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

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Good morning Chairman Oberstar and members of the Committee. 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 metals, organic chemicals, biological pollutants, oil and oil spill dispersants on many species, including corals, reptiles, fish and oysters. Today I am representing my views as a researcher in the field of environmental health. My career path as an aquatic toxicologist was set in place at the young age of 6, after stepping on a tar ball at a local beach. That left a lasting impression on me and I grew up fascinated with the rock pools and, unfortunately the all too often, oil sheens within. 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 effects and uncertainties (data gaps) regarding oil spill dispersants and dispersed oil using case examples from peer-reviewed studies in addition to my own research. I will summarize with issues and questions pertinent to the current Gulf oil spill.

The three key points I would like to raise during my testimony 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 and delayed effects.
- Few studies have addressed the impacts to sensitive at risk species (e.g. corals)
- There are inherent difficulties in monitoring and assessing the actual impacts during a spill event.

2. Ecosystem-based approaches.

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

3. What 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.
    - Issues relating to the two drivers of toxicity; concentration and time.
    - New application methods (subsurface rather than surface).

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

Organisms can die if they are coated with, inhale or ingest large amounts of oil. Often these are the enigmatic species that are highlighted in the news; the oil coated birds washed onshore, the dead marine mammals exposed to the oil slick because they come up to the surface to breath. Also the oil coated shorelines, that not only decimate intertidal food reserves for ourselves (e.g. oysters, crabs, fish) and other organisms but cripple recreational activities and local economies. Sensitive coastal habitats, such as wetlands, often serve as nursery grounds to numerous species, including those that migrate long distances to these breeding areas. Oil coated shorelines can chronically expose and continually impact local resources for years or decades following an oil spill.

When oil is spilled response decisions must be quickly made (within hours) and are based upon the best available science and on numerous and often continually changing variables; what specific type of oil is spilled, how much, what are the weather conditions, where will the oil go based on hydrodynamic models (i.e. oil trajectory), what response options are available, what and where are the sensitive habitats and species (for ecological, social and economic reasons). Ultimately the question is what habitats and organisms do I need to protect from the oil the most?

Dispersants are used to redirect an oil slick from the surface of the water into the waters below. The objective of dispersant application is to protect organisms coming into contact with the slick itself and to protect sensitive shorelines from the slick coming ashore. This is an example of a known pollutant, albeit one often classified as having low to moderate toxicity to environmental organisms, purposely added to the marine environment. It is used because its overall benefit to the environment offsets its risk. However, it actually represents an environmental trade-off, the protection of one habitat is at the cost of another i.e. the protection of shoreline 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). They 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 deep waters below (termed chemically dispersed oil[1]). These small droplets stay suspended in the water column and spread in three dimensions instead of two. The movement of dispersed oil and

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[1] In comparison the term physically (or naturally) dispersed oil is used in reference to the oil that is in the water beneath an oil slick. This includes mainly dissolved oil constituents (PAHs etc) in addition to some larger oil droplets due to natural wave action. For simplicity we will refer to this as dissolved oil throughout this document and chemically dispersed oil as dispersed oil.

dispersants in all dimensions in such a huge volume of water, such as the open ocean results in a plume of dispersed oil and dispersants that is quickly reduced to low levels. For example, at depths >10m water, it is estimated that the concentration of dispersed oil under a slick is <12.5ppm[2] (REF 11). In addition, this dispersal effectively increases the surface area to volume ratio of oil so that microorganisms (bacteria) that naturally degrade oil can be more effective in doing so.

It should be noted that dispersants do not remove oil from the environment they simply change the inherent chemical and physical properties of the oil and in doing so change the oil's transport, fate and potential effects. Given that dispersed oil can rapidly dilute to low concentrations in the water column resulting in a small area of concern for effects to water column organisms and minimal (if at all) impact to the seabed (benthic communities) the use of dispersants in the U.S. is pre-approved for application on open ocean oil spills (i.e. generally >3nm from shore and in waters <10m deep). However, trade-off decisions will become more complex if the water column hosts, for example, a densely populated school of spawning fish or other oceanic species, or if the slick moves into coastal areas. The issues surrounding the impacts and effects of using dispersants on the sea is summarized in the 1989 NRC report (REF 12).

