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Testimony Before The:
Senate Committee on Environment and Public Works
Economic and Environmental Impacts of the Recent Oil Spill in the Gulf of Mexico
Room 410 Dirksen Senate Office Building

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Good Morning, Chairman Boxer, Ranking Member Inhofe, and Members of the Committee. My name is Eric May, and I am a research scientist and lecturer at the University of Maryland Eastern Shore. Though I am part of the NOAA Living Marine Resources Cooperative Science Center and the University of Maryland Eastern Shore, I am speaking today for myself and not as an official representative of either those bodies.

Oil spills and releases represent one of the most serious and potentially devastating forces on marine ecosystems worldwide. Due to technological constraints, offshore oil wells often are placed where, should a leak occur, the likelihood of the oil reaching shorelines is high as we are seeing with the Gulf of Mexico spill. Of all marine ecosystems, near shore and land/water interfaces are some of the most complex, biologically active and fragile systems known. The degree to which these systems are impacted will depend on when the event occurs (spring, summer, fall, winter), amount of oil released, and weather conditions. My areas of expertise are in fish pathology, comparative pathology, and toxicology; and have experience with ecology, marine science and fishery management. For this document I will focus on the effects of oil on marine organisms and on potential broad ecosystem level effects. At this point it is important to mention that the nature, type and extent of damage will be directly related to the level of exposure to oil from a leak which is a function of rate and duration of discharge along with prevailing weather patterns at the time the event is occurring. It is a complicated and frustrating task to predict what the outcome may be.

Effects on Marine Organisms

The potential effect on marine organisms can be broken down as to nature of injury; and the life style of the organism (plant or animal). Injury in this case will either be physical or toxic. Physical injury will be the coating of respiratory membranes with oil, coating of hair and feathers, and coating of sediment

surfaces. Toxic injury is usually classed as acute (rapid onset and death), sub-acute (onset with delayed death) or chronic (delayed onset and delayed death or functional impairment). Toxic injury varies between the complexity of the organism i.e. jellyfish as opposed to red drum, and between related species where the sensitivity of one species may be greater than another, for example, a brown bullhead catfish as opposed to anchovy with anchovy the more sensitive species.

It is important to realize that, in the case of the Gulf of Mexico oil spill as with other similar leaks and oil spills from tankers, while the distribution of the oil is concentrated in the beginning, wind and wave action disperses the oil unevenly. Thus in a short period of time the concentrations of oil in the water becomes non-uniform with areas of concentrated oil and other areas of dispersed oil. This also holds true for the vertical concentrations of oil in the water column i.e. distribution from the surface to the bottom of the water body.

Physical Injury – The most visible group of species to be affected will be marine mammals, birds and turtles. For mammals, birds and turtles damage to the lungs due to aspiration of oils resulting in pulmonary emphysema and break down of interstitial tissue is rapid leading to death (acute) or to secondary bacterial infections and then death (sub-acute). If the individuals affected survive, chronic effects would include loss of lung function which will reduce their chances of survival. For marine mammals and birds, another effect will be the loss of oils that maintain feather and hair integrity resulting in the inability to fly for birds, and loss of insulation for birds and mammals leading to hypothermia and death, especially under cold ambient conditions. Fish too will experience physical injury with oils directly affecting the gill membranes reducing or eliminating the ability to get oxygen and remove carbon dioxide. In general the occurrence of physical injury is the first set of responses to oil spills and the most obvious with dead birds, mammals, turtles and fish seen floating on the surface or beached along the shore lines.

Toxic Injury – Toxic injury as opposed to physical injury is much less visible and more insidious in the long run. Crude oil is a mixture of thousands of different organic compounds that include alkanes, cycloalkanes and aromatics. Within these groups a myriad of specific chemical species exist, each with differing mode of action (how it works) and degree of toxicity (how much exposure is required to cause damage and/or death). The constituents of the crude oil mixture can also be broken down as to number of carbons or molecular weight which affects their physical properties in water. Classes of compounds such as volatile organic compounds (VOC), light fractions, and heavy fractions, which are based on their molecular weight or number of carbons, behave differently and will have differing effects on biological systems. To summarize the state of knowledge regarding the toxic impacts of crude oil on ecosystems, species, and life stages of individual species would be impossible during this briefing, with over 2000 articles in scientific journals since 1995, most written specific to particular species and to a specific set of constituents found in crude oil. However, and as my comments on toxic injury will follow, there are some clear and accurate generalizations that can be made which are directly applicable to the Gulf of Mexico oil spill.

