Lawrence Anthony EARTH ORGANIZATION
Because None Survive Alone

A CALL FOR A TWENTY-FIRST-CENTURY SOLUTION IN OIL SPILL RESPONSE

FOR THE WATERS OF THE WORLD - EARTH DAY 2015 EDITION

In observance of Earth Day 2015 and the 5th anniversary of the Deepwater Horizon Gulf of Mexico oil spill disaster, LAEO is re-releasing its 2014 oil spill response research paper to make this vital information more broadly available.

We all have a stake in strengthening the protections and preservation of Earth's waters and interdependent life eco systems.

In the spirit of Cooperative Ecology™ and finding a better way forward, the Lawrence Anthony Earth Organization Science and Technology Committee is seeking collaborative partnerships for advancing research in this field. We truly hope that Oil Spill Response Professionals will accept our help and avail themselves of this information as critical to their decision-making process when selecting methods to be used for removing oil and other chemical spills from our oceans and waters.

Cover photo:

What you see are pristine waters with a white-sand bottom and healthy turtle grass, contributing to a well-balanced ecosystem. But what if that dark area were *crude oil* and your job was to clean it up without damaging the environment; could you do it?

Because words often have more than one definition, several words are footnoted as they occur in context. Additionally, we provide a glossary at the end of this paper.

Originally published in April 2013, revised and updated September 2014 to reflect additional peer reviews by environmental science and oil spill response professionals and to update the **Bioremediation Fact Sheet** revisions and recommendations for Regional Response Teams and interagency stakeholders.

ISBN: 978-0-615-75424-6

Lawrence Anthony Earth Organization (LAEO)
3443 Oceanview Blvd.
Glendale, CA 91208

This publication can be downloaded along with amendments and supplements at:
www.protectmarinelifenow.org

Cover photo: Pristine tropical waters and island.
(iStockphoto, standard license; photographer: Rainer von Brandis)

Page 3 photos:
Plane spraying chemical dispersant (US Air Force photo, Tech. Sgt. Adrian Cadiz)
Burning oil spill (US Navy photo, Mass Communication Specialist 2nd Class Justin Stumberg)
Oil cleanup responders (photographer unknown)
Failed boom (photographer unknown)

Written and Compiled by the

Lawrence Anthony
EARTH ORGANIZATION
Because None Survive Alone

Science & Technology Advisory Board

Marynette Herndon, Environ Eng, REM (Registered Environmental Manager), CHMM (Certified Hazardous Materials Manager)
President, Herndon & Associates, Inc.
Chairperson, LAEO Science & Technology Advisory Board

Paul W. Sammarco, PhD
Professor and Senior Scientist
Louisiana Universities Marine Consortium (LUMCON)

Alex Nicholson, Mech Eng, MBA, PE
Former NASA Aerospace Engineer
Environmental Specialist

Jeanne Pascal, Esq
EPA Northwest District Debarment Counsel, retired (1984–2010)
Former in-house EPA attorney for oil spill relief

Patricia Hilgard, PhD
EPA HQ Toxicologist (1976-2009)
Former new chemicals technical integrator/risk assessor (TSCA Section 5)

Barbara Wiseman
International President
Lawrence Anthony Earth Organization

Diane Wagenbrenner
Vice President Operations & Public Information
Lawrence Anthony Earth Organization

Dedicated to the determined and resolute peoples of the Gulf Coast

Acknowledgments

GRATEFUL ACKNOWLEDGMENT GOES TO

All the selfless scientists, environmental groups and their supporters, journalists, and concerned citizens who have donated their effort and expertise to produce and/or make available important studies and information cited in this research paper. These include

Earthjustice
EcoRigs
Gulf Rescue Alliance
Gulf Restoration Network
Louisiana Economic Foundation
Louisiana Environmental Action Network (LEAN)
Natural Resources Defense Council (NRDC)
OSEI Corporation
Public Employees for Environmental Responsibility (PEER)
Waterkeeper Alliance
Senator A. G. Crowe
Strategic Consulting, LLC
Surfrider Foundation
J. A. Turley (author), *The Simple Truth: BP's Macondo Blowout*

as well as national and regional response network members of conscience, and government officials and congressional representatives who have the personal integrity and fortitude to continue to work toward the implementation of better technologies for safer and more effective oil spill cleanup methodology.

Special acknowledgement is also made to the following people for their professional contributions to this paper:

Rosemary Delderfield, Copyeditor
Editorial & Proofreading Services

Ray McKay, Desktop Publishing
Media City Marketing

Dana Hanson, Research
Government Administration Outsourcing

Contents

Executive Summary

An important and fundamental principle in oil spill response was overlooked during and after the 2010 BP oil spill:

The foremost reason one cleans up an oil/chemical spill is to *remove* the pollutants/toxicity from the environment as rapidly as possible so that living organisms can survive.

Escalating the importance of this premise, the Science & Technology Advisory Board of the Lawrence Anthony Earth Organization (LAEO-STB) compiled this research paper to dramatically change emphasis in oil spill contingency planning and the science and technology research priorities related to such.

Utilizing this principle as a fundamental standard for oil spill cleanup guidance and policy establishes a valuable frame of reference by which one can evaluate response methods, (e.g. booming and containing using absorbents, mechanical recovery, in situ burning, chemical dispersants and other agents such as bioremediation) as to their effectiveness, safety and economic viability.

Several analyses and summations of the cleanup practices used during the British Petroleum Deepwater Horizon (BP-DWH) disaster did not take into account the necessity of the above principle; one being the early 2012 interagency report to Congress,[i] and another, a special feature published in the Proceedings of the National Academy of Sciences (PNAS) journal of December 2012.[ii] The latter report includes an introduction by federal interagency environmental science experts stating, "*Despite aggressive recovery and removal efforts, only around one-quarter of the oil was removed by the federally directed response.*" And, in spite of this, the report deemed the cleanup was adequate and arrived at an overall conclusion that indicates similar methodology will likely be used on future spills.

In light of the above, LAEO is concerned that federal agencies tasked with protecting our waters and natural resources hold the viewpoint that (a) there are no better methods, and (b) the negative effects of chemical dispersants "need more study" before anyone will know for sure, while they continue to use them.

> ***"Despite aggressive recovery and removal efforts, only around one-quarter of the oil was removed by the federally directed response."***
>
> PNAS of December 3, 2012, Perspective: "Science in Support of the *Deepwater Horizon* Response"

If there were no economically viable and effective methods for swiftly achieving a better result—closer to complete removal of oil spills from the environment, then the situation would be dire indeed.

However, the federal government's National Oil and Hazardous Substances Pollution Contingency Plan (NCP) overseen by the Environmental Protection Agency (EPA) currently lists a ***category*** of *nontoxic first-response* oil spill cleanup technology that safely and effectively removes hydrocarbons from a spill site, resulting in full and swift restoration of the environment to pre-spill conditions with no negative environmental trade-offs.

This research paper addresses how it came to be that a fully developed science-based spill cleanup system continues to be overlooked by US federal and state regulators and industry professionals despite the fact that it vastly exceeds the results of currently deployed first-response technologies.[iii] This method not only quickly detoxifies and diminishes the adhesive properties of a spill (and, if need be, detoxifies any deployed dispersants), but its end point is a conversion of close to 100 percent of the

i. US Interagency Coordinating Committee on Oil Pollution Research [ICCOPR] Report—2012 Biennial Report to Congress.
ii. Proceedings of the National Academy of Sciences (PNAS) Special Feature: "Science in Support of the Deepwater Horizon Response."
iii. See pages 11–19 for details on dispersant-alternative technology.

toxic spill components to harmless carbon dioxide and water in a matter of a few days to a few weeks. [iv]

This guidance material is a constructive offering for every oil-producing country in the world and their potentially contaminated waters although it utilizes the *ongoing* BP/Deepwater Horizon blowout disaster in the Gulf of Mexico as an example. While there have been many studies and reports published about lessons learned during and after this disaster and oil spill response, this paper brings a new analysis and assessment of the information. It also contains guidelines for the selection process for oil spill cleanup agents, along with an evaluation process that can be used to assess potential effectiveness of those agents in swiftly *removing* spilled oil from the environment.

Current interagency documents guiding National, Regional, and Area Response Teams in their oil spill response planning are missing considerable information on alternate technologies, specifically *bioremediation* … which resulted in the elimination of a nontoxic first-response bioremediation technology from the response selection process for the BP spill. Liken this to the stigmatization of a star football player left off the playing field based on a biased opinion, not fact. This "first string" exclusion of a viable option for use on the BP oil spill—*NCP-listed Bioremediation Agent Enzyme Additive [EA] Type*—was unfortunate and arbitrary.

The effective cleanup of oil-polluted waters is a life-or-death proposition for future generations. An intellectual awakening in both the public and private sectors of the vital importance of preserving our waters brings a demand for non-toxic spill solutions that demonstrate long-term sustainability.

If the agenda is not to just devote the Gulf of Mexico, Niger Delta, Persian Gulf, Alaskan/Arctic regions, California coast, or other energy production areas to the sole purpose of energy acquisition, then it is time to take bold steps to raise the bar on effective spill response. This means remedies must be employed that will remove closer to 100 percent of the toxicity being added to the environment by energy acquisition activities so that living organisms, from the tiniest microbes up to the largest mammals, can survive.

LAEO has compiled and released this material in support of all sides and stakeholders, recognizing the importance of supporting the indispensable economic contributions to society that oil and gas companies provide. We believe it is vital, and entirely possible, to simultaneously produce energy and economically protect the environment.

The information presented here is intended to provide a gateway for achieving far higher standards in oil spill response as well as for meeting the compliance criteria of the Clean Water Act.

The LAEO Science & Technology Advisory Board (LAEO-STB)urges all national, regional, and area oil spill response professionals to consider the data offered herein and to engage in taking a new look at contingency plans and the science on which they are based, to achieve the higher level of oil spill removal standards as set by the Clean Water Act.

iv. See Reference Note #41

The Fundamental Premise

Traditionally, oil spill cleanup focuses on addressing two problems: 1) how to keep the oil from damaging wildlife, marshes, beaches, waterfronts, and other sensitive habitats and 2) how to reduce toxicity and remove the hydrocarbons from the environment.

The perspective on changes needed in the NCP become very evident when assuming the paradigm that the purpose of cleaning up an oil spill is to swiftly remove the offending toxicity so that even the smallest living organisms can survive—thus ensuring survival for all life forms in the affected area.

Over the past quarter century, oil spill response methodology has mainly consisted of mechanical recovery and cleanup, containment with booms, absorbtion, in situ burning and chemical dispersant agents. The problem is that these broadly adopted approaches act as models but do not, as a combined system, result in the complete removal of spilled oil or a full restoration of marine environments and other sensitive ecosystems. In general, these methods remove only a fraction of toxic hydrocarbons from an impacted area and, in the case of dispersants, frequently add additional toxicity that adversely affects wildlife and human health.

Current Inadequate Spill Cleanup Systems

One of the most difficult decisions that oil spill responders and natural resource managers face during a spill, is evaluating the environmental trade-offs when selecting a response method. For example, recent reviews of the decision to use dispersants on the BP-DWH oil spill cast doubt on the benefits being greater as science studies after the response now show overwhelming evidence that dispersants cause harm to all life they come in contact with. Part of this decision-difficulty is caused by the regulatory guidance itself, which fails to bring forth that within the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) there are safer, more effective, and considerably less expensive processes listed that can *remove* toxins from the environment and restore marine habitats and other sensitive ecosystems.

Hence, the real problem to be solved is not how do we quickly disperse and sink spilled oil below surface waters to protect feathers, fur, marsh grass, and beach; but instead, how do we rapidly remove closer to 100 percent of the toxicity and hydrocarbons of the oil spill from affected waters so that living organisms can survive? Adding dispersants containing polluting substances that make the environmental impacts of the oil (combined with these chemicals) many times more toxic is contrary to the basic purpose of cleaning up a spill. [v] And, burning, which results in releasing toxins into the atmosphere, along with collection methods that necessitate relocating the toxic elements of a spill to somewhere else, does not remove the spill from the environment.

v. See Reference Note#23 and 40

The LAEO-STB recognizes the difficult circumstances and “trade-offs dilemma” the response community faced during the BP oil spill. However, it was also known at the time that there were science-based oil spill cleanup solutions and protocols which, had they been a part of the NCP, would have averted a great deal of damage to the Gulf ecosystem still in desperate need of relief today. We believe there is a means for bringing about a win-win situation for all sides—environmental interests, business stakeholders, those who rely on the indispensable economic contributions that oil and gas companies provide, and all who cherish their way of life along the Gulf Coast.

One of the missions of the National Response Team (NRT) and its vast network of oil spill response professionals, science advisors and other resources, should be to assist with finding effective technologies to clean up the polluted waters of the world, the Gulf of Mexico being an important target. A priority task would be to identify and authenticate more effective spill cleanup technologies, tools and non-toxic agents and get these technologies officially designated for use as remedies during spill emergencies and disasters, replacing toxic solvents and chemicals that have proven to be destructive to all life. While seemingly inherent as a vital function, this necessity is being treated with low priority by most responsible parties in this sector, although a minority few have begun to take on the task. LAEO is in agreement with those countries that have taken necessary action to ban and/or restrict dispersants, but isn’t in agreement with it taking years to get something better in place.

While there is an alarming amount of evidence that dispersants do more harm than good, such data brought forth here is not the main purpose of this paper. The intent of this paper is to offer solutions to the actual problem. As demonstrated by Unified Command actions during the BP spill, the NRT has no *practical* guidelines in the NCP that standardize the assessment process for identifying and selecting nontoxic remediation methods for the removal of hydrocarbons from the environment without damage to living organisms. In other words, the actual problem is that decision makers who have the authority to act in a spill situation have no plans/guidance in place for any region to support decisions for nontoxic solutions, but rather only a preapproved system using mechanical, burning, and chemical dispersant cleanup methods, which do not remove pollutants from the environment but instead relocate and reposition them. This amounts to having a preapproved system in place that does not get the job done.

The LAEO-STB herein offers a perspective on alternative technologies already listed in the US EPA’s NCP Product Schedule and recommends guidance for assessing and selecting effective, nontoxic solutions.

Decision makers who have the authority to act in a spill situation have no plans/ guidance in place … to support decisions for nontoxic solutions, but rather only a preapproved system using mechanical, burning, and chemical dispersant cleanup methods, which do not remove pollutants from the environment but instead relocate and reposition them.

We urge all oil spill response professionals to consider the fundamental premise and data brought forth herein and collaborate in taking a new look at contingency plans and the science on which they are based. Only the willingness to conduct an open and honest review of the facts and end results will serve to move government and industry beyond the current less-than-adequate response plans to the next and better level of response methodology.

What is at stake?

Future generations’ supplies of clean water and food, and sustainable habitats for marine life and wildlife.

