants are proprietary and do not list their chemical components in detail on the MSDS sheets. In addition, toxicity studies are often limited in scope (i.e. they are acute short-term toxicity tests in two standard test organisms). Acute toxicity tests are used to compare toxicity between chemicals and between organisms to identify highly toxic chemicals and sensitive organisms. Results are standardized and presented as the lethal concentration of a chemical that causes death to 50% of the test organisms following a set exposure time (i.e. LC50, 24-96 hours). The **lower** the LC50 level is (i.e. the number), the more toxic the chemical.

With respect to dispersants, toxicity depends upon the specific dispersant under study, the species being tested and also the life stage of the particular species under investigation. Some organisms are much more sensitive to (i.e. affected by) dispersants than others. For example, gulf mysids and copepods (crustaceans), diatoms (algae) and fish larvae are affected at low concentrations of Corexit 9500 (i.e. LC50, 96 hour at the low ppm level). However, other organisms are only affected by 3-10-fold higher concentrations of Corexit 9500. To date the majority of toxicity studies (those listed in the NCPPS table and in the scientific literature; see REF 10) have been focused on the Corexit formulations. Fewer toxicity studies (i.e. less species evaluated) have been carried out for Corexit 9500 compared with the earlier Corexit 9527 formulation. In comparison, to date even more limited and scientifically robust data exists (that is publically available) for any alternative formulations. Some studies have found dispersants to be less toxic compared with oil or dispersed oil in direct comparisons, although some studies report an increased dispersant toxicity compared with oil or dispersed oil (see REF 10).

*b) How toxic is dispersed oil?*

There is conflicting scientific evidence to date regarding the toxicity of dispersed oil in comparison to oil. The 2005 NRC report addresses this at length (REF 10). For example, some studies have stated that dispersed oil is more toxic than oil, others have shown that the toxicities of dispersed oil and oil are equivalent. The NRC 1989 report concluded that the acute lethal toxicity of chemically dispersed oil is primarily associated not with the dispersant but with the dispersed oil and it's dissolved constituents following dispersal. Some species and life stages are much more sensitive than others, for example, the LC50s for oyster and fish larvae were as low as 3mg / l (i.e. 3ppm) for dispersant alone (Corexit 9527) and 1mg / l (i.e. 1ppm) for dispersed oil (REF 13).

It is inherently difficult to compare dispersed oil with oil and discrepancies can arise simply due to the experimental design of the toxicity tests. Therefore, in the 1990's efforts were made to standardize toxicity tests (i.e. CROSERF and following publications; see discussion in REF 10). Great advances were made at that time, however, there is a dire need to expand this work further to include new additional and complicating issues that will be discussed in the following sections.

Understanding basic toxicity mechanisms and species sensitivity across diverse taxa in laboratory studies aid in the risk assessment of what organisms are potentially those most at risk. During a spill these data can be compared with the predicted dispersed oil concentrations (using computer modeling) or actual oil concentrations measured in the field. There is still a need to fill the serious fundamental scientific data gaps regarding the basic toxicology of dispersants and dispersed oil as highlighted in the NRC reports.

Recently the EPA (directive dated May 10$^{th}$ and addendum 2 on May 20$^{th}$) requested that BP should use a less toxic dispersant. Given their LC50 guidelines only **four** of the listed products on the EPA NCPPS would meet these toxicity criteria. BP responded to EPA's request within 24 hours (posted on May 22$^{nd}$) and defended their use of the Corexit formulations stating limited toxicity data, potential long-term effects of some components in some alternative formulations coupled with limited availability in the volumes required for the Gulf spill. Following BP's response the EPA announced (addendum 3 on May 26$^{th}$) that in addition to requiring that BP reduces it's use of dispersant (by around 75%) particularly at the surface they also stated that they will be carrying out toxicity tests to further evaluate these alternative products.

