EXPERT REPORT OF DR. DAMIAN SHEA

Rebuttal Report to the Expert Reports of:
Stanley D. Rice and Donald F. Boesch

In re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico
MDL 2179
U.S. District Court for the Eastern District of Louisiana

September 12, 2014

CONFIDENTIAL PURSUANT TO PTO 13

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Damian Shea Date

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I. INTRODUCTION

I have reviewed the reports of Drs. Stanley Rice and Donald Boesch as they relate to toxicity and fate and transport issues. While both Drs. Rice and Boesch acknowledge the enormous quantities of environmental data available, neither Dr. Rice nor Dr. Boesch utilized these data to develop their opinions of the harm, or lack of harm, from the *Deepwater Horizon* oil spill. Instead Drs. Rice and Boesch hypothesize about "potential for toxicity damage" and "actual and potential harm," extrapolating from other oil spills, theoretical mechanisms described in journal articles, popular press reports, and inappropriate laboratory experiments. Largely ignoring the actual chemistry data collected in the field, Drs. Rice and Boesch then speculate about what *might* have happened or what *could potentially* happen in the future.

For the reasons stated in my initial report and set forth below, it is my opinion to a reasonable degree of scientific certainty that there was no actual or potential harmful exposure to oil, oil-related compounds or dispersants in the vast majority of the areas investigated. The few offshore areas where there was the potential for harmful exposure were limited in space and time, mostly in the areas close to the wellhead during the summer of 2010. As explained in my opening report, my findings of potential harm (as limited as they were) are highly conservative (*i.e.*, they overstate potential harm) since the findings are based upon very protective assumptions.

The United States experts rely upon flawed and unproven toxicity methodologies including studies that only expose organisms to oil after mixing the oil with water at extremely high speeds in a commercial food blender. The ocean, however, is not a blender and the high speed blender method is not used or accepted by the U.S. Environmental Protection Agency (EPA), the United States' primary environmental agency responsible for enforcing the nation's environmental laws. But perhaps most importantly: even if the laboratory toxicity methods relied upon by Drs. Rice and Boesch were correct (which they are not as explained below), the occurrence of potential sublethal effects to individual organisms is still very low, limited in space and time to between 1% and 3.5% of the nearly 18,000 water samples collected during the *Deepwater Horizon* environmental investigation.

Finally, I will also address several issues raised by Drs. Rice and Boesch related to surface oil, dispersants, and the deep sea transport and weathering of oil and oil-related compounds.

II. THE UNITED STATES' ENVIRONMENTAL EXPERTS RELY UPON FLAWED TOXICITY METHODS TO SPECULATE ABOUT POTENTIAL HARM

A. Dr. Rice's "New Paradigm" of Oil Toxicity is Not New and is Not Correct

1. Dr. Rice bases much of his understanding of the effects of the *Deepwater Horizon* incident on a "change in the oil response and assessment paradigm" that he claims

emerged in the aftermath of the *Exxon Valdez* oil spill.[1] Indeed, in the late 1990s and early 2000s, Dr. Rice did publish a series of papers related to his work on the *Exxon Valdez* oil spill that describe a "changing paradigm" of oil toxicity and that claim there is a new "emerging appreciation" for oil toxicity.[2,3,4] What Dr. Rice fails to mention in his Report is that these prior publications have been heavily criticized by others in peer-reviewed scientific literature, showing that his "new understanding" is really a "misunderstanding."[5,6]

2. Several principles associated with Dr. Rice's "new paradigm" are misleading or incorrect:

    a. First, Dr. Rice incorrectly assumes that the aquatic toxicity of polycyclic aromatic hydrocarbons (PAHs) that have 3, 4, or 5 aromatic rings are all the same. It is a very well established fact that different PAHs have different toxicities, a fact known to science since at least 1954.[7] However, the studies that form the basis for Dr. Rice's "new paradigm" did not include an analysis of the individual toxicities of the specific PAHs present, as is prescribed by EPA.[8] Similarly, the more recent studies Dr. Rice relies upon in assessing toxic impacts from this

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[1] Expert Report of Dr. Stanley Rice at 15.

[2] Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., and Irons, D.B. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 302(5653):2082-2086.

[3] Carls, M.G., Rice, S.D., and Hose, J.E. 1999. Sensitivity of fish embryos to weathered crude oil. Part I. Low-level exposure during incubation causes malformations, genetic damage, and mortality in larval Pacific herring (*Clupea pallasi*). Environ. Toxicol. Chem. 18:481–493, http://dx.doi.org/10.1002/etc.5620180317.

[4] Heintz, R.A., Short, J.W., and Rice, S.D. 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. Environ. Toxico.l Chem. 18:494–503.

[5] *See, e.g.*, DiToro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36 (The incorrect conclusion offered by the authors [in the 1999 Carls, Rice and Hose study]—that weathering increases toxicity—was caused by the incorrect use of total PAH EC50s to judge toxicity.").

[6] *See, e.g.*, Neff, J.M., Page, D.S., Landrum, P.F., and Chapman, P.M. 2013. The importance of both potency and mechanism in dose–response analysis: An example from exposure of Pacific herring (*Clupea pallasi*) embryos to low concentrations of weathered crude oil. Mar. Pollution Bulletin 67:7-15 (criticizing the 1999 Carls, Rice and Hose study and noting that the 1999 Heintz, Short and Rice study was "similar.").

[7] Van Overbeek, J. and Blondeau, R. 1954. Mode of Action of Phytotoxic Oils. Weeds. 3:55-65.

[8] Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., and Irons, D.B. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 302(5653):2082-2086.

incident[9,10] also did not include this important analysis. In contrast, my initial Report relied on the very well developed (over decades) individual PAH toxicity database that scientists from the EPA, the U.S. Geological Survey (USGS), and the National Oceanic and Atmospheric Association (NOAA) have used in their previous assessments of the *Deepwater Horizon* oil spill.[11,12,13]

b. Second, Dr. Rice incorrectly claims that weathered oil is more toxic than fresh oil. As pointed out by Dr. Di Toro and others, "[t]he idea that weathering [of oil] increases toxicity is based on the erroneous use of the total petroleum hydrocarbons or the total polycyclic aromatic hydrocarbons (PAHs) concentration as if either were a single chemical that can be used to gauge the toxicity of a mixture, regardless of its makeup."[14]

c. Third, Dr. Rice implies that the *Exxon Valdez* oil spill resulted in a "delayed impact to and recovery of the Prince William Sound population of herring."[15] Scientists associated with Dr. Rice's work on the *Exxon Valdez* oil spill had published work suggesting that oil-related effects had contributed to this herring population crash, however, in 2007, Rice, along with one of these scientists admitted that, in fact, "[n]o plausible oil-related mechanisms have been developed

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[9] Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A., and Scholz, N.L. 2014. *Deepwater Horizon* crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15):E1510-E1518, doi: 10.1073/pnas.1320950111.

[10] Mager, E.M., Esbaugh, A.J., Stieglitz, J.D., Hoenig, R., Bodinier, C., Incardona, J.P., Scholz, N.L., Benetti, D.D., and Grosell, M. 2014. Acute Embryonic or Juvenile Exposure to *Deepwater Horizon* Crude Oil Impairs the Swimming Performance of Mahi-Mahi (*Coryphaena hippurus*). Environ. Sci. & Tech. 48(12):7053-7061.

[11] U.S. EPA, EPA Response to BP Spill in the Gulf of Mexico, Water Quality Benchmarks for Aquatic Life, What are benchmarks? *Available at* http://www.epa.gov/bpspill/water-benchmarks.html#gen2.

[12] Nowell, L.H., Ludtke, A.S., Mueller, D.K., and Scott, J.C. 2011. Organic Contaminants, Trace and Major Elements, and Nutrients in Water and Sediment Sampled in Response to the Deepwater Horizon Oil Spill. In: U.S. Geological Survey (Ed.), U.S. Department of the Interior, Reston, Virginia, Open-File Report 2011-1271 at 128.

[13] Bejarano, A.C., Levine, E., and Mearns, A.J. 2013. Effectiveness and potential ecological effects of offshore surface dispersant use during the Deepwater Horizon oil spill: a retrospective analysis of monitoring data. Environ. Monit. Assess. 185(12):10281–10295.

[14] DiToro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36.

[15] Expert Report of Dr. Stanley Rice at 17.

to explain a delayed response [in pacific herring impacts,]" and "[t]he resulting lack of recovery is more than likely the contribution of several factors."[16]

d. Fourth, Dr. Rice claims that the fact that toxicity can take place at lower concentrations of PAHs is a "new emerging appreciation" of PAH toxicity. Dr. Boesch reiterates this claim.[17] However, evidence for potential chronic toxicity from lower concentrations of PAH and for higher sensitivity of fish embryos and larvae date back to at least the late 1970s,[18] and, most importantly, chronic toxicities at lower concentrations *are already incorporated* into the EPA Final Chronic Values used for the EPA Toxic Unit Benchmark method relied upon in my initial Report.[19] Again quoting from Di Toro and others,[20] "[i]t is incorrect, however, to assume [as Dr. Rice does] that 1 μg/L of total PAHs would be chronically toxic; it depends entirely on the composition of the PAHs making up the mixture. Therefore, total hydrocarbon or total PAH concentration should not be used to quantify the toxicity of a mixture of PAHs. Rather, TUs [Toxic Units] should be used to normalize the different aqueous toxicity from the different PAHs present in mixtures." It is this Toxic Unit method that EPA uses and that I used in my original report. Dr. Rice and most of the toxicity studies he cites ignore this very basic premise of toxicology.[21]

3. Dr. Rice's near exclusive reliance on a subset of peer-reviewed literature is inappropriate for another reason. As acknowledged by Dr. Boesch, the peer review process often is not able or designed to verify results and conclusions given the incompleteness of the available information. Erroneous or incomplete scientific papers (even those that have been peer reviewed) can remain uncorrected for a very long time. Dr. Rice's co-authored papers which purport to identify a "new paradigm" are an example of this: the errors in

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[16] Rice, S.D., Carls, M.G. NOAA. 2007. *Exxon Valdez* Oil Spill Restoration Project Final Report. Prince William Sound Herring: An Updated Synthesis of Population Declines and Lack of Recovery.

[17] Expert Report of Dr. Donald F. Boesch at 8-9.

[18] Neff, J.M. 1979. Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. Applied Science Publishers, London. ISBN-10: 0853348324, 262 pp.

[19] DiToro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36.

[20] *Id.*

[21] What Dr. Rice is doing is equivalent to the early toxicity studies on oil from the 1960s and early 1970s where total oil and total PAHs are used rather than using the actual individual PAH chemicals as is now done by EPA and as I did in my initial report. DiToro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36.

those papers were not fully known until 2007,[22] 2011,[23,24] 2012,[25] and 2013.[26] Thus, it is inappropriate for decision-making to rely too heavily on recent scientific research papers before this process allows independent verification. This is especially true where the results and methods in question are novel or otherwise conflicting with a larger and stronger body of evidence, as discussed below.

B. Drs. Rice and Boesch Largely Ignore Massive Amounts of High Quality Environmental Data Collected in the Gulf

Both Dr. Rice and Dr. Boesch almost completely avoid use of the extensive, high-quality data related to oil exposure and toxicity in the Gulf of Mexico during and after the *Deepwater Horizon* incident.

1. Dr. Rice states "[f]urther, I have also examined data provided to and by BP [...] however, I do not rely heavily on these materials because they are overwhelmingly large, have not been analyzed and summarized into a format and volume conducive for review, and are part of ongoing NRDA, so drawing final conclusions about the data at this point would be premature."[27] In fact, the environmental data are quite conducive to scientific review; that is precisely what I have done in my initial report. Furthermore, the United States has had access to most of the data for years and has had access to the data compilations on Gulfsciencedata.bp.com since November 2013.[28]

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[22] Di Toro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36.

[23] Landrum, P.F., Chapman, P.M., Neff, J., Page, D.S. 2011. Evaluating the Aquatic Toxicity of Complex Organic Chemical Mixtures: Lessons Learned from Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Case Studies, Integr Environ Assess Manag 8:217-230.

[24] Page, D.S., Neff, J.M., Landrum, P.F., Chapman, P.M. 2011. Letters to the Editor. Sensitivity of Pink Salmon *(Oncorhynchus Gorbuscha)* Embryos to Weathered Crude Oil. Eviron. Toxicol. Chem. 31:3:469-476.

[25] Page, D.S., Chapman, P.M., Landrum, P.F., Neff, J., Elston, R. 2012. A perspective on the toxicity of low concentrations of petroleum-derived polycyclic aromatic hydrocarbons to early life stages of herring and salmon. Human Ecol. Risk Assess. 18, 229–260.

[26] Neff, J.M., Page, D.S., Landrum, P.F., and Chapman, P.M. 2013. The importance of both potency and mechanism in dose–response analysis: An example from exposure of Pacific herring (*Clupea pallasi*) embryos to low concentrations of weathered crude oil. Mar. Pollution Bulletin 67:7-15.

[27] Expert Report of Dr. Stanley Rice at 5

[28] BP Press Release, *BP Makes Gulf of Mexico Environmental Data Publicly Available* (Nov. 18, 2013), *available at* http://www.bp.com/en/global/corporate/press/press-releases/bp-makes-gom-environmental-data-available.html. Data have been periodically updated since the initial release.

