American Bar Association, Toxic Torts and Environmental Law Committee, Phoenix, AZ, April 8, 2006

Who spilled the chlorinated solvents? B. Murphy

Workshop on U.S. Seawater Vaporization: Getting to Resolution, Houston, TX, January 26, 2006

An evaluation of the approaches used to predict potential impacts of open loop LNG vaporization systems on liberty resources of the Gulf of Mexico. D. Nielsen

International Society for Exposure Analysis/International Society for Environmental Epidemiology, ISEA/ISEE 26th Annual Conference, Paris, France, September 2-6, 2006

Oral bioavailability and dermal absorption of arsenic from soil in vivo research and progress toward in vitro methods. Y. Lawyee, S. Robert, R. Wasser

5th International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Monterey, CA—May 22–25, 2006

Transport modeling to assist design of enhanced dechlorination system. A. Hywwamani and F. Maksoud

Mercury Global Problem, Local Solution, a Specialty Conference—Gary Bigham will lead the opening session at the jointly sponsored conference on September 19, 2006, offered by the Air & Waste Management Association, Oregon Chapter, and the Northwest Environmental Business Council. Other participants are K. Futornick/Exponent/Chair, Air & Waste Management Association, Oregon Chapter.

Air & Waste Management Association/Pacific Northwest International Section,* Annual Conference, PNWIS 2006 Conference November 8–10, Victoria, B.C. Canada

Sustainability—Habitat Restoration (will also be presenting on Alcoa project). P. Booth, Session Chair

Sustainability—Decision-Making Tools, P. Booth, Session Chair

Green Buildings and Development (will also be presenting on LEED ranking system), K. Futornick, Session Chair

K. Futornick, Session Chair, Stormwater Management

What’s in the Draft? The Answer Is In The Details, L. Benton (authors L. Benton, W. Shields, M. Edwards)

Health Effects and Risk Assessment, K. Koetzell, Session Chair

Exponent Scientist Awarded Fellow Grade of Membership

Julian A. Levy, Jr., Senior Managing Scientist in the Environmental practice, was recently awarded by the Air & Waste Management Association the Fellow Grade of Membership in 2006. The award recognizes professional attainment and accomplishments related to the mission and objectives of A&WMA based on a process, product, or regulatory development; project leadership; management achievement; the education of specialists, peer-reviewed technical publications; patents; and research or theoretical developments.

Exponent is a leading engineering and scientific consulting firm dedicated to providing solutions to complex problems.

About Exponent

Our environmental consulting services include:

- Ecological risk assessment
- Environmental forensics
- Environmental liability
- Human health risk assessment
- Hydrogeological investigations
- Natural resource damage assessment
- Occupational medicine/mold management
- Product stewardship
- Site investigation and remediation.

Please visit our website, www.exponent.com, for information on all of our consulting services.

(888) 656-EXPO info@exponent.com 18 regional and 3 international offices

Environmental Perspectives

SUMMER 2006

Emerging Issue: Use of Biomarkers to Assess and Quantify Injury in Natural Resource Damage Assessments

Dr. Nicholas Gard and Ms. Linda Ziccardi

Natural resource damage assessments (NRDAs) focus extensively on methods to determine whether injuries (defined as measurable adverse changes in the quality or viability of natural resources resulting from exposure to oil or a hazardous substance) have occurred; and to quantify the service losses resulting from those injuries. A rapidly emerging trend is for trustees to rely on biomarker measurements in individual organisms as a short cut to determining population scale injuries/changes as an input to service reductions calculations. This trend adds convenience to the process, but at the same time it introduces significant uncertainties.

Under U.S. Department of the Interior (DOI) NORDA regulations, determination of injury to biological resources primarily relies on measurement of sub-organism or organism-level [i.e., individual/level] endpoints. For example, 43 CFR §11.62[0](1) defines injury as occurring if a biological resource or its offspring have “undergone or at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions [including malformations in reproduction], or physical deformations.” By contrast, for quantification of injury, the DOI regulations state “the extent to which the injured biological resource differs from baseline should be determined by analysis of the population or the habitat or ecosystem levels” [43 CFR §11.7(1)]. Thus, there is an inherent mismatch between the level of biological organization at which injuries are defined and at which they are quantified. This mismatch creates problems in NRDA cases because of the difficulty in extrapolating data for injury identification (i.e., has injury occurred?) to injury quantification (i.e., measuring the extent of the injury). This is important because injury quantification is the basic metric for determining the scope of liability (restoration or monetary compensation) in an NORDA claim.