*c). Sublethal, delayed toxicity and potential long-term effects.*

As summarized in the recent NRC publications oil and oil spill dispersants can cause many effects, including death and a variety of sublethal impacts including reduced growth, reproduction, cardiac dysfunction, immune system suppression, metabolic and bioenergetic effects, developmental deformities, carcinogenic, mutagenic, teratogenic effects and alterations in behavior (REFS 10, 11). These more subtle endpoints than death can none-the-less have huge consequences for populations. Additionally, delayed effects may occur which are hard to track and follow following an oil spill event unless monitoring programs span years after the spill event. Even then these monitoring programs may come too late i.e. if baseline monitoring before the spill was not carried out it is impossible to fully assess the final extent of damage. Some aquatic species are more sensitive than others to dispersants and /or dispersed oil. Therefore, making trade-off decisions between species is difficult if toxicity data is not available for those or closely related species. Additionally, it has been shown that it is the early life stages of organisms, e.g. eggs and larvae that are more sensitive to chemicals and are at particular risk. This is especially of concern given that these life stages often inhabit surface waters, especially as is the case for the Gulf of Mexico now given that this is the spawning and reproductive period for many species.

*i) Water column organisms:* Organisms resident in the water column are those at risk following dispersant application. A dispersed oil plume contains high levels of dispersant, dissolved oil and oil droplets meters down into the water column. It is in these surface waters that many organisms are concentrated in. This includes phytoplankton (algae) and zooplankton (small invertebrates or larvae of fish and other organisms); essential components at the base of the food web that organisms (including shoreline species) rely upon.

Other organisms at risk include fish, reptiles and marine mammals. A dispersed plume is not static. Like a surface slick it will move with the wind and ocean currents. In some cases the larger organisms (large fish, reptiles and mammals) having detected a harmful substance may be able to move away and avoid the plume if their sensory systems and behavioral mechanisms have not already been impacted by the oil plume. This is not the case for the smaller organisms. They will more than likely move with the plume increasing their duration of exposure to the toxicants. Dispersed oil may affect these water column organisms in a number (or combinations) of ways:

1) direct toxicity through exposure to the dissolved oil components and/or dispersant.
2) ingestion of oil particles and hence bioaccumulation of oil components.
3) coating of external surfaces (e.g. gills/skin) by oil droplets potentially enhancing oil uptake (dissolution) across surfaces or simply physical effects reducing respiration leading to eventual smothering and death.

Recent studies demonstrating sublethal effects and new toxic pathways suggest that the full impact of exposure to dispersed oil may be underestimated and further studies are required to investigate this in detail. For example, in translucent organisms (e.g. fish larvae) the toxicity of accumulated oil can be 12-50,000 times underestimated because the traditional toxicity tests were not carried out under conditions of natural sunlight (REF 14, REF 10). This phenomenon called ‘photoenhanced toxicity’ may be critical in determining the effects of dispersed oil in surface dwelling (e.g. translucent pelagic larvae) and shallow water translucent organisms (including corals).

Studies have also shown that dispersants may facilitate the uptake and potentially the bioaccumulation of oil constituents in organisms from ingestion routes (e.g. see REF 15) or by oil droplets sticking to biological surfaces (e.g. fish gills; see REF 16) and facilitating the dissolution of oil components (dissolved polycyclic aromatic hydrocarbons (PAHs)) into tissues. However, dispersed oil has also been shown to be less ‘sticky’ and does not interact with biological surfaces or sediment (see discussions in REF 10). These issues relating to the fate (i.e. where the oil ends up) are important to know for a full risk assessment on the impact of dispersants. As with photoenhanced toxicity any enhanced bioaccumulation routes would increase the ‘footprint’ of the potential effects of dispersed oil and further studies are required to address these data gaps and uncertainties in predicting the fate and effects of dispersed oil.

*ii) Benthic/Intertidal organisms (e.g. oysters, mussels and crabs):* In a deep open ocean spill benthic organisms are usually at minimal risk of exposure and the direct effects of surface dispersed oil. Although they still could be indirectly affected by the oil spill if their food source is impacted. However, if the dispersed plume comes towards shallower coastal locations then intertidal and benthic organisms will be exposed. Suspension (filter) feeders, such as oysters and mussels, will bioaccumulate oil droplets in addition to the dissolved oil components. Dispersed oil droplets generally range in size from $<3$ to 80µm. These sizes overlap with the preferred size range of food for many suspension-feeding organisms, including zooplankton (see later). Oysters and amphipods can select these particles, as they are similar in size to the phytoplankton they feed upon.