Summary on the effects of dispersants and dispersed oil

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

The decision to apply dispersants to an open ocean spill is less complex than those that would need to be made for a near-shore, coastal location oil slick (summarized in REF 10). In an open water spill it is generally assumed that water-column organisms will indeed be impacted by the dispersed oil plume, but the extent of this harm will be less than the resulting impacts to a shoreline habitat. Assumptions include, for example;

1) the area (body of water) affected by a lethal plume of dispersed oil is small.
2) the numbers of affected organisms is reduced.

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[2] The term ppm refers to parts per million (e.g. 1 μl of a chemical in 1 liter of water).

3) the length of time that harm will occur will be less and that recovery will be quicker for the water column habitat.

However, even in this simple scenario there are still uncertainties involved, that an increased knowledge into the fate and effects of dispersant and dispersed oils would help answer (summarized in the 1989 NRC report; REF 12). Ultimately these trade-off decisions are based upon a habitat's sensitivity to oil and/or dispersed oil. These ecological risk assessments are derived from knowing what species are there and how sensitive they are to the oil and/or dispersed oil. Ultimately this data is derived from laboratory toxicity tests or field observations during an actual spill.

Both NRC reports (REFS 10, 12) concluded that limited toxicological information exists to fully assess the risks to organisms (i.e. water column and potentially benthic species) exposed to dispersants (e.g. the Corexit formulations that are the main dispersants currently in use in the U.S.) 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 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 (see summary tables in Chapter 5 of the 2005 NRC report, REF 10). 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 on their own, 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; see REF 13). However, many of the dispersants are proprietary and do not list their chemical components in detail. Most of the toxicity data available are from acute short-term toxicity tests (see tables 5-2 and 5-3 in the 2005 NRC report, REF 10). 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, the more toxic the chemical.

For 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[3]). However, other organisms were only affected by 3-10-fold higher concentrations of Corexit 9500. Less toxicity data (i.e. less species evaluated) is available for Corexit 9500 compared with the earlier Corexit 9527 formulation. My research laboratory has recently demonstrated that soft corals were affected at environmentally relevant (see REF 12) low ppm concentrations of Corexit 9500 (LC50, 96 hours <16.5ppm). 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 discussions in REF 10).

b) How toxic is dispersed oil?

Oils are a mixture of thousand's of different chemicals (including hydrocarbons and metals) all with their own specific physical, chemical and biological properties. Different oils contain varying amounts of these individual components. In addition, dispersants contain mixtures, including proprietary chemical components, so that we do not know exactly what the exact chemical make-up of a dispersed oil plume is. Individual chemicals in complex pollution mixtures can often interact with each other making them more toxic than could have been predicted from the sum of the individual components (this is called synergism where the toxicity of chemicals A and B is greater together than their individual toxicities).
There is conflicting scientific evidence to date regarding the toxicity of dispersed oil[1] in comparison to oil[1]. The 2005 NRC report addresses this at length (see REF 10).

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[3] NOTE: 10ppm (v/v) is 10μl of dispersant in 1 liter of water. To put this in a rough perspective this would be one drop in 5 liters of water.

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 (REF 12). 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 for dispersant alone (Corexit 9527) and 1mg / l for dispersed oil (REF 14).

It is inherently difficult to compare dispersed oil with oil and discrepancies can arise simply due to the experimental design of the tests. Therefore, in the 1990's efforts were made to standardize toxicity tests (i.e. CROSERF and following publications; see discussion in REF 10). Many of the studies demonstrating toxic equivalencies of oil and dispersed oil compare the results based upon equal concentrations of oil (e.g. equal TPH (total petroleum hydrocarbons)). There are two issues to consider regarding this experimental design.