The Case against Corexit and Other Dispersants

Obsolete Cleanup Technology Must be Brought up to Match the Exceedingly Advanced Levels of Exploration and Drilling Tech

The limitations and issues with our current *preapproved* oil spill response systems and tools are illustrated using the BP-DWH blowout and oil spill response as an example. Although spill/spray/injection volumes have been debated, multiple reports indicate that at least 5 million barrels of oil were released into the Gulf of Mexico, with an unprecedented volume of nearly 2 million gallons of Corexit dispersants applied for mitigation purposes. Despite the fact that chemical dispersants such as these have a stated purpose of protection of shorelines and wildlife by sinking and dispersing the oil below the surface, preventing the oiling of sensitive habitats, feathers, and fur; the mix of Macondo oil and Corexit had mutagenic,[vi] teratogenic,[vii] and other harmful effects on the marine food web and is still having such an impact at the time of this writing, now four years later.[1] This response method is intended to break the oil into fine particles, making it more easily biodegradable by indigenous oil-metabolizing microbes. That intent, however, is *not* achieved but instead has an end product of preventing biodegradation and causing a gassing off or transference of toxic compounds from water to air, sediment, soil, or other mediums, rendering the "unsightly goo" invisible but, nevertheless, easily detectable and still capable of harming the ecosystem; hence, little oil is in fact removed from the environment using dispersant chemicals. Additionally, with the unprecedented high quantities of chemical dispersants injected at the site of the blowout, 5,000 feet beneath the surface waters, the bioaccumulative and long-term negative effects on the plankton and subsequently all life throughout the food web raise important concerns.[2]

For instance, a Woods Hole Oceanographic Institute study found that dispersants were suspended within an oil-gas-laden plume in the deep ocean and had still not degraded some three months after they were applied.[3] DOSS (dioctyl sodium sulfosuccinate),[viii] a component of Corexit, contributed to this plume, acting as a biocide[ix] and killing the native microbes in the region, effectively retarding the natural biodegradation process.[4] This may account for oil that had sunk but ascended again and was redistributed onto shorelines after storms, such as Hurricane Isaac, triggering a second cleanup effort.[5,6] Official responses to these concerns do not address these problems today any better than they did in the past. Regulators are now calling for more costly long-term studies, stating that "*effects are still uncertain and a better understanding is still needed*."[7] Thirty years of experience with questionable cleanup results from scores of major oil spills that have contributed to the collapse of some fisheries and negative human health impacts should be enough.[8] These impacts have been documented by various research facilities and, as a result, it can be argued that adequate data exists to be able to judge that present modes of spill response are unsatisfactory for the task at hand.[9]

With the unprecedented high quantities of chemical dispersants injected at the site of the blowout, 5,000 feet beneath the surface waters, the bioaccumulative and long-term negative effects on the plankton and subsequently all life throughout the food web raise important concerns.

In short, this independent Science & Technology Board objects to the current stance asserted by the EPA, Coast Guard and NOAA that 25 percent dispersed and burned and 2–8 percent mechanically removed is good enough, "*since nature will do the rest*." Their statistical

vi. **mutagenic**. Capable of causing or increasing the rate of unnatural mutations in living organisms.
vii. **teratogenic**. Capable of causing birth defects and negatively impacting the development of a fetus.
viii. **DOSS (dioctyl sodium sulfosuccinate)**. A toxic surfactant that is a component of Corexit. Common side effects of exposure to DOSS include a breakdown of red blood cell walls and subsequent rectal bleeding, stomach pain, diarrhea, serious allergic reactions, and cramping.
ix. **biocide**. Any toxic chemical that has the potential of destroying life forms by poisoning.

reports that claim this measurement of "removal" cannot be verified and we can all agree any sizeable percent of a spill remaining is absolutely an unacceptable cleanup standard.[10] We assert that the only acceptable standard for oil spill cleanup/removal is close to 100 percent remediation accomplished swiftly.[11]

The Gulf of Mexico is one of the world's great hydrocarbon basins and a major contributor to US energy security, delivering a quarter of the country's total oil output. The oil and gas industry in the Gulf is also an important driver of the regional and national economy. As the Gulf expands as an oil-producing region, an increasing proportion of activity and production will take place in ultra-deep waters of 5,000 feet or greater.

The Energy Outlook report issued on November 12, 2012, by the US Energy Information Administration (EIA) states that the United States will overtake Saudi Arabia as the world's leading oil producer by about 2017 and will become a net oil exporter by 2030.

Unfortunately, spill cleanup methods are not technologically advancing at the same urgency and pace. To their credit, numerous countries throughout the world have, however, banned or strictly limited the use of dispersants. For instance, New Zealand, Australia and India restrict usage, and in Saudi Arabia environmental policies were established against chemical dispersant usage in their waters because they are wholly dependent upon desalinization for their drinking water.

Today the Gulf of Mexico is a distressed body of water, as evidenced by lesions on fish, mutations, heightened chemical and acidic levels, and consequential health issues in humans. It has been known for decades that dispersants cause long-term damage to the entire ecosystem, so why are we using them and continuing to stockpile them at all?

With the stepping up of oil and gas production in the United States, the industry is wholly capable of employing safer drilling practices and cleanup solutions. The aftermath of the BP spill and its lessons indicate it is absolutely imperative that new contingency plans be put in place that do not involve the use of dispersants containing toxic compounds, but instead utilize cleanup methods that factually remediate water and soil pollution and predominantly *remove toxins* so that living organisms can survive in a healthy ecosystem.

There is no life without water. The day is coming when clean water will be the new oil, as our vast underground water supply is shrinking. The Ogallala Aquifer—the largest in North America and a major source for agriculture, stretching from Texas to South Dakota—is currently being pumped at a rate 8 times greater than it can be replenished. California predicts, if more supplies are not found, that by 2020 the State will face a shortfall of clean water nearly as great as the amount that all of its cities and towns together are consuming today.[11-1]

Moving forward in this era of expanded oil production requires a shift in paradigm to more closely align with a standard of *complete removal* of pollutants, which is legally mandated by the Clean Water Act (CWA), enacted over 25 years ago. However, this has apparently been deemed unachievable by regulators and too costly by industry, and as a result, both industry and environmental interests have much of their time and resources focused on *regulating, defending and studying the effects of dispersants* instead of focusing on bringing forth, field testing, and incorporating better technology that does in fact remove all spilled oil from ocean and fresh water ecosystems.

Two US federal laws, the Clean Water Act (CWA) and the Endangered Species Act (ESA), contain provisions that specifically ensure that dispersant approval and use will not jeopardize imperiled wildlife and the resources on which it depends. We contend that the preapproval status bestowed upon Corexit,[12] the immediate authorization of its deployment in response to the BP oil spill emergency and, finally, its use being an integral part of nationwide response planning (in which it is staged and ready for deployment in all US waters) are a clear violation of the Clean Water Act in many respects.[13]

Revitalization of the Clean Water Act

The Clean Water Act (CWA) was enacted in 1948 as the Federal Water Pollution Control Act, but the statute was significantly changed and amended in 1972 and became known as the Clean Water Act.

The following is an analysis of how current spill response systems rate against the intent of the law as expressed in the Clean Water Act.

1. The CWA establishes "*it is the national policy that the discharge of* ***toxic pollutants*** *in* ***toxic amounts*** *be* ***prohibited***"[14] [emphasis added].

2. ***Toxic pollutant*** defined: Toxic pollutants, a subset of hazardous substances, include pollutants that "after discharge and upon exposure, ingestion, or inhalation … [by] any organism" will "cause death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions, … or physical deformations in such organisms or their offspring" (33 U.S.C.A. § 1362).[15]

3. **Dispersants** (Corexit 9527, 9500, etc.) **contain toxic pollutants**, which were applied in **toxic amounts** in the Gulf of Mexico, which adversely affected human health and marine life.[16]

4. ***Toxic amounts*** defined: Relative to a multitude of environmental and other factors, "*any degree of harmful impacts to any life form by exposure*" would be a good working definition for the CWA expression of *toxic amounts*. Prior to May 2010, the EPA had no clear-cut guidelines for the determination of what would constitute "toxic dispersant amounts." Further, the Agency has admitted that long-term effects of dispersants on aquatic life are unknown.[17] In June 2010, in response to public concerns and reports of resultant illness over the use of Corexit dispersants in the Gulf of Mexico, the EPA conducted short-duration tests on an emergency basis to determine the *least toxic* dispersant to use and then modified toxicity threshold levels related to the application of dispersants.[18] Just prior to this, BP had also responded to the EPA's request to find a less toxic dispersant.[19] The public was then reassured by the EPA that the toxicity range of Corexit 9500 recommended by BP, fit within the LC 50[x] toxicity range for aquatic organisms of >10–100 ppm (parts per million), deemed "slightly toxic" per EPA's "five-step scale of toxicity categories used to classify *pesticides*" (see page 8).

With respect to this criterion, a lower toxicity number indicates a more toxic compound; thus, between 10 and 100 falls within a range considered *slightly toxic* by the EPA (Corexit 9500 was found to be in a range of 25-130 ppm). It needs to be understood however, that these toxicity thresholds are based on what amount of dispersant it takes to kill 50% of aquatic organisms in a given vicinity with a one-time exposure over a 24-96 hour period of time. Longer-term exposures and the effects on all species, their reproduction, general health and impacts on the food chain were not cited or determined which has raised questions and debate within a variety of scientific institutions conducting research in this area. It should also be noted that adding dispersants to the toxic compounds of oil, raise the overall level of toxic effects on human, marine and other species.

We question how nearly 2 million gallons of a dispersant containing 57 chemicals applied on the surface and subsea for a protracted period of time in a broad area could be deemed *not toxic amounts* and/or *slightly toxic*. Subsequent studies cited by the EPA and NOAA still express a noncommittal position on this point with the long-term fate of the parent components mixed with the released crude oil still unknown.[xi]

x. **LC 50**. *LC* = lethal concentration. *LC 50* is the concentration of a substance that is lethal to 50 percent of the test organisms in a specified time period, typically 48 or 96 hours. (See also page 22, Toxicity Values chart.)
xi. See Proceedings of the National Academy of Sciences (PNAS) Special Feature: "Science in Support of the Deepwater Horizon Response" and other citations listed in this paper.

Ecotoxicity Categories for Terrestrial and Aquatic Organisms

Toxicity Category	Avian: Acute Oral Concentration (mg/kg)	Avian: Dietary Concentration (ppm)	Aquatic Organisms: Actue Concentration (ppm)	Wild Mammals: Acute Oral Concentration (mg/kg)	Non-Target Insects: Acute Concentration (pg/bee)
very highly toxic	<10	<50	<0.1	<10	
highly toxic	10-50	50-500	0.1 - 1	10 - 50	<2
moderately toxic	51-500	501-1000	>1 - 10	51 - 500	2 - 11
slightly toxic	501-2000	1001-5000	>10 - 100	501 - 2000	
practically nontoxic	>2000	>5000	>100	>2000	>11

EPA Established Thresholds Five-Step Scale of Toxicity Categories

(EPA toxicity thresholds scale can be found at http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm#Ecotox, and EPA Dispersant Toxicity Testing study at http://www.epa.gov/bpspill/reports/ComparativeToxTest.Final.6.30.10.pdf.)

Common sense would indicate that when introducing any chemical substance into a freshwater or marine ecosystem that is not native to that environment (for instance, crude oil or hydrocarbon-based dispersants), any toxicity level other than **nontoxic** would be of concern for the health of the local environment, let alone potential impacts on the regional human populations. For example, according to the New Jersey Department of Health, the presence of 2-butoxyethanol (a surfactant ingredient in Corexit 9527 and evident in 9500 per EPA 1999 NCP Notebook) has no *nontoxic* range.[20] The MSDS (Material Safety Data Sheet) states clearly: "*Do not contaminate surface waters* [with this product]."

The CWA establishes "*it is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited.*" … Prior to May 2010, the EPA had no clear-cut guidelines for the determination of what would constitute "toxic dispersant amounts." Further, the Agency has admitted that long-term effects of dispersants on aquatic life are unknown.

5. The CWA and subsequent regulations (OPA 90[21] and 40 CFR[22]) call for the design of plans and actions that result in the ***REMOVAL*** of hazardous waste and toxic pollutants from the environment. The EPA and Coast Guard are the two primary agencies responsible for initiating, managing, and overseeing appropriate *removal* actions.

6. The now obsolete but primary response method of **dispersant** application, amounts to **using toxic pollutants to treat toxic pollutants**—a primitive and counterproductive action that increases the toxicity of a spill by a factor of 10x or greater.[23] The mechanism of action of chemical dispersants, such as Corexit, is as a detergent. Detergents provide a solubilizing action, similar to a solvent or soap, to make oil soluble in water. The greatest immediate impact of the use of a chemical dispersant, such as Corexit, is to make the normally insoluble oil "disappear" by "dissolving" it in the water column. While the oil contamination is not seen visually by the naked eye, it is nevertheless still present in the environment and can be readily detected by scientific instrumentation. This "solution to pollution by dilution" is inconsistent with the original purpose of the Environmental Protection Agency and its responsibility for Clean Water Act enforcement. In other words, chemical dispersants render the containment or removal of spilled oil impossible by making (normally) separated oil and tar-like phases soluble in water to result in maximum dilution and "dispersion" of the oil. In addition, the detergent chemical interaction from dispersants applied to a spill can act as a biocide by disrupting or lysing[xii] the cells of biological organisms and bacteria that come into contact with these dispersants.

xii. **lyse**. To cause dissolution or destruction of cells by lysins. **lysins**. Antibodies or other agents that cause red blood cells or bacterial cells to break down.

Detergents are commonly used in laboratory and scientific research to disrupt the integrity of or dissolve (lyse) biological cell walls to release cellular contents for use in the laboratory. The effect of cell lysing is to liquefy cell wall membranes, resulting in cell death. Thus, chemical dispersants are not designed to detoxify or remove oil from the environment; they solubilize it and alter the natural biological mechanisms and defenses that marine and other life forms have against toxic chemicals increasing exposure risks from the bottom to the top of the food chain over scores of years. Human, mammalian and all marine life forms will more easily uptake toxins associated with oil when it is treated with dispersants. These chemicals also hinder nature's own oil-eating microbes.

Using toxic pollutants to treat toxic pollutants [is] a primitive and counter-productive action that increases the toxicity by a factor of 10x or greater. … The detergent action provided by chemical dispersants … can act as a biocide by disrupting or lysing the tissues of biological organisms. … The effect of cell lysing is to liquefy cell wall membranes, resulting in cell death.

As covered above, studies have confirmed that oil plus its associated chemical dispersants remain in the environment/water column for extended periods of time, resulting in adverse impacts on flora and fauna for up to 20 to 30 years, as occurred after the Ixtoc and Valdez spills.