The importance of this oil droplet (or particle bound oil PAH) exposure route was highlighted in studies flowing the New Carissa Oil spill near Coos Bay, Oregon. Mussels (suspension feeders) contained much higher levels of oil constituents (PAHs; ~500 times more) than crabs (an omnivore) collected from the same area (REF 17). Chemical (PAH) profiles also highlighted that the mussels had accumulated the PAHs both from the dissolved oil constituents in the water and from oil droplets whereas crabs had only accumulated them from the dissolved phase. These data are very important as current computer models designed to predict the effects of an oil spill do not take into account exposure routes other than the dissolved components. This research has implications for the effects of a dispersed oil plume on coastal fisheries and highlights the importance in understanding the routes of exposure of oil to species and in determining the levels of oil constituents in each of these phases for a better understanding of risk.

Of additional relevance for the DWH oil leak is the novel use of dispersants at the subsurface. This type of application has never been done before and the impacts are unknown.

*iii) Corals:* In the last few years my research group has investigated the toxicity of dispersants and dispersed oil on corals. Laboratory experiments were conducted to investigate the acute, sublethal and delayed effects of dispersant and dispersed oil (Corexit 9500 and weathered Arabian light crude oil, 1:25 ratio). In summary, soft corals died in environmentally relevant concentrations of dispersant ($LC_{50}$ 8 hours ~30ppm; $LC_{50}$ 96 hours $<16.5$ppm). Sublethal behavioral effects (narcotic response resulting in the cessation of coral pulsing) were observed within hours at low (10ppm) exposures. In attempting to mimic a dispersed oil plume moving through a reef corals were exposed for 8 hours to dispersant alone (at 20ppm i.e. the dose used for the 1:25 (v/v) dispersant:oil ratio), dispersed oil (dissolved PAHs and oil/dispersant droplets and dispersant) and undispersed oil (i.e. dissolved PAHs under an oil slick) using an oil loading of 0.5g $l^{-1}$ oil:water (1:2000 w/v). After exposure corals were placed in clean seawater to follow potential delayed effects and sub-lethal repercussions. Thirty-two days after exposure coral growth was significantly reduced in the chemically dispersed oil and dispersant exposures and delayed effects (further death in the dispersed oil treatments) were observed. The cnidarians accumulated oil (PAHs) in their tissues derived from both the dissolved oil components and the oil droplets. This highlights that to fully assess and understand the risks involved from dispersed oil consideration must be given to the exposure route of the oil for a particular species rather than simply the total amount of oil.

***2. Food web effects.***

As mentioned in previous sections the upper layers of the water column are teeming with phytoplankton and zooplankton that are critical components of the food chain. All complex food webs, including those for shoreline/coastal species contain these organisms at their base. If these organisms are removed then higher trophic level organisms simply will not have food to eat and will ultimately suffer reduced growth, reproductive output and eventually death.  Therefore, dispersants and dispersed oil do not have to directly affect an organism for them to have serious repercussions. This is called indirect toxicity, whereby the contaminant impacts organisms that another organism needs for food.

These lower food chain organisms can also accumulate oil (either inside them or stuck on the outside of their bodies) so that organisms feeding on them become, and often to much higher levels, contaminated with oil. Suspension feeding organisms, like zooplankton (e.g. copepods), which are extremely important food sources at the lower end of food webs, have been found to feed on dispersed oil particles (size range 5-60µm).  This has effects on those organisms; organisms higher up the trophic level that feed on them and ultimately may poses severe food safety issues for humans (contaminated seafood etc). Information related to the trophic transfer of contaminants is relevant to fully understand and evaluate the risks of oil exposure. Models currently based on dissolved oil levels can significantly underestimate oil exposure.

***3. In summary what we still don't know (data gaps and uncertainties).***

In addition to those highlighted in the previous sections there are still many unanswered questions that we need to know to fully assess the risks involved with dispersants and dispersed oil. These were highlighted in the 2005 NRC report (REF 10). Although the 2005 NRC study was specifically tasked to address the potential risks of dispersant use in near-shore environments many of the conclusions of the report are valid in open-ocean spills, such as the DWH leak. Many questions and data gaps needed for improved risk analyses and ultimately effective oil spill responses were highlighted.  Some basic concepts and issues regarding dispersed oil fate and effects simply lacked adequate research. In addition other areas of study require increased research efforts, as conflicting data currently exists.

