Optimizing Oil Spill Response

Identification and Assessment Methods for Contingency Plans

Lawrence Anthony
EARTH ORGANIZATION
Because None Survive Alone

In observance of Earth Day 2015 and the 5th anniversary
of the Deepwater Horizon Gulf of Mexico oil spill disaster; we have created this oil spill solutions pamphlet excerpted from the Lawrence Anthony Earth Organization, Science and Technology Committee research paper entitled:

A Call for a Twenty-First Century Solution in Oil Spill Response.

While it is recommended that the complete research paper be studied, these spill response-planning guidelines are being made widely available as vital information for educational purposes.

The complete research paper may be downloaded at www.protectmarinelifenow.org

In the spirit of Cooperative Ecology™* and finding a better way forward in oil spill response methods the Lawrence Anthony Earth Organization Global Environmental Solutions Institute is seeking collaborative partnerships for advancing research in this field. We strongly urge oil spill response professionals to avail themselves of this information as critical to their decision-making process when selecting efficient methods for removing oil and other chemical spills from our oceans and waters.

* Definition of Cooperative Ecology is on page 28 of this document.

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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 deepwater 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.*"

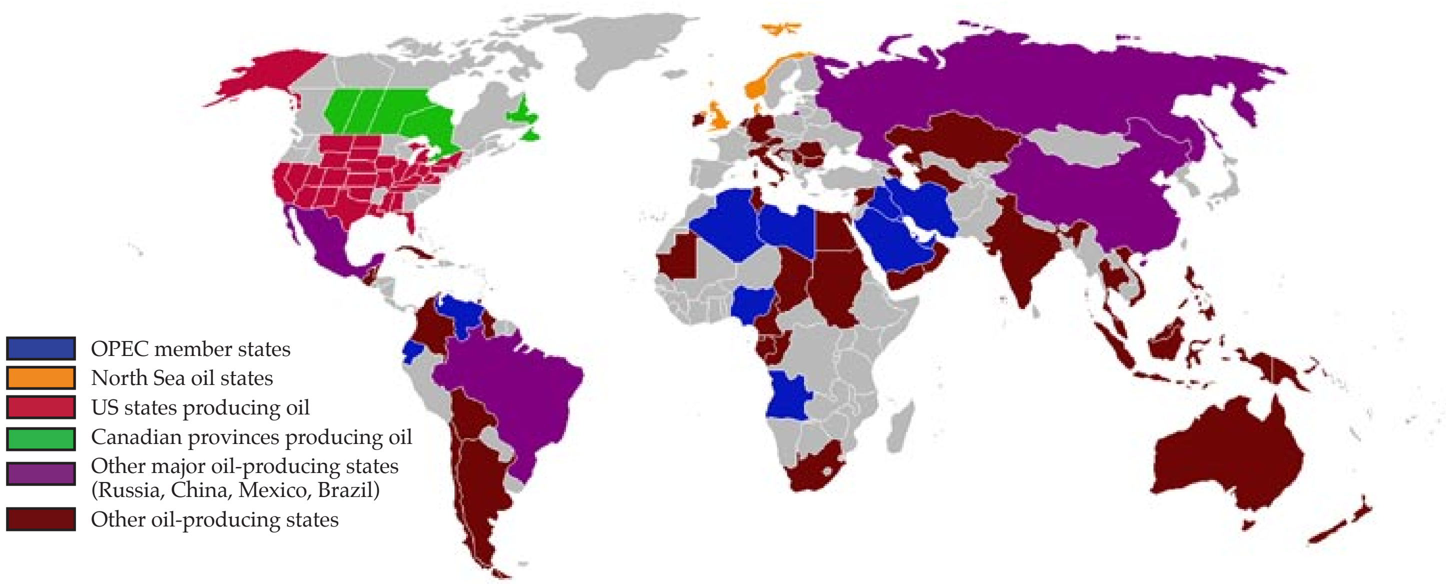
Proper assessments and protocols need to be developed for each *type* of Bioremediation Agent as to its suitability in terrestrial, coastal, freshwater, brackish, and marine environments. This would then result in the proper definitions and designations for the term *bioremediation* and recognition of 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

The Reference Notes/Citations and Glossary for this excerpt are available online at the Knowledge Base Tab at: http://protectmarinelifenow.org/knowledge-base

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