7. Moreover, the *de facto* sole-sourcing and preauthorization of dispersants (large stockpiles of Corexits dominating contingency plan staging at the time of this writing), are <u>in effect</u> *sanctioned by* the EPA and USCG and other emergency response agencies to the exclusion of other less-toxic products. This, which is in operation currently, is an illegal procurement authorization of sole-sourced proprietary product categories owned by private companies. (The US government is required to foster free and open competition of products it uses to implement the CWA.) The National Response Team system overseen by the US Coast Guard and EPA grades and lists Oil Spill Response Organizations (OSROs) based on stockpile volumes and capacity for deployment of chemical dispersants as one of its main criteria. Hence, cleanup companies are awarded contracts on this basis as an important factor in their qualifications. It should be noted that numerous manufacturers of less toxic products have experienced arbitrary regulatory hurdles of such huge proportions that many years of work, including meeting expensive EPA test requirements, have only resulted in closed doors for suppliers/companies ready to deploy these less harmful alternatives. Furthermore, this bureaucracy has also made it difficult for On-Scene Coordinators (OSCs) to request usage of dispersant alternatives (such as Bioremediation *EA Type*) already on the NCP Product Schedule, since these are outside the "long-established system," with no clear-cut protocols for requesting or deploying such an agent.

The US Interagency Coordinating Committee on Oil Pollution 2010–2011 Research Report (ICCOPR), 2012 Biennial Report to Congress,[24] stated: "*Some use the BP Deepwater Horizon oil spill response to suggest that oil spill technology has not changed since* Exxon Valdez*; however, a closer examination … suggests otherwise.*" The report defends and asserts that the BP Macondo spill response was successful using "*effective techniques*" and "*science-based decision protocols*." While many aspects of this response represented a mammoth feat and genuinely sincere efforts by many competent people, there are a large number of professionals, scientists, and industry leaders who have observed that these assertions of '*successful science-based cleanup protocols*' are contrary to their aftermath which show resulting damage to the seabed, marine life, fisheries, wildlife, and the public's health and area livelihoods. This inarguably mandates major changes in methodology. At minimum, the wide chasm in differing views suggests contrary facts that require independent investigation and reconciliation.

To their credit, the plans expressed in the ICCOPR Report to Congress also emphasized "*the Interagency Committee is committed to expanding our knowledge and tools to meet future oil spill response challenges.*" All concerned should welcome that open invitation and should be committed to providing expanded knowledge, working in tandem with this national committee.

The preapproval status bestowed upon Corexit, the immediate authorization of its deployment in response to the BP oil spill emergency, and finally, its use being an integral part of nationwide response planning (in which it is staged and ready for deployment in all US waters) are a clear violation of the Clean Water Act in many respects.

8. The CWA was weakened in 2006 by two Supreme Court decisions (2001 and 2006), which established precedents resulting in reduced enforcement of the law.[xiii] The EPA and the Army Corps of Engineers, as a result of these court decisions, changed their policies and abandoned more than 500 Clean Water Act cases being pursued, which cast doubt on how to assess what bodies of water might fall under CWA protections.

Oil spills may result in only temporary disruption to the company and industries that cause them, but they are permanent injuries for the rest of us. The purpose of the Clean Water Act is to protect us and future generations from irresponsible actions that do not take into account the long-term impacts.

It is ironic that the penalties for an oil spill are partially calculated by counts. How many dead turtles and dolphins? How many square miles of oil sheen? Penalties based on "*quantity visually gone*" encourage practices like the use of dispersants rather than incentivizing nontoxic solutions that completely remove the oil and all its toxic compounds. Open discussion between industry and regulatory agencies to review how these penalties are calculated would be an important step in refocusing efforts on effective cleanup measures.

In light of the above, a restoration and revitalization of the Clean Water Act is in order.

---

xiii. See cleanwateraction .org article "How the Clean Water Act Was Weakened" at http://cleanwateraction.org/mediakit/overview-clean-water-restoration-act-2009.

A Star Player on the Sidelines: How (Mis)Guidance Closed the Door

After reviewing and grading the interagency response to the BP-DWH oil spill, the National Oil Spill Commission,[25] along with the Government Accountability Office and EPA's Inspector General,[26] have expressed a priority to modify the NCP[27] in light of BP-DWH lessons learned.

LAEO conducted an analysis of existing guidance currently in use by the response community. This analysis revealed that current interagency documents guiding National, Regional, and Area Response Teams in their oil spill response planning, are missing considerable information on alternate cleanup technologies, specifically *bioremediation guidance*.

For instance, the NRT Science and Technology Committee Bioremediation Fact Sheet of May 2000 (a pivotal guidance paper issued for federal On-Scene Coordinators and Regional and Area response officials and professionals) has not been updated since 2001, despite substantial advancements made in this field.[28] This guidance document is missing information on the different bioremediation processes and incorrectly classifies each time as <u>*identical*</u>, when one of the three categories (*Enzyme Additive Type*) has an entirely different mode of action and natural processes. Thus, going into the BP blowout disaster, we had a misidentification that grouped an entirely different type of agent with general bioremediation products classified as "final-stage cleanup" agents; which resulted in the elimination of a nontoxic *first-response bioremediation technology* from the response selection process and tool kit for the BP spill. Liken this to the stigmatization of a star football player left off the playing field based on a biased opinion, not fact. This "first string" exclusion of a viable option for use on the BP oil spill—*NCP-listed Bioremediation Agent Enzyme* [xiv] *Additives [EA] Type*—was an unfortunate arbitrary.

So herein lies the problem: When this viable nontoxic alternative to dispersants was presented to the OSCs and other stakeholders charged with selecting the first-string response during the BP oil spill emergency, they kept it out of the game.

In hindsight, the consequences of inadequate and out-of-date guidance of this sort were very significant, as key decision makers in the EPA and Coast Guard were basing their decisions on outdated information in their manuals, which in fact contain language discouraging the use of any such product as a first-response method for a spill on open water.

Further, this out-of-date NCP Bioremediation Guidance has filtered down and been incorporated into NOAA, Coast Guard, and all Regional and Area Response Team guidance, procedural, and training materials. This has consequently set an erroneous "science-based" precedent, mistakenly equating all three bioremediation agent categories as "finishing-up products,"[xv] with limited and restrictive use after a spill has been treated with dispersants and/or otherwise contained. Clearly, two of the bioremediation cleanup agent categories on the NCP Product Schedule are inappropriate for first-response application in open water; however category *EA Type* is a nontoxic first-

xiv. **enzyme**. A biological molecule that increases the rate of chemical reactions. Enzymes are responsible for the thousands of chemical interconversions that sustain life.

xv. **finishing-up product**. A term used to describe oil spill cleanup products that cannot successfully address fresh oil because of the oil's high level of toxicity and/or other characteristics and are not deemed appropriate in certain types of environments.

response enzyme-based oil spill cleanup system containing no live microbes, with a mode of action that swiftly detoxifies and nullifies the harmful aspects of the oil with an end point of removing a near 100% of the pollutants from the environment, greatly surpassing chemical dispersant methods.

So herein lies the problem: When this viable nontoxic alternative to dispersants was presented to the OSCs and other stakeholders charged with selecting the first-string response during the BP oil spill emergency, they kept it out of the game; and even when it was field tested and requested by numerous state officials, the error in classification caused confusion, keeping this star player off the field.

This publication sets forth the full text of recommended corrected guidance that would have put a viable nontoxic remediation technology solution on the table. (See pages 14–19.)

Bioremediation Agents, Common Misconceptions

BIOREMEDIATION is defined as *the use of microorganism metabolism to remove pollutants*. This is a technology that harnesses the natural character and action of certain beneficial microorganisms to return toxic sites to their pre-spill condition. This technique has existed and been utilized in Superfund land cleanups for decades. Those agents that support the natural process of the microorganisms *indigenous*[xvi] to the environment where the spill has taken place have the best record.

One of the broad concerns with bioremediation products is that many contain foreign microbiological cultures and/or nutrients that increase the growth rate of the microorganism population to unnatural levels. Most countries do not allow products containing foreign species or microbes to be introduced into their ecosystems due to unpredictable interactions and side effects that may occur and/or develop over time that would be detrimental to maintaining the delicate balance in these environments.

A pertinent example of this would be the cane toads that were brought from Hawaii to Australia in 1935 in an effort to control the native cane beetle destroying their sugar cane crops. The toads, being nonindigenous (not native to that region), adopted another food source, became a dominant in the environment anyway, but failed to control the beetle populations. The same is true for mongooses that were introduced to St. Croix, USVI, in the 1880s to control rat populations. Instead of doing this, they adopted ground-nesting birds and snakes as their key prey, significantly depressing those populations, and they themselves became dominant in the terrestrial community, having no impact on the rats. Hence, many oil spill cleanup bioremediation products have been placed in the same category as these ill-conceived introductions and have mistakenly been positioned with scary "bio-monster" connotations. Rightly so, there are concerns that these organisms could potentially alter and adversely affect the natural biodiversity when newly introduced into marine environments and coastal areas.

NCP-listed Bioremediation Agent *EA Type*, however, is a very different bioremediation process than what is generally defined and understood in the industry and contains no microbes.

The toads in Australia and the mongooses in St. Croix serve as good examples of why we should guard against the intrusion of nonindigenous species so that future problems can be prevented.

xvi. **indigenous**. A description of a living organism (plant or animal) that is native to a specific geographical region.

NCP-listed Bioremediation Agent *EA Type*, however, is a very different bioremediation process than what is generally defined and understood in the industry and contains no microbes. It is therefore important to understand precisely what this technique is.

As a first-response alternative that complies with the Clean Water Act by removing the oil rather than dispersing it and increasing toxicity, the 'EA' category has already been carefully considered and extensively tested, and, as such should be immediately preapproved as one of the primary methods of first response.

In July of 2012, US EPA Regional Response Team VI (RRT VI), which, along with RRT IV, oversees spill response plans in the Gulf of Mexico region, sent a request to their Science and Technology Committee to review their bioremediation guidance and evaluate Oil Spill Eater II (OSE II), a first-response bioremediation agent (*EA Type*). The product being nontoxic to marine species, wildlife, and responders has been in use for 25 years on over 24,000 spill cleanups in the United States and numerous other countries.

As part of this review, the OSEI Corporation CEO (S. Pedigo) lent his expertise to the EPA's RRT VI Science Committee as a member of their Bioremediation Guidance Review Subcommittee. The purpose of the subcommittee was to assist the RRT VI to update the Bioremediation Guidance for the NCP, the last review of which was done in 2001. What resulted was the discovery of important omissions in the EPA guidance documents, which contain no mode of action or proper definitions for the three main types of bioremediation: 1) microbiological cultures, 2) nutrient additives, and 3) enzyme additives. Subsequently, new guidance recommendations were compiled and submitted for federal and state interagency response network use by a team of LAEO Science Advisors in collaboration with Mr. Pedigo when he served on the RRT VI subcommittee.

To ensure this vital information is available, the authors have inserted the updated guidance, as proposed, in this paper.

It is strongly recommended this document be added to the National Response Team (NRT) and Regional Response Teams (RRT) Bioremediation Guidance for the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and that it be used to update Regional Contingency Plans (RCP) and Area Contingency Plans (ACP) on *EA Type* Bioremediation capabilities.

BIOREMEDIATION *TECHNIQUES, CATEGORY DEFINITIONS, AND MODES OF ACTION IN MARINE AND FRESHWATER ENVIRONMENTS* is presented herein and published for all industry stakeholders; oil companies, responsible parties, the Coast Guard, and state and local responders. For those engaged in the development of safer oil spill response plans, who are looking to minimize natural resource ruin while greatly reducing the cost of oil spill response, this newly updated guidance paper will likely provide welcome answers and solutions.

Important Note: The Lawrence Anthony Earth Organization has no financial ties of any kind to, nor does it receive any financial benefit from, companies that manufacture and/or sell the bioremediation oil cleanup products we advocate. As clearly covered throughout this position paper, LAEO's interest is purely to bring this information forth for education purposes and open up a global conversation to the result of implementing greatly improved spill response methodology.

BIOREMEDIATION TECHNIQUES, CATEGORY DEFINITIONS, AND MODES OF ACTION IN MARINE AND FRESHWATER ENVIRONMENTS FACT SHEET

(Originally compiled to update and revise RRT IV Spill Response Guidance, *Types of Bioremediation* Section and *Bioremediation Response Plan Appendix D*, in coordination with RRT VI Science and Technology Committee, who called for revisions of this material. Original NRT/RRT material quoted herein is *italicized* to differentiate from proposed revisions or additions.)[1]

Recommended Revisions by:
Steven Pedigo, (acting as RRT 6 Science and Technology Sub-Committee Appointee)
Marynette Herndon, Environ Eng, REM, CHMM
Paul W. Sammarco, PhD

Updated September 2014

The original purpose of this Fact Sheet was to update and supplement the US National Response Team (NRT) Science and Technology Committee's *Bio-remediation in Oil Spill Response Fact Sheet* published in May 2000 and Regional Response Team (RRT) Bioremediation Response Plan guidance issued for On-Scene Coordinators and oil spill response professionals. Although existing NRT and RRT technical information covers important facts about bioremediation, this material does not adequately define and differentiate among the three primary types of bioremediation categories and their attendant modes of action. This is particularly important because their respective efficacies require precise application parameters, which vary between target environments and types of oil/hazardous spills to which they are applied. While currently issued material designates bioremediation agents to be suitable only as *finishing or polishing tools*, with expressed limitations, this '*polishing off*' designation is not consistent with the advance mode of action for one of these categories, Bioremediation *Enzyme Additive Type (EA)*. With its multifaceted mode of action, *EA Type* overcomes the earlier designated limitations and concerns reclassifying it as a *first response* tool with much broader capabilities.

The following information is provided to clarify and simplify the OSC decision-making process when considering the three bioremediation categories and evaluating their appropriateness in the cleanup strategy for a spill.

NCP PRODUCT TYPES LISTED

The three Bioremediation Agent Types listed on the US NCP Product Schedule are designated as follows:

Microbiological Cultures	(MC)
Nutrient Additives	(NA)
Enzyme Additives	(EA)

The first type (MC) constitutes a bioremediation process that utilizes *non*indigenous bacteria. While useful in controlled or contained environments, a prevailing concern with these types of products has been that the introduction of foreign species into a given eco system is unpredictable and might cause future problems that may not become apparent for some time. Additionally, as noted in NRT's May 2000 Fact Sheet, "*there is usually no reason to add hydrocarbon degraders unless the indigenous bacteria are incapable of degrading one or more important contaminants*". The second type (NA) comprises those agents that contain nutrients or fertilizers to support indigenous microorganisms already present in the spill environment. Both MC and NA types have been correctly regarded as inappropriate for use in open-water environments. See 2001 EPA Guidance *Guidelines for the Bioremediation of Marine Shorelines and Freshwater Wetlands*, which extensively covers appropriate usage of these two agent types. That information will not be repeated here except to provide definitions and mode of action summaries for comparison purposes to

1. Submitted to RRT VI Science and Technology Committee in August 2012. Although the chair of the committee conceded that key portions of this paper should be integrated into the revised guidance, as of the date of this research paper, that has not yet taken place. While facts about MC and NA Bioremediation Types have been covered in these NRT and RRT Fact Sheets, these materials completely omit any information and important facts on the NCP-listed EA Bioremediation Category and its mode of action, which are critical to accurate decision-making using science-based protocols.

differentiate the more complex and advance mode of action of *EA Type*.