First, that the dispersed oil consists of a complex mixture of dispersant, dissolved oil constituents (e.g. polycyclic aromatic hydrocarbons; PAHs) and oil droplets. The oil alone exposures are (for the most part) just dissolved oil components (e.g. PAHs) derived from mixing oil with water, allowing the 'slick' to resurface and using the water in these tests. This is used to approximate the dissolved oil components that water column organisms would be exposed to in shallow depths under a slick. Therefore, these tests do not take into account the route of exposure of the oil to organisms and the different components that would be in each fraction i.e. some specific PAHs will be more enriched in the dissolved phase, other less soluble ones will be in the oil droplets. However, these tests are useful in comparing (based on the same amount of oil) if dispersants enhance oil toxicity. This is still under debate. Second, these tests are not environmentally relevant. To prepare solutions of equal oil content much less oil is used in the exposures containing the dispersant and dispersed oil. This would not be the case under a slick. Elevated oil concentrations would be seen following dispersant application as oil is dispersed.

Toxicity data aids in the risk assessment of what organisms are the species 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.

c). Sublethal and delayed toxicity.

As summarized in recent NRC publications (see REFS 10 (specifically Table 5.7), 12, 15) 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 (see Table 1 below for a summary of dispersed oil sublethal effects). 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. Some aquatic species are more sensitive than others to dispersants and /or dispersed oil (again see tables within Ref 10). Therefore, making trade-off decisions between species is difficult if toxicity data is not available for those or closely related species[4]. 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.

d). Specific Issues relating to the dispersed oil effects (using specific species as case examples).

i) Water column organisms.

Organisms resident in the water column will be 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

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[4] Laboratory based toxicity studies often use standard test organisms from which resident species of similar taxonomy can be compared with. Often specific resident species of concern for a particular ecosystem are not amenable to laboratory tests. Although there are some additional taxonomic groups for which data is lacking e.g. corals.

invertebrates or larvae of fish and other organisms); essential components at the base of the food web that organisms (including shoreline species) rely upon.

Table 1: Summary of some of the sublethal effects reported in organisms exposed to dispersed oil[5]. The studies detailed are only those reported since the 2005 NRC report as tables exist for sublethal effect studies from 1989-2005 within that report (see REF 10).

Species	Sublethal Effect Observed	Reference
Mytilus edulis (mussel)	Decreased feeding rate	16
Zostera marina (Seagrass)	Altered photosynthetic index	16
Fundulus heteroclitus (Mummichog larvae)	Increased enzyme activity (EROD)*; reduction in body size.	17
Hyphessobrycon erythrostigma (amazonian fish)	Altered sodium fluxes, CYP1A induction*	18
Stylophora pistillata / Pocillopora damicornis (corals)	Reduced growth	19
Atherinops affinis embryos (topsmelt)	Inhibition of hatching and development; cardiovascular effects	20
Montastraea franksi (coral)	Cellular stress response; Increases in protective enzymes; HSP70 and P-glycoprotein**	21
Colossoma macropomum (tambaqui fish)	Impaired gill ion regulation; altered blood parameters; membrane effects	22
Trout (fish)	CYP1A induction*	23
Xenia elongata (soft coral)	Cessation of pulsing; ulceration and dissolution of tissues; reduced growth	4

*; These are enzymes up-regulated (increased) in response to dispersed oil (PAH) exposure. They demonstrate that PAHs are bioaccumulated, the organism is trying to remove them from its body by these detoxification enzymes. **; These are protective enzymes up-regulated in response to stress (oil dispersant exposure and bioaccumulation). NOTE * and ** represent an energetic cost to the organism, which if continued, will divert energy away from normal growth and reproductive processes and ultimately can result in death.

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

[5] Note: I have made no attempt to relate these to environmentally relevant levels, studies also use a range of oils and dispersant mixtures.

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 (discussed at length in REF 10). 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 24, 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 25) or by oil droplets sticking to biological surfaces (e.g. fish gills; see REF 26) and facilitating the dissolution of oil components (dissolved 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. 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 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 27). 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. Our studies with anemones and corals also showed that bioaccumulation resulted from exposure to both of these fractions. 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 a particular species and in determining the levels of oil constituents in each of these phases for a better understanding of risk.

iii) Corals.