Acute Effects – In the areas close to the source of the spill or leak there will be acute effects which usually lead to death quickly. For many of the microscopic free-floating animals (zooplankton) and plants (phytoplankton) there will be significant impacts as many of the compounds found in crude will affect the membranes of the animals resulting in rupture or breaching. While some phytoplankton species are resistant, these are usually confined to those with shells or resistant outer covering. For fish larvae in the area, there will be gill and skin damage; the gills will rupture and the skin which has yet to become impermeable will be degraded. As the heavier oil constituents settle to the bottom organisms living on or in the sediment (benthics) will suffer similar fates for the same reason. Juvenile, sub-adult and adult fish swimming through the area of the spill will have significant damage to gills and also rapidly die. One visible effect of oil contamination will be the appearance of dead fish on the surface of the water. As noted above with regard to physical effects; mammals, birds and reptiles will have significant damage to respiratory membranes due to the toxicity of many of the compounds that are aspirated or brought into the lungs.

Sub-acute Effects with Secondary Responses – As you move away from the epicenter of the oil discharge (source) to areas where the concentration of the oil is diminished, sub-acute responses are seen with damage to lung, esophageal, gastric and intestinal tissues. In birds, mammals and turtles esophageal, gastric and intestinal damage is usually in form of ulcers which lead to secondary bacterial infections and death. Lung tissues will exhibit emphysema and necrosis with secondary bacterial infections. In fish, debilitation of gill membranes will lead to rapid thickening of the membrane (proliferative change) which impedes oxygen movement across the membrane. Necrosis of gill, gastric and intestinal membranes will also occur with secondary bacterial infections leading to death. The external surfaces of most organisms save for plants will exhibit ulcers or erosions with similar consequences. The same sub-acute effects will be seen in most organisms exposed to the oil at concentrations where immediate death does not occur.

Chronic Effects – Unlike acute and sub-acute effects, chronic effects can manifest in weeks, months or in some cases years. Such chronic effects can be seen in brain, liver, kidney, muscle, skin, and spleen. The nature and degree to which these effects manifest will be a function of the concentration of contaminants in the water and how long the individual is exposed to the contaminants. Recorded effects include tumor formation and cancers, loss of immune response which leads to secondary infection by viruses, bacteria and protozoa, liver dysfunction, kidney failure, brain damage leading to aberrant behavioral responses. A rough picture of metabolic and physiologic processes that can occur in the animal (organismal level) due to contamination with oil is presented in figure 1. Since there are a myriad of

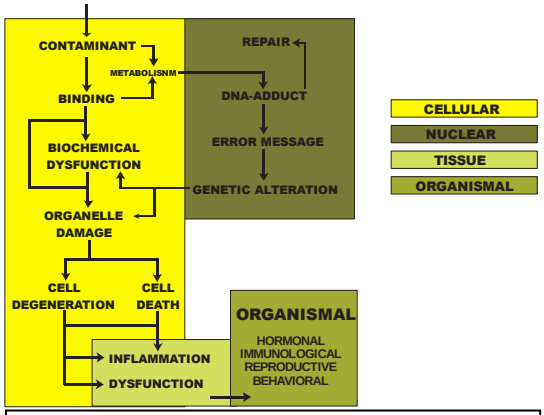


Figure 1 – Physiological process that result from the entry of a contaminant into an animal with subsequent changes that lead to deleterious responses in the organism affected.

compounds present in crude oil it is not possible to discuss all of these processes and possible outcomes as many are specific to compound and species. Responses such as cancers can take as long as 20 years to manifest in long-lived species. Chronic effects eventually will lead to the death of the individual affected, however the usual consequences for fish is that they will be eaten by a predator.

Species Sensitivity – Not all species will be affected in the same way or to the same degree. There are highly resistant species which are not affected unless concentrations are high, and highly sensitive species which are affected at exceedingly low concentrations of a contaminant. It is impossible to tell which of the many species will be affected by the spill and to what degree. It is known that oligochaetes (sediment dwelling segmented worms) are much more sensitive than some polychaetes which also are sediment dwelling. As such it can be expected that there will be loss of some species and retention of others. All of which will depend on the concentration of the oil.