As noted above, determination of injury to biological resources is often made on the basis of adverse effects to an organism. Typically, these types of effects might be a measure of some reduction in survival, growth, or fecundity. However, as defined by the DOI NORDA regulations, injury determination can also be made on the basis of adverse effects at the cellular or subcellular level (i.e., biomarkers). The NOAA (1996) guidance document for NRDA under the Oil Pollution Act of 1990 (OPA) defines a biomarker as “a biochemical, physiological, or histological indicator of either exposure to, or effects of, xenobiotic contaminants such as oil at the suborganismal or organismal level.” The problem regarding data extrapolation as described earlier (extrapolating data for injury identification to injury quantification) tends to be more intractable for injury determinations that rely on biomarkers than those that rely on...
New Faces

SUSAN B. KANE DRISCOLL, PH.D.
Managing Scientist, ExxonMobil Environmental Resources, Maynard, MA

Dr. Driscoll is an aquatic toxicologist specializing in ecological risk assessments for RCRA, Superfund, and state hazardous waste sites nationwide, assessing impacts from industrial and hazardous waste on aquatic life, environmental quality, and governmental clients. Dr. Driscoll has experience in the preparation of field sampling plans, quality assurance project plans, risk assessment work plans, and the negotiation of their acceptance with state and federal regulatory authorities. She has more than 10 years of experience as a field team leader, taking responsibility for coordination and management of staff for the collection of field samples, implementation of quality control procedures, and coordination with subcontractors. Dr. Driscoll is also experienced in the development of technically defensible, risk-based cleanup levels.

References


The limitations in using biomarkers to assess chemical impacts on populations have been discussed extensively by others; see, for example, Forbes et al. (2006).

In the quantification phase of an NRDA, an attempt is made “to establish the extent of the injury to the resource in terms of the loss of services that the injured resource would have provided had the discharge or release not occurred” (43 CFR §111.13(f)).

Measurements of effects or use of biomarkers at the cellular or subcellular levels are not recommended for injury quantification because of the high degree of uncertainty in translating such measurements to population-level effects. For these reasons, Exponent recommends developing technical strategies in support of NRDA claim defense that focus on evaluating impacts at the organism, population, or community levels to counter trustee injury claims based on biomarker studies.

Dr. Nicholas Gard is a Managing Scientist in Exponent’s EcoSciences practice. He specializes in ecological risk assessment and natural resource damage assessment, with an emphasis on the evaluation of effects of chemicals on terrestrial, wetland, and aquatic ecosystems. He has 19 years of experience in toxicology, ecology, and wildlife biology. Dr. Gard has conducted natural resource damage assessments to quantify injuries to fish, birds, and mammals from exposure to PCBs and mercury, and to analyze habitat restoration requirements needed to appropriately compensate for damages resulting from these injuries.

Ms. Linda Ziccardi is a Senior Ecologist in Exponent’s EcoSciences practice. She is an ecologist with 16 years of experience evaluating environmental impact assessments in industrial and development settings nationwide. Her particular expertise is conducting CERCLA ecological risk assessments and natural resource damage assessments for chemically impacted sites. Her projects have included fish, wildlife, and vegetation baseline assessments, bioaccumulation studies, and quantitative risk analyses.

The Exxon Valdez experience.


Environment and Ecosciences News


In the quantification phase of a NRDA, an attempt is made “to establish the extent of the injury to the resource in terms of the loss of services that the injured resource would have provided had the discharge or release not occurred” [43 CFR §11.13(b)(2)], where services are defined as “the physical and biological functions performed by the resource including the human uses of those functions” [43 CFR §11.14(d)]. As measured by ethoxyresorufin O-deethylase (EROD) activity assays, or gene mRNA expression.

The limitations in using biomarkers to assess chemical impacts on populations have been discussed extensively by others; see, for example, Forbes et al. (2006). The limitations in using biomarkers to assess chemical impacts on populations have been discussed extensively by others; see, for example, Forbes et al. (2006).

The limitations in using biomarkers to assess chemical impacts on populations have been discussed extensively by others; see, for example, Forbes et al. (2006).

Mr. Mueller is a registered professional engineer with 25 years of experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Recent/Upcoming Publications


Mr. Gift has more than 15 years professional experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Dr. Nicholas Gard is a Managing Scientist in Exponent’s Ecosciences practice. He specializes in ecological risk assessment and natural resource damage assessment, with an emphasis on the evaluation of effects of chemicals on terrestrial, wetland, and aquatic ecosystems. He has 19 years of experience in toxicology, ecology, and wildlife biology. Dr. Gard has conducted natural resource damage assessments to quantify injuries to fish, birds, and mammals from exposure to PCBs and mercury, and to analyze habitat restoration requirements needed to appropriately compensate for damages resulting from these injuries. Ms. Linda Ziccardi is a Senior Ecologist in Exponent’s Ecosciences practice. She is an ecologist with 16 years of experience evaluating environmental management and development impacts in local, state, and federal regulatory authorities. She has more than 10 years of experience as a field team leader, taking responsibility for coordination and management of staff for the collection of field samples, implementation of quality control procedures, and coordination with subcontractors. Dr. Driscoll is also experienced in the development of technically defensible, risk-based cleanup levels. Todd E. Gift Senior Managing Scientist, Environmental Sciences, Chicago, IL 2006. Study: Proposed offshore gulf LNG terminals will have minor effects on fish populations. Oil and Gas Journal 104:28, July 28.