The third type (EA) is appropriate as a first-response tool in open water, intertidal zones and sensitive estuary ecosystems, as well as for soil, ground water remediation and contained environments. Experience with Bioremediation *EA Type* in the field on actual spills has evolved in recent years with considerable technological advances in usage protocols giving it a wide applicability for oil spill response in fresh, brackish, and marine environments, under temperature conditions as low as 28°F. The mode of action of this type will be reviewed in detail here.

CONTEXT

"Many compounds in crude oil are environmentally benign, but significant fractions are toxigenic or mutagenic. The latter are the ones we are most interested in removing or destroying in an oil spill. Bioremediation is a technology that offers great promise in converting the toxigenic compounds to nontoxic products without further disruption to the local environment."

The primary reason for cleaning up oil spills is to reduce or eliminate the toxic and/or harmful components, thus enabling the survival of flora and fauna, including single-cell organisms, in each niche of the food chain. Although chemical dispersants commonly used today eliminate the visual and other damaging aspects of the spill on the surface, the spill's toxicity problem remains in the environment and at times, is worsened by the adding of chemicals contained in dispersants. The goal of the bioremediation process is to convert toxic compounds in oil/hydrocarbon-based material to nontoxic such as CO_2 and water, thereby permanently removing oil/hydrocarbons from the environment and returning the affected spill area to pre-spill conditions.

Herewith, the three main types of bioremediation are further defined, along with their modes of action:

Essential facts stated in the ***May 2000 NRT SCIENCE AND TECHNOLOGY COMMITTEE Fact Sheet: Bioremediation in Oil Spill Response:***

"Several factors influence the success of bioremediation, the most important being the type of bacteria present at the site, the physical and chemical characteristics of the oil, and the oil surface area…

"Effective bioremediation requires that

1) nutrients remain in contact with the oiled material, and

2) nutrient concentrations are sufficient to support the maximal growth rate of the oil-degrading bacteria throughout the cleanup operation."[2]

CATEGORY TYPE MICROBIOLOGICAL CULTURE ADDITIVES (MC)

As covered in NRT Science and Technology Fact Sheet, "… *Bioaugmentation*" *is the process by which "oil-degrading bacteria are added to supplement the existing microbial population.*"

DEFINITION

"Microbial agents are concentrated cultures of oil-degrading microorganisms grown on a hydrocarbon-containing medium, which have been air or freeze-dried onto a carrier (e.g., bran, cornstarch, oatmeal). In some cases, the microorganisms may be colonized in bioreactors at the spill site. This type of agent is intended to provide a massive inoculum of oil-degrading microbes to the affected area, thereby increasing the oil-degrading population to a level where the spilled oil will be used as a primary source of food for energy. Addition of oil-degrading bacteria has not been shown to have any long-term beneficial effects ...over and above bio-stimulation of already present oil degraders."

2. Bioremediation (Types MC and NA) for open-water spills is not considered to be appropriate because of the above two requirements. When nutrients are added to a floating slick, they immediately disperse into the water column, being diluted to near-background levels (with the exception of NCP-listed EA Type which binds to fresh or weathered hydrocarbons/oil, and has recently demonstrated an 80 percent rate of reduction on Macondo Block, La., sweet crude containing Corexit, per BP Biochem Strike Team leader D. Tsao, LSU R. J. Portier, and L. M. Basirico, *Laboratory Screening of Commercial Bioremediation Agents for the Deepwater Horizon Spill Response*, March 3, 2011).

MC TYPE MODE OF ACTION

Bioremediation Agent Type MC mode of action utilizes non-native cultures of microorganisms to address a spill.

Bioaugmentation is considered to be a process used as a "polishing-up" or "finishing" response tool because the microbial action is too slow at converting fresh oil to less harmful components since its toxicity concentrations are initially too high.

When foreign microorganisms are exposed to an oil or hazardous spill, they attempt to release enough quantities of biosurfactants to detoxify and insulate themselves from the spill so as not to be adversely impacted by the spill's toxicity. The oil-degrading bacteria (both indigenous or nonindigenous) produce enzymes to develop protein-binding sites, which permit the bacteria to convert the molecular structure of the hydrocarbons to one that can be used as a food source.

While bio-augmented bacteria are taking their time to acclimate to the newly available oil, temperature of the environment, pH, and available nutrients, other environmental factors may produce adverse conditions that can forestall the breakdown action. These factors, along with the unknown time frames associated with their acclimation process, are at least partially responsible for the uncertainty associated with using Bioremediation *MC Type* as a first response cleanup methodology.

MC Type should only be used where there is very little water movement in a contained environment. Water movement causes the agent to dilute to ineffective levels incapable of supplying sufficient population numbers to produce enough biosurfactants and enzymes to start the breakdown of the molecular structure of the hydrocarbons.

Next to the toxicity of the spill, and a questionable ability to compete with indigenous bacteria already acclimated to the target area, indigenous bacteria are often competitively superior. The use of nonindigenous bacteria in most countries is not permitted due to the uncertain effects of introducing them into sensitive environments.

Bio-augmented bacteria developed specifically for fresh water must be used in freshwater settings only. Products containing saltwater bacteria can only be utilized in salt water.

MC Type bioremediation is best used on closed and/or controlled environments and should not be considered effective in open-water environments.

CATEGORY TYPE
NUTRIENT ADDITIVES (NA)

As covered in NRT Science and Technology Guidance, this next category (NA)—"*bio-stimulation*"—is a process "*in which nutrients, or other growth limiting [sic],* (suggest 'enhancing') *substances, are added to stimulate the growth of indigenous oil degraders*."

DEFINITION

Nutrient Additives are bioremediation agents that "*contain nitrogen and/or phosphorous as the primary means to enhance the rate of growth of indigenous oil-degrading microorganisms. This type of agent is intended to increase the oil-degrading biomass already present in an affected area to a level where the oil will be used as a primary source of food or energy. Because the natural environment may not have sufficient nutrients to encourage bacterial metabolism and growth, extra nutrients may be required. The purpose of this type of agent, therefore, is to provide the nutrients necessary to maintain or increase microbial activity and the natural biodegradation rate of spilled oil.*"

NA TYPE MODE OF ACTION

The NA mode of action involves the general use of nutrients or fertilizers that contain various volumes of nitrogen and phosphorus. "*Effective bioremediation requires nutrients to remain in contact with the oiled material...*".

Given the nutrients remain at high enough levels, the native microbes enhanced by them will need time to secrete biosurfactants to attack the molecular structure of the spill by solubilizing the oil/hydrocarbons, emulsifying the spill and increasing the oil-water interface. This helps to detoxify the hydrocarbons to a point where enriched indigenous bacteria can utilize the spill as a food source.

It can be difficult to apply nutrients or fertilizers to enhance oil-eating microbe population growth in a spill area containing toxic oil. Many microbes indigenous to the spill environment are initially weakened and or killed by the toxicity of the oil. And, because of the oil's toxicity, the nutrients are usually precluded from enhancing the remaining indigenous microbes.

Further, supplying nutrients or fertilizers in concentrations necessary to enhance oil-degrading bacteria without increasing the nitrogen levels to the point where they become toxic to aquatic life is a major problem. It is also difficult to contain or bind the nutrients or fertilizers with the oil in windy and otherwise undesirable weather conditions that generate wave and turbulent water motion.

The process of enhancing indigenous organisms with nutrients or fertilizers with the expectation that they will secrete biosurfactants and enzymes in sufficient quantities to catalyze the bioremediation process is unpredictable and often takes a protracted period of time.

Bioremediation category NA can be effectively used where there is little tidal flush and where the oil has weathered reducing its toxicity to the point that indigenous bacteria can survive.

CATEGORY TYPE ENZYME ADDITIVES (EA)

Although the NRT and RRT guidance documentation addresses the MC and NA bioremediation types in the 2001 *Guidelines for the Bioremediation of Marine Shorelines and Freshwater Wetlands,*[3] this guidance does not sufficiently detail the mode of action of *Bioremediation EA Type*.

DEFINITION (*EA TYPE*)

*"Enzymatic agents are biocatalysts that are designed to enhance the emulsification and/*or solubilization of hydrocarbon-based chemicals/ crude oil to *make it more available to microorganisms that can utilize such as a source of food or energy. These agents are generally liquid concentrates that may be mixed with* bio*surfactants and nutrients manufactured through fermentation. This type of agent is intended to enhance biodegradation by indigenous microorganisms."*

EA TYPE MODE OF ACTION [4]

Enzyme Additive Bioremediation is a *system* appropriate for use in open/moving water (fresh, salt, and brackish), marsh/estuaries, shoreline, and soil environments. Its complex mode of action begins by detoxifying the oil and eliminating the harmful characteristics of an oil spill by employing naturally derived biosurfactants which act to rapidly emulsify the contaminants enabling multiple enzymes to move in creating binding sites on the contaminant. The indigenous bacteria then feed on the nutrients included in the *EA Type* formula enhancing their growth and colonization process.

The biosurfactant action eliminates the adhesion properties of the oil, usually within the first 5 to 30 minutes (depending upon temperature and specific gravity). The emulsified oil will continue to float near the surface, thereby eliminating any secondary impact to the water column and seabed and completely avoiding any dissolved oxygen (DO) risks during the process. With the toxicity and adhesive properties eliminated, wildlife that may come in contact with the emulsified hydrocarbons will not become coated in oil, and oil adherence to marsh, shorelines, sands, and man-made structures is greatly reduced. Flammability is eradicated rapidly, protecting ports, harbors, and oil/gas platforms from potential explosion hazards associated with fuel spills.

---

3. 2001 EPA Guidelines for the Bioremediation of Marine Shorelines and Freshwater Wetlands, http://www.epa.gov/osweroe1/docs/oil/edu/bioremed.pdf. Note that this guidance does not cover EA Type use specifically, nor does it address open water application of such, hence it inadvertently precluded it from consideration by OSCs.
4. As of September 2014, there is only one product on the NCP list that falls under this Bioremediation Agent Type EA classification: B-53—EA—OIL SPILL EATER II; thus, descriptions above regarding the mode of EA interaction at this time are related solely to this EA product. Any newly added *EA Type* listings would require review and validation for being categorized under this mode of action.

DILUTION FACTOR, WAVE MOTION AND CURRENTS

A further difference in Bioremediation *EA Type* is that its numerous enzymes and other constituents attach themselves to the hydrocarbon molecules forming protein-binding sites and eliminating dilution issues from wave motion and current-prone environments. These sites become safe mediums where oil-eating microorganisms can reside. The multiple enzymes also act as a catalyst to accelerate the biodegradation process by inducing the indigenous bacteria to more rapidly ingest the detoxified oil/hydrocarbons as a food source. The EA category contains ingredients that cause the agent's constituents to remain in contact with the spilled oil/hydrocarbons during the remediation process.

FATE OF *EA* TYPE

Over ensuing days or weeks (again, depending on temperature), nutrients in the agent rapidly facilitate an increase in indigenous bacterial populations. The enhanced microorganisms consume the detoxified hydrocarbon emulsion, digesting the oil and converting it to CO_2 and water—permanently removing the spill from the environment. As covered in the NRT/EPA May 2000 Bioremediation Fact Sheet, when microorganisms break down petroleum hydrocarbons, progressive oxidation takes place leading to a reduction of the different toxic compounds that make up oil. The combination of biosurfactants, nutrients and more than 150 different types of enzymes in the *EA Type* agent form a system that attract native microorganisms to the hydrocarbons which eventually convert the spill to a harmless carbon dioxide and water. The complex process could be likened to biological processes associated with the human or other life forms' digestion of food. As oxygen, combined with the other agent ingredients is added to the oil compounds, they become more water soluble, less toxic and, finally, break up their molecular structures and are fully digested. This process will not cause environmental damage or toxic effects at any stage to nearby organisms. Furthermore, the rate of dilution from the tidal or open water wave and current motion is so great that any amounts of the benign constituents entering the food chain are likely to be negligible. Thus, the effect of biochemical end products from the easily metabolizable compounds in oil will be insignificant in the environment.

Without category EA support, this natural process may take up to 30 years or more to reach the end point of a complete degradation of an oil spill; and the lingering toxicity of the oil would remain in the environment for that duration.

SHORELINES / MARSHES

An additional benefit is that one can use the EA agent on near shore waters and environments as well as deep water locations, unlike dispersants, which are usually restricted to three miles off shore in waters 10 meters deep or greater due to their toxicity. When a spill makes landfall or contaminates near shore areas, *EA Type* can be safely applied to lift the spill off the marsh grass (or sandy beaches or shorelines), greatly reducing the time that sensitive ecosystems and people are exposed to the toxic compounds in oil.

The use of *EA Type* does not deplete O_2 since the oil it is applied to remains buoyant (able to float) and the nutrient and enzyme ingredients use atmospheric O_2 for their biochemical interactions.

There are no known trade-offs, deleterious effects, or collateral damage associated with the EA method. And, as is the case with chemical dispersants, there is no limited time window for its application to be effective.

CLOSING COMMENT

The three types of bioremediation and their modes of action (described above) have been detailed here to help responders understand how these agents will interact with a spill. The different types and their modes of action are clearly independent of each other, even though their stated end point, in principle, is the same. The ability to reach that end point, and the amount of time it takes to do so, is observably different.

REFERENCES

Alleman, B. C., and E. A. Foote. 1997. *Evaluation of Amendments for Enhancing Microbial Activity in Soils from Site 18 at MCAGCC*, Twentynine Palms, California. Battelle, Columbus, OH. Performing Organization Report D.O. 1795. Sponsoring Agency Report TCN 96-026. February 7, 1997.

Bonner, J. S., and R. L. Autenrieth. *Microbial Petroleum Degradation Enhancement by Oil Spill Bioremediation Products*. October 1995. Report submitted to Texas General Land Office (Comparative analysis of 13 NCP Listed Bioremediation Products, EA Type PAH reduction efficacy exceeded MC and NA Types).

BP BCST D. Tsao, LSU R. J. Portier, and L. M. Basirico. March 3, 2011. *Laboratory Screening of Commercial Bioremediation Agents for the Deepwater Horizon Spill*

NRT SCIENCE AND TECHNOLOGY COMMITTEE Fact Sheet. May 2000. *Bioremediation in Oil Spill Response. An information update on the use of bioremediation*. US EPA.

US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory, Land Remediation and Pollution Control Division, 26 W. Martin Luther King Drive, Cincinnati, OH. Added bacteria seem to compete poorly with the indigenous population (Tagger et al., 1983; Lee and Levy, 1989; Venosa et al., 1992). Biostimulation alone had a greater effect on oil biodegradation than the microbial seeding (Jobson et al., 1974; Lee and Levy, 1987; Lee et al., 1997, Venosa et al., 1996).

US EPA. 2012. NCP Product Schedule. http://www.epa.gov/oilspill. http://www.epa.gov/oem/content/ncp/products/oseater.htm.

Zhu, X., A. D. Venosa, and M. T. Suidan. 2004. EPA/600/R-04/075 *Literature Review on the Use of Commercial Bioremediation Agents for Cleanup of Oil-Contaminated Estuarine Environments*. http://www.epa.gov/oem/docs/oil/edu/litreviewbiormd.pdf.