In the last few years my research group has investigated the toxicity of dispersants and dispersed oil on sensitive species such as corals. A series of laboratory experiments were conducted to investigate the acute, sublethal and delayed effects of Corexit 9500 and dispersed oil (Corexit 9500 and weathered Arabian light crude oil, 1:25 ratio) on symbiotic cnidarians (anemones and corals). In summary, soft corals died in environmentally relevant (see REF 12) low ppm concentrations of Corexit 9500 (LC50 8 hours ~30ppm; LC50 96 hours <16.5ppm). Sublethal behavioral effects (narcotic response resulting in the cessation of coral pulsing) were observed within hours at low (10ppm) dispersant exposures. In attempting to mimic a dispersed oil plume moving through a coral reef the soft 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 8 hours of exposure these corals were placed in clean seawater to follow potential delayed effects and sub-lethal repercussions of exposure.

Following thirty two days of recovery in clean seawater 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 (see EXHIBIT 1). Our research also demonstrated that 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. These results have been submitted to the funding agency in the form of a final report and peer-reviewed publications are pending. I will be happy to provide any further information on these subjects.

3. 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 ourselves (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 concentrations can significantly underestimate oil exposure.

4. What we still don't know (data gaps)

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 11). 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 recent Gulf oil spill. 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 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?
2. There are limited studies on sensitive at risk organisms (e.g. corals).
3. Does dispersed oil reduce or enhance uptake/bioavailability of oil to organisms?
4. Does photoenhanced toxicity increase the 'footprint' of effects?

5. Does dispersed oil reduce or enhance microbial degradation? If enhanced will this bacterial 'bloom' result in an increased dead zone in the water (reduction in water oxygen levels)?
6. Is dispersed oil less 'sticky' to biological surfaces and sediment?
7. What are the routes of exposure to organisms to dispersed oil? Is it dissolved PAHs or the oil droplets, or both.
8. How will the food web (directly or indirectly) be impacted? Issues relating to trophic transfer and species loss.

Unfortunately many of these questions are still 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 12) 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 progress has been made in addressing the data gaps outlined. In summary, papers (numbers in parenthesis) have focused on determining dispersant effectiveness (10), chemistry and fate (4), microbial biodegradation (8) and toxicity (16)[6].

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 12). For example, besides protecting the shoreline protecting birds and marine mammals from the surface slick is a primary consideration. But does dispersing the oil protect birds? Again conflicting data exists. Some studies have shown that birds coming into contact with a dispersed oil plume may have similar issues to those that they face in going through a surface slick. Dispersants can strip the natural oils from bird's feathers, putting them at risk

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[6] An updated bibliography list of research since the NRC 2005 report can be provided if requested. (Information was obtained from an ISI Web of Science search).

of hypothermia. Similar issues have been raised for marine mammals and fur properties (see REFS 10 and 12 for a full discussion of these issues).

Similarly, another main argument for using dispersants is that they enhance microbial degradation of the oil. Again 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 (see NRC 2005 for a full discussion on this in Chp's 4 and 5). 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)?

5. Specific issues regarding the Gulf Oil spill.

The unfortunate recent events in the Gulf have once again raised many of the issues regarding the effects of dispersants and dispersed oil. 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 (>250,000 gallons). Furthermore, this is a continued spill, in toxicology the concentration of and the duration of exposure to a toxicant determines its effect. Additionally, dispersants are usually only applied to surface slicks. In this case dispersants are being applied at the seafloor at the site of the oil leak. 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? The agencies and oil spill responders at the site will be running models predicting the oil plumes concentration and trajectory. As part of the SMART protocol[7] measurements of oil concentrations will be taken at depths in the Ocean around the spill site. This will providing real-time data that can ground truth the models to more accurately assess where and at what concentration of oil the plume is at. Only in knowing the size of this plume in all 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. 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 will 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. 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