The many questions and issues that we have limited data for include the following;

1. What is the fate of dispersants and dispersed oil (i.e. where will they end up, in what form, how

biodegradable are they and what are the break-down products? Are the break-down products more or less toxic?

2. What are the potential-long term effects of dispersant and dispersed oil, even after a brief exposure, to aquatic organisms? What are the sublethal effects? Will there be delayed effects?
3. There are limited studies on sensitive at risk organisms (e.g. corals).
4. Does dispersed oil reduce or enhance uptake/bioavailability of oil to organisms?
5. Does photoenhanced toxicity increase the 'footprint' of effects?
6. Does dispersed oil reduce or enhance microbial degradation? If enhanced will this bacterial 'bloom' result in an increased dead zone in the water (i.e. increased footprint in hypoxic zones or just a significant reduction in water oxygen levels)?
7. Is dispersed oil less 'sticky' to biological surfaces and sediment?
8. What are the routes of exposure to organisms to dispersed oil? Is it dissolved PAHs or the oil droplets, or both.
9. How will the food web be impacted? Issues relating to trophic transfer and species loss.
10. What are the new risks with subsea application? Is the oil readily biodegradable? Will it cause more damage than allowing the oil components to disperse into the air, weather and degrade by abiotic and biotic surface processes?

Unfortunately many of these questions are unanswered given the very limited opportunities available to carry out research in these areas. Some of the research recommendations made in the 1989 NRC report (REF 11) were once again highlighted in the 2005 NRC report (REF 10) as these research questions had not been undertaken during those 16 years. Since the 2005 NRC report some limited progress has been made in addressing the data gaps outlined.

As stated before oil spill responders base their decisions on the sound scientific data that is available to them regarding species that would be at higher risk than others from the impact of oil or dispersed oil. The NRC report (2005) highlighted that some of the very basic assumptions made concerning the use of dispersants have still not been adequately investigated, despite being highlighted in the earlier 1989 NRC report (REF 11). For example, one main argument for using dispersants is that they enhance microbial degradation of the oil. Conflicting data exists regarding this assumption. Some studies have shown that dispersants are toxic to some bacteria and that biodegradation is reduced in chemically dispersed oil exposures. Other studies have shown enhanced biodegradation and increased numbers (blooms) of bacteria. The question is if blooms occur will this have a significant impact on dissolved oxygen levels in the water (i.e. likened to nutrient enrichment and eutrophication)?

**Additional Specific issues regarding the Gulf Oil spill.**

The unfortunate recent events in the Gulf have once again raised many of the issues discussed above regarding the fate and effects of dispersants and dispersed oil in addition to adding further questions regarding the novel use of undersea dispersant application. As many have asked in the past weeks, potentially what will the environmental consequences be of the dispersant application, what will be affected, to what extent and how? This is impossible to predict for many reasons.

As mentioned earlier open ocean spills are pre-approved for dispersant application given the minimal perceived risks to the ocean and the seafloor based upon the depth and volume of water available to dilute the dispersed oil. However, this spill is unique and a first for many reasons opening up many questions regarding the decision to use dispersants and what their potential effects may be. First, the sheer volume of dispersants applied is unprecedented; no spill in U.S. waters has used the amount of chemical dispersants that have currently been released (nearly 1 million gallons as of June 6$^{th}$, 2010). Although it should be noted that the IXTOC spill (1979; see REF 19) in the Gulf of Mexico used a total of 2.5 million gallons of dispersant (not in U.S. waters), two-thirds of which were Corexit 9527. As in the IXTOC spill dispersants are usually only applied to surface slicks. In the DWH leak dispersants are also being applied at the leak site. The question is how will this dispersed oil impact the benthic (seafloor) environment?