2. Dr. Rice states that his analysis assessed "whether the expectation of harm should be adjusted in light of the nature of the Deepwater spill," citing three factors: 1) the volume of oil spilled, 2) volume of dispersant used, and 3) oil at the water surface and in a submerged plume.[29] However, these three factors, by themselves or together, do not equate to harm. Toxicity depends on exposure to the oil, and more specifically which individual PAHs are present in that sample. Understanding this in the context of the *Deepwater Horizon* oil spill requires analysis of actual exposure and toxicity data. Dr. Rice is simply speculating based on the volume of oil spilled, volume of dispersant used, and the location of observation of oil, rather than analyzing the data that can answer his questions about the extent of harmful exposures.

3. Importantly, nothing in the United States' reports rebuts my conclusion regarding the high quality or quantity of the environmental data. As reported, I evaluated almost 18,000 water samples and over 8,000 sediment samples that were collected in federal and state waters. I also reviewed over 900 separate toxicity tests. The water and sediment samples and data relied upon in forming my opinions were collected under well-designed quality assurance plans, following strict chain-of-custody and other quality assurance/quality control procedures. These data, the majority of which were collected by the United States and validated by independent auditors, all meet minimum standards of traceability and quality assurance using appropriate methods set forth in EPA published guidelines.

4. In sum, the use and extrapolation of a few research papers, while ignoring the high-quality data collected from the Gulf of Mexico is a fundamental flaw in the analysis of both Dr. Rice and Dr. Boesch.

C. To the Extent that Dr. Rice Reviewed Data, He Did So in a Manner that is Inconsistent with Fundamental Principles of Toxicology

1. Dr. Rice states that "[m]ore than 300 of the 650 samples collected from the top 50 m in May contained measureable amounts of oil" and "[t]he PAH concentration was ≥ 0.5 ppb[30] in about half of the oiled water samples."[31] These statements regarding the sampling of the upper water column are flawed in several ways.

2. First, the metrics Dr. Rice uses to discuss the water samples are misleading:

[29] Expert Report of Dr. Stanley Rice at 4.

[30] A ppb is a part-per-billion, or one part PAH for every billion parts of water. This is equivalent to a microgram-per-liter or μg/L. One ppb is like a single hamburger in a chain of hamburgers that circles the earth at the equator, two and a half times.

[31] Expert Report of Dr. Stanley Rice at 21-22.

a. Dr. Rice discusses the number of samples that contained "measurable amounts of oil" and fails to acknowledge the fact that many of these samples likely had no toxic impact because the concentrations of oil were below toxic levels. The mere presence of oil in the water ***does not*** equate to impacts or harm. Toxic impacts are a function of the concentration of oil-related chemicals in the water, the space over which these concentrations exist, and the amount of time a given organism is exposed to these concentrations within this space. These are fundamental principles of toxicology.

b. Basing the comparison on a concentration of 0.5 ppb of total PAHs is also misleading for several reasons. Because individual PAHs have different toxicities, total PAH concentration is not an appropriate metric to quantify the toxicity of a PAH mixture. Furthermore, a concentration of 0.5 ppb of any PAH, even those that are more toxic, is extremely low and there is little, if any, scientific evidence that this concentration would cause toxic impacts. In fact, even the publications relied upon by Dr. Rice demonstrate that concentrations below 1.2 μg/L (ppb) and more likely 7.5 μg/L (ppb) are safe for even the most sensitive species at its most sensitive life stage (see Table 1 below).

3. Second, several key pieces of information are missing from Dr. Rice's analysis, preventing anyone from replicating his results or evaluating the accuracy of his calculations. For example, his stated source of data is "NRDA publicly available data," however, he fails to specify, either in his report or in his consideration materials, exactly which NRDA publicly available data he relied upon. He also fails to provide definitions for several ambiguous concepts like "measurable amounts of oil" and "oiled water samples."

4. Finally, Dr. Rice's discussion of potential oil impacts in the deep water column suffers from many of the same flaws. He states that "[p]ublically available NRDA data indicate that the plume extended about 500 km in a NE – SW direction by September; PAH concentrations were ≥ 0.5 μg/L or greater in some samples over this distance."[32] However, in my initial report, I showed that the few water samples that exceeded EPA toxicity benchmarks were largely limited to an area much closer in distance to the wellhead and disappeared soon after the wellhead was capped.

[32] Expert Report of Dr. Stanley Rice at 28.

D. Dr. Rice and Dr. Boesch Rely upon Novel, Unreliable and Unrealistic Toxicity Testing Methods

Drs. Rice and Boesch rely upon unproven laboratory methodologies; these methods have not been accepted by the scientific community or by the EPA; however, even these flawed methods show limited environmental impact from the *Deepwater Horizon* oil spill.

1. To estimate the potential toxicity of PAHs in the water, Dr. Rice relies almost exclusively on data from two laboratory-based research papers published in the past few months by Incardona[33] and Mager.[34] The results of these studies are inappropriate to use for several reasons.

2. *The Blender Method* – A critical scientific flaw in the United States' reports is the reliance upon non-standard experimental laboratory methods that artificially increase toxicity and do not represent actual oil exposure in the Gulf of Mexico. The experimental method in question is called the High-Energy Water Accommodated Fraction (HEWAF) method of creating an oil emulsion through the use of a high-speed commercial food blender. Some of the limitations with the laboratory HEWAF method are discussed in my initial report and are summarized here.

    a. The standard, accepted method of testing the toxicity of oil in water is to mix oil and water in a glass container using well-documented mixing techniques. This method – called a Water-Accommodated Fraction (WAF) – has a long history and has been highly standardized over time. Furthermore, it is widely acknowledged that the WAF is designed to simulate the "worst case scenario" exposure to oil-related chemicals.[35,36] A standard, accepted version of the WAF is the Chemically Enhanced WAF (CEWAF) that tests a mixture of oil with dispersant, where the test is otherwise performed in much the same way as the WAF.

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[33] Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A., and Scholz, N.L. 2014. *Deepwater Horizon* crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15):E1510-E1518, doi: 10.1073/pnas.1320950111.

[34] Mager, E.M., Esbaugh, A.J., Stieglitz, J.D., Hoenig, R., Bodinier, C., Incardona, J.P., Scholz, N.L., Benetti, D.D., and Grosell, M. 2014. Acute Embryonic or Juvenile Exposure to *Deepwater Horizon* Crude Oil Impairs the Swimming Performance of Mahi-Mahi (*Coryphaena hippurus*). Environ. Sci. & Tech. 48(12):7053-7061.

[35] Expert Report of Dr. Damian Shea at Appendix G, p. 96-97.

[36] *See* SINTEF. 2010. Chemical and toxicological characterization of water accommodated fraction (WAF) of crude oils, ("the data generated gives a kind of "worst case scenario" conditions: The solutions used are assumed to be "saturated" and therefore represents a conservative estimate of concentrations foreseeable in the field."), *available at* http://www.sintef.no/upload/Materialer_kjemi/Marin%20milj%C3%B8teknologi/faktaark/WAF-web.pdf.

b. A HEWAF, on the other hand, is a non-standard variation on the WAF that uses a commercial blender to artificially create an oil and water emulsion at very high energies. *See* Figure 1 for a depiction of high energy mixing similar to the HEWAF blender method.

c. The HEWAF blender method is untested, has not been validated, and does not meet the EPA criteria of "comparability." In both the scientific and regulatory context, new methods must be proven "comparable" or otherwise "better" to be acceptable.[37,38,39] I can find no documentation that the HEWAF method has undergone this independent validation process.

d. In her deposition, Dr. Amy Merten (NOAA) acknowledged that HEWAFs would have more droplets of oil[40] and smaller droplets of oil[41] compared to a standard WAF. These changes in droplet number and size distributions lead to instability of the oil-in-water emulsion.[42,43] This instability in the emulsion, in turn, leads to an instability in the chemical (PAH) composition because the rate at which the PAHs move from an oil droplet to dissolve in water increases when the droplet size is smaller and there are more droplets. If both the size and number of droplets are changing, then the chemical (PAH) composition also is changing. Dr. Merten also acknowledges that the HEWAF would have a different chemical composition compared to a standard WAF.[44] This inherent instability and uncertainty calls into question any toxicity dose-response relationships derived from such a method. In contrast, WAFs and CEWAFs are standard methods with well-documented stability of oil droplet number and size, and also chemical (PAH) composition.

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[37] *See e.g.*, U.S. EPA. 1988. Availability, Adequacy, and Comparability of Testing Procedures for the Analysis of Pollutants Established Under Section 304(h) of the Federal Water Pollution Control Act; Report to Congress. EPA/600/9-87/030.

[38] U.S. EPA. 1991. Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests. EPA/600/4-90/031.

[39] Williams, L.R. 1985. Harmonization of Biological Testing Methodology: A Performance-Based Approach. In Aquatic Toxicology and Hazard Assessment: Eighth Symposium, ASTM STP891, Bahner, R.C. and Hansen, D.J., Eds. American Society for Testing and Materials, Philadelphia, pp. 288-301.

[40] Deposition of Dr. Amy Merten at 51.

[41] Deposition of Dr. Amy Merten at 54.

[42] Langevin, D., Poteau, S., Hénaut, I., Argillier, J.F. 2004. Crude Oil Emulsion Properties and their Application to Heavy Oil Transportation. Oil & Gas Science and Technology – Rev. IFP, 59(5):511-521.

[43] El-Sayed Abdel-Raouf, M. 2012. Factors Affecting the Stability of Crude Oil Emulsions. In: Crude Oil Emulsions- Composition Stability and Characterization. Prof. El-Sayed Abdul-Raouf, M. (Ed.), ISBN: 978-953-51-0220-5, InTech, *available at* http://www.intechopen.com/books/crude-oil-emulsions-compositionstability-and-characterization/factors-affecting-the-stability-of-crude-oil-emulsions.

[44] Deposition of Dr. Amy Merten at 51.

e. The HEWAF method creates an oil/water "milk shake" or artificial emulsion that is not applicable to actual conditions in the environment. The high-energy HEWAF conditions do not generally exist in the Gulf of Mexico; simply stated, the ocean is not a blender.[45] Even the United States' witness admitted that significant energy, breaking waves or greater, would be required before surface conditions would arguably be similar to a HEWAF.[46] In reality, even a major storm would not provide the same shear energy of a blender.

f. The HEWAF blender creates an oil micro-droplet environment that is unique to the "blender method." It is not known what effect this micro-droplet emulsion might have on the toxicity tests of the HEWAF.

g. The HEWAF blender increases concentrations of oil-related chemicals in the water. Figure 2 below, reproduced from the NOAA HEWAF protocol,[47] shows that the HEWAF has about 10 times more PAHs than the CEWAF under otherwise identical conditions. In other words, the HEWAF dramatically increases the concentration of PAHs in the water over a WAF or CEWAF.

h. The relative amounts of specific PAHs in these HEWAFs do not match most of the water samples collected in the Gulf of Mexico (see Figure 3). The data from Incardona even show substantial differences in the relative amounts of specific PAHs among his own experiments – chemical differences that can cause big differences in toxicity. Dr. Rice believes this does not matter because he uses total PAHs to quantify PAH toxicity (as do Incardona and Mager), but as discussed above, this is a scientifically incorrect belief and invalidates the use of this method.

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[45] High energy conditions did exist at the immediate point of release at the wellhead. However, Dr. Rice does not rely on these tests to assess impact exclusively within this very limited area around the wellhead – he implies that they can be extrapolated to understand toxicity throughout the water column.

[46] Deposition of Dr. Amy Merten at 71-72.

[47] Quality Assurance Project Plan: Deepwater Horizon Laboratory Toxicity Testing Version 4. Prepared for: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Prepared by: Stratus Consulting Inc., February 4, 2014. Protocols for Preparing Water Accommodated Fractions, Appendix A1.

Figure 1. *A sample of Southern Louisiana crude oil and water are depicted before and after undergoing mixing via a blender. This process is similar to the HEWAF method used in toxicity studies cited by Dr. Rice. The high energy blender makes a "milk shake" out of the oil and water and is not a realistic representation of the level of energy associated with wave action in the Gulf of Mexico.*

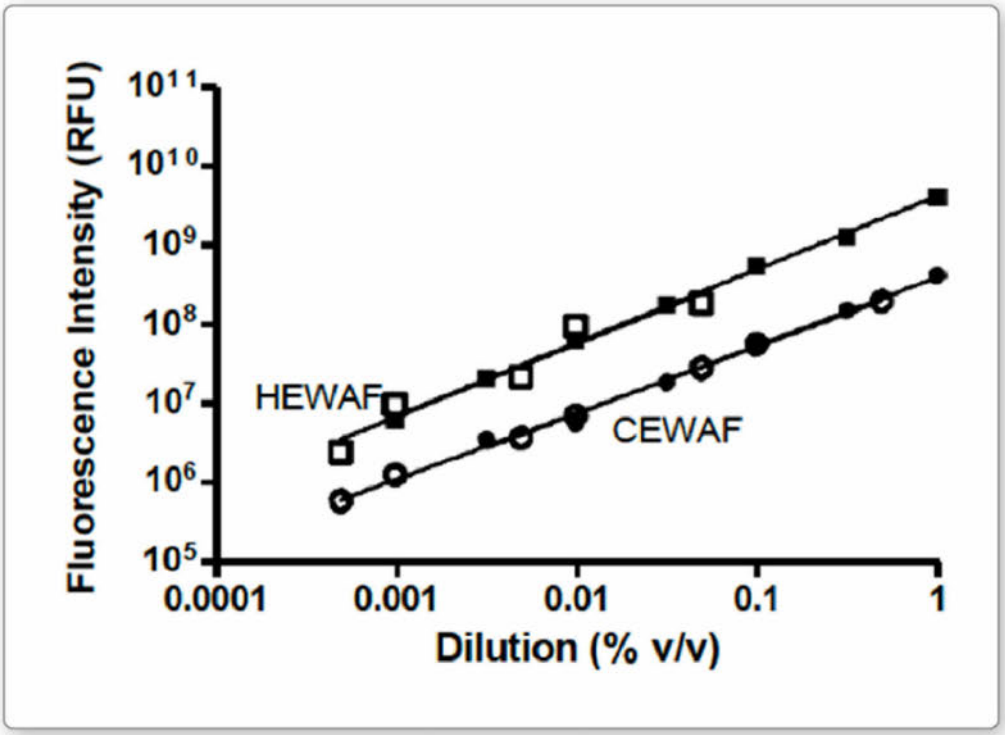

Figure 2.[48] *This chart shows the relationship between standard curves prepared from stock solutions of HEWAF and CEWAF of crude oil and dilution curves for toxicity test solutions prepared from the same stock solutions and sampled immediately after preparation. The chart shows that under otherwise identical conditions, the HEWAF method resulted in about 10 times more PAHs than did the CEWAF method.*

[48] Quality Assurance Project Plan: Deepwater Horizon Laboratory Toxicity Testing Version 4. Prepared for: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Prepared by: Stratus Consulting Inc., February 4, 2014. Protocols for Preparing Water Accommodated Fractions, Appendix A1.