Zhu, X., A. D. Venosa, M. T. Suidan, and K. Lee. September 2001. *Guidelines for the Bioremediation of Marine Shorelines and Freshwater Wetlands*. US EPA.

Zwick, T. C., E. A. Foote, A. J. Pollack, J. L. Boone, B. C. Alleman, R. E. Hoeppel, and L. Bowling. 1997. *"Effects of Nutrient Addition during Bioventing of Fuel Contaminated Soils in an Arid Environment." In-Situ and On-Site*

Bioremediation 1: 403–09. Columbus, OH: Battelle Press.

***EA Type* References**

Bartman, Galen. *Oil Spill Eater Respirocity Evaluation CAI Lab. No. 3265*. July 1990. Additive [EA] has a meaningful and significant effect on decreasing the oil concentration and increasing the oxygen take up. [*Respirocity*: see http://en.wikipedia.org/wiki/Respirometry.]

Brown, Elvin E. University of Alaska Fairbanks. 1990. Bioremediation performed on PAHs shows extreme or great reduction in the target analytes using EA Type. Report of Exxon tested Bioremediation EA Type in 1989 at Florham Park, New Jersey, showing effective by a factor of better than 90% on the North Slope Alaskan crude oil from the *Valdez* spill.

Flores, M. en C. Gabriel Peneda, and Q.B.P. Norma Pescador Elizondo. 2002. Ecologia microbiana lab, University of Mexico—Instituto Politécnico Nacional, Escuela Nacional de Ciencias Biológicas. Efficacy test of EA Type on heavy (Maya crude) and medium-weight crude oil demonstrates significant reduction of PAHs (54% reduction in 30 days on the Maya crude, and medium crude reduced 80% in 30 days).

Louisiana State University, Department of Environmental Sciences. June 2011. *Characteristics, Behavior, & Response Effectiveness of Spilled Dielectric Insulating Oil in the Marine Environment*. For US Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE), Herndon, VA. http://www.bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/aa%283%29.pdf.

Merski, A. T. 1993. NETAC *Oil Spill Response Bioremediation Agents, Evaluation Methods Validation Testing, Discussion of Results*.

Resource Analysts, Inc. Subsidiary of Millipore. June 1990. References: 1) EPA SW 846, 3rd Edition. Determination of No Trace Elements and Chlorinated Hydrocarbons in EA Product.

Sowman, B. 16 July, 2012. Environmental Protection Authority New Zealand, Hazardous Substances Division. SOS # 1001797. Determination of the Status of Oil Spill Eater II—Non-hazardous.

State of Alaska. Legal Closure Letter. The soils have been remediated to the most stringent (ADEC) cleanup levels. 75–80, http://osei.us/tech-library-pdfs/2011/OSEI%20Manual_FINAL-2011.pdf.

State of New York. Groundwater remediation of heating oil by Alpha Geoscience with complete sampling and testing certified by NYSDEC. Summary and Results of In Situ Soil Remediation. Spill No. 95-16786. 80–86, http://osei.us/tech-library-pdfs/2011/OSEI%20Manual_FINAL-2011.pdf.

US Marine Corps at Twentynine Palms utilizing EA remediated tank washout and several types of fuels (including tretraethyl lead) to State of California acceptable levels, DOD Environmental Award. "Testing and Evaluation of Enzymatic Catalysis for the Remediation of Petroleum Contaminated Soils." October 1993. 66–68, http://osei.us/tech-library-pdfs/2011/OSEI%20Manual_FINAL-2011.pdf.

Ward, R. H. SRI San Antonio Texas. 1999. EA Type does not sink oil into water column or sediments. Swirl Flask Dispersant Effectiveness Test. SwRI Project 08-2326-088. Work Order 8783.

See modified citations and updated information from RRT VI at: http://gisweb.glo.texas.gov/atlas/atlas/misc_doc/rrt6_bio_position.pdf

Identification of Nontoxic Methods for Contingency Plans

The establishment and enactment of new contingency plans associated with remediation of oil spills (including those response plans submitted by oil companies requesting permits) is urgently needed, using methodologies other than application of chemical dispersants. The commencement and acceleration of new deep-water drilling in the Gulf of Mexico and the Beaufort Sea in Alaska, for instance, particularly in the absence of updated contingency plans in the event of a spill, is quite concerning. In other words, hundreds of permits have been issued since September 2010 with no significant change in spill contingency planning—other than more advanced deepwater dispersant injection systems that have been added to plans, which will produce a repeat of the BP-DWH toxic response.

The information presented here is for distribution to Regional / Area Committees and all stakeholders responsible for maintaining up-to-date contingency plans for safeguarding our aquatic, marine, and terrestrial environments. The article included regarding bioremediation category definitions and their modes of action, along with further information below, should overwrite previous guidance on bioremediation because it clarifies use of the Bioremediation Agent *EA Type* as a *first response* agent.

Bioremediation Agent Enzyme Additive Type can clearly serve as a first-response alternative to the use of chemical dispersants, which no longer have a place in modern-day oil spill cleanup in navigable waters.

NCP–Listed Bioremediation Agent (*EA Type*) as a Solution and Alternative to Chemical Dispersants

Independent investigation of *EA Type* is strongly recommended as a promising potential solution to oil spill response in deepwater drilling and difficult access environments, particularly as a first-response method for open-water oil spills, in lieu of chemical dispersants of any kind.

LAEO-STB has determined that this type of agent can clearly serve as a first-response alternative to the use of chemical dispersants, which no longer have a place in modern-day oil spill cleanup in worldwide navigable waters.

The US EPA is now being pressed to find safer response agents to replace these outdated chemical modes, which, when combined with oil pollutants, are more toxic than the oil itself and therefore contrary to the intent of the US Clean Water Act.[29] To reiterate, the Act stipulates that, for a response method to be utilized, it must **REMOVE** oil from the environment. Dispersants do not fulfill this requirement; in fact, studies have shown that use of dispersants prolongs the time that oil plus chemical dispersants remain in the environment, resulting in adverse impacts to flora and fauna for up to five years or longer.[30,31]

The good news is that there are developed protocols for identifying and assessing the degree of usefulness of spill-response products, and they are not complicated.

How Oil Spill Cleanup Products Should Be Assessed and Prioritized

The LAEO conducted nearly three years of research to identify methods for remediating oil spills that result in complete removal of a spill in compliance with the CWA and are less toxic than those currently used. It has also been working to gain the necessary authorizations for utilizing these more effective techniques to clean up the waters of the Gulf and its shorelines still impacted by the Macondo spill.

The first step in this search was to vet the applicable products already on the EPA NCP Product Schedule. A set of guidelines was developed by which to initially review listed products and determine their eligibility for use in all types of environments. No specific product category was being looked for, but rather, any of those that fell under the outlined criteria for desired effectiveness, as follows:

- Listed on the NCP Product Schedule.
- Swift and effective removal of the toxic constituents of oil, not just dispersal of it by solubilizing or dissolving it into the water column.
- Nontoxic with no destructive trade-offs associated with its application.
- Able to also detoxify chemical dispersants—e.g., the two types of Corexit that have been broadly used domestically and internationally.
- Using neither nonindigenous microbes nor genetically modified organisms.
- Complete scientific documentation substantiating the product's efficacy.
- A track record of success when used on actual spills or simulated environments.
- Pretested and screened as usable any place where water travels — open water, sandy beaches, marshes, etc., as a first-response method (i.e., predetermined as applicable in all US navigable water environments to enable rapid response without the need for assessment during an emergency).
- The manufacturer has sufficient quantities in stock and immediate production capabilities to handle a spill of significance.
- Its use and application must be economically reasonable and within acceptable ranges of expected remediation costs.
- Eliminates or significantly reduces the necessity for secondary cleanup, such as the cleaning or storing of boom and absorbents, removing tar mats formed by sinking the oil using dispersants, disposal of hydrocarbon-based material in landfills, or other methods of disposal.

The extensive search revealed only one oil spill cleanup agent that fulfilled all of these requirements—one under the Bioremediation subcategory EA on the NCP list: Oil Spill Eater II (OSE II). LAEO-STB continues to look for other products that fulfill these criteria but, as of the writing of this paper, the only product that met these guidelines thus far has been OSE II.

In response to a documentary film that LAEO produced to educate the public about bioremediation and to encourage researchers and companies with products that meet the above criteria to step forward,[32] several products were submitted for LAEO advocacy. Some, although promoted as "nontoxic," upon inspection were found to be at least as toxic as crude oil. Others had nutrient pollution issues associated with surface water applications.

New and innovative solutions utilizing all available technology are needed for the on-going situation in the Gulf of Mexico, as well as future hydrocarbon-based spills that will continue to cumulate and impact all the waters of the world. If we stay on the same track, we run the risk of collapsed fisheries, chemical-stressed water ecosystems worldwide, and progressively worsening human health issues.[33]

Characteristics of an Effective Solution—Feasibility Assessment Criteria

The protection of human health should be the foremost concern of any oil spill cleanup decision-making process. Human health is dependent upon the relative health of the surrounding environment; hence it is important to understand the criteria by which cleanup methods must be gauged as to their value and effectiveness. To reiterate, the primary reason for clean up of an oil spill or hazardous materials is to rapidly reduce the impact of their toxicity so that all living organisms can survive. And again, if even the smallest organisms can survive, then the ecosystem will be able to sustain itself all the way up the food chain.

Thus, it logically follows that recommended standards for the ideal technology or agent for use in cleaning up a hazardous spill would be these:

1. **Must swiftly** and thoroughly **detoxify** the oil or hazardous substances as a first step in order to protect the indigenous microbial populations and all life forms.

2. **Must nullify** the oil's **adhesive qualities** so that it does not stick to marine life, wildlife, marsh grass, rocky shorelines, sandy beaches, or seabed sediment.

3. **Must keep the oil on the surface** so that it can more rapidly be digested by indigenous microbes, utilizing existing airborne oxygen and protecting the 60 percent of marine life that resides in the subsurface area and seabed. (Note: This also makes it accessible for physical removal methods working in tandem with nontoxic agents.)

4. Understanding that nature uses surfactants[xvii] in the natural process of cleaning up an oil spill, an effective product **would not contain any toxic synthetic surfactants** such as are contained in both Corexit 9527 and 9500. By way of example, the LAEO-STB review found that Bioremediation *EA Type*/OSE II contains **non-toxic biosurfactants**. Comparing toxicity levels using established EPA standards cited earlier, Corexit 9500 had much higher level toxicity readings, for example 354 ppm for 9500 compared to OSE II which had a reading of 10,000 ppm for one of the most sensitive marine species tested (O. mykiss = steelhead trout); and note well, that the higher the number, e.g. 10,000, the lower the toxicity level. This means that Corexits are as much as 150 times more toxic than the bioremediation alternative. (See Toxicity Values chart pg. 23.)

5. Must have **a scientifically substantiated, predictable and positive end point** that can be standardly and consistently achieved from its application. For instance, one of the NCP-listed products LAEO STB researched had an end point that within a matter of days to, maximally, a few weeks, close to 100 percent of the oil would have been removed; consumed by indigenous oil eating microbes and thus converted into CO_2 and water—two benign substances—without any adverse side effects, or trade-offs related to its application, thereby protecting responders, wildlife, and marine life.

6. Its application must be **economically viable**—for example, comparable in cost to current methods and, ideally, significantly less.

xvii. **surfactant**. A substance that lowers the surface tension of water, making it easier for organic compounds to be dissolved in the water. There are toxic and nontoxic surfactants; i.e., chemical based with various degrees of toxicity, and plant/living-organism based = nontoxic. Surfactants may act as detergents, emulsifiers, foaming agents, and dispersants.

Aquatic Toxicity (ppm*) Comparison--Bioremediation EA vs. Corexits						
Environment Canada Tests					US EPA Tests	
Species	Oncorhynchus mykiss	Photobacterium phosphoreum	Gasterosteus aculeatus	Daphnia magna	Menidia (silverside fish)	Mysidopsis (shrimp)
Corexit 9500	354 (96hr)	0.065 (IC50)	not listed	not listed	25.2 (96hr)	32.23 (48hr)
Corexit 9527	108 (96hr)	not listed	103 (96 hr)	42 (48 hr)	14.57 (96hr)	24.14 (48hr)
Bioremediation EA (OSE II)	10,000 (96 hr)	5109 (IC 50)	not listed	10,000 (48hr)	8839 (96hr)	6698 (48hr)
Higher # = less toxic, lower # = greater toxicity						

* expressed in terms of LC 50 values except for IC 50 where noted. LC 50 = Lethal Concentration values in parts per million measuring level in which there is mortality with 50% of species being exposed over a specific period of time.

Toxicity Comparison, Environmental Canada and US EPA Tests, Bioremediation EA vs. Corexits (34)

The discovery of the existence of an *EA Type* bioremediation technology that actually worked and met every point of the above criteria, of which was also being used successfully in more than 40 countries was an unexpected godsend. Its results contrast strongly with those derived from dispersants predominantly still part of the NCP and designated for preauthorized use in US navigable waters. Additionally, the *EA Type* system costs are a fraction of other methods and would therefore represent an economic boon, not only to the responsible parties, who could avoid damage claims and heavy fines, but also to those living in the environment, reducing business disruptions with rapid cleanup, bringing a quick return to their livelihoods. In other words, in addition to preserving the health and safety of the waters, there would be little impact on tourism, coastal businesses, and fisheries.

The value of a product should be rated and characterized by how rapidly and thoroughly it meets the above criteria while introducing no additional toxicity to the scene already created by the hazardous spill.

Due to the many common misconceptions about bioremediation, and especially the subcategory *EA Type*, the LAEO-STB opted to include the above summary of its vetting process in this research paper as a useful means for screening spill-response methods.

Independent investigation of *EA Type* is strongly recommended as a promising potential solution to oil spill response in deep-water drilling and difficult access environments, particularly as a first-response method for open-water oil spills, in lieu of chemical dispersants of any kind. … To reiterate, the primary reason for cleanup of an oil spill or hazardous materials is to rapidly reduce the impact of their toxicity so that all living organisms can survive. And again, if even the smallest organisms can survive, then the ecosystem will be able to sustain itself.

Challenging Current Methods and Rethinking Oil Spill Response

Being willing to challenge and debate brings different views into the open to improve outcomes. To recap, as of the date of this writing, more than 250 permits[xviii] for new deepwater wells have been approved since the BP-DWH spill; yet response contingency plans required for the issuance of permits have not changed and continue to utilize outmoded toxic dispersants and other methods which do not fully clean up spills. To the Department of Interior's credit, this agency recently conducted independent comparative testing between dispersants and the NCP-listed *EA Type* bioremediation agent Oil Spill Eater II, finding it removed 67 percent of heavy oil in 30 days, while the dispersants demonstrated no removal capabilities at all. And in 2012, Regional Response Team VII conducted similar tests demonstrating a reduction of 72% indicating an eventual 100 percent removal capability of this *EA Type* agent.[35]

According to the Operational Science Advisory Team report initiated by the US Coast Guard, natural petroleum seeps release more than 17 million gallons (404,750 barrels) of oil into the Gulf of Mexico annually. Comparatively, the BP Deepwater Horizon oil spill released more than 211 million gallons (4.93 million barrels) over the first 87 days. Their statement that "*an estimated 25 percent of this volume was burned or collected, leaving the remainder available for natural attenuation or collection along shorelines*" appears to lightly regard the significant remainder of oil that has been left in the Gulf to do ongoing harm. Many scientists and experienced responders estimate that a far smaller percentage of the oil that was released into the Gulf has actually been removed from the environment. Assuming the official figures are correct—that 25 percent was burned or collected—this would still leave 1 million barrels (42 million gallons) of oil as a conservative assessment. Going by the USCG estimate, if 75 percent were left to natural attenuation, this would represent an area one inch thick covering 83 square miles. And given the fractured and faulted condition of the seabed floor around Macondo Block 252, it is expected oil will continue releasing from this site for up to 10 years or more.