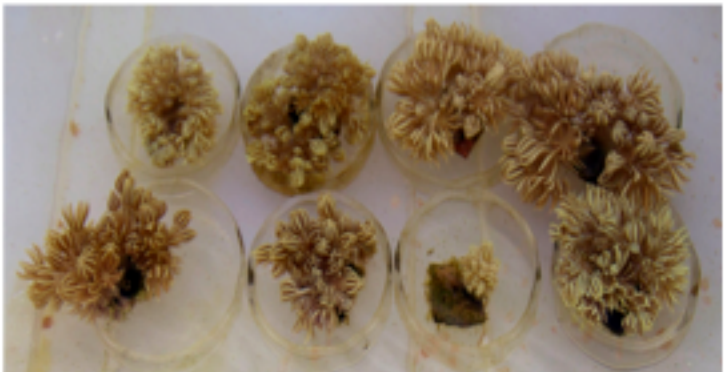
Chairman Oberstar and members of the committee I would like to thank you again for allowing me to testify today regarding the effects of oil spill dispersants. We face huge challenges to protect our coastal and oceanic ecosystems. As in the case of oil spills this sometimes involves making difficult trade-off decisions on what ecosystem to protect at the

[7] Used for analyzing the effectiveness of the dispersant application and it's environmental impacts.

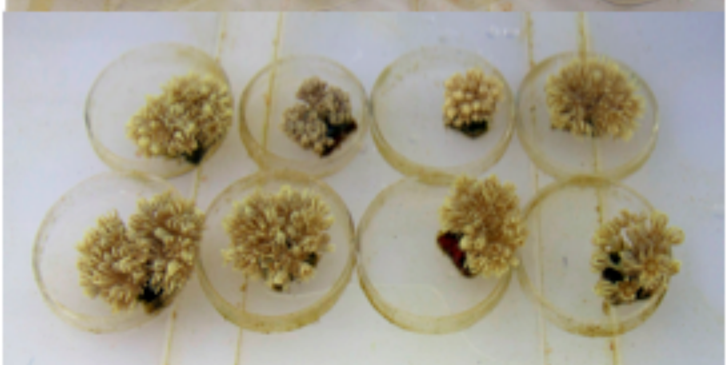
expense of another. However, pollution cannot simply be treated as 'out of sight out of mind' or that 'the solution to pollution is dilution'. These assumptions need careful analyses that depend upon sound scientific data. The proprietary components in dispersants should be made available to researchers. 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.

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.

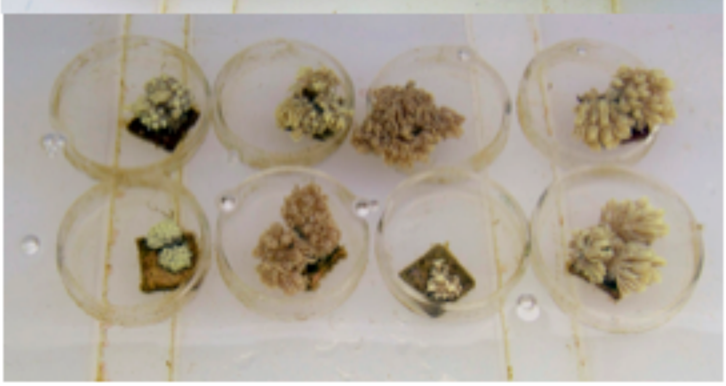
Exhibit 1: Photo depicting corals held in clean seawater 32 days after an exposure to Corexit 9500 and dispersed oil (using Corexit 9500 and weathered Arabian light crude oil). Significant reductions in growth were observed compared with controls.



CONTROL SOFT CORALS



SOFT CORALS EXPOSED TO COREXIT 9500 (20ppm, 8 hours).



SOFT CORALS EXPOSED TO DISPERSED OIL (using 20ppm Corexit (1:25 ratio dispersant:oil) and 0.5g l^{-1} weathered Arabian light crude oil with 8 hour exposure).

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