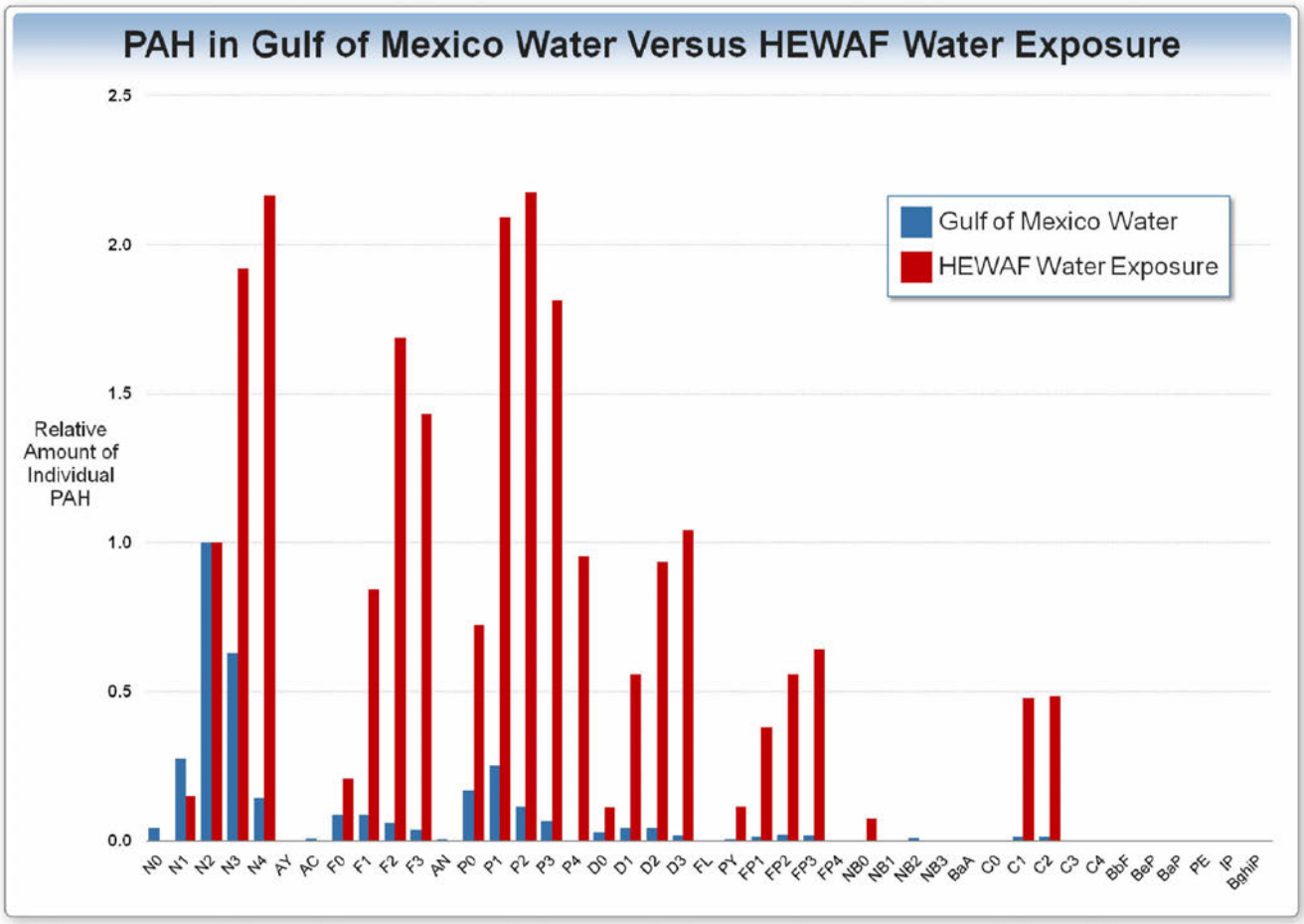

Figure 3. *Above is an example of a HEWAF PAH water exposure (red bars) reported by Incardona that did not match a common PAH pattern found in the Gulf of Mexico (blue bars). In general, the toxicity of the PAHs increase as you move from left to right in the graph. One can see that the Gulf of Mexico water sample is dominated by the less toxic PAH while the HEWAF sample is dominated by the more toxic PAH. The critical point here is that even if the* <u>*total*</u> *PAH in the two samples are similar, the amounts of specific PAH can be very different and this can dramatically affect the toxicity of the sample. The EPA Toxic Unit method that I used in my initial report accounts for these differences while the methods of Incardona and Mager that were relied upon by Dr. Rice ignore these important differences.*

3. *Other Problems* – In addition to the flawed blender or HEWAF method, there are several other problems with the studies relied upon by Dr. Rice and Dr. Boesch, including the following:

   a. First, the observation in embryos most sensitive to the oil exposure was edema (accumulation of fluid) and this is what Incardona and Dr. Rice focus on most in attempting to establish a "threshold." However, edema itself can be quickly reversible and is not harmful until it becomes large enough to impair heart function.[49] Incardona has even reported that heart function impairment is reversible when PAH exposure is removed.[50] Furthermore, Incardona reports only the "presence" or "absence" of edema. Thus "presence" could be a trivial level of edema that has no meaningful effect at all.

   b. Second, the observation by Mager (and relied upon by Dr. Rice) of a slower swimming speed of mahi-mahi fish exposed to oil did not include standard dose-response data, as required to quantify toxicity. Also, Mager himself admits that there was no associated reduced aerobic or metabolic function in the fish.[51]

   c. Third, Incardona and Mager use total PAH concentration to quantify the toxicity of a mixture of PAHs notwithstanding data from Incardona himself showing the individual toxicity differences of different PAHs.[52,53] There are overwhelming data demonstrating that individual PAHs have different toxicities.[54,55,56,57,58] In

[49] Butler JD, Parkerton TF, Letinski DJ, Bragin GE, Lampi MA, Cooper KR. 2013. A novel passive dosing system for determining the toxicity of phenanthrene to early life stages of zebrafish. Science of the Total Environment 463–464 (2013) 952–958.

[50] Incardona JP, Collier TK, Scholz NL. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicology and Applied Pharmacology 196 (2004) 191–205.

[51] Mager, E.M., Esbaugh, A.J., Stieglitz, J.D., Hoenig, R., Bodinier, C., Incardona, J.P., Scholz, N.L., Benetti, D.D., and Grosell, M. 2014. Acute Embryonic or Juvenile Exposure to *Deepwater Horizon* Crude Oil Impairs the Swimming Performance of Mahi-Mahi (*Coryphaena hippurus*). Environ. Sci. & Tech. 48(12):7053-7061.

[52] Incardona, J.P., Carls, M.G., Teraoka, H., Sloan, C.A., Collier, T.K., and Scholz, N.L. 2005. Aryl Hydrocarbon Receptor–Independent Toxicity of Weathered Crude Oil during Fish Development. Environ. Health Perspectives 113(12):1755-1762.

[53] Incardona, J.P., Collier, T.K., and Scholz, N.L. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicol. Appl. Pharmacol. 196:191–205.

[54] Billiard, S.M., Meyer, J.N., Wassenberg, D.M., Hodson, P.V., Di Giulio, and R.T. 2008. Nonadditive effects of PAHs on Early Vertebrate Development: Mechanisms and Implications for Risk Assessment. Toxicological Sciences 105(1):5–23.

order to address this issue, Incardona and Mager would need to conduct their experiments on individual PAHs, as done by EPA.

d. Fourth, the paper by Incardona uses a non-standard method for estimating toxicity threshold concentrations, the level above which harmful effects might be observed.[59] Incardona provides no evidence to support his approach.

e. Fifth, the studies of Incardona utilize organisms that are already highly stressed to the point that almost no lab in the world can keep them alive in captivity.[60] Thus it will be very difficult, if not impossible, to independently confirm these novel research results. The extreme physical contact sensitivity of these fish also calls into question how well any experiments (using these fish) in captivity would represent what happens in nature where the fish are not confined to small beakers.

4. *Limited Utility of Lab Tests* – it is important to keep in mind that laboratory toxicity experiments only test for the potential harm to exposed ***individual*** organisms and do not

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Footnote continued from previous page

[55] Di Toro, D.M., McGrath, J.A., and Hansen, D.J. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Environ. Toxicol. Chem. 19(8):1951–1970.

[56] Di Toro, D.M., McGrath, J.A. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. II. Mixtures and sediments. Environ. Toxicol. Chem. 19:1971–1982.

[57] U.S. EPA. 2003. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. EPA-600-R-02-013, available at http://www.epa.gov/nheerl/download_files/publications/PAHESB.pdf.

[58] Li, R., Zuo, Z., Chen, D., He, C., Chen, R., Chen, Y., and Wang, C. Inhibition by polycyclic aromatic hydrocarbons of ATPase activities in Sebastiscus marmoratus larvae: Relationship with the development of early life stages. Mar. Environ. Res. 71:86-90.

[59] Incardona states that the thresholds were "[b]ased on the intersection between the upper 95% confidence limit of controls and the 95% confidence band for individual concentration-response nonlinear regressions." Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A., and Scholz, N.L. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15):E1510-E1518 at E1513, doi: 10.1073/pnas.1320950111. This is not an accepted method of defining thresholds in toxicology.

[60] Dr. Boesch, at page 28, comments on this, stating, "[t]hese open ocean fish are very sensitive to physical contact, thus only a few broodstocks exist throughout the world to allow this experimentation." Incardona also states, "[m]oreover, land-based facilities capable of maintaining captive broodstocks of large pelagic predators are rare, making experiments challenging. For example, the capacity to spawn bluefin tunas in captivity in controlled land-based facilities has only been accomplished recently, at a single location." Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A., and Scholz, N.L. 2014. Deepwater Horizon crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15):E1510-E1518 at E1516, doi: 10.1073/pnas.1320950111.

necessarily indicate harm to a ***population*** in nature. Indeed, a recent paper published by researchers from various universities pointed out that while laboratory experiments may demonstrate the potential for injury to individual animals, field studies do not show any measurable injury to populations resulting from the Deepwater Horizon oil spill.[61] Specifically, these researchers stated that, "[f]our years after the spill, responses of estuarine fishes to oil pollution have been studied at organismal through population levels, and there is an emerging mismatch between consistent negative impacts detected among individual organisms and absence of measurable negative impacts among populations."[62]

5. *Limited Toxicity Regardless* – Finally, even if the studies relied upon by the United States were valid, the concentrations of PAHs that are purported to cause toxicity were rarely exceeded in the Gulf and would not change my previous opinion. Table 1 below shows the number and percent of water column samples that exceed the reported threshold values using the Incardona and Mager studies. Specifically, even if the United States' relied-upon toxicity methods were correct, the occurence of potential sublethal effects to individual organisms is still very limited in space and time, between 1% and 3.5% of the nearly 18,000 water samples collected during the environmental investigation.

	Incardona et al PNAS 2014				Mager ES&T 2014	
	Lowest Heart Rate IC50 Above 7.5 ug/L		Lowest Arrhythmia EC50 Above 2.9 ug/L		Swimming Performance Above 1.2 ug/L	
	All Samples	Top 200m	All Samples	Top 200m	All Samples	Top 200m
# of exceedances	183	88	377	213	628	389
% of samples	1.02%	0.91%	2.11%	2.21%	3.51%	4.04%

Table 1. *The number and percentage of samples exceeding reported toxicity endpoints in the recent papers cited by Dr. Rice. Note that the swimming performance data from Mager did not use a true toxicity experiment that could quantify a meaningful toxicity endpoint and the lowest Arrhythmia value from Incardona was based on a simple observation of "occurrence" (i.e., yes or no) and thus has no quantitative toxicological meaning. Data from the top 200 meters of the water are shown separately because it is where the embryo and larvae of many fish reside. Concentrations are TPAH based on 50 PAHs.*

[61] Fodrie, J.F., Able, K.W., Galvez, F., Heck, K.L., Jensen, O.P., Lopez-Duarte, P.C., Martin, C.W., Turner, R.E., Whitehead, A. 2014. Integrating Organismal and Population Responses of Estuarine Fishes in Macondo Spill Research. BioScience 64: 778-788. doi:10.1093/biosci/biu123.