More than 250 permits for deepwater drilling activities have been approved since the BP Deepwater Horizon spill; yet response contingency plans have not changed and continue to depend upon outmoded toxic dispersants …

The Coast Guard study arrives at this final conclusion: "*The degree and rate of weathering of Deepwater Horizon oil is still uncertain. Better understanding of the degradation processes of oil in the environment is still needed.*"

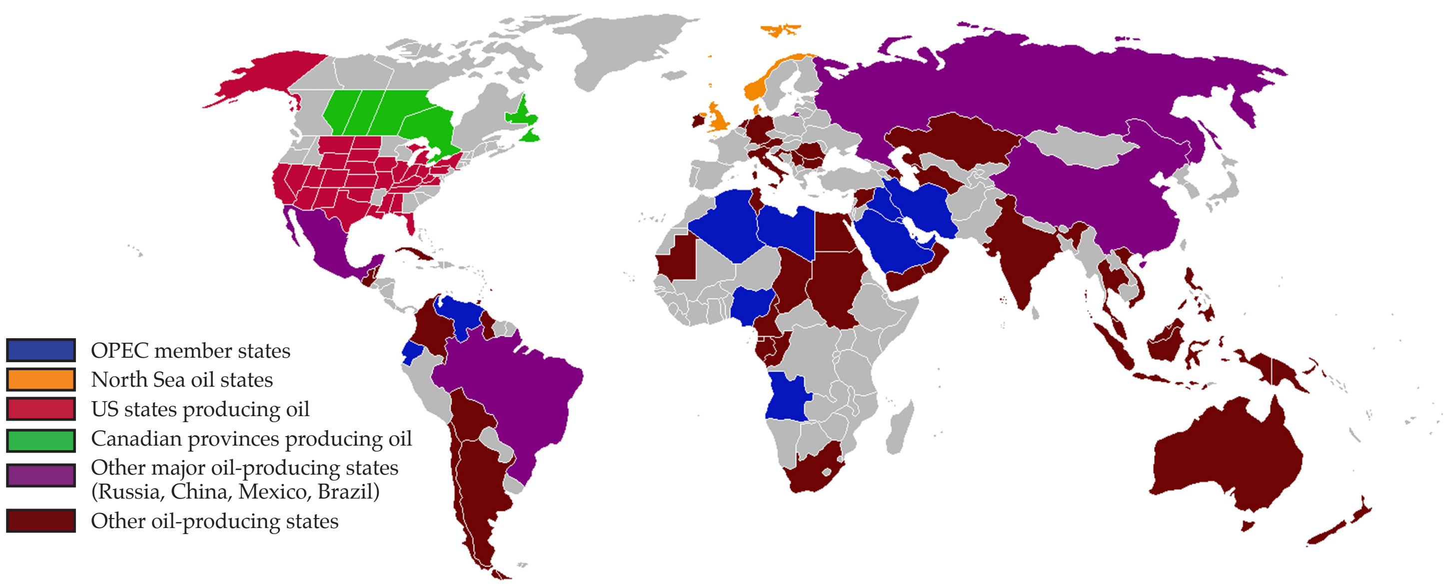
Proper assessments and protocols need to be developed for each *type* of Bioremediation Agent as to its suitability in terrestrial, coastal, freshwater, brackish, and marine environments. This would then result in the proper definitions and designations for the term *bioremediation* and recognition of the differences in and diverse functionality of the different types of bioremediation agents. All uses and classes of these agents would then be properly understood and precisely characterized, the information on which can then be readily accessed and used by multi-agency regulators, decision makers, and spill-response management structures. The lack of such will continue to act as a barrier to legitimate use of nontoxic remedies

xviii. Drilling permits data is at BSEE site: http://www.bsee.gov/Exploration-and-Production/Permits/Status-of-Gulf-of-Mexico-Well-Permits/. Also see graphic representation: http://www.geographic.org/deepwater_gulf_of_mexico/leasing_activity.html and, more importantly, continue the suboptimal course of inadequate response, denying relief to all flora and fauna exposed to industrial toxins.

It is incumbent upon all stakeholders, that **urgent revisions must be made to the National Oil and Hazardous Substances Pollution Contingency Plan in compliance with US laws.**

Industry professionals and response team decision makers at federal, state, and local levels tasked with updating their oil spill response capabilities should review material compiled by experts in the Bioremediation Technology sector who have demonstrated competence in factually cleaning up spills and hazardous waste, portions of which have been made available in this publication. Such engagement should result in identifying nontoxic solutions that comply with the Clean Water Act, resulting in improved response plans with a more certain end point of fully removed oil and contamination from the Gulf of Mexico and all US navigable waters.

According to the Operational Science Advisory Team report initiated by the US Coast Guard … *"The degree and rate of weathering of Deepwater Horizon oil is still uncertain."* … Given the fractured and faulted condition of the seabed floor around Macondo Block 252, it is expected oil will continue releasing from this site for up to 10 years or more.



(Source: en.wikipedia.org/wiki/File:Oil_producing_countries_map.png)

All oil-producing countries should review their spill contingency plans and adopt clean cleanup solutions.

A Final Comment on Dispersants — There are Better Water Cleanup Solutions

Dispersants are building a negative reputation in many countries outside the United States, with an aggregate of studies indicating their use can cause enormous natural resource destruction.

This stance is reinforced by the 33-year tracking of the outcomes of Ixtoc, Valdez, and other spills of significance, followed by the now unprecedented BP-DWH spill wherein the President's Gulf Oil Spill Commission called for a critical review of the response, strongly advising a reappraisal and update of the US NCP, with a better assessment of the efficacy of various dispersants and their associated trade-offs. This review included a request for updated guidance on Bioremediation Agents. Legislation is also being proposed in light of concerning discoveries made over dispersant use.

In August 2012, a coalition of US public health, wildlife, and conservation organizations filed a Clean Water Act lawsuit naming the US Environmental Protection Agency (EPA) for failure to make available science-based information on the toxicity levels of dispersants listed on the NCP Product Schedule.[36] This failure allegedly resulted in faulty decision making during the 2010 Gulf spill.

The Clean Water Act specifically calls for oil spill response to *remove* oil from the environment. Dispersants combined with other current methods have no means of completely achieving this.

Regulatory guidance unfortunately describes the use of dispersants in terms of "*being effective*" without defining what *effective* means. This phrase might imply a method that is successful in cleaning up a spill. However, cleaning up a spill (making the environment uncontaminated and removing the oil) is not the US EPA's definition in this situation. For a chemical dispersant to be included on the official NCP Product Schedule, the US EPA merely requires that the dispersant have an ability to sink 45 percent of the oil below the surface within 30 minutes after application.[37] This definition is not an acceptable standard for oil spill cleanup. It is, however, what is meant when the EPA describes dispersants as being "effective." The qualifications for being listed as a dispersant on the NCP Product Schedule do not include a requirement of having the capability of removing hydrocarbons from the environment; and as has been demonstrated, chemical dispersants do not have that capacity.

These concerns were aptly summarized by *The Nation*, citing a study conducted by Dr. J. H. Diaz published in the *American Journal of Disaster Medicine* in 2011.[38]

"Crude oil contains polycyclic aromatic hydrocarbons (PAHs), a group of more than 100 chemicals that are highly toxic and tend to persist in the environment for long periods. PAHs, some of which are human carcinogens, can bioaccumulate up the food chain (i.e., the toxins stored in the body of an organism are passed along when the body is consumed by a larger organism). Like VOCs, they target the skin, eyes, ears, nose, throat and lungs. But the EPA was not sampling for PAHs in the air until the very end of the spill."

Added to the oil was Corexit, "two types of which were used in the Gulf: Corexit 9527A and 9500. The first type contains 2-BTE (2-butoxyethanol), a toxic solvent that can injure red blood cells (hemolysis), the kidneys and the liver. The CDC has reported chronic and acute health hazards associated with it. Corexit 9500 contains propylene glycol, which can be toxic to people and is a known animal carcinogen. Both can bioaccumulate up the food chain. Toxipedia Consulting Services, a moderated wiki run by the Institute of Neuro-toxicology and Neurological Disorders, has found *'reports among Gulf residents and cleanup workers of breathing problems, coughing, headaches, memory loss, fatigue, rashes, and gastrointestinal problems [that] match the symptoms of blood toxicity, neurotoxicity, adverse effects on the nervous and respiratory system, and skin irritation associated with exposure to the chemicals found in Corexit.'"*

Non-Toxic Water Cleanup Solutions

As it is fundamental to all life, clean water will be the gold of the future. A vital target for any group dedicated to cleaning up the polluted waters of the world would be to identify and authenticate effective nontoxic cleanup technologies and get these officially designated for use and applied.

It will take collaborative action on the part of many professionals and science-based organizations to get this work done. It is not enough to add nontoxic solutions to current cleanup systems or tool kits; long-term survival requires retiring the offending agents, whether these be for chemical spills, ocean vessel discharges, pipeline, railroad, refinery accidents, fracking fluids or agents used for wastewater treatments.

Had federal agencies and BP officials been aligned with an intent to use nontoxic means—which current technologies do provide—to remove all possible oil from the Gulf waters, it would have saved BP billions of dollars and averted disastrous public-health consequences and long term damage to natural resources. One significant stumbling block to real change in oil spill response is the resistance to admitting that dispersants are not the best solution.

The Gulf of Mexico states were forced to take this known poison pill, which destroys natural resources and spreads the adverse impact of a spill to the water column, seabed, shoreline, and beyond (now proven by scientists who found Corexit in 80 percent of the pelican eggs tested on a migratory destination island in a Minnesota lake, all attributed to the use of Corexit on the BP-DWH spill[39]).

This situation calls for providing better tools for and educating key decision makers and all interagency response network members regarding available nontoxic methods of oil spill cleanup technology.

As of the writing of this paper, Bioremediation *EA Type* is the only agent on the NCP Product Schedule that met LAEO-STB guidelines. Other products submitted in future which prove they meet these minimum standards should be given full support, as well.

Cooperative Ecology™ - A New Worldwide Movement

One of the largest and most bounteous interdependent life systems in the world, the Gulf of Mexico, has been devastated by the Deepwater Horizon disaster added to the years of cumulative pollution pouring into the Gulf from various sources. The BP response required was greater than what had been prepared for, and the agencies of response were not equipped with strategies to adequately address it. Constrained by adherence to outdated guidance that advocates the use of dispersants as a preapproved cleanup method, decision makers, expecially OSCs were effectively hampered from having any other options for the selection of available alternatives and more workable solutions.

The past is behind and errors can be forgiven if action is taken by government, industry and private sectors to implement nontoxic solutions in oil spill remediation. But will it be done? It sometimes takes courage and a fearless approach to bring about change.

Renowned conservationist Dr. Lawrence Anthony, founder of the Earth Organization[xix], had a reputation for bold conservation initiatives, including the rescue of the Baghdad Zoo at the height of the 2003 US-led coalition invasion of Iraq, and his traverse into an off-limits and remote territory deep in the Congo jungle to negotiate with leaders of the infamous Lord's Resistance Army to get their help to protect the last living Northern White Rhinoceros. As an author of three popular non-fiction books dedicated to raising public awareness of how finite, vulnerable, and interconnected Earth's integrated systems of plant and animal life are, Anthony coined a new term in which LAEO bases its work: *Cooperative Ecology*.

The objective of Cooperative Ecology - is to generate improved science and policy that increases the survival potential and productivity for all interdependent life to a level of balanced abundance, guaranteeing mutual perpetuity.

Cooperative Ecology™ (CoEco) (*noun*) is defined as the study of the mutual interdependency and cooperation of all life forms and the material world. It is based on the premise that all life forms are interdependent and engaged upon the same objective—to survive—and are acting in mutual support of this objective for their joint perpetuation. The moment life forms, including man, fall away from the concept of mutual cooperation with all other life forms and the material world, their capability to survive diminishes and becomes less effective. CoEco includes the study of man's sciences in the light of this cooperative relationship of all life forms, and it determines the value of sciences on these principles. Whether sciences bring about a steady improvement for life forms and the material world or whether they create imbalances determines to what degree the sciences themselves are cooperating with life and, thereby, their relative value. The study includes, as well, ecological and economic policy and their impacts based on these principles. It is holistic, by necessity, and requires the interaction with, and study of, 1) the full spectrum of scientific methods and views; 2) all life forms and their interrelationships; 3) micro to macroeconomic and governmental policies; 4) religious influence; and 5) population systems. And it must, inevitably, study the interrelationships of each of the above points as they influence the environment.

xix. **Earth Organization**. The Earth Organization was renamed in memory of Lawrence after he passed away in 2012, now the Lawrence Anthony Earth Organization (LAEO).

Moving Forward

Unless we examine and seek an understanding of true data and engage in a worldwide effort towards truly achieving Cooperative Ecology as a necessity instilled in the minds and behaviors of mankind as a whole, life on earth, as we know it, will not sustain.

The objective of Cooperative Ecology is to generate improved science and policy that increases the survival potential and productivity for all interdependent life to a level of balanced abundance, guaranteeing mutual perpetuity.

Positive progress in achieving such an objective would be made by raising pollution removal standards up to the original intent of the Clean Water Act. This would require agreement, planning, and action by all members of industry and commerce that have the potential of creating oil spills, to only name and employ NCP-listed products that are strictly not toxic or otherwise harmful and, to set a standard in their spill countermeasure plans and cleanup protocols that insures these plans do, in fact, utilize methods that swiftly and completely *remove* oil from a spill area.

Recommended Actions

- All stakeholders in the business of making decisions regarding oil spill countermeasures should adopt the Assessment Criteria on pages 20-23 of this paper for the identification and implementation of non-toxic oil spill cleanup agents. Such criteria should also be added to regional and area contingency plans and existing plans reviewed to eliminate or replace any products that do not meet the criteria herein.
- All O&G companies and Oil Spill Response Organizations should conduct their own internal audits and reviews of existing spill countermeasure plans associated with their operations to ensure they employ best available technology and practices, guided by the Assessment Criteria on pages 20-23 of this paper, implementing protocols that will meet Clean Water Act standards.