Life Stage Sensitivity – As with variation in species responses, life stages too vary in susceptibility to the adverse effects of contaminants. As a rule, eggs tend to be impervious to organic compounds, however, in recent studies it has been shown that eggs of flounder exposed to contaminated sediments and water exhibit deformities, increased mortality, and reduced developmental rates. Larvae are highly susceptible to many contaminants and can be expected to suffer high mortality rates at lower concentrations than adults. In general, smaller fish are more susceptible than larger fish; however some minnows are very resistant to contaminants.

Effects on Ecosystems

Predicting the outcome following an oil leak or spill at an ecosystem level will be difficult. Depending on location, ecosystems vary from simple to complex. Land and water interfaces are some of the most complex ecosystems in the world. As above there are generalities that can be made.

Factors Influencing Susceptibility to Oil Spills – Our experiences with the Amoco Cadiz off the coast of Brittany, Exxon Valdez in Prince William Sound, Prestige off the coast of Portugal and Spain all have provided much information. The potential effects on ecosystems can be broken down as to where (open sea, near shore), type of ecosystem affected (marine, estuarine, freshwater), time of year (spring, summer, fall, winter), and latitude (northern/southern, to equatorial) an oil leak or spill occurs.

The Role of Ecosystem Complexity and Biological Activity – Ecosystems are often more complex in nearshore systems than offshore or open sea systems. Complexities of estuarine systems tend to be greater than open water marine. Colder regions such as the Arctic and Antarctic tend to have simpler systems than temperate regions (North America for example). Areas where nutrients are raised from the sea floor to the continental shelf have greater complexities than where such upwellings are absent. In general the simpler the ecosystem the more susceptible it is to catastrophic events. Seasonal fluctuations in species diversity occurs and it has been shown, for example, that in the coastal lagoons off Maryland and Virginia species, diversity is highest in the spring and early fall, probably a function of temperature. Another consideration that in some sense supersedes the above considerations is that in

early spring the biological activity dramatically increases largely due to migration and spawning activities for many marine and estuarine species of fish and for plants, emergence of shoots. It is at this time many ecosystems are at their highest vulnerability to catastrophic events. For the Gulf of Mexico oil spill it is occurring in early to middle spring where biological activity in the gulf coast zones can be expected to be very high.

Ecosystem Responses to Oil Spills – Many researchers have shown that in the years following an oil spill the diversity of bottom dwelling organisms is reduced and in some cases does not return to the previous level of diversity. The same has been shown for sediment dwelling organisms and fish that are resident to estuarine zones. In general, it can be assumed that there will be loss of diversity and a reduction in the productivity of ecosystems severely affected by oil spills and leaks. This loss of diversity can affect food supplies at all trophic (feeding) levels of the ecosystem, and thus reduce the stability of the entire system. The loss of phytoplankton which in estuarine systems are the food source of the system at the beginning and loss of zooplankton on which many species depend will result in a significant change in the character of the ecosystem.

Of particular concern is the occurrence of the Gulf Oil Spill during one of the most biologically active periods of the year. In spring most offshore species of fish have spawned or are spawning. At this time floating eggs and larvae are in the water, and particularly larvae, most susceptible to contaminants. This loss of larvae, fish and crustacean will result in lower juvenile recruitments and affect the diversity for many years to come. Many perennial dormant plants are emerging. Seeds from the previous year are germinating and shoots are emerging. Submerged aquatic vegetation is now growing and young plants developing. While most plants appear to be somewhat resistant to contaminants, early life stages are not.

Impact on the Fisheries

If we accept the concept that there will be loss of larvae and other early life stages of many of the marine organisms in the area affected then it is not a stretch to realize that important commercial and recreational fisheries will be affected to some degree. Presently commercial and recreational fishing is already impacted with loss of days fishing for commercial and likely loss of recreational fishing which will impact ancillary businesses that depend on it. Fish, shellfish and crustaceans in the gulf that have accumulated sufficient oil will be unpalatable to the human taste and cannot be sold. In the long run the impact can only be estimated. With all of the above being said, the worst case scenario is that there will be a major loss of early life stages (eggs, larvae, juveniles) which will result in a poor year class for each of the commercial and recreational species. In the case of the Gulf of Mexico oil spill a wide variety of species would be affected ranging from blue crabs whose zoea larvae are highly sensitive to contaminants from spills to reef fish whose eggs and larvae are at risk. The shrimp industry is already impacted and at a time when some shrimp species are at harvest size and others are beginning reproduction there is no question that this fishery is in danger. Oyster reproduction is in progress and the spat is at high risk to being killed from the heavier oil off shore and any of the oil moving into the shallow waters. The diversity of fish species is significant and would be greatly impacted. The impacts