[62] *Id.*

III. THE ENVIRONMENTAL IMPACT FROM SURFACE OIL WAS FAR LESS THAN THE UNITED STATES CLAIMS

Both Drs. Boesch and Rice rely on improper citations and unscientific findings to support their exaggerated statements regarding the extent of surface oiling.[63]

1. Dr. Boesch's report states that "Floating oil spread over the continental shelf from southeastern Louisiana to the western Florida panhandle [...] From the time of the Macondo well blowout through August 2010, 180,000 square kilometers (68,000 square miles) of sea surface had floating oil at one time or another, an area more than 50% greater than the land area of the state of Louisiana."[64] In support of this statement, Dr. Boesch cites a blog post at SkyTruth.org that purports to show the cumulative surface oiling footprint based on satellite imagery.[65]

2. The SkyTruth blog is not an appropriate, scientific source for determining the scope and extent of impacts associated with the spill. For example, the blog post does not provide sufficient information to determine what data were relied upon or how the estimate was calculated.

3. It appears that the SkyTruth estimate relies, at least in part, on satellite imagery data. There are significant limitations in the utility of satellite data for estimating surface oiling.[66]

    a. First, the maps (called composite anomaly maps) use aggregate satellite data from multiple satellites that imaged the Gulf of Mexico at different times. The

[63] In evaluating Dr. Rice's and Dr. Boesch's claims with regard to surface oiling, I considered all data available at the NOAA public website http://gomex.erma.noaa.gov/erma.html.

[64] Expert Report of Dr. Donald Boesch at

[65] Dr. Rice's report uses the same figure – 68,000 square miles of cumulative surface oiling – and cites an article available at the user-edited Encyclopedia of Earth website. *See* Expert Report of Dr. Stanley Rice at 20. This article cites the SkyTruth blog as its source for the 68,000 square miles figure. *See* Cleveland, C., "Deepwater Horizon Oil Spill," Encyclopedia of Earth (2010, updated 2013) *available at* http://www.eoearth.org/view/article/161185/. Therefore, both reports rely on the same ultimate source for this estimate.

[66] Because the SkyTruth blog does not discuss its data sources or its methodologies, it is impossible to raise specific critiques of that source's data and methodologies. For purposes of this section, I will discuss deficiencies in the NOAA National Environmental Satellite, Data and Information Service (NESDIS) satellite imagery data available on the ERMA website. NESDIS was "the primary source of all remote imagery during the spill." Deposition of Mark Miller at 119. The NESDIS composite anomaly maps are publicly available at ftp://satepsanone.nesdis.noaa.gov/OMS/disasters/DeepwaterHorizon/composites/2010/ and http://gomex.erma.noaa.gov/erma.html. Any analysis based on satellite images, whether the SkyTruth estimate or an estimate based on NESDIS data, would likely be equally susceptible to the limitations discussed in this section.

anomaly areas from each given day represents an estimate of the total area that might have experienced some degree of oiling over the course of that day. A total cumulative map from the entire spill period would then aggregate the anomaly maps from each day. So, a total cumulative square miles figure based on satellite anomaly data is not a snapshot of estimated surface oiling at a single point in time and provides no information as to how long surface oiling might have persisted at any given location within the Gulf of Mexico. Of the 88 NESDIS daily composite anomalies produced between April 26 and August 3, 2010, the majority identified daily anomaly areas less than 10,000 square kilometers (3,861 square miles). So, while Dr. Boesch discusses only the composite figure of 68,000 square miles, which is likely a high estimate even of composite satellite anomalies,[67] in fact, on most days during the spill, fewer than 3,861 square miles of the Gulf contained some satellite anomalies for some period of the day. This is less than 6% of the 68,000 square miles discussed by both Dr. Boesch and Dr. Rice. If you conservatively define the northern Gulf of Mexico as a quarter of the total Gulf, then on most days from April 26 - August 3, 2010, less than 2.5% of the northern Gulf contained satellite anomalies which, as discussed below, may or may not indicate surface oiling.

[67] The total cumulative area of NESDIS daily composite anomalies from April 26 - August 3, 2010 is 120,112 km^2. This is the equivalent of approximately 46,000 mi^2. This estimate is consistent with estimates published in peer-reviewed literature. *See* Garcia-Pineda, O., MacDonald, I.R., Xiaofeng, L., Jackson, C.R., and Pichel, W.G. 2013. Oil Spill Mapping and Measurement in the Gulf of Mexico with Textural Classifier Neural Network Algorithm (TCNNA). IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 6(6):2517-2525. While 46,000 mi^2 is a significant area, it is still far less than the 68,000 mi^2 estimated by SkyTruth that Dr. Boesch relies upon. While I am not aware of a source fully describing SkyTruth's data sources and methodology, SkyTruth did publish a blog post comparing its estimate of total surface oiling to NOAA's and admitted its estimate was higher. *See* Skytruth, BP/Gulf Oil Spill - Cumulative Oil Slick Footprints, Sept. 21, 2010, *available at* http://blog.skytruth.org/2010/09/bp-gulf-oil-spill-cumulative-oil-slick.html.

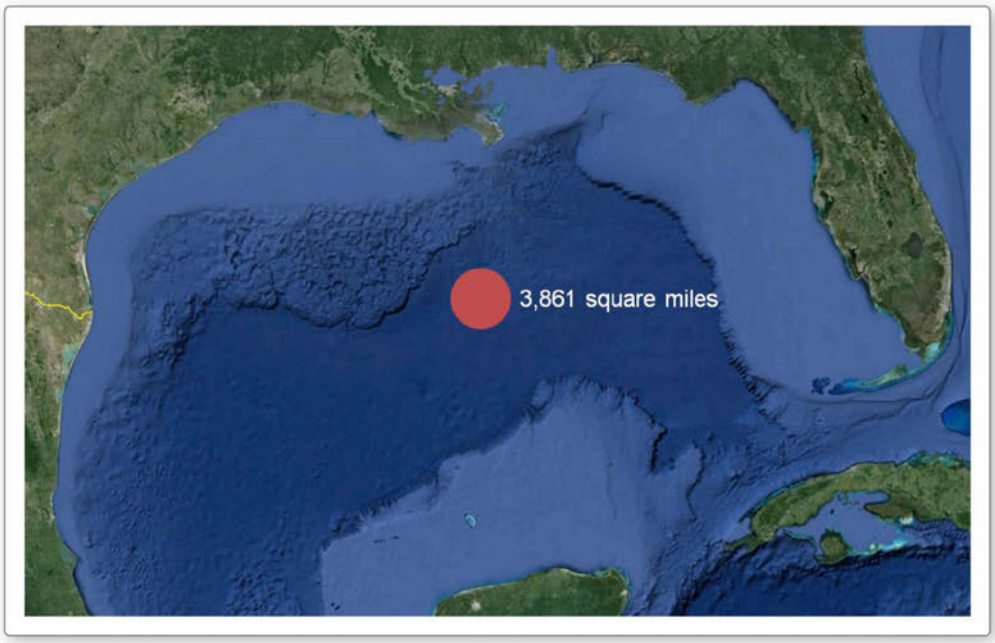

Figure 4. *On most days from April 26, 2010 - August 3, 2010, fewer than 3,861 square miles of the Gulf contained some satellite anomalies for some period of the day. This estimate does not take into account the fact that identification of surface oiling through satellite anomalies is imperfect and is replete with examples of non-oil anomalies like floating seaweed and cloud shadows being included within the estimates.*

b. Second, composite maps of satellite image anomalies, like those purportedly relied upon by the SkyTruth blog, do not necessarily differentiate between different types of anomalies. For example, satellite data anomalies depicted in the maps may include anomalies unrelated to the *Deepwater Horizon* incident such as floating seaweed (which Dr. Boesch agrees are common in the Gulf of Mexico[68]), oil from natural seeps, and oil leaks from passing vessels.[69] Weather phenomenon like sunlight, wind sheen, and cloud cover may further confound the identification of oil through satellite imagery.[70] "Thin sheens are particularly susceptible to misidentification, as they appear similar to non-oil biological slicks. In fact, the sea surface's upper 1 mm is well described as a gelatinous biofilm."[71]

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[68] Expert Report of Dr. Donald F. Boesch at 18.

[69] Deposition Mark Miller at 169–172.

[70] Leifer, I., Lehr, W.J., Simecek-Beatty, D., Bradley, E., Clark, R., Dennison, P., Hu, Y., Matheson, S., Jones, C.E., Holt, B., Reif, M., Roberts, D.A., Svejkovsky, J., Swayze, G., and Wpzencraft, J. 2012. State of the art satellite and airborne marine oil spill remote sensing: Application to the BP *Deepwater Horizon* oil spill. Remote Sensing of Environ. 124:185-209.

[71] *Id.*

c. These composite anomaly maps also do not speak to the thickness of oil at any given location, nor do they distinguish between surface oiling characteristics (*e.g.*, sheen vs. mousse). As stated by Mark Miller, the United States' representative for its official position on surface oiling, "[n]ot only does it [satellite anomaly data] not show uniform coverage of oil, but also the synthetic aperture radar was not able to distinguish thickness."[72] As discussed in my initial report, surface oil slicks are often microscopically thin.[73]

d. As a result of these limitations, estimates of surface oiling based upon satellite anomaly maps, like the SkyTruth estimate relied upon by Dr. Boesch, significantly overestimate the scope and extent of surface oiling.

4. Aerial overflight data from the spill response provide some of the important detail missing from satellite anomaly maps because observers recorded the characteristics and extent of oiling seen from the airplane. Appendix B includes a comparison of composite anomaly maps to aerial overflights that occurred on the same day. These comparisons show that in areas where composite anomaly maps showed uniform oiling, aerial overflight crews observed extremely low percentages of surface oil coverage. For example, on June 25, 2010, in one area that composite anomaly maps showed to be uniformly oiled, aerial overflight crews observed that only 1%-5% of that area was covered in "silver, rainbow and dull sheens," and only 1%-5% of that area was covered in "orange emulsion," there was no other surface oil observed in that particular area.[74]

5. Because aerial overflights were not conducted over the entire area of the spill, and aerial overflight observations are themselves susceptible to "false positive" identifications of oil,[75] it is impossible to estimate the exact degree to which composite satellite anomaly maps overestimate the nature and extent of surface oiling.[76] It is reasonable to assume that this overestimation is significant.

6. It is also important to understand the limitations of potential impacts to aquatic organisms associated with surface oiling. As discussed in my initial report, the *Deepwater Horizon* oil spill was unusual in that the oil had a significant distance to travel before reaching the

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[72] Deposition Mark Miller at 166, lines 16-19.

[73] Expert Report of Dr. Damian Shea at 53.

[74] *See* Appendix B, figure B.2.

[75] *See* NOAA, *Open Water Oil Identification Job Aid for Aerial Observation* at 37-42 (Version 2, Jul. 2012) (identifying the following "water and biological phenomena that may be observed and may tend to be mistaken for oil": kelp beds, jellyfish, red tide, herring spawn, water depth change, and cloud shadows), admitted as Ex. 12382 in the Deposition of Mark Miller.

[76] *See* Oil Spill Science and Technology: Prevention, Response, and Cleanup at 153 (Ed. Martin Fingas 2011) ("At the present time and for the foreseeable future, there is no single 'Magic Bullet' sensor that will provide all the information required to detect, classify, and quantify oil in the marine and coastal environment."), relevant excerpts admitted as Ex. 12383 in the Deposition of Mark Miller.

surface and underwent significant weathering as it rose.[77] As discussed by Dr. Rice, weathered oil is less soluble in water and it is, therefore, less likely to become bioavailable to marine organisms.[78] The significant weathering that occurred prior to oil reaching the surface reduced the solubility and bioavailability of surface oil. The oil then continued to weather and become less bioavailable at the surface.[79]

IV. DRS. RICE AND BOESCH INCORRECTLY IMPLY THAT DISPERSANTS CAUSED A SIGNIFICANT INCREASE IN TOXICITY EXPOSURE

1. Drs. Rice and Boesch are correct that dispersants increase the rate at which oil dissolves and disperses. However, this does not necessarily increase toxicity. Dr. Mace Barron – the United States' representative on the subject of dispersant toxicity and one of the co-authors of the study primarily relied upon by Dr. Boesch – agreed that "[w]hen the dispersants were mixed with the oil [...] mixtures were not more toxic than the oil itself."[80] Because we have extensive data regarding the concentrations of oil in the water column (which is discussed at length in my initial report), the fact that dispersants were applied to some of this oil does not impact the assessment of how toxic that oil was to aquatic organisms.

2. Drs. Boesch and Rice almost entirely ignore the fact that as chemical dispersants accelerated dissolution and dispersion of the oil, other physical processes acted to *decrease* rather than *increase* the time and space in which toxic concentrations of oil existed in the water column.[81] When oil-related chemicals spread in water they also become less concentrated – the faster the oil-related chemicals are diluted, the faster they decrease below toxic concentrations. Furthermore, as oil disperses, bacteria and other microscopic organisms are then able to act more quickly than they otherwise would to degrade the oil within the droplets. Therefore, application of chemical dispersants accelerated the disappearance of surface oil, reducing the potential for exposure (Figure 5).