  - Assistance with how to employ best chemical screening practices can be found by consulting with organizations that specialize in finding environmentaly safe alternatives such as:
    - Clean Production Action's GreenScreen Program at: www.greenscreenchemicals.org
    - USEPA Design for the Environment Program and their Alternatives Assessment Criteria for Hazard Evaluation: http://www.epa.gov/dfe/alternatives_assessment_criteria_for_hazard_eval.pdf
- List and include Bioremediation Enzyme Additive Agent Type in spill countermeasure plans as a *first response* option for removal of oil and other hydrocarbon-based chemical spills in ocean and fresh water environments. References and full technical library reference links are available at: https://www.changeoilspillresponse.org/response-tools.html

Respectfully submitted by the
Lawrence Anthony Earth Organization, Science & Technology Advisory Board

CONTACT INFORMATION

Lawrence Anthony Science & Technology Advisory Board
Phone: 818-769-3410
E-mail: info@theearthorganization.org

Strategic Partnerships
International President
Barbara Wiseman
E-mail: barbara@theearthorganization.org
Phone: 818-769-3410

Media and Technology Inquiries
Science and Technology Advisory Board Coordinator
Diane Wagenbrenner
E-mail: diane@theearthorganization.org
Phone: 818-769-3410 or 858-531-6200

Website: www.protectmarinelifenow.org
Who We Are: http://theearthorganization.org/Whoweare.aspx

Lawrence Anthony Earth Organization
P.O. Box 2287
Toluca Lake, CA 91610

REFERENCES & NOTES

1. *National Geographic*, April 19, 2012, "Gulf Spill Pictures: Ten New Studies Show Impact on Coast," Barbara Mulligan, http://news.nationalgeographic.com/news/energy/2012/04/pictures/120420-gulf-oil-spill-impact-studies/; Paul W. Sammarco et al., "Distribution and Concentrations of Petroleum Hydrocarbons Associated With the BP/ Deepwater Horizon Oil Spill, Gulf of Mexico," *Marine Pollution Bulletin*, 73, no.1 pp. 129-143 (2013), http://www.sciencedirect.com/science/article/pii/S0025326X13002762; see also Reference Note 9, "Ample Studies".
2. Siddhartha Mitra et al., "Macondo-1 Well Oil-Derived Polycyclic Aromatic Hydrocarbons in Mesozooplankton from the Northern Gulf of Mexico," *Geophysical Research Letters* 39, L01605 (2012), doi:10.1029/2011GL049505; "Analysis of Potential Health and Environmental Impacts of Chemicals in Dispersant Products" (August 2011), Toxipedia Consulting Services; Earth Justice, http://earthjustice.org/sites/default/files/Oil_Dispersants_Report.pdf.
3. *Woods Hole Oceanographic Institution Study,* http://www.whoi.edu/news/89188/, appearing in the American Chemical Society (ACS) online journal *Environmental Science & Technology (January 26, 2011)*, is the first peer-reviewed research to be published on the dispersant applied to the Gulf spill and the first data in general on deep application of a dispersant; see also 2014 Woods Hole and Haverford Collage Study "Long-Term Persistence of Dispersants following the Deepwater Horizon Oil Spill," *Environmental Science & Technology Letters* (2014), *1* (7), pp 295–299, doi: 10.1021/ez500168r, http://pubs.acs.org/doi/abs/10.1021/ez500168r
4. Using a new, highly sensitive chromatographic technique that she and WHOI colleague Melissa C. Kido Soule developed, chemist Elizabeth B. Kujawinski reports that those concentrations of DOSS in the plume of oil from the Deepwater Horizon spill indicate that little or no biodegradation of the dispersant substance had occurred. The deep-water levels suggested any decrease in the compound could be attributed to normal, predictable dilution and not as a result of the biodegradation of the dispersant substance. They found additional evidence that the substance did not mix with the 1.4 million gallons of dispersant applied at the ocean surface and appeared to have become trapped in deep-water plumes of oil and natural gas reported previously by other WHOI scientists and members of this research team. The team also found a striking relationship between DOSS levels and levels of methane, which further supports their assertion that DOSS became trapped in the subsurface.
5. Mary L. Landrieu, United States Senate, letter to Admiral Robert J. Papp, Jr., USCG (August 10, 2012), http://www.landrieu.senate.gov/files/documents/2012_08_14_coastguard.pdf.
6. UPI wire story, "Hurricane Churned Up Deepwater Horizon Oil," (2012), http://www.upi.com/Top_News/US/2012/10/18/Hurricane-churned-up-Deepwater-Horizon-oil/UPI-92561350559653/?spt=hs&or=tn
7. Operational Science Advisory Team, *Summary Report for Fate and Effects of Remnant Oil Remaining in the Beach Environment*, http://gulfsciencedata.bp.com/external/content/document/6145/1962614/1/OSAT-2%20Report%20with%20Annexes%20-%20February%2010,%202011.pdf (2011). Note that dispersants are only effective when applied to fresh oil; yet reports indicate Hurricane Isaac cleanup included the use of dispersants. See also, Michael M. Singer et al., "Comparison of Acute Aquatic Effects of the Oil Dispersant Corexit 9500 with Those of Other Corexit Series Dispersants," *Ecotoxicology and Environmental Safety* (1996), 35 no.98. This article provides scientific evidence that shows that the toxicity level of the newest Corexit dispersant (9500) is very similar to all of the other Corexit series dispersants.
8. Ryan Dezember, "Ixtoc Spill Still Contaminates Coastlines; Is That Northern Gulf's Fate?" (2010), http://blog.al.com/live/2010/09/ixtoc_spill_still_contaminates.html; Information on dispersants, Corexit toxicity levels: see Reference Note 7 above; M. Fingas, A Review of Literature Related to Oil Spill Dispersants 1997–2008, http://www.pwsrcac.org/wpcontent/uploads/filebase/programs/environmental_monitoring/dispersants/review_of_alaska_related_osd_literature_2002-2008.pdf ; Charles R. Fisher et al., "Footprint of Deepwater Horizon Blowout Impact to Deep-Water Coral Communities," *Proceedings of the National Academy of Sciences of the United States of America* 2014, http://www.pnas.org/content/111/32/11744.full; see also Prince William Sound Regional Citizens' Advisory Council studies on chemical dispersants, http://www.pwsrcac.org/?s=chemical+dispersants&x=0&y=0
9. Ample studies: http://www.eoearth.org/article/Journal_articles_related_to_the_Deepwater_Horizon_oil_spill and http://www.lib.noaa.gov/researchtools/subjectguides/dwh_bibliography.pdf; Mote Marine Laboratory Study-Dispersant and Oil from Deepwater Horizon Toxic to Baby Corals, Jan 2013 http://dx.plos.org/10.1371/journal.pone.0045574
10. Since doubt was cast by PEER on the accuracy of oil spill volume during the DWH disaster, "NOAA Declines to Probe Vast Underestimate of BP Spill," (2013), http://www.peer.org/news/news-releases/2013/01/03/noaa-declines-to-probe-vast-underestimate-of-bp-spill/, and the conservative assessment made by NOAA that an estimated 25% of the oil is unaccounted for, more should be done to locate and remove at least 1 million barrels of oil still residing in the Gulf. Historically, mechanical cleanup has been able to remove 2%–8%, while dispersants do not remove any, and unknown quantities evaporate. See also *National Geographic* interview with Dr. Jane Lubchenco, former Director of NOAA, http://channel.nationalgeographic.com/channel/explorer/videos/noaa-on-the-oil-spill/embed/; interview with Lisa Jackson, http://channel.nationalgeographic.com/channel/explorer/videos/the-epa-on-the-oil-spill/embed/.
11. Catherine Kilduff and Jaclyn Lopez, "Dispersants: The Lesser of Two Evils or a Cure Worse Than the Disease?" *Ocean and Coastal Law Journal*, 16, no. 2, http://mainelaw.maine.edu/academics/oclj/pdf/vol16_2/vol16_oclj_375.pdf.

11-1. Maude Barlow. "The Global Water Crisis and the Commodification of the World's Water Suply," 2001, http://www.ratical.org/coglobalize/BlueGold.pdf

12. USCG Guidance, Preapproval in US Regions, https://homeport.uscg.mil/mycg/portal/ep/contentView.do?contentTypeId=2&channelId=-30095&contentId=125795&programId=114824&programPage=%2Fep%2Fprogram%2Feditorial.jsp&pageTypeId=1348.

13. 33 U.S.C. § 1321(j)(4). The EPA and the Coast Guard, as co-chairs of the Region 6 RRT, approved the Regional Response Team Oil Spill Dispersant Use Policy in 1995; see also Dispersant Background White Paper, https://www.thestateofthegulf.com/media/72686/Dispersant-Background-White-Paper.pdf. Zygmunt J.B. Plater, Professor of Law, Boston college Law School. Learning from Disasters: Twenty One Years After the Exxon Valdez Oil Spill, Will Reactions to the Deepwater Horizon blowout Finally Address the Systemic Flaws Revealed in Alaska? Research Paper December 15, 2010, http://ssm.com/abstract=1726053; Section II, Response System Failures.

14. 33 U.S.C. §§ 1251 et seq. (1972), http://water.epa.gov/lawsregs/rulesregs/101a.cfm.

15. *Toxipedia*, Toxicity of Dispersant Chemicals, Summary of 57 chemical ingredients (January 25, 2012), http://toxipedia.org/display/toxipedia/Potential+Effects+of+Oil+Dispersant+Chemicals+on+Human+Health+and+the+Aquatic+Environment; USCG Dispersants, On-Water Oil Removal Capacity: Dispersant Preapproval Listings https://homeport.uscg.mil/mycg/portal/ep/contentView.do?contentTypeId=2&channelId=-30095&contentId=125795&programId=114824&programPage=%2Fep%2Fprogram%2Feditorial.jsp&pageTypeId=13489; See also, Section 307 of CWA

16. Dispersants' constituents and their ingredients are subject to regulation under the Toxic Substances Control Act; see report from Earthjustice and Toxipedia Consulting Services, "The Chaos of Clean Up", http://earthjustice.org/features/the-chaos-of-clean-up.

17. Earth Justice study with citations, Patti Goldman, Marianne Engelman Lado, and Matthew Gerhart, "The Approval and Use of Dispersants in Oil Spill Responses: Proposals for Reform," (2010), http://earthjustice.org/library/The%20Approval%20and%20Use%20of%20Dispersants%20in%20Oil%20Spill%20Responses%3A%20Proposals%20for%20Reform.

18. US EPA Dispersant Toxicity Testing (June 2010), http://www.epa.gov/bpspill/reports/ComparativeToxTest.Final.6.30.10.pdf.

19. BP response to EPA re locating a less toxic dispersant; see chart page 10, http://www.epa.gov/bpspill/dispersants/5-21bp-response.pdf.

20. Right to Know Hazardous Substance Fact Sheet: 2-Butoxy Ethanol, NJ Department of Health & Senior Services (August 2008), http://nj.gov/health/eoh/rtkweb/documents/fs/0275.pdf; Agency for Toxic Substances and Disease Registry ToxFAQs (August 1999), 2-BUTOXYETHANOL and 2-BUTOXYETHANOL ACETATE, CAS # 112-07-2 and 111-76-2, http://www.atsdr.cdc.gov/toxfaqs/tfacts118.pdf. [It has been stated by the manufacturer of Corexit 9500 that it does not contain 2-Butoxyethanol. Minimally, since the 1999 EPA NCP Notebook record showed that Corexit 9500 contained 2BE, failure to update the NCP listing with this information made this product questionable for use. If Corexit 9500 does not contain 2BTE, then it does contain chemicals equally toxic (e.g., propylene glycol and DOSS at minimum); because when the MSDS's of 9500 and 9527 are compared, they are identical, i.e., causing kidney failure and mortality, etc.]

21. Oil Pollution Act of 1990, http://www.epa.gov/oem/lawsregs.htm#ncp.

22. Each EPA regulation is referenced by its location in the Code of Federal Regulations (CFR). For example, "40 CFR 300" means that the regulation is in Title 40, Part 300, of the CFR.

23. Roberto Rico-Martínez, Terry W. Snell, and Tonya L. Shearer, "Synergistic Toxicity of Macondo Crude Oil and Dispersant Corexit 9500A® to the *Brachionus plicatilis* Species Complex (Rotifera)," *Environmental Pollution* 173 (February 2013): 5–10. This recently published study indicates toxicity levels of Macondo oil plus Corexit 9500A were 52 times more toxic than the oil itself. Woods Hole Oceanographic Institution, *Dispersant from Deepwater Horizon Spill Found to Persist in Environment* (July 2014) http://www.whoi.edu/news-release/dwh-dispersant; see note 25 "Synergistic Toxicity of Macondo Crude Oil and Dispersant Corexit 9500A® to the *Brachionus plicatilis* Species Complex (Rotifera)"

24. Interagency Coordinating Committee on Oil Pollution 2010- 2011 Research Report, http://www.iccopr.uscg.gov/iccopr/i/files/Biennial%20rpt_FY2010%20and%202011_4Jun2012.pdf

25. Oil Spill Commission Action report, *Assessing Progress—Implementing the Recommendations of the National Oil Spill Commission* (April 17, 2012), http://oscaction.org/wp-content/uploads/OSCA-Assessment-report.pdf.

26. EPA Inspector General recommendations (August 25, 2011), http://www.epa.gov/oig/reports/2011/20110825-11-P-0534.pdf.

27. The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan or NCP, is the federal government's blueprint for responding to both oil spills and hazardous-substance releases. Full text at http://www.epa.gov/oem/lawsregs.htm#ncp.

28. Preamble to the Proposed RRT VI Bioremediation Position Paper, RRT VI Science & Technology Committee (January 2001), http://gisweb.glo.texas.gov/atlas/atlas/misc_doc/rrt6_bio_position.pdf.

29. Of the recent toxicity studies of dispersed oil, most researchers found that chemically dispersed oil was more toxic than physically dispersed oil, and biodegradation is not supported by the use of chemical dispersants. M. Fingas, *A Review of Literature Related to Oil Spill Dispersants 1997–2008*, http://www.pws-osri.org/programs/projects/annual_reports/2008/08-10-08-a.pdf

30. J. W. Tunnell, Jr., Texas A&M University, *An expert opinion of when the Gulf of Mexico will return to pre-spill harvest status following the BP Deepwater Horizon MC 252 oil spill* (January 31, 2011), http://media.nola.com/2010_gulf_oil_spill/other/Tunnell-GCCF-Final-Report.pdf.

31. Bob Marshall, *Hurricane Isaac Showed That BP Oil-Spill Woes Remain* (September 23, 2012), see interview with Robert Barham, Secretary of the Louisiana Department of Wildlife and Fisheries, http://www.nola.com/sports/index.ssf/2012/09/hurricane_isaac_showed_that_bp.html.