Mr. Mueller is a registered professional engineer with 25 years of experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Recent/Upcoming Publications


One prominent example of the application of biomarkers is in the Exxon Valdez NRDA, where recent “reopener” claims by the Trustees are based, in part, on data from molecular endpoints such as cytochrome P450 CYP1A1 (liver enzyme) induction and other assay techniques. The trustees are attempting to use these non-consent-specific biomarkers to argue continuing exposure 16 years after the spill at a very small number of sites in a vast ecosystem, and to make the case for population-level effects. Measurements of effects or use of biomarkers at the cellular or sub-cellular levels are not recommended for injury quantification because of the high degree of uncertainty in translating such measurements to population-level effects. For these reasons, Exponent recommends developing technical strategies in support of NRDA claim defense that focus on evaluating impacts at the organism, population, or community levels to counter trustee injury claims based on biomarker studies.

Toxicity endpoints or other measures of organism-level effect. For example, injuries such as reduction in survival, growth, or fecundity can be extrapolated to vital rates of the population, such as abundance, productivity, or survivorship, using fairly well-established ecological modeling methods. However, no such methods exist for reliably extrapolating physiological or metabolic effects to population- or ecosystem-level effects. In fact, the relevance of many biomarker endpoints to the growth, survival, or reproduction of an individual organism is unknown. Thus, extrapolation of these measurement endpoints to population-level endpoints introduces substantial additional uncertainty to injury quantification.

Despite these limitations, natural resource trustees have implement-ed injury assessment approaches using biomarkers to predict ecosystem service loss in many NRD cases, including the assessments conducted for the Lower Fox River/Green Bay, and the Exxon Valdez reopener (described below). In CERCLA cases and oil spills, trustees used data such as counts of killed fish and birds, toxicity studies, or decreases in population abundance or fecundity to quantify injury. Today it is becoming commonplace for trustees to measure biomarker endpoints such as enzyme induction or inhibition, physiological responses, reductions in growth, immunosuppression, and histopathology to identify natural resource injuries, and then apply simplistic approaches to infer some level of service reduction in the injury quantification phase of an NRDA. These biomarker-based injury determination methods are gaining popularity among trustees because they are relatively easy to perform, inexpensive, provide rapid approaches to measure exposure, and are generally more sensitive to lower contaminant concentrations than endpoints such as growth, survival, or reproduction.

One prominent example of the application of biomarkers is in the Exxon Valdez NRDA, where recent “reopener” claims by the Trustees are based, in part, on data from molecular endpoints such as cytochrome P450 CYP1A1 (liver enzyme) induction and other assay techniques. The trustees are attempting to use these non-consent-specific biomarkers to argue continuing exposure 16 years after the spill at a very small number of sites in a vast ecosystem, and to make the case for population-level effects. Measurements of effects or use of biomarkers at the cellular or sub-cellular levels are not recommended for injury quantification because of the high degree of uncertainty in translating such measurements to population-level effects. For these reasons, Exponent recommends developing technical strategies in support of NRDA claim defense that focus on evaluating impacts at the organism, population, or community levels to counter trustee injury claims based on biomarker studies.

Mr. Mueller is a registered professional engineer with 25 years of experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Recent/Upcoming Publications


Mr. Gift has more than 15 years professional experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Recent/Upcoming Publications


Mr. Gift has more than 15 years professional experience in the environmental field, including water resources (surface water and groundwater), industrial waste treatment and disposal, and hazardous waste management. His experience includes surface water and groundwater resource management, drinking-water system evaluation and design, wastewater design and management (including treatment and permitting of industrial process water), and RCRA and CERCLA-driven investigations and closure (including risk-based closure projects). Mr. Mueller has significant experience in complex site investigations, including transport and fate issues in soil, surface water, and groundwater. He has developed and conducted training courses on environmental regulatory compliance and has written and presented numerous papers on this subject.