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[77] Expert Report of Dr. Damian Shea at 53.

[78] Expert Report of Dr. Stanley Rice at 7-8.

[79] Expert Report of Dr. Damian Shea at 54.

[80] Deposition of Dr. Mace Barron at 212.

[81] Dr. Rice, at page 8, does admit that "chemical dispersant [...] improves the rate of natural oil removal processes" including through dissolution and biodegradation, but neither his nor Dr. Boesch's Report takes this benefit of dispersant application into account in discussing impacts associated with the spill.

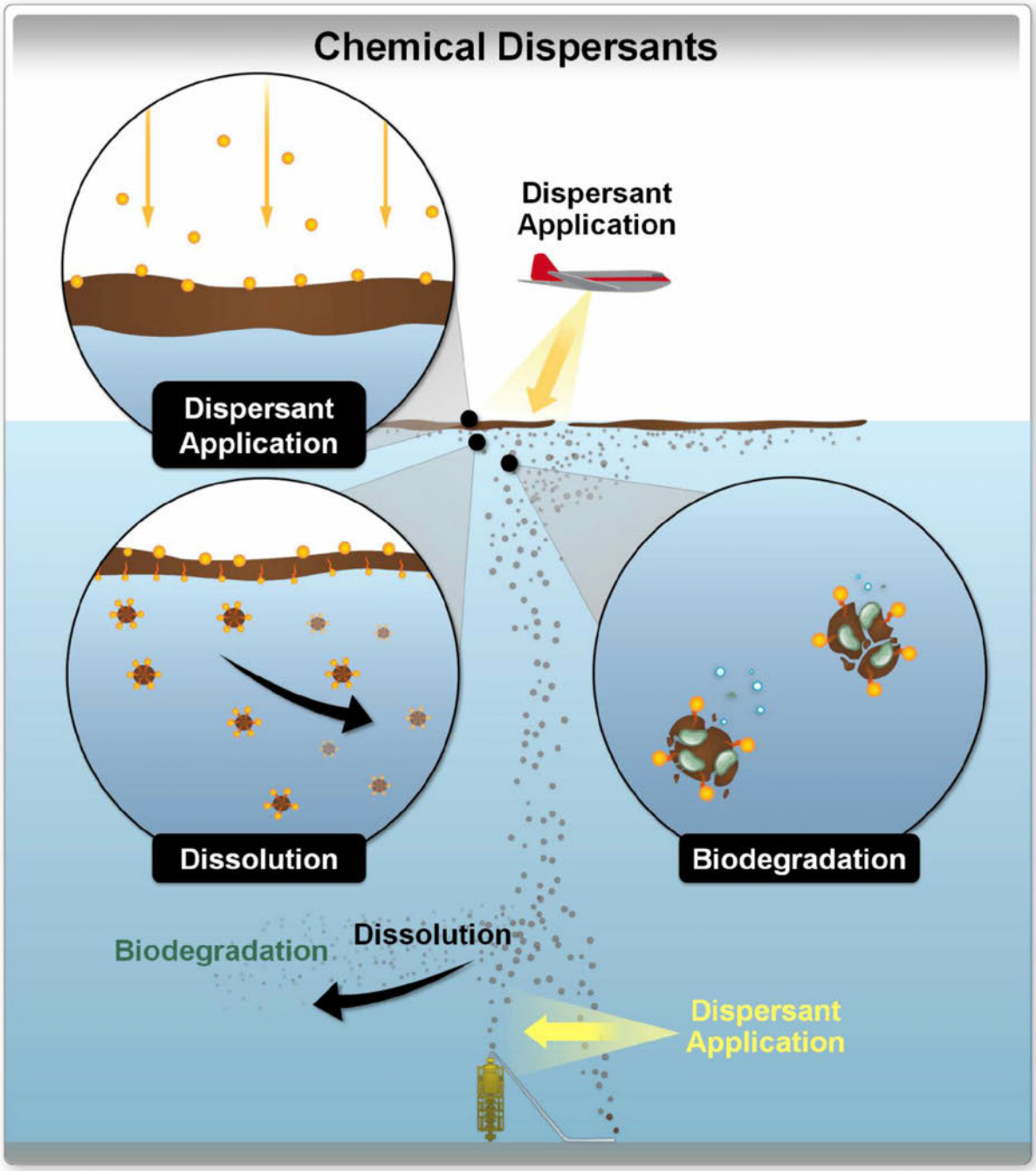

Figure 5. *Chemical dispersants act to accelerate dissolution and dispersion, rapidly decreasing concentrations of oil in the water column, and allowing the oil to naturally biodegrade more quickly than it otherwise would have.*

3. Application of chemical dispersant also effectively prevented much of the oil from reaching the most biologically important and sensitive regions of the Gulf. The EPA Administrator at the time of the *Deepwater Horizon* spill, Lisa Jackson, has acknowledged that application of subsea and surface dispersants were effective in preventing oil from reaching the Gulf's sensitive shoreline habitats.[82] By significantly reducing the oil that reached these biologically important and sensitive areas, dispersants likely decreased environmental impacts resulting from the incident.

4. Dispersants rarely reached toxic concentrations in the water column. As shown in my initial report, of the 5,672 water samples analyzed for the dispersant chemical DOSS, only 16 exceeded EPA's most stringent toxicity benchmark, and at least some of these were likely false positives attributable to "blank contamination."[83] Indeed, Dr. Boesch admits that "chemical dispersant [...] had little toxicity in itself."[84]

5. Spill response protocols prevented the application of dispersants in the most biologically sensitive regions of the Gulf. For example, application of dispersants within 3 nmi of the shoreline was prohibited so as to avoid potential impacts to sensitive shoreline ecosystems.[85]

6. Various monitoring, including for potential hypoxia, was implemented in connection with the application of subsea dispersants. As documented by the Joint Analysis Group reports[86] and explained by Dr. Lubchenco, the monitoring data show that "[n]one of the measurements that were taken during the spill indicated [...] hypoxia."[87]

7. Dr. Rice's characterization of chemical dispersant use as a "chemical spill"[88] is misleading and factually incorrect. Both Corexit products used during the incident were

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[82] Statement by EPA Administrator Lisa P. Jackson from Press Conference on Dispersant Use in the Gulf of Mexico with US Coast Guard Rear Admiral Landry, May 24, 2010 ("While [dispersant] use has understandably generated discussion and debate, based on all the information we have to date, it has proved to be an effective tool in preventing the oil from devastating the gulf's delicate coastline. EPA science tells us dispersant was effective in breaking up the oil."). *See also* Deposition of Captain James Hanzalik at 46 ("when we were doing subsea dispersant operations or aerial dispersant operations, we saw a lot less oil on the surface and a lot less oil hitting the shoreline.").

[83] Expert Report of Dr. Damian Shea at 31.

[84] Expert Report of Dr. Donald F. Boesch at 8.

[85] Expert Report of Dr. Donald F. Boesch at Fig. 6, p. 21.

[86] NOAA, *Joint Analysis Group, Deepwater Horizon Oil Spill: Review of R/V Brooks McCall Data to Examine Subsurface Oil*. NOAA Technical Report NOS OR&R (June 1, 2011), *available at* http://service.ncddc.noaa.gov/rdn/www/media/documents/activities/jag-reports/NTR-NOS-ORR-24-062011.pdf.

[87] Deposition of Dr. Jane Lubchenco at 88.

[88] *See* Expert Report of Dr. Stanley Rice at 19 ("In addition to the oil release, approximately 1.8 million gallons of chemical dispersant were applied during the DWH spill, and this release of chemical dispersant constituted one of the larger chemical spills in U.S. waters.").

on the National Contingency Plan (NCP) Product Schedule at the time of the incident and are still on the NCP Product Schedule today.[89] Dispersant use was pre-authorized (in the case of surface dispersants) and authorized (in the case of subsea dispersants) by Regional Response Team VI, which included an EPA representative.[90] Dispersant application, at the surface and subsea, was approved and monitored by the FOSC.[91]

8. On May 26-27, 2010, at the request of NOAA, over 50 scientists, engineers, and spill response practitioners from numerous organizations, including federal agencies, met in Baton Rouge, Louisiana, with the goal of "[p]rovid[ing] input to the affected Regional Response Teams (RRTs) on the use of dispersants going forward in the DWH incident."[92] At that meeting, several conclusions were reached, including that "[i]t is the consensus of this group that up to this point, use of dispersants and the effects of dispersing oil into the water column has generally been less environmentally harmful than allowing the oil to migrate on the surface into the sensitive wetlands and near shore coastal habitats."[93]

9. I am not aware of any studies performed or scientific literature published since April 20, 2010, that materially altered the scientific community's understanding of the toxicity of dispersants or the toxicity of oil-dispersant mixtures. The studies performed since the *Deepwater Horizon* oil spill have merely confirmed long-standing consensus on the toxicity of various dispersants, including Corexit 9500A, and the toxicity of oil-dispersant mixtures.

V. DR. BOESCH'S DISCUSSION OF A "DIRTY BLIZZARD" IS THEORETICAL; ACTUAL DATA DEMONSTRATES LIMITED IMPACT ON THE SEA FLOOR

1. Dr. Boesch hypothesizes that marine snow "entrained suspended sediments and oil droplets" to form a "dirty blizzard." Dr. Boesch's only citation for this hypothesis is a news article summarizing unpublished, unreviewed findings that were presented at a scientific conference.

2. In the only article cited by Dr. Boesch, Dr. Boesch himself was interviewed and responded to the idea that a dirty blizzard may have sent a significant amount of oil to the sea floor. He stated, "I find it hard to believe" and noted that "oil concentrations

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[89] U.S. EPA. 2010. National Contingency Plan Product Schedule; U.S. EPA. 2012. National Contingency Plan Product Schedule.

[90] On-Scene Coordinator Report: *Deepwater Horizon* Oil Spill at 33 (September 2011), *available at* http://www.uscg.mil/foia/docs/dwh/fosc_dwh_report.pdf.

[91] *Id.*

[92] Coastal Response Research Center, *Deepwater Horizon Dispersant Use Meeting Report May 26-27, 2010*, (June 4, 2010), admitted as Ex. 12055 in the Deposition of Dr. Mace Barron, at 1.

[93] *Id.* at 4.

measured in most sediments have been small."[94] Other government scientists have made similar statements – one NOAA scientist and top science advisor to the U.S. Coast Guard was quoted as stating, "[t]he concept of a big slick of oil sinking to the bottom is kind of an anathema [...] [w]e have not found anything that we would consider actionable at 5,000 feet or 5 feet."[95]

3. Even if marine snow contained oil when it was formed, much of the oil would have been degraded by the time it reached the sea floor. Marine snow, called "floc," has been generated in the laboratory from Gulf of Mexico bacteria and MC252 oil, and the researchers found it to be "comprised of a complex structure of EPS ["exopolysaccharides," which are complex sugars], protein, oil, and oil degradation products and bacteria."[96] The researchers found that the marine snow provided a convenient platform for bacteria to degrade oil, and their results suggested that "the oil tended to initially concentrate in the floc material, but was subsequently degraded."[97] Thus, by the time the marine snow reached the bottom of the Gulf, much of the associated oil would have been biodegraded.

4. Finally, any oil droplets entrained in sinking marine snow would have been measured in the sediment sampling performed on the sea floor. As discussed at length in my initial report, of the 8,181 sediment samples collected for PAHs, 98% were found to be safe for sediment dwelling organisms.[98] Dr. Rice utilized a single scientific publication by Montagna[99] to infer a large and long-lasting impact in the seafloor due to the oil spill. However, this inference does not rely upon a chemical analysis matching or fingerprinting the MC252 oil to the degraded areas, but instead relies mostly on the "coincidence of the [oil] plume and the benthic impact area."[100] The actual sediment data show 1) that impacts were confined mostly close to the wellhead and 2) that very little harm is expected beyond this area.[101] Furthermore, even the impacts discussed in the

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[94] Schrope, M. 2013. Dirty blizzard buried Deepwater Horizon oil. Nature, doi:10.1038/nature.2013.12304, at 1.

[95] Jervis, R., "Research teams find oil on bottom of Gulf," USA Today (Oct. 25, 2010), *available at* http://usatoday30.usatoday.com/news/nation/2010-10-25-oilresearch25_ST_N.htm?csp=24.

[96] Baelum, J., Borglin, S., Chakraborty, R., Fortney, J.L., Lamendella, R., Mason, O.U., Auer, M., Zemla, M., Bill, M., Conrad, M.E., Malfatti, S.A., Tringe, S.G., Holman, H.Y., Hazen, T.C., and Jansson, J.K. 2012. Deep-Sea bacteria enriched by oil and dispersant from the Deepwater Horizon spill. Environ. Microbio. 14(9):2405-2416, doi:10.1111/j.1462-2920.2012.02780.x.

[97] *Id.* at 5.

[98] Expert Report of Dr. Damian Shea at 35.

[99] Montagna, P.A., Baguley, J.G., Cooksey, C., Hartwell, I., Hyde, L.J., Hyland, J.L., Kalke, R.D., Kracker, L.M., Reuscher, M., and Rhodes, A.C.E. 2013. Deep-Sea Benthic Footprint of the Deepwater Horizon Blowout. PLoS ONE 8(8):e70540.