will be protracted over a few too many years with few young being recruited into the adult catchable population. Thus, long after the spill, there would be much fewer catchable fish affecting harvests for the commercial fisheries and success rates for recreational anglers. The social and economic impacts would be significant since many of the coastal communities depend on the commercial and recreational fishing industry for income.

Human Health Concerns

The risk to seafood consumers of the gulf region is unknown. Many of the chemicals that make up crude oil following a spill or leak will appear in the aquatic food web. Through the processes of biotransformation, bioconcentration, and biomagnifications, chemicals move through the food web and appear in fish, and shellfish (bivalves and crustaceans) of importance as food for humans. Biotransformation is the process by which a chemical is metabolized from one form to another, which in some cases results in a product that is more toxic or carcinogenic than the original product. Bioconcentration and biomagnifications, while different mechanistically result in increased concentrations of contaminants appearing in certain species, usually species that serve as food for fish and humans. One example is the polynuclear aromatic hydrocarbons or PAHs. These have been shown to move through the food chain and appear frequently in fish and shellfish. It has been suggested that 75% of all PAHs in the environment come from oil spills and leaks. While PAHs do appear in food consumed by humans, no clear relation to the incidence of cancers among exposed individuals has been demonstrated. However given the thousands of different chemical constituents of oil, there must always be a concern for human health beyond direct exposure.

Chemical Dispersants

Chemical dispersants have been used in many of the more recent oil spills and is being proposed for the Gulf of Mexico oil spill. Their use is controversial particularly in areas of low salinity (dissolved salts). Numerous studies suggest that the effect of dispersants is to increase the rate at which the oil is biodegraded and removed from the system. A variety of dispersants have been used, organic and inorganic. The action of the dispersant is to form small oil droplets that are surrounded by the dispersant molecules. These oil droplets would then dissipate, drop to the ocean floor and be degraded. There is no real consensus in the scientific literature as to positive or negative ecological effects as a result of applying dispersants. In some cases benthic organisms were shown to have been lost in areas where dispersants were applied as opposed to areas where the oil was left untouched or skimmed. Studies on phytoplankton and zooplankton communities in areas where dispersants were applied demonstrated no effect with diversity and abundance when compared to unaffected populations where no oil spill occurred. I believe that there remains sufficient controversy over dispersant use that further research into their use is warranted, however they so far remain as one of the few tools available to mitigate oil spills.

Closing Remarks

What I have stated in the above testimony is essentially the biological basis for the expected responses to the Gulf of Mexico oil spill. The degree to which these responses will manifest will depend on how much oil is released, and prevailing weather patterns which will dictate where the oil will go; but harmful outcomes will manifest and are already manifesting along the Gulf coast. While much research has been done, it provides only minimal clues as to what the final outcome will be. Honorable senators, you are witnessing the perfect ecological storm; a spill near ecologically sensitive areas, weather patterns driving oil into those areas, and at a time when those areas are most biologically active.

That damage has been done already is not in question, it has. The question is how much. Loss of mammals, birds and larger fish along with their forage base (plankton, smaller fish, etc.) will destabilize the ecological balance upon which the Gulf of Mexico systems depend. The damage to key commercially important species such as blue crabs, shrimp, drum and others could be immense. Beyond the direct economic threat the commercial fishing industry, the protracted damage will extend to the stability of the communities which depend on the income from the industry. The recreational fisheries will be similarly affected along with a myriad of businesses that depend on the recreational anglers for their economic future.

As a consequence of the Gulf of Mexico oil spill, the “what ifs” are staggering. What if a similar spill occurs off the mouth of the Chesapeake Bay, and equally sensitive ecosystem as the Gulf of Mexico? What if a similar species occurs of New Jersey or Delaware where highly sensitive systems of coastal lagoons exist? As we promote oil exploration, and we will, let us also consider the ecological risks associated with such activities and how we can be ready for them.

Respectfully yours,



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