The surface oil slick is easily viewed via satellite but what about the sub-surface plume(s)? In toxicology it is the concentration of and the duration of exposure to a toxicant that determines its effect. Therefore, we need to know where the plume is, at what concentration, for how long and what species are present. Various agencies, oil spill responders and independent scientists are running models trying to predict the oil plumes concentration and trajectory. Additionally some measurements of oil concentrations/ particle sizes are being taken at depths in the Ocean around the spill site. Only in knowing the size of this plume in three dimensions, the concentration of the dispersed oil in the plume at these locations and the duration of exposure in one area, will predictions be able to be made of the potential effect. Indeed increased monitoring of subsurface plumes was a recommendation from the recent dispersant meeting (REF 18). Unlike with oil impacts along the coast and shoreline, it is very difficult to see the actual effects of the dispersed oil in the Ocean. Organisms, that die will fall to the seafloor. Those that do not die may not show sublethal repercussions for a while. Declining populations of a water column species may occur and shoreline species may become severely limited in their food sources in addition to being faced with a contaminated food source.

With the increasing volume of oil and dispersants entering the system for extended periods of time there may be, at some time, a point reached in which the harm to the water column organisms (and now potentially benthic organisms) does not outweigh the harm to the shoreline. This may be particularly relevant if shorelines are increasingly being impacted by the oil. Therefore, these original trade-off decisions will become less clear. These dispersants are approved for use in the open ocean, although there is no limitation as to how much and for how long they can be used. How long can the ‘solution to pollution’ reasoning hold? Furthermore, with the continued production of dispersed oil plumes from the surface and from the ocean floor will the dispersed oil plume reach the shallower, coastal locations that the decision to use dispersants has been based on? It is quite possible that a dispersed oil plume may reach and impact a shoreline.

**In summary**

Chairman Bordallo and members of the subcommittee I would like to thank you again for allowing me to testify today regarding the effects of oil spill dispersants. We face huge challenges to protect our coastal and oceanic ecosystems. As in the case of oil spills this sometimes involves making difficult trade-off decisions on what ecosystem to protect at the expense of another. However, pollution cannot simply be treated as ‘out of sight out of mind’ or that ‘the solution to pollution is dilution’. These assumptions need careful analyses on a continued basis that depend upon sound scientific data. The proprietary components in dispersants should be made available to researchers and further toxicity testing of dispersants is required especially if considering alternate formulations. Although many decisions are based upon acute short-term toxicity studies we are constantly unraveling new and more subtle sublethal toxicological pathways and toxicity mechanisms. These sublethal impacts ultimately have dire consequences to a species survival, consequences of which alter the fine balance of food webs, alter ecosystem services, and the overall health of the environment. During an oil spill event it is hard to assess the effects on the organisms that you do not see and equally challenging to follow the potential long-term consequences of the spill. More respect needs to be given to efforts directed at baseline monitoring and mapping of our Oceans and seafloor ecosystems. We cannot assess impacts or follow restoration efforts unless we know what species were there beforehand. We need to monitor the subsurface plume(s) in space and time.

There are still many unanswered questions and uncertainties associated with the decisions to apply dispersants. I emphasize the recommendations for additional studies made in the recent NRC report that will help fill these critical data gaps in the knowledge and understanding of the behavior and interaction of dispersed oil on the biotic components of ecosystems (see REF 10). Whatever choices are made this unfortunate recent event in the Gulf will impact ecosystem health, local economies, food sources and recreational activities, the extent to which is currently unknown. We need better information to close these uncertainty gaps that oil spill response decisions are based upon and we need it now. Thank you.