[100] Expert Report of Dr. Stanley Rice at 29.

[101] Expert Report of Dr. Damian Shea at 35-40.

Montagna paper are extremely limited: "[t]he most severe relative reduction of faunal abundance and diversity extended to 3 km from the wellhead in all directions covering an area about 24 km^2. Moderate impacts were observed up to 17 km towards the southwest and 8.5 km towards the northeast of the wellhead, covering an area 148 km^2."

5. Just as it is unlikely that marine snow resulted in a significant spill-related impact to bottom sediments, it is equally unlikely that marine snow had a significant impact on bottom coral communities. While, as noted by Dr. Boesch, brown flocculent material was observed on some coral communities near the wellhead, "extensive measurements of hydrocarbon concentrations in the deep layer within 20 km of the wellhead indicate no more than 0.1–1.0 mg/L (ppm) of oil and 1–10 μg/L (ppb) of polycyclic aromatic hydrocarbons (PAHs) was present, hardly the concentrations that would produce the brown flocculent material observed and sampled."[102] There is no conclusive evidence showing that oil from the spill resulted in these impacts to deepwater coral communities.[103]

[102] Boehm, P.D. and Carragher, P.D. 2012. Location of natural oil seep and chemical fingerprinting suggest alternative explanation for deep sea coral observations. PNAS 109(40):E2647.

[103] Indeed, hydrocarbons found at coral communities near the wellhead has not been definitively fingerprinted as MC252 oil, and it is likely that oil from the incident that remained deep in the water column was floating at a depth where it would not have come into contact with the distressed coral communities that have been observed. *See Id.* ("the base of this water layer in the vicinity of the coral was located [...] at 1,230 m, some 140 m above the corals, which are on the seabed at 1,370 m. In other words, the corals were below the measured layer that contained Macondo oil.") (internal citations omitted).

VI. APPENDIX A: Consideration Materials

1. Confidential Reports, Deposition Transcripts, and Other Material

APPENDIX A.1. Confidential Reports, Deposition Transcripts, and Other Material	
Doc Date	**Document Title / Description**
2010-06-04	Coastal Response Research Center, *Deepwater Horizon Dispersant Use Meeting Report May 26-27, 2010*, (June 4, 2010), admitted as Ex. 12055 in the Deposition of Mace Barron, at 1.
2014-06-24	Deposition of Mace Barron.
2014-06-17	Deposition of Captain James Hanzalik.
2014-07-10	Deposition of Jane Lubchenco.
2014-06-11	Deposition of Amy Merten.
2014-07-10	Deposition of Mark Miller.
2014-08-15	Expert Report of Donald F. Boesch.
2014-08-15	Expert Report of Stanley Rice.
2014-08-15	Expert Report of Damian Shea.
2014-02-04	Quality Assurance Project Plan: Deepwater Horizon Laboratory Toxicity Testing Version 4. Prepared for: U.S. Department of Commerce, National Oceanic and Atmospheric Administration. Prepared by: Stratus Consulting Inc. February 4, 2014. Protocols for Preparing Water Accommodated Fractions, Appendix A1.

2. Articles, Books, Papers, Reports and Data in the Public Domain

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2012-00-00	Baelum, J., Borglin, S., Chakraborty, R., Fortney, J.L., Lamendella, R., Mason, O.U., Auer, M., Zemla, M., Bill, M., Conrad, M.E., Malfatti, S.A., Tringe, S.G., Holman, H.Y., Hazen, T.C., and Jansson, J.K. 2012. Deep-Sea bacteria enriched by oil and dispersant from the Deepwater Horizon spill. Environ. Microbio. 14(9):2405-2416, doi:10.1111/j.1462-2920.2012.02780.x.
2012-07-00	Beazley, M.J., Martinez, R.J., Rajan, S., Powell, J., Piceno, Y.M., Tom, L.M., Andersen, G.L., Hazen, T.C., Van Nostrand, J.D., Zhou, J., Mortazavi, B., Sobecky, P.A. 2012. Microbial Community Analysis of a Coastal Salt Marsh Affected by the *Deepwater Horizon* Oil Spil. PloS One 7(7):e41305.
2013-07-13	Bejarano, A.C., Levine, E., and Mearns, A.J. 2013. Effectiveness and potential ecological effects of offshore surface dispersant use during the Deepwater Horizon oil spill: a retrospective analysis of monitoring data. Environ. Monit. Assess. 185(12):10281–10295.
2008-00-00	Billiard, S.M., Meyer, J.N., Wassenberg, D.M., Hodson, P.V., Di Giulio, and R.T. 2008. Nonadditive effects of PAHs on Early Vertebrate Development: Mechanisms and Implications for Risk Assessment. Toxicological Sciences 105(1):5–23.
2012-10-02	Boehm, P.D. and Carragher, P.D. 2012. Location of natural oil seep and chemical fingerprinting suggest alternative explanation for deep sea coral observations. PNAS 109(40):E2647.
N/A	BP. Gulf Science Data, Surface Dispersant Application Data File. Website: http://gulfsciencedata.bp.com/, directory: Other; subdirectory: Surface Dispersant Application; filename: DispersantApplication_OTH-01v01-01a.zip. Last modified January 2014.
N/A	BP. Gulf Science Data, Surface Dispersant Application Shapefile. Website: http://gulfsciencedata.bp.com/, directory: Other; subdirectory: Surface Dispersant Application; filename: DispersantApplication_OTH-01v01-01b.zip. Last modified January 2014.
N/A	BP. Gulf Science Data, Surface Dispersant Application Data File. Website: http://gulfsciencedata.bp.com/, directory: Other; subdirectory: Subsurface Dispersant Application; filename: DispersantApplication_OTH-02v01-01.zip. Last modified January 2014.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2013-11-18	BP Press Release, *BP Makes Gulf of Mexico Environmental Data Publicly Available* (Nov. 18, 2013), *available at* http://www.bp.com/en/global/corporate/press/press-releases/bp-makes-gom-environmental-data-available.html.
2013-00-00	Brannon, E. L., et al. 2013. Oiling effects on pink salmon. In Oil in the Environment: Legacies and Lessons of the Exxon Valdez Oil Spill; Wiens, J. A., Ed.; Cambridge University Press: Cambridge, U.K.: 263–291.
2012-00-00	Brannon, E. L., et al. 2012. Review of the Exxon Valdez oil spill effects on pink salmon in Prince William Sound, Alaska. Rev. Fish. Sci. 20 (1): 20–60.
2006-00-00	Brannon, E.L., et al., 2006. Toxicity of Weathered Exxon Valdez Crude Oil to Pink Salmon Embryos. Environ. Tox. Chem. 25(4):962–72.
2013-10-00	Butler, J.D., Parkerton, T.F., Letinski, D.J., Bragin, G.E., Lampi, M.A., Cooper, K.R. 2013. A novel passive dosing system for determining the toxicity of phenanthrene to early life stages of zebrafish. Sci. Total Environ. 463–464:952–958.
1999-03-00	Carls, M.G., Rice, S.D., and Hose, J.E. 1999. Sensitivity of fish embryos to weathered crude oil: Part I. Low-level exposure during incubation causes malformations, genetic damage, and mortality in larval Pacific herring (*Clupea pallasi*). Environ. Toxicol. Chem. 18:481–493, http://dx.doi.org/10.1002/etc.5620180317.
2004-00-00	Clarke, L.M.J. , C.W. Khan, P. Akhtar, P.V. Hodson, K. Lee, Z. Wang, J.W. Short. 2004. Comparative Toxicity of Four Crude Oils to the Early Life Stages of Rainbow Trout (Oncorhynchus mykiss). pp 785-792 In: Proceedings of the 27th Arctic and Marine Oilspill Program (AMOP) Technical Seminar, June 8-10, Edmonton, AL, Environmental Science and Technology Division, Environment Canada, Ottawa.
N/A	Cleveland, C., "Deepwater Horizon oil spill," Encyclopedia of Earth (2010, updated 2013) *available at* http://www.eoearth.org/view/article/161185/.
2000-00-00	Di Toro, D.M., McGrath, J.A., and Hansen, D.J. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Environ. Toxicol. Chem. 19(8):1951–1970.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2000-00-00	Di Toro, D.M., McGrath, J.A. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. II. Mixtures and sediments. Environ. Toxicol. Chem. 19:1971–1982.
2007-01-00	Di Toro, D.M., McGrath, J.A., and Stubblefield, W.A. 2007. Predicting the toxicity of neat and weathered crude oil: toxic potential and the toxicity of saturated mixtures. Environ. Toxicol. Chem. 26(1):24–36.
2012-03-02	El-Sayed Abdel-Raouf, M. 2012. Factors Affecting the Stability of Crude Oil Emulsions. In: Crude Oil Emulsions- Composition Stability and Characterization. Prof. El-Sayed Abdul-Raouf, M. (Ed.), ISBN: 978-953-51-0220-5, InTech, *available at* http://www.intechopen.com/books/crude-oil-emulsions-compositionstability-and-characterization/factors-affecting-the-stability-of-crude-oil-emulsions.
2014-09-00	Fodrie, J.F., Able, K.W., Galvez, F., Heck, K.L., Jensen, O.P., Lopez-Duarte, P.C., Martin, C.W., Turner, R.E., and Whitehead, A. 2014. Integrating Organismal and Population Responses of Estuarine Fishes in Macondo Spill Research. BioScience 64:778-788, doi:10.1093/biosci/biu123.
2013-00-00	Garcia-Pineda, O., MacDonald, I.R., Xiaofeng, L., Jackson, C.R., and Pichel, W.G. 2013. Oil Spill Mapping and Measurement in the Gulf of Mexico with Textural Classifier Neural Network Algorithm (TCNNA). IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing 6(6):2517-2525.
1999-00-00	Heintz, R.A., Short, J.W., and Rice, S.D. 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered *Exxon Valdez* crude oil. Environ. Toxicol. Chem. 18(3):494–503.
2004-00-00	Incardona, J.P., Collier, T.K., and Scholz, N.L. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicol. Appl. Pharmacol. 196:191–205.
2005-12-00	Incardona, J.P., Carls, M.G., Teraoka, H., Sloan, C.A., Collier, T.K., and Scholz, N.L. 2005. Aryl Hydrocarbon Receptor–Independent Toxicity of Weathered Crude Oil during Fish Development. Environ. Health Perspectives 113(12):1755–1762.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2014-03-24	Incardona, J.P., Gardner, L.D., Linbo, T.L., Brown, T.L., Esbaugh, A.J., Mager, E.M., Stieglitz, J.D., French, B.L., Labenia, J.S., Laetz, C.A., Tagal, M., Sloan, C.A., Elizur, A., Benetti, D.D., Grosell, M., Block, B.A., and Scholz, N.L. 2014. *Deepwater Horizon* crude oil impacts the developing hearts of large predatory pelagic fish. PNAS 111(15):E1510-E1518, doi: 10.1073/pnas.1320950111.
2010-10-25	Jervis, R., "Research teams find oil on bottom of Gulf," USA Today (Oct. 25, 2010), *available at* http://usatoday30.usatoday.com/news/nation/2010-10-25-oilresearch25_ST_N.htm?csp=24.
2011-11-00	Kostka, J.E., Prakash, O., Overholt, W.A., Green, S.J., Freyer, G., Canion, A., Delgardio, J., Norton, N., Hazen, T.C., and Huettel, M. 2011. Hydrocarbon-Degrading Bacteria and the Bacterial Community Response in Gulf of Mexico Beach Sands Impacted by the Deepwater Horizon Oil Spill. Appl. Environ. Microbiol. 77(22):7962, doi: 10.1128/AEM.05402-11.
2011-00-00	Landrum, P.F., Chapman, P.M., Neff, J., and Page, D.S. 2011. Evaluating the Aquatic Toxicity of Complex Organic Chemical Mixtures: Lessons Learned from Polycyclic Aromatic Hydrocarbon and Petroleum Hydrocarbon Case Studies. Integr. Environ. Assess. Manag. 8:217–230.
2004-00-00	Langevin, D., Poteau, S., Hénaut, I., Argillier, J.F. 2004. Crude Oil Emulsion Properties and their Application to Heavy Oil Transportation. Oil & Gas Science and Technology – Rev. IFP, 59(5):511–521.
2012-00-00	Leifer, I., Lehr, W.J., Simecek-Beatty, D., Bradley, E., Clark, R., Dennison, P., Hu, Y., Matheson, S., Jones, C.E., Holt, B., Reif, M., Roberts, D.A., Svejkovsky, J., Swayze, G., and Wpzencraft, J. 2012. State of the art satellite and airborne marine oil spill remote sensing: Application to the BP *Deepwater Horizon* oil spill. Remote Sensing of Environ. 124:185–209.
2011-02-00	Li, R., Zuo, Z., Chen, D., He, C., Chen, R., Chen, Y., and Wang, C. Inhibition by polycyclic aromatic hydrocarbons of ATPase activities in *Sebastiscus marmoratus* larvae: Relationship with the development of early life stages. Mar. Environ. Res. 71:86-90.
2014-05-23	Mager, E.M., Esbaugh, A.J., Stieglitz, J.D., Hoenig, R., Bodinier, C., Incardona, J.P., Scholz, N.L., Benetti, D.D., and Grosell, M. 2014. Acute Embryonic or Juvenile Exposure to *Deepwater Horizon* Crude Oil Impairs the Swimming Performance of Mahi-Mahi (*Coryphaena hippurus*). Environ. Sci. & Tech. 48(12):7053-7061.
2009-00-00	McGrath, J. & Di Toro, D.M. 2009. Validation of the Target Lipid Model for Toxicity Assessment of Residual Petroleum Constituents: Monocyclic and Polycyclic Aromatic Hydrocarbons. Environ. Tox. Chem. 28(6):1130-1148.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2013-11-12	Mahmoudi, N., Porter, T.M., Zimmerman, A.R., Fulthrope, R.R., Kasozi, G.N., Silliman, B.R., and Slater, G.F. 2013. Rapid Degradation of *Deepwater Horizon* Spilled Oil by Indigenous Microbial Communities in Louisiana Saltmarsh Sediments. Environ. Sci. Technol. 47:13303-13312, dx.doi.org/10.1021/es4036072.
2013-08-07	Montagna, P.A., Baguley, J.G., Cooksey, C., Hartwell, I., Hyde, L.J., Hyland, J.L., Kalke, R.D., Kracker, L.M., Reuscher, M., and Rhodes, A.C.E. 2013. Deep-Sea Benthic Footprint of the Deepwater Horizon Blowout. PLoS ONE 8(8):e70540.
2011-01-00	National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. 2011. Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling, Report to the President.
1979-00-00	Neff, J.M. 1979. Polycyclic Aromatic Hydrocarbons in the Aquatic Environment. Applied Science Publishers, London. ISBN-10: 0853348324, 262 pp.
2013-02-15	Neff, J.M., Page, D.S., Landrum, P.F., and Chapman, P.M. 2013. The importance of both potency and mechanism in dose–response analysis: An example from exposure of Pacific herring (*Clupea pallasi*) embryos to low concentrations of weathered crude oil. Mar. Pollution Bulletin 67:7-15.
2012-07-00	NOAA, *Open Water Oil Identification Job Aid for Aerial Observation* (Version 2, Jul. 2012), admitted as Ex. 12382 in the Deposition of Mark Miller.
2011-06-01	NOAA. *Joint Analysis Group, Deepwater Horizon Oil Spill: Review of R/V Brooks McCall Data to Examine Subsurface Oil*. NOAA Technical Report NOS OR&R 24 (June 1, 2011), *available at* http://service.ncddc.noaa.gov/rdn/www/media/documents/activities/jag-reports/NTR-NOS-ORR-24-062011.pdf.
N/A	NOAA. ERMA Deepwater Gulf Response, *available at* http://gomex.erma.noaa.gov/erma.html.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
N/A	NOAA. NESDIS composite anomaly maps, *available at* ftp://satepsanone.nesdis.noaa.gov/OMS/disasters/DeepwaterHorizon/composites/2010/ and http://gomex.erma.noaa.gov/erma.html.
2011-00-00	Nowell, L.H., Ludtke, A.S., Mueller, D.K., and Scott, J.C. 2011. Organic Contaminants, Trace and Major Elements, and Nutrients in Water and Sediment Sampled in Response to the Deepwater Horizon Oil Spill. In: U.S. Geological Survey (Ed.), U.S. Department of the Interior, Reston, Virginia, Open-File Report 2011-1271.
2011-00-00	Oil Spill Science and Technology: Prevention, Response, and Cleanup (Ed. Martin Fingas 2011), relevant excerpts admitted as Ex. 12383 in the Deposition of Mark Miller.
2011-09-00	On-Scene Coordinator Report: *Deepwater Horizon* Oil Spill (Sept. 2011), *available at* http://www.uscg.mil/foia/docs/dwh/fosc_dwh_report.pdf.
2011-02-00	Operational Science Advisory Team (OSAT-2). 2011. Summary Report for Fate and Effects of Remnant Oil in the Beach Environment at 2, *available at* http://www.restorethegulf.gov/sites/default/files/u316/OSAT-2%20Report%20no%20ltr.pdf.
2011-00-00	Page, D.S., Neff, J.M., Landrum, P.F., and Chapman, P.M. 2011. Sensitivity of pink salmon (Oncorhynchus gorbuscha) embryos to weathered crude oil. Environ. Tox. Chem. 31(3)469-471.
2012-00-00	Page, D.S., Chapman, P.M., Landrum, P.F., Neff, J., Elston, R. 2012. A perspective on the toxicity of low concentrations of petroleum-derived polycyclic aromatic hydrocarbons to early life stages of herring and salmon. Human Ecol. Risk Assess. 18:229–260.
1995-00-00	Pearson WH, Moksness E, and Skalski JR. 1995. A field and laboratory assessment of oil spill effects on survival and reproduction of Pacific herring following the Exxon Valdez spill. In: Wells PG, Butler JN, Hughes JS (eds), Exxon Valdez oil spill: fate and effects in Alaskan waters. ASTM STP 1219, American Society for Testing and Materials, Philadelphia, USA: 626-61.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2003-12-19	Peterson, C.H., Rice, S.D., Short, J.W., Esler, D., Bodkin, J.L., Ballachey, B.E., and Irons, D.B. 2003. Long-Term Ecosystem Response to the Exxon Valdez Oil Spill. Science 302(5653):2082-2086.
2007-09-00	Rice, S.D. and Carls, M.G. NOAA. 2007. Exxon Valdez Oil Spill Restoration Project Final Report. Prince William Sound Herring: An Updated Synthesis of Population Declines and Lack of Recovery. Restoration Project 050794, Final Report.
2013-01-26	Schrope, M. 2013. Dirty blizzard buried Deepwater Horizon oil. Nature, doi:10.1038/nature.2013.12304.
2010-04-00	SINTEF. 2010. Chemical and toxicological characterization of water accommodated fraction (WAF) of crude oils, *available at* http://www.sintef.no/upload/Materialer_kjemi/Marin%20milj%C3%B8teknologi/faktaark/WAF-web.pdf.
2010-09-21	Skytruth, BP/Gulf Oil Spill - Cumulative Oil Slick Footprints, Sept. 21, 2010, *available at* http://blog.skytruth.org/2010/09/bp-gulf-oil-spill-cumulative-oil-slick.html.
2010-05-24	Statement by EPA Administrator Lisa P. Jackson from Press Conference on Dispersant Use in the Gulf of Mexico with US Coast Guard Rear Admiral Landry, May 24, 2010.
2010-07-15	Statement of Lisa P. Jackson Administrator, U.S. Environmental Protection Agency, Legislative Hearing on Use of Dispersants in BP Oil Spill, Senate Committee on Appropriations: Subcommittee on Commerce, Justice, Science, and Related Agencies, July 15, 2010.
1988-09-00	U.S. EPA. 1988. Availability, Adequacy, and Comparability of Testing Procedures for the Analysis of Pollutants Established Under Section 304(h) of the Federal Water Pollution Control Act; Report to Congress. EPA/600/9-87/030.
1991-01-00	U.S. EPA. 1991. Manual for the Evaluation of Laboratories Performing Aquatic Toxicity Tests. EPA/600/4-90/031.