32. Crisis in the Gulf Documentary, http://earthorganization.com/News.aspx?tid=108.

33. Jong Nam Kim et al., "Effects of Crude Oil, Dispersant, and Oil-Dispersant Mixtures on Human Fecal Microbiota in an *In Vitro* Culture System," *mBio* (2012), 3(5):e00376-12, doi:10.1128/mBio.00376-12, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482501/. *"Dispersed oil affected the intestinal microbiota more than either oil or dispersant alone. This may be due to the increased solubility of dispersed oil, which could provide more surface area of hydrophobic and toxic compounds for microbial contact than oil alone. Therefore, dispersed oil may be more bioavailable to the microbiota than oil alone. Previous studies reported that chemical dispersants may increase the concentration of PAHs in the water column. The toxicity of dispersed oil showed that chemically dispersed oil increased the toxicity and concentrations of TPHs and PAHs in fish more than mechanically dispersed oil, dispersant alone, water-soluble oil fractions, or seawater alone."*

34. Sample Toxicity Comparison LC 50 Values on chart can be found at EPA/BP Tests, http://www.epa.gov/bpspill/reports/ComparativeToxTest.Final.6.30.10.pdf; Environment Canada Reports, http://www.etc-cte.ec.gc.ca/databases/SpillTox/Default.aspx.

35. OSEI Corporation Summary of the US EPA Regional Response Team VII Testing of OSE II on Heavy Waste Oil, February 1 to March 8, 2012, http://www.osei.us/pdf%20files/RRT%20plus%20testsing.pdf. Oil Spill Cleanup Demonstration on Arabian Gulf, http://osei.us/archives/1135. See also the US Department of Interior study shoing that Oil Spill Eater II is far more successful at remediating oil when compared to Corexit 9500 and Corexit 9527, "Characteristics, Behavior, & Response Effectiveness of Spilled Dielectric Insulating Oil in the Marine Environment," (Jne 2011), http://www.bsee.gov/uploadedFiles/BSEE/Research_and_Training/Technology_Assessment_and_Research/aa%283%29.pdf.

36. Complaint for Declaratory and Injunctive Release Case 1:12l-cv-01299, Document 1, filed 08/06/12, http://www.shb.com/newsletters/ECU/Etc/ACATvEPA.pdf.

37. 40 CFR, Part 300, Appendix C, 2.5, numbers 5, 6, and 7, describes the 20-minute time test on the shaker table, then 10 minutes of settling, for a total of 30 minutes, to allow the oil to sink. This section of 40 CFR is where the EPA derived its statement regarding the test of dispersant "effectiveness."

38. The Nation, May 7, 2012, http://www.thenation.com/article/167461/investigation-two-years-after-bp-spill-hidden-health-crisis-festers; J. H. Diaz, "The legacy of the Gulf oil spill: Analyzing acute public health effects and predicting chronic ones in Louisiana," *American Journal of Disaster Medicine 6*, no. 1 (January/February 2011): 5–22, doi:10.5055/ajdm.2011.0040.

39. Minnesota Department of Natural Resources report, MPR News (May 16, 2012): *BP Oil Spill Residue Found on Pelicans in Minn,* http://www.mprnews.org/story/2012/05/16/environment/oil-residue-found-on-pelicans.

40. Magdalena Pacwa-Plociniczak et al., "Environmental Applications of Biosurfactants: Recent Advances," *International Journal of Molecular Sciences* 12, pp. 633-654 (2014), doi:10.3390/ijms12010633; see also Rita de Càssia F. S. Silva et al., "Applications of Biosurfactants in the Petroleum Industry and the Remediation of Oil Spills," *International Journal of Molecular Sciences* 15, doi:10.3390/ijms150712523.

41. An LAEO Science and Technology Committee Review: Water/Soil Pollution Cleanup Technology Oil Spill Eater II —*Enzyme Type* Bioremediation – For the Removal of Oil and Chemical Spills: http://protectmarinelifenow.org/?ddownload=10992 ; Referenced in LAEO Review Paper: Bio Aquatic Lab NCP Complete Testing: http://protectmarinelifenow.org/?ddownload=10984 ; Referenced in LAEO Review Paper: OSE II Efficacy Documentation: http://protectmarinelifenow.org/?ddownload=10983; King Fahd University of Petroleum & Minerals, Research Institute, Dharan, Saudi Arabia; A Report on the Evaluation of Oil Spill Eater II.

GLOSSARY

biocatalyst. A substance, such as an enzyme, that starts or increases a chemical reaction in a living body.

biocide. Any toxic chemical that has the potential of destroying life forms by poisoning.

biodegradable. Capable of being decomposed into nontoxic components by bacteria or other living organisms.

biodegradation. The process that microbial organisms use, through metabolic or enzymatic action, to break down toxins into their nontoxic components.

bioremediation. Utilization of the metabolic and enzymatic processes of microorganisms to remove pollutants from the environment.

biosurfactants. Substances produced by microorganisms that lower the surface tension of water and increase the ability of organic compounds, like crude oil, to more easily dissolve in water, thereby making them more available for microbial degradation. (See also *surfactant*.)

carcinogen. A substance that is capable of causing cancer in humans or animals.

***Clean Water Act* (*CWA*)**. The Clean Water Act establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1972. Source: http://www.epa.gov/lawsregs/laws/cwa.html.

Corexit. A line of solvent products licensed by Exxon to Nalco Holding Company for production and distribution. They are primarily used as dispersants for breaking up oil slicks and sinking the oil out of sight below the surface waters. Corexit was used as the primary dispersant in the British Petroleum Deepwater Horizon oil blowout in the Gulf of Mexico. It causes the oil to break up into small globules that remain suspended in the water, eventually sinking to the seabed and then ultimately washing up on beaches as currents and storms churn the oil up off the seabed and from the water column. See "NALCO Corexit and Crude Oil: A Laboratory Experiment," http://www.bust-video.info/v/yt:BdAtvB9OtRs/1.

Deepwater Horizon. An offshore oil drilling rig owned by the Transocean corporation and leased to British Petroleum. On April 20, 2010, during drilling in a geographical area of the Gulf of Mexico called the Macondo Prospect, a blowout killed 11 crewmen. Two days later, after a second explosion, the rig sank, leaving at least one well and a crater in the seabed floor gushing oil uncontrollably, causing the largest offshore oil spill disaster in US history.

detergent. A surfactant or a mixture of surfactants that facilitate the mixing of compounds like oil and grease with water, normally used for cleaning purposes.

dispersant. A liquid or gas added to a mixture such as oil in order to promote dispersion of the oil or to maintain suspension of the dispersed oil particles.

DOSS (*dioctyl sodium sulfosuccinate*). A toxic surfactant that is a component of Corexit. Common side effects of exposure to DOSS include a breakdown of the cellular walls of red blood cells and subsequent rectal bleeding, stomach pain, diarrhea, serious allergic reactions, and cramping.

ecosystem. Short for ecological system. The symbiotic relationships between all living organisms in a particular geographical area and the nonliving components of their environment, such as air, water, and soil. These organisms and components operate together through nutrient cycles and energy flows.

emulsification. The resulting blended mixture of two or more liquids that are normally not able to be mixed or blended, such as oil and water. In an emulsion, the particles of one liquid are dispersed in the other, rather than dissolved.

Environmental Protection Agency (*EPA*). A US federal government agency whose mission statement is to protect the health of the public and the environment by writing and enforcing regulations based on laws passed by Congress. Led by a senior administrator appointed by the US president and approved by Congress, the EPA, although not a cabinet department, is directly under the president and is responsible for fulfilling the president's constitutional mandate to protect and defend the natural resources of the US.

enzymes. Biological molecules that increase the rate of chemical reactions. They are responsible for the thousands of chemical interconversions that sustain life.

federal On-Scene Coordinator (*OSC*). See On-Scene Coordinators.

finishing-up product. A term used to describe an oil spill cleanup product that cannot successfully address fresh oil because of the oil's high level of toxicity.

fishery. An ecosystem in a particular geographic area of water or seabed, which includes the people involved, method of fishing, class of fishing boats, one or more species or type of fish, including shellfish, and the purpose of the activities—i.e., recreational or commercial.

genetic. Pertaining to the heredity of traits.

hydrocarbons. Organic compounds made up solely of hydrogen and carbon. There are many types of hydrocarbons, and the majority found on earth naturally occur in crude oil. Some forms of hydrocarbons are carcinogenic and/or otherwise toxic and harmful to most forms of life.

indigenous. A description of a living organism (plant or animal) that is native to a specific geographical region.

in situ burning. An oil spill response method of controled burning of oil at the spill location. The particulates released into the atmosphere by in situ burning are a concern to many people. This spreads toxic oil compounds into the atmosphere, which eventually arrive somewhere else. See NOAA website for more information http://response.restorationnoaa.gov/oil-and-chemical-spills.oil-spills/resources/in-situ-burning.html.

insoluble. Incapable of being dissolved in water or another liquid.

Ixtoc I. An exploratory oil well being drilled by the semisubmersible drilling rig Sedco 135-F in the Bay of Campeche of the Gulf of Mexico, about 100 km (62 mi) northwest of Ciudad del Carmen, Campeche, in waters 50 m (160 ft) deep. On June 3, 1979, the well suffered a blowout resulting in one of the largest oil spills in history.

***Lawrence Anthony Earth Organization* (*LAEO*)**. An environmental and conservation nonprofit founded in 2003 by South African conservationist, author, and humanitarian Lawrence Anthony. As of this writing, the organization has 23 chapters in 21 countries. Since the beginning of the BP-DWH blowout and oil spill, the US chapter has focused on finding and getting implemented workable solutions that will result in returning the Gulf of Mexico's contaminated waters to their pre-blowout condition, as a part of the organization's larger campaign to return polluted waters of the world to their pristine condition. The LAEO's mission is to work with governments, industry, and the broad public to stably reverse decaying environmental and conservation situations through education and hands-on projects. Among their many accomplishments, they have created two large game reserves in South Africa, reopening migration corridors for the wildlife and aiding local tribes in transferring from poaching to eco-tourism as an economic base. Three books have been written about Lawrence Anthony's achievements—*Babylon's Ark*, *The Elephant Whisperer*, and *The Last Rhinos*—and a Hollywood feature film is being produced about his life. LAEO coined a new term, *Cooperative Ecology,* to clearly define the philosophical basis upon which the organization operates. Commonly shortened to "Co-Eco," the term is defined fully on page 28 of this document.

lyse. To cause dissolution or destruction of cells by lysins.

lysins. Antibodies or other agents that cause red blood cells or bacterial cells to break down.

Macondo. The Macondo Prospect (Mississippi Canyon Block 252, abbreviated MC252) is a geographic area in the Gulf of Mexico off the coast of Louisiana containing a massive geological trap for oil and gas. It was the site of the British Petroleum Deepwater Horizon oil blowout disaster of April 20, 2010.

mechanical cleanup. Generally, in oil spill cleanup, this is the use of booms to try to contain oil or keep it away from sensitive areas, and skimmers designed to skim as much of the oil off the surface as possible. *In situ* burning of the oil is also a common method, but this is potentially hazardous to human health.

metabolism. The chemical processes occurring in living organisms that result in growth of the organism, production of energy, elimination of waste, and other basic organic functions. —v. *metabolize*.

microbe, microorganism. Any living organism too small to be seen without the use of a microscope.

microbiological. Having to do with the structure, function, uses, and modes of existence of microscopic organisms.

miscible. Applies to liquids: capable of mixing together completely to form a solution.

mutagenic. Capable of causing or increasing the rate of unnatural mutations in living organisms.

mutation. An unnatural change within the structure of a living organism caused by exposure to a mutagenic toxin.

***National Contingency Plan* (*NCP*)**. The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan or NCP, is a government document delineating required response protocols and methods in circumstances where oil and hazardous substances have been released into the environment.

NCP Product Schedule. Subpart J of the National Contingency Plan is a Product Schedule that contains dispersants and other chemical or biological products that have gone through the EPA's testing requirements to be considered for use in carrying out the NCP when oil or other hazardous substances have been spilled. Being on the NCP list does not give automatic approval status for the various products that are listed on the Product Schedule. Each time an oil or hazardous substance spill occurs on US navigable waters, approval for which product(s) can be utilized on that specific spill must be obtained by Regional Response Teams and Area Committees, or by the federal OSC, in consultation with EPA representatives. It is interesting to note that, in the past 23 years, the only product that has ever been approved for use when an actual oil spill on US navigable waters has occurred is Exxon's product line called Corexit, despite the existence of other products on the NCP list that are less expensive, more effective, and have fewer damaging side effects.

nutrients. As used in this paper, these include nitrogen and/or phosphorous which form the building blocks needed to grow microorganisms.

***On-Scene Coordinators* (*OSCs*)**. Federal officials predesignated by the US EPA and Coast Guard to coordinate response resources in disaster situations. Under the National Contingency Plan, if federal involvement is necessary because state and local resources have been exceeded, the OSC is obligated to coordinate the use of these resources to protect public health and the environment.

PAH. Polycyclic aromatic hydrocarbon, a molecule made up of hydrogen and carbon, with multiple carbon rings. PAHs are persistent, bioaccumulative, and toxic pollutants (PBT), which include carcinogenic substances and environmental toxins.

Persistent organic pollutant. (PBTs or POPs) are of greatest concern in the broad range of chemicals that are considered pollutants. PBTs are organic compounds that are resistant to degradation. As such they persist in the environment, bioaccumulate in human and animal tissue and food chains. (See Wikipedia for more information)

plankton. Tiny organisms occurring in a body of water, primarily comprising microscopic algae and protozoa.

pollutants. Toxins that contaminate water, soil, and air.

***Regional Response Team* (*RRT*)**. Regional planning and coordination of preparedness and response actions for disasters are accomplished through the RRT. There are 13 RRTs, one for each of ten federal regions, plus one for Alaska, one for the Caribbean, and one for the Pacific Basin. Each RRT maintains a Regional Contingency Plan (RCP) and has state, as well as federal government, representation. EPA and the Coast Guard co-chair the RRTs. Standing RRTs are planning, policy, and coordinating bodies and do not respond directly to disaster scenes. The

RRT provides assistance as requested by the On-Scene Coordinator during an incident. Source: http://www.rrt.nrt.org/.

solubility. The relative ability of a substance to be dissolved in water or other liquid.

solubilization. The action of dissolving in a liquid.

solvent. A substance that has the capacity to dissolve another substance.

surfactant. A substance that lowers the surface tension of water, making it easier for organic compounds to be dissolved in the water. Detergents are an example of surfactants, as they help remove organic compounds from a given material by making them dissolve more readily in the water in which the material is washed. Both toxic man-made surfactants and nontoxic natural surfactants exist.

teratogenic. Capable of causing birth defects and negatively impacting the development of a fetus.

toxin. Any substance that is poisonous to live organisms.

trade-offs. A trade-off is a circumstance or situation that involves making a decision that has a downside that is considered offset by an upside. An *environmental trade-off* could be defined as assessing a benefit as being greater than a negative or destructive aspect of a method or action. An environmental compromise that is considered reasonable by decision makers in one point in time may be subject to debate when new data becomes available.

***volatile organic compounds* (*VOCs*)**. Organic chemicals that have a high vapor pressure at ordinary room-temperature conditions. VOCs are numerous, varied, and present everywhere. They include both human-made and naturally occurring chemical compounds. Harmful VOCs are typically not acutely toxic, but instead have compounding long-term health effects.