Recent/Upcoming Publications

American Bar Association, Toxic Torts and Environmental Law Committee
Phoenix, AZ
April 8, 2006
Who spilled the chlorinated solvent? B. Murphy
Workshop on U.S. Seawater Vaporization: Getting to Resolution
Houston, TX
January 25, 2006
An evaluation of the approaches used to predict potential impacts of open loop LNG vaporization systems on library resources of the Gulf of Mexico, D. Nielsen
International Society for Exposure Analysis/International Society for Environmental Epidemiology, ISEA/ISEE 26th International Conference
Paris, France
September 2–6, 2006
Oral bioavailability and dermal absorption of arsenic from soil in vivo research and progress toward in vitro methods, Y. Lowery, S. Roberts, R. Waster
5th International Conference on Remediation of Chlorinated and Recalcitrant Compounds
Monterey, CA
May 22–25, 2006
Transport modeling to assist design of enhanced dechlorination system, A. Nyuwawami and F. Nielsen
Mercury Global Problem, Local Solution, a Specialty Conference—Gary Bigham will lead the opening session at the jointly sponsored conference on September 19, 2006, offered by the Air & Waste Management Association, Oregon Chapter, and the Northwest Environmental Business Council. Other participants are K. Futornick/Exponent/Chair, Air & Waste Management Association, Oregon Chapter.
Air & Waste Management Association/Pacific Northwest International Section,* Annual Conference, PWNIW 2006 Conference
November 8–10
Victoria, B.C. Canada
Sustainability—Habitat Restoration (will also be presenting on Alcoa project), P. Booth, Session Chair
Sustainability—Decision-Making Tools, P. Booth, Session Chair
Green Buildings and Development (will also be presenting on LEED ranking system), K. Futornick, Session Chair
K. Futornick, Session Chair, Stormwater Management
What’s in the Dust? The Answer Is In The Details, L. Bentley (authors: Bentley, W. Shields, M. Edwards)
Health Effects and Risk Assessment, E. Kootzol, Session Chair
Exponent Scientist Awarded Fellow Grade of Membership
Julian A. Levy, Jr., Senior Managing Scientist in the Environmental practice, was recently awarded by the Air & Waste Management Association the Fellow Grade of Membership in 2006. The award recognizes professional attainment and accomplishments related to the mission and objectives of A&WMA based on a process, product, or regulatory development; project leadership; management achievement; the education of specialists, peer-reviewed technical publications; patents; and research or theoretical developments.
Exponent is a leading engineering and scientific consulting firm dedicated to providing solutions to complex problems.
Our environmental consulting services include:
• Ecological risk assessment
• Environmental forensics
• Environmental liability
• Epidemiology
• Human health risk assessment/toxicology
• Industrial hygiene/mold investigations
• Natural resource damage assessment
• Occupational medicine/health
• Product stewardship
• Site investigation and remediation.

Steps to take to ensure that data are usable, meaningful, and legally defensible, J. Mc Ateer
Natural resource damage assessments (NRDAs) focus extensively on methods to determine whether injuries (defined as measurable adverse changes in the quality or viability of natural resources resulting from exposure to oil or a hazardous substance) have occurred, and to quantify the service losses resulting from those injuries. A rapidly emerging trend is for trustees to rely on biomarker measurements in individual organisms as a short cut to determining population scale injuries/changes as an input to service reductions calculations. This trend adds convenience to the process, but at the same time it introduces significant uncertainties.
Under U.S. Department of the Interior (DOI) NORDA regulations, determination of injury to biological resources primarily relies on measurement of sub-organism or organism-level (i.e., individual- or group-sized endpoints. For example, 43 CFR §11.62(1)[i]) defines injury as occurring if a biological resource or its offspring have “undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions [including malfunctions in reproduction], or physical deformations.” By contrast, for quantification of injury, the DOI regulations state “the extent to which the injured biological resource differs from baseline should be determined by analysis of the population or the habitat or ecosystem level” [43 CFR §11.7][1]. Thus, this is an inherent mismatch between the level of biological organization at which injuries are defined and at which they are quantified. This mismatch creates problems in NORDA cases because of the difficulty in extrapolating data for injury identification (i.e., has injury occurred?) to injury quantification (i.e., measuring the extent of the injury). This is important because injury quantification is the basic metric for determining the scope of liability (restoration or monetary compensation) in an NORDA claim.
As noted above, determination of injury to biological resources is often made on the basis of adverse effects to an organism. Typically, these types of effects might be a measure of some reduction in survival, growth, or fecundity. However, as defined by the DOI NORDA regulations, injury determination can also be made on the basis of adverse effects at the cellular or sub-cellular level (i.e., biomarkers). The NOAA (1995) guidance document for NORDA under the Oil Pollution Act of 1990 (OPA) defines a biomarker as “a biochemical, physiological, or histological indicator of either exposure to, or effects of, xenobiotic contaminants such as oil at the suborganism or organismal level.” The problem regarding data extrapolation as described earlier (extrapolating data for injury identification to injury quantification) tends to be more tractable for injury determinations that rely on biomarkers than those that rely on...