APPENDIX A.1. 1. Articles, Books, Papers, Reports and Data in the Public Domain	
Doc Date	**Document Title / Description**
2003-11-00	U.S. EPA. 2003. Procedures for the derivation of equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. EPA-600-R-02-013, *available at* http://www.epa.gov/nheerl/download_files/publications/PAHESB.pdf.
2010-07-08	U.S. EPA. 2010. National Contingency Plan Product Schedule.
2010-12-00	U.S. EPA. 2010. Guidelines for Deriving Numerical National Water Quality Criteria for the Protection Of Aquatic Organisms and Their Uses. PB85-227049, 54 pp.
2012-08-01	U.S. EPA. 2012. National Contingency Plan Product Schedule.
N/A	U.S. EPA, EPA Response to BP Spill in the Gulf of Mexico, Water Quality Benchmarks for Aquatic Life, What are benchmarks?, *available at* http://www.epa.gov/bpspill/water-benchmarks.html#gen2.
N/A	U.S. EPA, Water Quality Standards Review and Revision, *available at* http://water.epa.gov/scitech/swguidance/standards/rev.cfm.
1954-00-00	Van Overbeek, J. and Blondeau, R. 1954. Mode of Action of Phytotoxic Oils. Weeds. 3:55-65.
1985-00-00	Williams, L.R. 1985. Harmonization of Biological Testing Methodology: A Performance-Based Approach. In Aquatic Toxicology and Hazard Assessment: Eighth Symposium, ASTM STP891, Bahner, R.C. and Hansen, D.J., Eds. American Society for Testing and Materials, Philadelphia, pp. 288-301.
2011-03-00	Word., J.Q., Word, L.S., Watts, S.D., Pinza, M.R., and Schuh, T.L. 2011. Framework for Assessment of Causal Relationships between Life Stage Development Anomalies of *Clupea pallasi* and *Cosco Busan* Oil, An Interpretive Summary of 2007, 2008, 2009, and 2010 Datasets. Submitted to Pearson, W., Peapod Research, and Mauseth, G. Submitted by NewFields.

3. ERMA Data Considered

I have considered all data available at NOAA's publically available Environmental Response Management Application (ERMA) website, http://gomex.erma.noaa.gov/erma.html, including but not limited to data in the following categories:

- BP Deepwater Horizon Oil Spill
- Wellhead Surface Location
- Deepwater Horizon Wreckage
- Areas of Operation
    - Command Locations
    - Shoreline Divisions
    - USACE Emergency Permits
- BP Community Support
    - BP Claim Centers
    - BP Community Outreach Centers
    - Comprehensive One Stop Career Centers
    - Affiliate One Stop Career Centers
    - Small Business Administration Offices
- Satellite, Radar and Aerial Images of the Spill
    - Hurricane Isaac
    - TCNNA SAR Potential Oiling Footprints
    - NESDIS SAR Potential Oiling Footprint (Archive)
    - NOAA Pre-Landfall Mosaic Aerial Imagery
    - DWH NRDA Aerial (2010 - 2013, post-oiling)
    - EPA Aspect Aerial Imagery - Hosted by Telascience
    - Medium Resolution Satellite Imagery
- NRDA Workgroup Data
    - Cumulative Oiling
    - Analytical Data (Validated)
    - Marine Mammals
- Response Operations
    - Dispersant Operations
- Overflight Observations and Photos
    - Houma, LA
    - Mobile, LA
    - Venice, LA
- Response Sampling and Monitoring
    - CTD Profile Data
    - Dissolved Oxygen Data
    - Fluorescence Data
    - Fingerprinting Analysis Results
    - Location Data
    - Seafood Sampling Locations and Results
    - Sentinel Snare Oil Monitoring (SSOM) Data

    - Sorbent Probe Observational Data
    - Trawl/VIPERS Observational Data
    - Subsurface Monitoring Unit Operations
- Fishery Closures
    - NMFS
    - Alabama
    - Mississippi
    - Louisiana
- SCAT
    - Louisiana
    - SCAT Grids
    - LA SCAT Photos
    - Sector Mobile
    - Mobile SCAT Photos
    - Maximum Oiling Observed
    - Texas Cleanup Operations
- Trajectories
    - Nearshore Trajectories
    - Offshore Trajectories
- Wildlife Observations
    - Bird Observations (USFWS)
    - Turtle & Marine Mammal Observations (NMFS)
- Deepwater Report Products (JAG and OSAT)
    - Joint Analysis Group (JAG) Reports
    - OSAT 1 - Subsurface Oil and Dispersant Detection
    - OSAT 2 - Fate and Effects of Oil on Beaches
    - OSAT Ecotoxicity Addendum
- Admin Boundaries & Reference Features
- Geopolitical Boundaries
    - Louisiana Parishes
    - US Counties
    - Gulf State Boundaries (line)
    - Interstate Boundaries
    - 113th Congressional Districts
    - Economics: National Ocean Watch (ENOW)
- Federal Agency Regions & Offices
    - EPA Gulf Regional Boundaries
    - Gulf Region USCG AORs
    - USCG Florida Stations
    - NPS Current Unit Boundaries
    - USCG Districts
    - USCG Captain of the Port Zones
- Marine Jurisdictions
    - Marine Jurisdictions
    - Continental Shelf Boundary
    - U.S. Maritime Zones/Boundaries

- Bathymetry & Hydrology
- Bathymetry
    - Sea Surface Depth Map
    - Gulf of Mexico Bathymetric Contours (meters)
    - Estuarine Bathymetry
    - NOAA Hillshade
    - High-Resolution Hillshade of select U.S. coastal regions
    - NGDC Mosaic Bathymetry
    - Near Wellhead Bathymetry
- Shoreline
    - Medium Resolution Vector Shoreline (1:80,000)
- Imagery & Remote Sensing
- GOES Imagery
    - GOES Infrared Imagery
    - GOES Visible Imagery
- MODIS Imagery
    - MODIS AQUA - Latest Image
    - MODIS TERRA - Latest Image
- Natural Resources, Habitats, & Managed Areas
- Habitat Areas
    - Benthic Habitat
    - Bird
    - Fish
    - Shellfish
    - Marine Mammals
    - Turtles
    - Vegetation
- Critical Habitat Areas
    - NOAA NMFS Critical Habitat
    - USFWS Critical Habitat
- Essential Fish Habitat (EFH)
    - Essential Fish Habitat - Areas Protected from Fishing
    - EFH Coastal Migratory Pelagics (Gulf of Mexico)
    - EFH Coral and Coral Reefs (Gulf of Mexico)
    - EFH Red Drum (Gulf of Mexico)
    - EFH Feef Fish (Gulf of Mexico)
    - EFH Shrimp (Gulf of Mexico)
    - EFH Spiny Lobster (Gulf of Mexico)
    - EFH Stone Crab (Gulf of Mexico)
    - Habitat Areas of Particular Concern (HAPC)
- Managed Areas
    - Federal and Other Gulf Managed Areas
    - Federal Fisheries Closed Areas (50 CFR Part 622.34)
    - Florida Managed Areas
    - Louisiana Managed Areas