**References Cited:**

1. Solé M., Porte C., Biosca X., Mitchelmore C.L., Chipman J.K., Livingstone D.R. and Albaiges J. 1996. Effects of the Aegean Sea oil-spill on biotransformation enzymes, oxidative stress and DNA-adducts in digestive gland of the mussel (*Mytilus edulis* L.). Comp. Biochem. Physiol. C-Pharmacology, Toxicology and Endocrinology, 113, 2, 257-265.
2. Rowe, C.L., Mitchelmore, C.L. and Baker, J.E. 2009. Lack of biological effects of water accommodated fractions of chemically- and physically-dispersed oil on molecular, physiological, and behavioral traits of juvenile snapping turtles following embryonic exposure. STOTEN, 407, 20, 5344-5355.
3. Mitchelmore, C.L., Teasdale, M., Yost, D. and Hatch, W. (to be submitted Summer 2010). Effects of the oil dispersant Corexit 9500 on two symbiotic cnidarian species following short-term laboratory exposures. (Data available now in the final report submitted to the funding agency if requested).
4. Mitchelmore, C.L., Teasdale, M., Walters, J., Beard, E. and Baker, J.E. (to be submitted Summer 2010). Acute and sublethal effects of oil, dispersant (Corexit 9500) and dispersed oil on the temperate sea anemone (*Anthopleura elegantissima*) following laboratory exposures. (Data available now in the final report submitted to the funding agency if requested).
5. Mitchelmore, C.L., Teasdale, M., Yost, D., McDonald, A., Beard, E., Baker, J.E. and Hatch, W. (to be submitted Summer 2010). Acute, sublethal and long-term effects of oil, dispersant (Corexit 9500) and dispersed oil on the tropical soft coral (*Xenia elongata*) following laboratory exposures. (Data available now in the final report submitted to the funding agency if requested).
6. Mitchelmore, C.L. and Hyatt, S. 2004. Assessing DNA damage in cnidarians using the Comet Assay. Mar. Environ. Res., 58, 2-5, 707-711.
7. Mitchelmore C.L. and Chipman J.K. 1998. DNA strand breakage in aquatic organisms and the potential value of the comet assay in environmental monitoring. Mutation Res.-Fundamental and Molecular Mechanisms of Mutagenesis, 399, 2, 135-147.
8. Mitchelmore C.L. and Chipman J.K. 1998. Detection of DNA strand breaks in Brown Trout *Salmo trutta*) hepatocytes and blood cells using the single cell gel electrophoresis (comet) assay. Aquat. Toxicol., 41, 1-2, 161-182.
9. Mitchelmore C.L., Birmelin C., Livingstone D.R. and Chipman J.K. 1998. Evidence for cytochrome P450 catalysis and free radical involvement in the production of DNA strand breaks by benzo[a]pyrene and nitroaromatics in mussel (*Mytilus edulis* L.) digestive gland cells. Aquat. Toxicol., 41, 3, 193-212.
10. NRC, 2005. Oil Spill Dispersants; Efficacy and Effects. National Academies Press, Washington DC.
11. NRC, 1989. Using Oil Spill Dispersants on the Sea. National Academies Press, Washington DC.
12. http://www.epa.gov/oem/docs/oil/ncp/schedule.pdf
13. Clark, J.R., Bragin, G.E., Febbo, R.J. and Letinski, D.J. 2001. Toxicity of physically and chemically dispersed oils under continuous and environmentally realistic exposure conditions: Applicability to dispersant use decisions in spill response planning. Pp. 1249-1255 in Proceedings of the 2001 International Oil spill Conference, Tampa, Florida. American Petroleum Institute, Washington, D.C.
14. Barron, M.G. and L. Ka'aihue. 2001. Potential for Photoenhanced toxicity of spilled oil in Prince William Sound and Gulf of Alaska waters. Marine Polution Bulletin, 43, 86-92.
15. Wolfe, M.F., Schwartz, G.J.B., Singaram, S.,Mielbrecht, E.E., Tjeerdema, R.S. and Sowby, M.L. 2001. Influence of dispersants on the bioavailablity and trophic transfer of petroleum hydrocarbons to larval topsmelt (*Atherinops affinis*). Aquatic Toxicology, 52, 49-60.
16. Ramachandran, S.D., Khan, C.W., Hodson, P.V., Lee, K. and King, T. 2004. Role of droplets in promoting uptake of PAHs by fish exposed to chemically dispersed crude oil. Pp. 765-772 in Proceedings of the Twenty-Seventh Arctic Marine Oillspill Program (AMOP) Technical Seminar, Edmonton, Alberta, Canada.
17. Payne, J.R. and Driskell, W.B. 2003. The importance of distinguishing dissolved- versus oil-droplet phases in assessing the fate, transport, and toxic effects of marine oil pollution. Pp. 771-778 in Proceedings of the 2003 International Oil Spill Conference, Vancouver, Canada. American Petroleum Institute, Washington, D.C.
18. http://www.crrc.unh.edu/dwg/dwh_dispersants_use_meeting_report.pdf
19. Jernelov, A. and Linden, O. 1981. Ixtoc I: A Case Study of the World's Largest Oil spill. Ambio, 10, 6, 299-306.