    - Mississippi Managed Areas
- Environmental Sensitivity Index (NOAA ESI)
    - ESI PDF Overlay, AL
    - Alabama (NOAA ESI 2007)
    - Florida (NOAA ESI 1995 - 1997)
    - Louisiana (NOAA ESI 2003)
    - Mississippi (NOAA ESI 2010)
    - Texas (NOAA ESI 1995)
- Navigation & Marine Infrastructure
- NOAA Navigation Charts
    - NOAA Nautical Chart Footprints
    - Raster Nautical Charts
- Vessel Traffic Zones & Shipping Lanes
    - Maritime Collision Regulation Lines for U.S. Waters
    - Anchorage Areas in U.S. Waters
    - ENC Shipping Lanes in U.S. Waters
    - Dredge Disposal Areas Affecting Navigation in U.S. Waters
- Public Safety & Infrastructure
- Oil & Gas
    - BOEM Active Leases
    - BOEM 5, 8, and 10 year lease term areas
    - BOEM 8(g) Zone Delineation
    - BOEM Districts
    - BOEM Field Units
    - BOEM Lease Blocks
    - BOEM Lease Blocks (Labels)
    - BOEM Lease Blocks (clipped)
    - BOEM Offshore Pipelines
    - BOEM Oil Platforms
    - BOEM Protraction Areas
    - BOEM Protraction Polygons (clipped)
    - Louisiana Oil Extraction Site Pit Study
    - Louisiana Oil, Gas, and Injection Wells
    - Louisiana State Waters Pipelines
    - Louisiana Offshore Pipelines
- Response Planning
- Area Contingency Plan
    - Sectors Mobile / St. Petersburg / Key West / Miami / Jacksonville / Savannah / Charleston
    - Sectors Corpus Christi / Houston/Galveston
    - Sector New Orleans
- Severe Weather Evacuation
    - Alabama Evacuation Routes
    - Alabama Contraflow
    - Louisiana Evacuation Routes
    - Louisiana Contraflow Evacuation

    - Mississippi Primary Evacuation Routes
    - Mississippi Secondary Evacuation Routes
    - Mississippi Contra Flow
- Restoration
- Restoration Sites
- Weather, Oceanography, & Natural Hazards
- Buoys & Gliders
    - NCDDC Glider Data
    - Buoy Stations
    - Mobile Offshore Drilling Unit ACDP
- Currents
    - Loop Current
    - HF Radar Hourly (2014_01_24_0800)
    - HF Radar Hourly (2014_01_24_0700)
    - HF Radar Stations (Live IOOS)
- Hazardous Weather
    - Watches/Warnings (NOAA)
    - Graphical Tropical Weather Outlook (NOAA)
    - Tropical Cyclone Location and Forecast (NOAA)
    - Tropical Storm Wind Speed probability (NOAA)
    - Probabilistic Storm Surge from SLOSH Model (NOAA)
    - Flood Outlook (NOAA)
    - Flood Warnings
- Precipitation
    - Weather Radar Mosaic (NOAA)
    - Quantitative Precipitation Animation - 0-48 hr (NOAA)
    - Quantitative Precipitation Forecast - 0 hr (NOAA)
    - Quantitative Precipitation Forecast - 12 hr (NOAA)
    - Quantitative Precipitation Forecast - 24 hr (NOAA)
    - Quantitative Precipitation Forecast - 36 hr (NOAA)
    - Quantitative Precipitation Forecast - 48 hr (NOAA)
- Salinity Zones
    - US Salinity Zones
    - Gulf of Mexico Salinity Zones
- Seeps & Anomalies
    - BOEMRE Seismic Amplitude: Negative Anomalies
    - BOEMRE Seismic Amplitude: Pockmark
    - BOEMRE Seismic Amplitude: Positive Anomalies
- Temperature
    - Apparent Temperature
    - Sea Surface Temperature
- Tides & Water Levels
    - River Level Stations & Data
    - Tide Prediction Stations
- Wave Height

    - Nearshore
- Wind
    - Surface Winds (Knots)
    - Surface Wind Velocity - 0hr forecast
    - Surface Wind Velocity - 6hr forecast
    - Surface Wind Velocity - 12hr forecast
    - Surface Wind Velocity - 18hr forecast
    - Surface Wind Velocity - 24hr forecast
    - Surface Wind Velocity - 30hr forecast
    - Surface Wind Velocity - 36hr forecast
    - Surface Wind Velocity - 42hr forecast
    - Surface Wind Velocity - 48hr forecast
    - Surface Wind Velocity - 72hr forecast
    - Surface Wind Animation

VII. APPENDIX B: Comparison of Composite Satellite Anomaly Maps to Aerial Overflight Data

Figures B.1 and B.2 below include the NESDIS composite satellite anomaly map for June 25, 2010, in two different areas of the Gulf. Layered on top of each area of the NESDIS map are data from a NOAA aerial overflight survey that took place in that area that day. These two figures show that in areas where the NESDIS map indicated a consistent polygon of oiling, in fact between 95-99% of the area observed contained no surface oil at the time the aerial overflight took place that day. In other words, very little of the area that the satellite maps indicate was consistently oiled actually contained oil.

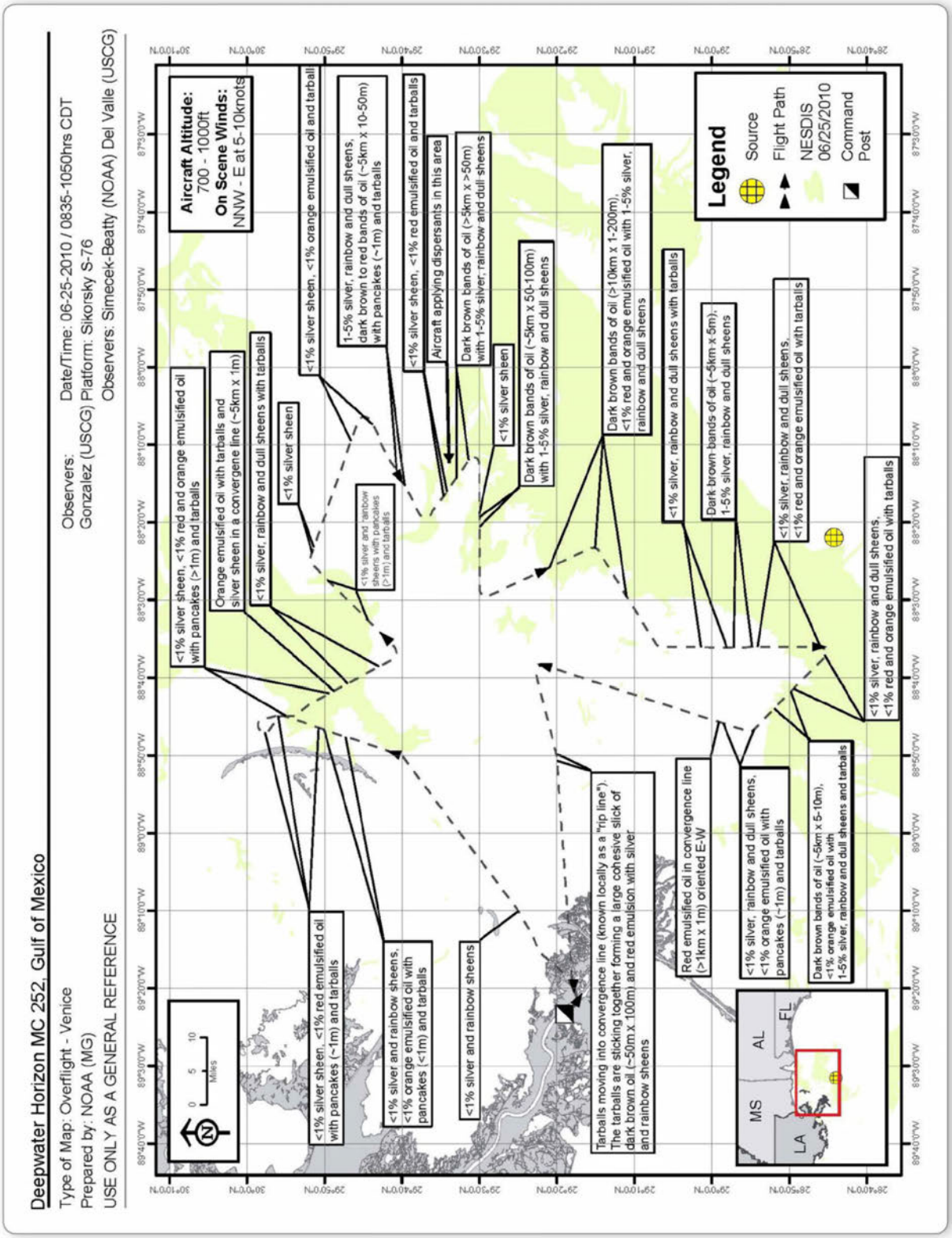

Figure B.1. NOAA overflight survey for June 25, 2010 at 08:35-10:50 hours CDT layered on top of NESDIS composite satellite anomaly map for June 25, 2010.

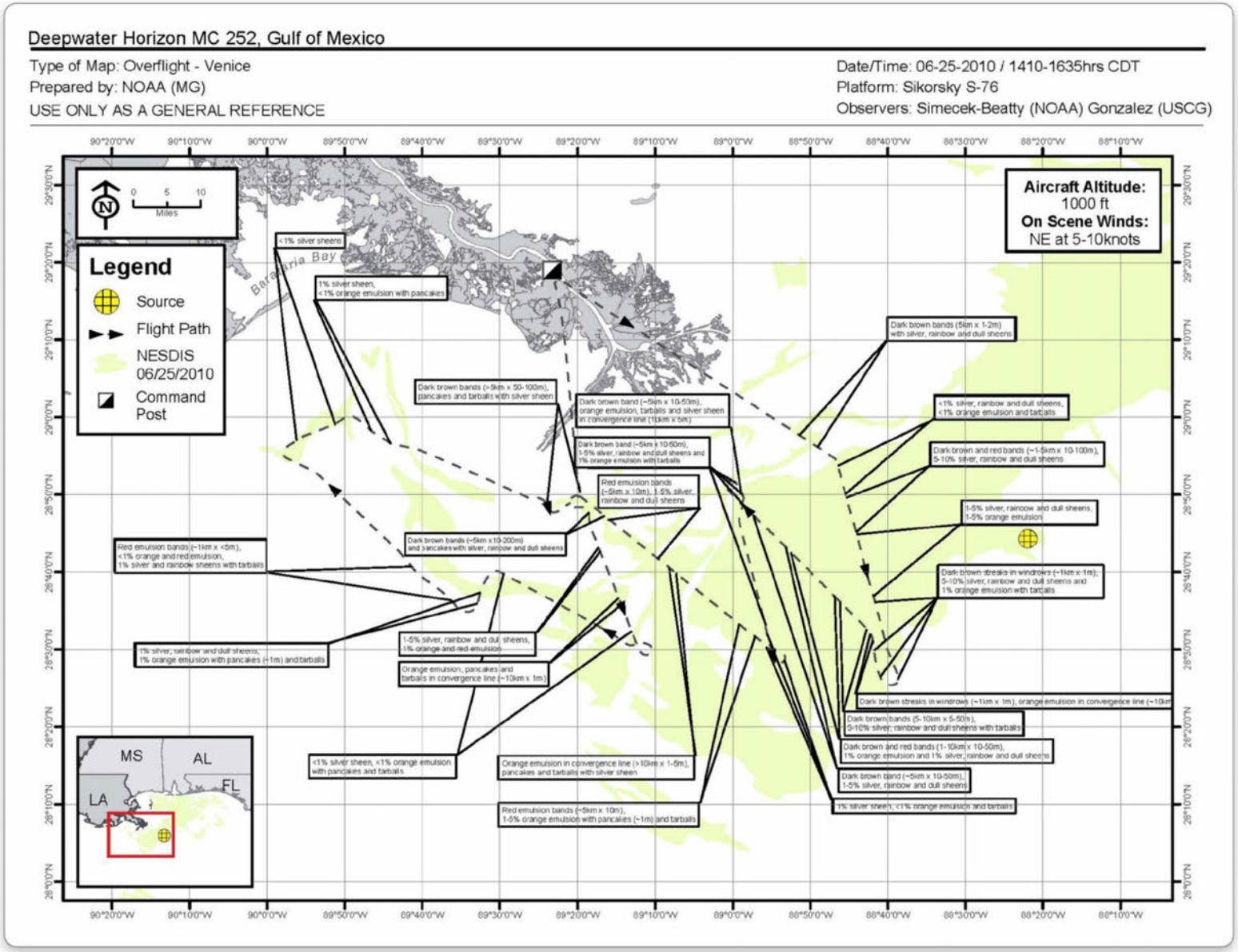

Figure B.2. NOAA overflight survey for June 25, 2010 at 14:10-16:35 hours CDT layered on top of NESDIS composite satellite anomaly map for June 25, 2010.